EVALUATION OF DESCHUTES RIVER FALL CHINOOK SALMON

Technical Report 96-6

Roy E. Beaty

July 1, 1996

Columbia River Inter-Tribal Fish Commission
729 N.E. Oregon St., Portland, OR 97232
(503) 238-0667

EVALUATION OF DESCHUTES RIVER FALL CHINOOK SALMON

Technical Report 96-6

Roy E. Beaty

Columbia River Inter-Tribal Fish Commission
729 NE Oregon, Suite 200
Portland, OR 97232

1 July 1996

ACKNOWLEDGEMENTS

Funding for this work was provided by the Bureau of Land Management, through a grant to the Bureau of Indian Affairs, and by the Columbia River Inter-Tribal Fish Commission. Jim Griggs (CTWS); Ron Wiley (BLM Oregon State Office); Jim Eisner (BLM Prineville Office); Ron Eggers, Val Elliot, and Tim Brown (BIA Portland Area Office); and Matthew Schwartzberg and Phil Roger (CRITFC) were instrumental in formulating the project and/or in administering contracts and funding. I greatly appreciate their efforts to make this project possible.

I also extend warmest thanks to the dedicated biologists who opened their files and gladly shared their extensive first-hand knowledge of the Deschutes R. and its fish resources: Mark Fritsch and Jim Griggs (CTWS), Steve Pribyl and Jim Newton (ODFW, The Dalles), and Don Ratliff (PGE, Round Butte). Leslie Nelson (ODFW, The Dalles) was most professional and efficient in building a computer database of historical trapping data from Sherars Falls, which made several of my summaries and analyses possible. Tom Farnam (BLM, Prineville, River Ranger), in a two-day raft patrol, provided many insights on the Deschutes R. that leavened and balanced the information available from data and literature.

Grant and Emily Waheneka, Pierson Mitchell, and Delbert Frank, Sr. (CTWS members) hospitably gave of their time and oral history of Deschutes R. tribal fisheries, thereby adding depth to the limited written information available. Many thanks to them.

Members of the Technical Coordinating Committee provided invaluable guidance on research plans and priorities and on the development of this report. Mark Fritsch and Colleen Fagan (CTWS), Doug Hatch and Ken Collis (CRITFC), Jim Newton and Bob Lindsay (ODFW), Don Ratliff (PGE), and Jim Eisner (BLM) reviewed and provided useful comments on drafts of this report. Kathy McRae (CRITFC) conscientiously proof-read the final draft; any remaining errors are my omissions in editing.

CONTENTS

FIGURES

Figures *(continued)*

TABLES

Appendix Tables

Appendix Tables *(continued)*

SUMMARY

Fall chinook (*Oncorhynchus tshawytscha*) runs in the Deschutes R., particularly the component that spawns above Sherars Falls, have been low, declining, and highly variable in recent years. This project summarized and analyzed existing information about the population and developed research and management options.

The "fall" chinook run in the Deschutes R., as presently defined and managed, includes the remnants of a summer run probably native to the Metolius R. and other areas above Pelton and Round Butte dams. These summer-migrating adults — which may have dominated the summer/fall run above Sherars Falls before Euroamerican settlement — are all but extirpated.

Estimates of overall summer/fall chinook run size between 1977 and 1992 can be described as generally declining and variable on a cycle of approximately five years. The decline may have begun immediately after the apparently large runs of 1968 and 1969, although data prior to 1977 can not support firm conclusions. The rapid decline from 1989 to 1991 was experienced by several other stocks, strongly suggesting that ocean or other broad-scale, common factors were highly influential. Redd counts indicate that most, if not all, of the total decline has occurred above Sherars Falls, which suggests that smaller-scale factors may differentially and adversely affect the survival and/or distribution of the above-falls component of the summer/fall run.

Estimates of record runs in recent (1993-95) years tend to assuage concern over the welfare of the stock as a whole, although there are good reasons to question the accuracy of those estimates. For example, if runs of adults have been at record levels, why have redd counts in index and random survey areas been below average, despite good redd counting conditions in two of the last three years? Errors (e.g., in redd counts) and biases (e.g., from fallback of tagged fish at Sherars Falls) also contribute to the variability in estimates of run size. Because present estimation methods use fish trapped and tagged during upstream passage at Sherars Falls, the resulting estimates are less accurate and precise when the relative and absolute sizes of the above-falls component are low. I suspect that recent historically large runs, particularly of adults in 1993 and jacks in 1994, are — in part — artifacts of the estimation methods.

Existing data have a limited usefulness for identifying causes of the observed variability and trends in run size. For example, without estimates of juvenile production, we cannot estimate freshwater or marine survival. Hence, it is difficult even to identify whether the freshwater or marine environment may be most responsible for the decline.

Taking run size estimates at face value, their variability since 1977 can best be explained by changes in ocean conditions, such as coastal upwelling and strength of the Aleutian Low Pressure System. The downward trend, particularly for the summer and above-falls components of the run, is probably the continuing, cumulative result of fisheries and habitat loss and degradation that were occurring well before 1977. These conclusions are

based on my examination of the life-cycle of the population, beginning with returning spawners.

Upstream migrants in the Deschutes R., particularly summer migrants, may be deterred by high summer temperatures near the mouth and by other factors. Reduced flows (due to upstream withdrawals) and a substandard fishway probably discourage migration above Sherars Falls, as might operation of the trap and heavy recreational use of the upper river. The above-falls component of the run has been and will continue to be exploited at higher rates by the inriver fisheries than has the below-falls component.

Gravel conditions for spawning and incubation below Pelton Reregulating Dam have declined. Although I found no meaningful difference in peak flows before and after impoundment, gravels transported out of the reach obviously are not replaced by recruitment from upstream of the dam. The same is true for large woody debris. As suggested by others, I suspect that the high gravel quality in this area in the 1960s through 1980s may be largely a result of the continual intensive spawning activity that was occurring then. I also hypothesize that the concentration of spawning immediately below Pelton Reregulating Dam may be partially an artifact of dam construction, which restricted summer-run chinook (and possibly others) from reaching ancestral spawning grounds in the Metolius R. and perhaps other upstream production areas.

The data available on juvenile rearing conditions are limited, but differences in water temperature and fish growth and outmigration timing between above-falls and downstream areas provide useful clues regarding differences in the ecology — and probably the survival — of juveniles produced above and below the falls. Slower-growing, later-migrating above-falls juveniles encounter a "thermal trap": high temperatures in the lower Deschutes R. and mainstem Columbia R. that probably aggravate disease (e.g., ceratomyxosis), predation, and other mortality factors. Land-use practices (e.g., management of riparian areas) and competition/predation by rainbow trout/steelhead probably also adversely affect survival of juvenile summer/fall chinook, although good data are lacking.

Subyearling summer/fall chinook, particularly those migrating later in summer, are killed by mainstem dams (Bonneville and The Dalles) and predators. Turbine bypass systems are marginally, if at all useful in abating dam passage mortality of subyearling chinook, given typical dam operations. The ongoing program to control northern squawfish (*Ptychocheilus oregonensis*) appears to be reducing the prevalence of predator concentrations near dams.

Migrants that reach the estuary find conditions that are physically limited (e.g., by flow regulation) and probably biologically over-subscribed. In addition to hundreds of millions of juvenile salmonids (mostly hatchery-produced) that use the estuary, exponentially increasing runs of exotic American shad (*Alosa sapidissima*) also produce hundreds of millions of juveniles, some of which occupy the estuary year-round.

Ocean conditions seem to have a large impact on survival of Deschutes R. summer/fall chinook, as reflected in widespread synchrony in run size among salmonid stocks, high correlation between recruits-per-spawner of Deschutes R. stock and indices of upwelling and the Aleutian low pressure system, and associations between physical ocean conditions

and biological conditions important for salmon production. Using ocean harvest rate estimates for Lewis R. wild fall chinook as a surrogate, it appears that ocean fisheries continue to take a relatively constant 20-25% of the Deschutes R. summer/fall chinook that would otherwise return to spawn. Although ocean conditions are very influential and may be sensitive to salmonid densities, the size of runs to the Deschutes R. is still a direct function of how many smolts are produced by the Deschutes R.

Adult migrants through the Columbia R. mainstem encounter predation by marine mammals, mortality related to passage at two mainstem dams, and fisheries. The impact by marine mammals is probably small, and the mortality associated with dams and fisheries appears to be fairly constant (in recent years) at 10% and 20% mortality, respectively.

I believe that the summer component, the above-falls component, and the fisheries at Sherars Falls are integrally related: the fisheries depend on a healthy run above the falls and the above-falls run is probably dependent on restoration of the summer run native to upstream reaches. I identify several potential reasons why the above-falls component is failing, but they boil down to the "population" presently being confined to environments and exposed to conditions that are not, and perhaps rarely have been, adequate for it to be self-sustaining. Although infrequent improvements in ocean conditions may provide some small and short-lived increase in escapement above the falls, I expect the above-falls component to be extirpated soon, unless strong restoration and swift measures are implemented. The 1996 flood also may have reset environmental factors to conditions more favorable to fish survival, if the 1964 flood helped produce large runs in 1968 and 1969.

My first recommendation is to establish management goals for the stock that explicitly address the summer and above-falls components and the Sherars Falls fisheries. Subsequent recommendations are organized according to two alternative potential management goals: 1) restore the summer run, the above-falls component, and meaningful Sherars Falls fisheries, ***or*** 2) modify the *status quo*. The restoration option includes several relatively radical recommendations, including restoration of passage to/from production areas above the dams, improving fish passage at Sherars Falls, and active reintroduction and/or supplementation. If this option is not acceptable, given the actions necessary to implement it, then the alternative, *status quo* goal can be easily implemented. Recommendations for the latter include reducing human-caused ocean and mainstem Columbia R. mortalities, replacing present escapement estimation methods, and directing habitat enhancement and fisheries to reaches farther below Sherars Falls.

INTRODUCTION

Background

The Deschutes River, a Columbia River tributary draining approximately 27,000 km^2 of north central Oregon (Fig. 1), is home to a natural spawning run of fall chinook salmon (*Oncorhynchus tshawytscha*) that no longer supports traditional fisheries at Sherars Falls.

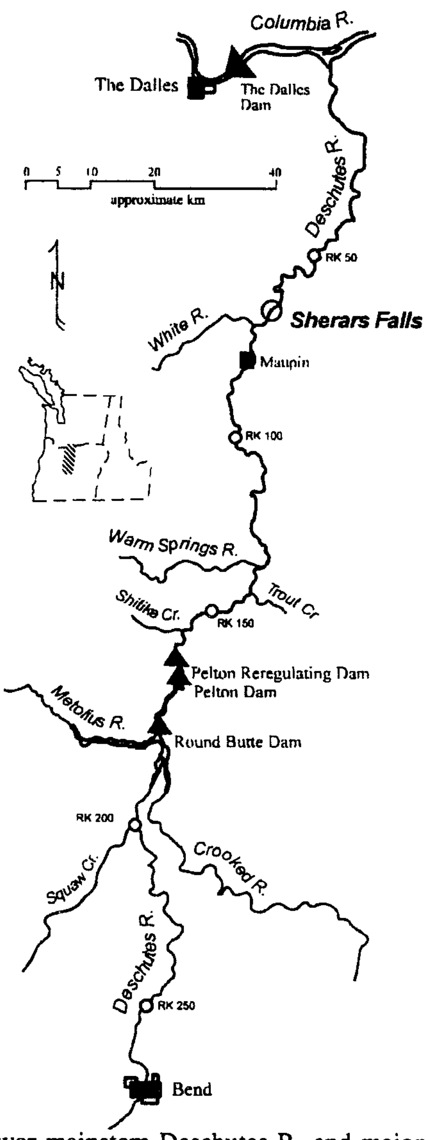


Figure 1. Lower mainstem Deschutes R. and major tributaries.

Fed by springs and snowmelt from the east slope of the Cascade Mountains, the Deschutes R. historically has had exceptionally stable flows of high-quality water (Aney et al. 1967). However, since first Euroamerican settlement in the basin in the early 1800s, natural stream flow has been reduced or otherwise altered by agricultural practices, irrigation diversions, storage impoundments, and hydroelectric operations (Moore et al. 1995; Nehlsen 1995). The three-dam Pelton and Round Butte hydroelectric complex has regulated mainstem flows into the river's lowermost 161 km since 1958 (ODFW and CTWS 1990).

Construction of the dams also terminated runs of anadromous salmonids above river kilometer (RK) 161, site of Pelton Reregulating Dam. Efforts to maintain naturally spawning runs above the dams were abandoned in 1968 (Newton 1973). Subsequent hatchery mitigation was provided only for steelhead and spring chinook salmon, although some summer-running chinook salmon were spawned, reared, and released from Round Butte Hatchery in the mid-1970s (Aho and Fessler 1975, Fessler et al. 1976), when spring chinook runs did not provide sufficient broodstock for the hatchery program (D. Ratliff, PGE, pers. comm. 12/16/95).

Fishery biological surveys began in the Deschutes R. Basin as early as 1949[1], when introduced brown trout (*Salmo trutta*) and brook trout (*Salvelinus fontinalis*) were furnishing angling opportunities throughout the stream system. Recreational fisheries for resident rainbow trout and steelhead (both *O. mykiss*) continue to be the focus of fishery management in the lower (RK 0 to RK 161) Deschutes R. today (Schroeder and Smith 1989; LDRMP 1993).

Run size (harvest and escapement) of fall chinook salmon has been estimated annually since 1977 (Fessler et al. 1978; CTWS and ODFW 1993). Estimates are based on trapping and marking upstream migrants as they pass Sherars Falls (RK 70.6) (CTWS and ODFW 1993). Adults have been harvested in the Deschutes R. primarily by the Confederated Tribes of the Warm Springs Reservation of Oregon (CTWS) and non-tribal recreational anglers in the Sherars Falls vicinity (ODFW and CTWS 1990; Jonasson and Lindsay, undated) (Fig. 1). The stock is also exploited in Columbia R. fisheries and by ocean fisheries from California to southeast Alaska (Jonasson and Lindsay, undated). Declines in run size above Sherars Falls, particularly after 1989, have been severe enough to prompt exceptional restriction and complete closure of inriver harvests (CTWS and ODFW 1993) and to attract special management review (Anonymous, undated).

Problem

Between 1986 and 1993, the total (jack plus adult) run size objective of 10,000-12,000 fall chinook salmon to the mouth of the Deschutes R. (ODFW and CTWS 1990) was not met (CTWS and ODFW 1993; S. Pribyl, ODFW, pers. comm.) (Fig. 2). Total runs for 1990-92 averaged 4,951, less than half the objective, although the runs in 1994 and 1995 were estimated to be historical (since 1977) highs. Total run size apparently is no longer declining, but the fisheries at Sherars Falls still lack fish.

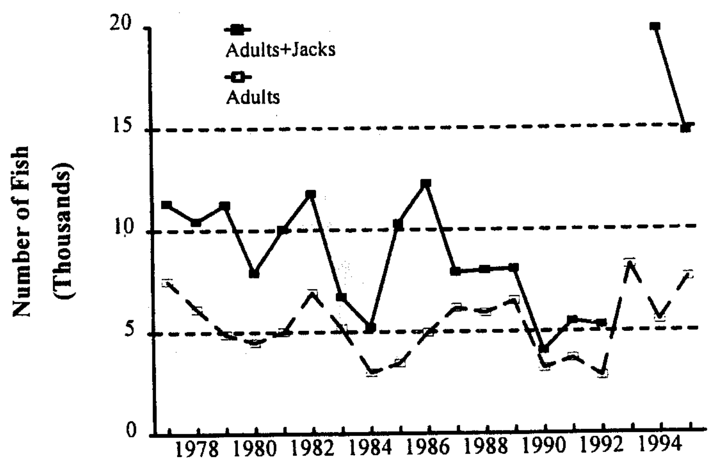


Figure 2. Estimated run size of Deschutes R. summer/fall chinook, 1977-95. Data from CTWS and ODFW (1995).

[1] *Survey of the Deschutes R. Tributaries on the Warm Springs Indian Reservation -- July 1949* and *Catch Estimates for Sherars Falls: 1949*. Excerpts of unpubl. MS reports maintained in the files of M. Fritsch, CTWS.

As run size declined into the early 1990's, the spawning distribution also shifted from areas predominantly above Sherars Falls (Fig. 1) to areas below (Anonymous, undated). Redd counts above the falls declined dramatically between the 1970s and 1990s (Fig. 3, solid trend line), leaving the spawning area of highest apparent quality (between Pelton Reregulating Dam and Shitike Cr.; Huntington 1985) almost unseeded (CTWS and ODFW 1994). The recreational fishery for fall chinook salmon at Sherars Falls was closed in 1991 and has not reopened. The CTWS subsistence harvest at Sherars Falls has been capped since 1992; it has taken fewer than 70 fish in each of the last four years (i.e., 1992-1995; CTWS and ODFW 1995).

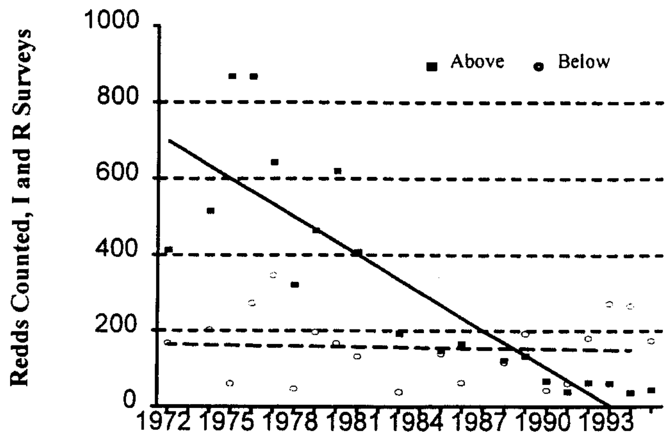


Figure 3. Redd counts and trends for reaches above (solid) and below (dashed) Sherars Falls, 1972-95. Data from CTWS and ODFW (1995).

Special work groups met in 1992 to develop proposals to address the problem (M. Fritsch, CTWS, pers. comm.). A preliminary analysis of existing data by ODFW researchers suggested that the low runs in 1990 and 1991 were caused by an effect above Sherars Falls in the 1985-87 period (Anonymous, undated). Questions that remained unanswered after the preliminary analysis are the subject of this project.

Purpose and Objectives

The purpose of this project is to determine the potential causes of the decline in returns of fall chinook salmon to the Deschutes R., particularly to areas above Sherars Falls, and to identify measures to enhance the population. The objectives of Phase I have been to:

1. Conduct an analysis of existing information in the initial project stage and develop a research plan and statement of work for 1995;
2. Establish a Technical Coordination Committee (TCC) for technical review and project coordination; and
3. Summarize escapement, harvest, and spawning distribution data of fall chinook salmon in the Deschutes R.

The analysis, planning, coordination, and data summaries were proposed to culminate in implementation of field research in Phase II beginning in 1995. This report presents the results of Phase I.

Approach

The results of the analysis of existing information (part of Objective 1) and data summary (Objective 3) are presented here according to the population's life cycle, starting at the point when adults pass Sherars Falls. Most information available about this population is derived from monitoring efforts at Sherars Falls. Working hypotheses are used to focus consideration of each life stage. The research plan for 1995 (part of Objective 1) and record of TCC activities (related to Objective 2) are presented in Appendix 1 and Appendix 2, respectively.

Debate about whether this is strictly a fall stock (Fessler et al. 1978; ODFW and CTWS 1990) warrants defining the population precisely. ODFW and CTWS (1990) recommended that the summer-run versus fall-run issue be revisited. This is done in the following section.

My fundamental purpose is to identify factors that may limit the population's production. **Any condition that causes loss (i.e., mortality) in the population (or an important component thereof) is a limiting factor when population size is below desired levels.** Population viability requires in the long term that cumulative mortalities, from all sources, remain below the threshold that would preclude population replacement. This definition is broader than approaches that consider relative magnitude of mortality rates among factors and/or that consider only a subset of factors (e.g., those within a limited spatial and/or temporal range, such as within the Deschutes R. since 1964). However, I pay particular attention to the portion of the population spawning above Sherars Falls. Conditions that limit access to habitats favoring production, although not necessarily direct sources of mortality, may also be limiting factors.

STOCK COMPOSITION

This is not strictly a fall stock; it is either a melding of relatively discrete summer and fall stocks ***or*** a spatially and temporally compressed metapopulation of summer- and fall-running fish. I will use the term "summer/fall" chinook salmon — which encompasses the probable ancestry of, and the life history diversity within the stock — hereafter when referring to this stock.

Stocks are conventionally identified based on measurable characteristics that presumably reflect genetic differences and on management convenience (Howell et al. 1985; Beaty 1992). Chinook salmon stocks in the Columbia R. are typically distinguished by adult run timing at Bonneville Dam (table, left).

CHINOOK RUN	PASSAGE TIMING AT BONNEVILLE DAM
Spring	Before 1 June
Summer	1 June - 31 July
Fall	After 31 July

Cut-off dates between runs correspond generally with nadirs between seasonal modes in passage. Similar, but shifted, dates are used at upstream sites to segregate runs. For example, dates in mid-June have been used to separate spring and summer chinook salmon that entered the trap at Pelton Reregulating Dam (Aho and Fessler 1975).

Based solely on run timing, the "fall" chinook salmon run in the Deschutes R. comprises summer as well as fall constituents. Summer-run chinook salmon in the Deschutes R. historically came at the end of June and early July (D. Frank, Sr., pers. comm. 3/22/95), timing that corresponds generally with the early (July) peak cited as evidence for a separate summer run by ODFW and CTWS (1990). In the 1920s, some tribal members would fish at least into September at Sherars Falls (E. Waheneka, CTWS member, pers. comm. 3/20/95). The chinook salmon run would continue until early November at the falls (P. Mitchell, CTWS member, pers. comm. 2/10/95).

Historically, summer chinook may have been abundant in the Deschutes R. Overharvest in the late 1800s, mostly in the mainstem Columbia R., all but eliminated the once-dominant run of prized Columbia R. summer chinook salmon (including those native to the Deschutes R.), leaving just the early and late migrants that had been protected by spring and fall fishery closures (Thompson 1951; Beaty 1992). Also, in the late 1800s an intense commercial fishery across the mouth of the Deschutes R. (Davidson 1953, cited by Nehlsen 1995) probably took another significant toll on the summer run to the Deschutes R. Summer chinook were heavily exploited in Columbia R. commercial fisheries through the early 1900s as well. A mean exploitation rate of 83% can be calculated from annual estimates for 1928-40 (Gangmark 1957). Chapman et al. (1994) estimate an average Columbia R. mainstem (below present site of McNary Dam) rate of about 90% on summer chinook for 1938-42. As with their Columbia R. counterparts, summer chinook in the

Deschutes R. were first decimated by a century of overharvest, then eliminated from historical production areas by impassable dams and habitat degradation.

Some investigators have hypothesized that Sherars Falls was impassable to summer/fall chinook, because of seasonally low flows, before the fish ladder was installed there (Jonasson and Lindsay, undated; ODFW and CTWS 1990). This hypothesis may be partially valid, particularly for late-running fish since the late 1800s. Land-use practices and water withdrawals in the Deschutes basin before and around the turn of the century (Nehlsen 1995) reduced summer flows, perhaps by as much as three feet at Sherars Falls (P. Mitchell, CTWS member, pers. comm. 2/10/95, citing oral history related by his grandmother). With lower flows, the side channels that facilitated passage for adults around the falls were reduced or eliminated. Nevertheless, some fish could still leap the falls even before the first fish ladder was constructed in the late 1920s (G. Waheneka, CTWS member, pers. comm. 3/20/95). An inverse correlation between efficiency of the Sherars Falls trap and river flows has been interpreted as evidence that higher flows facilitate passage over or around the falls itself (rather than through the fishway) (Jonasson and Lindsay, undated). Reduced flows caused by land and water management practices probably obstructed, but did not eliminate passage of summer chinook salmon at Sherars Falls even before fishways were built.

Pelton and Round Butte dams denied spawner access to the Metolius R., believed by some to be the principal ancestral spawning area for summer chinook in the Deschutes basin (G. Waheneka, CTWS member, pers. comm., 3/20/95). The Deschutes and Metolius rivers were the major Columbia Basin streams below the confluence of the Snake R. in which chinook salmon tagged during the summer run at Bonneville Dam were recovered (Galbreath 1966).[2] Summer chinook may have spawned in other tributaries and mainstem reaches above the dam sites (D. Ratliff, PGE, pers. comm., 12/16/95).

A remnant of the summer run persists. A small mode of adults entering the Pelton trap in September during 1959-62 (Newton 1973), if not fall-run fish, were more likely summer stock than spring stock. Summer-run fish were briefly propagated (1974 and 1975 brood years) separately from spring chinook salmon at Round Butte Hatchery to maintain the integrity of the races (Aho and Fessler 1975; Fessler et al. 1976). Ongoing trapping at Sherars Falls typically begins in mid-June to sample the summer-running component. As recently as the late 1980s, large bright chinook — "distinctly different" from the spring chinook — entered the Pelton Dam trap beginning in late June and were tallied separately from the spring run (D. Ratliff, PGE, pers. comm., 12/16/95).

---

[2] Others doubt the evidence and the conclusion that summer chinook spawned in the Metolius R. (D. Ratliff, PGE, pers. comm., 12/16/95). However, the results reported by Galbreath (1966) clearly demonstrate the migration of summer-run chinook into the Metolius R.: the three specimens recovered there were all tagged in July when passing Bonneville Dam. These results also comport with tribal oral history.

The summer stock's distinctive morphology has been noted by others. In 1969, creel checkers at Sherars Falls described a minor peak in the chinook run in mid-July, a peak separated from both spring and fall runs by definite breaks (Scherzinger 1970). These summer fish are reported as having "a definite different body configuration:" sharp nose, narrow caudal peduncle, and streamlined appearance. In mid-June at Sherars Falls, adult summer chinook salmon could easily be distinguished from spring-run fish by their brightness and large size (Fessler et al. 1977). This larger size is evident in tag-return data from 1973 (Newton 1973, his Table 4[3]).

Historical evidence for a fall chinook salmon run in the Deschutes R. prior to fishway installation is scant. P. Mitchell (CTWS member, pers. comm. 2/10/95) reports that early in this century the chinook salmon run at Sherars Falls continued until early November, which indicates presence of a fall-running component. Side-channel flows may have persisted (and facilitated passage) at the falls until November (P. Mitchell, CTWS member, pers. comm. 2/10/95). Fall migrants spawned between Sherars Falls and the Pelton dam site in the early 1950s (Nehlsen 1995, citing pers. comm. with M. Montgomery; B. Smith, CTWS member, pers. comm., 2/1/96), but none were documented above Pelton dam site before its completion in 1958. Construction of the fishway at Sherars Falls probably provided easier access for fall migrants to upstream spawning areas. The present predominance of the fall component may be the result of many, perhaps individually small, management actions over the past century.

The summer component, probably abundant historically, could be functionally lost. Its historical spawning areas are presently inaccessible, habitat loss and damage has not been mitigated, spawning in the uppermost accessible reaches has all but ceased, and interbreeding with the fall component has occurred for decades (Fessler et al. 1978). Dominance of the fall component is reflected in results of electrophoretic studies. In an analysis of allele frequencies, life history traits, and ecological and physiographic information from Columbia R. chinook salmon populations, Deschutes R. summer/fall chinook clustered with mid-Columbia (Marion Drain in the Yakima R. system) and Snake R. fall chinook (A. Marshall, WDFW, pers. comm. 1/93). The decline in spawning above Sherars Falls may mark the loss of the summer component.

Managing the summer component as a "fall" stock may contribute to the loss. For example, because fall chinook salmon are not known to have spawned above the site of Pelton Dam, there is little or no incentive to restore or compensate for lost summer chinook salmon (managed as "fall" stock) habitat above that site. Similarly, common beliefs about fall chinook salmon (e.g., that they have a subyearling or ocean type life

---

[3] Two fish in this data table are particularly interesting: those with tag numbers 3696 and 3876. Tagged at Bonneville Dam during the last half of May (last two weeks of the official spring run), they were classified as spring chinook. However, their large size (100 cm and 98 cm) and late time of arrival at the Pelton Trap (30 July and 21 August) are very exceptional among the spring chinook and resemble those of fish listed later in the table as summer chinook. Summer-run chinook have been noted for their large size.

history) may be misapplied to summer chinook salmon. I believe that managing diverse components as a single unit facilitates loss of diversity.

RUN SIZE ESTIMATES AND TRENDS

H_1: Run size has been declining since 1977 and perhaps since the late 1960s.

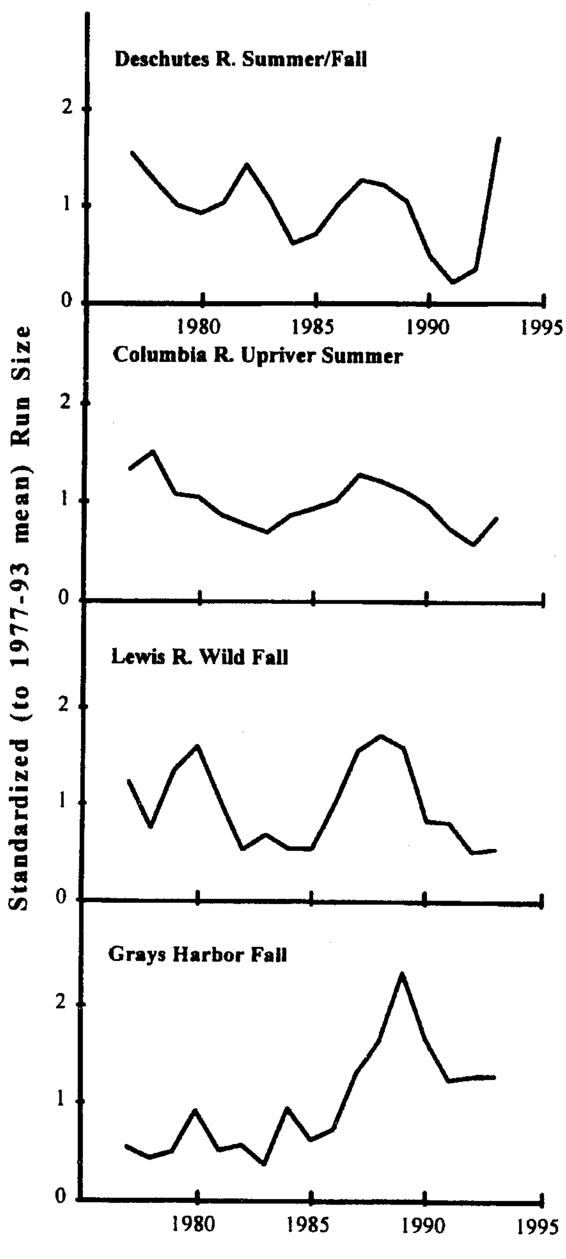


Figure 4. Standardized run sizes for four summer and fall chinook salmon stocks, 1977-93. See Appendix 3.1 for data.

Estimated run size of summer/fall chinook salmon has been quite variable and has generally declined since monitoring began in 1977 (Fig. 2). The substantial decline in adult numbers from 1989 to 1990 is similar in slope and endpoint to an earlier (1982-84) downturn, although after the more recent decline run size remained depressed until 1993. The run as a whole rebounded in 1993 to the highest estimated number of adults (8,250) in the 16 yr of record (Table 1, *following page*). An exceptional run of jacks in 1994 produced a respectable, but less exceptional, run of adults in 1995. Extinction does not appear imminent for the run as a whole, as presently defined, provided estimation methods are accurate (but see H_4, following section).

Thus far, the variability in run size, particularly for adults, appears to be cyclic with a relatively regular period of about 5 yr (Fig. 2). Other stocks have patterns that are similar in some respects (Fig. 4): a local minimum in 1983 or 1984, a substantial local maximum between 1987 and 1989, and another local minimum in 1991 or 1992 (see Appendix 3.1 for comparison methods). Such similarities suggest that conditions common to all the stocks (e.g., climate, ocean environment, mixed stock harvests) have had a substantial effect on their run sizes, a phenomenon that will be explored in more detail later.

Table 1. Harvest, escapement, and run size for summer/fall chinook salmon in the Deschutes R., 1977-95. Data from CTWS and ODFW (1995).

	ADULTS				JACKS				TOTAL			
YEAR	[A] Harvest	[B] Escape-ment	[C] Run Size (A+B)	% Exploit-ation (100*A/C)	[D] Harvest	[E] Escape-ment	[F] Run Size (D+E)	% Exploit-ation (100*D/F)	[G] Harvest (A+D)	[H] Escape-ment (B+E)	[J] Run Size (G+H)	% Exploit-ation (100*G/J)
1977	1861	5631	7492	24.8	1672	2125	3797	44.0	3533	7756	11,289	31.3
1978	1971	4154	6125	32.2	1597	2708	4305	37.1	3568	6862	10,430	34.2
1979	1592	3291	4883	32.6	2000	4338	6338	31.6	3592	7629	11,221	32.0
1980	1951	2542	4493	43.4	1507	1904	3411	44.2	3458	4446	7904	43.8
1981	1837	3183	5020	36.6	1294	3728	5022	25.8	3131	6911	10,042	31.2
1982	2016	4890	6906	29.2	1506	3360	4866	30.9	3522	8250	11,772	29.9
1983	1496	3669	5165	29.0	678	859	1537	44.1	2174	4528	6702	32.4
1984	970	2025	2995	32.4	987	1237	2224	44.1	1957	3262	5219	37.5
1985	807	2645	3452	23.4	1454	5384	6838	21.3	2261	8029	10,290	22.0
1986	1153	3801	4954	23.3	1428	5872	7300	19.6	2581	9673	12,254	21.1
1987	2057	4097	6154	33.4	242	1515	1757	13.8	2299	5612	7911	29.1
1988	2391	3520	5911	40.5	245	1859	2104	11.6	2636	5379	8015	32.9
1989	1730	4770	6500	26.6	150	1429	1579	9.5	1880	6199	8079	23.3
1990	970	2224	3194	30.4	140	727	867	16.1	1110	2951	4061	27.3
1991	154	3532	3686	4.2	59	1746	1805	3.3	213	5278	5491	3.9
1992	37	2776	2813	1.3	4	2483	2487	.2	41	5259	5300	.8
1993	11	8239	8250	.1	0	—	—	—	11	—	—	—
1994	69	5455	5524	1.2	8	14,276	14,284	.1	77	19,731	19,808	.4
1995	36	7588	7624	.5	17	7121	7138	.2	53	14,709	14,762	.4

Removing the effects common among these four runs (see Appendix 3.1 for detailed methods) reveals when run size of the Deschutes stock has been relatively exceptional (Fig. 5). For example, the local maximum in 1982 and the 1991 local minimum remain in this derivation, indicating these events were unique to the Deschutes stock. However, the 1987-88 run peak is much diminished in this representation because it was common to all stocks. This diminished peak suggests an effect of large-scale, common factors on cohorts returning during these years. The sharp decline in run size from 1989 to 1991 that raised concerns earlier (Anonymous, undated) may have been the return to a longer-term (since at least the early 1980s) downward trend following exceptionally big runs in the late 1980s. The rebound in the Deschutes stock since 1991 has been relatively very strong and unique among the four stocks.

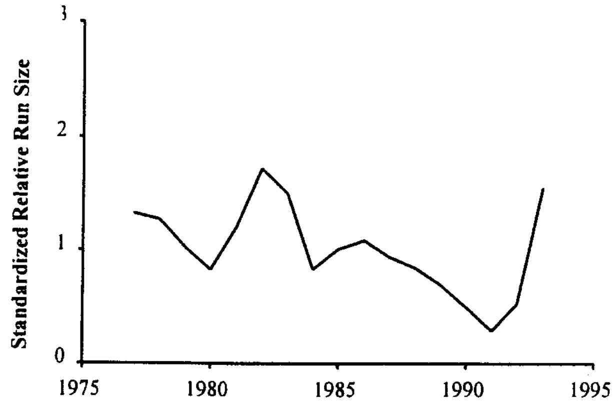


Figure 5. Standardized Deschutes R. summer/fall run size relative to four other chinook salmon stocks. Methods in Appendix 3.1.

Spawner/recruit analysis (adapted and extended from Anonymous, undated; methods described in Appendix 3.2) reveals no long-term trend (Fig. 6), but does show the same 5-yr cyclic pattern that was evident in the run size data (Fig. 2). Only the 1977, 1982, and 1987 brood years did not replace themselves back to the Deschutes R., although inriver harvest reduced the number of recruits that escaped to the spawning grounds. The three brood years of poor recruitment and the years of exceptionally good recruitment (1984 and 1985) are noteworthy and will be referenced again.

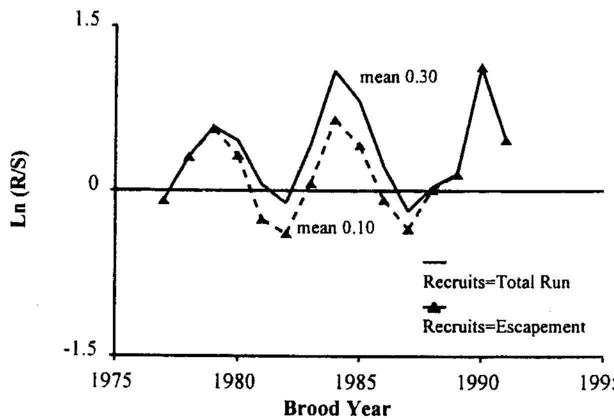


Figure 6. Recruits-per-spawner ratios (Ln) for Deschutes adults, 1977-91 brood years. Means are through 1998; 0=replacement. Data source and methods in Appendix 3.2.

Earlier data from other sources suggest that recent run size trends may be the continuation of a general decline from large runs in 1968 and 1969 (Fig. 7, *following page*). Counts of adult summer/fall chinook in the Pelton trap (PeltAd; data in Appendix 3.10), redd densities

(Redd/Mi; Newton 1973), and Sherars Falls sport harvest (SF Sport; Newton 1973) all have peaks in 1968 or 1969 (Fig. 7). Pelton trap counts, which provide the only continuous data set through the 1960s and 1970s, show a broad peak in the number of adults entering the trap from 1968 to 1973, followed by a general decline (with substantial variability) through 1995. Redd counts above Sherars Falls (ReddsAbv; CTWS and ODFW 1995) likewise decline exponentially after 1976, although the variations in the 1970s appear to oppose those of the Pelton trap counts. We do not know whether the trap counts or any of the other indices of abundance represent run size well.

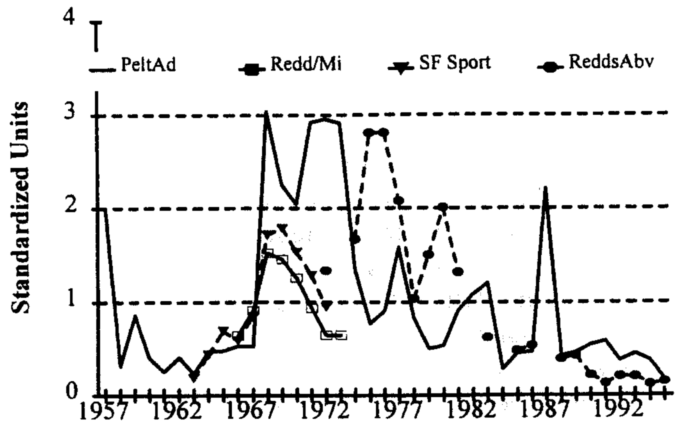


Figure 7. Selected indices of summer/fall chinook abundance, 1957-95. See text for legend and data source information.

Hence, despite the recent upswing in recruits per spawner and absolute and relative run sizes, all is not necessarily well. Indices of abundance, especially for the above-falls component, are very low relative to some historical levels (e.g., 1968-69). High variability in run size at low abundances, like that evident in the Deschutes run in recent years, has elsewhere been associated with severe habitat disturbance, adverse ocean conditions, and sustained high exploitation (Holtby and Scrivener 1989). Also, the foregoing analysis applies to the summer/fall run as a whole without consideration for seasonal (i.e., summer or fall) or geographic (i.e., above or below Sherars Falls) components of the run. Reasons to question the accuracy of escapement and run size estimates are discussed later (see especially Appendix 3.11).

H_2: The decline has been greater above Sherars Falls.

Most of the loss has occurred in the above-falls component, which may differ genetically from the below-falls component. Redd counts reflect a substantial reduction in spawning activity above Sherars Falls and little change in spawning below the falls since 1972 (Fig. 3). Redd counts in random and index survey areas above Sherars Falls averaged 584 in the 1970s (1972-79), but have not exceeded 66 in any year in the 1990s (Appendix 3.4). The distribution of redds in index and random sampling areas has reversed with respect to the falls: now four times as many redds are counted below the falls as above (Appendix 3.4).

This change in distribution is particularly important if fish spawning above and below the falls differ genetically. If there were genetic differences, the change could represent the loss of a unique component, such as the vestigial summer run. Loss of the upstream component also would make the fisheries at Sherars Falls and reseeding the area above the falls dependent on downstream fish that overshoot their natal areas below the falls, unless supplementation were employed.

There probably has been some degree of genetic difference between fish spawning above and below the falls. The tendency for the early-running summer fish to migrate and spawn higher in the system (Fessler et al. 1978; Lindsay et al. 1980; Jonasson and Lindsay, undated), suggests that the summer component composed a higher proportion of spawners above the falls than below.

H_3: The large runs of 1968 and 1969 may be related to the 1964 flood and other factors.

Abundance indices spanning the late 1960s show a large increase in run size in 1968 (Fig. 7). From 1967 to 1968, adult counts at Pelton trap increased by a factor of 6.0, while redd densities and Sherars Falls sport catch increased by factors of 1.7 and 2.0, respectively. Examining this increase may provide clues about causes for recent declines.

The six-fold increase in counts of adults at Pelton trap from 1967 to 1968 is much greater than corresponding increases in some other indices of run size (Fig. 7). This disparity raises questions about how exceptional the 1968 run actually was and whether Pelton trap counts are representative of total run size. Interannual changes in run size ranging up to two-fold (e.g., the increases in redd density and Sherars Falls sport catch indices from 1967 to 1968) are probably within the range of normal variability for stocks like this; the six-fold increase at the trap may have been caused by factors other than exceptionally large run size. In recent years, Pelton trap counts have not correlated well with redd counts nor with escapement estimates (Table 2). Trap counts may be sensitive to changes within a component of the stock (e.g., upstream spawners), physical conditions that

Table 2. Correlations (r) and probabilities (*p*) of Pelton trap counts with redd counts and escapement estimates of summer/fall chinook, 1972-95. Probabilities are from Fisher's R to Z (Abacus Concepts, Inc. 1992).

			PELTON TRAP COUNTS			
			Adults		Adults + Jacks	
ABUNDANCE INDEX	AREA	N	r	*p*	r	*p*
Redd Counts	Above Sherars	19	.366	*.124*	.342	*.155*
	All Areas	19	.363	*.128*	.310	*.200*
Escapement Estimates	Above Sherars	15	.129	*.653*	.437	*.105*
	Entire River	15	-.177	*.536*	.147	*.608*

encourage/discourage fish to enter the trap, and other factors aside from run strength. Nevertheless, all three of the indices show a substantial peak in run size in the late 1960s.

Two hypotheses have been articulated regarding the cause for the 1968 peak: (1) straying of upper-Columbia R. fish due to closure of John Day Dam (Nehlsen 1995, citing pers. comm. from M. Montgomery) and (2) favorable freshwater habitat changes caused by the 1964 flood (D. Ratliff, PGE, pers. comm. 12/16/96). Another hypothesis is that the peak (3) reflects broad-scale phenomena. Counts of adult summer and fall chinook at mainstem dams on the Columbia R., and other information, suggest that all three hypotheses are plausible, particularly in combination.

I found no evidence to support the straying hypothesis (1). Conversion rates[4] for summer and fall chinook between The Dalles and McNary dams do not show atypical interdam losses for those runs in 1968 (Fig. 8), although a small — perhaps undetectable — proportion of strays from the large Columbia R. runs could substantially increase the size of the smaller Deschutes R. runs. We do know that the spring chinook run encountered lethal dissolved gas levels below John Day Dam in 1968 (Beiningen and Ebel 1970), which could have also affected runs in later seasons and contributed to straying into the Deschutes R.

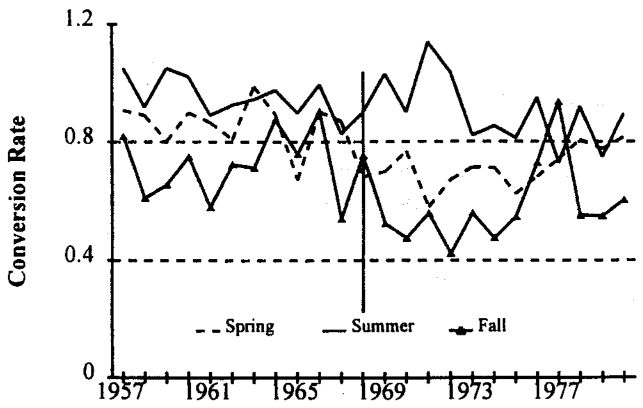


Figure 8. Conversion rates of spring, summer, and fall chinook between The Dalles and McNary dams, 1957-80.

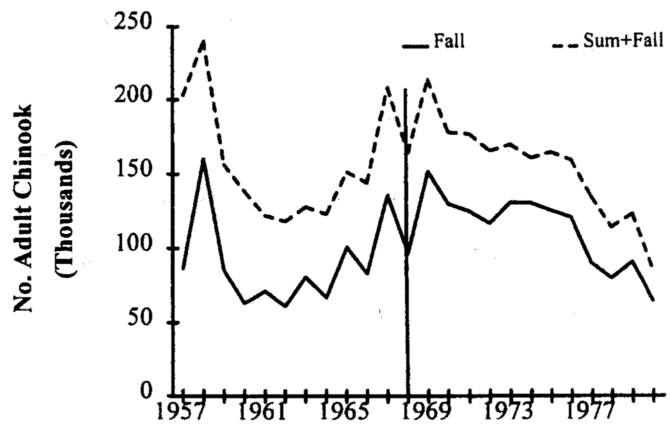


Figure 9. Counts of adult summer and fall chinook at The Dalles Dam, 1957-80. Data from USACE 1980.

---

[4] Conversion rates are the proportion of a run (e.g., summer chinook) that passed completely through a river reach based on counts (e.g., dam ladder counts) at downstream and upstream ends of the reach. The Dalles Dam (downstream) and McNary Dam (upstream) bracket a reach that includes both the mouth of the Deschutes R. and the site of John Day Dam.

The second hypothesis (flood effects) is supported by counts of adults entering the Pelton trap (Fig. 9, *preceding page*). Low jack counts in 1966 (Fig. 10) may reflect the redd loss that almost certainly occurred during the flood, when incubating embryos would have been scoured out of the gravel. In contrast, subsequent brood years had high production, which may have resulted from favorable post-flood habitat and survival conditions. Jack counts soared in 1967, when the 1965 brood began returning. As might then be expected, adult counts climbed in 1968 with the return of 3-yr-olds from the 1965 brood. A contrary decline in counts of Columbia R. stocks at The Dalles Dam in 1968 (Fig. 9, *preceding page*) suggests that the large runs into the Deschutes R. that year were not solely the result of a systemwide phenomenon.

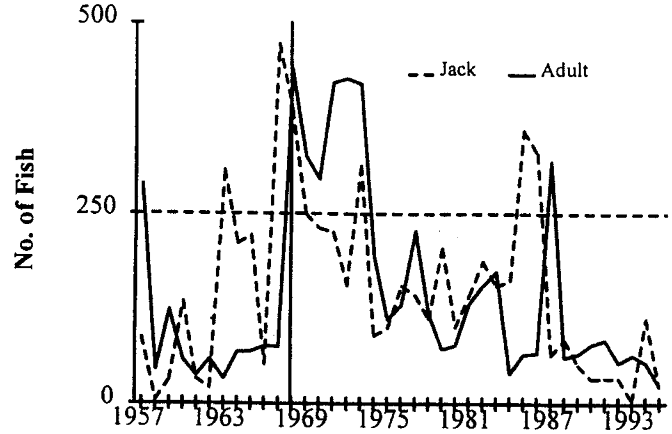


Figure 10. Counts of "fall" chinook jacks and adults at Pelton trap, 1957-95. Data from Appendix 3.10.

Hypothesis (3) is supported by long-term trends in ocean conditions and by sizes of Columbia R. runs in general. Waters of the northeast Pacific Ocean cooled gradually from the mid-1940s until the early 1970s (Ricker et al. 1978). Cool ocean water during smolt outmigration years is associated with better survival of some Columbia R. fall chinook stocks (van Hyning 1973; Mathews 1984). Based on fishway counts at The Dalles Dam, Columbia R. runs of summer and fall chinook were increasing through the 1960s toward peaks in 1967 and 1969 (Fig. 9). Large Deschutes R. runs in 1968 and 1969 may have reflected, in part, generally good ocean survival of fish returning in those years.

As stated earlier, we do not know how well the indices reflect the size of the entire run, and the lack of good year-to-year correspondence between the two longest data series (above-falls redd counts and Pelton trap adult counts) suggests they are a weak foundation for firm conclusions. We will probably never know the nature of the 1968 peak and the length of the decline in the above-falls run we are now witnessing. The flood hypothesis will be tested soon as the effects of the 1996 flood (1995 brood year) are expressed. A resurgence in at least the above-falls run in the year 1999 (probably presaged by a large jack run in 1998) will provide strong evidence that the capacity of the stream to sustain a summer/fall chinook run depends on ecological reset by major flood events.

H_4: The recent large runs in 1993-95 are partially artifacts of estimation methods.

Estimates of record high escapements in the last 3 yr (Table 1) do not comport with below-average redd counts in those years (Fig. 3 and Appendix Table 3.4). For example, compared to the large escapement in 1977, the total adult escapement in the record-breaking year of 1993 was estimated to be 46% *higher*, while the redd counts in all I, R, and I+R survey areas was 66% *lower*. This contradiction — which became apparent when this report was in final review — was sufficiently striking to invite closer examination. Much of the data treatment and many of the conclusions elsewhere in this report do not fully weigh my present concerns about the accuracy of these estimates.

