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STREAMNET THE NORTHWEST AQUATIC RESOURCE INFORMATION NETWORK REPORT ON THE STATUS OF SALMON AND STEELHEAD IN THE COLUMBIA RIVER BASIN - 1995

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STREAMNET
THE NORTHWEST AQUATIC RESOURCE INFORMATION NETWORK

REPORT ON THE STATUS OF SALMON AND STEELHEAD IN THE COLUMBIA RIVER BASIN - 1995

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Abbreviations and Acronyms Used in this Report

- number
Abund - abundance
Admin - administration
Apr - April
Aug - August
Avg - average
BC - British Columbia
Be1 - below
BON - Bonneville Dam
BPA - Bonneville Power Administration
C - Centigrade
C&S - ceremonial and subsistence
CDFO - Canadian Department of Fisheries and Oceans
cfs - cubic feet per second
Ch - chinook salmon
Chf - chief
CHJ - Chief Joseph Dam
CIS - Coordinated Information System
Co - coho salmon
Co1 - Columbia
Collect - collected
Comm - commercial
Comp - compensation
Coord - coordination
Cr - creek
CRFDP - Columbia River Fisheries Development Program
CWT - coded wire tag
dd-day
Dist - distributed
DS - Distributed System
ENS0 - El Niño/Southern Oscillation
Est - estimate
ETSD - Environmental Technical Services Division
FPC - Fish Passage Center
FPDEP - Fish Passage Development and Evaluation Program
Frm - from
FSOC - Fish Screening Oversight Committee
fi -'foot
FW - freshwater
Gr - Grande
IDFG - Idaho Department of Fish and Game
IHN - infectious hematopoietic necrosis
IHR - Ice Harbor Dam
Is - island
JDA - John Day Dam
Jun - June
Juve -juvenile
kcfs - 1,000 cubic feet per second
km - kilometer
Koot - Kootenai
LGS - Little Goose Dam
LGR - Lower Granite Dam
Li - little
LMN - Lower Monumental Dam
Lo - lower
LSRCP - Lower Snake River Compensation . Program
m - meter
Mar - March
MCN - McNary DAm
MFSR - Middle Fork Salmon River
mi - mile
Misc - miscellaneous
mm - month
n - number
N-north
NA i not available
NC - north central
NID - National Inventory of Dams
NMFS - National Marine Fisheries Service
NWHS - Northwest Hydropower System
NWPPC - Northwest Power Planning Council
O&M - operation and maintenance
ODFW - Oregon Department of Fish and Wildlife
OEA - OEA Research
Ore - Oreille
OWRD - Oregon Water Resources Department

PC - personal computer
Pend Ore - Pend Oreille
PFMC - Pacific Fishery Management Council
PIT - Passive Integrated Transponder
Pop - population
PRD - Priest Rapids Dam
Prelim - preliminary
Proj - project
PSC - Pacific Salmon Commission
PSMFC - Pacific States Marine Fisheries Commission
R - river
Rap - rapids
Res - reservoir or resident
RIS - Rock Island Dam
RM - river mile
RMIS - Regional Mark Information System
RMPC - Regional Mark Processing Center
RRH - Rocky Reach Dam
SE - southeast
sec - second
Sep - September
SMP - Smolt Monitoring Program
So - sockeye salmon
SO1 - Southern Oscillation Index
Spawng - spawning
Spok - Spokane
Spr - spring
St - steelhead
Steelhd - steelhead
StlHead - steelhead
TAC - U.S. v. Oregon Technical Advisory Committee
TDA - The Dalles Dam
Temp - temperature
Trans - transported
URB - upriver bright
USDOE - U.S. Department of Energy
USGS - U.S. Geological Survey
UW - University of Washington
Vanc - Vancouver
W - west
Wash - Washington
WDFW - Washington Department of Fish and Wildlife
WEL - Wells Dam
Yr - year

Introduction

Information on fish populations, fisheries, and fish habitat is crucial to the success of ongoing programs to protect, recover, enhance, and manage fish resources in the Columbia River Basin. However, pertinent data is often difficult to locate because it is 'scattered among many agencies and is often unpublished. The goal of this annual report is to bring many diverse data types and sources into a single comprehensive report on the status of anadromous fish runs in the Columbia River Basin and the environmental conditions that may affect that status. Brief summaries are provided to identify the type and scope of available information. This synopsis is intended to complement other more detailed reports to which readers are referred for comprehensive treatment of specific subjects.