The estimates of record escapements and run sizes in recent years are artifacts, in part, of the estimation methods. This conclusion is based on:

- Low and declining precision of the above-falls escapement estimates derived from the modified Petersen estimator;
- The increased potential for positive bias in the above-falls escapement estimates when abundance of the above-falls component declines;
- The effects of changing expansion methods in 1989 from using redd counts in random survey areas to using total (all areas) redd counts;
- Large increases in the factor used to expand above-falls escapement estimates to the entire river, thereby magnifying errors; and
- The good conditions for redd counts in at least 1993 and 1994 (data sheets and S. Pribyl, ODFW, pers. comm. 6/96), which makes it unlikely that the below-average redd counts were due to an unusually high proportion of undetected redds.

Total escapement and run size estimates hinge on the estimates of above-falls escapement and on redd counts above and below Sherars Falls. Like the estimates of above-falls adult escapement themselves, the precision of the estimates have declined to very low levels (Fig. 11). I indexed the precision of above-falls adult escapement with the ratio of the point estimate to the range of its 95% confidence interval using data from CTWS and ODFW (1995) (Eqn. 1, *following page*). This means that the true abundance of adults escaping above Sherars Falls in recent years could differ greatly from the estimates.

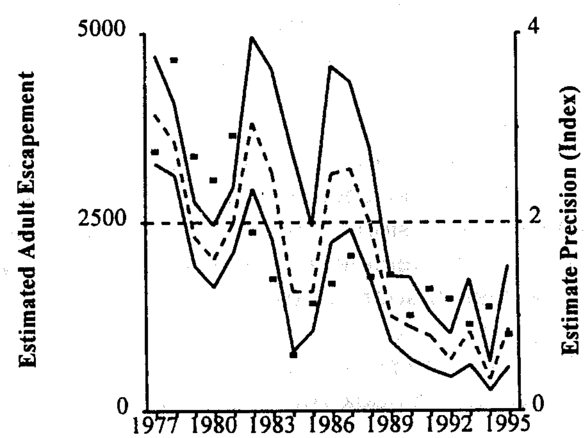


Figure 11. Point estimates of above-falls adult escapement (--), 95% confidence bounds (—), and an index of estimate precision (▪), 1977-95.

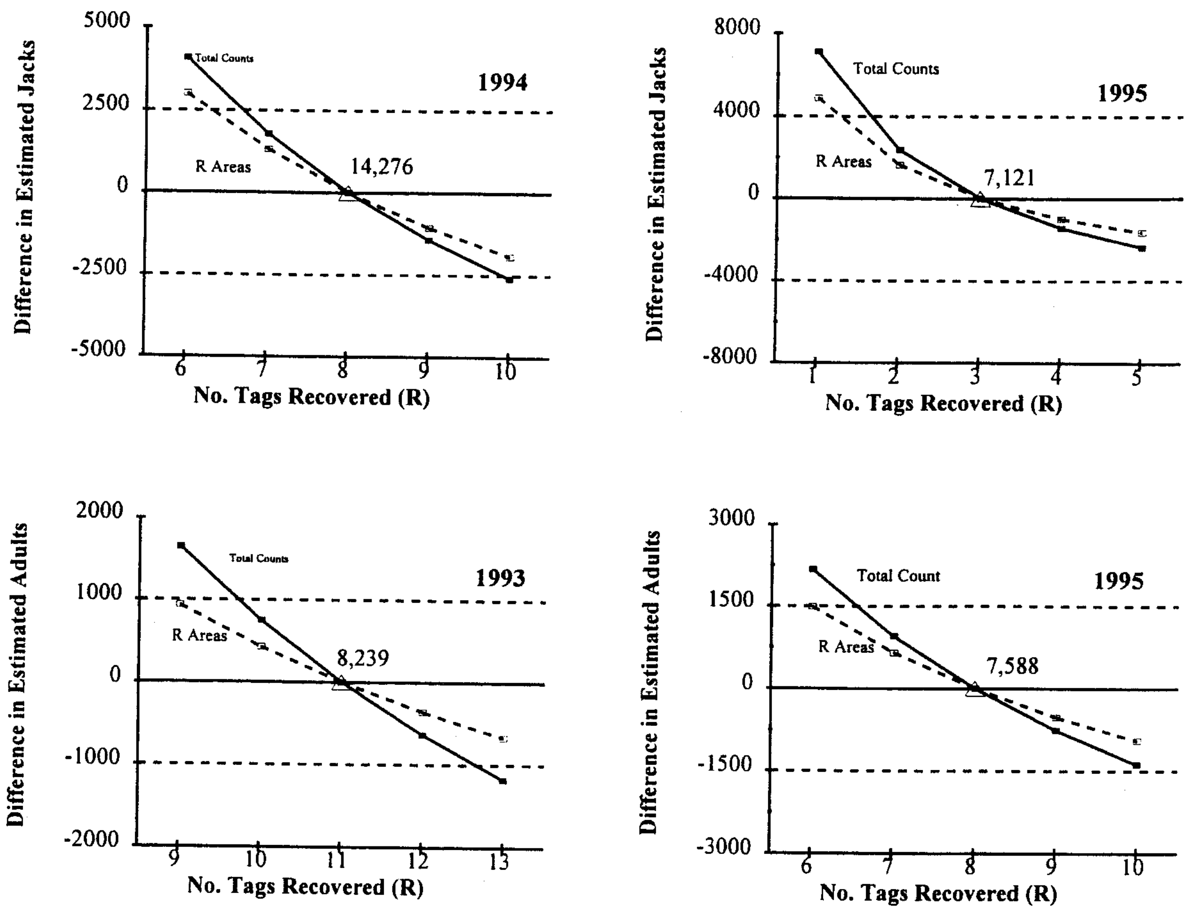


Figure 12. Hypothetical changes in large total escapement estimates (Δ, no.) of jacks and adults with increments in no. of tags recovered using expansions based on total redd counts (used 1989-present) and random survey area redd counts (used before 1989).

This relatively low precision, and the effects of expansion for the lower river, is reflected in the incremental change in escapement estimates associated with (hypothetically) fewer or more tag recoveries in recent years of large estimated escapements (Fig. 12). For example, the estimated total escapement of adults in 1995 would have been about 10% (760) lower had a ninth tag been recovered. The effect is even more apparent with the 1995 jack escapement estimate: one *more* tag recovery would have reduced the escapement estimate by 1,424, one *fewer* tag recovery would have increased it by 2,374. At low above-falls escapements and low tag recoveries, the

$$\frac{N^{*}_{above\text{-}falls\ adults}}{CI_{upr\ 95\%} - CI_{lwr\ 95\%}} \qquad (1)$$

influence of chance in the number of tags recovered can have a relatively large effect on estimates of total escapement.

Unlike random error, which can influence the estimates either upward or downward, bias can cause estimates to be ***consistently*** high or low. Fallback (loss of tagged fish from the recovery area) is one potential source of *positive* bias, as will be discussed in more detail later. Low above-falls escapements (relative to those below the falls) is likely to be accompanied by an increase in fallback rate. Curtailment and closure of the Sherars Falls fisheries since 1991 have virtually eliminated the opportunity to detect, via creel censuses, fallback in these recent years of high escapement estimates.

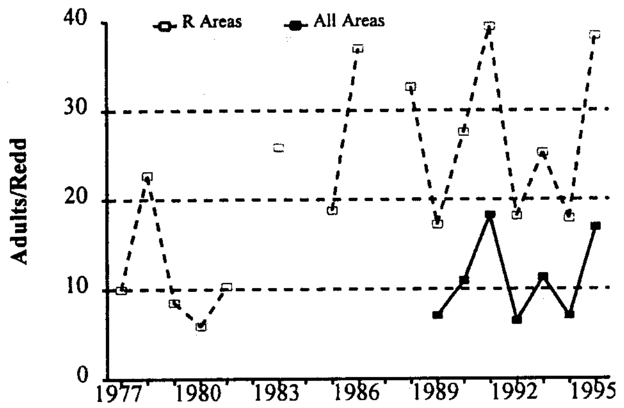


Figure 13. Ratios of adults per redd above sherars Falls based on redd counts in random (R) survey areas and on total counts.

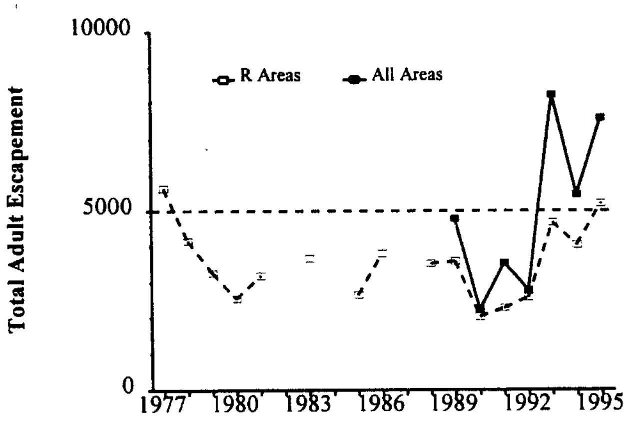


Figure 14. Estimates of total adult escapement using expansions based on total redd counts and redd counts in random (R) survey areas.

However, ratios of adults per redd do *not* show any sustained increase that might be attributable to a growing positive bias (Fig. 13). The ratios are generally high and variable, suggesting the potential effects of errors in escapement estimates and/or redd counts.

The most obvious artifact contributing to the recent record run sizes is the change in expansion methods beginning in 1989. From 1977 to 1988, escapement estimates from above the falls were expanded to include areas below the falls using a ratio of redds counted in random (R) survey areas only. However, beginning in 1989 redds were counted throughout the reaches above and below the falls, and estimates have subsequently been expanded using these total counts. The resulting estimates of total escapement are higher than those that would have been produced by the R-area expansion (Fig. 14). Runs probably would not have set records in 1993-95 had the same estimation methods been used in 1977.

Estimates based on the R-area expansion are consistently lower (by approximately 33%, on average), because the proportion of total redds counted in R areas below the falls (0.28, 1989-95 mean) is less than the same proportion above the falls (0.41, 1989-95 mean). The expansion method implicitly assumes that counts used in the expansion ratio are equal proportions of their wholes. Assuming total counts generate more accurate estimates, escapements and run sizes prior to 1989 were probably greater than those reported by CTWS and ODFW (1995).

Another potential source of artifacts in these estimates is the expansion itself, which has used factors (ratios) that are much higher in recent years (Fig. 15). When most of the run spawned above Sherars Falls, escapement estimates for that reach had to be expanded only slightly to account for the small proportion of the run spawning below the falls. Prior to 1989, the mean expansion factor was 1.3 (based on R-area redd counts); in 1994 the expansion factor was 13.3, an order of magnitude higher (based on total counts; 9.8 based on R-area counts). Such large expansion factors greatly magnify errors and would be a particular problem if the estimate being expanded (i.e., above-falls escapement) were biased. Even a small positive bias could cause the recent large escapement estimates when such high expansion factors are applied. It may be no coincidence that the three recent years of exceptionally high adult escapement estimates (i.e., 1993-95; Table 2) are the years with the highest expansion factors (Fig. 14 and Fig. 15).

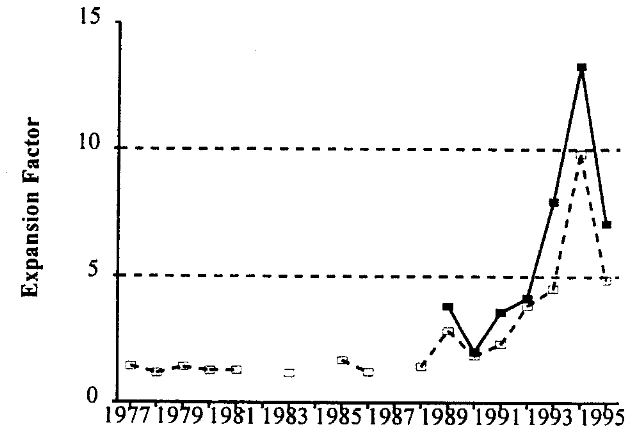


Figure 15. Factors for expanding above-falls escapement estimates based on redd counts in R areas (--) and all areas (—), 1977-95.

The disparity of high escapement estimates and coincidentally low redd counts in index and random survey areas ***does not*** appear to be caused by a shift in redd distribution out of these survey areas. The proportions of redds counted in index and random areas has declined little or not at all since total redd counts have been made (Fig. 15A). Hence, low redd counts in survey areas in 1993-95 reflect relatively low numbers of redds counted throughout the river.

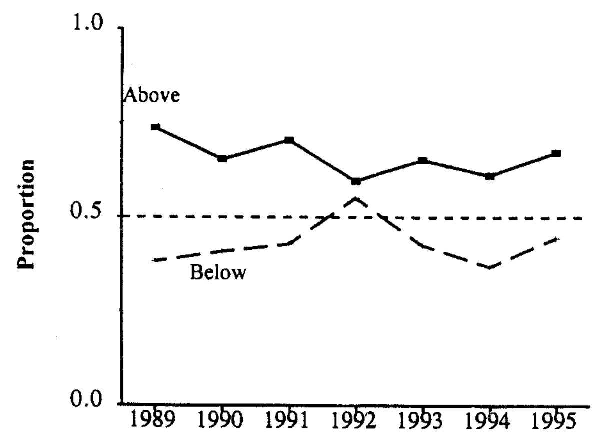


Figure 15A. Proportions of total redds counted in index and random survey areas above and below Sherars Falls, 1989-95.

In conclusion, the large escapement and run size estimates in 1993-95 may not be accurate, and the run may not be as healthy as some believe. Redd counts in I, R, and I+R areas (Fig. 3) suggest that the above-falls component has crashed and that the below-falls component remains at modest levels.

OTHER LIMITATIONS OF EXISTING DATA

Our series of run-size estimates (beginning in 1977) is not only relatively short, it is based largely on mark-recapture estimates of spawning escapement above Sherars Falls and also on redd counts. All estimating methods require some assumptions, are limited in their precision, and merit some critical examination.

Simple Freshwater/Ocean Survival Model

H_1: Existing data may not be adequate to attribute observed variability in estimates of run size to changes in either ocean or freshwater survival.

Run-size estimates based on trapping and marking at Sherars Falls provide a snapshot of the population at that point in its life cycle (Fig. 16, *following page*). The abundance of spawners migrating over Sherars Falls reflects all factors that have affected the survival of the fish through their entire lives. Knowing the age distribution of the migrants allows the calculation of relative brood year strength and spawner-recruit survival, but still does not tell us where in the life cycle (e.g., fresh water or ocean) the relative brood year strength was determined, let alone which factors were instrumental in causing the change.

$$s_{oc} = \frac{N_{ad}}{N_{juv}} \qquad (2)$$

$$N_{ad} = s_{fw}\, s_{oc}\, N_{egg} \qquad (3)$$

In part because spawning activity (redd counts) declined above Sherars Falls while changing little below the falls (Fig. 3), Anonymous (undated) hypothesized that the 1989-91 decline in the summer/fall run could be attributed to something that affected the 1985-87 broods above the falls. Earlier I offered an alternative explanation for trends in overall run size, but not for the change in spawning distribution. The data we have are not sufficiently precise to provide clear answers.

Precise estimates of juvenile production, preferably for both the area above Sherars Falls and below (Fig. 16, *following page*), would be required to obtain separate estimates of freshwater and ocean survival. If the number of juveniles leaving the Deschutes R. (N_{juv}) could be estimated with precision, then freshwater survival (s_{fw}) could be estimated from the potential egg deposition in the spawning escapement (N_{egg}; Eqn 2).

Similarly, ocean survival (s_{oc}) could be estimated from the number of returning adults (N_{ad}) and the number of juveniles (N_{juv}) in the appropriate outmigration years (Eqn. 3).

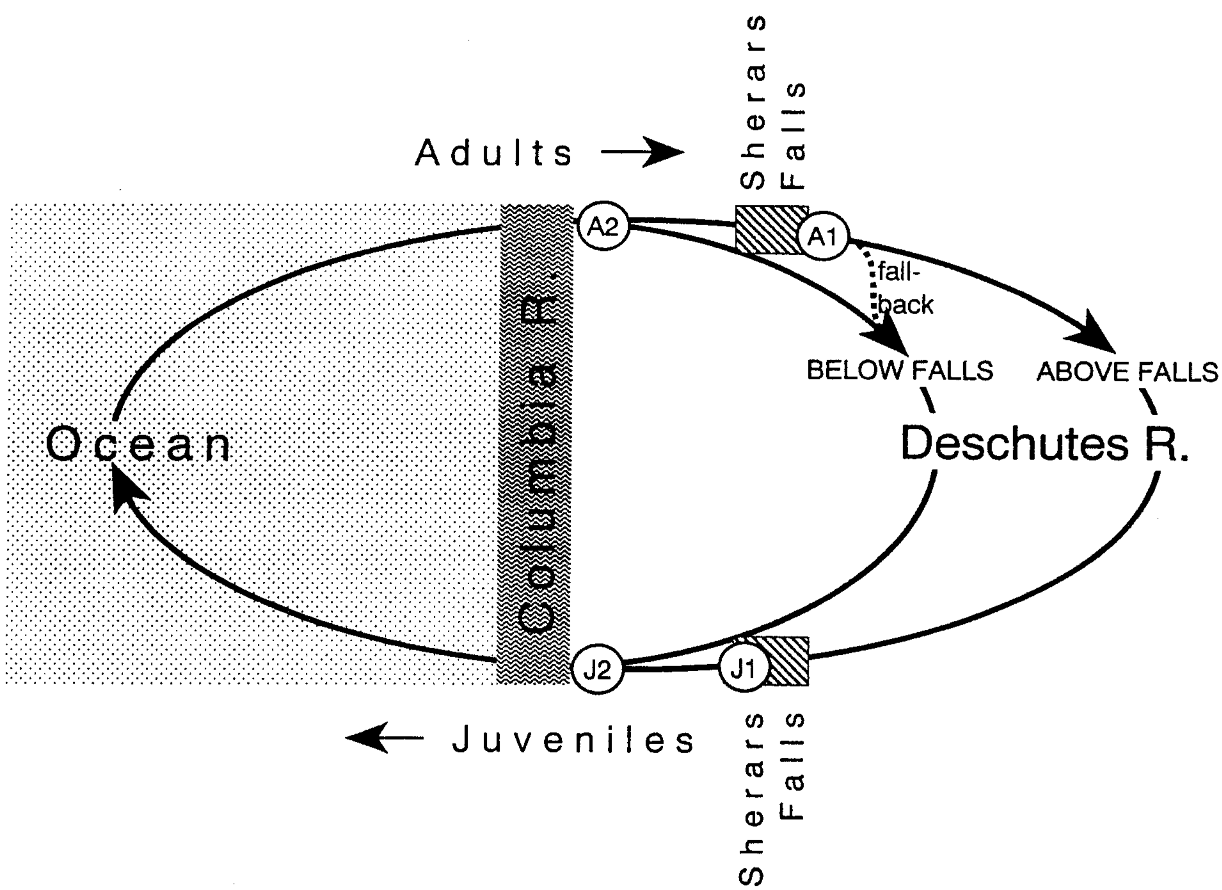


Figure 16. Life cycle of Deschutes R. summer/fall chinook. Point A1 is the existing adult monitoring point at the Sherars Falls trap. Other points for monitoring the abundance of adults (A2) and juveniles (J1 and J2) would be necessary to estimate freshwater and ocean survivals separately for components of the population above and below Sherars Falls.

Using a simple model, the number of returning spawners (N_{ad}) is a function of the number of eggs (equivalent to escapement scaled by average fecundity) in the contributing brood years and survival through the two major environments (Eqn. 4).

We could more easily attribute variability in run size (N_{ad}) and recruits per spawner (N_{ad} / N_{egg} , scaled by a fecundity factor) at least to variability in freshwater or ocean survival if we had precise estimates of

$$S_{fw} = \frac{N_{juv}}{N_{egg}} \quad (4)$$

juvenile abundance. Until such estimates are obtained, comparisons among stocks or components, as employed by Anonymous (undated), are necessary and can provide some insight.

H_2: Freshwater and ocean survival are not independent.

The conventional assumption that survival rates in the two major environments (freshwater and ocean) are independent is not necessarily valid. Common factors can affect both environments, so freshwater and ocean survival may be correlated. Large-scale atmospheric and oceanographic systems are linked (Mysak 1986; Polonsky 1994); temperatures and flows in the freshwater environment, for example, are often related to physical conditions (e.g., sea surface temperature, salinity) in the ocean environment. These linkages mean that changes in survival may be caused by factors in both environments working in concert, not to factors exclusively in one environment. This is particularly important when separate estimates of survival are not available for the freshwater and ocean phases of the life cycle.

Potential Biases and Their Effects

H_1: Straying from out-of-basin stocks could be augmenting spawning escapement, especially below Sherars Falls.

Strays from other Columbia R. summer and fall chinook salmon stocks could confound data for the Deschutes R. summer/fall population, although we have no means of identifying most strays nor of quantifying the proportion of strays. Based on coded-wire-tag recoveries, an estimated 100 stray summer and fall chinook salmon were "caught" in the Deschutes R. in the 1978-85 period (Jonasson and Lindsay, undated). Of 124 carcasses sampled below Sherars Falls in 1995, one was adipose-clipped (J. Newton, ODFW, pers. comm.) and therefore known to be a stray. Assuming that 10% of the potential strays from the Columbia R. were adipose-clipped[5], then the one adipose-clipped fish found in 1995 represented another nine unmarked strays and an 8% frequency of strays among the carcasses sampled. Strays could compose a higher or lower proportion of the spawners in the Deschutes R. than this 8%, which is used solely to illustrate that straying, even at high rates, may be virtually undetectable because so few strays can be identified.

---

[5] The 10% adipose-clip rate among potential strays is entirely arbitrary. A reasonable estimate of the true proportion would require deriving a weighted estimate of mark rates among the various summer and fall stocks migrating to production areas in the Columbia R. Basin upstream from the mouth of the Deschutes R. Based on my previous work with the upriver bright stock of fall chinook (produced primarily at Priest Rapids Hatchery and naturally in the Hanford Reach), the actual average mark rate would probably be lower than 10%, and the estimated frequency of strays would then be higher.

Straying into the Deschutes by summer steelhead is very common (ODFW and CTWS 1990), and Columbia R. summer and fall chinook may respond similarly — but not necessarily to the same degree — to whatever factors (e.g., mainstem transportation of smolts, difference in water temperature between the Deschutes and Columbia mainstems) cause the steelhead to stray.

In-basin spawning by strays would bias estimates of the Deschutes summer/fall chinook population upward, provided the number of strays spawning in the Deschutes R. were lower than the number of Deschutes summer/fall chinook spawning outside the basin. Strays, assuming they are more likely to spawn below Sherars Falls, a migration barrier, could be contributing to the downstream shift in spawning.

H_2: Fallback of tagged fish at Sherars Falls may bias population estimates upward.

Migrating salmon fall back over Sherars Falls, and such fallback probably biases run and escapement estimates of Deschutes summer/fall chinook salmon. Salmon — which naturally wander, overshoot, and "prove" (Ricker 1972) prior to spawning — frequently move downstream. Also, fish recovering from anesthesia, handling, and tagging at the Sherars Falls trap may be more likely to fall back over the falls than fish that are not handled and tagged.

Fallback rates at Sherars Falls can be estimated with existing data. Of fish (jacks and adults) tagged each year since 1977, an average of 0.007 (unweighted annual mean, range 0.0 - 0.025) have been recaptured in the trap while reascending the fishway at the falls (Appendix Table 3.3.1). However, recaptures are probably a small fraction of the fallbacks. The probability of recapturing a tagged fish in the trap is a function of the joint probabilities (i.e., rates) of fallback, of reascent through the fishway, and of passing out of the fishway when the trap is in operation (Eqn. 5).

$$P_{recap} = P_{fallback} P_{reascend} P_{trap} \qquad \textbf{(5)}$$

A fallback rate ($P_{fallback}$) of 0.028 (2.8%) is associated with a P_{recap} of 0.007, given $P_{reascend}$ = 1.0 and P_{trap} = 0.25 (see Appendix Table 3.3.2 for sources of probability values). The average recapture rate for adults (0.009) is higher and is equivalent to a fallback rate of 0.036 (3.6%). At least five (0.28) of the 18 summer/fall chinook salmon radio-tagged and released at Sherars Falls in 1989 fell back over the falls (CTWS, unpubl. data), although stress and injury during handling and tagging no doubt contributed to this rate. These estimates of fallback are low (i.e., < 0.05) primarily because the reascension rate is assumed to be 1.0: all fish that fall back reascend the falls.

Reascension rate is a critical factor in these estimates; fallback ceases to be an issue when all (or nearly all) fish reascend. Although empirical studies of fallback at mainstem Columbia R. and Snake R. dams **have not** measured reascension rates over 0.20 (Appendix Table 3.3.2), field data from the Deschutes R. indicate that virtually all summer/fall chinook that fall back over Sherars Falls reascend the falls. No tag from the Sherars Falls trap has been recovered from over 4,800 fish sampled below Sherars Falls during creel censuses and spawning ground surveys from 1986 to 1995 (Appendix Table 3.3.3). The aggregate probability of drawing this many samples without finding a tag is small (→0), given the numbers of fish tagged, except when fallback rate is < 0.05 and/or reascension rate is > 0.90 (Fig. 17, Appendix Table 3.3.4). These low fallback and high reascension rates contrast sharply with those measured at mainstem dams and, if accurate, bear important implications.

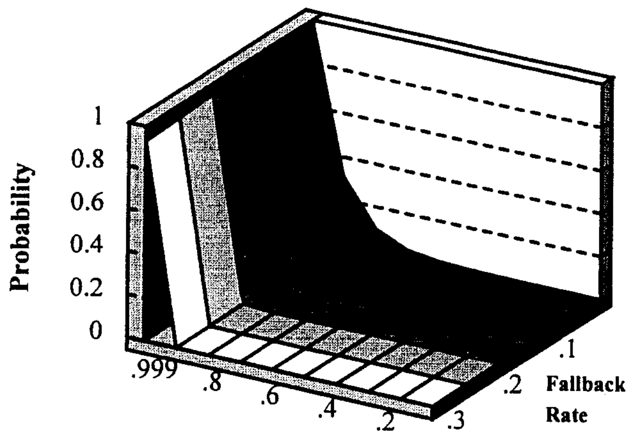


Figure 17. Probability of **not** detecting a tag in creel census and spawning ground sampling given various rates of fallback and reascension.

One major implication of such low net fallback[6] at Sherars Falls is that little upstream "wandering" is occurring over the falls: faithful reascencion suggests that nearly all fish passing above the falls are homing to their natal areas. If so, then restoration of an abundant above-falls run depends solely on improved survival of the above-falls component or on supplementation; the below-falls component will contribute little to rebuilding the upstream run through natural wandering and straying above Sherars Falls. A corollary is that the above-falls run is relatively isolated genetically from the below-falls component. A second implication is that Sherars Falls and its fishway do not deter upstream migration, because, if they did, fewer of the fallbacks would reascend. Together, these implications appear somewhat contradictory: fish that are natural wanderers do not casually pass a point that is easily passable.

When fallback occurs without reascension at Sherars Falls, it creates an upward bias in estimates of escapement and run size. The escapement of summer/fall chinook salmon in the Deschutes R. is estimated using Chapman's modification of the Petersen mark-recapture method (Ricker 1975; Heindl and Beaty 1989; CTWS and ODFW 1993). Fish are trapped and marked as they ascend the fishway at Sherars Falls, and marks are

[6] *Net fallback* is the proportion of all fish passing the falls that fall back and **do not** reascend.

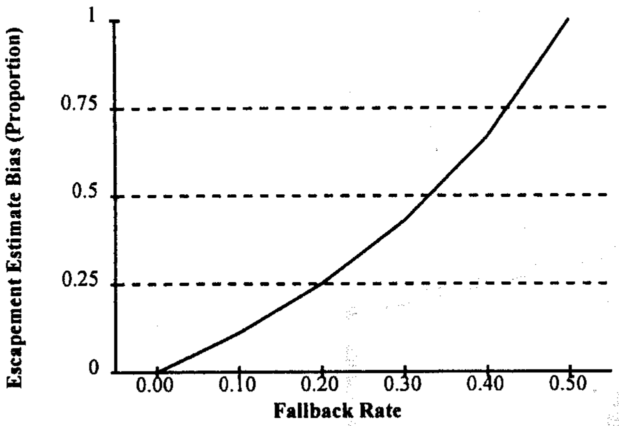


Figure 19. Bias in escapement estimates as a function of net fallback rate at Sherars Falls. (Appendix 3.3)

subsequently recovered during spawning ground surveys between Trout Creek (RK 140) and Pelton Reregulating Dam (RK 161) and in the trap at Pelton Reregulating Dam (CTWS and ODFW 1993) (Fig. 18, *following page*). The estimated abundance above the falls is expanded for the area below using redd counts and the ratio of fish per redd calculated for the reach above the falls. This method assumes that no tags are lost between time and place of marking and time and place of recovery (Ricker 1975).

The degree of bias depends on the net fallback rate. For example, a liberal net fallback rate of 0.20 (hypothetical) would bias these escapement estimates upward by 0.25, and the bias would be independent of fallback rate for ***un***marked fish (Appendix 3.3; Figure 19). Because they would be a function of biased escapement estimates, exploitation rates would then also be biased; the nature of that bias is discussed later.

Other factors (e.g., tag shedding, handling and tagging effects) that cause tagged fish to be under-represented in the spawning survey area can bias estimates in much the same way as fallback. Estimates of tag loss in summer/fall chinook have ranged from 0 to 4.0% (Heindl and Beaty 1989).

A fish's subsequent migration and viability are also affected by handling and tagging. For example, of the 18 fish radio-tagged at Sherars Falls in 1989, only three (0.167) were subsequently tracked to the spawning survey area upstream from Trout Creek, where, if marked, their marks could have been recovered (CTWS, unpubl. data). In the mid-Columbia R., newly radio-tagged fall chinook salmon migrated much slower through the same reach than fish that had been handled and tagged farther downstream (Stuehrenberg et al. 1995). Similarly, only a minor proportion (0.305 in 1991; 0.208 in 1992) of the fall chinook salmon radio-tagged and released 12.4 km downstream of the trapping point on the Snake R. (Ice Harbor Dam fishway) migrated back upstream to the trap (from data in Mendel et al. 1992, 1994). Usual handling and tagging conditions at the Sherars Falls trap, although more benign than conditions in these radio-telemetry studies, nevertheless must influence to some degree the migration and distribution of tagged fish. The cumulative bias from all of these factors is greater than that caused by fallback alone, but is not necessarily unacceptable.

The potential bias from fallback exists regardless of what proportion of ***un***tagged fish fall back. Fewer tags are still available to the recovery effort than believed, and, in the case of equal fallback of tagged and untagged fish, the resulting estimate is of the number of fish that passed the falls (including those that fell back), not the number that spawned above

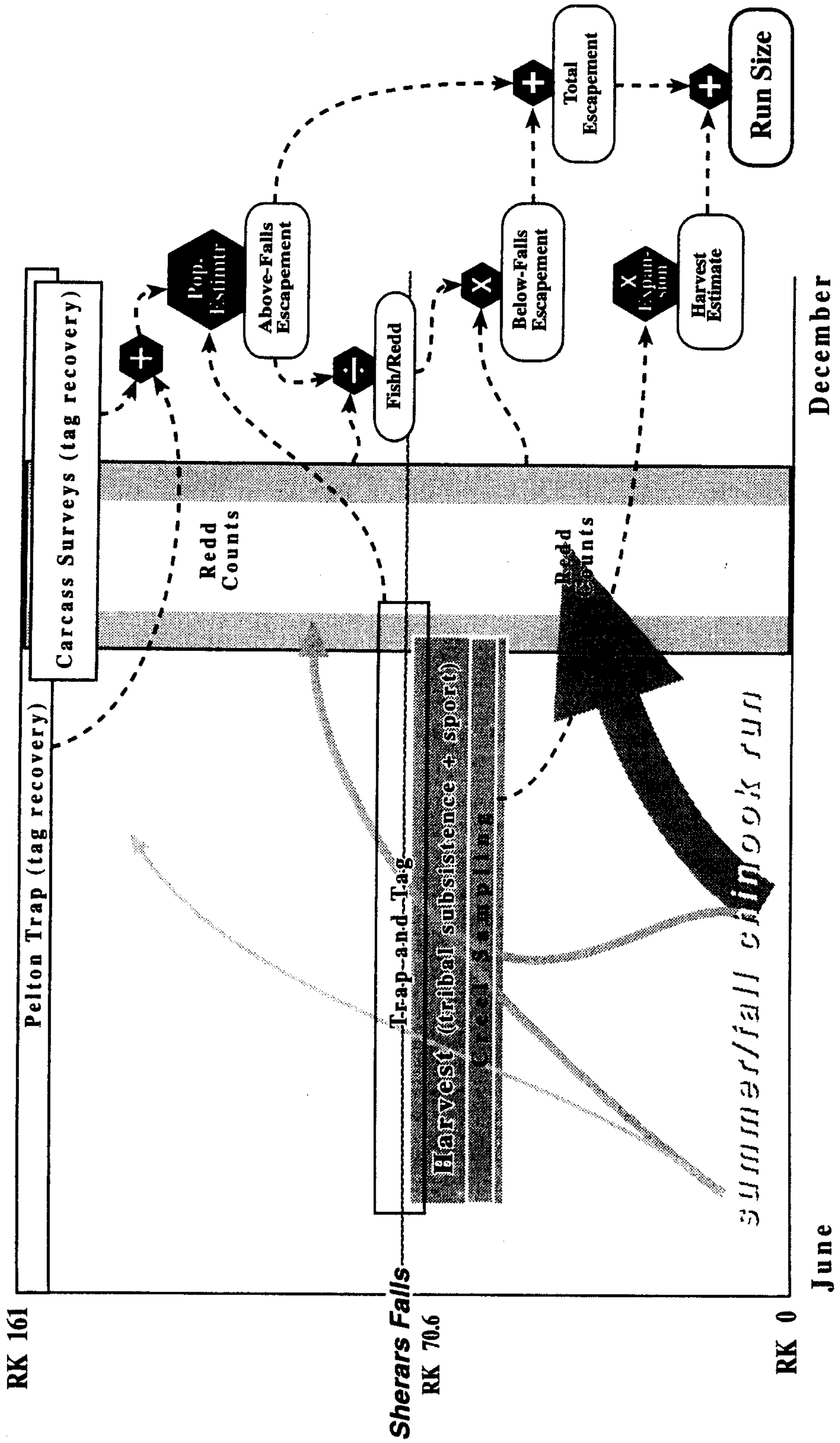


Figure 18. Process for estimating harvest, escapement, and run size of Deschutes R. summer/fall chinook.

(Appendix 3.1). Because the fallbacks cannot be accounted for, the fish-per-redd ratio above the falls is inflated (same bias as for the escapement estimate), and the inflated ratio is applied to redds below the falls, including those produced by spawners that fell back (therefore double-counting the fallbacks).

A final noteworthy point is that fallback rates and the resulting biases probably increase as the spawning distribution shifts from above to below the falls. If a relatively constant proportion of the below-falls spawners overshoot or for other reasons ascend the falls and fall back, then the number of fallbacks increases as the "population" below the falls increases. An increasing or constant number of fallbacks, coupled with a decreasing number of fish that actually spawn above the falls, will increase the fallback rate. Because the proportions spawning above and below the falls has reversed recently (now 80% spawn below) and because most sampling occurred before the reversal (e.g., creel censuses were discontinued after 1991), fallback could have increased without being detected.

H_3: The precision of escapement and run-size estimates is limited by redd count data.

Much of the variability observed in escapement and run size may result from inaccurate redd counts. As described earlier, escapement estimates in the reach above Sherars Falls are expanded to include the reach below the falls based on redd counts (Fig. 18). This method assumes that an equal (but not necessarily constant) proportion of the redds in each reach is counted each year. The escapement estimate above the falls is based solely on the mark-recapture methods (with its errors and biases); the escapement estimate below the falls is based on the results of the above-falls mark-recapture estimate and on the limited accuracy of redd counts in both reaches. The potential error increases as the spawning distribution shifts to below the falls, because then larger portions of the estimates are based on the redd counts.

Obtaining accurate redd counts in the Deschutes R., as in many other rivers, is virtually impossible. Budgets limit the amount of effort, weather limits the frequency and timing of aerial surveys, and water and weather conditions limit the visibility of redds, especially those at greater depths. Similar limitations affect redd counts for upriver bright fall chinook salmon in the Hanford Reach of the mid-Columbia R. (Dauble and Watson 1990) and for Snake R. fall chinook salmon (Mendel et al. 1994). Radio-tracking spawners (Mendel et al. 1994) and underwater searches (Garcia et al. 1994) are used to obtain more accurate counts and spawning distribution information for the endangered Snake R. fall stock.

In addition to the error potentially introduced in estimates by unequal proportions of redds being counted above and below the falls, bias would result if a consistently lower proportion of the redds were counted in Index and Random survey areas in either of the two reaches. For example, if water turbidity, water depth, and lighting conditions make it more difficult to identify redds in major spawning areas below Sherars Falls (e.g., Jones Canyon) than in areas above the falls, then the proportion of the redds counted below the falls will probably be lower than that counted above. In this case, estimates for escapement below the falls (and consequently for the entire river) will be biased low.

In conclusion, we may not be able to account for errors and biases in existing data nor find the resources necessary to improve the quality of data presently being collected. However, we must be aware that estimates we make and use — which are affected by limitations of the data — may not reflect actual conditions well.

INRIVER ADULT PASSAGE AND FISHERIES

Adult Passage

The ability and willingness of salmon to migrate to upstream spawning areas depends on many factors (Bell 1986), some of which may not be apparent to humans. Potential effects of the factors vary. For example, difficult passage conditions (e.g., high water temperature) at the river's mouth could reduce run size to the river or delay the run. An instream migration barrier (e.g., a waterfall where passage success is flow-dependent) may cause a downstream shift in spawning distribution, especially if it persists across years and/or if fish spawn precisely in natal areas. Although some of these conditions could also affect the survival of embryos and juveniles, those effects will be considered later.

H_1: Water temperatures in the lower Deschutes R. may be high enough in July and August to deter some summer migrants.

Deschutes R. water temperatures, although moderate and stable just below Pelton Reregulating Dam, become quite warm at the river's mouth during the summer (Fig. 15, *following page*). Mean temperatures at the mouth exceed the Oregon State water quality standard (14.4°C; DEQ 1994) from June through September. Maximum temperatures during July and August can reach 21°C, which has been identified as the incipient lethal temperature for fall chinook salmon (Coutant 1970) and the temperature associated with migrational delays in spring chinook (Stabler 1981) and sockeye salmon (Major and Mighell 1966). Rainbow trout are sensitive to temperature changes of ±0.1°C (Murray 1971), which suggests that migrating adult salmonids may respond to small increments in high temperatures. Summer chinook salmon migrating through the lower Deschutes R. during July and August encounter temperature conditions that are more severe than those encountered by earlier (i.e., spring) and later (i.e., fall) migrants.

I compared water temperature conditions encountered by adult Deschutes summer/fall chinook salmon using data from gage stations at Pelton Reregulating Dam (station 14092500) and near the mouth of the Deschutes R. (station 14103000) and scroll case temperatures from The Dalles Dam (USACE 1972, 1973, 1975, 1976, 1979), about 20 RK below the mouth, to . Data were obtained from the US Geologic Survey (USGS) for Deschutes R. stations from the early 1950s through the early 1980s. I used data from 1972, 1973, 1975, 1976, and 1979 — years following construction of Round Butte Dam (POST-DAMS) for which the series of at least daily maximum and minimum temperatures were complete for the two stations from May through September. The mid-point between daily minimum and maximum temperatures was used *in lieu* of the mean temperature when the latter was missing. Average mean temperature is the grand mean for all days within the month over the five years. Average maximum temperature is the mean over five years of the highest daily maximum for the month.

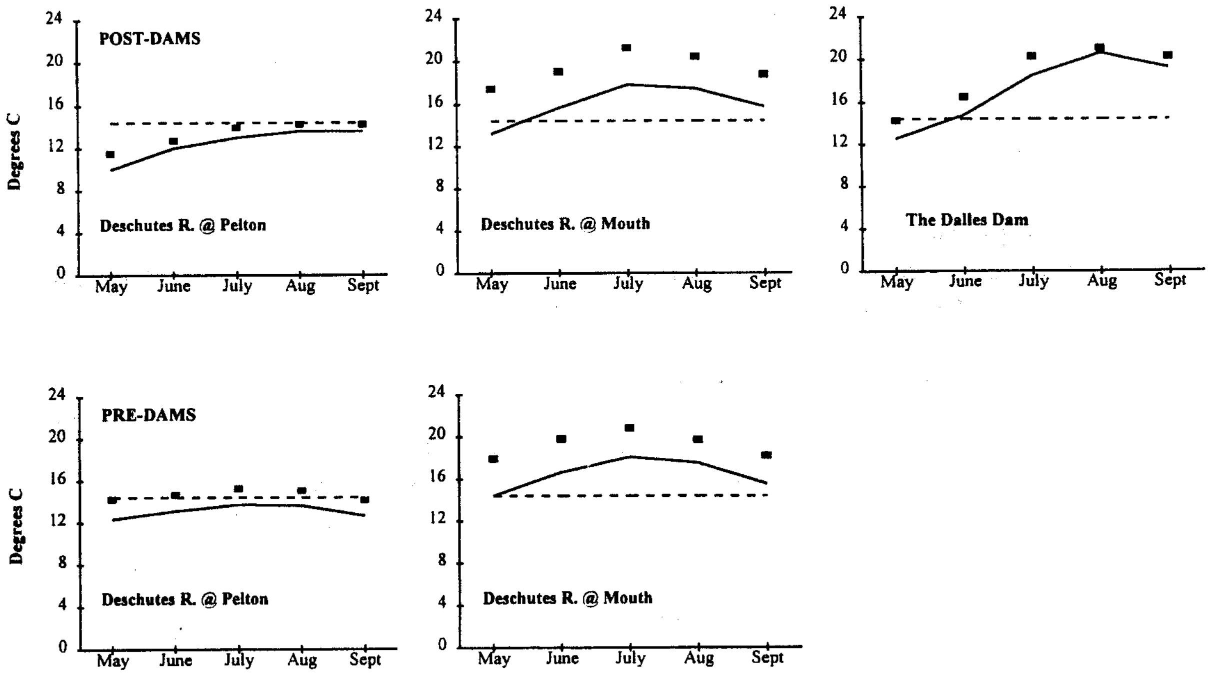


Figure 20. Average mean (line) and maximum (points) monthly summer water temperatures at Pelton Reregulating Dam, at the mouth of the Deschutes R., and at The Dalles Dam on the mainstem Columbia R. Dashed line is 14.4°C, the DEQ water quality maximum standard.

The high variability in temperatures near the mouth relative to both Pelton and to the Columbia R. at The Dalles Dam (Fig. 15, note distance between line for mean and points for maximum) suggests that the lower Deschutes R. is sensitive to diel cycles in atmospheric conditions, such as air temperature extremes. Water temperature follows atmospheric temperature more closely (and therefore varies more) when the stream is shallow (i.e., surface area is high relative to cross-sectional area) and lacks cover from solar radiation (Theurer et al. 1985; Rhodes et al. 1994, in general). High water temperatures in the lower Deschutes R. could be tempered by processes that increase shading and decrease channel width (e.g., riparian revegetation).

Although temperatures in the Deschutes R. at its mouth may hinder summer migrants, they would not necessarily block fish migration out of the mainstem Columbia R. Maximum temperatures in the Columbia R. are also high in the summer (Fig. 15), commonly exceeding 21°C during August (Collins 1963; Shew et al. 1988). We would expect a thermal block at the mouth of the Deschutes only if Deschutes R. temperatures were higher than those in the adjacent Columbia R. mainstem, which they generally are not. In fact, the Deschutes R. provides Columbia R. fish a refuge from high temperatures during August and September (Chapman et al. 1994), which may partially explain the abundance of stray summer steelhead in the Deschutes R.

Assuming that summer-migrating chinook salmon are more likely to migrate above Sherars Falls, high summer temperatures in the Columbia and lower Deschutes rivers could be one factor in the decline of spawning above the falls.

*H_2: Construction of the Pelton/Round Butte Project probably has **not** contributed to the high temperatures in the lower Deschutes R.*

Compared to temperatures from years before completion of the Pelton/Round Butte Project, mean and maximum temperatures at Pelton in post-dam years have been slightly cooler (particularly in May), and the summer peak has occurred about a month later (Fig. 15). Except for slightly lower temperatures in May and June, little difference is apparent between pre-dam and post-dam patterns near the mouth.

Such changes are expected. Impoundments that are large relative to stream flow reduce annual temperature variability (i.e., less extreme high temperatures in summer) and shift (delay) the annual temperature cycle, with the effect decreasing downstream (Jaske and Goebel 1967).

Impoundment and hypolimnion releases would have had a greater, and probably a biologically beneficial, effect on summer water temperatures if upper reaches of the Deschutes R. were not already naturally cool. The ability to cool the lowermost reach, where temperatures are more extreme, is diminished by equilibration with atmospheric conditions over 161 km of river. Keep in mind that we do not know what water temperature conditions prevailed in the lower river before Euroamerican settlement.

These results are based on limited data sets for both post-dam and pre-dam years. Post-dam data were identified above. Pre-dam data for 1953-58 (exclusive of 1957; 5 yr) were used for the USGS station at Pelton, a monitoring site that may be affected by dam facilities (Aney et al. 1967). Data for 1955-58 and 1963 were used for the station near the mouth (Moody). An 8-d gap in mean temperatures in 1958 was filled by linear interpolation.

The effects of temperatures and dam-related temperature changes on other life stages are considered in subsequent sections.

H_3: The Sherars Falls fishway probably impedes upstream movement relative to more advanced designs.

Sherars Falls is a substantial migration barrier; successful passage by upstream migrants is probably highly dependent on the fishway, particularly at low river flows. As already noted, natural stream flow has been greatly reduced by management practices following Euroamerican settlement (Nehlsen 1995), and summer/fall chinook no longer encounter the side-channel flows that facilitated fish passage at the falls in earlier times (P. Mitchell, CTWS member, pers. comm. 2/10/95). Unless natural flows can be re-established, conservation of summer and fall runs above Sherars Falls requires an effective passage alternative.

We do not know how effective the existing fishway is. Upstream migrants, including thousands of summer/fall chinook salmon in some years (CTWS and ODFW 1995), have used the fishway for decades, so to some degree it is effective. However, we do not know what proportion of the fish approaching the falls succeed in passing nor how long their migration may be delayed during passage. The amount of night-time passage through the Sherars Falls fishway is exceptional when compared to the paucity of night-time passage (generally <10% of total counts) at mainstem dams (Bell 1986; Bjornn and Peery 1992), which suggests that fish may be wary of exposure in the fishway.

Detailed passage information is being acquired and analyzed for fishways at mainstem dams on the Columbia and Snake rivers by tracking radio-tagged fish (Bjornn et al. 1992; Mendel et al. 1992; Stuehrenberg et al. 1995). Radio-telemetry has also been used on the Deschutes R. In 1989, 18 summer/fall chinook salmon caught in the trap at Sherars Falls were radio-tagged and tracked (M. Fritsch, CTWS, unpubl. data). However, because the radio-tagged fish were released above the falls, the study did not address passage at the falls itself.

The fishway was inspected in November 1994 by S. Rainey, a fish passage engineer with the National Marine Fisheries Service. In his report (Appendix 4), Mr. Rainey describes the existing ladder as substandard compared to recent designs, citing hydraulic problems in the ladder at low and high flows, low attraction flows at the ladder entrance, and poor entrance location with respect to tailrace hydraulic conditions. He identifies four alternatives for improving the fishway, but recommends that an adult radio-telemetry study be used to assess the severity of passage limitations before major facility changes are made.

An additional step was added to the top of the fishway in 1987 without the design assistance of an engineer (J. Newton, ODFW, pers. comm. 1/25/96). Its effect on fish passage was not evaluated.

In conclusion, fish passage over Sherars Falls could be improved, perhaps greatly, by higher flows to restore side-channel passage and/or by installing a better fishway. The effect of problems with the existing fishway, whatever they are, are likely to be chronic, impacting the viability of the upstream component gradually over a long period rather than suddenly. Improvements in fish passage would be expected to reduce catch rates in the fisheries at Sherars Falls, assuming that fish delayed in passage are more vulnerable than those that pass the falls quickly. The cumulative effects of passage problems and other detrimental factors, if great enough, would include a decline in the above-falls component of the stock and/or a shift in spawning distribution to below the falls, both of which already have been observed.

H_4: Operation of the Sherars Falls trap may discourage fish from using the fishway.

We know very little about how fish behave when passing Sherars Falls via the fishway, but evidence from elsewhere suggests that passage behavior is affected by trap operation in fishways. For example, operation of the trap in one fishway at Wells Dam on the mid-Columbia R. was associated with an increase in activity of radio-tagged sockeye salmon at the fishway entrance (Swan et al. 1994). Researchers hypothesized that the increased activity reflected indecisiveness about passage. Likewise, Mendel et al. (1994) believed that trapping operations for steelhead kept salmon from entering the trap at Ice Harbor Dam on the Snake R. Trap rejection may be responsible for increased spawning downstream of traps (S. Rainey, Appendix 4).

The trap at Sherars Falls obviously does not prevent all fish from attempting to pass when it is in operation, and it is operated only about one-quarter of the hours during the migration season. However, it could be a minor factor that discourages passage, making it less likely that some fish will choose to migrate above the falls for spawning. Further study would be necessary to identify the effect, if any.

H_5: Other human activities may have affected the quality of the migration environment above Sherars Falls.

Earlier analysis suggested that something happened above Sherars Falls in the 1985-87 period that triggered the 1987-91 decline in run size (Anonymous, undated). Although my analysis suggests that the 1987-91 decline was caused primarily by a return to a generally declining trend after a brief period of exceptionally good and widespread smolt-to-adult survival (considered further in later sections of this report), it is possible that single events or chronic conditions above Sherars Falls have contributed to the decline in spawning there.

I was able to identify and obtain information about several activities that affected the river (Table 3), some of which (e.g., construction at Pelton Reregulating Dam) have been hypothesized as potentially contributing to the decline in summer/fall chinook salmon above Sherars Falls (RK 70.6). None of the activities in the 1985 to 1987 period appear severe enough to explain the low returns of fish from those brood years.

Two of the larger events, in 1981 and 1988, occurred in a sensitive month and area for summer/fall chinook salmon migration and spawning. The earthen cofferdam at Pelton Reregulating Dam was removed in October 1981, when summer/fall chinook salmon were migrating into and beginning to spawn in their primary spawning area immediately downstream of the dam. According to J. Manion, General Manager of Warm Springs Power Enterprises, turbidity was monitored downstream during the work and appeared to be much less than during a storm event 2-3 mo. later, when turbidity was not monitored. The proportion of redds counted above Sherars Falls in 1981 was not exceptional (Fig. 3). The recruits-per-spawner ratio for the entire stock was low for that brood year (Fig. 6),

Table 3. Some activities that may have affected inriver conditions for upstream migrants or other life stages of summer/fall chinook salmon.

ACTIVITY	PERIOD	LOCATION	DESCRIPTION	SOURCE
Pelton Reregulating Dam construction to install turbine and generator unit.	1980-82 cofferdam removed fall, 1981	RK 161	Bulk excavation, powerhouse redesign, upstream earthen cofferdam construction and removal. Turbidity during cofferdam removal was monitored and is believed to have been far lower than during a storm 2-3 mo. later.	WS Power Enterprises Project file: *Chronology of Progress of Construction*. J. Manion, pers. comm. 11/7/94.
Burlington Northern sidecasting	1986	(not avail.)	(not available)	ODFW files, The Dalles
I-84 bridge piers	1986	RK 0.5	Riprap placed around pier footings.	ODFW files, The Dalles
Harris Ranch side-channel excavation	1986	RK 20	Removed plug of gravel from upstream end of side-channel with bulldozer.	ODFW files, The Dalles
Hwy 26 bridge modification	1986-88	RK 153	Bridge widened, ca. 27 yd^3 of used sand entered river, temporary work bridge installed and removed.	ODFW files, The Dalles
Sherars Falls fish ladder modification	1987	RK 71	New weir and pool added to upper end of fishway.	J. Newton, ODFW, pers. comm. 1/25/96
Heritage Landing boat ramp	Spring 1988	RK 1	Constructed new ramp.	ODFW files, The Dalles
Irrigation diversions, Frog Springs Cr.	Oct. 1988	RK 146	Erosion associated with 3 small irrigation diversions at head of Frog Springs Cr. added hundreds of cubic yards of fine sediment to the Deschutes R. over a few days, muddying the river to its mouth.	S. Pribyl, ODFW, pers. comm. 11/1/94, from field notes

although ocean conditions when that brood migrated to sea (1982) contributed to the low ratio (see later section on Ocean Productivity).

In October 1988, a problem with irrigation diversions on Frog Springs Cr. (RK 146) caused a relatively large load of sediment to enter the Deschutes R. (Table 3). Much material settled in an eddy just downstream from Frog Springs Cr., and the Deschutes R. was muddied all the way to its mouth (S. Pribyl, ODFW, pers. comm. 11/1/94). The proportion of redds counted above the falls that year was low relative to preceding years (Fig. 3), and the recruits-per-spawner ratio was also relatively low for that brood year (Fig. 6).

Unfortunately, we will probably never know the acute effects on the fish migrating and spawning in the weeks when these activities occurred nor know the lingering effects on production (e.g., reduction in gravel quality and spawning success) in subsequent years. Again, the chronic and cumulative — rather than specific — effects of such activities and other factors may be the biggest threat to the stock.

Intensive and escalating summer recreational use of the Deschutes R. above Sherars Falls has also been identified as a potential factor in the declining returns to that reach. Each weekend day in July and August, thousands of people in hundreds of rafts float management Segment 2, the 75-km reach immediately upstream from Sherars Falls (LDRMP 1993). Concentrations of human scent, sweat, beer, urine, lotions, and other substances in this "splash-and-giggle" zone are almost certainly sufficient to be detected by the keen olfactory sense of migrating adult salmon. Rinses of mammalian skin and a constituent thereof, L-SERINE, are detectable by salmonids at concentrations as low as 10^{-6} M and elicit strong repellent actions at dilutions of 8×10^{-10} (Hara 1971). The primary raft haul-out site, formerly a few meters above Sherars Falls on the fishway side, has been moved upstream, away from the falls, approximately 4 km (J. Griggs, CTWS, pers. comm.). This will not necessarily diminish human contact with this segment of the river, although it may reduce the effects, if any, of rafting on passage at the falls. Summer migrants and the above-falls component may be most greatly affected by this recreational activity.

Inriver Fisheries

Inriver harvest by recreational angling and tribal subsistence fisheries, occurring primarily in the Sherars Falls vicinity, has been monitored and estimated each year since at least 1977 (Lindsay et al. 1980). Because of low summer/fall chinook salmon runs, the recreational angling fishery has been closed and the tribal subsistence fishery has been capped since 1991 (CTWS and ODFW 1993, 1994). Harvest of this stock in ocean and Columbia R. fisheries will be covered in later sections.

Estimated exploitation rates for the run as a whole (i.e., adults and jacks) since 1977 have ranged from 43.8% (1980) to 0.8% (1993) and averaged approximately 25% (Table 1). Exploitation rate estimates for adults and jacks generally have been similar.

H_1: Actual exploitation rates for the run as a whole may be higher than estimated because of fallback (i.e., the estimates may be biased low).

Because escapement (and run-size) estimates may be biased high, exploitation rates calculated from those estimates may also be biased (Appendix 3.3). In this case, the bias in exploitation rates would be negative (i.e., estimated rates are lower than actual rates) and would be proportionately less extreme than that for escapements, ranging from 0 to the additive inverse of the net fallback rate. The most extreme biases would occur as exploitation rates approach zero. Actual escapements of Deschutes summer/fall chinook salmon may have been lower than estimated, and actual exploitation rates may have been higher than estimated.

H_2: The inriver fisheries have imposed a higher mortality (exploitation rate) on the above-falls component than on the run as a whole.

The longer fish are exposed to a fishery, the greater their vulnerability and exploitation rate will be. In the Deschutes R., fish that are destined for areas above Sherars Falls must pass through the entire fishery area and probably endure a protracted exposure while trying to pass Sherars Falls. A portion of the fish that spawn below Sherars Falls undoubtedly wander through the fishery area and some spawn there, but the below-falls spawners in general probably have been less exposed and vulnerable to the fisheries than the above-falls spawners. Because exploitation rate estimates apply to the run as a whole (Table 1), they underestimate the rate at which the above-falls component is harvested and overestimate the rate for below-falls fish.

We do not know how high the exploitation rate of above-falls fish is relative to those below the falls nor to the run as a whole, nor can it be readily measured. However, we can evaluate the effect of various differences (Appendix 3.5 for methods). For example, if above-falls fish have been exploited at twice the rate of those below, then exploitation rates for the run as a whole since 1977 have been, on average, approximately 0.17 lower (negative bias) than actual rates for the above-falls fish (Fig. 21; Appendix Table 3.5.1).

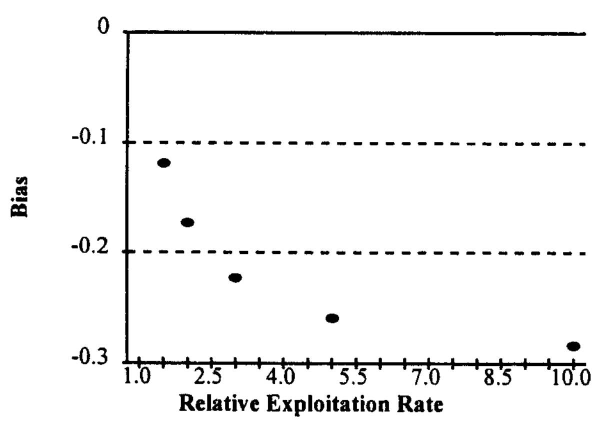


Figure 21. Negative bias in exploitation rate estimates becomes more extreme at higher relative exploitation rates on above-falls fish. (Appendix Table 3.5.1)

The magnitude of bias depends on several factors. Bias increases (actual exploitation rates become even higher than aggregate estimates) as the proportion of the run above the falls decreases and as overall exploitation rates decrease. Both have occurred in recent years. However, even a large bias is rather inconsequential when exploitation rate is low. The effect of fallback rate has already been presented: higher fallback causes greater (i.e., more negative) bias in exploitation rate. Relative exploitation rate also is important. If above-falls fish are harvested at rates two, three, or more times higher than the below-falls component, then it becomes increasingly important to curtail harvest at Sherars Falls as the run above there declines.

In conclusion, although exploitation rates on the above-falls fish have almost certainly been higher than for the run as a whole, by themselves they probably have not been sufficient to decimate the run above Sherars Falls. However, it is quite possible that they have, in concert with other factors, contributed to the decline and to the downstream shift in spawning. Of course, the flip side of this selective harvest situation is that the below-falls component is probably harvested at rates well below the overall exploitation rate. The risk of inadvertently overharvesting the above-falls component will increase when the overall exploitation rate increases, unless there is a concurrent upstream shift in spawner distribution.

SPAWNING AND INCUBATION

Gravel Quantity and Quality

Spawning gravel has been a central issue in the management of summer/fall chinook salmon in the Deschutes R. Attention has focussed on the effects of impoundment on the distribution and quality of spawning gravel, particularly in the reach just below Pelton Reregulating Dam, where most spawning formerly occurred.

Aney et al. (1967) documented the highest concentration of streambed spawning gravel in the 8.4 km reach (Section I) between Pelton Reregulating Dam and Shitike Cr. (RK 152.5). In this section gravels were relatively free of sand and silt and generally had the highest permeability values. Areas of apparently high-quality spawning gravels were spawned in very densely. In contrast, gravel below the confluence of the White R. (Section IV) was relatively scarce and poor; permeability was limited by high concentrations of silt and fine sand.

Two decades later, Huntington (1985) described the same general patterns with some noteworthy differences. He estimated a 26% reduction in spawning gravel in Section I since the work in the 1960s, presumably from export during high flows. Erosion of gravel from islands apparently offset what could have been higher losses. He speculated that degradation (erosion) was responsible for the deepened (since 1960) channel at the Pelton gage transect. Although gravel permeabilities remained generally highest in Section I, some of the highest measurements were obtained in heavily spawned areas of Section IV. Noting that gravel areas throughout the river tend to be armored, compacted, embedded, and/or underlain by coarse substrata, he hypothesized that (summer/)fall chinook salmon spawning activity can create good spawning habitat by loosening and cleaning gravel. Huntington (1985) recommended adding gravel to fill troughs of spawning dunes in Section I, protecting islands from further erosion in the same area, and scarifying compacted gravel bars. He acknowledged the conflict between increased flushing flows for cleaning spawning gravels in Section I and preventing further gravel export from that reach.

During the Northwest Power Planning Council's subbasin planning process, ODFW and CTWS (1990) planners identified gravel quality and quantity throughout the lower Deschutes R. as the greatest habitat constraints for (summer/)fall chinook salmon production. The Lower Deschutes R. Management Plan (LDRMP 1993) prescribes that approximately 250 yd^3 of suitable gravel be placed in the 4.8 km immediately below Pelton Reregulating Dam and calls for the Federal Energy Regulatory Commission to require spring flushing flows as a condition for forthcoming project relicensing. In 1994, Portland General Electric Company, owner and operator of the project, initiated a study by Oregon State University "to determine the effect of the Pelton-Round Butte Project on channel morphology and gravel supply, transport, deposition, and quality in the lower Deschutes River" (Grant et al. 1995, p. 1).

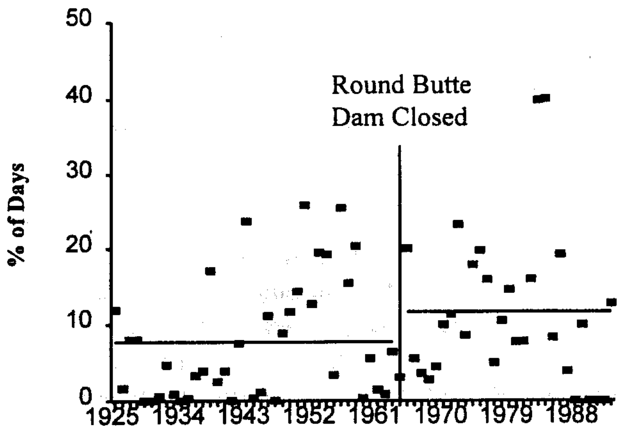


Figure 22. Percent of days when flow exceeded 6,000 cfs at site of Pelton Reregulating Dam, 1925-93. Pre- and post-1964 means are horizontal lines.

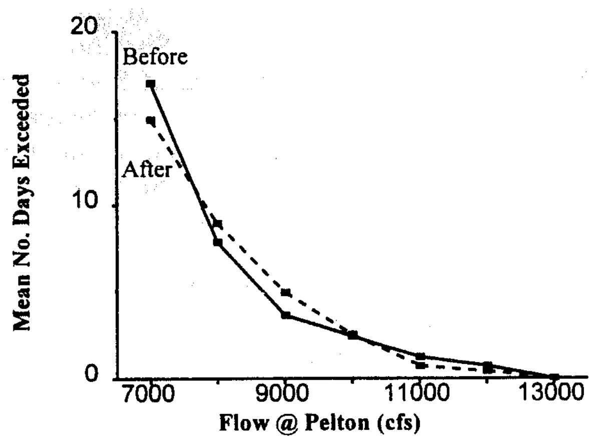


Figure 23. Mean number of days per year when flow exceeded various high levels in the decades before and after completion of Round Butte Dam.

I give this topic only cursory coverage. Past and ongoing research have been relatively comprehensive, although many of the most pertinent questions (e.g., quality of spawning gravel as measured by spawning success and egg-to-fry survival) will require careful and perhaps extensive field research.

H_1*: *Closure of Round Butte Dam in 1964 and subsequent flow regulation did not substantially alter the magnitude and frequency of high flow events.

Impoundment of Lake Billy Chinook behind Round Butte Dam increased forty-fold the project's active storage capacity[7], thereby enabling substantial modification of the river's natural hydrograph. One potential risk is that water storage could reduce the high flows that move and clean spawning gravels below the project. However, the proportion of days when flows exceeded 6000 cfs (an arbitrary level) at the Pelton Reregulating dam site did not change noticeably after 1964 (Fig. 22; data from USGS gage station no. 14092500). Likewise, the mean frequency of high flow events (number of days per year exceeding various flow levels) was virtually the same in the decade before (1954-63) and the decade after 1964 (1965-74; Fig. 23). High flow events after completion of

[7] Active storage capacities (R. Osborn, PGE, pers. comm., 7/11/95):

Pelton Dam (Lake Simtustus)	3,830 ac·ft
Pelton Reregulating Dam Reservoir	3,296 ac·ft
Round Butte Dam (Lake Billy Chinook)	280,000 ac·ft

Round Butte Dam apparently were as competent for moving and cleaning spawning gravels as those preceding dam construction.

The annual hydrograph of mean monthly flows is different in the decade after 1964, with higher flows in January and lower flows from February through May (Fig. 24). The difference is probably attributable to a change in runoff pattern rather than to Round Butte Dam, because similar changes occurred in tributaries of the lower Deschutes R. (Huntington 1985).

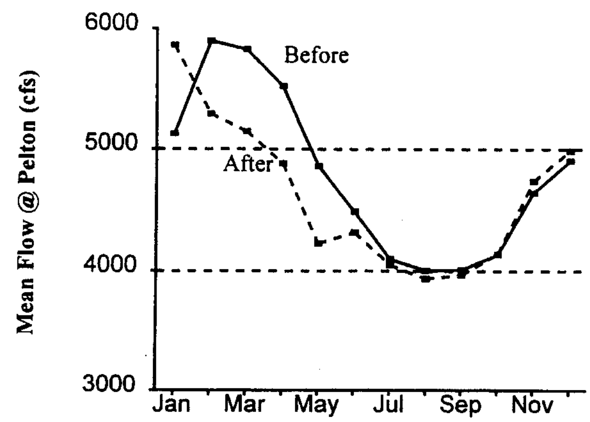


Figure 24. Mean monthly flows at Pelton dam site in decades before and after completion of Round Butte Dam.

H_2: The quantity and quality of spawning gravel below Pelton Reregulating Dam may be limited by the presence of the reservoirs and dams.

Impoundments like Lake Billy Chinook and dams like Pelton Reregulating Dam prevent the movement of sediment and bedload into the reach immediately downstream. Clearwater releases from reservoirs usually entrain a new load of sediment from the stream channel, promoting a process of degradation and bank erosion that is often limited by exposure of a protective layer of cobbles or rubble that is too large to be moved and that may become compacted (Armitage 1984). For example, severe substrate armoring has occurred below four dams on Colorado's Gunnison R. (Stanford and Ward 1984; Kellerhals and Church 1989). Huntington (1985) hypothesized that this degradation process may have been responsible for the changes in the section below Pelton Reregulating Dam between the 1960s and 1980s: reduction in spawning gravel, erosion of islands, channel deepening at the Pelton gage transect, and coarser gravel texture in some areas. Overall, these observations suggest that the dams and reservoirs may be promoting deterioration of substrate in the reach immediately below Pelton Reregulating Dam that has been so heavily used by summer/fall chinook salmon spawners. Deterioration in the quality of spawning gravel could represent another factor reducing the viability of the above-falls component.

Unfortunately, we know little about the qualities of the substrate in this reach before the dams were constructed. Chinook spawned around at least one island approximately 2 km below the site of Pelton Reregulating Dam in the early 1950s (B. Smith, local resident, pers. comm., 2/1/96), suggesting that spawning gravels were adequate in some places. The superior quality of the gravel in the 1960s (Aney et al. 1967) may have been due as much to the intensive salmon spawning activity (Huntington 1985) as to pre-existing conditions.

H_3: The decrease in salmon spawning activity above Sherars Falls may partially result from a degenerative cycle in which gravel quality declines as spawning use declines.

Spawning intensity and gravel quality are at least somewhat mutually dependent: salmon spawn where gravels of suitable size are relatively loose and clean of fine sediments (i.e., permeable), and spawning salmon loosen and clean the gravel (Chapman and McLeod 1987; Everest et al. 1987; both cited by Rhodes et al. 1994). This correspondence has been noted for Deschutes R. summer/fall chinook salmon (Aney et al. 1967; Huntington 1985) and may underlie phenomena observed for similar stocks. For example, fall chinook salmon in the Hanford Reach of the mid-Columbia tend to spawn in high-use areas (Dauble and Watson 1990). When population size increases, spawning densities increase in these same areas, while few spawners recruit to new and apparently suitable areas. Spawning may be the only process that cleans the gravel in the Hanford Reach, where, because of flow regulation, there is little mass movement of bedload (Chapman et al. 1986). Likewise, spawning by Snake R. fall chinook salmon has been concentrated at a few sites since 1987 (Connor et al. 1994b). Biologists have noted a tendency for salmonids to spawn where gravels have been disturbed (loosened), such as by vehicle traffic (J. Newton, ODFW, pers. comm. 10/17/49). Spawning in the Deschutes R. may be concentrated in areas where spawning in previous years has improved and maintained gravel quality.

This hypothesis has a corollary: the less a spawning area is used and the longer an area remains unused, the more difficult it will be for the population to re-establish or increase successful spawning by itself. An exceptional hydraulic event or human intervention may be necessary to undo the effects of processes that increase substrate compaction and embeddedness. Assuming that spawning gravel quality deteriorates with disuse, it may be very difficult to keep an area like that below Pelton Reregulating Dam sufficiently seeded to prevent deterioration without improvements in survival during the emergence-to-spawner portion of the life cycle. A field study could help identify trends in gravel quality relative to intensity and continuity of spawning.

H_4: Incubating embryos and alevins benefit from the same gravel conditions that adults seek and create during spawning.

Incubating embryos and alevins need the same loose and clean (i.e., permeable) substrates for their survival that the adults need for spawning (Rhodes et al. 1994). Relatively low levels of spawning in preceding years and in the immediate area the same year may diminish gravel permeability and could conceivably depress embryo and alevin survival. Sedimentation may smother or entomb the incubating young, but I found no sediment-generating anthropogenic events (Table 3) and know of no natural events that I could clearly link to the rather sudden decline in the above falls component since the brood years of the mid-1980s.

Thermal Conditions

H_1: Upstream impoundments may not have changed the river's thermal regime sufficiently in winter to affect the emergence time of fry.

Emergence of summer/fall chinook fry, as estimated by the accumulation of temperature units at the USGS Pelton gage, has been approximately five days later since 1964 in the reach below Pelton Reregulating Dam (Fig. 25). This is contrary to my expectation.

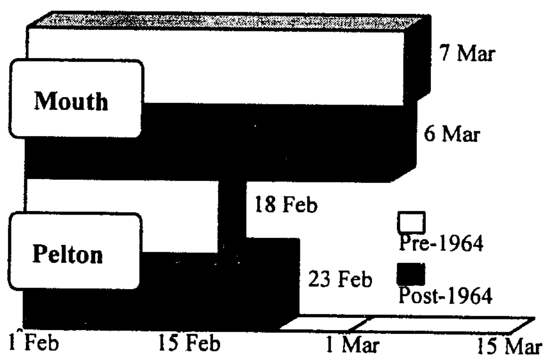


Figure 25. Mean estimated emergence date for summer/fall chinook salmon based on water temperatures.

PELTON		MOUTH (MOODY)	
Pre-1964	Post-1964	Pre-1964	Post-1964
1953	1972	1955	1972
1954	1973	1957	1974
1955	1974	1958	1976
1956	1976		1978
	1977		

I expected an earlier estimated date of emergence because impoundments tend to buffer against seasonal thermal extremes, such as cold water temperatures in winter (Jaske and Goebel 1967; Gregoire and Champeau 1984). Warmer water temperatures in winter would hasten the embryonic development and emergence of summer/fall chinook salmon. Mean water temperatures at the Pelton gage for the years used in this comparison were actually cooler after 1964 than before. There was virtually no change in mean water temperatures and hypothetical date of emergence at the mouth of the Deschutes (Fig. 25).

Mean daily temperatures from gage stations at Pelton (USGS 14092500) and at Moody (USGS 14103000; near the mouth) were not available for all days in all years. I filled gaps in mean daily temperature with the midpoint between minimum and maximum when those two values were present and selected groups of water years (inset, left) with complete series of mean/mid temperature values from November through March for both sites pre- and post-1964.

I estimated emergence at 1600 temperature units (Piper et al. 1982) after 1 November for each year, then calculated the mean date for each group of years. A temperature unit equals 1 °F above freezing per day. Spawning (as reflected in presence and abundance of carcasses) spans from late-September to mid-December with a peak usually in the last half of November (Jonasson and Lindsay, undated).

The unexpected results for Pelton could be a result of the relatively small number of years used (i.e., the effect of random events could be high), an artifact of the location of the gage station, and/or a reflection of changes in the river's unique thermal and hydrologic cycle. Aney et al. (1967) believed that Pelton temperatures were not useful because they were taken near the discharge point for the Pelton fish collection facilities. D. Ratliff (PGE, pers. comm. 12/16/96) offers a plausible explanation for these results: impoundments have buffered the effects of temperate (12°C) springs on winter water temperatures, which would cause the incubation period to be longer after dam construction.

JUVENILE REARING

Survival of juvenile summer/fall chinook from time of emergence to migration out of the Deschutes R. is affected by many factors. Unfortunately, no juvenile survival data are available. The limited information available on juvenile ecology in the Deschutes R. is from investigations by ODFW in 1978-80 (Jonasson and Lindsay, undated). I used this information to identify some factors that may be contributing to long-term trends in run size and to the downstream shift in spawning distribution.

Fry, some of which have already grown to 60 mm, are present as early as February (Fessler et al. 1977; Lindsay et al. 1980), and the presence of 45-mm fry in mid-May (Jonasson and Lindsay, undated) suggests that fry may be emerging through April. This emergence period is the same as that for summer/fall chinook salmon in the Wenatchee R. (Chapman et al. 1994) and about a month earlier than for upriver bright fall chinook in the Hanford Reach (Beaty 1992) and for Snake R. fall chinook (Connor et al. 1994a). Distribution of juveniles is comparable to that of spawning distribution (Lindsay et al. 1980); most juveniles apparently rear in the same general area (e.g., above Sherars Falls) in which they are spawned. Many juveniles show high fidelity to one section of the river until the peak of outmigration (Jonasson and Lindsay, undated). Conditions for growth and survival may differ among spawning/rearing areas.

Differences have been noted in size and movement of juveniles that occupy upstream and downstream reaches. Average lengths in May were 10 mm greater below Sherars Falls than in sections above (Fessler et al. 1978). Lindsay et al. (1980) hypothesized that larger fish size below the confluence of the Warm Springs R. could have resulted from better growth in downstream reaches and/or downstream drift of larger fish. Outmigration, inferred from sharp declines in seine CPUE, occurred first in the late spring (May) in the lower river and moved progressively upstream (Fessler et al. 1978, Jonasson and Lindsay, undated). Except for some precocious males (140-180 mm), few fish were present in samples after July (Fessler et al. 1977, 1978), suggesting that the outmigration is complete by mid-summer. A small proportion (< 5%) of the population migrates as yearlings, based on analysis of adult scales (Jonasson and Lindsay, undated). These differences in size and migration timing and the early migration at small size from the lower river are consistent with what we know about the temperature profile of the river and the ecology of subyearling chinook salmon.

***H_1*:** *Higher spring and summer water temperatures toward the mouth of the Deschutes R. probably promote faster spring growth and earlier outmigration of juveniles rearing below Sherars Falls, relative to those above.*

Juvenile chinook salmon prefer temperatures of about 12-14°C (Brett 1952, cited by Becker 1973) and grow best on a high ration at about 15-16°C (Brett 1979). Temperature

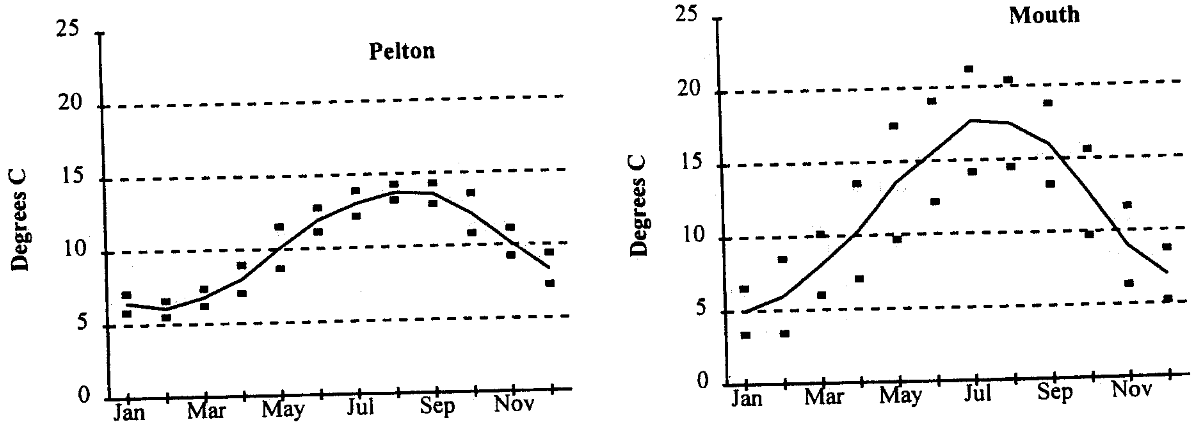


Figure 26. Monthly mean (line) and maximum-minimum (points) water temperatures at Pelton and the mouth in the 1970s. Data from USGS gage stations 14092500 (Pelton) and 14103000 (mouth/Moody).

variations and/or diet limitations reduce the temperature at which growth is optimum (Brett 1979). Temperatures beyond this point not only reduce growth potential, but also increase the adverse impacts of other factors.

Water temperatures at the mouth of the Deschutes R. appear to be more favorable than those at Pelton for spring growth of juveniles. Although highly variable, temperatures at the mouth reach into the 12-15°C range already in April and May; Pelton does not experience these temperatures until June (Fig. 26). Larger size of juveniles in downstream reaches (Fessler et al. 1978; Lindsay et al. 1980) may be partially a result of these temperature differences promoting faster growth. Peak outmigration consistently occurs progressively later with increasing distance above Sherars Falls (i.e., above RK 71), although mean size of fish changes little (Fig. 27, *following page*). This comports with the expectation of slower growth in the cooler upstream waters.

Size is a significant factor in downstream migration/displacement rates of subyearling chinook salmon (Connor et al. 1994a; Nelson et al. 1994), and there appears to be minimum size threshold for initiation of migration. For example, both Snake R. fall chinook (Connor et al. 1994a) and mid-Columbia summer/fall chinook (Chapman et al. 1994) show a migration threshold of approximately 80-85 mm. Subyearling fall chinook in Columbia R. tributaries below Bonneville Dam apparently migrate when 80-105 mm, and differing temperature regimes among streams may affect fish size and, hence, timing of migration (Reimers and Loeffel 1967). With the noteworthy exception of the fish below Sherars Falls, mean fork lengths at the time of peak migration in the Deschutes R. seem consistent with a 80-90 mm migration size threshold (Fig. 27, *following page*). Although juveniles in

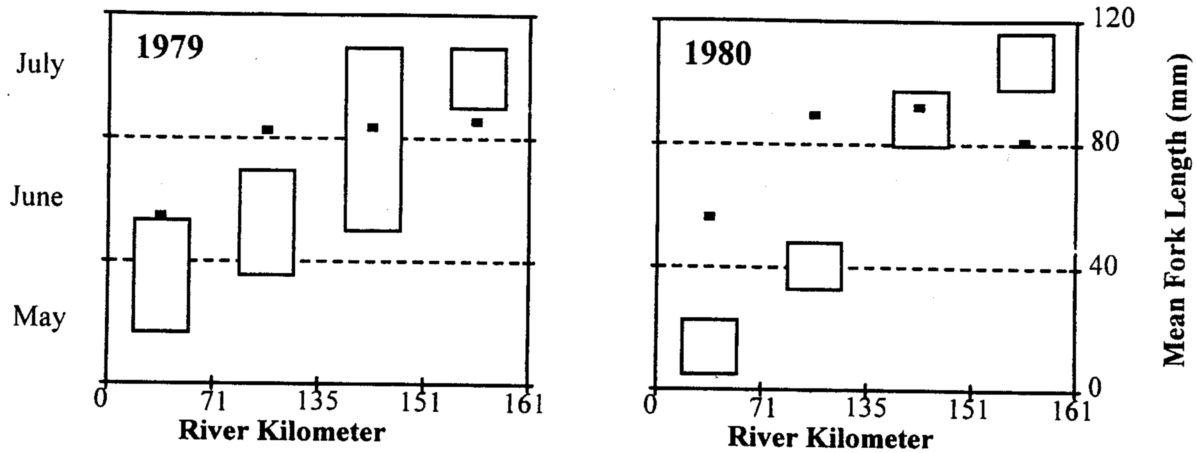


Figure 27. Peak migration timing (bars) and size (points) of juvenile summer/fall chinook from four study sections. Sherars Falls = RK 71. From Jonasson and Lindsay (undated), Table 21.

the lower river may be growing faster than those upstream, they leave well before reaching the expected migration size.

Early migration at an unusually small size suggests flight from unfavorable conditions, and high water temperatures provide a plausible explanation. Regardless of their size, juveniles must leave when water temperatures become too high for good growth and survival (i.e., beyond 16°C). At the mouth, that level is reached as early as May, which corresponds to peak outmigration from that reach (Fig. 27). By July, mean temperatures are above optimum, and maximum temperatures can be harmful (> 19°C; Fig. 26). Similar conditions exist in the nearby John Day R., where subyearling spring chinook salmon vacate lower river reaches when water temperatures approach 19°C (Rhodes et al. 1994 based on results in Lindsay et al. 1986), which corresponds approximately to the upper limit of the range for positive growth (Rhodes et al. 1994). In 1992, Snake R. fall chinook migrated relatively early at relatively small size after a rapid increase in water temperature (Connor et al. 1994a). Becker (1985) suggests that temperature is an important factor in outmigration timing of subyearling chinook from the Hanford Reach of the mid-Columbia R. Subyearling (fall) chinook in Columbia R. reservoirs apparently begin leaving littoral areas when temperatures approach 16°C and are not caught where temperatures exceed 21°C (Key et al. 1994). In Lower Granite Reservoir (Snake R.), subyearling chinook leave shoreline habitats as water temperatures exceed 18°C, the temperature corresponding to cessation of positive growth predicted by a bioenergetics model (Curet 1993). Migration from the lower Deschutes R. in May and early June is probably precipitated by temperatures that are climbing to unfavorable levels.

Temperatures in the Pelton area, however, probably do not get high enough to force migration, even in July and August.

H_2: Harsh summer temperatures in the lower river select against late subyearling migrants, such as those from upriver reaches.

Juveniles migrating out of the upper reaches in June, July, and perhaps August must pass through a harsh environment downstream. Residents of the lower river migrated weeks earlier as temperatures became unfavorable. Relatively cool conditions below Pelton Reregulating Dam do not spur migration before adverse conditions have developed in the lower river.

Metabolic demands, predation, competition from warmwater-tolerant species, and some diseases all increase at higher temperatures. Growth rate of juvenile chinook decreases beyond about 15°C (lower as ration is more restricted), mostly because of increased metabolic demand (Brett 1979). Consumption rates by northern squawfish (*Ptychocheilus oregonensis*), an indigenous predator on juvenile salmon, increase to a maximum at 21°C (Vigg and Burley 1991). Redside shiners (*Richardsonius balteatus*) dominate and affect the distribution and production of juvenile salmonids when temperatures exceed approximately 18°C (Reeves et al. 1987; Hillman 1991, cited by Chapman et al. 1994). Ceratomyxosis, a significant mortality source for Deschutes wild fall chinook in the late 1970s (Ratliff 1981), generally becomes more prevalent as temperatures increase (Ratliff 1983). For example, mortality of juvenile coho salmon (*O. kisutch*) from ceratomyxosis increases four-fold, from 22% to 84%, between 15°C and 20.5°C (Udey et al. 1975). Other infectious fish diseases exist in the Deschutes R. subbasin; bacterial kidney disease has been a problem in spring chinook at Round Butte Hatchery (ODFW and CTWS 1990) and Warm Springs National Fish Hatchery (C. Fagan, CTWS, pers. comm., 12/95). Separately and in combination, these forces can be expected to take a higher toll on the juveniles from upstream reaches, which are exposed to high summer temperatures in the lower river.

H_3: Ceratomyxosis probably poses a greater risk to juveniles rearing above Sherars Falls than to those rearing below.

The prevalence of *Ceratomyxa shasta* in the Deschutes R. is not known at present. Historically, infectious stages of the pathogen emanated from the reservoir hypolimnions seasonally as temperatures approached 10°C (Ratliff 1983). Ceratomyxosis was common in juvenile fall chinook in the late 1970s, occurring in up to 50% of wild subyearlings in late June and early July (Fessler et al. 1978). The disease appeared to be an important mortality factor after May (Fessler et al. 1978), as might be expected with increasing temperatures. The number of infectious *C. shasta* units declined significantly from 1978 to 1981, which coincides with termination of stocking susceptible trout in Lake Simtustus (Ratliff 1983). Prevalence of the pathogen in the river and the disease in subyearling chinook apparently has not been investigated since 1981, so we do not know if ceratomyxosis is still an important mortality factor.

If *C. shasta* still emanates from the reservoirs, then juveniles rearing in the upper reaches below Pelton Reregulating Dam are more exposed and may incur higher mortalities than those rearing below Sherars Falls. Reasons include:

1. Longer exposure because they migrate later (i.e., after May) (Fessler et al. 1978);
2. Exposure to higher temperatures in the lower river because of their later migration; and
3. The number (and concentration) of infectious units in the river is probably higher upstream and diminishes downstream because of their limited longevity and active removal or neutralization by susceptible fish (Ratliff 1983).

Ceratomyxosis may or may not be one of the perhaps many factors contributing to the decline in spawning above Sherars Falls, assuming fish that reared above the falls are more likely to return and spawn in the same area.

H_4*: Land-use practices, by affecting rearing habitat for juveniles, may be contributing to the decline above Sherars Falls.

Land-use practices can have large and long-term effects on how well juvenile salmon grow and survive. Healthy riparian zones on tributaries and the mainstem limit erosion and sediment delivery, provide shading and thermal regulation, stabilize banks, control channel width in alluvial streams, and provide large woody debris that enhances instream habitat complexity (Rhodes et al. 1994). Livestock grazing, vehicle use, and recreational activities have degraded riparian vegetation and damaged fish habitat in the Deschutes R. (LDRMP 1993). We do not know the degree to which this habitat damage has limited survival of summer/fall chinook, but the impact is clearly negative. The most likely effects are on long-term production (e.g., run size, recruits per spawner) and perhaps on spawning distribution.

Riparian vegetation standards and goals have been established for the river (ODFW and CTWS 1990; LDRMP 1993). I do not know whether these goals are being met.

Land-use practices seem to differ somewhat between the upper and lower reaches. An extensive review of land uses and habitat conditions was not within the scope of this project. However, recreational and vehicle use appears to me to be higher upstream. I have no information on the relative distribution of grazing, although intensive use is obvious in some areas above Sherars Falls, and the 8-year-old livestock exclosure in the 19 km above the mouth has allowed dramatic growth of riparian vegetation. Subyearling chinook fry are often abundant in the lush littoral vegetation of this reach during trout surveys (S. Pribyl, ODFW, pers. comm.). Some biologists hypothesize that the relatively strong below-falls component of the run may be partially attributable to improved juvenile habitat conditions in this exclosure reach. This assumes fish that rear as juveniles below the falls are more likely to spawn in the same reach.

Despite the absence of data, it is clear that establishing and maintaining a healthy riparian zone in all reaches will benefit juvenile summer/fall chinook production.

H_5: Competition and/or predation by rainbow trout/steelhead may be limiting production of summer/fall chinook.

Rainbow trout and steelhead support the most important recreational fisheries of the lower Deschutes R. (Schroeder and Smith 1989). Juveniles of the resident rainbow trout and the anadromous steelhead probably compete to some degree with subyearling summer/fall chinook, and larger resident rainbow trout may prey upon chinook fry. Higher densities of rainbow trout above Sherars Falls (Schroeder and Smith 1989) could be related to declines in the above-falls component of the summer/fall chinook population.

Data are not available to rigorously test a competition hypothesis. Density and size (% > 31 cm) of rainbow trout at RK 93 (above Sherars Falls) increased greatly from 1974 to a peak of approximately 1,000 fish[8]/km in 1983, then declined to about 560 fish/km in 1985 (ODFW 1985) and 400 fish/km in 1995 (Newton and Nelson 1995). At the sites above Sherars Falls, growth of fish in size classes larger than subyearling chinook attain appeared to be density dependent and was likely to be affected by the abundance of competitors, especially juvenile steelhead (Schroeder and Smith 1989). The diet of mountain whitefish (*Prosopium williamsonii*), which may be even more abundant than rainbow trout in some areas, overlaps considerably with that of rainbow trout, although differences in feeding areas may reduce the potential for competition (Schroeder and Smith 1989). The potential for competition with subyearling summer/fall chinook is greatest in June and July when yearling rainbow trout are the same size and might occupy the same habitats (Schroeder and Smith 1989). By June, most of the subyearling chinook have left the river, so their exposure to trout may be less than for salmon above the falls.

Juvenile steelhead and chinook have been observed using dissimilar habitats in some other streams (Chapman et al. 1994). The similarity in diets among the juvenile salmonids, their relatively high abundances, and some evidence of density-dependent growth all suggest that summer/fall chinook may have to compete with trout, particularly above Sherars Falls.

Trout prey on subyearling chinook in some streams (Chapman et al. 1994), although I know of no direct evidence for such predation in the Deschutes R. Newly emerged mountain whitefish and sculpins (*Cottus* spp.) were the only fish identified in the diet of Deschutes R. rainbow trout during a limited study in 1976 (Schroeder and Smith 1989). Unfortunately, the methods used to distinguish mountain whitefish fry from other salmonids (e.g., fall chinook fry) potentially in the diet were not described. Peak densities

[8] Includes only fish > 25.0 cm.

of large (≥31 cm) rainbow trout were estimated at 300+ per km at RK 93 and 500+ per km at RK 117 in 1982-83 (both sites above Sherars Falls; ODFW 1985). Schroeder and Smith (1989) hypothesize that growth of larger rainbow trout may be limited by low availability or vulnerability of larger prey (e.g., fish and crayfish). It seems unlikely that a relatively high density of large — possibly underfed — rainbow trout above Sherars Falls represents an advantageous situation for fingerling chinook, but I believe we do not have sufficient data to evaluate that suspicion.

There are certainly other salmon predators — aquatic, terrestrial, and avian — in the Deschutes R. (Newton 1973), but it appears we know extremely little about their impact on subyearling summer/fall chinook.

JUVENILE EMIGRATION

The migration of subyearling summer/fall chinook out of the Deschutes R. begins in May, when relatively small fish leave the lower river, and extends through at least July, as larger migrants depart from upstream areas (Fig. 27). Once out of the Deschutes R., these migrants must pass two dams and their reservoirs and through the 235 km of Columbia R. and estuary below Bonneville Dam before reaching the Pacific Ocean. Mortalities *en route* can be significant.

I examined this life stage for factors that may be limiting (i.e., depressing) long-term production, that may have contributed to the dramatic decline in run size after 1989, and/or that may help explain the recent downstream shift in spawning distribution in the Deschutes R.

H_1: The survival of migrating juveniles has been depressed by hydroelectric development on the mainstem Columbia R.

Turbine mortalities are estimated at about 10-30% per dam (NPPC 1986), and reservoir passage mortalities for subyearling chinook may be of similar magnitude[9]. These sources are likely to act independently of density; mortality rates of approximately 30-60% may be incurred by each cohort, large or small, as it passes through The Dalles Dam, Bonneville Pool, and Bonneville Dam. In a 1979 experiment with "fast-reared" fall chinook from Round Butte hatchery, juveniles transported and released below Bonneville Dam were recovered in higher proportions in estuary seining than were juveniles released below Pelton Reregulating Dam, although the difference was not statistically significant (Aho et al. 1979). Although subyearling chinook can rear and grow in mainstem reservoirs (Miller and Sims 1984; Rondorf et al. 1990), survival in the reservoirs relative to other environments (e.g., free-flowing tributary, estuary) is uncertain. Mortality rates in the former natural river are not known, but they were probably lower than under present conditions. Bonneville Dam has been taking its toll since 1938; The Dalles Dam since 1957.

Construction of upstream storage impoundments has enabled the hydroelectric system to greatly reduce the mainstem Columbia R. flows from May through July that formerly ushered subyearling chinook quickly to the estuary (Fig. 28, *following page*). Lower flows increase the time required for young chinook to pass through reservoirs (DeHart and Karr

[9] Beaty (1992) estimated total (dam + reservoir) passage mortality of 35-51% per dam/reservoir project in the lower Columbia R. based on relative recoveries (Dawley et al. 1986) of transported and untransported groups of (Ringold) hatchery fall chinook in the estuary in 1968 and 1969. Mortality due to predation alone has been estimated at 7-61% (depending on month) just in John Day Reservoir (Rieman et al. 1991).

1990), thereby increasing their exposure to predators.

Hydroelectric development has most likely affected the stock primarily by reducing long-term productivity and size of the overall run or its components.

H_2: The installation of turbine bypass systems has not substantially improved dam passage survival of Deschutes R. subyearling chinook at Bonneville Dam.

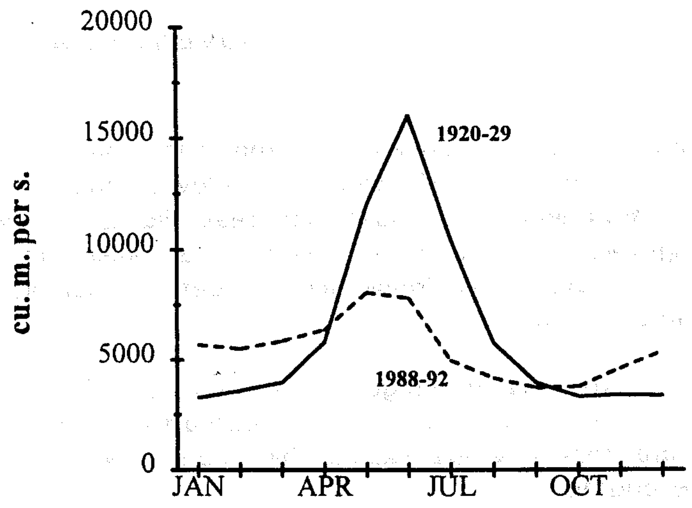


Figure 28. Pre- (1920-29) and post-hydro development (1988-92) mean monthly flow at The Dalles. Data from USGS station 14105700 and USACE (1988-92).

Turbine bypass systems use screens to divert juvenile salmonids out of turbine intakes and into alternative conduits to the tailrace. The percentage of juveniles (by species or race) diverted out of turbine intakes is the measure of fish guidance efficiency (FGE) of the screening system. A full set of screens was installed at Bonneville Powerhouse I in 1983 (Monk et al. 1995), the same year that FGE tests began at the newly completed Bonneville Powerhouse II (Gessel et al. 1990). Testing of diversion screens did not begin at The Dalles Dam until 1993 (Absolon et al. 1995), and a bypass system has not yet been installed there. Except for small amounts of spill in some years (e.g., FPC 1992) and operation of the ice and trash sluiceway as a bypass route, all juvenile Deschutes R. summer/fall chinook have had to pass The Dalles Dam via the turbines.

Under the best conditions (in spring), screens at Bonneville Dam generally guide fewer than half of the subyearling chinook out of the turbines, and summer (July) FGEs are often very poor. For example, late spring FGE for subyearling chinook at Bonneville Powerhouse I in 1988 and 1989 was a modest ~40% and declined by July to 11.4% (1988) and 4.4% (1989) (Gessel et al. 1989, 1990). FGEs of 44-64% have been measured for subyearling chinook at Powerhouse II in spring (Monk et al. 1995). Seasonal declines in FGE for subyearling chinook also have been noted at John Day and McNary dams (Brege et al. 1992). Even with spill to augment the low guidance of the juvenile bypass system (e.g., FPC 1992), most subyearling chinook pass through the turbines at Bonneville Dam.

The corollary is that later-migrating fish (e.g., Deschutes summer/fall chinook originating above Sherars Falls) are less likely to be guided out of turbines than earlier migrants (e.g., from below Sherars Falls), although unguided fish that pass through the turbines do not necessarily suffer higher mortalities than bypassed fish.

Bypass at Bonneville Dam may not confer a survival advantage to subyearling chinook relative to passing through the turbines. Test fish released into the bypass systems at Bonneville Powerhouse II and Powerhouse I have been recovered at rates similar to or lower than the rates for turbine-released groups (Ledgerwood et al. 1990, 1991, 1994; Gilbreath et al. 1993). Hydraulic conditions in the bypass system and predation by northern squawfish at and downstream of the bypass outfall may be responsible for the unexpectedly poor survival of bypassed subyearling chinook relative to turbine-passed fish (Ledgerwood et al. 1994).

The juvenile bypass systems at Bonneville Dam have been, at best, only moderately effective at diverting subyearling chinook away from turbines and apparently have not improved the chances for survival of fish that are diverted. In my opinion, the juvenile bypass systems probably have had a negligible, if any, effect on trends in run size of Deschutes R. summer/fall chinook since 1977.

H_3*: *Predation, particularly by northern squawfish, may be depressing survival of migrating summer/fall chinook in the Columbia R.

Predation rates on subyearling chinook in the Columbia R. can be high. For example, in the 1980s approximately 14% of the juvenile salmonids entering John Day Reservoir may have been consumed by predaceous fishes, with northern squawfish accounting for about 78% of the loss (Rieman et al. 1991). Predation rates increased through the summer from 7% in June to 61% in August (Rieman et al. 1991). Uremovich et al. (1980) estimated that northern squawfish consumed 11% of the juvenile salmonids that entered Bonneville Pool in 1980, with the majority of the loss occurring between mid-July and mid-August. In 1990, as many as 24,000 observable attacks by northern squawfish occurred in one 5-hr evening period (28 June) in one part of the forebay of Bonneville Powerhouse I (L. Hawkes, NMFS, unpubl. data). Feeding concentrations of northern squawfish were also common in the tailrace of The Dalles Dam (pers. observation). Subyearling Deschutes summer/fall chinook, especially those migrating later in the summer, have probably incurred high mortalities when passing through areas of intense predation near The Dalles and Bonneville dams.

It is not clear whether hydroelectric development has promoted an increase in the number of predators, but predator efficiency and predation rates probably have been greater in the highly altered environment. Kirn et al. (1986) documented a large increase in beach seine CPUE of northern squawfish in the Columbia R. estuary from about 1970 to 1982. On the other hand, the number of northern squawfish passing upstream over The Dalles Dam has not changed noticeably since the dam was completed in 1957. The count in 1990 (83,000) (D. Rawding, WDW, unpubl. data) was essentially the same as the mean for the 13-yr period after The Dalles Dam was completed (82,000, range 52,000-108,000)

(USACE 1969). Data regarding abundance of northern squawfish in the lower Columbia R. are neither comprehensive nor consistent. Summer flows are now lower (Fig. 28) and less turbid, so summer-migrating subyearling chinook are more exposed to predators. The tailraces of dams — where dead, injured, or disoriented juvenile salmonids exit the turbines, bypasses, and spillways — have long been recognized as areas of high predation (Thompson 1959; Buchanan et al. 1981; Rieman et al. 1991). Predation mortality to juvenile Deschutes R. summer/fall chinook probably increased after 1938, when Bonneville Dam was completed.