This first report focuses mainly on anadromous salmon and steelhead (primarily through 1994) but we intend to expand the scope of future issues to include resident species. ***This is the first of what we intend to be an annual report. We welcome constructive suggestions for improvement.***

In this report, we identify available information but make no attempt to evaluate its implications. Inclusion does not represent endorsement of methods or results. When applying the information, it is incumbent on the reader to understand the limitations of the data imposed by the method of collection and related assumptions. We do attempt to flag controversial issues. Most of the summary data in this report was generated using the **StreamNet** (formerly Coordinated Information System and Northwest Environmental Data Base) database system. The **StreamNet** Distributed System (DS) is a PC based database application containing fully- referenced data and a user friendly interface to query, report, or export the data. Contents of the DS are shown in Appendix A (to receive a copy, contact Duane Anderson at **503-650-5400).** ***As with any summary information derived from a database, this report represents conditions to the best of our knowledge. No warranty for the correctness, accuracy, or usefulness of this data is expressed or implied. If errors or inaccuracies are discovered please contact any of the author's of the report.*** Data in the report that came from sources other than the **StreamNet** database are cited in the bibliography.

This report is a product of the **StreamNet** project which is funded by the Bonneville Power Administration **(BPA),** U.S. Department of Energy, as part of **BPA's** program to protect, mitigate, and enhance fish and wildlife affected by the development and operation of hydroelectric facilities on the Columbia River and its tributaries. The project is called for in the Fish and Wildlife Program **of the** Northwest Power Planning Council. The project's objective is to promote exchange and dissemination of information in a standardized electronic format throughout the basin. This project is administered by the Pacific States Marine Fisheries Commission with active participation by tribal, state, and federal **fish** and wildlife agencies.

To facilitate the presentation of large amounts of data in this report, the Columbia River Basin has been divided into four regions. Included in each region are both the **mainstem** Columbia and/or Snake rivers and their adjoining tributary systems. The regions are defined as follows: Below Bonneville - the Columbia River and its tributaries below Bonneville Dam; Bonneville to

Priest Rapids - the Columbia River and its tributaries between Bonneville Dam and Priest Rapids Dam; Snake - the Snake River and its tributaries up to Hells Canyon Dam; and Priest Rapids to Chief Joseph - the Columbia River and its tributaries 'between Priest Rapids Dam and Chief Joseph Dam.

1. Abundance / Survival Information

A. *Adults/Jacks*

1. Total Columbia River Run

Since 1938, the minimum number of salmon and steelhead, including jacks, entering the Columbia has ranged from a high of 3.2 million fish in 1986 to a new low of 856,500 fish in 1994 (Figure 1). 1994 Columbia River commercial landings were the second lowest in history (Figure 1).