Juveniles from above Sherars Falls, because of their later migration, may incur higher predation mortalities than earlier migrants (e.g., from below the falls). A general increase through the summer in the apparent benefit of barge transportation of subyearling chinook from McNary Dam (Chapman et al. 1994) suggests that conditions for juvenile migration in the lower Columbia R. deteriorate as the summer progresses. One reason may be that higher water temperatures in July and August increase the metabolism and consumption rates of northern squawfish (Vigg and Burley 1991; Rieman et al. 1991). However, the in-reservoir survival of small juveniles that leave the lower Deschutes R. in May and early June may not be superior to that of later (but larger) migrants if the former are exposed to predation during an extensive reservoir rearing period.

Predator control fisheries, tested in 1990 and implemented full-scale in 1991, have probably ameliorated the predation rates. Over 100,000 predaceous-size northern squawfish reportedly were removed from Bonneville Pool between 1990 and 1994 (unweighted mean annual exploitation rate ≈ 6.4%); another 280,000 reportedly were removed in the same period below Bonneville Dam (unweighted mean annual exploitation rate ≈ 10.8%) (M. Zimmerman, ODFW, pers. comm. 8/95). Feeding concentrations of northern squawfish are no longer common near the dams.

Some feeding was observed at the mouth of the Deschutes R. in spring 1994 (J. McCormack, CRITFC, pers. comm.) and predator control fisheries were initiated there by a CTWS crew in 1996. This predator control gillnetting crew removed 225 predaceous-size northern squawfish from the mouth of the Deschutes R. through 12 May, 1996, with the third-highest year-to-date CPUE of the 13 sites fished (CRITFC, unpubl. data). Predation may take a significant toll of subyearling chinook migrating out of the Deschutes R., particularly in summer when water temperatures are higher.

The survival benefits, if any, from predator control efforts would be manifest in run sizes of Deschutes R. summer/fall chinook beginning in about 1993, when 3-yr-olds from the 1991 outmigration (the year control fisheries were fully implemented) returned. There was a rebound in adult run size in 1993 (Fig. 2), which may be coincidental.

Of course, other species also prey on juvenile salmonids in the Columbia R. Introduced warmwater predators — walleye (*Stizostedion vitreum*), smallmouth bass (*Micropterus dolomieui*), and channel catfish (*Ictalurus punctatus*) — consume juvenile salmonids (Rieman et al. 1991). Smallmouth bass have been frequently caught on smolt-like lures by

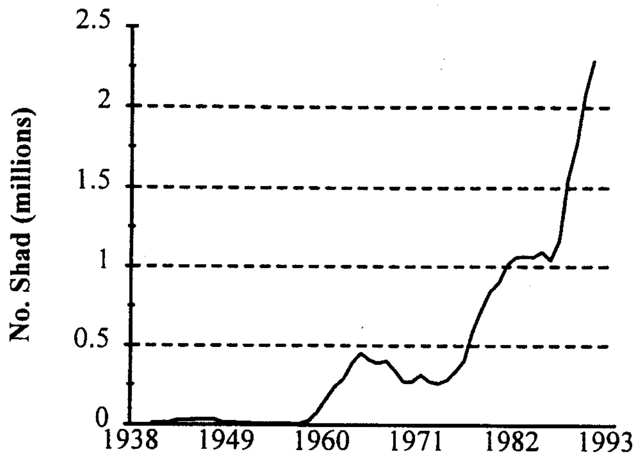


Figure 29. Counts (5-yr smoothed) of adult American shad at Bonneville Dam, 1938-93. (USACE 1993)

anglers for northern squawfish at The Dalles Dam (CRITFC, unpubl. data). Adult American shad (*Alosa sapidissima*), whose upstream migration during June and July coincides with the downstream migration of subyearling chinook, also reportedly prey on juvenile salmon (Wendler 1967; Hamman 1981; both cited by Chapman et al. 1991). Also an introduced species, American shad have increased tremendously in abundance in the Columbia R. recently (Fig. 29). Chapman et al. (1991) speculate that abundant juvenile shad in the late summer and fall may sustain and improve the over-winter survival of northern squawfish that prey upon juvenile salmonids in the spring. Avian predators are also active along the mainstem Columbia R., and their potential impact on smolt survival is beginning to attract renewed attention.

In summary, predation in the Columbia R. has probably limited to some degree the smolt-to-adult survival and run size of Deschutes R. summer/fall chinook, at least since completion of Bonneville Dam in 1938. Predation may be contributing to the downstream shift in spawning in the Deschutes R. by causing higher mortality in above-falls (later) migrants, assuming that spawners tend to return to the freshwater area in which they reared. I cannot determine whether predation contributed to the 1989-92 decline in run size. Predator control fisheries in recent years may or may not have contributed to the upswing since 1992 by improving juvenile passage survival.

***H_4:** The physical and biological capacity of the Columbia R. estuary may be limiting production of summer/fall chinook.*

Estuaries are important habitat for subyearling chinook (reviews by Fraser et al. 1982; Levy 1984; Simenstad and Wissmar 1984; Chapman et al. 1994), and the physical and biological properties of the Columbia R. estuary have been changed dramatically by human actions. Large-scale flow regulation, which began around 1969 (Sherwood et al. 1990, cited by Chapman et al. 1994), has altered the salinity intrusion and may be responsible for the currently high accretion (sedimentation) rate in the estuary, both of which affect the estuarine faunal community (Weitkamp 1994). Seasonal floods formerly expanded the estuary from May through July (Fig. 28), when the bulk of juvenile salmonids were migrating into and through it. In addition, approximately 39% of the estuary's tidal swamps, marshes, and flats — littoral feeding areas favored by subyearling chinook

(Bottom et al. 1984; Dawley et al. 1986) — were lost between 1870 and 1970 (Sherwood et al. 1990, cited by Chapman et al. 1994). Kaczynski and Palmisano (1992) estimate that the preferred foods of salmonids in the estuary have been reduced 83%. The physical capacity of the estuary has diminished while greater biological demands have been placed on it.

The most obvious and pertinent biological demands are made by hatchery-produced juvenile salmonids and introduced American shad. Hatchery releases of fall (subyearling) chinook in the Columbia R. approached 100 million by the early 1980s (Bottom et al. 1984). Kaczynski and Palmisano (1992) estimated that 101 million subyearlings were released in the Columbia R. Basin by hatcheries in 1990 and another 118 million wild subyearlings were produced (estimation methods were not described), although not all survived to reach the estuary. Historical production of wild (subyearling) fall chinook smolts in the basin may have been less than half of this 219 million fish total (Kaczynski and Palmisano 1992). Subyearling chinook spend more time in the estuary and use a greater variety of estuarine habitats than other age classes and species of juvenile salmonids (Bottom et al. 1984).

American shad may be competing more intensely with juvenile salmonids in the Columbia R. estuary since 1960, because their abundance has increased so dramatically (Fig. 29). Including areas below Bonneville Dam, the total shad run could exceed 4 million fish (Chapman et al. 1991). The abundance of juvenile American shad has not been estimated, but probably is in the hundreds of millions (Kaczynski and Palmisano 1992). Young-of-the-year are most common in the estuary from September through December, although there is a year-round resident population (Hamman 1981, cited by Chapman et al. 1991). During March through September, juvenile American shad are commonly associated with subyearling chinook in the estuary, and their diets significantly overlap (McCabe et al. 1983). Hamman (1981, cited by Chapman et al. 1991) speculated that the American shad population may have been approaching the estuary's carrying capacity in 1981, and the adult population passing Bonneville Dam has doubled since then (Fig. 29).

Consumption data support the hypothesis that, even in 1980, the estuary's present carrying capacity for subyearling chinook and their competitors was being approached. Consumption rates of subyearling chinook in the Columbia R. estuary have compared poorly to those measured in other estuaries (review by Bottom et al. 1984), although reasons other than forage limitations exist (e.g., smolts are actively migrating rather than feeding; Dawley et al. 1986).

To summarize, increasing biological demands on an estuary physically limited by land and water management practices may have been depressing survival of Deschutes R. summer/fall chinook since before the beginning of run-size monitoring in 1977. Declines in run size since then, except for the post-1992 upswing, coincide generally with the seemingly exponential increase in American shad abundance, although the relationship is not necessarily one of cause and effect.

OCEAN REARING

Juvenile summer/fall chinook mostly depart the estuary in summer and spend the following 1-5 yr (up to 80% of their life) in the N. Pacific Ocean. Based on recoveries of coded-wire-tags (1977-79 brood years) in ocean fisheries, Deschutes R. summer/fall chinook inhabit waters from Alaska to northern California. Nearly half of the recoveries were made off Washington and Oregon, with most of the remainder split between British Columbia and Alaska (Fig. 30, *following page*). Generally, fewer than 1 in 100 fish survive their ocean residency.

H_1 *: Conditions in the N. Pacific Ocean affect the survival and run size of Deschutes R. summer/fall chinook.*

This hypothesis is supported by three lines of circumstantial evidence:

1. A correlation between atmospheric/ocean physical conditions and lifetime survival (recruits per spawner, R/S) of Deschutes summer/fall chinook,
2. Associations between physical conditions and biological conditions important for salmon production, and
3. Widespread synchrony in run size among salmonid stocks that rear in the same ocean region.

Recruits per spawner (R/S) estimates for Deschutes summer/fall chinook (brood years 1977-89) are correlated ($r = 0.690$, $P = 0.009$) with a composite ocean index (COI) of upwelling and intensity of the Aleutian Low Pressure System (ALPS) (Fig. 31, *following page*). This means that variability in the COI explains approximately half the variability ($r^2 = 0.477$) observed in estimates of lifetime survival (i.e., R/S), a relatively high level given the probably low precision of run size estimates (the basis for R/S) and the number of freshwater factors potentially affecting survival. In general, the COI is the sum of standardized values for March-September upwelling off the Washington coast (T. Nickelson, ODFW, unpubl. data) and values for the Aleutian Low Pressure Index (Beamish and Bouillon 1993; and R. Beamish, CDFO, Nanaimo, BC, unpubl. data; see Appendix 3.6 for data and detailed methods). This correlation may not reflect a direct cause-effect relationship, although it is consistent with the expected biological effects of upwelling and a strong ALPS.

Upwelling, induced by northerly winds along the Pacific coast of N. America, fuels primary production by lifting deep nutrient-rich water into the euphotic zone (Hsieh et al. 1995). Coastal bathymetry, cross-shelf circulation, and the Columbia R. plume also influence the intermittent upwelling off the coast of Washington and Oregon (Pearcy 1992). Summer upwelling can be very influential during the first few weeks of a juvenile salmon's ocean life, a critical period when mortalities can be high. For example, the survival of coho

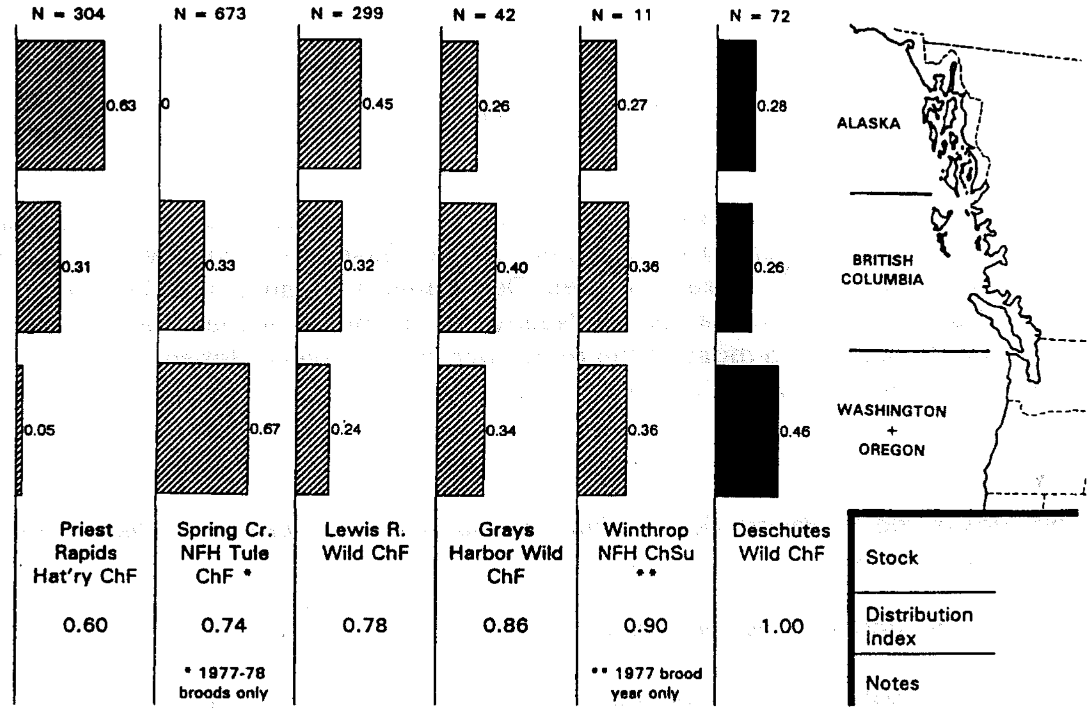


Figure 30. Ocean distribution of CWT recoveries for selected summer (ChSu) and fall (ChF) chinook stocks, 1977-79 brood years. Detailed methods in Appendix 3.6.

salmon in the Oregon Production Area, which spans from northern California to southern Washington, depends on upwelling (Scarnecchia 1981; Nickelson 1986). Mortality rates in this early ocean-period are generally highest for small species [e.g., pink salmon fry (*O. gorbuscha*)] and individuals (review in Pearcy 1992), so subyearling chinook may be affected more than the large yearling coho in this example. PSC (1994) conclude that variations in natural mortality for chinook occur primarily before ocean age 2 and that variations in natural mortalities are large relative to variations in fishery exploitation rates and maturation rates. A high correlation (r = 0.845, P = 0.0003) between jacks (in brood year + 2) per spawner (adult escapement in the brood year) and R/S of Deschutes R. summer/fall chinook likewise suggests that mortalities

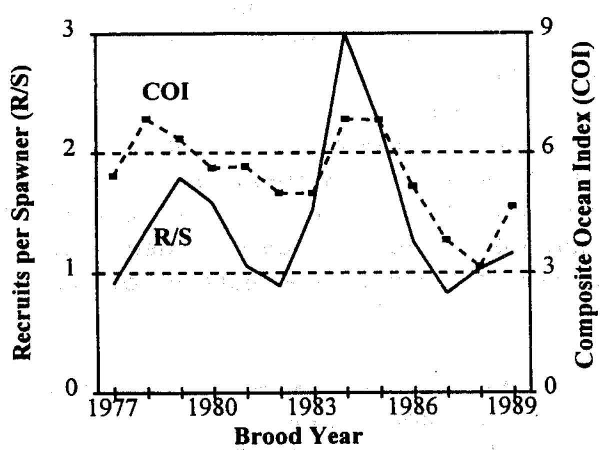


Figure 31. Recruits per spawner and composite ocean index, 1977-89 brood years. Methods in Appendix 3.7.

during the first year in the ocean (and/or during the period of freshwater residency) are very important in establishing the overall lifetime survival rate for a cohort. The mechanism(s) through which upwelling acts on juvenile salmon is not known, but Pearcy (1992) favors the hypothesis of predation, which is prey-size dependent (Parker 1971; Taylor and McPhail 1985), over food limitations to explain poor survival during years of low upwelling.

The ALPS, typically centered over the Aleutian Islands, dominates winter climatic and oceanographic processes in the NE Pacific Ocean (Beamish and Bouillon 1993). Strength of the ALPS is correlated with copepod production in the northern N. Pacific Ocean and is closely associated with trends in salmon production in that region (Beamish and Bouillon 1993). These relationships could be the result of upwelling in the center of the Aleutian Low and increased productivity in surface waters that are transported along the coast of N. America by horizontal divergence (Beamish and Bouillon 1993). A general increase in intensity of the ALPS from the late 1970s to the late 1980s, a decade when sea surface temperatures also increased (Tabata 1985; Pearcy 1992), coincided with an increased N. Pacific salmon catch, particularly in N. America (Beamish and Bouillon 1993). That trend is not apparent in the 1977-89 estimates of R/S for Deschutes R. summer/fall chinook (Fig. 31), however, perhaps because much of the stock appears to be distributed southward, off Oregon and Washington, beyond the ALPS's area of greatest influence.

Climatic and oceanographic processes may have different effects on Deschutes R. summer/fall chinook depending on whether members of the stock rear in southern or northern areas of their known ocean range (Fig. 30). In southern areas (i.e., California to British Columbia), seasonal production is highly dependent on nutrients provided by upwelling, whereas production cycles farther north, in the Gulf of Alaska, may be limited by light, temperature, and other factors (Hobson 1980; McLain 1984). Upwelling intensity decreases northward from California to Alaska (Bakun 1973, cited by Nickelson and Lichatowich 1984). Ocean warming has different effects in California and Alaska waters (McLain 1984). Hollowed et al. (1987) found significant negative pair-wise correlations between extreme year-class strengths of northerly and southerly species groups of marine fishes, which they attributed to the strong influence of environmental conditions on recruitment success. Strong year classes of herring (*Clupea harengus pallasii*) in southeast Alaska are associated with strong-to-moderate El Niños (when water temperatures are warm; Westpestad and Fried 1983) during the year of spawning, whereas trends for Vancouver Island stocks oppose those of the more northerly stocks (Pearcy 1983). Fluctuations in salmon catches between Alaska and Oregon/Washington are out of phase (Cooper and Johnson 1992), and there is an inverse relationship between Bristol Bay, AK, and British Columbia sockeye abundances (Peterman 1984).

I expect that Deschutes R. summer/fall chinook just entering the ocean and those rearing in the southern part of the range (i.e., Washington/Oregon) benefit from high upwelling but suffer from El Niños, whereas those rearing in the north (i.e., Gulf of Alaska) are more likely to benefit from intense ALPS and El Niños. Furthermore, if there is a genetic difference between stock components that spawn above or below Sherars Falls (e.g., those above have a stronger summer-run ancestry), then there could well be a difference in their ocean distributions. Since the 1970s, members of the stock that rear in the north have probably benefitted from the warmer winter sea surface temperatures (McLain 1984; Pearcy 1992) and the larger, more intense ALPSs (McLain 1984) that coincide with improved salmon production in Alaska (Eggers et al. 1984; Cooper and Johnson 1992; Rogers 1984).

El Niños — winter (and weakly spring) events generated by tropical atmospheric oscillations — cause high sea levels, warm sea surface temperatures, and low salinities off California-British Columbia every 2-7 yr (Mysak 1986; Hsieh et al. 1995). Such physical changes are associated with changes in fish distribution, abundance, survival, and condition (Pearcy 1983, 1992; Mysak 1986; Nickelson 1986; Holtby and Scrivener 1989).

The extraordinarily strong El Niño event in 1982-83 had a profound effect on the ocean environment off the coast of the Pacific Northwest and, probably, on runs of Deschutes R. summer/fall chinook. Sea levels were the highest ever recorded (Mysak 1986), a decade-long sea-surface warming trend reached a maximum, and warming in subsurface layers exceeded that of the 1957-58 El Niño event (Tabata 1985). Zooplankton communities were shifted and altered (Fulton and LaBrasseur 1985), as were fish assemblages (Pearcy 1992). In the Oregon Production Area, survival of juvenile and adult coho was extremely low in 1983 and still in 1984; poor growth depressed average size (lowest on record in 1983) and fecundity of the survivors (Pearcy 1992).

Low production (R/S) from the 1982 brood year (ocean entry in 1983) of Deschutes summer/fall chinook (Fig. 31) corresponds with this strong El Niño, and other low-production brood years in 1977 and 1987 correspond generally with moderate El Niños in 1976 and 1987 (Fig. 31; Hsieh et al. 1995). Similarly, low adult runs in 1979-1980, 1984-85, and 1990-91 (Fig. 2) correspond approximately with the 1976, 1983, and 1987 El Niños, respectively, given a lag to account for the predominance of age classes 3 and 4 in the adult runs (Appendix Table 3.2.1). Declines in production of stocks in other basins also coincide generally with El Niños or observed poor ocean conditions, such as occurred in the early 1980s and 1990s (Olsen and Richards 1994).

The synchrony of large runs of Deschutes R. summer/fall chinook in the late 1980s with large runs of many other stocks (e.g., Fig. 4) is further circumstantial evidence that something in the ocean, or another broad-scale factor, has a strong effect on survival. Indices of survival to age 2 were high for the 1984 brood year (1985 outmigration year) for Columbia R. upriver bright fall chinook, Lyons Ferry (Snake R.) fall chinook, and Columbia R. tule fall chinook (PSC 1992). Many hatchery and wild steelhead stocks in Oregon, Washington, and British Columbia had high survivals and return rates in the mid- to late-1980s, followed by declines to 1991 (Cooper and Johnson 1992), a pattern matching that for Deschutes R. summer/fall chinook (Fig. 4) and several other stocks of chinook (Olsen and Richards 1994). The exceptional survival of broods that entered the ocean just after the 1982-83 "El Niño of the Century" has been referred to as "the El Niño rebound effect," although there is no evidence of a direct cause-effect relationship (W. Pearcy, OSU, pers. comm. 8/14/95).

In conclusion, patterns in Deschutes R. summer/fall chinook run size since the late 1970s are similar to those of many other stocks of anadromous salmonids. I concur with Cooper and Johnson (1992) and Olsen and Richards (1994) that ocean conditions provide the most plausible explanation for the observed patterns. Pearcy (1992) likewise concludes that interannual covariation in the survival of year classes of stocks and species of fish suggest a link between large-scale oceanographic processes and variability in survival.

H_2: Ocean harvests depress run size but apparently contribute little to the observed variation in the stock's run size.

Direct estimates of ocean harvest of Deschutes R. summer/fall chinook are available only for 1977-80 brood years, a sample of which were coded-wire-tagged as juveniles (Jonasson and Lindsay, undated). These broods were exploited in the ocean at an aggregate rate of 0.283, based on catch and escapement estimates (not adjusted for adult equivalents[10]) by Jonasson and Lindsay (undated; their Table 5). Harvests of more recent brood years can be estimated indirectly through an indicator stock that is more consistently tagged and that has a similar ocean distribution. The Pacific Salmon Commission's Joint Chinook Technical Committee (CTC) monitors several potential indicator stocks (PSC 1994).

Lewis R. (WA) wild fall chinook may be the best CTC indicator stock available for the Deschutes R. summer/fall stock, based on similarity of ocean exploitation rates during the late 1970s and early 1980s, ocean distribution of CWT recoveries, quantity of recovery data available, and geographic proximity of natal areas. The 0.283 exploitation rate of 1977-80 brood years of Deschutes R. summer/fall stock is very similar to the 0.29 ocean exploitation rate estimated for Lewis R. wild fall chinook (all ages) in the CTC's base period (i.e., 1979-82 harvest years)(PSC 1994). The Lewis R. estimate is in terms of adult equivalents for all fishing-related mortalities, including incidental mortalities, in monitored ocean fisheries (PSC 1994). The 0.78 relative ocean Distribution Index (see methods in Appendix 3.6) for the Lewis R. stock is superior to the other four non-Deschutes R. stocks for which a reasonable number of recoveries is available (Fig. 30). Therefore, CTC estimates of ocean exploitation rates for the Lewis R. stock may be useful as indirect measures of the same rates for the Deschutes R. stock.

[10] The CTC estimates exploitation rates as ***adult equivalents***, which accounts for the proportion (< 1.0) of fish of a given age that would, in the absence of fishing, subsequently leave the ocean to spawn. Adult equivalent estimates are lower than conventional estimates, because some of the harvested fish otherwise would have succumbed to natural mortality before they matured.

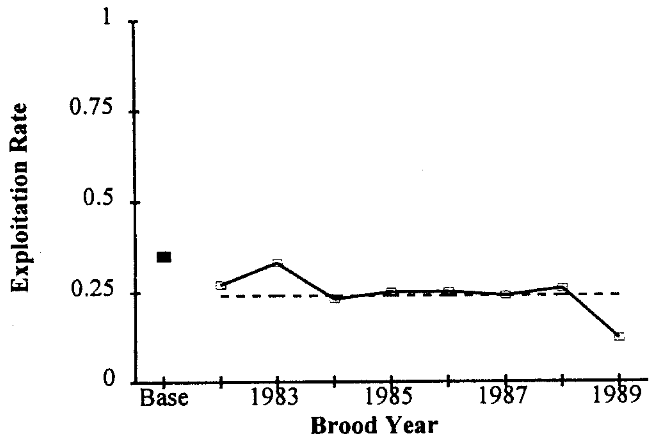


Figure 32. Ocean exploitation rates of Lewis R. wild fall chinook, 1982-89 brood years (PSC 1994). Base=1979-82 harvest years; horizontal line = 1982-89 mean.

Assuming that the Lewis R. stock is a suitable indicator, then ocean exploitation rates for the Deschutes R. stock have been relatively stable in recent years at approximately 24% (mean for 1982-89 brood years), which is 10 percentage points (29%) lower than for the 1979-82 base period prior to implementation of PSC harvest-reduction measures (Fig. 32; PSC 1994). The stability of the estimates and the fact that the few slight variations (upward for the 1983 brood year, downward for the 1989 brood year) do not correspond well with the large variations in R/S (Fig. 6) suggest that ocean harvests have contributed little, if any, to ***variability*** in run size. Variations in natural mortalities (primarily before ocean age 2) have been large relative to variations in fishery exploitation rates and maturation rates for many stocks (PSC 1994). However, Deschutes R. summer/fall chinook run sizes probably have been depressed approximately 25% by ocean fisheries. Combined ocean and terminal (i.e., total) exploitation rates will be considered later.

The reductions in ocean harvest anticipated from implementation of PSC harvest controls have not been realized for the group of CTC indicator stocks that includes Lewis R. wild fall chinook (PSC 1994). Reductions in brood survival mean that ceiling-regulated fisheries, which are limited to a maximum ***number*** of fish landed, are allowed to exploit the stocks at higher-than-expected rates, and reductions in brood exploitation rate associated with reported catch have been offset somewhat by increased incidental mortality (PSC 1994).

Authorized high seas driftnet fisheries for salmon and squid probably take relatively small numbers of Columbia R. salmon (Cooper and Johnson 1992, Chapman et al. 1994), although salmonid by-catches in illegal fisheries may have totaled 5.5 million fish during 1986-1990 (Cooper and Johnson 1992). I did not attempt to estimate what proportion of Deschutes R. summer/fall chinook may be included in this estimate.

H_3: Ocean survival rate is independent of abundance of Deschutes R. summer/fall chinook.

Although there is a growing body of evidence suggqesting that marine survival and growth of salmon in the N. Pacific, especially in some years, may be density dependent, the Deschutes R. stock is so relatively small that it has little, if any, effect on density. The important corollary of this hypothesis is that — for any set of ocean conditions (e.g., natural and fishing mortality) — adult run size of the Deschutes R. stock is directly proportional to the number of its juveniles entering the ocean: produce twice as many smolts and twice as many adults will return.

Density-dependent marine survival is still in question (Pearcy 1992). During years of poor upwelling in the Oregon Production Area, increased releases of hatchery coho salmon beyond 40-50 million smolts did not increase adult production (McGie 1984), which suggests density-compensatory survival. Reviewing this and other research, Pearcy (1992) concludes that there is a better case for density-dependent growth than density-dependent mortality, and cites — in particular — size reductions in Japanese chum salmon (*O. keta*) concurrent with large increases in production. Along the Pacific coast of N. America the numbers of hatchery-released salmon increased three-fold from the mid-1970s (~0.5 billion) to 1990 (~1.7 billion, 0.6 billion Alaska pink salmon alone), for a total of approximately 2 billion hatchery juveniles (in addition to wild fish) throughout the N. Pacific (Cooper and Johnson 1992). Cooper and Johnson (1992) speculate that the N. Pacific Ocean may be reaching its carrying capacity for salmonids, although Pearcy (1992) concludes that the effects of ocean conditions appear to predominate over density-dependent effects. Chapman et al. (1994) suggest that — because salmon may clump in some areas of the ocean rather than distributing uniformly — managers "may best assume ocean density interactions rather than the contrary" (p. 137). Any downturn in ocean conditions or increase in salmonid abundance is more likely to reduce survival in an ocean environment that is already at or near saturation.

Regardless, the number of Deschutes R. wild summer/fall chinook smolts (perhaps one million) is very small (by a factor of about 0.0005) in comparison to even the number of hatchery fish released into the ocean, so abundance of the stock has very little effect on ocean density and, consequently, on any density-dependent processes that may be operative. The benefit (in returning adults) of any increase in smolt production effectively will not be diminished by a density-limited ocean environment.

Chapman et al. (1994) echo Lawson (1993) to summarize the implications of variable and unpredictable ocean conditions for salmon survival:

> *In light of the inability of man to manipulate conditions in the sea, other than densities of some fish components of the ecosystem, one must consider it important to husband fresh-water habitat to provide more elasticity in naturally-spawning salmon populations.* (p. 140)

In short, we must continually manage freshwater habitat of Deschutes R. summer/fall chinook to provide the safety margin needed for population survival when ocean conditions become adverse.

ADULT MIGRATION

Maturing summer/fall chinook must survive predation by marine mammals, passage through two dams and reservoirs, and Columbia R. mainstem fisheries *en route* to their Deschutes R. spawning grounds.

H_1 *: Predation by marine mammals probably has little impact on adult summer/fall chinook entering the Columbia R.*

There is a paucity of data on which to base conclusions regarding the severity of marine mammal predation on adult salmonids. In general, the most serious and perhaps best-documented cases occur in the lower reaches of rivers, in estuaries, and in nearshore areas, particularly when salmon are already caught on commercial or sport fishing gear (Fiscus 1980). Six marine mammal species in the eastern North Pacific are known or suspected predators on free-swimming adult salmonids, although Fiscus (1980) asserts that there is little evidence of major predation except in some local situations (e.g., see Fiscus 1980; Cooper and Johnson 1992).

The Columbia R. estuary in spring may present one of those situations. California sea lions (*Zalophus californianus*) range upstream as far as Bonneville Dam (RK 235), although they are probably less of a predation threat than are harbor seals (*Phoca vitulina*). Up to 6,000 harbor seals may inhabit the lower Columbia R. during seasons of peak abundance (Park 1993). The size of the Columbia R. harbor seal herd has approximately doubled since 1978 and is growing at about 6% per year (Park 1993). In some years, the incidence of seal bites or other marine mammal injuries on spring chinook trapped and inspected at Bonneville and Lower Granite dams can exceed 20% (Table 4, *following page*), which suggests that unobserved mortality from successful marine mammal attacks and subsequent delayed mortality of injured fish may be substantial (Park 1993).

However, marine mammal injuries are less common in summer-run chinook than in spring-run chinook (Park 1993), and the single estimate of injury incidence available for fall-run fish is lower still (Table 4, *following page*). Also, injured fish may not suffer a meaningfully higher incidence of delayed mortality than non-injured fish, based on recoveries of fall chinook that had been marked during fall-back studies at McNary Dam (Wagner and Hillson 1993). Chapman et al. (1994, p. 166) conclude that "*marine mammal wounding is a trivial cause of delayed mortality in summer/fall chinook of mid-Columbia origin.*" Although not necessarily trivial, the immediate and delayed mortalities caused by marine mammal predation on Deschutes R. summer/fall chinook probably is not great and has most likely depressed run size only slightly over time.

Table 4. Incidence of marine mammal injury in spring and summer chinook trapped at mainstem Columbia R. and Snake R. dams, 1990-93.

		Incidence of Marine Mammal Injury in Chinook Runs						
		Spring		Summer		Fall		
Dam	Return Year	N	%	N	%	N	%	Source
Lower Granite	1990	1700	(Both runs)		19.2			Park 1993
	1991	?	20.9	?	9.4			
	1992	?	17.4	?	7.6			
Bonneville	1992	547	14.3	281	3.9			Fryer and Schwartzberg 1993, 1994
	1993	679	23.0	399	9.3			
McNary	1991					181	0.6	Wagner and Hillson 1993

H_2: Upstream passage at Bonneville and The Dalles dams and through their reservoirs, probably has a small and relatively constant effect on the survival of migrating adults.

Estimates of chinook mortality associated with upstream passage vary from 4% to 29% per dam/reservoir project, with the highest rates occurring during high spring discharges (Bjornn and Peery 1992). For example, mortalities of 13% (Weiss 1970, cited by NPPC 1986) and 22% (Young et al. 1978, cited by Chapman et al. 1994) have been estimated for combined spring and summer chinook at Bonneville Dam. Park (1993) hypothesizes that some of the high spring passage mortalities may be the delayed results of marine mammal injuries. Most estimates are based on interdam "losses" — differences in dam counts that cannot be accounted for by harvest and tributary escapement between the dams — which may not be very precise given the many inherent sources of error (Bjornn and Peery 1992). Still, the number of estimates in the 4-5% range, especially for summer and fall runs (Table 5, *following page*) is surprisingly consistent. Assuming a mortality rate of 5% per project for summer/fall chinook (4-5% recommended by Chapman et al. 1994) is probably reasonable in the absence of dam- and stock-specific data. A 10% mortality can then be assumed for Deschutes R. fish passing Bonneville and The Dalles dams.

Dam passage mortality of adults has probably contributed little, if any, to the variability observed in Deschutes R. summer/fall chinook run size since monitoring began in 1977. Bonneville Dam was completed in 1938; The Dalles Dam was completed in 1957. The only significant change in the upstream fish passage facilities at these dams since 1977 has been the construction of a second powerhouse and additional fishways at Bonneville Dam, which was completed in 1982. Flows during the summer and fall runs generally are not high enough to cause the flow-dependent passage difficulties that can occur during the high and inter-annually variable flows of spring. The assumed 10% total mortality for passage at both Bonneville and The Dalles dams is probably relatively constant across years.

Table 5. Estimates of passage mortality rates (per dam/reservoir project) of adult chinook at mainstem Columbia and Snake river dams. All estimates, except for one noted, were calculated based on interdam "losses."

Chinook Run	Dam(s)[a]	% Mortality (per project)	Year	Source	Notes
Spring/ Summer	BO	13	1970	Weiss 1970[b]	
	TD	12-25	1970	Weiss 1970[b]	
	BO	22	1976	Young et al. 1978[c]	Corrected for fallback; highest losses with high flows.
	JD, MC, PR/IH	4.6	?	Chapman et al. 1991[c]	Interdam loss varied directly with flow in 1970's, not in 1980s.
	IH →LG	3.4	1991	Bjornn et al. 1992	Radio-tracking method; 87% survival over 4 dams.
Summer	BO	4	1977	Young et al. 1978[c]	Corrected for fallback; highest losses with high flows.
	BO →IH	5	?	Dauble and Mueller 1993[c]	
	BO →LG	4.0	1986-94	JCRMS 1995	
Fall	BO →MC	7.2	1986-91	Dauble and Mueller 1993[c]	Interdam spawning may have contributed to "loss."
	BO →MC	4.1	1986-94	TAC 1995	

[a] BO = Bonneville
IH = Ice Harbor
JD = John Day
LG = Lower Granite
MC = McNary
PR = Priest Rapids

[b] Cited by NPPC 1986.

[c] Cited by Chapman et al. 1994.

H_3: Columbia R. fisheries probably have had a moderate and relatively constant effect on the survival of adult Deschutes R. summer/fall chinook.

Aggregate harvest rates of summer/fall chinook in Columbia R. mainstem fisheries below the mouth of the Deschutes R. have varied between approximately 0.18 and 0.40 since 1977 (Fig. 33; data and detailed methods in Appendix 3.8). These estimated rates may be higher than actual; a Columbia R. harvest rate of 10% was estimated from CWT recoveries of 1977-79 broods (Jonasson and Lindsay, undated).

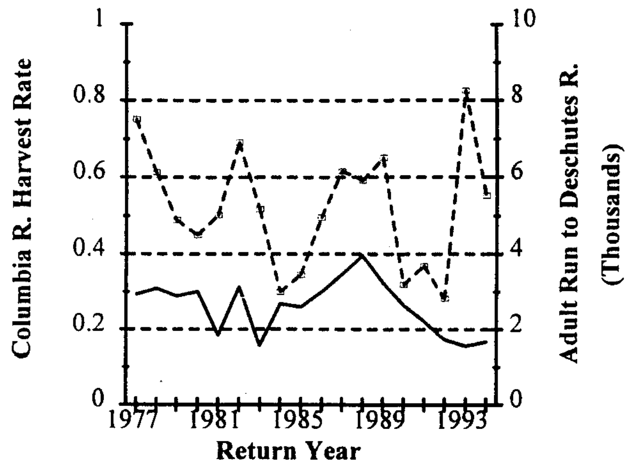


Figure 33. Estimated harvest rates in Columbia R. mainstem fisheries (solid line) and adult run sizes to the Deschutes R. (dashed line), 1977-94.

The fisheries have probably dampened the variability in run size to some degree, because high harvest rates (e.g., in 1987-89) often correspond with high run sizes. Although mainstem fisheries have reduced escapement of Deschutes R. summer/fall chinook, the fisheries otherwise do not appear to be responsible for the variability observed in estimates of run size into the Deschutes R.

Mainstem harvest rates are much higher during the fall run than during the summer run (Appendix Table 3.8.1), so the weaker summer component in the Deschutes R. is harvested at lower rates than the composite rates shown here (Fig. 33).

SYNTHESIS

Changes in Run Size

What has caused the changes in run size of Deschutes R. summer/fall chinook, particularly the near-loss of the component spawning above Sherars Falls? In this section I distill the information presented earlier and more directly address the questions that motivated this study. I sometimes range beyond present knowledge to speculate about past and future conditions.

It is useful to consider two types of change — trend and variability — which differ primarily in temporal scale. ***Trend*** describes the general direction of change throughout the time series, in our case from about 1977, when run size estimates began, or from the 1950s, when other monitoring began, to the present. I use ***variability*** to describe year-to-year changes or deviations from the trend; repeating patterns of variability in run size could be called cycles. The stock's long-term health is reflected in the run size's trend; the effects of environmental factors and management practices are most apparent in run size variability. The trend and variability in run size may be caused by completely different factors.

Much of the variability in run size of this stock since 1977 appears to be driven by marine factors. This conclusion is based more on the similar run-size patterns among species and stocks than on the correlation between a composite index of ocean conditions and recruits-per-spawner of the Deschutes R. stock. Broad-scale environmental factors other than (but perhaps related to) marine conditions may also be involved. Error (e.g., from inaccurate redd counts) also contributes, to an unknown degree, to variability in run size estimates.

This variability appears to be superimposed on a generally downward trend in run size, at least in the relatively short, 18-yr series of run-size estimates. The decline may have begun shortly after the large runs of the late 1960s, although data prior to 1977 are not adequate for firm conclusions. I suspect that even by the 1960s the size of the run (particularly the summer component) had already been reduced significantly from historical, pre-development levels. Some indices (e.g., Pelton trap counts, redd densities; Fig. 7) suggest that above-falls escapements prior to the large runs of the late 1960s, were as low as at present. Variable runs and a declining trend can be expected when cycles in marine survival are combined with the effects of long-term habitat degradation (Lawson 1993), although factors other than habitat degradation may be involved. Salmon habitat in the Deschutes R. subbasin and throughout the Columbia R. Basin has been continually lost (e.g., due to blockage by dams) and degraded (e.g., through water and land management practices) since Euroamerican settlement began (NPPC 1986; Moore et al. 1995; Nehlsen 1995).

Estimates of historically high escapements and runs in recent years may not be accurate. Redd counts in Index and Random survey areas — probably the most complete and continuous index of adult escapement in the last 20+ yr — strongly suggest that the run is not nearly as robust as estimates indicate.

I suspect that the generally downward trend is caused by factors that were already influential before 1977, although the nature of those factors is far from clear. I found no new (since 1977) inriver events or activities that could readily explain the latter-day decline. Outside the Deschutes R. subbasin, however, the explosive increase in American shad using the limited carrying capacity of the Columbia R. estuary stands out as a significant new event that may affect survival of summer/fall chinook. Ocean and mainstem Columbia R. fisheries and mortalities related to juvenile and adult passage at Bonneville and The Dalles dams have changed little in the last two decades (Fig. 34), so they apparently have not contributed to any new declines in lifetime survival since 1977. Neither have these sources of mortality been meaningfully curtailed as the run has declined. The decline may well be the continued expression of several small conditions that cumulatively depress stock fitness.

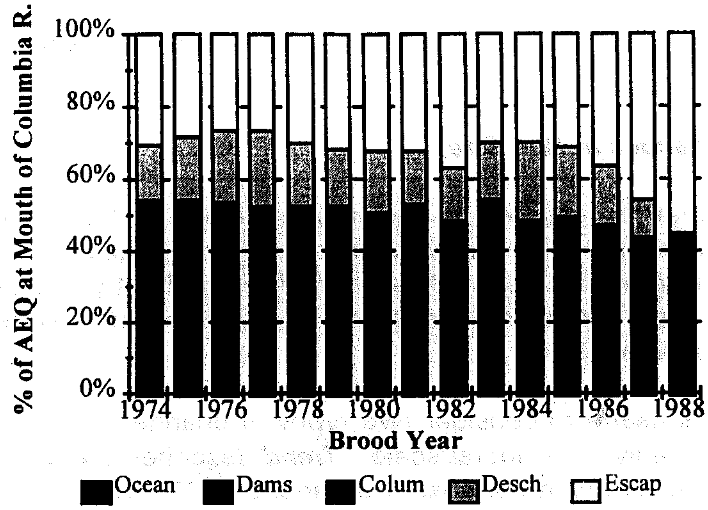


Figure 34. Harvest in **Ocean**, **Columbia** R., and **Deschutes** R. fisheries; mortality at **Dams**; and **Escapement** (Appendix 3.9).

Whichever factors are responsible for the general decline appear to be operating particularly on the above-falls component of the run; redd counts suggest that overall spawning activity below the falls has diminished little, if at all, since 1977 (Fig. 3).

Above-falls Component

The above-falls component of the run is faring worse than the component spawning below Sherars Falls. Trends in redd counts suggest that all of the decline in run size documented since 1977 may be attributed to losses above Sherars Falls, as noted by Anonymous (undated). This could be the result of:

1. Lower lifetime survival of the above-falls component, assuming relatively faithful homing to natal reaches (i.e., above- or below-falls);
2. More above-falls fish spawning in the below-falls reach relative to the opposite condition; and/or
3. More out-of-subbasin strays spawning below the falls than above.

We have no data to evaluate the absolute or relative contributions of these three alternatives. Nor do we know whether the below-falls component is self-sustaining, given that its redd counts show no trend and may be augmented by straying (items 2 and 3, above). Although data are lacking for a complete picture, I identified a few of the probably myriad factors that may be contributing — chronically, in small but cumulatively meaningfully degrees — to the decline in the above-falls component:

· Truncated (by impassable dams) spawning/rearing area above the falls and displacement of upstream (summer-run) fish into habitat of uncertain quality below Pelton Reregulating Dam. Below this dam, gravel and large woody debris are no longer available from upstream. Gravel quality has probably declined with diminished spawning use in recent years and perhaps with the lack of major flood events, like that of 1964.

· Difficult adult passage at Sherars Falls because of reduced flows and a (presently) substandard fishway. Trap operation may also impede passage through the fishway.

· Harvesting the above-falls component at higher rates in the Sherars Falls fisheries than the below-falls component.

· Possibly greater habitat degradation above the falls due to recreation and land-use activities.

· Higher spring and summer temperatures in the lower river may contribute to higher mortality in juveniles from above the falls, which migrate later than those below. Summer-migrating adults may also encounter unfavorably high temperatures in the lower Deschutes R.

· Higher exposure of above-falls juveniles to infectious units of *C. shasta*, if those units still emanate from reservoirs of the Pelton/Round Butte Project.

· Potentially greater competition for, and/or predation on, above-falls juveniles by trout and/or other species.

Spawning and/or rearing conditions immediately below Pelton Reregulating Dam may not be, and historically may not have been, adequate to sustain long-term production, given levels of other mortality throughout the life cycle. We may have mistakenly inferred, based on sometimes high spawning density and apparently high habitat quality (Huntington 1985), that production in this reach confers some advantages over production elsewhere (e.g., below Sherars Falls). Chinook were spawning on at least one island just below the eventual site of Pelton Reregulating Dam in the early 1950s (B. Smith, long-time resident, pers. comm., 2/1/96), but I found no written or oral evidence of the same high spawning densities as those observed in this area in the 1970s and early 1980s. A belief that this area is now greatly underseeded and far below its production potential has been fostered by some periods of high spawning densities and gravel quality.

However, historically high spawning densities below Pelton Reregulating Dam may be partially an artifact of the dam and the effectiveness (or lack thereof) of its adult fish passage facilities. Gunsolus and Eicher (1962) concluded that the collection system for upstream migrants at the Pelton Project *"functioned satisfactorily, and adult fish readily entered the Buckley trap"* (p. 127). However, the appraisers did not define their standard for satisfactory functioning nor report their methods for measuring readiness or delay in entry. Modern methods for gauging adult fish passage success (i.e., radio-telemetry) were not available then. Spawning activity often increases below fish weirs and traps (Hevlin and Rainey 1993), presumably because some migrants refuse to enter the traps. A generally inverse relationship between counts of adults trapped at Pelton Reregulating Dam and redd counts in survey areas above the falls (Fig. 7) also suggest that spawning densities are higher when trap entry is lower. Many of the spawners in the reach below Pelton Reregulating Dam in the late 1950s may have been summer-run and other chinook produced in, and destined for, the Metolius R. or other production areas above the dam sites.

High gravel quality in the reach below Pelton Reregulating Dam (Aney et al. 1967; Huntington 1985) was probably at least partially a result of the intense spawning activity there every year. Huntington (1985) hypothesized that this relationship may exist. Therefore, high gravel quality does not necessarily indicate that the area is or was capable of supporting a productive, self-sustaining "population."

Gravel quality in this reach has declined since 1960 (Huntington 1985; J. Griggs, CTWS, pers. comm.), probably due to lack of gravel recruitment and diminished spawning activity. This decline may represent self-reinforcing, degenerative conditions for spawning and/or egg-to-fry survival.

Many other conditions may be depressing the lifetime survival of fish spawned just below the dam (see list above). Among the most noteworthy is the possibility of a "thermal trap," the idea that fingerling chinook growing slowly in the cool waters below the dam encounter hostile conditions in the lower river and mainstem Columbia R. if they outmigrate as subyearlings in summer. Alternatively, slower-growing individuals in this reach may not migrate their first summer (i.e., they adopt a yearling life history), because development rate (e.g., smoltification, maturity) is a function of growth rate (Alm 1959; Nordeng 1983; Thorpe 1986; Beaty 1992). The quantity and quality of summer rearing habitat (e.g., cool water, adequate food production) and over-wintering habitat (e.g., velocity refuges) available to these nonmigrants is not known, but may be limited. I speculate that mainstem reaches from about Sherars Falls downstream favor a subyearling life-history type (typical of fall chinook) and that ancestral production areas for spring and summer chinook in the Metolius R. favor a yearling life-history type (typical of spring chinook), mostly because of temperature regimes. Conditions encountered by fish produced immediately below Pelton Reregulating Dam may not favor either type.

Redd count trends are also germane to our consideration of the production potential of the reach between Sherars Falls and the dams. The distinct difference in redd count trends above the falls (declining rapidly) and below the falls (little change) over the last 22 yr strongly suggest that conditions encountered by the above-falls component are unfavorable.

To summarize, the above-falls component of the run may be failing because it is confined to environments and exposed to conditions that are not, and perhaps rarely have been, adequate for the "population" to sustain itself, given levels of other mortality during its life cycle.

The above-falls component may die out soon unless strong measures are taken (see Recommendations, following). An upswing in ocean conditions may allow marine survival rates that will occasionally (e.g., on a 5-yr cycle) produce a temporary small-to-modest increase in escapement above the falls, but that increase will probably not be sufficient to support fisheries at Sherars Falls or to reverse the downward spiral in abundance. Likewise, the 1996 flood may reestablish, at least temporarily, conditions that once again favor production of summer/fall chinook above the falls.

I believe that the future of the above-falls run and the Sherars Falls fisheries depend on preserving and restoring the summer run, particularly in its ancestral natural production areas above the dams. The existing, primarily fall, stock obviously has not been sufficiently productive in its environment to sustain itself and support the inriver fisheries in recent years.

Health of the summer/fall stock is of some national and international importance. Summer chinook in the Deschutes R. could be candidates for protection under the Endangered Species Act (ESA), although it may be too late — or at least very difficult — to identify a distinct summer segment of the population. Careful examination of genetic and life-history traits of early- and late-running fish and of above-falls and below-falls fish probably would be necessary for this purpose. If Deschutes R. summer/fall chinook were listed, federal control under the ESA could decrease the effectiveness of local management and constrain recovery options.

The aggregate Deschutes R. (summer/)fall stock — which ODFW considers a healthy natural population (McIsaac 1995) — could play a role in restoring closely related stocks that are listed under the ESA. However, there is some uncertainty about which other stocks it is most closely related to (Table 6, *following page*). The Deschutes R. population could be a donor for restoring endangered Snake R. fall chinook and/or for reintroducing fall chinook into the John Day, Umatilla, and Walla Walla rivers.

On an international level, the Joint Chinook Technical Committee (CTC) uses Deschutes R. summer/fall chinook as an escapement indicator stock for monitoring progress in (1) halting escapement declines and (2) attaining escapement goals by 1998 under the US/Canada Pacific Salmon Treaty (PSC 1996). The CTC — using the classification system of Columbia R. harvest managers — considers the Deschutes R. stock as upriver bright fall chinook, which also includes Priest Rapids Hatchery and Hanford Reach natural stocks. However, because specific escapement goals have not been established for the Deschutes R. stock, the CTC does not evaluate the rebuilding status of this stock as it does for most other escapement indicator stocks. Some funds for implementing the US/Canada Pacific

Table 6. Classifications of Deschutes R. (summer/)fall chinook with related populations. ODFW = Oregon Department of Fish and Wildlife; WDFW = Washington Department of Fish and Wildlife; NMFS = National Marine Fisheries Service. ChSu = summer chinook; ChF = fall chinook.

Organization	Population Group	Closely Related Populations	Basis of Relationship	Source
ODFW	***Genetic Conservation Group:*** Isolated. (Does not cluster closely with any of the other Oregon populations studied.)	Yakima R. ChF[a] Snake R. ChF[a] *possibly, extirpated ChF populations in*: John Day R. Umatilla R. Walla Walla R.	Primarily allozyme analyses, secondarily life histories and meristics.	Kostow 1995
WDFW	***Major Ancestral Lineage:*** Upper Columbia R. ChSu and ChF, Snake R. ChF, mid- and lower-Columbia R. chinook. ***Genetic Conservation Management Unit:*** (maybe) Mid-Columbia and Snake ChF.	Marion Drain ChF (Yakima R.) Snake R. ChF (Lyons Ferry Hatchery)	Genetic differences (enzyme electrophoresis), geographic distribution, life histories.	Marshall et al. 1995
NMFS	***Evolutionarily Significant Unit:*** (potential) Lwr Columbia R. bright ChF.	Lewis R. ChF Sandy R. ChF	?	Bishop 1995

[a] Based on WDFW analyses and conclusions.

Salmon Treaty are used to conduct the Sherars Falls trapping, tag recovery in spawning ground surveys, and escapement estimation as part of the Pacific Salmon Commission's research program to develop escapement estimation techniques (PSC 1992). The diminished run above Sherars Falls reduces the precision of escapement estimates for Deschutes R. summer/fall chinook and makes the stock even less useful as an escapement indicator.

RECOMMENDATIONS

What is the Goal?

Recommendations, for any purpose, require an explicit or implicit goal: a condition desired for some future time. A realistic goal will be achievable at reasonable financial and social costs, with ***reasonable*** defined by the parties that must weigh the opportunity costs. For example, which cultural cost is more reasonable to members of the CTWS: living without the subsistence harvest at Sherars Falls that may be provided by better adult fish passage facilities at the falls, or altering the bedrock at Sherars Falls to construct a new fishway?

Aside from general escapement and harvest goals, I am not aware of management goals for the Deschutes R. summer/fall stock. ***Restoration*** is a common but nebulous objective, requiring that some *past* abundance level (or fraction thereof) be identified as the target. Unfortunately, we typically have little knowledge of relevant historical conditions, such as:

- Annual harvests at Sherars Falls before Euroamerican settlement;
- Average summer runs to the Deschutes R. in 1860, before wanton mainstem harvesting began;
- Potential run sizes above the Pelton/Round Butte project site in the early 1950s in the absence of both over-fishing and wholesale water withdrawals for irrigation; or even
- Run size above Sherars Falls in the relatively recent boom(?) year of 1968.

Also, a restoration — or historical — orientation usually does not acknowledge that human activities (and probably climatic conditions) will continue to change and to influence the productive potential of the stock. An alternative orientation is to consider what may be possible given present and likely future conditions. For example, is it really relevant whether summer chinook formerly spawned in the Metolius R. if they could do so now?

My first recommendation, then, is that managers formulate goals for the stock, goals that consider the summer component, the above-falls component, and the fisheries at Sherars Falls. My second recommendation is to not accept existing escapement and run-size estimates at face value; high estimates for recent years are particularly suspect. Lacking definitive goals at present, I have organized the following recommendations according to two alternative, and arbitrary, management goals. There is little common ground between the two objectives; hence, managers would face an either/or decision if they wished to adopt any of these recommendations.

The first alternative goal is to preserve and restore the summer run, the above-falls component, and meaningful Sherars Falls fisheries. These three things appear to be interdependent, perhaps integrally so. By ***restore***, I mean to establish runs of sufficient abundance to support, at modest (e.g., 20-30%) exploitation rates, inriver harvests comparable to those of the 1980s (i.e., 1000-2000 adults). Recommendations toward this goal are broad and relatively radical, reflecting my belief that the goal will be difficult to achieve. I believe each recommendation contributes in some unmeasurable degree to the cause, but there is no assurance that even implementation of all recommendations will fully succeed. Such are the risks inherent in resource management. Decisions not to implement one or more recommendations will reduce the probability that there will be a summer run, an above-falls component, and fisheries at Sherars Falls. Resource managers must decide whether this goal is worth the cost.

The second alternative goal is simply to manage whatever is left with the limited resources presently available: the status quo. Recommendations toward this goal are more specific and easier to achieve, including even a relaxation of some management practices. Likely results of this goal include complete loss of the summer run, continuing decline in the above-falls component with occasional short-lived rebounds, continuation of a variable and modest below-falls run, and irregular and small fisheries — if any — at Sherars Falls.

Alternative Goal I: Restoration

Considerations

These recommendations reflect that time is critical. I favor management actions that produce immediate benefits; maintaining even remnants of the summer and above-falls components preserves future options and reduces the likelihood that more radical human intervention ultimately will be required. Further research will certainly be useful, but it will not substitute for management action. The research plan originally proposed (Appendix 1) is not satisfactory because it is predicated on too-liberal appraisals of the time and funding available. Likewise, actions with delayed results (e.g., restoring riparian vegetation) are necessary, but cannot sustain these components through the immediate crisis.

In these recommendations I also distinguish passive from active management actions. Passive actions — which may include riparian restoration, improving passage conditions at Sherars Falls, and improving the quality of spawning gravel below Pelton Reregulating Dam — promote improved survival of fish that volitionally use those habitats or facilities. Alternatively, active options intervene in the life cycle of the fish to substantially change their distribution and/or (presumably) increase their survival.

At this juncture, passive actions alone may not be sufficient to sustain — let alone restore the strength of — the summer- or above-falls components. For example, if adult and juvenile passage were restored to and from the Metolius R. (passive actions), it is not likely that a summer chinook run could be re-established there without interim supplementation, an active management measure. As a less extreme example, a rebuilt and improved fishway at Sherars Falls and spawning gravel management below Pelton Reregulating Dam does not ensure that meaningful numbers of spawners will use the fishway and naturally recolonize the spawning area. In this case, trapping adults downstream and transporting them to the reconditioned spawning areas (or similar active measures) may be necessary to promote seeding and restoration of the above-falls run. I am aware that managers have not supported supplementation and other active measures for managing the summer/fall chinook run in the past.

Recommendations

1. Reduce harvest rates in ocean and mainstem Columbia R. fisheries and dam passage mortality of juveniles and adults.
2. Restore passage access to and from reaches above the dams for adult and juvenile migrants and reintroduce summer-run chinook (adults or their artificially propagated progeny) trapped at Pelton trap or, alternatively, Sherars Falls trap. This assumes that — dam and reservoir passage conditions aside — freshwater habitat in ancestral natural production areas above the dams is superior for survival of summer chinook than habitat in the mainstem reach below Pelton Reregulating Dam.
3. Manage for higher summer and fall stream flow to restore side-channel passage routes around Sherars Falls and/or install a more effective fishway at the falls.
4. Manage spawning gravels below Pelton Reregulating Dam according to the recommendations of Huntington (1985), ODFW and CTWS (1990), and LDRMP (1993), and add large woody debris. Supplement natural seeding in this area with summer-run adults trapped ***below*** Sherars Falls or their artificially propagated progeny. I recommend trapping brood stock below the falls because adults passing Sherars Falls already have a high probability of spawning naturally in the target area.
5. Manage (probably curtail) recreation and other river- and land-use activities to improve the adult migration, spawning, incubation, and juvenile rearing environment above the falls. Continue to restore riparian vegetation throughout the lower 161 RK to improve habitat for juveniles and to abate summer high temperatures; include tributaries when resources are available. It may also be necessary to supplement natural seeding in the above-falls reach in the short term.
6. Particularly in the above-falls reach, manage fish assemblages rather than individual species. For example, decisions regarding trout and steelhead management should be made with consideration for potential effects on the above-falls component of the summer/fall chinook run.
7. Manage the stock for a minimum escapement of approximately 500 adult **summer**-run chinook above Sherars Falls, with 500 additional adults above Pelton/Round Butte Project when passage is restored. I assume that management for this weak component will provide adequate conditions for (presently) stronger components, such as the fall run and those spawning below Sherars Falls.

Alternative Goal II: Status Quo

Considerations

These recommendations are predicated on the assumption that a moderately large (relative to historical numbers) self-sustaining spawning "population" below Sherars Falls represents a "healthy" (McIsaac 1995) summer/fall run, without consideration for the future of the summer run, the above-falls component, or the fisheries at Sherars Falls. This below-falls component has sustained itself with little management attention, although riparian restoration in the lowermost reach is a noteworthy exception. The recommendations also assume that funding for management of summer/fall chinook in the Deschutes R. is limited to approximately current levels.

Recommendations

1. Reduce harvest rates in ocean and mainstem Columbia R. fisheries and dam passage mortality of juveniles and adults.

2. Abandon the trapping at Sherars Falls and the above-falls mark-recapture population estimation in favor of either of two alternatives:

   a. Trapping and tagging at a downstream point (e.g., at or below Macks Canyon) for population estimates. This alternative will probably be difficult, therefore expensive, and will probably trap/tag a higher proportion of out-of-subbasin strays than does the present operation.

   b. Suspend population estimation and rely solely on redd counts to approximately track variability in escapement and run size. When (as now) the vast majority of spawning occurs below the falls, estimates of total escapement and run size are based primarily on redd counts anyhow. Also, the precision of estimates of above-falls escapement decreases (e.g., due to fallback and smaller sample sizes) when the absolute and/or relative strengths of the above-falls component are small.

   A decision to adopt either of these alternatives is reversible: present or alternative operations can be reinstated whenever warranted by future conditions (e.g., resurgence of the above-falls component).

3. Direct most instream and mainstem riparian restoration efforts to the reach below Sherars Falls, which is used by juvenile and adult fish originating from both above-falls and below-falls production areas. Emphasize measures that restore riparian vegetation and ameliorate atmospheric heating of the river in spring and summer; include tributaries when resources are available.

4. Initiate/continue research to quantify the effects of spawning gravel conditions on spawner-to-fry production (or egg-to-fry survival) and the effects of riparian vegetation and restoration on juvenile survival.

5. Explore opportunities for inriver fisheries downstream of Sherars Falls (e.g., between the mouth and Macks Canyon), when run size allows.

Appendix 1

Research Plan for Phase II

DESCHUTES FALL CHINOOK PROJECT
DESCRIPTION OF TASKS PROPOSED FOR 1995
September 20, 1994

TASK 1: ESTIMATE JUVENILE AND SPAWNER PRODUCTION

Rationale: Accurate and relatively precise data on juvenile and spawner abundances are prerequisites for monitoring changes in freshwater and ocean survival, identifying environmental factors affecting survival, and measuring the results of management actions on survival (i.e., fish production). Only the abundance of spawners is presently estimated, and those estimates may be biased (perhaps by tag loss through fallback at Sherars Falls). To isolate and measure spawner-to-smolt production within the Deschutes River, good estimates of smolt abundance must also be obtained. Given the emphasis on the area above Sherars Falls and the *a priori* assumption that one or more factors have reduced production in that area relative to below the falls, the abundance of smolts originating above the falls must also be measured.

Ideally, spawner and juvenile abundances would be measured both near the mouth and near Sherars Falls (Figure 1). However, in 1995 we anticipate only being able to improve estimates of spawner abundance by augmenting existing methods (i.e., CTWS and ODFW tagging at Sherars Falls) to account for fallback of tagged fish at Sherars Falls. Trapping migrating adults nearer the mouth, although difficult, would have advantages and will be investigated further. In 1995 two downstream migrant traps will be deployed near the mouth, perhaps at Moody Rapids where ODFW previously fished a trap, and engineers will be consulted for designing a juvenile trapping facility just below Sherars Falls. Obtaining sufficient trap efficiency to provide relatively precise estimates of juvenile abundance is a major concern. Beach seining will be used to augment catches of the trap near the mouth.

Elements:

1.1 Estimate juvenile production.
Trapping and seining near the mouth to estimate juvenile production from entire river.

1.2 Research and design for juvenile trapping just below Sherars Falls.
Stream morphology and hydraulics in this area may require innovative trapping techniques to obtain sufficient efficiency. A consulting engineer will be retained under contract for this element.

1.3 Estimate spawner returns above and below Sherars Falls.

1.3.1 Maintain present monitoring.
Ongoing CTWS and ODFW activity; no cost to this project in 1995.

1.3.2 Estimate fallback of tagged fish at falls.
A subsample of the fish trapped at Sherars Falls will be radio-tagged and tracked. This radio-telemetry will also help us identify migration patterns and may also reveal previously undetected spawning areas.

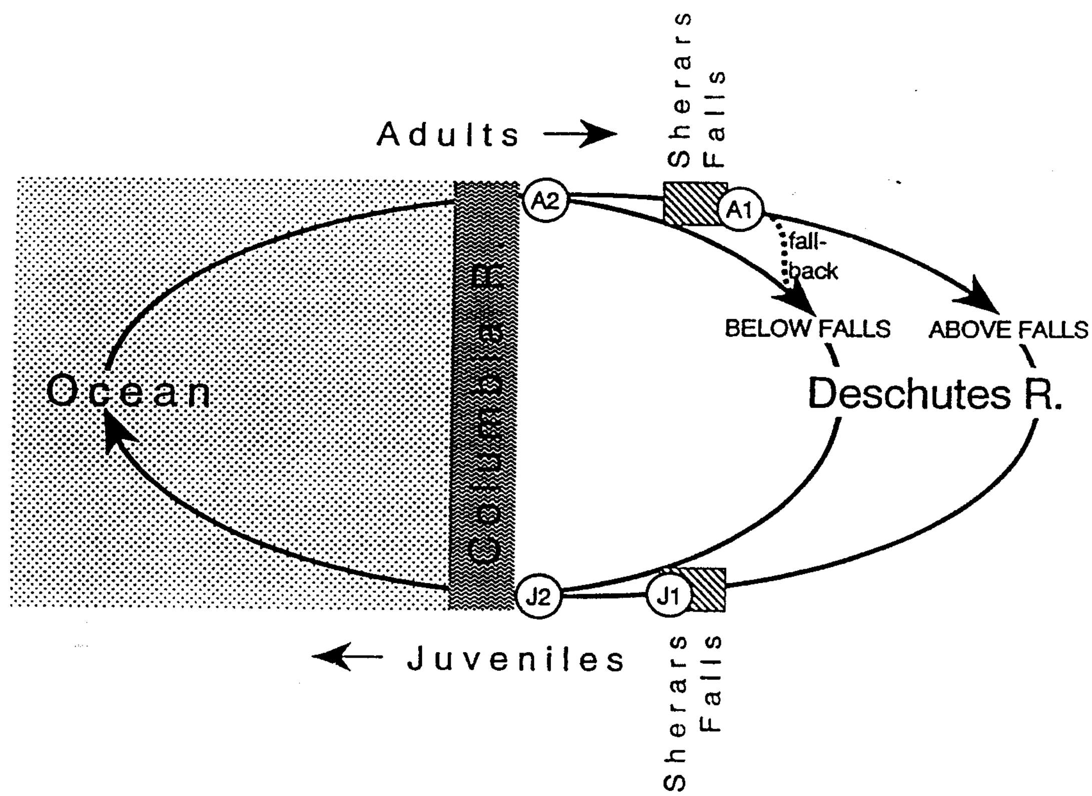


Figure 1. Schematic of Deschutes River fall chinook salmon life cycle with monitoring points for adult escapement to, and juvenile production from areas above and below Sherars Falls.

A1 = Adult monitoring point (Sherars Falls trap) for area above the falls.
A2 = Adult monitoring point (near mouth) for entire lower Deschutes River.
J1 = Juvenile monitoring point (just below Sherars Falls) for production above the falls.
J2 = Juvenile monitoring point (near mouth) for production of river as a whole.

<u>Examples of Possible Calculations</u>
Smolt-to-adult survival = A2 estimate (apportioned by scale age to out-migration year) ÷ J2 estimate (in out-migration year)
Smolt production per spawner above Sherars Falls = J1 estimate ÷ A1 estimate (previous year; net of fallback)

Products:

a) Estimate of smolt production and spawner-to-smolt recruitment for the river as a whole.
b) Engineering feasibility analysis and (if feasible) design specifications for juvenile trapping facility just below Sherars Falls.
c) Estimate of fallback rate of adults at Sherars Falls.
d) Improved estimates of spawner abundance above and below Sherars Falls.
e) All results included in an annual progress report.

Schedule:

Element 1.1: Field activities March-September, 1995; analysis and reporting September-December 1995.
Element 1.2: March-September 1995.
Element 1.3: Field activities July-December, 1995; analysis and reporting January-March 1996.

TASK 2: EVALUATE FISH PASSAGE AT SHERARS FALLS

Rationale: Adult escapement above Sherars Falls may limit production of juveniles in that area due to underseeding. Human activities (e.g., eelers, rafters, trap operation) and scent in the water at the falls may deter upstream migrants, and physical factors (e.g., hydraulics) in the fishway may discourage its use. In 1995 we propose a simple, no-cost test of the effects of human scent in the fishway. Evaluating the passability of the falls and fishway, perhaps using radio-telemetry of adult fish tagged below the falls, may be proposed in a subsequent year. The effects of trap operation may also be proposed for testing later.

Elements:

2.1 Evaluate the effects of human scent and activity in the fishway on salmon passage through the fishway.

Products:

a) An estimate of the relative effect of human scent in the water on passage through the fishway and trap, included in the annual progress report.

Schedule: July-October 1995.

TASK 3: EVALUATE RELATIVE EFFECTIVENESS OF RIPARIAN AREA TYPES FOR JUVENILE PRODUCTION

Rationale: Rearing conditions for subyearling chinook salmon in littoral areas is probably very dependent on riparian conditions, which are in turn dependent on land management practices. Three or four riparian area types will be evaluated: pristine (if available), revegetated, intensively grazed, and heavily trafficked by recreational users. Study sites will be selected that are representative of these three or four riparian area types. BLM riparian survey crew will train technicians. Public information will be emphasized.

Elements:

3.1 Measure physical properties of riparian and littoral habitats in study sites.
3.2 Estimate densities of subyearling chinook in study areas.
Data on other species (e.g., rainbow trout/steelhead) also may be obtained. [Cooperation with proposed PGE/OSU trout/steelhead early life-history study may be possible.]
3.3 Estimate survival and growth of subyearling chinook in study sites.
Littoral-area enclosures will be stocked with known-size fry/fingerlings, whose survival and growth will be monitored periodically for 2-3 months.

Products:

a) Multiple regression analysis of how physical properties are related to survival and growth of subyearling chinook salmon in littoral areas.
b) Estimates of the relative potential of the three or four habitat types to produce juvenile fall chinook salmon (biomass).
c) Results reported in annual progress reports and possibly published in a scientific journal.

Schedule: Field activities March-June, 1995; analysis and reporting July-December, 1995.

TASK 4: EVALUATE COMPETITION AND PREDATION BY RESIDENT TROUT

Rationale: Populations of resident trout appear to be increasing concurrent with declines in fall chinook salmon populations in the Deschutes River. It is very likely that juveniles of all salmonid species in the mainstem compete to some degree for food and space. It is also possible that adult resident trout may prey upon rearing and/or migrating subyearling (fall) chinook salmon. Competition and/or predation by a growing population of resident trout could be limiting survival of juvenile fall chinook salmon.

Elements:

4.1 Estimate niche (diet and space) overlap of juvenile trout and subyearling chinook salmon.
Space overlap will be evaluated by electrofishing to determine relative densities and relating those densities to physical (e.g., substrate type, water depth and velocity) and biological factors (e.g., sympatric species). Sampling conducted under Element 4.2 may provide useful samples for this element. Some juveniles of all salmonid species commonly present will be sacrificed for diet analysis to determine diet overlap. [Cooperation with proposed PGE/OSU trout/steelhead early life-history study may be possible.]

4.2 Estimate predation by trout on subyearling chinook salmon.
Stomachs of large resident trout will be examined (non-lethal sampling preferred) for presence of subyearling chinook salmon.

Products:

a) Characteristics of the habitats occupied and the diets of juvenile trout and subyearling chinook salmon and an estimate of degree of niche overlap between them.
b) Frequency of occurrence of subyearling chinook salmon in the diets of resident trout and estimate of total subyearling chinook salmon preyed upon by resident trout.
c) Results reported in annual progress reports and possibly published in a scientific journal.

Schedule: Field activities February-July, 1995; lab and data analysis June-October 1995; report writing October 1995 through February 1996.

TASK 5: EVALUATE EFFECTS OF *Ceratomyxa shasta* ON SUBYEARLING CHINOOK SALMON POPULATIONS

Rationale: Earlier work determined that wild juvenile fall chinook salmon in the Deschutes River are susceptible to *C. shasta* (Ratliff 1981). Because the infective stage can emanate from reservoirs of the Pelton Hydroelectric Project and is infectious for only a short period (< 10 d.; Ratliff 1983), juvenile fall chinook salmon above Sherars Falls may have higher rates of infection and death than juvenile fall chinook salmon rearing farther downstream. This could explain in part the decline in adult escapement above Sherars Falls, if the Deschutes River population includes above- and below-falls demes.

This task is not proposed for funding in 1995; more time is required to define experimental protocols.

TASK 6: ESTIMATE EGG-TO-FRY SURVIVAL IN SPAWNING AREAS ABOVE AND BELOW SHERARS FALLS

Rationale: If the quality of spawning gravel below Pelton Reregulating Dam were inferior to that of gravel below Sherars Falls (e.g., Gert Canyon and Macks Canyon reaches), then it could be responsible in part for declining production above the falls. This limitation, if it exists, should be reflected in lower egg-to-fry survival relative to spawning areas below the falls. Design and preparation will occur in FY 95, and field work will begin early in FY 96. *[Cooperation with PGE/OSU geomorphology study may be possible.]*

Products:

a) An estimate of the relative egg-to-fry survival in redds above and below Sherars Falls, presented in an annual progress report.

Schedule: Field activities October 1995 through March 1996; data analysis and reporting April-June 1996.

REFERENCES

Ratliff, D. E. 1981. *Ceratomyxa shasta*: epizootiology in chinook salmon of central Oregon. Trans. Am. Fish. Soc. 110: 507-513.

Ratliff, D. E. 1983. *Ceratomyxa shasta*: longevity, distribution, timing, and abundance of the infective stage in central Oregon. Can. J. Fish. Aquat. Sci. 40: 1622-1632.

Deschutes Fall Chinook Project Staffing

Posit'n	Budg'd Mo.	Task	CY 94 Oct	Nov	Dec	CY 95 Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	CY 96 Jan	Feb	Mar	FTE
PM	3	All				aaa	a a	a a	a a	a	a	a	a	a	a	a	a				0.25
RPL	12	1.1			p p	p p	p p	pFFF	sFF	sF	sF	sFsF	sF	Fd	ddd	rdrr	rr				0.40
		1.2						c c	c	c	c		c	c							0.05
		1.3							p p	p	ppp	FF	F F	F F	F F	dF	ddd	ddd	rd	rrrr	0.15
		2										pFF	dF	dF	dFrrr						0.10
		3				s	s s	s	F s	d	s	d s	s s	r	s	r s	r r				0.10
		4				c	c s	F s		s	s	d		s	r	r r	r	r r	r r		0.10
		5											*	* *	*	*	*	*	*		0.05
		6											s	s	s	s	s	s	s d		0.05
APL	12	3.1				p	ppFF	F	F	d F	d	d d	r d	r d	r d	r r	r r				0.15
		3.2				p	p pFF	F F	F F	F F	F F	d d	d d	r d	r d	r	r r				0.25
		3.3				p	pppp	pFF	FFF	FF	FFF	F d d	d d	d r	r d	r r	r r				0.30
		4						cF	c F	c	F	c d	d	d d	d r	r r	r r	r r			0.10
		6											p p	p p	pFF	FF	FF	FFF	FF	FF	0.20
SFTIII-1	12	1.1					p pFF	FFF	FFF	FF	F F F	F F F	F F	F F	mdm	dmm	m r				0.85
		1.3										p F	F F	F	F F	F	d d	d d			0.15
SFTIII-2	8	4				p p	p F F	F F F	??F	??F	?FIF	FIFF	lmlld					p	pFF	FFF	0.67
FTII-1	6	1.3									p p	FFF	FFF	FFF	FFF	FFF	FFF	d m	m m		0.50
	6	3					pppF	FFF	FFF	FFF	FF F	F F							p p	p FF	0.50
FTII-2	6	6												ppp	ppFF	FF	FF	FFF	FFF	FFF	0.50
FTI-1	6	1.1						pFF	FFF	FFF	FFF	FFF	FFF	F						pFF	0.50
FTI-2	5	4					pFF	FFF	??F	??F	?FIF	FIFF	mlm						pFF	FFF	0.42
FTI-3	5	4					pFF	FFF	??F	??F	?FIF	FIFF	mlm						pFF	FFF	0.42
FTI-4	5	4					pFF	FFF	??F	??F	?FIF	FIFF	mlm						pFF	FFF	0.42
			Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	7.17

FY 95 (Oct–Sep) FY 96 (Oct–Mar)

KEY

Positions	
PM	Program Manager
RPL	Research Project Leader
APL	Assistant Project Leader
SFTIII	Supervising Fishery Tech'n
FTII	Fishery Technician II
FTI	Fishery Technician I

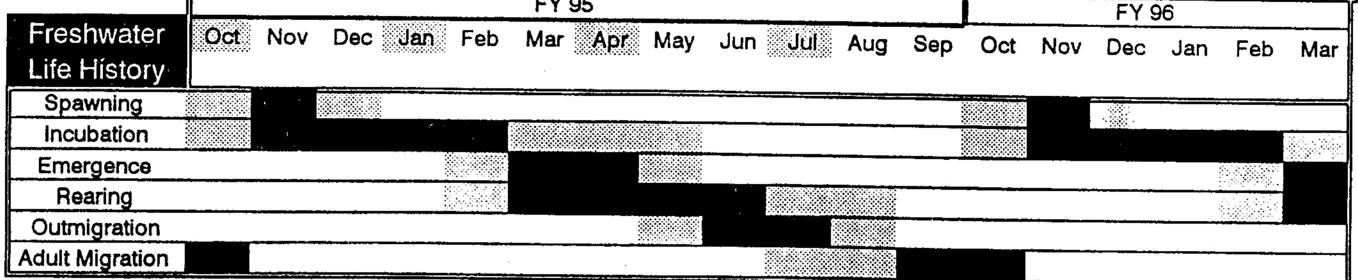
Duties/Activities			
a	administration	p	preparation
c	contractor coordination	r	report writing
d	data analysis	s	supervison
F	Field sampling	*	project development
l	lab analysis	?	(possible) ODFW-funded creel survey
m	maintenance		

Formats
- Re: ODFW Trout Subcontract
- Reduced from Original Budget
- (Spacing of codes reflects intensity of activity.)

C:\USERS\BEAR\QP\DescPers.WQ1

Deschutes Fall Chinook Project Staffing

Task	Position	CY 94 – CY 95: Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep	CY 95: Oct Nov Dec	CY 96: Jan Feb Mar	FTE	Task FTE
All	PM	a a a a a a a a a a a a a	a a a		0.25	0.25
1.1	RPL	p p p p p p p F F F s F F s F s F s F s F s F F d	d d d, r d r r r r		0.40	
	SFTIII-1	p p F F F F F F F F F F F F F F F F F F	m d m d m m m r		0.85	
	FTI-1	p F F F F F F F F F F F F F F F F F F F F		p F F	0.50	
1.2	RPL	c c c c c c c			0.05	
1.3	RPL	p p p p p p p F F F F F F	F F d F d d d	d d d r d r r r r	0.15	
	SFTIII-1	p F F F F	F F F d d	d d	0.15	
	FTII-1	p p F F F F F F F F F	F F F F F F F F F	d m m m	0.50	2.60
2	RPL	p F F d F d F	d F r r r		0.10	0.10
3	RPL	s s s s F s d s d s s s r	s r s r r		0.10	
	FTII-1	p p p F F F F F F F F F F F F F F F		p p p F F	0.50	
3.1	APL	p p p F F F F d F d d d r d r d	r d r r r r		0.15	
3.2	APL	p p p F F F F F F F F F F d d d d r d	r d r r r r		0.25	
3.3	APL	p p p p p p F F F F F F F F F F F F F d d d d d d r	r d r r r r r		0.30	1.30
4	RPL	c c s F s s s d s	r r r r	r r r r	0.10	
	APL	c F c F c F c d d d d	d r r r r r	r r	0.10	
	SFTIII-2	p p p F F F F F ? ? F ? ? F ? F I F F I F F l m l l d		p p F F F F F	0.67	
	FTI-2	p F F F F F ? ? F ? ? F ? F I F F I F F m l m		p F F F F F	0.42	
	FTI-3	p F F F F F ? ? F ? ? F ? F I F F I F F m l m		p F F F F F	0.42	
	FTI-4	p F F F F F ? ? F ? ? F ? F I F F I F F m l m		p F F F F F	0.42	2.12
5	RPL	* * *	* * *	* *	0.05	0.05
6	RPL	s s	s s s	s s d	0.05	
	APL	p p p p	p F F F F F F	F F F F F F F	0.20	
	FTII-2	p p p	p p F F F F F F F	F F F F F F F F F	0.50	0.75
		FY 95	FY 96		7.17	7.17



C:\USERS\BEAR\QP\DescPers.WQ1

27 Sept 1994

Appendix 2

Project Documentation

Appendix 2.1

Project Chronology

Appendix Table 2.1.1. Project chronology.

DATE	EVENT/ACTIVITY[a]	NOTE
7/7/94	Project organizational meeting, Warm Springs.	Meeting notes included in Appendix 2.2.
8/1/94	Project agreement signed between BIA and CRITFC.	
8/4/94	Project tasks and associated budgets submitted to BLM for 1995 budget planning deadline.	(revised) Proposal is Appendix 1
8/30/94	Draft 1995 project proposal (description of tasks) distributed to Technical Coordinating Committee (TCC) with project update.	(revised) Proposal is Appendix 1. Copy of project update is in Appendix 2.4.
9/14/94	TCC meeting to review draft 1995 proposal, Warm Springs. BLM instructs that program coordination task be omitted.	
9/28/94	Revised draft 1995 proposal distributed to TCC.	Proposal is Appendix 1.
10/4/94	Revised budget associated with 9/28 proposal submitted.	
10/94	Comments on 1995 proposal received from PGE and ODFW.	Included in Appendix 2.4.
10/17/94	TCC meeting, Warm Springs Power Enterprises. BLM announces that only $5-10K of BLM funding will be available to project for 1995. Planning is dropped from present work in favor of data analysis and final report.	Meeting notes included in Appendix 2.2.
10/31/94	Draft outline of final report distributed to TCC for review and comment with project update.	No comments received re: final report outline. Copy of project update is in Appendix 2.4.
6/21/95	Part of draft final report distributed to TCC as evidence of progress. Comments were not solicited.	
12/5/95	Draft final report distributed to TCC for review and comment.	Written comments received from BLM, ODFW, and PGE included in Appendix 2.4.
12/18/95	TCC meeting, Warm Springs Housing Authority, to discuss draft report and comments.	

[a] Less significant events and activities are noted in quarterly reports, Appendix 2.3.

Appendix 2.2

Technical Coordinating Committee Membership and Meeting Notes

Appendix Table 2.2.1. Technical Coordinating Committee representatives.

MEMBER	ORGANIZATION
Jim Newton	Oregon Department of Fish and Wildlife
Jim Griggs	Confederated Tribes of the Warm Springs Reservation of Oregon
Val Elliot/Doug Tedrick	Bureau of Indian Affairs
Jim Eisner	Bureau of Land Management
Roy Beaty	Columbia River Inter-Tribal Fish Commission

DRAFT MEETING NOTES

Deschutes River Fall Chinook Project
Coordination Meeting

7 July 1994, 9:00
Warm Springs Power Enterprises

1. Attendees (Attachment 1)

2. CTWS Perspective and Concerns

Jim Griggs The CTWS subsistence fishery on Deschutes fall chinook was capped at 49 fish before the huckleberry harvest in 1992 and caught only 11 fish in 1993. These are poor numbers for an Indian nation that has fished the Deschutes, particularly Sherars Falls, since time immemorial and reserved their fishing rights in the 1855 treaty. The lack of fish for the tribal subsistence fishery at Sherars Falls is a considerable hardship for tribal families. The only thing worse than present conditions would be if tribal members did not recognize closures of the fishery. JG approached Ron Wiley about a year ago to determine whether BLM could use Salmon Summit dollars to address the problem. BLM was agreeable, but administratively could not contract directly with the Tribe.

3. BLM Oregon State Office Research and Management Interests

Ron Wiley Federal agencies are now officially recognizing that they can't just manage on their own lands, which is leading toward watershed analysis and spending money off federal lands. Given the tribal interest in the Deschutes, the BLM, despite its limited ownership and scattered lands in the subbasin, saw an opportunity to promote basin-wide planning, cooperative programs among agencies and private parties, data sharing, and cost spreading. BLM wishes to include the US Forest Service in the process, too. BLM must still pass agreements to the Tribe through the BIA. RW thinks legislation would be required to enable direct agreements with the Tribe, because it is a sovereign nation. Salmon Summit funds will be budgeted next year and may be earmarked through PacFish. The District level has more budget flexibility.

4. BLM Habitat Projects in the Deschutes Subbasin

Jim Eisner (see Attachment 2, handout synopsis) Also, BLM has photos from railroad construction (early 1900's) at 50-60 points, and BLM is currently reshooting those points that are on BLM land.

Jim Newton Infrared video? Light penetration limited effectiveness of IR stills. ODFW has black and white stills from Aney's work in the 1960s, and Oregon Historical Society has other photos.

Jim Eisner Polarizing filters will be used for videos in 1994, but BLM is not hopeful that they will improve video quality. Evaluating the 89 BLM allotments in the lower Deschutes is now a priority and is proceeding. Descriptions of the two evaluation methods, step-point and green-line, will be provided. The mainstem Deschutes will be evaluated in addition to the tributaries.

Ron Wiley Russ Strach (sp?) (NMFS) and Gordon Haugen (USFWS) coordinate with BLM on habitat matters.

Re: microhabitat surveys (Hankin-Reeves), ODFW has surveyed the lower 24 mi. of Buck Hollow Cr., BLM uses a modified House method (streams listed on handout, Attachment 2), and no one present knew the methods used by the USFS.

Don Ratliff PGE may be able to cooperate with BLM on mainstem surveys.

5. ODFW Habitat Projects on the Mainstem

Jim Newton Twenty years ago there was very little riparian vegetation in the lower few miles of the river, attributable mostly to intensive and year-round livestock use. The Oregon Heritage Foundation purchased the lower 12 miles in 1983 and deeded them to ODFW, which then began riparian and pasture-division fencing and upland spring development for livestock water. Results of these ongoing habitat protection measures were demonstrated in several series of photos: riparian vegetation (esp. alders) recovery via natural seeding, extension of grasses and sedges into river margins, and stream narrowing. JN expects that these new conditions improve rearing habitat for subyearling chinook salmon, and may account in part for the increased fall chinook salmon production in the river below Sherars Falls. Woody vegetation is lost wherever there is dry-season grazing. The Harris side channel was reopened, and riparian areas disturbed during reopening were quickly revegetated. Chinook salmon rearing, but so far no spawning, has been documented so far in the side channel.

JN and Jim Eisner Power boat wakes erode banks and (JE) trails at dispersed camping areas also cause erosion.

Ron Wiley PacFish says restoration?/conservation? of riparian vegetation is a higher management priority than recreation. Are there cottonwoods in the area, and are they needed for long-term recovery?

JN Some cottonwoods, but beavers get them quickly.

RW Climax communities may be different now that the river is regulated.

Stephen Ahern USGS says the Deschutes is [even under a natural flow regime] the most stable river it has studied.

Jim Griggs Important to evaluate juvenile salmon use of restored habitat.

6. Fall Chinook Research and Monitoring

Roy Beaty List of key Deschutes fall chinook-related references:

- Aney *et al.* 1967. Lower Deschutes flow study. Final Report.
- Jonasson and Lindsay. 1988. Fall chinook salmon in the Deschutes River, Oregon. 1975-86.
- Ratliff. 1981 and 1983. *Ceratomyxa shasta.*
- Huntington. 1985. Deschutes River spawning gravel study. 1983-84.
- CTWS and ODFW. Deschutes fall chinook monitoring program. 1987-present.
- ODFW and CTWS. 1990. Deschutes River Subbasin plan.
- (Schroeder). (1992). Deschutes River fall chinook salmon. Unpubl. MS.

Copies of all have been obtained and reviewed, except for Aney *et al.* 1967 (since provided by Don Ratliff). Escapement goals are not entirely consistent: 6,000 to 7,000 to the river (ODFW and CTWS 1990) and a minimum of 2,000 adults above Sherars Falls (Jonasson and Lindsay 1988; assumes 80% of spawning above falls), but escapement goals may not be germane to this project. A graph (Attachment 3) of average redds per spawning survey site above (sites 1-4, above rm 94) and below (sites 19-26, below rm 34) Sherars Falls shows how redd densities in the uppermost miles have declined dramatically, while densities in the lowermost reaches have increased recently, but not to exceptional levels. Spawning gravel quantity and quality, as well as sedimentation and streambank degradation, have been identified as major habitat constraints to fall chinook salmon production in the lower Deschutes River subbasin (ODFW and CTWS 1990). Are we committed to exclusively natural production?

Jim Griggs Until the subbasin plan and Power Council policy change, the CTWS is committed to a wild fish policy.

Steve Pribble Adult escapement estimation methods now differ from those used by Jonasson and Lindsay (1988).

Don Ratliff *Ceratomyxa shasta* will not be addressed in PGE's water quality study. Heidi Fassnacht's research will be strictly geomorphology, and there is room for collaboration with the fall chinook project. Requested copy of Schroeder's report (since provided by RB). Pelton trap fish counts (1957-present) may be useful to this project.

Jim Griggs and Mark Fritsch Howard Shaller (ODFW) did some analysis and a white-paper report, which MF can provide to RB.

7. PGE-funded Research

Don Ratliff PGE will be funding three studies:

- Geomorphology - gather information and develop study plan this year; first major field season next year.
- Crayfish - Now in progress in Lake Billy Chinook.
- Water quality study - to ENS (Jim Sweet) via subcontract from CH_2MHill. DR has a copy of the old Malarky (sp?) (ODFW) report.

DR also wants to initiate a study of early life-history and population dynamics of rainbow trout/steelhead, including juvenile rearing and genetic comparisons (e.g., rainbow/steelhead, hatchery/wild). Have also considered a kokanee life-history study in Lake Billy Chinook, where over 100,000 are harvested per year. In addition to native kokanee/sockeye stocks, Leavenworth and other stocks have been introduced.

8. Project Structure and Timeline

Roy Beaty Intend to take a life-cycle approach to examine factors for population trends in the Deschutes. Fall chinook returns 1977-91 in the Deschutes, entire Columbia, and Tillamook (Oregon coastal) show very similar trends since 1984 (i.e., dramatic peaks in 1987-88, steep decline through 1991)(Attachment 4), suggesting dominant effects of ocean environment. Ocean factors may mask, but probably not negate improvements in freshwater production.

This year, funds and agreements flow from BLM though BIA and CRITFC to CTWS. ODFW is a full, but presently unfunded, cooperator. BIA and CRITFC are involved only for administrative and technical expediency. CTWS will be the lead in 1995, with funds probably channeled through BIA. General timeline:

July	Review & analysis; form Technical Coordinating Committee.
Aug.	Review & analysis; develop research plan and budget estimate.
Sept.-Oct.	Prepare work statement, budget, and completion report.
1995-96	Research activities, analysis, and reporting.

Jim Eisner Week of 13 August is the deadline for the budget; only a rough number is needed at that time.

Ron Wiley AWP development drags on through January, however.

Jim Griggs Expects 7-8 major tasks, some of which (e.g., juvenile trapping) may be big-ticket items.

RW BLM has developed a guidebook for FEMAT analysis, and he will provide a copy to RB. BLM is looking for tasks that can be implemented now, and expects this to be a long-term project.

Mark Fritsch Based on tribal oral history, the spring run dominated the chinook salmon runs in the Deschutes. There have been a few large [summer/fall-run ocean-type fish?] in the river, but mostly since the ladder was installed at Sherars.

RW BLM wants this project eventually to have more than a single-species focus; there is an interest in a more general approach that includes all species basin-wide. BLM is interested primarily in tributary lands and in expanding this type of work into the John Day subbasin. Need to pull everything together, get the US Forest Service involved.

Don Ratliff Gordon Grant and Gordie Reeves (possible PI for rainbow/steelhead life-history study) are both with the USFS Pacific Northwest Lab.

Jim Newton Little anadromous habitat on USFS lands in the lower Deschutes.

Someone expressed a desire for a clearinghouse for fish information in the subbasin.

9. Other

10. Site Visit to Sherars Falls

View windrowed spawning area downstream of Pelton Reregulating Dam. Jim Griggs, Ron Wiley, Steve Ahern, and Roy Beaty continued on to Sherars Falls, where the trap was partially installed. JG described plans to move raft removal site upstream and to the bank opposite the trap to reduce human contact with water that enters the fishway. In the past eelers have also reached into the fishway to remove lamprey. A new diesel water pump, purchased by NMFS with Mitchell Act funds, will provide more easily the volume of flow required by the steeppass.

Attachments (4)

J:\USERS\BEAR\WP\DESCH\MtgNotes.074 *July 27, 1994*

DRAFT MEETING NOTES

Deschutes River Fall Chinook Project
Technical Coordination Meeting

17 October 1994, 1:00 p.m.
Warm Springs Power Enterprises

Attenders

Steve Pribyl, ODFW
Mike Paiya, Warm Springs NFH
Jim Newton, ODFW
Keith Hatch, CRITFC/CIS
Jim Griggs, CTWS
Mark Fritsch, CTWS
Jim Eisner, BLM
Roy Beaty, CRITFC
Duane Anderson, PSMFC/CIS
Stan Allen, PSMFC/CIS
Stephen Ahern, ND&T

Coordinated Information System Orientation and Demonstration

Stan Allen, Chief of Information Management Services, and Duane Anderson, CIS Regional Data Manager, both from the Pacific States Marine Fisheries Commission (PSMFC), demonstrated the present CIS and a prototype for the next version. The CIS is currently a distributed database (available on diskettes), as well as a network for sharing information on anadromous fishes in the Columbia River Basin. Stock status reports are the core of the system, and additional components are being added. CRITFC supports the CIS library. There are no special fees for any party to access the system. In addition to the Regional Data Manager, the tribes (Keith Hatch, CRITFC), Washington, Oregon, and Idaho each have data managers available to assist system users. For more information contact Stan Allen or Duane Anderson (503/650-5400), Keith Hatch (503/238-0667), or the manager for your state's fishery agency.

Fall Chinook Project

BLM informed project cooperators earlier in the day that only about $5K-$10K of BLM funds are available for this project in FY 1995; up to $30K may be available through matching fund opportunities. This amount is not sufficient for even the first project task, and CTWS will explore with BLM why so little money was allocated to the project. **Roy Beaty** said that, given these conditions, he believed his work henceforth should focus on data analysis; little time will be devoted to coordination or developing a research plan. An outline of the final report will be distributed for review and comment about 1 November, the draft report will be distributed early in December for a two-week review, and the final report should be complete in early January.

PGE-funded Studies

Stephen Ahern -- Northrop, Devine, & Tarbell, Inc. -- summarized seven projects that are presently in progress or planned:

Fish Passage -- Gonzalo Castillo, one of Hiram Li's graduate students at OSU, will review the literature on fish passage for juvenile and adult life stages of all anadromous species. Jon Truebe -- a fish passage engineer with Lakeside Engineering, Inc. of New Hampshire -- will advise PGE on methods of monitoring and designing fish passage. Jon, a member of the bioengineering section of AFS, has expertise with side-scan sonar and will conduct a water velocity study with laser doppler technology. PGE has spoken with ODFW (Chip Dale, Stephanie Burchfield, and Rick Krueger) about the work, which will last at least through 1995.

Kokanee Spawning -- A part-time USFS employee has been hired to count redds on index transects in the Metolius, where total counts are not possible. An expanded creel census in 1995 will be tied to the water quality study to help determine in-reservoir life history and factors limiting kokanee production.

Water Quality -- All reservoir inlets and outlets will be monitored monthly, except for one month in winter. Vertical arrays of recording thermographs will be used to study reservoir thermal stratification. **Jim Griggs** commented that the study write-up looks real good.

Crayfish -- Sampling in the Crooked and Metolius arms of Lake Billy Chinook is complete for the year. The Deschutes arm will be sampled next year.

Bull Trout -- The final redd count will be conducted 18 October. Many redds have been located, and many fish have been trapped and marked.

Gravel Geomorphology -- A large bibliography on gravel, compiled by Gonzalo Castillo as part of a mining extraction study, will be passed on to Heidi Fassnacht to assist in her literature review.

Lower River Rainbow/Steelhead Early Life History -- Gordie Reeves is taking a preliminary look at alternatives for determining numbers of young juveniles. Methods such as removal and monitoring repopulation in an area may be useful. Chris Zimmerman, Gordie's graduate student, will begin work the first of the year, although it's unclear yet what he will do.

PGE also intends to fund a search for information about the lower Deschutes river, perhaps by persons presently employed as seasonals by ODFW and/or USFS. DN&T is collecting hydrologic and operation data for the whole system for modeling (modified HEC-V) by one of its engineers. Bathymetry (5' contours) of all three reservoirs will define storage capacity. Asked whether PGE might be willing to channel some contract funds (non-federal dollars) through a program that would make matching federal dollars available, Stephen mentioned that there had been much discussion at PGE about such a possibility.

CTWS Riparian Fencing *et al.*

Mark Fritsch is the CTWS lead for working with Dave Nolte, Bring Back the Natives (BBN), to obtain some federal matching funds for riparian fencing on the reservation side of the river northward from the county line to Dry Creek. The proposal to BBN drafted by Dave had used the fall chinook project, as proposed for 1995 in the tasks, as the context in justifying the request for matching funds. The CTWS understands that no boaters pass fees are available for tribal riparian fencing, although the tribe apparently had been encouraged to accept and use some of the funds in earlier years.

Oregon Trout Steelhead Work Group Meeting, 1-2 December

It was unclear to some attenders what the motivation was for the OT meeting and why chinook issues were on the agenda. **Jim Newton** noted that the previous week (of 10 October) OT received a $50K restoration and enhancement grant from ODFW for a steelhead project that also considers other species.

Other Items --

NMFS is convening a meeting in Lewiston on 18 October regarding species of concern. Summer steelhead appears to be the only Deschutes River stock being considered.

The next meeting was not scheduled.

J:\USERS\BEAR\WP\DESCH\MtgNotes.104

CC
729 I

SH COMMISSION

Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: September 9, 1994

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 April - 30 June, 1994
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

This report covers only June 1994, during which the Project and Phase I activities were initiated.

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- Gathered and reviewed 10-15 documents re: Deschutes R. fish management and fall chinook salmon, including *Deschutes River Subbasin Plan*; ODFW Information Report 88-6, *Fall Chinook Salmon in the Deschutes River, Oregon*; Anonymous (K. Schroeder) whitepaper report, *Deschutes River Fall Chinook Salmon*; BPA/C. Huntington Final Report, *Deschutes River Spawning Gravel Study*; CTWS & ODFW whitepaper report, *Deschutes River Fall Chinook Salmon Monitoring Program, 1993*.
- Met w/ Ron Wiley (BLM/OSO) and Jim Griggs (CTWS) re: project administration, technical coordination (i.e., TCC), and scope, 6/15.
- Field orientation on Deschutes River (Heritage Park, Deschutes Club locked gate to Macks Canyon) and Round Butte Hatchery annual coordination meeting at Pelton/Round Butte Project Office, 6/27-29.

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
V. Elliot, BIA
J. Matthews, CRITFC

J:\USERS\BEAR\WP\PRED\Qtr2.094

FILE

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: October 19, 1994

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 July - 30 September, 1994
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- An organizational meeting was held 7 July in Warm Springs. Meeting notes and supplementary materials were distributed later to attenders and other interested parties. (Objectives 1 and 2)
- A mailing list of parties with interests in this project has been compiled and distributed. (Objective 2)
- Attended Snake River fall chinook research coordination meeting 11 August, in Lewiston, ID. Notes relevant to Deschutes River fall chinook salmon were distributed to everyone on the mailing list for the Deschutes fall chinook project. (Objective 1)
- Organized Technical Coordinating Committee (TCC), and held first meeting on 14 September in Warm Springs to review draft tasks proposed for 1995. Cooperators and other interested parties also met at other times to develop tasks and budgets. (Objectives 1 and 2)
- Seven draft tasks and associated budgets were prepared and submitted to BLM on 4 August. Tasks and budgets were revised and distributed, with complementary information (e.g., staffing requirements by task and month), in late September, subsequent to the TCC meeting. (Objective 1)
- Continued to acquire and review literature relevant to the project. (Objectives 1 and 3)
- Began to obtain and analyze relevant data, including temperature and flow data from USGS and escapement estimation data. (Objectives 1 and 3)

- Began to identify and refine alternative technologies for field experiments in 1995. For example, accompanied BLM Ranger on patrol of river reach between Warm Springs and Maupin to observe field conditions, met with ODFW biologists with expertise in juvenile salmon trapping and sampling, and consulted others with radio-telemetry experience. (Objective 1)

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
V. Elliot, BIA
J. Matthews, CRITFC

J:\USERS\BEAR\WP\DESCH\Qtr3.104

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: January 9, 1995

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 October - 31 December, 1994
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- CWT tag recovery data were downloaded from PSMFC's Regional Mark Information System for Deschutes River fall chinook salmon and some Pacific Salmon Commission chinook salmon indicator stocks. Distributions of recoveries in ocean fisheries of Deschutes fall chinook for 1977-79 brood years are more similar to some other indicator stocks (e.g., Grays River fall chinook, Lewis River wild fall chinook, and mid-Columbia summer chinook) than to Priest Rapids fall chinook. (Objectives 1 and 3)
- Some recently published literature on the effects of ocean conditions on salmon stocks was obtained and reviewed. (Objective 1)
- Summarized and analyzed temperature data for Pelton and Moody (mouth of Deschutes) sites pre- and post-dam construction for potential effects during fall chinook spawning and egg/fry incubation. (Objective 1)
- Gathered information from ODFW, CTWS, and Warm Springs Power Enterprises re: construction and other activities in the 1980's that may have affected fall chinook, particularly above Sherars Falls. (Objective 1)
- Provided funds to ODFW to enter Sherars Falls trap data into computer; reviewed and edited computer data with Leslie Nelson (ODFW); and summarized data on marks released, tag recaptures (fallbacks), trapping and handling mortality, and trap efficiency (i.e., portion of the estimated run tagged at trap). (Objectives 1 and 3)
- Estimated the effects of various (hypothetical) fallback rates of tagged fish on population and exploitation estimates. (Objectives 1 and 3)

- Searched CTWS and ODFW (The Dalles District) files and gathered information on radio-telemetry studies, harvest monitoring methods, and other management activities. (Objective 1)
- Distributed draft copy of outline for completion report to TCC and others for review and comment. No comments received to date. (Objectives 2 and 3)
- Inspected Sherars Falls fishway with Mr. Steve Rainey, NMFS fish passage engineer. His brief report will be an appendix to CRITFC's completion report. (Objectives 1 and 3)
- Attended Deschutes River salmonid workshop sponsored by Oregon Trout. (Objectives 1 and 2).
- Amended grant agreement with BIA for no-cost extension (to 30 April) and budget line item modification. (Objectives 1 and 3)

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
V. Elliot, BIA
J. Matthews, CRITFC

J:\USERS\BEAR\WP\DESCH\Qtr4.015

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: May 15, 1995

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 January - 31 March, 1995
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- Draft completion report is in progress. Supplemental literature and data have been obtained, summarized and analyzed as they became available and as needed during composition. (Objective 3).

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
V. Elliot, BIA
J. Matthews, CRITFC

J:\USERS\BEAR\WP\DESCH\Qtr1.055

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: July 11, 1995

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 April - 30 June, 1995
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- Draft completion report still in progress. Portion of report distributed to Technical Coordinating Committee in June.

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
V. Elliot, BIA
J. Matthews, CRITFC

J:\USERS\BEAR\WP\DESCH\Qtr2.075

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: January 16, 1996

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 October - 31 December, 1995
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- Draft completion report was distributed at the end of November to TCC members for their review and comment.
- A report review meeting was held with CTWS and ODFW in Warm Springs on 18 December. Final revisions will be made to the report beginning in late January, after further comments have been received.

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
Doug Tedrick, BIA (replaces V. Elliot)
M. Shenker, CRITFC

J:\USERS\BEAR\WP\DESCH\Q14 016

Roy B.

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: April 8, 1996

TO: Ron Eggers, Fisheries Program Administrator

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Quarterly Performance Report, 1 January - 31 March, 1996
Grant No.: GTP00X90104
Evaluation of Fall Chinook Salmon in the Deschutes River Subbasin

I. Accountable Property

(None purchased this quarter.)

II. Work Accomplished Relative to Overall Objective

- Final draft of the completion report is being prepared following review and comment. Some new data have been added, and some existing data have been re-analyzed.

cc: J. Griggs, CTWS
J. Eisner, BLM
J. Newton, ODFW, The Dalles
Doug Tedrick, BIA (replaces V. Elliot)
M. Shenker, CRITFC

J:\USERS\BEAR\WP\DESCH\Qtr1.046

C
72

H COMMISSION

Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: 30 August 1994

TO: Deschutes River Fall Chinook Project Parties

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Project Update

Tasks for 1995

Jim Griggs and I outlined seven tasks for 1995 and drafted corresponding budgets for a 4 August BLM budgeting deadline. The tasks, described in Enclosure 1, may be modified considerably as BLM, CTWS, ODFW, BIA (optional), and CRITFC work on technical and budget details in the months ahead. The tasks are listed generally in order of preference/priority for the CTWS. However, Task 1 addresses the wishes of BLM and others to develop a comprehensive multi-species, subbasin-wide program and is not an integral part of the fall chinook project itself.

Snake River Fall Chinook Research Coordination Meeting, 8/11/94, Lewiston, ID

Mark Fritsch (CTWS) and I attended this meeting to observe the direction and process being used to coordinate research on endangered Snake River fall chinook salmon. My general impression is that their process is refreshingly clean of political influences, but it may lack the policy guidance that is useful in maintaining priorities and focus. For example, an inordinate amount of resources appear to be directed toward obtaining minutiae to quantify the amount of suitable spawning habitat available at given flow levels to build better computer simulation models. Meeting notes relevant to our project are enclosed (Enclosure 2).

To facilitate this research coordination, each quarter BPA distributes a hefty package of reports, correspondence, and other documents relevant to Snake River fall chinook. Most of the documents distributed in the last year and a half that are potentially relevant to our project are referenced in Enclosure 3. If you desire a copy of any document, I suggest contacting BPA publications (503-230-5131) for BPA reports and Debbie Watkins, BPA biologist, (503-230-4458) for other documents. I may also be able to provide some copies.

Project Portfolio

With your help, I wish to compile and distribute a portfolio of fish-related projects on the lower Deschutes River. Perhaps no more than a page in length, the portfolio would provide a synopsis of projects, including funding organization, investigator/implementer/contact person, purpose, fish species of interest, duration, status, perhaps approximate annual budget ($0,000s), etc. I expect that this portfolio will enable funding and cooperating organizations to understand and to communicate how their work fits into the puzzle and how work and costs are shared. This synopsis should be particularly useful as more organizations get interested and wish to contribute. For example, Oregon Trout has interests and a project that may complement this project (we have recently spoken with Geoff Pampush and Bill Bakke), and Jim Griggs suggests that ***Bring Back the Natives*** may be interested in investing in our work. Expect me to ask for your help in completing this portfolio in coming weeks.

TCC Membership and Meeting

The following have been named as representatives on the Technical Coordinating Committee:

BLM	Jim Eisner
BIA	Val Elliot
ODFW	Jim Newton
CTWS	Jim Griggs (tentative)
CRITFC	Roy Beaty

I am presently trying to schedule a TCC work meeting for early September to refine the tasks proposed for 1995.

Upper Deschutes Watershed Advisory Council and Deschutes River Foundation

I am inquiring about organizations that may impact or facilitate our work. A watershed advisory council has been proposed to the Oregon Water Resources Department (under HB 2215) for the upper Deschutes River (Deschutes County, only), which would enable state funds to be used for river management and research projects in Deschutes County. However, the original proposal was not accepted, based in part on too-restrictive geographical boundaries and representation. Although parts of Jefferson and Crook counties have been recommended for inclusion, I do not foresee that this council, if formed, would meaningfully impact our project in the near term, nor would it preclude the formation of a similar council for the lower Deschutes River. However, my first glance does not reveal much that a Lower Deschutes Watershed Advisory Council could offer our project.

The ***Lower Deschutes River Management Plan and Environmental Impact Statement*** (§ IV. A., p. 87) states that a Deschutes River Foundation will be established to facilitate land acquisitions and lease arrangements. I would appreciate receiving any information available about the status of the Foundation and how it may complement the work of our project (e.g., as a source of funds and legal expertise for acquiring rights to riparian lands, as a service for administering private grant funds dedicated to fish research and management on the lower Deschutes River).

Information Clearinghouse

The Pacific States Marine Fisheries Commission administers the Coordinated Information System (CIS), which may be useful as a clearinghouse for fish-related information on the lower Deschutes River (blue brochure enclosed). The CIS Program managers are willing to demonstrate the CIS and discuss applications at a Deschutes coordination meeting.

Enclosures:
1. Draft tasks proposed for 1995
2. Snake R. fall chinook coordination meeting (notes)
3. Documents re: Snake R. fall chinook (possibly relevant to Deschutes fall chinook)
4. Blue CIS brochure

J:\USERS\BEAR\WP\DESCH\Memo24.084

COLUMBIA RIVER INTER-TRIBAL FISH COMMISSION
729 N.E. Oregon, Suite 200, Portland, Oregon 97232
Telephone (503) 238-0667
Fax (503) 235-4228

MEMORANDUM

DATE: 31 October 1994

TO: Deschutes River Fall Chinook Project Parties

FROM: Roy Beaty, Managing Fishery Scientist

SUBJECT: Project Update

TCC Meeting, 17 October, 1994

Draft meeting notes are Enclosure 1. Please let me know of substantive omissions or inaccuracies.

Data Analysis

The status of data analysis through mid-October is summarized in Enclosure 2. Thanks to Jim Newton for pointing out that harvest should also be addressed. Please let me know of other items that I overlooked. Project coordination and planning for 1995 are not included. Thanks to those of you that are providing data, anecdotal information, and access to files and archives.

Final Report

Please review the draft outline of the final report and suggest improvements (Enclosure 3). The outline is organized around the lifecycle of the fish and begins with spawning escapement, for which we appear to have the most information. The working hypotheses stated in the outline are my guesses about the most likely conditions. The outline is detailed and fairly comprehensive, but not necessarily complete. There will be no data, probably insufficient time, and perhaps no need to thoroughly address some of the hypotheses. I don't intend for the report to be wordy or unduly conjectural.

Enclosures (3)

J:\USERS\BEAR\WP\DESCH\Update31.104

RECEIVED
OCT 1 1 1994
FISH SCI DEPT

To: Roy Beaty October 4, 1994

From: Don Ratliff

Subject: Deschutes Fall Chinook Project, Revised 1995 Tasks, 9/25

Since I will be in the wilds of Idaho pursuing the elusive Wapiti October 17, I thought I would write down some of my concerns/ideas concerning the planned fall chinook project. Please excuse me if this seems too negative, I know how difficult it is to design studies, especially those to be carried out in a system as large and complex as the Deschutes. These ideas and questions are intended to strengthen this study design.

In general, I would like to see a much more detailed study plan for each of the proposed tasks. With what is given, it is difficult to know if the answers are obtainable on the track being pursued. I think the tasks listed might be better described as "Objectives". Each objective might include one or more hypotheses to be tested. Under each of these, it would be good to have a stepdown or sequential series of tasks or elements to be accomplished over time.

Decision criteria to be used before a hypothesis is accepted or rejected should be given, as well as assumptions inherent in each study. For instance, your assumption that growth and survival of subyearling chinook in littoral-area enclosures is related to their growth and survival in the wild may or may not be valid. Can this assumption be tested? Is there support for this method in the literature?

Details such as sample size to be used and the confidence level you are attempting to obtain should be given. For instance, it is difficult to determine trap size and labor requirements for smolt production estimates if you haven't determined how efficient your traps must be to provide relatively precise and accurate estimates. Also, how is efficiency to be determined and how frequently will sampling be done so that efficiency changes due to variations in flow and turbidity can be accessed?

Other comments/Questions by Task

Element 1.1 In order to achieve accurate estimates of total smolt production many thousands of fall chinook smolts will need to be captured and handled, some of them twice. Is there a concern with handling mortality?

Element 1.3 How many radio tags will be used? How precise will this estimate be? Will you make separate estimates for adult males, adult females, and jacks?

Element 2.1 Although this may be simple, how will it be accomplished? How many trials will be conducted to be certain that scent is the cause of variations observed? Have you looked at passage in relation to rafter numbers to see if there is a correlation? Negative correlation with weekends?

Element 3.1 Which physical properties for riparian and littoral habitats will be measured? How many replicate study sites will be necessary to reduce the effect of variations in flow, substrate, aspect, shading, etc.?

Element 3.2 I think the relation of physical (and biological) properties to the density of juvenile chinook in general should be determined. If some riparian or littoral area "type" consistently correlates with high densities of juvenile chinook, then we will have something. If there are also correlations with a certain flow, or depth, or submergent vegetation, we will know even more. I really do not like the idea of using riparian habitat type alone to determine study sites. Study sites or even better, reaches, should be determine randomly within reason. If it were keyed off riparian type, they probably should be selected as a stratified random sample.

Element 3.3 Although the use of enclosures might be tested, my observation after livecaging many groups of fish during my disease studies is that it is very impractical for this time period given the small mesh size necessary and the low-density levels needed to simulate a natural population. Also, I do not think it is natural for these fish to remain in shallow water in one area for this length of time.

Element 4.1 In my experience, it is very difficult to sample fish and determine their precise location when electrofishing. This is because they tend to flee the electricity. Where they are actually captured may have nothing with their preferred location. Also, because they tend to be drawn toward the anode, any vertical stratification in habitat use will be lost.

Diet preference in the wild is also hard to interpret. How many individuals of each species with how many similar food items are necessary before niche overlap is determined? With this, you will also have the tremendous variations in the numbers and assemblages of food items available which will be impossible to sort out. Fish feed opportunistically.

Some idea of space overlap or partitioning may be learned from direct observation by snorkeling. However, in general I think these kind of interactions need to be worked out in an artificial stream where environmental variation can be controlled. Have you searched the literature to see what studies have been done on the interactions of rainbow trout and juvenile chinook?

4.2 During the field season in 1975, Jim Fessler examined stomach contents of all the major fish species in the Deschutes River monthly. Large numbers of salmonid fry were observed in smaller rainbow stomachs in March. In the 1976 progress report they thought these were newly emerged chinook. In the final rainbow report they were listed as mountain whitefish. Perhaps Kirk Schroeder could shed more light on this. However, in 1975, the only fish observed in larger rainbow stomachs were cottids.

The number of cormorants on the upper portion of the lower Deschutes has also greatly increased in recent years.

Task 5 Rationale

Although I showed that the infective stage of <u>C. shasta</u> remains viable less than 10 days, this is plenty of time for it to move down to the area below Sherars. Perhaps a more important idea is that if all infections units in the lower Deschutes are emanating from Lake Simtustus, then the concentration would tend to become diluted as more tributaries enter the river. On the other hand, temperatures are warmer below Sherars, and ceratomyxosis is more virulent at warmer temperatures.

I doubt if there is be a substantial difference in the exposure of chinook above and below Sherars. This was substantiated by concurrent 1-week exposures of identical groups of rainbow trout below the Reg Dam and at Moody through the spring periods in 1978 and 1979. Infection frequencies were nearly identical at the two locations (see the 1983 paper, Fig. 2)

However, it would be interesting to hold some of the wild juvenile chinook seined from the river as I did in the late 70s to see if significant infections occur. Sick and dead fish observed in the downstream traps could also be looked at for <u>C. shasta</u> spores.

Task 6 It has been my observation (back when I got to go on chinook redd counts) that adults spawning below Sherars Falls tended to be larger on average, than those in the upper areas. Thus, without knowing eggs-per-female differences it would be hard to accurately quantify fry survival differences between above and below Sherars Falls spawning. I think there is enough known about spawning locations and what constitutes chinook spawning habitat that the substrate can be sampled directly to determine quality. I think that sites sampled by Huntington in 1985 will be revisited in the next several years to determine any significant changes that may have occurred in habitat conditions.

Hope this helps, sorry I'll miss the meeting, but my kids need the meat.

copies: Griggs, Newton, Eisner, Ahern

Oregon
DEPARTMENT OF
FISH AND
WILDLIFE
MID-COLUMBIA
DISTRICT OFFICE

October 7, 1994

Jim Griggs
Confederated Tribes of the Warm Springs Indian Reservation
Natural Resources Department
P.O. Box C
Warm Springs, Oregon 97761

Dear Jim:

This letter addresses concerns I have with the direction I see the Deschutes Fall Chinook Project heading. I am concerned that this project may be putting the proverbial "horse before the cart".

As you will probably recall, the first and I believe the most important objective initially laid out for this project was to analyze all the information available regarding fall chinook salmon in the Deschutes River. This exercise was also intended to examine existing information for factors potentially affecting fall chinook salmon within the Deschutes River, the Columbia River, and the ocean. In fact the agreed upon master plan stated that within 90 days [from initiation of the project] an analysis would be prepared to: (1) list the potential causes of the population decline, (2) analyze the present management program, and (3) list potential preventative measures to monitor.

In Roy Beaty's September 28, 1994 letter to "Deschutes Fall Chinook Project Distribution" and the October 4, 1994 letter concerning the revised budget for this project the emphasis is on field work tasks and there is no mention of any analysis of existing data. I am enclosing a copy of an excerpt from a recent report prepared by Washington Department of Wildlife, which evaluates trends in steelhead abundance along the Pacific Coast. Their conclusion was that ocean productivity may be the primary driving force causing fluctuations in salmon and steelhead abundance. If their conclusion is accurate and it applies to chinook salmon as well as steelhead populations, many of the tasks contained in the Deschutes Fall Chinook Project may provide "nice to know" information, but really not provide the answers we are looking for.

We do not need another fall chinook life history study. We

3701 West 13th Street
The Dalles, OR 97058
(503) 296-4628
FAX (503) 298-4993

already have one. This project does not seem to be oriented at identifying or solving the problem of low numbers of adult fall chinook. This project as currently designed may well require 5 - 10 years to get meaningful information (i.e. egg to fry survival). What will this knowledge do for us in the near future? There could be ways to test this issue much quicker by introducing new gravel below the Regulation Dam and comparing egg to fry survival to other spawning areas.

The issue of riparian habitat effectiveness is well addressed in literature. Why do further study? Why not use the funds to increase riparian restoration projects along the river?

One of the important tools that could be developed for assessing fall chinook spawning in the Deschutes, including numbers and distribution, would be videography. However it is my understanding that the helicopter chartered by CTWS for the 1994 redd counts will not have video capabilities for the October flight. Jim Eisner contacted me several weeks ago and mentioned that BLM would not repeat the 1993 fall chinook videography based on instructions from your staff. Therefore, unless some program adjustments are made in the very near future, we may lose our opportunity for spawning survey videography this year. This would be unfortunate.

Roy and others have expressed concern about fall chinook spawning escapement estimates in the Deschutes River because of potential problems associated with tag loss and fall back over Sherars Falls. Steve Pribyl went back and looked at some of the voluminous Deschutes data recently and concluded that there is existing data that suggests that neither of these issues is a significant problem. This may be a good example of how some of our questions could be answered by a thorough review of existing data.

I am also concerned by recent project developments that seem to indicate that this project may be rapidly evolving to include other anadromous species and other river basins. These are issues that were never included in the original cooperative agreement. It appears that the different entities need to reassess the project intent, direction and priorities in the very near future.

Sincerely,

James A. Newton
District Fish Biologist

cc: Chip Dale
Barry MacPherson
Roy Beaty
Jim Eisner
Tim Unterwegner

2

Oregon

DEPARTMENT OF
FISH AND
WILDLIFE

Mid-Columbia
District Office

December 8, 1995

Roy Beaty
Columbia River Inter-Tribal Fish Commission
729 N.E. Oregon, Suite 200
Portland, Oregon 97232

Dear Roy:

I received your latest draft of the Deschutes River Fall Chinook Evaluation Report. It is readily apparent that you spent considerable time preparing this document. This included reviewing available Deschutes River data and researching information concerning potential factors influencing salmon outside the Deschutes River subbasin. I sincerely appreciate your efforts on this project.

The following comments will not concentrate on all the good aspects of your report. For the sake of brevity I am confining these comments to specific questions or concerns that arose as I reviewed the document. I have referenced the specific items by the appropriate page and paragraph.

Page vii, paragraph 4: You mention errors and biases that could contribute to the variability of the run size estimates. This would be especially true if the counts or estimates were done in several different ways. In fact these counts and estimates have been done the same way each year. Why would we start to see large variability now? Redd counting conditions in 1993 and 94 were probably as good as they have ever been.

Page vii, paragraph 6: You refer to the potential affects of reduced river flow and a substandard fish ladder as factors contributing in the depressed run above Sherars Falls. The Deschutes River has one of the most stable flow regimes of any river in the country. The Sherars Falls ladder is unchanged and has obviously effectively passed summer/fall chinook in past years. Why would these factors only drive down adult escapement in recent years?

Page viii, paragraph 1: You mention heavy recreational use and the Sherars Falls fish trap as potential factors affecting passage above the falls. The Sherars Falls fish trap has operated each year since 1977, during years when there was higher escapement above the falls. Why would the trap deter adult passage now? River recreational use has been high in the area above Sherars Falls for many years, including concentrated raft takeout immediately above the Sherars Falls fishway. Why would these two factors only deter use in recent years? The closure of the Sherars boat ramp in 1995 did not appear to appreciably increase escapement.

Page viii, paragraph 3: You mentioned that competition/predation from rainbow trout/ steelhead probably adversely affects survival of juvenile chinook. It is ironic that the low escapement/production of summer/fall chinook above Sherars also corresponds to years with low returns of naturally produced summer steelhead and years when the trout population appears to be stable, not exploding by any means. Past food studies were conducted on resident rainbow above Sherars Falls in 1976. This study reported that of samples collected each month for one year, the only identified salmonid remains observed were newly emerged whitefish, which constituted the bulk of the diet of rainbow less than 15 cm. in March (Schroeder and Smith, 1989). There are no data for the Deschutes trout population that indicates that chinook are an important rainbow prey item.

Page ix, paragraph 3: You inferred that the Sherars Falls fishery and the above Sherars summer run component were integrally related. However, when considering the five year period from 1977 - 1981 fall chinook passing through the Sherars Falls trap after August 15 comprised over 80 percent of the summer/fall chinook total trap catch for four out of the five years. This seems to indicate that the later "fall" run component may have been an important contributor to the Sherars fishery.

Page 8, paragraph 2: You indicated that the adult passage at Sherars Falls increased as flows increased and that this increased passage was possible because of fish jumping the falls. In actuality the improved passage was likely not over the falls, but around. As flow increases there are good passage conditions for fish on either side of the falls, so fish do not have to fight against the turbulence and velocity at the falls.

Page 10, paragraph 2: You infer that there may have been summer chinook migrating above the Pelton/Round Butte Complex site, even though there were apparently no fall chinook. Will Nehlsen (1995) referred to a quote from Monte Montgomery about spawning surveys done prior to the closing of Pelton Dam, which could not locate any summer/fall chinook spawning above that site. It is illogical to assume that if there had been summer/fall chinook spawning documented above the dam site that there would not have been some required mitigation for these fish in the final PGE FERC license.

Page 16, paragraph 6: You mention that changes in survival may be caused by factors in both the freshwater and ocean environments. If this is true of the Deschutes summer/fall chinook, why would the above and below Sherars population components be affected differently if the environmental factors are the same for both?

Page 18, paragraph 1: You justify the straying problem by stating that "an estimated 100 stray summer/fall chinook were caught in the Deschutes River from 1978 - 85. That would average 12.5 strays caught per year. This appears insignificant considering the thousands of out-of-basin stray summer steelhead entering the river annually. I do not believe you can suggest chinook straying into the Deschutes is at all comparable to the steelhead straying.

Page 18, paragraph 2: This is misleading. There are years of harvest data collected from the sport and tribal fisheries at and downstream from Sherars Falls that do not indicate large numbers of stray summer/fall chinook in the river. In addition we have collected salmon carcasses below the falls and have found few marked hatchery stray chinook (i.e. 1995 = 124 carcasses, with one adipose clipped fish).

Page 18, paragraph 3: You infer that fallback of chinook at Sherars Falls may be significant. Other than the radio telemetry study, we have little indication that fallback is a significant problem. We have not seen large numbers of Sherars Falls tags appearing in the sport and Tribal fishery below the falls. We have not seen Sherars Falls tags in carcasses recovered below the falls. We have not seen large numbers of tagged fish passing through the Sherars trap. The fallback of the radio tagged fish was likely the result of excessive handling and/or injury, or death. I question if fallback is really a problem. We have attempted to minimize fallback by providing a recovery area that provides a quiet refuge for fish to recover from the anesthetic effects of CO2. Fish must be revived in order to find their way out of the recovery pool and back into the river. There is no way that 1 in 5 fish tagged falls back over the falls (page 19, paragraph 1).

Page 19, paragraph 2: You talk about the effects of lost tags when calculating population or escapement estimates. We agree that there is the potential for serious error if this tag loss were to occur. For that reason all summer/fall chinook have been double-tagged (one numbered tag and one colored filament) for many years. We estimate, based on five years data, that the probability of a fish losing both tags is 1.6%.

Page 20, paragraph 2: This paragraph talks about the affects of handling and tagging on fish migration and cites the example of fall chinook radio-tagged at Sherars in 1989. It is interesting to note that in 1979 ODFW radio-tagged 31 spring chinook at Sherars Falls and 28 of those fish migrated into the Warm Springs River. The other three fish remained in the Sherars Falls area and presumably died (Lindsay and Jonasson, 1989). In other words 90.3 percent of these fish appeared to migrate upstream without any adverse affects of the tagging or handling. Therefore, the radio telemetry example for fall chinook may not be representative of expected mortality, but may more accurately reflect tagging technique.

Page 22, paragraph 1: You mention that temperature of the Deschutes River at the mouth may discourage chinook from entering the river. Ironically, in the late summer the high water temperature at the mouth of the Deschutes is commonly in the Columbia River. The Deschutes River is usually several degrees cooler than the Columbia and it has been assumed that the Deschutes may even act as a type of thermal refuge and entice fish into entering the river.

Page 25, paragraph 4: You mentioned that night-time fish passage through the Sherars fishway suggests the fish may be wary of exposure while in the fishway. This is accurate, in fact we have seen an apparent increase in passage during the daylight since the sport and tribal fishery has been significantly restricted and the boater numbers were reduced by the closure of the Sherars Falls takeout.

Page 26, paragraph 5: The first sentence should read: ... fish from passing when it is **not** in operation,... You also suggest that the trap may discourage fish from using the fishway and thus inflate the numbers spawning below the falls. This trap has been operated each year since 1977. Why would we see an aversion reaction only in the last few years when there was no apparent problem earlier?

Page 27, paragraph 4: You mention the Frog Springs Creek washout and the potential affects on chinook spawning. Please remember that historically one of the most intensively used spawning areas on the river was the first three miles downstream from the Pelton Rereg Dam. This area was upstream of the washout and yet the numbers of spawners in this area has plummeted.

Page 28, Table 2: The Deschutes Club proposed, but never has installed any riprap or jetties in the river.

Page 29, paragraph 4: The average chinook exploitation rate since 1977 is very misleading. This average calculation included years with no sport and very restricted Tribal harvest. The average exploitation for years with full blown sport and tribal fisheries would be much greater than 25%. In fact if you calculate exploitation for the component of the run destined for above Sherars Falls rather than using the estimated run to the river, the rate may have been excessive and at least part of the reason for the collapse of this component of the run.

Page 33, paragraph 3: You cite Huntington's (1985) conclusion that erosion of gravel from islands has offset the loss of natural gravel recruitment by the dams. I have been flying the river at least twice annually from the early 1970's and I have not observed any gross changes in any island configuration below the Reg Dam. Therefore, I find it hard to believe there has been any appreciable island erosion compensating for the lack of natural gravel recruitment.

Page 37, paragraph 2: You speculate that fish spawning activity may actually help to maintain suitable gravel quality for future spawning. It does appear that this may be accurate. The other thing that appears to happen in some areas (i.e. immediately downstream from the dam) is the increase in rooted aquatic vegetation. This vegetation appears to have a domino affect, that is the more rooted vegetation the more fine material collected, which encourages the establishment of more and more rooted vegetation. I am not sure what reverses or breaks this cycle.

Page 39, paragraph 2: You cite Lindsay (1980), who determined that juvenile chinook usually rear in the same general area in which they were spawned. It has been my observation that these juveniles prefer the river margin for rearing where there is good hiding cover - usually in the form of emergent or over-hanging vegetation. This cover could be critical to avoid predation. The majority of the reservation bordering the river has been denuded by livestock in recent years (including near-shore rooted aquatic vegetation).

What affect has this habitat loss had on juvenile survival or escapement of adult chinook above Sherars Falls?

Page 43, paragraph 1: If C. shasta is a significant problem now, why was it not a problem in earlier years? A high incidence of C. shasta was found in juvenile chinook in the late 1970's (Fessler), but adult chinook escapement was good. What has changed to make this a major problem now? I should mention that I have personally observed concentrated gull feeding activities at Moody Rapids (river mile 0.5) and below in late July. It is difficult to determine what the birds are targeting, but it could be weakened chinook juveniles that are afflicted with C. shasta.

Page 44, paragraph 5: You state that higher densities of rainbow/steelhead could be related to the decline in chinook above Sherars Falls. Ironically it appears the river segment with the largest increase in trout numbers may be the river below Sherars Falls. Trout population inventory in two three-mile study reaches above Sherars Falls (river mile 55.5 - 58.5 and 68.8 - 71.8) in 1995 indicated that the population of trout over eight inches is stable - not increasing from previous years. Deschutes River steelhead runs have been depressed for a number of years, although there have been good numbers of out-of-basin stray hatchery fish entering the river. Some of these strays are undoubtedly spawning in the Deschutes. As I cited earlier, past rainbow food studies did not reveal any salmonid predation by rainbow, other than some emergent whitefish.

Page 45, paragraph 1: You stated that rainbow trout over 31 cm increased to approximately 1,500 fish/kilometer at RK 93 in 1983. In actuality the estimated number of rainbow/kilometer in this area in 1985 was actually 295 and by 1985 it was estimated to have been 81 fish/kilometer (Schroeder, 1989).

As mentioned above, it appears that the trout population below Sherars may have increased at a greater rate than the population above Sherars. If this is accurate, why are chinook doing better below Sherars Falls?.

Page 57, paragraph 2: You indicate that variability in run size is probably the result of something in the ocean. If this is the case, why are the run components from above and below Sherars Falls affected differently? Would this suggest that there are two separate populations with different ocean rearing distribution (i.e. north and south)? Coded wire tag recovery from Deschutes summer/fall chinook from ocean fisheries indicated that approximately 90% of the harvest occurred north of the Columbia River (Jonasson and Lindsay, 1988). This ocean harvest was occurring during the period when the run component above Sherars was strong.

Page 59, paragraph 1: You suggest that ocean harvest has contributed little to run size variability. But you then state that Deschutes run size has been depressed approximately 25% by ocean fisheries. Is this a contradiction here? It seems that 25% is significant.

Page 65, paragraph 2: "The variability in run size of this stock since 1977 appears to be driven by marine factors". If this is the fact, why the apparent discrepancy between the two components of the run?

Page 66, no.3: We have no data to suggest that there are more stray fish spawning below Sherars Falls (i.e. trap counts, carcass counts etc.). Actually the reduced escapement of adult chinook above Sherars Falls may indicate there has been poor survival of pre-smolt juveniles above the falls!

Page 67, paragraph 3: You speculate that poor passage at Sherars Falls may be responsible for the upper river decline. There have not been any obvious differences in river flow or trap operation that would cause this problem. Why have we not had a problem as a result of these problems during the late 1970's or early 80's?

Page 67, paragraph 6: In actuality, the temperatures in the Columbia River are probably a bigger concern than the temperatures in the lower Deschutes.

Page 69, paragraph 1: The problem does not appear to be adult chinook not finding suitable spawning habitat above Sherars Falls. The problem has been there are not the numbers of adults passing above the falls.

Page 72, no. 2: It appears that future chinook production in the Metolious River could result in downstream migrants facing the same speculative temperature and disease problems that are faced by juveniles rearing below the Reg Dam.

Page 72, no. 3: Where would the extra flow come from? The Pelton/Round Butte complex is operated as a run of the river facility during the spring, summer and fall months (i.e. the same amount of water entering the reservoirs is released downstream).

The only way to increase river flows during this period would be to draft the reservoirs, which poses many other problems above the dams.

I appreciate the opportunity to review and comment on this report. I hope these comments will be of some assistance.

Sincerely,

James A. Newton
District Fish Biologist

cc: Chip Dale
Jim Griggs
Mark Fritsch

Comments on the November 21, 1995 Review Draft

Evaluation of Deschutes River Fall Chinook Salmon
by Roy Beaty

Don Ratliff, December 16, 1995

Overall Impression

Roy has done a tremendous job putting together data available on Deschutes "summer/fall" chinook including possible impacts out of the basin. These efforts have made me think deeply about my assumptions, as he has forced me to think of his. This is a very healthy process. I have two major problems with the assumptions/hypotheses in this draft report. The first is that a discrete stock of summer chinook (different than spring chinook) spawned in the Metolius River. The second is that the large spawning concentration below the Pelton Reregulating Dam was the result of inadequate fish facilities that suddenly forced chinook to spawn there. I think this hypothesis stems from the concentration on information from 1977 to present, without looking hard at information available starting in 1957. This earlier information shows a significant increase in the summer/fall run starting in 1968. I hypothesize that this increase was due to changes in habitat and competition due to the 1964 flood. I also am concerned is that the schedule for this report is such that time may not be allocated to incorporate all available input and this report may not be as accurate as possible. The following includes comments on those sections where I have additional data or knowledge to share, and/or where I disagree with Roy's hypotheses. I appreciate the opportunity to learn from the other sections. I will comment referenced by page on the body of the report. These comments apply equally to both the Summary at the start, and the Synthesis at the end.

page 1-1st Paragraph

Although the three-dam Pelton Round Butte Hydroelectric has the storage capacity (page 34) to "regulate" flows the impression that flows have been significantly altered in incorrect. The reservoirs are kept nearly full to maximize head, and thus energy production. This is the reason there is no detectable difference in the magnitude and frequency of high flow events in the lower Deschutes River pre vs post Round Butte Dam closure (page 34).

page 2-1st Paragraph

Hatchery mitigation was provided only for spring chinook and summer steelhead because agencies involved (two state, two federal) in the 50s and 60s did not observe significant numbers of summer/fall chinook above this location. Chinook caught later than the normal spring chinook migration time were thought to be straggling spring chinook (George Eicher, personal communication). See comments on page 7. Summer-run chinook were reared in the mid-1970s because the spring chinook run was so low that not enough brood could be captured in the Pelton Trap for production requirements.

page 7

I agree completely that this group of fish is not strictly a fall stock. Pelton trap counts (attached) by month bear this out. Zeke Madden and I operated the Pelton Trap together from 1971 until Zeke retired about 1987 when this duty was transferred to the Round Butte Hatchery crew. Some large bright chinook have always entered the trap starting in late June. For several years we counted these separately-until the fall chinook study could not find any spatial or temporal difference with what they were calling fall chinook. However, these fish are distinctly different from the spring chinook (as noted on the bottom of page 8).

page 8-3rd Paragraph

The assumption I take strong exception to is that the historic spawning area for Deschutes summer chinook was the Metolius River. Although fish tagged at Bonneville Dam during the "summer run" have been observed in the Metolius (Galbreath 1964), these must have been stragglers from the spring chinook run. They also could have been Willamette Stock spring chinook which were being reared at the Fish Commission's Metolius hatchery at the time. Many Willamette spring chinook do not cross Willamette Falls until June. For this assumption to remain in the report, Roy needs to make a case for separating large bright later-running summer chinook from the smaller earlier-running spring chinook in the Metolius. Unlike most streams, the Metolius River gets colder as you move downstream due to the input of very cold spring tributaries (Riehle 1993). The historic spawning area for spring chinook was above bridge 99. I don't think there is any evidence of two discrete stocks of chinook spawning in the upper Metolius.

That is not to say that the Deschutes at one time did not have a large run of "summer chinook". Chinook once spawned in the Crooked River system, as well as into upper Squaw Creek. However, these components were lost to Agriculture early in the century. At the time of the first count in the late 1950s, chinook numbers with a summer/fall timing were relatively low (Pelton Counts attached). I think it is most likely that these fish spawned in the main Deschutes, and Crooked River below Opal Springs. They also could have spawned in lower Squaw Creek, and made the redds counted by Game Commission biologists from 1951-59 (summarized in Nehlsen

1995). Temperatures in lower Squaw Creek are maintained by springs (Alder Springs). However, these springs are considerably warmer (about 12 C) than springs in the Metolius Basin (10 to 6 C).

page **13**-2nd paragraph

Citing Anonymous, undated. This is a special pet-peeve of mine. I think this information was put together by Kirk Schroeder and Bob Lindsay for the special work group in 1992. If it is worth citing, we should make them put their names on it, even if we do it years later. Otherwise it is worse than "grey literature" (black literature?). It will be impossible for someone in 20 years to find it. I also have trouble with agency reports without an author(ie. ODFW 1994; CTWS and ODFW 1993). Someone wrote these, not an agency. They should put their names on them. Otherwise, who is one to talk to if they have questions in the future?? Having nameless sources not only hurts the credibility of the work reported, it undermines the ability of future biologists to build upon that work. A problem of this report.

page **15**- H3

Although run-size estimates were not available until trapping at Sherars started in 1977, we have aerial redd counts back to 1972, and drift boat counts back to 1966 (Newton 1973). There is Sherars Falls catch data back at least to 1963 (Newton 1973). We also have continually been counting chinook entering the Pelton Fish trap back to 1958 (attached). Both the Sherars Falls sport fishery (Newton 1973), and the Pelton Trap count show a significant increase in the summer/fall run starting in 1968. And as stated on page 15, this should "lend more confidence that the stock is presently somewhat robust".

page **18**-1st paragraph

Although Monty Montgomery (cited by Nehlsen 1995) theorized that the large number of chinook spawning below the Reregulating Dam in 1968 was due to the closure of John Day Dam, I find that hard to buy. It seems impossible that maintstem Columbia River spawners would drop downstream and move up a tributary 100 miles to spawn when they had trouble finding the fish ladders (see comments page 33 and 68 about increases in 1968). Although some stray CWT chinook have been seen in the Deschutes, their numbers are very small as compared to the percentages of stray steelhead.

page **33**

Some mention should be made of the 1964 flood-the largest flow on record-as an "exceptional hydraulic event" (page 36, bottom paragraph) that reformed bars, and moved out fine sediments. This is the most likely reason that Aney et al. (1967) documented the highest concentration of streambed spawning gravel in "Section I" between the Pelton Reregulating Dam and Shitike Creek.

page 35

The rate of streambed degradation below a dam is a function of the frequency and severity of bedload-mobilizing events. The work now being done on the geomorphology of the lower Deschutes River (Grant et al. 1995), should determine how frequently these events have occurred since 1923, when the river was first gauged.

page 36-2nd Paragraph

As noted above, the most likely reason for the superior quality of the gravel measured below the Reregulating Dam was the 1964 flood. As discussed later in the report (page 67, last paragraph) there is no evidence that this area had large concentrations of spawning chinook prior to dam construction in the late 1950. However, Pelton Trap counts (attached) show there were not large runs in the late 1950s or early 1960s either. Pelton counts and Sherars sport fishery monitoring (Newton 1973) both indicate that summer/fall chinook runs above the Falls increased dramatically in 1968. This would coincide with 1965 brood chinook, the first to spawn after the flood. Not only would these fish have benefitted from high quality spawning conditions, populations of potential resident fish predators and competitors would have been significantly reduced.

page 37-Thermal Conditions

Although impoundments tend to buffer against seasonal thermal extremes, I think Roy's analysis in this case is accurate. We must remember that the lower Deschutes is not a normal run-off system. Flows are, and always were maintained at a base level near 3,000 cfs from spring input relatively close to where temperatures were monitored. Springs entering the Deschutes below Lower Bridge and in the lower Crooked River (Opal Springs) are relatively warm, about 12 C, and always have "buffered" against seasonal temperature extremes. The lower Crooked River is coldest during run-off when snow melt from the Ochoco Mountains overwhelms the springs in the lower end. It is warmest during low flow periods.

page 43-Ceratomyxosis

There could be a differential mortality if fall chinook below Sherars Falls emigrate out of the Deschutes significantly earlier than those above Sherars. This would be especially true if mean emigration timing is before early June below Sherars

Falls (page 41, Figure 18). My earlier work showed peak concentrations of infectious units in the Deschutes in early June in 1979 and 1981 (Ratliff 1983). However, ceratomyxosis has been present at least since the mid 1960s (Conrad and Decew 1966), and should have been effecting survival of chinook even during the large runs in the late 1960s and early 1970s.

page 68-spawning concentrations below the Pelton Regulating Dam

All chinook were passed over the dams until 1965 when some were held for brood stock. I don't think any chinook were passed over after 1966. There is no evidence that the Buckley trap is not effective in collecting chinook. Chinook captured after the brood collection time for the spring chinook hatchery program (after July 1), were, and continue to be, put back into the Deschutes to spawn naturally. However, it is difficult to imagine that this would lead to the large numbers spawning there, if conditions were not favorable to their survival at the time. If the establishment of the spawning concentration below the Pelton Reregulating Dam is an artifact of the hydro project, it is more likely due to role played during the 1964 flood (Huntington 1985).

Reference I used not Cited in Report

Conrad, J.F., and M. Decew. 1966. First report of Ceratomyxa in juvenile salmonids in Oregon. Progressive Fish-Culturist 28:238.

Newton, J.A. 1973. Deschutes River spring Chinook salmon (Oncorhunchus tshawytscha) Walbaum, a literature review. Oregon Wildlife Commission Central Region Administrative Report No. 74-1. Bend, OR. 50p

Riehle, M.D. 1993. Metolius Basin water resources monitoring, 1988-1992, progress report. Sisters Ranger Distric, Deschutes National Forest. Sisters, OR. 73 p.

United States Department of the Interior

BUREAU OF LAND MANAGEMENT
Prineville District Office
P.O. Box 550 (3050 N.E. 3rd Street)
Prineville, Oregon 97754

IN REPLY REFER TO
6700

Roy Beaty
Columbia River Inter-Tribal Fish Commission
729 N.E. Oregon, Suite 200
Portland, Oregon 97232

0 7 1996

Dear Roy:

Hopefully this will finally make its destination. I made a mistake on the second attempt and it did not make it. First off, I think you have done a great job putting together this report. And you have also forced the biologist on the Deschutes River to reevaluate their assumptions as well as defend them. This is always a healthy process. As discussed in our telephone conversion, it appears that Don Ratliff and Jim Newton did a thorough job editing your report and have provided information that will strengthen this document. This has made my job much easier. Listed below is basically a reiteration of previous comments to emphasize areas I feel strongly about.

page 13-2nd paragraph
The citing of anonymous, undated needs to be replaced with the author. If the data is not good enough for them to put their name on it than it probably shouldn't be used.

page 33
The effects of the 1964 flood being a possible cause to the concentration of fall chinook spawning directly below Pelton Rereg Dam should be addressed.

And finally, I know there has been some discussions about the need for riparian vegetation for fry rearing. Could it be possible that the lack of riparian vegetation in areas above Sherar's Falls maybe limiting the success of fall chinook fry and this is contributing to lower adult returns?

Thanks for the opportunity to review this document.

Sincerely,

James M. Eisner II
Fisheries Biologist
Deschutes Resource Area

Appendix 3

Detailed Data, Data Sources, and
Analytical Methods

Appendix 3.1

Standardized and Relative Run Size

Variability in run size for Deschutes R. summer/fall chinook salmon becomes more meaningful when we compare it to that of other stocks. We can then start to determine which patterns are caused by factors common to many stocks (e.g., ocean rearing conditions) and which patterns are unique to the Deschutes R. stock.

Variability and trends in run size can be compared more easily among different stocks by first standardizing them; that is, by removing differences in overall run magnitude. One simple way to standardize is to express the run size in a particular year (N_i) as a ratio with the average run size for that stock over a base period ($N_{0\rightarrow n}$). The resulting standardized run size (N'_i; Eqn. 1) varies about the value 1.0, as long as all N_i compose the base period. I chose to compare standardized run sizes for the Deschutes R. summer/fall stock (adults only) with three other stocks having similar run timing and ocean tag recovery distribution and a complete data set for the period 1977-93 (Appendix Table 3.1.1, *following page*).

$$N'_i = \frac{N_i}{N_{0-n}} \qquad (1)$$

Long-term trends and the effects of inriver factors on the Deschutes R. stock may be revealed further by mathematically comparing its standardized run sizes to those of the other stocks. My objective was to remove some of the variability in run size that is caused by large-scale, common factors, thereby exposing the effects of the management and environments unique to that stock. This is most effective when common factors (e.g., the ocean environment) have a large and consistent effect on the survival of members of several stocks.

I compared the standardized run sizes of Deschutes R. summer/fall (*D*) to those of itself, Columbia R. upriver summer (*C*), Lewis R. wild fall (*L*), and Grays Harbor fall (*G*) again in this treatment. The relative run size of the Deschutes R. stock ($N^R_{D,i}$) is the ratio of its standardized run size in a particular year ($N'_{D,i}$) to the mean of the standardized run sizes of all four stocks in that year ($N'_{DCLG,i}$) (Eqn. 2; Appendix Table 3.1.1, *following page*). Obviously, different results would have been obtained for $N^R_{D,i}$ if other stocks had been used in the comparison.

$$N^R_{D,i} = \frac{N'_{D,i}}{N'_{DCLG,i}} \qquad (2)$$

Appendix Table 3.1.1. Actual, standardized, and relative run sizes of Deschutes R. summer/fall adults with those of similar stocks, 1977-93. Data from PSC (1994).

Return Year	Actual Run Size				Standardized Run Size					Relative Run Size
	D[a]	C[b] (000)	L[c] (000)	G[d] (000)	D[a]	C[b]	L[c]	G[d]	Mean	D[a]
1977	7492	34.3	29.8	13.2	1.55	1.34	1.24	.55	1.17	1.33
1978	6125	38.7	18.5	10.6	1.27	1.51	.77	.45	1.00	1.27
1979	4883	27.8	32.7	12.1	1.01	1.09	1.36	.51	.99	1.02
1980	4493	27.0	38.8	22.0	.93	1.05	1.61	.92	1.13	.82
1981	5020	22.4	25.0	12.4	1.04	.88	1.04	.52	.87	1.20
1982	6906	20.1	13.0	13.7	1.43	.79	.54	.58	.83	1.72
1983	5165	18.0	16.8	9.1	1.07	.70	.70	.38	.71	1.50
1984	2995	22.4	13.3	22.6	.62	.88	.55	.95	.75	.83
1985	3452	24.2	13.3	15.0	.72	.95	.55	.63	.71	1.01
1986	4954	26.2	24.5	17.5	1.03	1.02	1.02	.74	.95	1.08
1987	6154	33.0	37.9	31.2	1.28	1.29	1.57	1.31	1.36	.94
1988	5911	31.3	41.7	39.1	1.22	1.22	1.73	1.64	1.45	.84
1989	5088	28.8	38.6	56.0	1.05	1.13	1.60	2.35	1.53	.69
1990	2369	25.0	20.3	39.6	.49	.98	.84	1.66	.99	.49
1991	1060	18.9	19.9	29.5	.22	.74	.82	1.24	.76	.29
1992	1726	15.1	12.6	30.3	.36	.59	.52	1.27	.69	.52
1993	8250	22.0	13.4	30.5	1.71	.86	.56	1.28	1.10	1.55
MEAN	4826	25.6	24.1	23.8						

[a] Deschutes R. summer/fall adults.

[b] Columbia R. upriver summer adults.

[c] Lewis R. wild fall adults. Lewis R. is a Washington tributary of the Columbia R. below Bonneville Dam.

[d] Grays Harbor fall adults. Grays Harbor is a Washington coastal bay with several tributary streams.

Appendix 3.2

Spawner - Recruit Analysis

Spawner-recruit analysis can reveal which broods had exceptionally good or poor survival and therefore can help identify specific factors affecting year-class strength. The run of Deschutes R. summer/fall chinook salmon in any particular year may include members of up to five broods (representing age classes 2-6), so run size is the sum of a mix of age classes from brood years that experienced different lifetime survival rates. By assigning returning fish to their respective broods and summing (across return years) for each brood year, we can estimate the number of returning fish (recruits) produced by the spawners (escapement) in that brood year. The ratio of recruits to spawners (R/S) is also a measure of stock productivity: ratios > 1.0 indicate the spawners at least replaced themselves and, if continued, the stock will increase in numbers. On the logarithmic scale I use, 0 is equivalent to 1. Spawner-recruit analysis is most useful for detecting exceptional survivals during the first year of life (egg deposition, embryo/alevin development, freshwater rearing, juvenile migration, and early ocean rearing), when members of a year class are isolated from those of other year classes.

I extended and modified slightly the spawner-recruit analysis of Anonymous (undated) (Appendix Tables 3.2.1 and 3.2.2, *following pages*), which is based upon estimates of age-at-maturity/return for brood years 1975-80 (Jonasson and Lindsay, undated). I used the age composition shown in the inset of Appendix Table 3.2.1 to assign returning adults to brood years. To provide estimates of recruits from 1989-1991 brood years, returns of older fish after 1994 were projected from average distributions of age-at-maturity for earlier brood years.

In a parallel analysis, I substituted escapement for run size to represent recruits, which treats inriver harvest the same as all other lifetime mortalities (Appendix Table 3.2.2, *second page following*). This approach addresses the question, "Did inriver harvest, when added to all other mortalities, allow the stock to replace itself (i.e., R/S ≥ 1.0, Ln R/S ≥ 0)?"

Appendix Table 3.2.1. Distribution of returning adults to brood years based on average age compositions in spawning run (inset), brood years 1976-91. Projected numbers are shaded. Adapted from Anonymous (undated) using data from CTWS and ODFW (1994).

Return Year 1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	Recruits (Total)	Brood Year
5																			n/a	1973
327	5																		n/a	1974
2432	247	10																	n/a	1975
2119	2116	417	0																4652	1976
	2125	2555	449	0															5129	1977
		2038	3073	537	3														5651	1978
			3384	2268	230	3													5885	1979
				2360	1395	265	5												4025	1980
					1367	1608	380	6											3361	1981
						1576	2308	472	6										4362	1982
							2261	2867	453	7									5588	1983
								2809	2754	499	3								6065	1984
									2698	3028	245	4							5975	1985
										2967	1488	283	3						4741	1986
											1458	1717	216	8					3399	1987
												1681	1310	633	6				3630	1988
													1284	3844	424	5			5557	1989
														3765	2574	597	7		6943	1990
															2521	2606	483	5	5615	1991
4883	4493	5020	6906	5165	2995	3452	4954	6154	5911	6500	3194	3686	2813	8250	5524	n/a	n/a	n/a	**TOTAL RUN**	

Age Distribution

Age	%
6	0.10
5	7.67
4	46.59
3	45.64

Appendix Table 3.2.2. Recruits-per-spawner ratios using adult run size and adult escapement to represent recruits, brood years 1977-91. Recruit estimates based on run size are from Appendix Table 3.2.1; recruit estimates based on escapement used the same distribution method as shown in Appendix Table 3.2.1.

Brood Year	Spawners (S)	Recruits (R) = Run Size			Recruits (R) = Escapement		
		No.	R/S	Ln (R/S)	No.	R/S	Ln (R/S)
1977	5631	5129	.91	-.09	5129	.91	-.09
1978	4154	5651	1.36	.31	5650	1.36	.31
1979	3291	5885	1.79	.58	5810	1.77	.57
1980	2542	4025	1.58	.46	3510	1.38	.32
1981	3183	3361	1.06	.05	2452	.77	-.26
1982	4890	4362	.89	-.11	3296	.67	-.39
1983	3669	5588	1.52	.42	3919	1.07	.07
1984	2025	6065	3.00	1.10	3878	1.92	.65
1985	2645	5975	2.26	.81	4003	1.51	.41
1986	3801	4741	1.25	.22	3487	.92	-.09
1987	4097	3399	.83	-.19	2881	.70	-.35
1988	3520	3630	1.03	.03	3541	1.01	.01
1989	4770	5557	1.16	.15	5529	1.16	.15
1990	2224	6943	3.12	1.14	6901	3.10	1.13
1991	3523	5615	1.59	.46	5630	1.59	.47

Appendix 3.3

Fallback and Resulting Biases

Fallback Rate

Recaptures of tagged fish at Sherars Falls (Appendix Table 3.3.1, *following page*) can be used to estimate fallback rates by expanding for the probability (rate) that the fallbacks reascend the falls and by the probability (rate) that the reascending fish will be intercepted by the trap again. Reascension rates for fall chinook salmon at some Columbia and Snake river dams (Appendix Table 3.3.2, *second page following*) can be used in lieu of data specific to Sherars Falls, although those rates may be affected by turbine passage injuries and/or other factors. Also, inferences can be made from the absence of tag recoveries in creel censuses and carcass surveys below Sherars Falls.

Trap efficiency (i.e., probability that an ascending fish will be caught) can be estimated by assuming that hourly and daily passage rates are independent of trap operations and then expanding recaptures according to the proportion of each week that the trap is operated. The trap is operated about 40 hr each week (CTWS and ODFW 1993), or about 0.25 of the time (40 hr ÷ 168 hr/wk = 0.238). Alternatively, using the proportion of tags recovered among fish sampled above Sherars Falls from 1977 to 1995 suggests that only 0.15 (range 0.03-0.28) of the adults and 0.11 (range 0-0.31) of the jacks pass through the trap at Sherars Falls when it is in operation (and hence are tagged). Using lower recapture rates like these would produce a higher estimate of fallback with this method.

Data from creel censuses and carcass surveys below Sherars Falls provide another perspective on potential fallback rates. In 10 yr of such samples, zero tags from Sherars Falls have been recovered (Appendix Table 3.3.3, *third page following*). The aggregate (from both sources and all years) probability of taking so many samples without recovering at least one tag is essentially zero, except at very low fallback rates and/or at extremely high reascension rates (Appendix Table 3.3.4, *third page following*). For this method, I assumed — **very** conservatively — that the creel census is a sample of the entire run and that only the net fallback (total fallback minus reascension) number of tags are available for recovery. I also assumed that the carcass survey is a sample of the below-falls escapement and that only the net fallback number of tags are available for recovery.

Appendix Table 3.3.1. Recapture rates of summer/fall chinook salmon in the Sherars Falls trap, 1977-94. Blank values are zero. Data are summarized from the Sherars Falls trap database, ODFW, The Dalles, OR.

	JACKS[a]			ADULTS[b]			TOTAL		
YEAR	No.[c] Tagged	No. Recap-tures[d]	% Tags Recap-tured	No.[c] Tagged	No. Recap-tures[d]	% Tags Recap-tured	No. Tagged	No. Recap-tures	% Tags Recap-tured
1977	356	5	1.4	773	13	1.7	1129	18	1.6
1978	371	3	0.8	982	10	1.0	1353	13	1.0
1979	591	13	2.2	510	15	2.9	1101	28	2.5
1980	426	1	0.2	393	4	1.0	819	5	0.6
1981	480	3	0.6	504	2	0.4	984	5	0.5
1982	110			269	1	0.4	379	1	0.3
1983	69			212			281		
1984	18			41			59		
1985	88			113			201		
1986	68			197			265		
1987	195			266	2	0.8	461	2	0.4
1988	219			303	2	0.7	522	2	0.4
1989	119			203	1	0.5	322	1	0.3
1990	65			118	1	0.8	183	1	0.5
1991	93			81	2	2.5	174	2	1.1
1992	82	1	1.2	166	1	0.6	248	2	0.8
1993	38			124	3	2.4	162	3	1.9
1994	70			82			152		
MEAN			0.4			0.9			0.7
MIN.			0.0			0.0			0.0
MAX.			2.2			2.9			2.5

[a] *Species* code 11 in database.
[b] *Species* code 10 in database.
[c] *Tag Type* field not blank in database.
[d] Recapture noted as *Comment* in database.

Appendix Table 3.3.2 Fallback and reascension rates for fall chinook salmon at some Columbia and Snake river dams, 1990-93.

			FALLBACK		REASCENSION			
SITE(S)	YEAR	[A] PASSAGE EVENTS[a]	[B] Events[b]	Rate (B/A)	[C] Events[c]	Rate (C/B)	SOURCE	NOTES
Snake R. dams	1991	79	18	0.23	0	0.00	Mendel et al. 1992	Adults trapped, radio-tagged, and released at Ice Harbor (upstream and downstream sites) and Lower Granite dams
	1992	164	49	0.30	9	0.18	Mendel et al. 1994	
mid-Columbia R. dams	1993	480	61	0.13	3	0.05	Stuehrenberg et al. 1995	Adults trapped, radio-tagged, and released at John Day and Priest Rapids dams
McNary Dam	1990	—	71	—	14	0.20	Wagner and Hillson 1993	Jacks and adults falling back downstream via the juvenile bypass system were floy-tagged, released, and observed reascending fishways. Some probably passed after the fishway counting season, so reascension rate is minimum.
	1991	—	167	—	26	0.16		
MEAN				0.22		0.12		

[a] One fish passing one dam = one passage event. Includes passage at the dam where trapped, if released at or above that site.

[b] One fish detected downstream of a dam that it had been recorded as passing.

[c] One fish detected above a site (dam) at which it had previously fallen back.

Appendix Table 3.3.3. Creel census and carcass survey sampling rates below Sherars Falls, 1986-95. Data from J. Newton, ODFW, The Dalles.

Year	Total Run Size[a]	Below-Falls Escapement[a]	Samples (N)		Sample Rate (%)			No. Tagged[b]
			Creel	Carcass	Creel	Escapement	Aggregate	
	A	*B*	*C*	*D*	*(C/A)*	*(D/B)*	*(C+D)/(A+B)*	
1986	12,254	1,690	1,126	0	9.2	0	8.1	265
1987	7,911	1,227	1,101	0	13.9	0	12.0	461
1988	8,015	1,597	1,012	0	12.6	0	10.5	522
1989	8,079	4,572	756	0	9.4	0	6.0	322
1990	4,061	1,490	424	48	10.4	3.2	8.5	183
1991	5,491	3,809	87	116	1.6	3.0	2.2	174
1992	5,300	3,990	0	9	0	.2	.1	248
1993	—	—	0	0	0	0	0	160
1994	18,808	12,793	0	0	0	0	0	151
1995	14,762	12,631	0	124	0	1.0	.5	348

[a] Data from, or calculated from, CTWS and ODFW (1995).
[b] Number of tags released was tallied from Sherars Falls trap database and differ slightly from data reported in CTWS and ODFW (1995).

Appendix Table 3.3.4. Aggregate probability of **not** recovering at least one Sherars Falls tag during creel censuses and carcass surveys below Sherars Falls, 1986-95, given various combined rates of fallback and reascension. ∅ = $< 1\times10^{-9}$; →0 = $< 1\times10^{-6}$.

Fallback Rate	Reascension Rate									
	.999	.90	.80	.70	.60	.50	.40	.30	.20	.10
.05	**.988**	**.310**	**.096**	.030	.009	.003	.001	<.001	→0	→0
.10	**.977**	**.096**	.009	<.001	<.001	<.001	→0	→0	→0	∅
.15	**.965**	.030	<.001	<.001	→0	→0	→0	∅	∅	∅
.20	**.954**	.009	<.001	→0	→0	∅	∅	∅	∅	∅
.25	**.943**	.003	<.001	→0	∅	∅	∅	∅	∅	∅
.30	**.932**	.001	→0	∅	∅	∅	∅	∅	∅	∅

Bias in Escapement Estimates Associated with Fallback

Escapement bias (B^E) describes the relationship between the escapement estimate (***N***) and the true escapement (***N****; Eqn. 3). In the general (unmodified) Petersen estimator (Eqn. 4), the bias from fallback without reascension arises because fewer marked fish are available to be recovered than were marked and believed to be available for recovery (***M***). The number of fish examined for marks in the spawning ground survey (***C***) and the number of marked fish recovered (***R***) are not material in the bias, as demonstrated below.

$$B^E = \frac{N}{N^*} - 1 \qquad (3)$$

$$N = \frac{MC}{R} \qquad (4)$$

After fallback, the number of marked fish actually available for recovery (***M****), differs from ***M***. Eqn. 3 can be rewritten using Eqn. 4 (Eqn. 5) and reduced to reveal a simple function of the numbers of marked fish (Eqn. 6).

$$B^E = \frac{\frac{MC}{R}}{\frac{M^*C}{R}} - 1 \qquad (5)$$

$$B^E = \frac{M}{M^*} - 1 \qquad (6)$$

The number of marked fish available is a function of the number of fish marked and the complement of the net fallback rate (***F***; Eqn. 7). By substituting into Eqn. 6 and reducing, we see that the bias depends solely on the fallback rate (Eqn. 8).

$$M^* = M(1 - F) \qquad (7)$$

$$B^E = \frac{1}{1-F} - 1 \qquad (8)$$

Bias in Exploitation Rate Estimates Associated with Fallback

Exploitation rate (***u***) is simply catch (***C***) as a proportion of the total run, i.e., catch plus escapement (***E***; Eqn. 9). By inspection, we see that change in ***u*** (i.e., bias, B^u) is not just a function of change (i.e., bias) in ***E*** (B^E), but is also dependent on the relative magnitude of ***C*** to ***E*** (i.e., ***u*** itself).

$$u = \frac{C}{C+E} \qquad (9)$$

The limits of B^u, as determined by the limits of ***u***, also can be defined by inspection. When catch (***C***) and exploitation rate (***u***) approach zero, the change (bias) in exploitation rate (B^u) approaches the inverse of the bias in escapement (B^E; Eqn 10). Substituting from Eqn. 6 and solving, we see that the bias in exploitation rate is limited to the additive inverse of the fallback rate (Eqn. 11).

$$\text{As } C \to 0, \quad B^u \to \frac{1}{B^E} \qquad (10)$$

$$B^u = -F \qquad (11)$$

Conversely, when catch increases relative to escapement and the exploitation rate approaches 1.0, the escapement is relatively small and its bias has little effect on the exploitation rate. Hence, the bias in exploitation rate (B^u) approaches zero as u approaches 1.0.

The bias in exploitation rate caused by net fallback is less than the escapement bias. For example, at an estimated exploitation rate of 0.30 and a net fallback rate of 0.20, the exploitation rate bias would only be -0.14, and the true exploitation rate would be 0.342.

When Marked and Unmarked Fish Fall Back at Equal Rates

When unmarked fish fall back over Sherars Falls at the same rate as marked fish, the bias still exists and the resulting estimate is for the number of fish that passed over the falls. This can be demonstrated with an empirical example, using variables from above (inset, right).

	Passage Over Falls (hypothetical)	Actual Escapement after 20% Net Fallback	No. Recovered (Assume 10% Sampling)
Unmarked	300	240	24
Marked	100 = M	80 = M*	8 = R
TOTAL	400	320	32 = C

Present estimation methods (Eqn. 4, in general) would estimate an escapement of 400 (Eqn. 12), which includes the 80 fish (400 - 320) that fell back and did not reascend. The bias is 0.25 (80/320), as shown earlier. Accounting for the loss of marks through fallback (M^*) produces an accurate estimate of spawning escapement above the falls (Eqn. 13). Similarly, I could show that if only marked fish fell back, the estimated and actual escapements would be different, but the 0.25 bias would remain.

$$N = \frac{100 \times 32}{8} = 400 \quad (12)$$

$$N^* = \frac{80 \times 32}{8} = 320 \quad (13)$$

Appendix 3.4

Redd Counts

Appendix Table 3.4.1. Redd count summary for Deschutes R. summer/fall chinook salmon in index (I), random (R), and index + random (I + R) survey reaches above and below Sherars Falls, 1972-95. Data from CTWS and ODFW (1995).

Year	Total Redds I, R, I+R	Above Sherars (surveys 1-18) No.	Above Sherars (surveys 1-18) Proportion	Below Sherars (surveys 19-26) No.	Below Sherars (surveys 19-26) Proportion
1972	578	412	.71	166	.29
1973	—	—	—	—	—
1974	716	514	.72	202	.28
1975	926	867	.94	59	.06
1976	1139	867	.76	272	.24
1977	988	642	.65	346	.35
1978	366	320	.87	46	.13
1979	659 [a]	463 [a]	.70	196	.30
1980	787	620	.79	167	.21
1981	538	407	.76	131	.24
1982	—	—	—	—	—
1983	229	191	.83	38	.17
1984	—	—	—	—	—
1985	285	147	.52	138	.48
1986	229 [b]	167 [b]	.73	62	.27
1987	—	—	—	—	—
1988	236	121	.51	115	.49
1989	324 [c]	132	.41	192 [c]	.59
1990	108	66	.61	42	.39
1991	98	38	.39	60	.61
1992	242	62	.26	180	.74
1993	332	60	.18	272	.82
1994	302	36	.12	266	.88
1995	216	43	.20	173	.80

[a] Data gaps for surveys 5 and 8 in 1979 were filled with counts of four and five redds, respectively, which were calculated from average proportions in preceding years.

[b] Analyses in this report used 226 total and 164 above, as mistakenly reported by CTWS and ODFW (1995, Appendix B).

[c] Analyses in this report used 324 total and 192 below, as mistakenly reported by CTWS and ODFW (1995, Appendix B).

Appendix 3.5

Exploitation Rates of Above-falls Component

Because of greater exposure to the Sherars Falls fisheries, exploitation rates on the above-falls component of the summer/fall run probably are higher than estimates calculated for the run as a whole. We do not know the extent of this difference in rates, but we can evaluate its effect based on assumptions about how much greater the exploitation rate on above-falls fish is relative to the rate on below-falls fish. For example, fish destined for areas above the falls might be harvested at rates 1.5-times, 2.0-times, 3.0-times, ... greater than below-falls fish, which need not pass through the fishery area. I call this factor the relative exploitation rate.

I calculated hypothetical exploitation rates for the above-falls component for relative exploitation rates ranging from 1.5 to 10.0 (Appendix Table 3.5.1, *following page*). Estimated escapements (adults plus jacks) for the area above Sherars Falls and for the entire river (CTWS and ODFW 1994) were used to calculate escapements for the area below Sherars Falls for 1977 and subsequent years. I then iteratively allocated each year's harvest (adults plus jacks; CTWS and ODFW 1994) to the above-falls and below-falls components to produce the desired relative exploitation rate (X) based on the hypothetical exploitation rates for the components above (u_a) and below (u_b) the falls (Eqn. 14).

$$X = \frac{u_a}{u_b} \qquad (14)$$

The bias (B^u) compares the overall estimated exploitation rate ($u*$; from CTWS and ODFW, 1994) to the hypothetical above-falls rate (u_a)(Eqn. 15). This value indicates how well the overall rate represents the rate on the above-falls component given the assumed relative exploitation rate.

$$B^u = \frac{u*}{u_a} \qquad (15)$$

Because the relative exploitation rates I use are all greater than 1.0, the bias is always negative. That is, the overall rate always underestimates the exploitation rate on above-falls component under these conditions.

Appendix Table 3.5.1. Mean hypothetical exploitation rates for the above-falls component and bias in overall exploitation rates at various relative (to below-falls) exploitation rates (*X*). Period covered is 1977-92 and 1994.

Relative Exploitation Rate (X)	Mean Exploitation Rate (%)		Bias		
	Overall (u^*)	Above-falls (hypothetical) (u_a)	Mean	Min. (1978)	Max. (1994)
1.5	25.8	28.4	- 0.19	- 0.04	- 0.31
2.0	25.8	29.8	- 0.17	- 0.06	- 0.46
3.0	25.8	31.3	- 0.22	- 0.07	- 0.61
5.0	25.8	32.7	- 0.26	- 0.08	- 0.72
10.0	25.8	34.0	- 0.28	- 0.09	- 0.81
2.0 and -0.25 bias in escapement due to fallback	29.9	34.4	- 0.29	- 0.18	- 0.56

Appendix 3.6

CWT Ocean Recovery Distribution

Coded-wire-tag (CWT) recoveries help define the ocean distribution of a stock, the marine environments to which it is exposed, and the exploitation rates of the stock in ocean fisheries. Deschutes R. summer/fall chinook subyearlings were coded-wire-tagged only in 1978-80 (1977-79 broods; Jonasson and Lindsay, undated). The Pacific Salmon Commission's Chinook Technical Committee (CTC) estimates exploitation rates and other statistics for several indicator stocks of summer and fall chinook in the Columbia R. Basin and elsewhere, but not for the Deschutes R. stock (PSC 1994). Therefore, the harvest and survival analyses of the CTC can be applied to the Deschutes R. stock only indirectly, through one of the indicator stocks, if a suitable one exists.

I assumed that a suitable surrogate stock for this purpose would have a similar pattern of CWT recoveries in ocean fisheries. CWT recovery data for the 1977-79 broods of Deschutes R. wild "fall" chinook and five other stocks (four are CTC indicators) were downloaded from the Pacific States Marine Fisheries Commission's Regional Mark Information System (Appendix Table 3.6.1, *following page*). I summarized the proportion of total recoveries of age classes 3-5 of those broods and stocks in the marine fisheries of Alaska, British Columbia, and Washington/Oregon (Fig. 30). I did not include recoveries in California, in high seas fisheries, or in fresh water. This method does not provide catch distribution estimates in part because I did not expand for tagging and fishery sampling rates, as Jonasson and Lindsay (undated; their Table 5) apparently did.

I also calculated a distribution index for the five other stocks relative to the Deschutes R. stock. The distribution index for a stock (DI_s) is based on the sum of the absolute differences in proportions of recoveries between the Deschutes R. stock ($P_{D,f}$) and this stock ($P_{S,f}$) in the three general fishery areas (f) (Eqn. 16). Potential values for DI_s range from 0.0 (no overlap in recovery distribution with the Deschutes R. stock) to 1.0 (recovery pattern is identical to that of Deschutes R. stock). These results are dependent on relative (among stocks) numbers of juveniles CWTed, relative (among stocks) vulnerability to the different fisheries, relative (among recovery years) exploitation rates by the various fisheries, and relative (among brood years) age composition at maturity of the stocks.

$$DI_S = \frac{2 - \sum_{f=1}^{3} |P_{D,f} - P_{S,f}|}{2} \qquad (16)$$

Appendix Table 3.6.1. CWT codes (1977-79 brood years) and number of recoveries of age classes 3, 4, and 5 in marine fisheries of Alaska (AK), British Columbia (BC), and Washington/Oregon (WA/OR) for Deschutes R. summer/fall ("Fall") and five other stocks of summer and fall chinook. NFH = National Fish Hatchery. Data from Pacific States Marine Fisheries Commission's Regional Mark Information System.

	CWT Codes by Brood Year			No. Recoveries by Area			
Chinook Stock	1977	1978	1979	AK	BC	WA/OR	Total
Deschutes R. Wild "Fall"	H70201 H70202 H70203 H70204 H70205	071662 071828 071834 071835 071836 071837	071848 072145 072146 072147 072150	23	26	23	72
Winthrop NFH Summer	631811 631820	n/a	n/a	3	4	4	11
Grays Harbor Wild Fall	631743	631646 631833 631837	632043	11	16	15	42
Lewis R. Wild Fall	631618 631619 H10101	631858 631859 631902 631910 632002 H10104 H10105	632123 632124 632125 632207 632208 632213 632214 H10201 H10202 H10205	119	90	90	299
Spring Cr. NFH Tule Fall	055401 056001 056201	050434	n/a	0	218	455	673
Priest Rapids Hatchery Bright Fall	631741	631821 631857 631958 632017	631948	195	92	17	304

Lewis R. wild fall chinook may be the best available CTC indicator stock for Deschutes R. summer/fall chinook, based on distribution of recoveries (DI = 0.78; Fig. 30) and quantity of data available (N = 299) for these brood years. Winthrop NFH summer chinook (DI = 0.90) and Grays Harbor wild fall chinook (DI = 0.86) both had higher DI values, but had more limited numbers of years and CWT recoveries available. Priest Rapids Hatchery (Columbia R. upriver bright) fall chinook appears less suitable because its recovery distribution is skewed greatly northward, whereas the Deschutes R. distribution is skewed slightly to the south (Fig. 30).

The ocean distribution of the Deschutes R. stock and/or the other stocks may have changed since these brood years. This is particularly true if the downstream shift in spawning in the Deschutes R. coincides with a change in the proportions of genetically different components (e.g., summer-run versus fall-run) of the stock. We do not know what the present ocean distribution of the Deschutes R. stock is or whether Lewis R. wild fall chinook is still a suitable indicator stock.

Appendix 3.7

Composite Ocean Index (COI)

Upwelling and intensity of the Aleutian Low Pressure System (ALPS) can affect the survival of Deschutes R. summer/fall chinook rearing in the N. Pacific Ocean. I examined two series of seasonal (March-September and July-September) summary indices (sum of monthly upwelling volumes, $m^3 \cdot s^{-1} \cdot 100\ m^{-1}$; Nickelson 1986) for upwelling at each of two stations — 45°N, 125°W (off the northern Oregon coast) and 48°N, 125°W (off the northern Washington coast) — for their correlation with survival (R/S) of the 1977-1989 brood years of Deschutes R. summer/fall chinook. Data were obtained from Bakun (1973) and NMFS Pacific Environmental Group, Monterey, CA, via T. Nickelson, ODFW, Corvallis Research Lab. I chose the March-September series for the 48° station for further examination because (1) it correlated best with R/S, (2) the stock generally distributes north of the Columbia R. mouth (Fig. 30), and (3) I suspect that total spring/summer (i.e., March-September) upwelling has a greater effect on primary and secondary production than does summer (i.e., July-September) upwelling alone. There is little correlation among indices for the two sites and for the two seasons (my results), and indices for individual months within the same years may not be correlated (Nickelson 1986).

I calculated several COIs using various combinations of upwelling indices in one or more years (brood year and subsequent years) and an index of ALPS intensity obtained from Beamish and Bouillon (1993) and from R. Beamish, Canada Department of Fisheries and Oceans, Pacific Biologicai Station, Nanaimo, BC. Because units for the upwelling and ALPS indices differed, I standardized both by the 1946-93 mean for the respective index before combining them in COIs.

The ALPS index is the sum of the areas of the N. Pacific Ocean covered in winter (December-February) and spring (March-May) by the ALPS less than 100.5 kPa in barometric pressure (Beamish and Bouillon 1993). As with the upwelling index, I included (usually by addition) the ALPS index for one or more years beginning with the brood year (i.e., months of incubation and freshwater rearing). Most of the COIs included no more than three years of upwelling and ALPS indices, because over 90% of the stock matures after three or fewer years in the ocean (i.e., age 4 or younger; inset in Appendix Table 3.2.1). In some cases I subtracted index values for the brood year (i.e., year before ocean entry) to determine whether a rebound (i.e., from relatively low to relatively high upwelling or ALPS) effect might be operating.

The highest correlation ($r = 0.689$, $P = 0.009$) with R/S was obtained with a COI that summed the upwelling index 1 yr after the brood year (BY+1) and the ALPS index in the 3 yr following the brood year (BY+1, +2, +3) (Appendix Tables 3.7.1, 3.7.2, *following pages*). Other COIs that included similar years of indices also correlated well with survival estimates of Deschutes R. summer/fall chinook cohorts.

Appendix Table 3.7.1. Combinations of upwelling and ALPS indices used to calculate the Composite Ocean Index (COI) and associated correlation coefficients (R, small "r"). See preceding text for data sources.

Values Included in COI[a]										
Upwelling Index 48°N, 125°W (March-Sept.)				ALPS Index					Rank	
BY	+1	+2	+3	BY	+1	+2	+3	R	(by R)	Note
+								-.011	19	
	+							.471	12	
-	+							.299	16	Subtract BY to test for rebound effect
		+						.187	17	
	+	+						.563	7	
	+	+	+					.497	9	
					+			.067	18	
						+		.455	13	
					+	+		.435	14	
					+	+	+	.584	6	
						+	+	.542	8	
	+				+			.478	11	
	+				+	+	+	.689	1	
	+	+			+	+	+	.647	3	
	+					+	+	.586	5	
	+						+	.486	10	
	+			-	+	+	+	.647	3	Subtract BY to test for rebound effect
	x				x	x	x	.657	2	Product
	$\sqrt[n]{x}$				x	x	x	.357	15	Geometric mean

[a] Values are included according to the symbols: + = added, - = subtracted, x = multiplied.

Appendix Table 3.7.2. Values used to calculate the COI that produced the highest correlation with R/S, which was used for Fig. 31. Sources of data are described above.

Brood Year (BY)	R/S[a]	Upwelling Index 48°N, 125°W (March-Sept.) BY+1	ALPS Index BY+1	ALPS Index BY+2	ALPS Index BY+3	COI
1977	.91	83	10,462,950	4,457,925	11,967,525	5.41
1978	1.36	173	4,457,925	11,967,525	13,409,775	6.85
1979	1.79	197	11,967,525	13,409,775	2,475	6.35
1980	1.58	94	13,409,775	2,475	13,959,000	5.61
1981	1.06	213	2,475	13,959,000	6,321,150	5.65
1982	.89	67	13,959,000	6,321,150	5,001,075	4.97
1983	1.52	88	6,321,150	5,001,075	12,646,125	4.97
1984	3.00	197	5,001,075	12,646,125	10,624,050	6.84
1985	2.26	132	12,646,125	10,624,050	8,901,225	6.82
1986	1.25	133	10,624,050	8,901,225	2,632,050	5.13
1987	.83	119	8,901,225	2,632,050	3,543,750	3.79
1988	1.03	93	2,632,050	3,543,750	6,685,650	3.15
1989	1.16	113	3,543,750	6,685,650	10,206,675	4.63
1946-93 Mean (for standardizing)		95.7		5,918,236		

[a] From Appendix Table 3.2.2.

The COI most highly correlated with R/S is the one referred to in the text. This high correlation — even when supported by known associations of both upwelling and the ALPS with salmon production — does not prove that a direct or indirect cause-effect relationship exists. I selected the summary upwelling index that provided the highest correlation from among four that are not well correlated. Eqn. 17 is the regression equation for this COI. Also, there are many other physical factors (e.g., sea surface temperature, salinity) correlated with fish distribution and abundance that may influence salmon survival more directly than does upwelling from March through September at 48°N, 125°W or the intensity of the ALPS.

$$\frac{R}{S} = -.580 + .373(COI) \qquad (17)$$

The COI has little value for predicting run size. It helps explain the variability in the survival of a brood (R/S), but incorporates values (e.g., ALPS intensity in BY+3) that are not available until after much of the cohort has returned. Also, even if we know beforehand how many of a cohort will survive to maturity, we cannot precisely allocate surviving members of a brood beforehand to run years, because the age distribution at maturity may vary among cohorts.

Appendix 3.8

Columbia R. Harvest Rates

Returning Deschutes R. summer/fall chinook are harvested each year in mainstem Columbia R. commercial, sport, and tribal ceremonial and subsistence fisheries. Because mainstem harvest rates differ greatly between the summer and fall runs and are reported separately for the two runs (e.g., WDFW and ODFW 1994), I had to make some assumptions and calculations to arrive at an aggregate harvest rate each year for the stock as a whole. In general, I estimated the proportions of summer- and fall-run fish based on trapping data at Sherars Falls and then used those proportions to weight the mainstem harvest rates reported for those seasons (WDFW and ODFW 1994), with an allowance for the fact that Deschutes R. fish are not exposed to the entire Zone 6 (Bonneville Dam to McNary Dam) fishery.

The proportions of summer- and fall-run adult chinook each year from 1977 to 1994, inclusive (Appendix Table 3.8.1, *following page*), are based on some qualifications and assumptions:

- Adults are those fish with lengths ≥ 54.1 cm, without regard to species classification (e.g., 10 = chinook, 11 = jack) or sex classification (e.g., 14 = jack) in the Sherars Falls trap database. Classifications in the database are not always consistent with respect to length cut-offs, and I consider length to be the most objective and consistent criterion for discriminating between adults and jacks.
- All adults arriving at the trap were tallied for this summary without regard to their Disposition (e.g., 52 = mortality).
- Summer-run fish are those adults arriving at the trap between 1 July and 15 August, inclusive, each year; those adults arriving thereafter I considered fall-run. The proportion of summer-run fish for a year is the number trapped during this period divided by the total number trapped during the entire season.
- The trap, when operating, samples both runs at equal rates. (This assumption may be invalid: summer-run fish probably are more likely to migrate above the falls and may therefore be sampled at higher rates by the trap.)
- The week-to-week timing of the summer run is relatively consistent across years. This assumption is necessary because trapping did not begin at the same time each year. The dates on which the first fish were trapped ranged from 16 June, 1977, to 10 August, 1984, so the proportion of fish trapped between 1 July and 15 August is also an artifact of when trapping began. Therefore, I adjusted for late starts by expanding the number of fish arriving during later summer periods (e.g., 10-15 August in 1984) by the proportion of summer-run fish arriving during the same period in years when trapping began earlier. Because trapping ended approximately 1 November every year, I made no adjustment for ending date.

Appendix Table 3.8.1. Harvest rates for summer/fall chinook in Columbia R. mainstem fisheries, 1977-94. Harvest rates are based on estimates of harvest and escapement by WDFW and ODFW (1994). n/a = not available.

Return Year	Date of 1st Trap Record	[A] Summer Run (proportion of all adults)	Columbia R. Harvest Rates[a]		
			[B] Summer Run	[C] Fall Run	Aggregate [AB+(1-A)C]
1977	16 Jun	.37	.017	.45	.29
1978	19 Jun	.17	.017	.37	.31
1979	19 Jun	.17	.022	.34	.29
1980	22 Jun	.10	.022	.33	.30
1981	30 Jun	.11	.029	.20	.18
1982	13 Jul	.12	.032	.35	.31
1983	9 Aug	.17	.008	.19	.16
1984	10 Aug	.22	.007	.34	.27
1985	24 Jul	.22	.021	.32	.26
1986	15 Jul	.29	.010	.42	.30
1987	5 Aug	.20	.018	.43	.35
1988	4 Jul	.14	.018	.46	.40
1989	19 Jun	.17	.002	.39	.33
1990	21 Jun	.21	0	.33	.26
1991	1 Jul	.23	.003	.29	.22
1992	17 Jun	.08	.003	.19	.17
1993	20 Jun	.17	.009	.19	.16
1994	21 Jul	.17	n/a	n/a	.17

[a] Assumes that Deschutes R. fish of both summer and fall runs are harvested in Zone 6 at half the rate that (Columbia R.) upriver stocks are.

Furthermore, I assumed that both summer and fall runs are harvested at only half the rate in Zone 6 (Bonneville Dam to McNary Dam) that can be calculated from catch and escapement estimates reported for (Columbia R.) upriver stocks (WDFW and ODFW 1994, their tables 31 and 36).

Aggregate (summer and fall) harvest rates of Deschutes R. summer/fall chinook in mainstem Columbia R. fisheries have ranged from 0.16 (1983 and 1993) to 0.40 (1988) based on my estimation methods (Appendix Table 3.8.1, *preceding page*). These rates are higher than those estimated from CWT recoveries of the 1977-79 broods (10%; Jonasson and Lindsay, undated). The difference in estimates may be attributable, in part, to my underestimating the proportion of summer-run fish, which are harvested at lower rates than fall-run fish in mainstem Columbia R. fisheries.

Appendix 3.9

Disposition of Adult Equivalents among Fisheries, Adult Dam Passage Mortality, and Escapement

The impact of the Deschutes R. fishery on the run is easily estimated, and managers are very aware of it. However, the effects of other fisheries and mortality factors, although potentially more severe, are less obvious than those of terminal fisheries. Therefore, I wished to define the impact of the Sherars Falls fishery relative to escapement and to other readily apparent and easily estimated sources of mortality in adults and subadults. I reconstructed the runs (adults only) for each year, 1977-94, back to the mouth of the Columbia R. by summing estimates of:

- Deschutes R. harvest (CTWS and ODFW 1994),
- Spawning escapement (CTWS and ODFW 1994; adjusted for an assumed fallback bias of 0.25),
- Columbia R. mainstem harvest (Appendix Table 3.8.1), and
- Adult passage mortality for Bonneville and The Dalles dams (5% per dam, with mortality for one dam incurred before, and one dam incurred after Columbia R. harvest).

The adults in these reconstructed runs were then assigned to brood years, based on assumed age structure (inset, Appendix Table 3.2.1) and added to estimates of ocean harvest. For ocean harvest, I used adult equivalent (AEQ) exploitation rates for brood years 1982-88 of Lewis R. wild fall chinook (PSC 1994) as a surrogate for the Deschutes R. stock, with the average base period rate (0.35) used for 1977-81 brood years (hence, the uniform rate for that period in Fig. 33). This provided a standard unit (i.e., AEQ at the mouth of the Columbia R. by brood year) for comparing the relative effects ***of these factors only*** on run size of this stock (Appendix Table 3.9.1, *following page*).

I focused on the more obvious and easily estimated human-caused mortalities in the post-smolt part of the life cycle. Many sources of perhaps substantial mortalities are not included.

Appendix Table 3.9.1. Estimated escapement, harvests, and dam mortalities of adult equivalent (AEQ; to mouth of Columbia R.) Deschutes R. summer/fall chinook [no. *(%)*] by brood year, 1974-88. Sources of data, qualifications, and methods are described in preceding text. Rounding causes some apparent discrepancies.

BROOD YEAR	SPAWNING ESCAPEMENT	HARVEST, BY FISHERY AREA: Ocean	HARVEST, BY FISHERY AREA: Columbia R. Mainstem	HARVEST, BY FISHERY AREA: Deschutes R.	DAM MORTALITY	TOTAL AEQ
1974	3808 *(30)*	4409 *(35)*	1799 *(14)*	1892 *(15)*	690 *(5)*	12,598
1975	2902 *(28)*	3631 *(35)*	1481 *(14)*	1793 *(17)*	568 *(5)*	10,375
1976	2348 *(26)*	3157 *(35)*	1240 *(14)*	1778 *(20)*	496 *(6)*	9,021
1977	2417 *(26)*	3206 *(35)*	1123 *(12)*	1902 *(21)*	511 *(6)*	9,160
1978	3212 *(30)*	3805 *(35)*	1356 *(12)*	1893 *(17)*	605 *(6)*	10,871
1979	3279 *(31)*	3688 *(35)*	1289 *(12)*	1692 *(16)*	588 *(6)*	10,537
1980	2260 *(32)*	2474 *(35)*	736 *(10)*	1198 *(17)*	401 *(6)*	7,067
1981	1962 *(32)*	2165 *(35)*	807 *(13)*	909 *(15)*	343 *(6)*	6,185
1982	2637 *(36)*	1952 *(27)*	1130 *(16)*	1066 *(15)*	446 *(6)*	7,230
1983	3135 *(30)*	3483 *(33)*	1678 *(16)*	1670 *(16)*	590 *(6)*	10,555
1984	3102 *(30)*	2388 *(23)*	2045 *(20)*	2186 *(21)*	659 *(6)*	10,381
1985	3202 *(31)*	2583 *(25)*	1935 *(19)*	1972 *(19)*	641 *(6)*	10,334
1986	2789 *(36)*	1936 *(25)*	1277 *(16)*	1253 *(16)*	489 *(6)*	7,746
1987	2305 *(45)*	1219 *(24)*	706 *(14)*	517 *(10)*	332 *(7)*	5,080
1988	2834 *(54)*	1354 *(26)*	594 *(11)*	88 *(2)*	337 *(6)*	5,208

Appendix 3.10

Pelton Trap Counts

Data in the following tables reflect different counting methods and exceptional conditions in different years, as described below:

Year	Method Change or Exceptional Condition
1957-71	All chinook arriving before 1 July were counted as spring chinook; those arriving on or after 1 July were counted as fall chinook.
1957	Counts were incomplete until 16 June due to barrier washout.
1962	Spring chinook adult total includes one large fish caught in February, 1962.
1972	Trap was inoperable from 31 May through 5 July.
1972-95	Fish arriving after 1 July were counted as spring chinook if they bore a hatchery fin clip. Unmarked fish arriving on or after 1 July were counted as fall chinook. Round Butte Hatchery has marked 100% of its spring chinook production beginning with the 1972 brood year.
1983	1 adult spring chinook was caught in November.
1984	Trap was not operated from 27 July to 10 September.
1985	Trap was not operated from 16 July to 18 October.

Appendix Table 3.10.1. Pelton trap counts of **spring** chinook **jacks**, 1957-95. From D. Ratliff, PGE.

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOT
1957		8	40							48
1958		7								7
1959	1	37	33							71
1960		12	47							59
1961		12	59							71
1962	1	10	13							24
1963		29	17							46
1964		12	22							34
1965		8	18							26
1966		1	2							3
1967		2	4							6
1968		8	21							29
1969		3	46							49
1970			16							16
1971										0
1972		3		84	28					115
1973		3	33	29	30	8	1			104
1974			2	3			1			6
1975			4	16	4	1				25
1976			14	11	18	3	1			47
1977			4	1	2					7
1978			4		2					6
1979			1	2	2					5
1980		3	34	11						48
1981		7	65	4	2		2			80
1982		2	86	4	1					93
1983		6	33	8						47
1984		47	275	10						332
1985		9	159	93						261
1986		32	259	16	8					315
1987		44	204	28	15					291
1988		49	284	37	6					376
1989		13	566	92	13					684
1990		25	93	42	13					173
1991		8	262	71	4					345
1992		14	75	49	2					140
1993		2	38	15						55
1994		36	23	2	2					63
1995		32	73	3	1					109

Appendix Table 3.10.2. Pelton trap counts of **spring** chinook **adults**, 1957-95. D. Ratliff, PGE.

Year	Apr	*May*	Jun	*Jul*	Aug	*Sep*	Oct	*Nov*	Dec	TOT
1957		*83*	128							**211**
1958	6	*183*	170							**359**
1959	12	*237*	38							**287**
1960		*367*	121							**488**
1961	14	*192*	234							**440**
1962	20	*264*	79							**364**
1963	12	*122*	30							**164**
1964	37	*213*	34							**284**
1965	1	*63*	75							**139**
1966	5	*241*	49							**295**
1967	1	*77*	19							**97**
1968		*43*	74							**117**
1969		*38*	86							**124**
1970		*40*	71							**111**
1971		*4*	108							**112**
1972		*23*		*28*	5	*1*				**57**
1973		*10*	54	*21*	12					**97**
1974		*2*	59	*32*	31	*8*	3			**135**
1975			21	*8*	2					**31**
1976			16	*16*	9					**41**
1977		*4*	26	*4*	5					**39**
1978			15	*4*	1					**20**
1979		*8*	30	*5*	2					**45**
1980		*7*	33	*7*	7					**54**
1981	4	*146*	154	*49*	22					**375**
1982		*52*	291	*23*	4					**370**
1983	1	*290*	256	*18*	11		1			**577**
1984		*147*	108	*17*						**272**
1985		*706*	570	*112*						**1388**
1986		*437*	957	*80*	75					**1549**
1987		*476*	568	*90*	80					**1214**
1988		*626*	330	*107*	88					**1151**
1989		*688*	879	*35*	5					**1607**
1990		*873*	614	*428*	168					**2083**
1991		*390*	819	*274*	100					**1583**
1992	52	*1287*	473	*93*	21					**1926**
1993		*623*	726	*46*	1					**1396**
1994		*383*	135	*45*	28					**591**
1995		*542*	225	*27*	4					**798**

Appendix Table 3.10.3. Pelton trap counts of "**fall**" chinook **jacks**, 1957-95. D. Ratliff, PGE.

Year	Apr	*May*	Jun	*Jul*	Aug	*Sept*	Oct	*Nov*	Dec	TOT
1957				28	50	10				**88**
1958				4			1			**5**
1959				23	5	1	2			**31**
1960				5	1	34	81	14		**135**
1961				10	5	6	12			**33**
1962				1	8	11	1			**21**
1963				38	53	51	138	26	1	**307**
1964				16	12	37	131	15		**211**
1965				22	21	75	101	3		**222**
1966				5	9	11	25	2		**52**
1967				2	8	11	295	154	3	**473**
1968				21	60	87	193	19	5	**385**
1969				55	13	73	86	17	5	**249**
1970				27		28	143	32	1	**231**
1971					47		77	92	10	**226**
1972				18	20	20	75	20	3	**156**
1973				9	30	37	199	34	4	**313**
1974				6	12	7	57	7	1	**90**
1975				8	5	8	27	52		**100**
1976				6	4	13	69	45	19	**156**
1977				2	3	5	77	54	2	**143**
1978				1	6	7	53	40	5	**112**
1979				2	6	5	101	85	6	**205**
1980				5	1	6	66	23		**101**
1981				2	4	4	51	79	3	**143**
1982				5	2	6	49	89	36	**187**
1983				5	2	2	58	70	18	**155**
1984				1		7	61	87	7	**163**
1985				3			164	178	14	**359**
1986				4	4	5	58	222	36	**329**
1987				10	14	1	20	16	3	**64**
1988					3	3	38	32	8	**84**
1989				5	2	1	6	35	2	**51**
1990				2	3	1	9	17	1	**33**
1991				2	2		11	18	1	**34**
1992				5	2		7	10	10	**34**
1993				2				1	1	**4**
1994					1	4	27	75	5	**112**
1995				2	1		12	8		**23**

Appendix Table 3.10.3. Pelton trap counts of **"fall"** chinook **adults**, 1957-95. D. Ratliff, PGE.

Year	Apr	*May*	Jun	*Jul*	Aug	*Sep*	Oct	*Nov*	Dec	TOT
1957				73	117	75	17	4	3	289
1958				24	8	9	3	1		45
1959				89	15	18	1		1	124
1960				13	2	9	24	10		58
1961				13	9	5	9	1		37
1962				35	9	12	2	1		59
1963				15	3	5	7	3		33
1964				9	1	9	38	11		68
1965				21	8	23	15	2		69
1966				14	8	32	20	2		76
1967				8	17	19	27	4		75
1968				174	187	42	33	1	2	439
1969				142	75	88	14	6		325
1970				133	34	77	42	9		295
1971				163	116	85	46	11	1	422
1972				61	245	41	52	28		427
1973				76	222	45	59	18		420
1974				24	116	25	29	1		195
1975				40	26	18	22	5		111
1976				42	51	8	23	4	3	131
1977				21	88	49	37	32	1	228
1978				36	47	10	9	13	4	119
1979				8	13		24	26	1	72
1980				17	8	2	30	19	1	77
1981				22	26	14	28	38	4	132
1982				37	9	22	49	32	7	156
1983				79	36	7	16	27	9	174
1984				13		7	7	11	2	40
1985				28			20	16	1	65
1986				12	16	4	15	15	5	67
1987				170	126	4	10	8	1	319
1988				23	25	2	6	4	1	61
1989				24	10	5	7	20		66
1990				34	29	1	5	9		78
1991				35	39		3	6	1	84
1992				25	15	1	3	3	7	54
1993				59	3			1	1	64
1994				2	20	2	6	10	14	54
1995				6	2		10	6		24

Appendix 4

Engineer's Report:
Sherars Falls Fishway

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
ENVIRONMENTAL & TECHNICAL SERVICES DIVISION
525 NE Oregon Street
PORTLAND, OREGON 97232-2737
503/230-5400 FAX 503/230-5435

JAN 4 1995 F/NWO3

RECEIVED
JAN 9 1994
FISH SCI DEPT

Mr. Roy Beaty
Columbia River Inter-Tribal Fish Commission
729 N.E. Oregon Street, Suite 200
Portland, Oregon 97232

Dear Mr. Beaty:

On November 16, 1994, Steve Rainey of my staff accompanied you on a site visit to Shearer's Falls on the Deschutes River in north central Oregon. The trip was for the purpose of investigating the potential of improving existing upstream passage facilities. There is particular concern that passage problems at this site may be contributing to declines in fall chinook natural spawning upstream of the falls.

A brief investigation of pertinent information relating to fall chinook passage at Shearer's Falls has resulted in the enclosed summary of findings and conclusions by Mr. Rainey. We hope this will aid in the preliminary planning process as you continue assessing factors relating to reduced fall chinook activity above the falls. If there is a decision to proceed with fish passage improvements, we encourage you to contact our staff. We would anticipate participating fully in the development of new or modified passage facility designs for this site.

If there are questions or comments, please contact Mr. Rainey at (503) 230-5418.

Sincerely,

Brian J. Brown
for Jacqueline V. Wyland
Division Chief

Enclosure

SUMMARY:
INVESTIGATION OF UPSTREAM PASSAGE AT
SHEARER'S FALLS ON THE DESCHUTES RIVER
IN NORTH CENTRAL OREGON

by Steve Rainey
National Marine Fisheries Service (NMFS)
December 7, 1994

INTRODUCTION

At the invitation of Mr. Roy Beaty of the Columbia River Inter-Tribal Fish Commission (CRITFC), I accompanied Mr. Beaty on a November 16, 1994, site visit to Shearer's Falls (River Mile 43, Deschutes River, Oregon) to investigate passage improvement concepts. The proportion of the Deschutes fall chinook run spawning above the falls has diminished in recent years, and it is believed that poor passage at the existing ladder may be at least partially responsible. This is a very important component of the run, since the tribal fishery is primarily at the falls and targets these fish. I agreed to provide Mr. Beaty with this summary of findings, and a list of improvements that may incrementally improve passage at Shearer's Falls.

Recent Fall Chinook Passage Trends at Shearer's Falls

It is estimated that approximately 80% of the Deschutes River fall chinook run has spawned above Shearer's Falls during the last few decades. Prior to construction of the existing fish ladder, fall chinook may not have been able to pass the falls during some years, due to generally low autumn streamflows and the formidable height of the barrier (approximately 18 feet). Totals have numbered in the thousands until approximately the mid-1980s. Last year, according to Mr. Beaty, only 37 redds were counted above the falls, which constitutes the worst run on record. This year, Mr. Beaty referenced a redd count of only 16 above the falls, and noted that many adults were spotted holding in the large pool near the bridge below the falls. This may or may not suggest these fish wanted to pass over the falls. While the redds are often not easily observed during surveys and the total is not intended to be precise, according to Oregon Department of Fish & Wildlife (ODFW) biologist Steve Pribble, comparison with other years does show an alarming downward trend.

ODFW estimates that the total return of fall chinook to the Deschutes River in 1993 was 8,000 fish (a substantial number), but most of these either were not able to pass the falls or were destined for a downstream spawning area.

In the past, as much as 40% of the run was harvested at the falls (which is essentially the only location of concentrated salmon fishing effort). However, the Warm Springs Tribes have not had a fishery at the falls in recent years in an effort to allow the upstream component to be restored. Though run sizes are diminishing on the entire west coast, the tribe and other management entities are concerned that the fall chinook component spawning above the falls is dwindling at an accelerated rate.

According to ODFW, the reversal of proportions of fall chinook spawning densities resulting in greater redd counts below the falls may be due, in part, to greatly improved riparian habitat at most downstream sites. ODFW believes juvenile survival has benefitted greatly during the last few years. Concurrently, management actions such as changed trout harvest regulations (greater emphasis on catch and release), possibly resulting in increased competition, may be having a deleterious effect on chinook populations above the falls. Reduced presence of fall chinook may also be related to deteriorating gravel quality and quantity below Pelton Regulating Dam. Conversely, gravel quantity and quality downstream of the falls does not appear to be limiting spawning activity.

Description of Shearer's Falls and the Passage/Trap Facilities

One key question relates to whether passage at the falls has changed from previous periods, when upstream-bound adults used the same facilities to pass in ample numbers. The following description touches on the nature of the barrier, the tailrace hydraulic conditions observed below the barrier, hydrology, and the fish ladder and trap. (See enclosed sketch).

Barrier and Tailwater Hydraulic Conditions

The Deschutes River runs almost due north at this location. Shearer's Falls is formed by the presence of a large basaltic bedrock outcrop in the path of the Deschutes River. Over the years, a narrow deep chute-type channel has been eroded in the bedrock formation. The river drops approximately 18 feet in an 80-foot horizontal length adjacent to the left bank ladder/trap. The next 200 feet of channel (in the downstream direction) are also relatively steep, although most anadromous fish adults can probably ascend to the ladder area through a full range of streamflows by staying close to the steep, irregular sides of the channel where velocities are lower. Turbulent, aerated flow extends hundreds of feet downstream from the base of the ladder. The ladder is adjacent to the upstream-most, steepest portion of the falls. The ladder channel was excavated in rock and is sheltered from the falls by a residual tongue of bedrock. The upstream break of the falls runs diagonally, and is oriented approximately southwest to northeast. As flow starts to accelerate along the uniform break line, it forms a formidable high-velocity chute on the east side of the bedrock tongue that is impassable. Flow from the upper, impassable segment of the falls is directed into the left bank, and has caused some erosion of the steep rock channel wall. Flow is then directed back in the northward direction.

Hydrology

Streamflow on the day of the site visit was approximately 4500 cfs, which is close to mean flow for this period. Streamflow variation is not appreciable due to upstream power and irrigation storage projects. Normal year-round variations in streamflow at this site are from 3000-5500 cfs.

Fish Ladder and Trap

The ladder was constructed over 30 years ago and is a notched weir design. Ten weirs allow an incremental drop at each weir, totaling 18 feet. The average drop per weir exceeds standard criteria (maximum 1.0-foot), since it creates excessive turbulence in each pool at higher ladder flows and limits holding and resting opportunities in each pool for fish. One of the weaknesses of this type ladder is that slightly higher forebay elevations allow too much flow in the ladder, and (conversely) low forebay elevations starve the ladder.

The ladder entrance is on the downstream side of the downstream-most extremity of the bedrock tongue and is backset slightly from high velocity, turbulent flow. Flow from the upper falls is directed into the left channel bedrock wall just downstream of the entrance. The ladder has no auxiliary water system, so total ladder flow is passed from pool to pool within the ladder. Total flow is approximately 10 cfs. Fish that approach the ladder must do so by either approaching along the left bank and passing through the primary falls flow directed into the rock wall on this side of the channel or passing under the primary flow component. The primary attraction to the ladder is probably the absence of turbulence near the entrance (which affords a rest pocket), not the total attraction flow from the ladder entrance (which is quite low compared to conventional ladders).

A high-flow ladder is located immediately downstream and above the existing, primary ladder. During extreme high streamflows fish can pick their way up the high-flow ladder. During this period, the river water surface overtops the steep side walls of the rock channel, spreading out over the bedrock shelf and (probably) providing a number of routes for fish to pass. Flows of this magnitude during fall chinook passage months would be extremely rare.

At the upper end of the ladder, an angled diffuser blocks fish while passing flow to the ladder. A steeppass ladder is then lowered into the exit channel to collect/trap adults. Steeppass flow is pumped via a portable diesel pump. These fish are then interrogated, tagged, and returned to a trap recovery and release pool upstream of the fish ladder exit.

Trap Operation

The ODFW trap is in its 18th year of operation. It currently operates from June 15 through October 31 each year, 5 days a week, from 4 p.m. through midnight. This allows adults that may reject the steeppass entrance to pass during non-trapping hours, although the trap is operated during peak passage hours for much of the week. Counts of fish trapped and tagged fish are maintained, but indexing is not intended since the number of fish passing during non-trapping hours in unknown. Tagged fish are later counted in the Pelton trap or through carcass surveys, then extrapolated to arrive at upstream and downstream total return figures.

Probable Current Passage Performance

The fact that redd counts above the falls are decreasing and below the falls are increasing leads to the assumption that the ladder performance has deteriorated. Yet little has changed in the ladder/trap layout, design, and operation during the last 18 years.

The existing ladder is sub-standard compared to recent designs, but it has allowed passage of large numbers of fall chinook in the past. There has been no assessment of the extent of delay encountered by fish attempting to pass the falls. However, based on radio telemetry studies at other tributaries, delay is probably appreciable at this site. The fishway entrance is very poorly located relative to tailrace hydraulic conditions. Tailrace hydraulic conditions are severe through the entire streamflow range. A better entrance location would have been on the right bank, just downstream of the diagonal flow into the left wall (as referenced above). It could be that an appreciable number of fish approaching the falls are not able to find the ladder entrance during typical years, and fall back to spawn downstream.

My immediate impression was that the increased proportion of downstream redds relates to trap rejection. This has been documented at other sites. Fish that are reluctant to enter the trap often fall back and out of the ladder. Many may remain downstream. While ODFW admits that some fish are rejecting the trap entrance, intermittent operation of the trap would seem to reduce the probability that trapping is the primary problem, especially since trapping operations have not changed appreciably over the years.

Fish Ladder Improvements

Several passage improvements can be initiated and are listed below. The tribes are concerned about minimizing adverse aesthetic impacts. The following improvements can be completed with a minimum aesthetic impact, but may or may not result in increased upstream spawning proportions:

1. Build a right bank fishway which satisfies current standards. Include an auxiliary water system and multiple entrances. This would be the optimum measure, with the greatest expected reduction in delay, but would also be the most costly (over $1 million).

2. Provide the left fish ladder with an auxiliary water system and new entrance wall and gate at the location of the lowest weir. Provide the ability to discharge up to 100 cfs through the entrance with a hydraulic drop of 1.0 foot. This would entail construction of an intake structure, pipelines, stilling structure, an enlarged lower ladder pool, an adjacent add-in diffuser, and the new entrance wall and gate. The gate would need to be approximately 3 feet wide and 5 feet high. Rock excavation would be required, but aesthetic impacts could be minimized relative to trenches and auxiliary water structures. This would allow a greater attraction flow to be discharged, perhaps increasing the number of fish ascending the ladder. However, some rejection and fallout during trapping operations could still be expected. This would cost in the range of a few hundred thousand dollars.

3. Improve flow control to the fishway by adding the ability to control flow depth over the upper notched weir. This is a smaller incremental benefit relative to Numbers 1 and 2.

4. Add roughness walls at the left channel steep rock wall extending into the main channel. These could be a half dozen, or more, walls to project several feet from the rock wall surface into high velocity flow in the main channel. These "roughness elements" would create pockets between new walls for fish to ascend, one wall at a time, until they reach the fishway entrance. These would aid fish in finding the ladder entrance, and would cost tens of thousands of dollars.

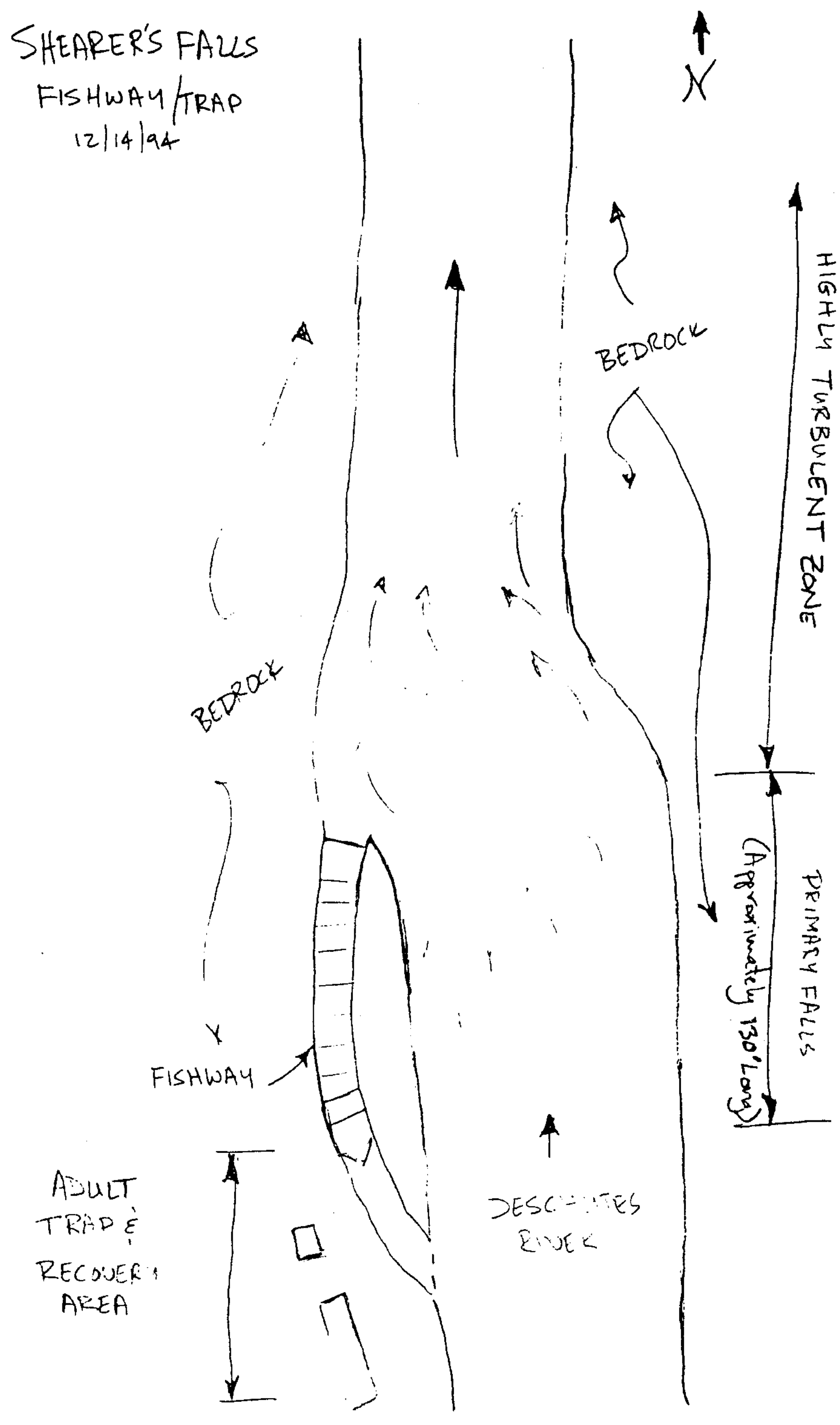
Tom Bumstead, a private consultant, has done a preliminary report on Shearer's Falls for the Warm Springs Tribes. However, I have not seen the report, nor do I have an understanding of the scope of work covered by that document.

CONCLUSIONS

Based on the above information, we conclude that some fall chinook are not able to pass Shearer's Falls each year. We attribute this to either the antiquated ladder design, or the trapping operations in the upper ladder.

We recommend the severity of passage limitations be assessed through an adult radio-telemetry study before major facility changes are implemented. The number of spawners downstream of Shearer's Falls may be due to passage limitations or a result of increased natural production downstream of the falls.

Enclosure


SHEARER'S FALLS
FISHWAY/TRAP
12/14/94
N
BEDROCK
HIGHLY TURBULENT ZONE
BEDROCK
PRIMARY FALLS
(Approximately 130' Long)
FISHWAY
ADULT
TRAP &
RECOVERY
AREA

REFERENCES

ABACUS CONCEPTS, INC. 1992. Statview®. Abacus Concepts, Inc. Berkeley, CA.

ABSOLON, R.F., D.A. BREGE, B.P. SANDFORD, AND D.B. DEY. 1995. Studies to evaluate the effectiveness of screens at The Dalles Dam, 1994. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

AHO, R.S., AND J.L. FESSLER. 1975. An ecological and fish cultural study of Deschutes River salmonids. Fed. Aid Prog. Rep.-Fish., Oreg. Dep. Fish. Wildl., Corvallis, OR.

AHO, R.S., G.L. CONCANNON, J.S. ZILLER, S. PRIBYL, AND R.K. SCHROEDER. 1979. An ecological and fish cultural study of Deschutes River salmonids. Oreg. Dep. Fish Wildl. Fish Div., Res. Dev. Sect., Portland, OR.

ALM, G. 1959. Connection between maturity, size, and age in fishes. Fish. Board Sweden, Inst. of Freshwater Res., Drottningholm, Rep. No. 40.

ANEY, W.W., M.L. MONTGOMERY, AND A.B. LICHENS. 1967. Lower Deschutes River, Oregon; discharge and the fish environment. Final Rep., Oreg. State Game Com., Portland, OR.

ANONYMOUS. undated. Deschutes River fall chinook salmon. Unpubl. MS Rep. by R.K. Schroeder, T.E. Nickelson, and R.B. Lindsay, 1992, Oreg. Dept. Fish. Wildl. Res. Dev. Sect., Corvallis, OR.

ARMITAGE, P.D. 1984. Environmental changes induced by stream regulation and their effect on lotic macroinvertebrate communities, p. 139-166. *In* A. Lillehammer and S. J. Saltveit [ed.] Regulated Rivers. Universitetsforlaget AS, Oslo, Norway.

BAKUN, A. 1973. Coastal upwelling indices, west coast of North America, 1946-71. NOAA Tech. Rep. NMFS SSRF-671. (cited by Nickelson and Lichatowich 1984)

BEAMISH, R.J., AND D.R. BOUILLON. 1993. Pacific salmon production trends in relation to climate. Can. J. Fish. Aquat. Sci. 50:1002-1016.

BEATY, R.E. 1992. Changes in size and age at maturity of Columbia River upriver bright fall chinook salmon (*Oncorhynchus tshawytscha*): Implications for stock fitness, commercial value, and management. MS thesis, Oreg. State Univ., Corvallis, OR.

BECKER, C.D. 1973. Food and growth parameters of juvenile chinook salmon, *Oncorhynchus tshawytscha*, in central Columbia River. Fish. Bull. 71:387-400.

BECKER, C.D. 1985. Anadromous salmonids of the Hanford Reach, Columbia River: 1984 status. Battelle Memorial Inst., Pac. NW Lab. Rep. No. PNL-537.

BEININGEN, K.T. AND W.J. EBEL. 1970. Effect of John Day Dam on dissolved nitrogen concentrations and salmon in the Columbia River, 1968. Trans. Am. Fish. Soc. 99:664-671.

BELL, M.C. 1986. Fisheries handbook of engineering requirements and biological criteria. US Army Corps Eng., North Pac. Div., Fish Passage Dev. Eval. Program, Portland, OR.

Bishop, S. 1995. October 31 memo to M. Matylewich, CRITFC, re: NMFS chinook status review: summary of PSBTC *[Pacific Salmon Biological Technical Committee]* meetings, 10/17 and 10/19. NW Indian Fish. Comm., Olympia, WA.

Bjornn, T.C., and C.A. Peery. 1992. A review of literature related to movements of adult salmon and steelhead past dams and through reservoirs in the lower Snake River. Idaho Coop. Fish Wildl. Res. Unit, Moscow, ID, Rep. to US Army Corps Eng., Walla Walla District, Walla Walla, WA.

Bjornn, T.C., R.R. Ringe, K.R. Tolotti, P.J. Keniry, J.P. Hunt, C.J. Knutsen, and S.M. Knapp. 1992. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries - 1991. Idaho Coop. Fish Wildl. Res. Unit, Tech. Rep. 92-2, Univ. Idaho, Moscow.

Bottom, D.L., K.K. Jones, and M.J. Herring. 1984. Fishes of the Columbia River Estuary. Final Rep. of the Fish Work Unit of the Columbia River Data Development Program, Oreg. Dep. Fish Wildl., to Columbia River Estuary Study Taskforce (CREST), Astoria, OR.

Brege, D.A., S.J. Grabowski, W.D. Muir, S.R. Hirtzel, S.J. Mazur, and B.P. Sandford. 1992. Studies to determine the effectiveness of extended traveling screens and extended bar screens at McNary Dam, 1991. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Brett, J.R. 1952. Temperature tolerance in young Pacific salmon, genus *Oncorhynchus*. J. Fish. Res. Board Can. 9:265-323. (cited by Becker 1972)

Brett, J.R. 1979. Environmental factors and growth. p. 599-675. *In* W.S. Hoar, D.J. Randall, and J.R. Brett [ed.] Fish Physiology, Vol. 8: Bioenergetics and Growth. Academic Press, Inc. New York, NY.

Buchanan, D.V., R.M. Hooton, and J.R. Moring. 1981. Northern squawfish (*Ptychocheilus oregonensis*) predation on juvenile salmonids in sections of the Willamette River Basin, Oregon. Can. J. Fish. Aquat. Sci. 38:360-364.

Chapman, D.W., and K.P. McLeod. 1987. Development of criteria for fine sediment in the northern rockies ecoregion. Unpubl. Rep., EPA910/9-87-162. EPA Region X, Seattle, WA. (cited by Rhodes et al. 1995)

Chapman, D.W., D.E. Weitkamp, T.L. Welsh, M.B. Dell, and T.H. Schadt. 1986. Effects of river flow on the distribution of chinook salmon redds. Trans. Am. Fish. Soc. 115:537-547.

Chapman, D., and 10 co-authors. 1991. Status of Snake River chinook salmon. Don Chapman Consultants, Inc. Boise, ID., for the Pacific Northwest Utilities Conference Committee, Portland, OR.

Chapman, D., and eight co-authors. 1994. Status of summer/fall chinook salmon in the mid-Columbia region. Don Chapman consultants inc. Boise, ID.

Collins, G.B. 1963. Fish-passage research in the Columbia River Basin. Trans. N. Am. Wildl. Nat. Resour. Conf. 28:356-360.

Connor, W.P., H.L. Burge, and W.H. Miller. 1994a. Rearing and emigration of naturally produced Snake River fall chinook salmon juveniles, p. 92-119. *In* D.W. Rondorf and W.H. Miller [ed.] Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Ann. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-029, Contract No. DE-AI79-91BP21708, Portland, OR.

Connor, W.P., A.H. Connor, and R.H. Taylor. 1994b. Snake River flows and temperature during the 1992 Snake River fall chinook salmon brood year, p. 20-38. *In* D.W. Rondorf and W.H. Miller [ed.] Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Ann. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-029, Contract No. DE-AI79-91BP21708, Portland, OR.

Cooper, R., and T.H. Johnson. 1992. Trends in steelhead abundance in Washington and along the Pacific coast of North America. Rep. 92-20, Wash. Dep. Wildl., Olympia, WA. 90 p.

Coutant, C.C. 1970. Thermal resistance of adult coho *(Oncorhynchus kisutch)* and jack chinook *(O. tshawytscha)* salmon, and adult steelhead trout *(Salmo gairdneri)* from the Columbia River. Battelle Memorial Inst., Pac. Northwest Lab., Richland, WA. Rep. BNWL-1508, UC-48. 24 p. [notes actually derived from review draft]

CTWS and ODFW (Confederated Tribes of the Warm Springs Reservation of Oregon and Oregon Department of Fish and Wildlife). 1993. Deschutes River fall chinook salmon monitoring program, 1993. Unpubl. MS. Rep., CTWS, Warm Springs, OR.

CTWS and ODFW (Confederated Tribes of the Warm Springs Reservation of Oregon and Oregon Department of Fish and Wildlife). 1994. Deschutes River fall chinook salmon monitoring program, 1993. Unpubl. MS. Rep., CTWS, Warm Springs, OR.

CTWS and ODFW (Confederated Tribes of the Warm Springs Reservation of Oregon and Oregon Department of Fish and Wildlife). 1995. Deschutes River fall chinook salmon monitoring program, 1995. Unpubl. MS. Rep., CTWS, Warm Springs, OR.

Curet, T.S. 1993. Habitat use, food habits and the influence of predation on subyearling chinook salmon in Lower Granite and Little Goose reservoirs, Washington. M.S. thesis, Univ. Idaho, Moscow, ID.

Dauble, D.D., and R.P. Mueller. 1993. Factors affecting the survival of upstream migrant adult salmonids in the Columbia River Basin. Recovery Issues for Threatened and Endangered Snake River Salmon Technical Report 9 of 11. Battelle PNW Lab. Rep. to Bonneville Power Adm., Proj. No. 93-026, Task Order No. DE-AT79-93BP00085 to Master Agreement DE-AI79-BP62611. (cited by Chapman et al. 1994)

Dauble, D.D., and D.G. Watson. 1990. Spawning and abundance of fall chinook salmon *(Oncorhynchus tshawytscha)* in the Hanford Reach of the Columbia River, 1948-1988. Battelle Memorial Inst., Pac. Northwest Lab., Richland, WA. Rep. PNL-7289, UC-600.

Davidson, F.A. 1953. Effect of the proposed Pelton Dam on anadromous fish production in the Metolius River, Oregon. Report for Portland General Electric. (cited by Nehlsen 1995)

Dawley, E.M., and eight co-authors. 1986. Migrational characteristics, biological observations, and relative survival of juvenile salmonids entering the Columbia River estuary, 1966-1983. U.S. Dep. Energy, Bonneville Power Adm., Portland, OR.

DeHart, M., and M. Karr. 1990. Fish Passage Managers 1989 annual report. Fish Passage Center, Portland, OR.

DEQ (Oregon Department of Environmental Quality). 1994. 1992-1994 Water quality standards review, Draft Issue Paper. Standards and Assessments Sect., Portland, OR.

Eggers, D.M., C.P. Meacham, and D.C. Huttunen. 1984. Population dynamics of Bristol Bay sockeye salmon, 1956-83, p. 200-225. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

Everest, F.H., R.L. Beschta, J.C. Scrivener, K.V. Koski, J.R. Sedell, and C.J. Cederholm. 1987. Fine sediment and salmon production: a paradox, p. 98-142. *In* E.O. Salo and T.W. Cundy [ed.] Streamside Management: Forestry and Fishery Interactions. Univ. Wash. Inst. For. Resour. Contrib. No. 57, Seattle, WA. (cited by Rhodes et al. 1995).

Fessler, J., R. Aho, G. Concannon, J. Ziller, S. Pribyl, D. Ratliff, and B. Cates. 1978. An ecological and fish cultural study of Deschutes River salmonids. Oreg. Dep. Fish Wildl. Fish Div., Res. Dev. Sect., Portland, OR.

Fessler, J., R. Aho, G. Concannon, J. Zakel, and B. Cates. 1977. An ecological and fish cultural study of Deschutes River salmonids. 1977 Annu. Rep., Oreg. Dep. Fish Wildl., Portland, OR.

Fessler, J.L., R. Aho, L. Sawyer, and J. Zakel. 1976. An ecological and fish cultural study of Deschutes River salmonids. Fed. Aid Prog. Rep.-Fish., Oreg. Dep. Fish. Wildl., Corvallis, OR.

Fiscus, C.H. 1980. Marine mammal-salmonid interactions: a review, p. 121-132. *In* W.J. McNeil and D.C. Himsworth [ed.] Salmonid Ecosystems of the North Pacific. Oregon State University Press, Corvallis.

FPC (Fish Passage Center). 1992. Fish Passage Center annual report 1991. Portland, OR.

Fraser, F.J., P. Starr, and A.Y. Fedorenko. 1982. A review of the chinook and coho salmon of the Fraser River. Can. Tech. Rep. Fish. Aquat. Sci. 1126.

Fryer, J. K., and M. Schwartzberg. 1993. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1992. Tech. Rep. 93-3, Columbia River Inter-Tribal Fish Commission, Portland, OR.

Fryer, J. K., and M. Schwartzberg. 1994. Age and length composition of Columbia Basin spring and summer chinook salmon at Bonneville Dam in 1993. Tech. Rep. 94-1, Columbia River Inter-Tribal Fish Commission, Portland, OR.

Fulton, J.D., and R.J. LaBrasseur. 1985. Interannual shifting of the Subarctic boundary and some of the biotic effects on juvenile salmonids, p. 237-247. *In* W. S. Wooster and D. L. Fluharty [ed.] El Niño North: Niño Effects in the Eastern Subarctic Pacific Ocean. Wash. Sea Grant Prog, Univ. Wash., Seattle WA.

GALBREATH, J.L. 1966. Timing of tributary races of chinook salmon through the lower Columbia River based on analysis of tag recoveries. Fish Com. Oreg. Res. Briefs 12(1)58-80.

GANGMARK, H.A. 1957. Fluctuations in abundance of Columbia River chinook salmon 1928-54. U.S. Fish Wildl. Serv. Spec. Sci. Rep. Fish. 189.

GARCIA, A.P., W.P. CONNOR, AND R.H. TAYLOR. 1994. Fall chinook salmon spawning ground surveys in the Snake River, p. 1-19. *In* D.W. Rondorf and W.H. Miller [ed.] Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Ann. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-029, Contract No. DE-AI79-91BP21708, Portland, OR.

GESSEL, M.H., B.H. MONK, D.A. BREGE, AND J.G. WILLIAMS. 1989. Fish guidance efficiency studies at Bonneville Dam first and second powerhouses - 1988. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

GESSEL, M.H., D.A. BREGE, B.H. MONK, AND J.G. WILLIAMS. 1990. Continued studies to evaluate the juvenile bypass systems at Bonneville Dam - 1989. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

GILBREATH, L.G., E.M. DAWLEY, R.D. LEDGERWOOD, P.J. BENTLEY, S.J. GRABOWSKI. 1993. Relative survival of subyearling chinook salmon that have passed Bonneville Dam via the spillway or second powerhouse turbines or bypass system: Adult recoveries through 1991. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

GRANT, G. E., H. FASSNACHT, AND E. MCCLURE. 1995. Deschutes River Geomorphology Study Plan -- **DRAFT** February 23, 1995. USDA Forest Serv., Pac. NW Res. Stn., Oreg. State Univ., Corvallis, OR.

GREGOIRE, A.M., AND A.M. CHAMPEAU. 1984. Physico-chemical parameters of a regulated river: the Verdun (France), p. 41-52. *In* A. Lillehammer and S. J. Saltveit [ed.] Regulated Rivers. Universitetsforlaget AS, Oslo, Norway.

GUNSOLUS, R.T., AND G.J. EICHER. 1962. Evaluation of the fish passage facilities at the Pelton Project on the Deschutes River in Oregon. Pelton Study Steering Committee.

HAMMAN, M.G. 1981. Utilization of the Columbia River Estuary by American shad, (*Alosa sapidissima*) (Wilson). MS thesis, Oreg. State Univ., Corvallis. (cited by Chapman et al. 1991)

HARA, T.J. 1971. Chemoreception, p. 79-120. *In* W.S. Hoar and D.J. Randall [ed.] Fish Physiology, Vol. 5: Sensory Systems and Electrical Organs. Academic Press, Inc. New York, NY.

HEINDL, A.L., AND R.E. BEATY. 1989. Escapement monitoring of some naturally spawning Columbia River Basin chinook salmon stocks, 1987. Columbia R. Inter-Tribal Fish Comm. Tech. Rep. 89-5, Portland, OR.

HEVLIN, W., AND S. RAINEY. 1993. Considerations in the use of adult fish barriers and traps in tributaries to achieve management objectives. Presented at Am. Fish. Soc. 123rd Ann. Mtg. (Copies available from NMFS, Portland, OR or from the author.)

HILLMAN, T.W. 1991. The effect of temperature on the spatial interaction of juvenile chinook salmon and the redside shiner and their morphological differences. Ph.D. dissertation, Idaho State Univ., Pocatello, ID. (cited by Chapman et al. 1994)

HOBSON, L.A. 1980. Primary productivity of the North Pacific Ocean -- a review, p. 231-246. *In* W.J. McNeil and D.C. Himsworth [ed.] Salmonid ecosystems of the North Pacific. Oreg. State Univ. Press, Corvallis, OR.

HOLLOWED, A.B., K.M. BAILEY, AND W.S. WOOSTER. 1987. Patterns in recruitment of marine fishes in the Northeast Pacific Ocean. Biol. Oceanogr. 5:99-131.

HOLTBY, L.B., AND J.C. SCRIVENER. 1989. Observed and simulated effects of climatic variability, clear-cut logging, and fishing on the numbers of chum salmon *(Oncorhynchus keta)* and coho salmon *(O. kisutch)* returning to Carnation Creek, British Columbia, p. 62-81. *In* C. D. Levings, L. B. Holtby, and M. A. Henderson [ed.] Proceedings of the National Workshop on Effects of Habitat Alteration on Salmonid Stocks. Can. Spec. Publ. Fish. Aquat. Sci. 105.

HOWELL, P., K. JONES, D. SCARNECCHIA, L. LAVOY, W. KENDRA, AND D. ORTMANN. 1985. Stock assessment of Columbia River anadromous salmonids, Vol. I: Chinook, coho, chum, and sockeye salmon summaries. U.S. Dep. Energy, Bonneville Power Adm., Portland, OR.

HSIEH, W.W., D.M. WARE, AND R.E. THOMSON. 1995. Wind-induced upwelling along the west coast of North America, 1899-1988. Can J. Fish. Aquat. Sci. 52:325-334.

HUNTINGTON, C.W. 1985. Deschutes River spawning gravel study. Vol. I. Fin. Rep. U.S. Dep. Energy, Bonneville Power Adm., Proj. No. 83-423, Contract No. DE-AC79-83BP13102, Portland, OR.

JASKE, R.T., AND J.B. GOEBEL. 1967. Effects of dam construction on temperatures in the Columbia River. J. Am. Water Works Assoc. 59:935-942.

JCRMS (JOINT COLUMBIA RIVER MANAGEMENT STAFF). 1995. Joint staff report concerning commercial seasons for spring chinook, sturgeon, shad, and other fisheries and miscellaneous regulations for 1995. Dated January 13, 1995. Oreg. Dept. Fish Wildl and Wash. Dep. Fish. Wildl. (available from the author)

JONASSON, B.C., AND R.B. LINDSAY. (undated). Fall chinook salmon in the Deschutes River, Oregon. Oreg. Dep. Fish Wildl. Fish Div. Info. Rep. 88-6, Portland, OR.

KACZYNSKI, V.W. AND J.F. PALMISANO. 1992. A review of management and environmental factors responsible for the decline and lack of recovery of Oregon's wild anadromous salmonids. Tech. Rep. for Oregon Forest Industries Council, Salem, OR.

KELLERHALS, R., AND M. CHURCH. 1989. The morphology of large rivers: characterization and management, p. 31-48. *In* D. P. Dodge [ed.] Proceedings of the International Large River Symposium. Can. Spec. Publ. Fish. Aquat. Sci. 106.

Key, L.O., J.A. Jackson, C.R. Sprague, and E.E. Kofoot. 1994. Nearshore habitat use by subyearling chinook salmon in the Columbia and Snake rivers, p. 120-150. *In* D.W. Rondorf and W.H. Miller [ed.] Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Ann. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-029, Contract No. DE-AI79-91BP21708, Portland, OR.

Kirn, R.A., R.D. Ledgerwood, and R.A. Nelson. 1986. Increased abundance and the food consumption of northern squawfish (*Ptychocheilus oregonensis*) at river kilometer 75 in the Columbia River. NW Sci. 60(3):197-200.

Kostow, K. *[editor]*. 1995. Biennial report: status of wild fishes in Oregon. Chapter 1: Chinook (*Oncorhynchus tshawytscha*) species overview. Oreg. Dep. Fish. Wildl., Portland, OR.

Lawson, P.W. 1993. Cycles in ocean productivity, trends in habitat quality, and the restoration of salmon runs in Oregon. Fisheries 18(8):6-10.

LDRMP (Lower Deschutes River Management Plan). 1993. Lower Deschutes River management plan and environmental impact statement. Volume 1. Bur. Land. Manage., Prineville Dist. Off., Prineville, OR.

Ledgerwood, R.D., E.M. Dawley, L.G. Gilbreath, P.J. Bentley, B.P. Sandford, M.H. Schiewe. 1990. Relative survival of subyearling chinook salmon which have passed Bonneville Dam via the spillway or the second powerhouse turbines or bypass system in 1989, with comparisons to 1987 and 1988. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Ledgerwood, R.D., E.M. Dawley, L.G. Gilbreath, P.J. Bentley, B.P. Sandford, M.H. Schiewe. 1991. Relative survival of subyearling chinook salmon that have passed through the turbines or bypass system of Bonneville Dam second powerhouse, 1990. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Ledgerwood, R.D., E.M. Dawley, L.G. Gilbreath, L.T. Parker, B.P. Sandford, and S.J. Grabowski. 1994. Relative survival of subyearling chinook salmon at Bonneville Dam, 1992. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Levy, D. 1984. Commentary: variations in estuary utilization among juvenile chinook salmon populations, p. 297-302. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

Lindsay, R.B., G.L. Concannon, J.S. Ziller, K.R. Schroeder, and K. Anderson. 1980. An ecological and fish cultural study of Deschutes River salmonids. Oreg. Dep. Fish Wildl. Prog. Rep., Fish Div., Portland, OR.

Lindsay, R.B., W.J. Knox, M.W. Flesher, B.J. Smith, E.A. Olsen, and L.S. Lutz. 1986. Study of wild spring chinook salmon in the John Day River system: 1985 Final Report by Oreg. Dep. Fish Wildl. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 79-4, Contract No. DE-AI79-83BP39796, Portland, OR.

MAJOR, R.L., AND J.L. MIGHELL. 1966. Influence of Rocky Reach and the temperature of the Okanogan River on the upstream migration of sockeye salmon. Fish. Bull. 66(1):131-147.

MARSHALL, A.R., C. SMITH, R. BRIX, W. DAMMERS, J. HYMER, L. LAVOY. 1995. Genetic diversity units and major ancestral lineages for chinook salmon in Washington. *In* C. Busak and J.B. Shaklee [ed.] Genetic Diversity Units and Major Ancestral Lineages of Salmonid Fishes in Washington. Wash. Dep. Fish Wildl. Tech. Rep. no. RAD 95-02, Olympia, WA.

MATHEWS, S.B. 1984. Variability of marine survival of pacific salmonids: a review. p. 161-182. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis, OR

MCCABE, G.T. JR., W.D. MUIR, R.L. EMMETT, AND J.T. DURKIN. 1983. Interrelationships between juvenile salmonids and nonsalmonid fish in the Columbia River estuary. Fish. Bull. 81:815-826.

MCGIE, A.M. 1984. Commentary:evidence for density dependence among coho salmon stocks in the Oregon Production Index Area. p. 37-49. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis, OR

MCISAAC, D.O. 1995. October 9 letter to Dr. Michael Schiewe, NMFS, re: ESA chinook status review. Oreg. Dep. Fish Wildl., Portland, OR.

MCLAIN, D.R. 1984. Coastal ocean warming in the Northeast Pacific, 1976-83, p. 61-86. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

MENDEL, G., D. MILKS, R. BUGERT, AND K. PETERSEN. 1992. Upstream passage and spawning of fall chinook salmon in the Snake River, 1991. Compl. Rep. by Wash. Dep. Fish., Olympia, WA. to U.S. Fish. Wildl. Serv., Lower Snake Compensation Plan, Boise, ID.

MENDEL, G., D. MILKS, M. CLIZER, AND R. BUGERT. 1994. Upstream passage and spawning of fall chinook salmon in the Snake River. Chapter 1 *In* H.L. Blankenship and G.W. Mendel [ed.] Upstream Passage, Spawning, and Stock Identification of Fall Chinook Salmon in the Snake River, 1992. FY 1992-93 Annu. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-046, Contract No. DE-BI79-92BP60415, Portland, OR.

MILLER, D.R., AND C.W. SIMS. 1984. Effects of flow on the migratory behavior and survival of juvenile fall and summer chinook salmon in John Day Reservoir. Annu. Rep. (FY83) to U.S. Dep. Energy, Bonneville Power Adm., Portland, OR. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

MONK, B.H., B.P. SANDFORD, AND D.B. DEY. 1995. Evaluation of fish guidance efficiency of submersible traveling screens and other modifications at Bonneville Dam second powerhouse, 1994. Rep. to U. S. Army Corps Eng. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

MOORE, D., Z. WILLEY, A. DIAMANT, C.R. CALICA, AND D.R. SEHGAL. 1995. Restoring Oregon's Deschutes River: Developing partnerships and economic incentives to improve water quality and instream flows. Environmental Defense Fund, 257 Park Avenue South, New York, NY, 10010.

MURRAY, R.W. 1971. Temperature receptors, p. 121-133. In W.S. Hoar and D.J. Randall [ed.] Fish Physiology, Vol. 5: Sensory Systems and Electrical Organs. Academic Press, Inc. New York, NY.

MYSAK, L.A. 1986. El Niño, interannual variability and fisheries in the Northeast Pacific Ocean. Can. J. Fish. Aquat. Sci. 43:464-497.

NEHLSEN, W. 1995. Historical salmon and steelhead runs of the upper Deschutes River and their environments. Portland General Electric Company, Portland, OR.

NELSON, W.R., L.K. FREIDENBURG, AND D.W. RONDORF. 1994. Swimming performance of subyearling chinook salmon, p. 39-62. *In* D.W. Rondorf and W.H. Miller [ed.] Identification of the Spawning, Rearing and Migratory Requirements of Fall Chinook Salmon in the Columbia River Basin. 1992 Ann. Rep. to U.S. Dep. Energy, Bonneville Power Admin., Project No. 92-029, Contract No. DE-AI79-91BP21708, Portland, OR.

NEWTON, J. A. 1973. Deschutes River spring chinook salmon (*Oncorhynchus tshawytscha*) (Walbaum): A literature review. Oreg. Wildl. Com., Central Region Admin. Rep. No. 74-1.

NEWTON, J. A., and L. D. Nelson. 1995. Lower Deschutes River resident trout population inventory. Unpubl. white paper rep., Oreg. Dept. Fish Wildl., Mid-Columbia Dist.

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

NICKELSON, T.E., AND J.A. LICHATOWICH. 1984. The influence of the marine environment on the interannual variation in coho salmon abundance: an overview, p. 24-36. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

NORDENG, H. 1983. Solution to the "char problem" based on Arctic char (*Salvelinus alpinus*) in Norway. Can. J. Fish. Aquat. Sci. 40:1372-1387.

NPPC (NORTHWEST POWER PLANNING COUNCIL). 1986. Compilation of information on salmon and steelhead losses in the Columbia River Basin. Portland, OR.

ODFW (OREGON DEPARTMENT OF FISH AND WILDLIFE). 1985. An ecological and fish cultural study of Deschutes River salmonids. Prog. Rep., Fish Div., Portland, OR.

ODFW AND CTWS (OREGON DEPARTMENT OF FISH AND WILDLIFE AND CONFEDERATED TRIBES OF THE WARM SPRINGS RESERVATION OF OREGON). 1990. Deschutes River subbasin salmon and steelhead production plan. Northwest Power Planning Council, Portland, OR.

OLSEN, D., AND J. RICHARDS. 1994. Inter-basin comparison study: Columbia River salmon production compared to other west coast production areas. Phase II analysis. US Army Corps Eng.

PARK, D.L. 1993. Effects of marine mammals on Columbia R. salmon listed under the Endangered Species Act. Recovery Issues for Threatened and Endangered Snake River Salmon Tech. Rep. 3 of 11 to U.S. Dep. Energy, Bonneville Power Admin., Project No. 93-013, Contract No. DE-AM79-93BP99654, Portland, OR.

PARKER, R.R. 1971. Size selective predation among juvenile salmonid fishes in a British Columbia inlet. J. Fish. Res. Board Can. 28:1503-1510.

PEARCY, W.G. 1983. Commentary: abiotic variations in regional environments, p. 30-34. *In* W.S. Wooster [ed.] From Year to Year. Wash. Sea Grant, Univ. Wash., Seattle.

PEARCY, W.G. 1992. Ocean ecology of North Pacific salmonids. Wash. Sea Grant Prog, Univ. Wash., Seattle, WA. 179 p.

PETERMAN, R.M. 1984. Interaction among sockeye salmon in the Gulf of Alaska. , p. 187-199. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

PIPER, R.G., I.B. MCELWAIN, L.E. ORME, J.P. MCCRAREN, L.G. FOWLER, AND J.R. LEONARD. 1982. Fish hatchery management. U.S. Dept. Interior, Fish Wildl. Serv., Washington, D.C.

POLONSKY, A.B. 1994. Comparative study of the Pacific ENSO event of 1991-92 and the Atlantic ENSO-like event of 1991. Aust. J. Mar. Freshwater Res. 45:705-725.

PSC (PACIFIC SALMON COMMISSION). 1992. Joint Chinook Technical Committee, long-term research plans for coastwide chinook stocks, Rep. TCCHINOOK (92)-3. Vancouver, BC.

PSC (Pacific Salmon Commission). 1994. Joint Chinook Technical Committee 1993 annual report, TCCHINOOK (94)-1. Vancouver, BC.

PSC (PACIFIC SALMON COMMISSION). 1996. Joint Chinook Technical Committee 1994 annual report, TCCHINOOK (96)-1. Vancouver, BC.

RATLIFF, D.E. 1981. *Ceratomyxa shasta:* epizootiology in chinook salmon of central Oregon. Trans. Am. Fish. Soc. 110:507-513.

RATLIFF, D.E. 1983. *Ceratomyxa shasta:* longevity, distribution, timing, and abundance of the infective stage in central Oregon. Can. J. Fish. Aquat. Sci. 40:1622-1632.

REEVES, G.H., F.H. EVEREST, AND J.D. HALL. 1987. Interaction between redside shiner (*Richardsonius balteatus*) and the steelhead trout (*Salmo gairdneri*) in western Oregon: the influence of water temperature. Can. J. Fish. Aquat. Sci. 44:1603-1613.

REIMERS, P.E., AND R.E. LOEFFEL. 1967. The length of residence of juvenile fall chinook salmon in selected Columbia River tributaries. Fish Comm. Oreg. Res. Briefs 13(1):5-19.

RHODES, J.J., D.A. MCCULLOUGH, AND F.A. ESPINOSA, JR. 1994. A coarse screening process for evaluation of the effects of land management activities on salmon spawning and rearing habitat in ESA consultations. Tech. Rep. 94-4, Columbia. R. Inter-Tribal Fish Com., Portland, OR.

RICKER, W.E. 1972. Hereditary and environmental factors affecting certain salmonid populations, p. 19-160. *In* R.C. Simon and P. A. Larkin [ed.] The Stock Concept in Pacific Salmon. H.R. MacMillan Lectures in Fisheries, Univ. British Columbia, Vancouver, B.C.

RICKER, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 191.

Ricker, W.E., H.T. Bilton, and K.V. Aro. 1978. Causes of the decrease in size of pink salmon (*Oncorhynchus gorbuscha*). Can. Fish. Mar. Serv. Tech. Rep. 820.

Rieman, B.E., R.C. Beamesderfer, S. Vigg, and T.P. Poe. 1991. Estimated loss of juvenile salmonids to predation by northern squawfish, walleyes, and smallmouth bass in John Day Reservoir, Columbia River. Trans. Am. Fish. Soc. 120:448-458.

Rogers, D.E. 1984. Trends in abundance of northeastern Pacific stocks of salmon, p. 100-127. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

Rondorf, D.W., G.A. Gray, and R.B. Fairley. 1990. Feeding ecology of subyearling chinook salmon in riverine and estuarine habitats of the Columbia River. Trans. Am. Fish. Soc. 119:16-24.

Scarnecchia, D.L. 1981. Effects of streamflow and upwelling on yield of wild coho salmon (*Oncorhynchus kisutch*) in Oregon. Can. J. Fish. Aquat. Sci. 38:471-475.

Scherzinger, R.J. 1970. 1969 Deschutes River anadromous fishery catch estimates: Sherars Bridge area. Oreg. State Game Com., Cent. Reg. Admin. Rep. (available from J. Newton, ODFW, The Dalles.

Schroeder, R.K., and L.H. Smith. 1989. Life history of rainbow trout and effects of angling regulations, Deschutes River, Oregon. Oreg. Dep. Fish Wildl. Fish Div. Info. Rep. 89-6, Portland, OR.

Sherwood, C.R., D.A. Jay, R.B. harvey, P. Hamilton, and C.A. Simenstad. 1990. Historical changes in the Columbia River estuary. Prog. Oceanography 25:299-352. (cited by Chapman et al. 1994).

Shew, D.M., R.D. Peters, R.J. Stansell, D.R. Bryson, W.R. Case, and A.R. Turner, Jr. 1988. Evaluation of adult fish passage at Bonneville and John Day dams in 1984. U.S. Army Corps Eng., Portland, Dist., Portland, OR.

Simenstad, C.A., and R.C. Wissmar. 1984. Variability of estuarine food webs and production may limit our ability to enhance Pacific salmon (*Oncorhynchus* spp.), p. 273-286. *In* W.G. Pearcy [ed.] The influence of ocean conditions on the production of salmonids in the North Pacific. Sea Grant Commun., Oreg. State Univ., Corvallis.

Stabler, D.F. 1981. Effects of altered flow regimes, temperatures, and river impoundment on adult steelhead trout and chinook salmon. MS Thesis, Univ. Idaho, Moscow, ID.

Stanford, J.A., and J.V. Ward. 1984. The effects of regulation on the limnology of the Gunnison River: a North American case history, p. 467-480. *In* A. Lillehammer and S.J. Saltveit [ed.] Regulated Rivers. Universitetsforlaget AS, Oslo, Norway.

Stuehrenberg, L.C., and seven co-authors. 1995. Migrational characteristics of adult spring, summer, and fall chinook salmon passing through reservoirs and dams of the mid-Columbia River. Fin. Rep. by Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Swan, G.A., and six co-authors. 1994. Wells Dam radio-telemetry study, 1992. Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Tabata, S. 1985. El Niño effects along and off the Pacific Coast of Canada during 1982-83, p. 116-122. *In* W.S. Wooster and D.L. Fluharty [ed.] El Niño North: Niño Effects in the Eastern Subarctic Pacific Ocean. Wash. Sea Grant Prog, Univ. Wash., Seattle, WA.

TAC (*US v. Oregon* Technical Advisory Committee). 1995. Biological assessment of the impacts of proposed 1995 fall season Columbia River and mainstem tributary fisheries on listed Snake River salmon species under the Endangered Species Act. Dated April 18, 1995. (available from the author)

Taylor, E.B. and J.D. McPhail. 1985. Burst swimming and size-related predation of newly emerged coho salmon *Oncorhynchus kisutch*. Trans. Am. Fish. Soc. 114:546-551.

Theurer, F.D., I. Lines, and T. Nelson. 1985. Interaction between riparian vegetation, water temperature, and salmonid habitat in the Tucannon River. Water Resour. Bull. 21:53-64.

Thompson, W.F. 1951. An outline for salmon research in Alaska. Univ. Wash., Fish. Res. Inst. Circ. No. 18, Seattle, WA.

Thompson, R.B. 1959. Food of the squawfish *Ptychocheilus oregonensis* (Richardson) of the lower Columbia River. U.S. Dep. Int., Fish Wildl. Serv., Fish. Bull. 158. Washington D.C.

Thorpe, J.E. 1986. Age at first maturity in Atlantic salmon, *Salmo salar*: freshwater period influences and conflicts in smolting, p. 7-14. *In* D.J. Meerburg [ed.] Salmonid Age at Maturity. Can. Spec. Publ. Fish. Aquat. Sci. 89.

Udey, L.R., J.L. Fryer, and K.S. Pilcher. 1975. Relation of water temperature to ceratomyxosis in rainbow trout (*Salmo gairdneri*) and coho salmon (*Oncorhynchus kisutch*). J. fish. Res. Board Can. 32:1545-1551.

Uremovich, B.L., S.P. Cramer, C.F. Willis, and C.O. Junge. 1980. Passage of juvenile salmonids through the ice-trash sluiceway and squawfish predation at Bonneville Dam, 1980. Annu. Prog. Rep. (contract no. DACW57-78-C-0058) to U.S. Army Corps Eng., Portland, OR, by Oreg. Dep. Fish Wildl.

USACE (U.S. Army Corps of Engineers). 1972-93 (various years). Annual fish passage report. N. Pac. Div., Portland, OR.

van Hyning, J.M. 1973. Factors affecting the abundance of fall chinook salmon in the Columbia River. Fish. Comm. Oreg. Res. Rep. 4(1): 1-87.

Vigg, S., and C.C. Burley. 1991. Temperature-dependent maximum daily consumption of juvenile salmonids by northern squawfish (*Ptychocheilus oregonensis*) from the Columbia River. Can. J. Fish. Aquat. Sci. 48:2491-2498.

Wagner, P., and T. Hillson. 1993. 1991 Evaluation of adult fallback through the McNary Dam juvenile bypass system. Wash. Dep. Fish. Final Proj. Rep. to US Army Corps Eng. for Contract DACW68-82-C-0077. Olympia, WA.

WDFW and ODFW (Washington Department of Fish and Wildlife and Oregon Department of Fish and Wildlife). 1994. Status report: Columbia River fish runs and fisheries, 1938-93.

Weiss, E. 1970. A tagging study to investigate the unexplained loss of spring and summer chinook salmon migrating past Bonneville and The Dalles dams. Oreg. Fish. Comm. Res. Rep. to US Army Corps Eng., N. Pacific Div., Portland, OR. (cited by NPPC 1986)

Weitkamp, L.A. 1994. A review of the effects of dams on the Columbia River estuarine environment, with special reference to salmonids. Final Rep. to U.S. Dep. Energy, Bonneville Power Admin., Contract No. DE-AI79-93BP99021, Portland, OR. and to Nat. Mar. Fish. Serv., Northwest and Alaska Fish. Center, Coastal Zone and Estuarine Studies Div., Seattle, WA.

Wendler, H.O. 1967. The American shad of the Columbia River with a recommendation for management of the fishery. Wash. Dep. Fish. (cited by Chapman et al. 1991)

Westpestad, V.G., and S.M. Fried. 1983. Review of the biology and abundance trends of Pacific herring (*Clupea harengus pallasi*), p. 17-29. *In* W.S. Wooster [ed.] From Year to Year. Wash. Sea Grant, Univ. Wash., Seattle.

Young, F., R. Michimoto, and G. Gibson. 1978. Passage problems of adult chinook salmon during 1976 and 1977 and steelhead trout during 1974 and 1975 in the Columbia River between Bonneville and McNary dams. Oreg. Dep. Fish. Wildl. Ann. Prog. Rep. to US Army Corps Eng., Contr. No. DACW57-77-C-0072. (cited by Chapman et al. 1994)