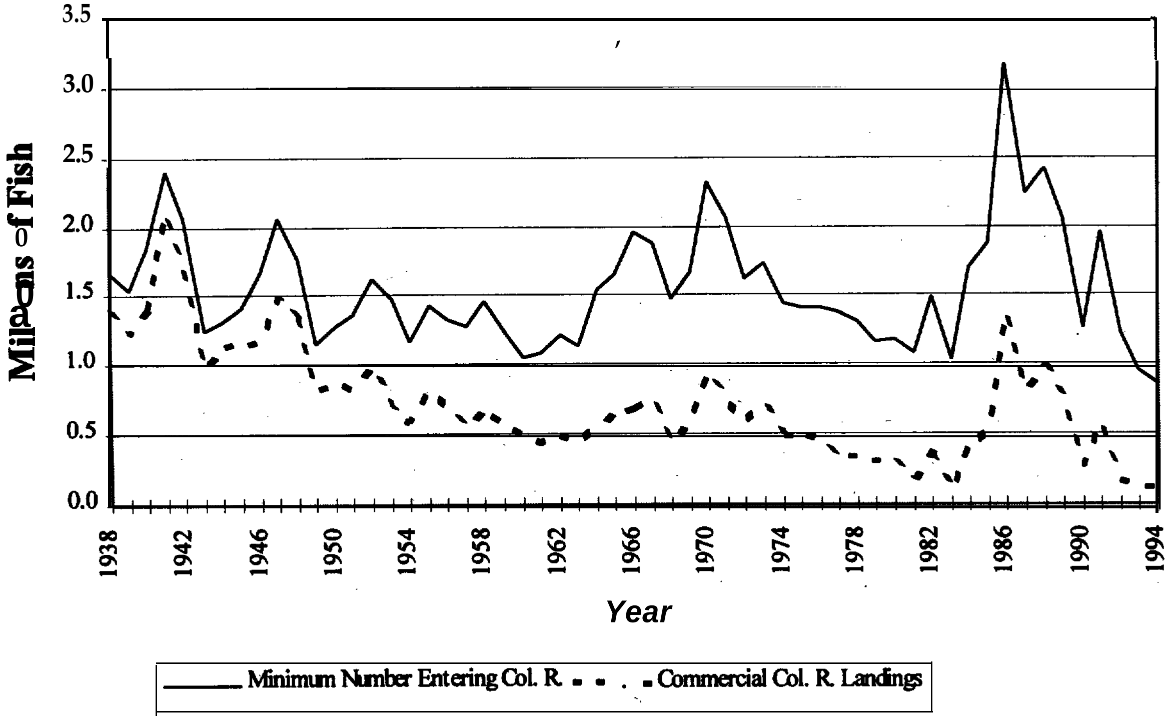


Figure 1. Minimum Numbers of Salmon and Steelhead Entering the Columbia River, **1938-** 1994, and Commercial Landings of Salmon and Steelhead **from** the Columbia River (ODFW, WDFW 1995).

2. Total Regional Escapement

Following a significant increase in the early **1980's,** total escapement to the various Columbia River regions has been in decline since 1986 (Figure 2). Total escapement to Columbia River Basin was just over 700,000 adults and jacks in 1994. Adult and jack escapement to regions above Bonneville Dam comprised only about 441,000 fish of that total. Total escapement of spring chinook **was the lowest in recorded history (Figure 3).**

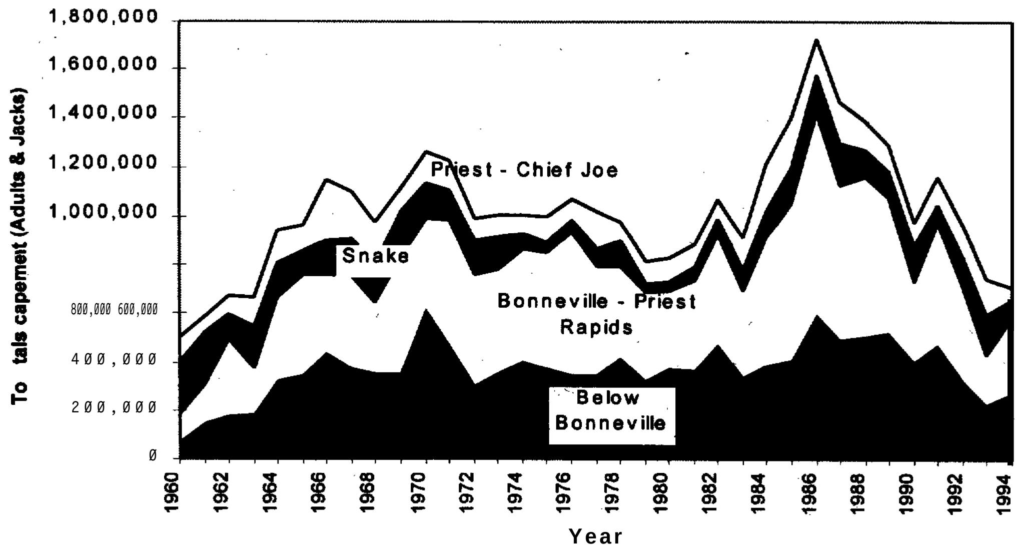


Figure 2. Estimate of total escapement (adults and jacks) to Columbia River Regions (PSMFC 1995 and ODFW, **WDFW** 1995).

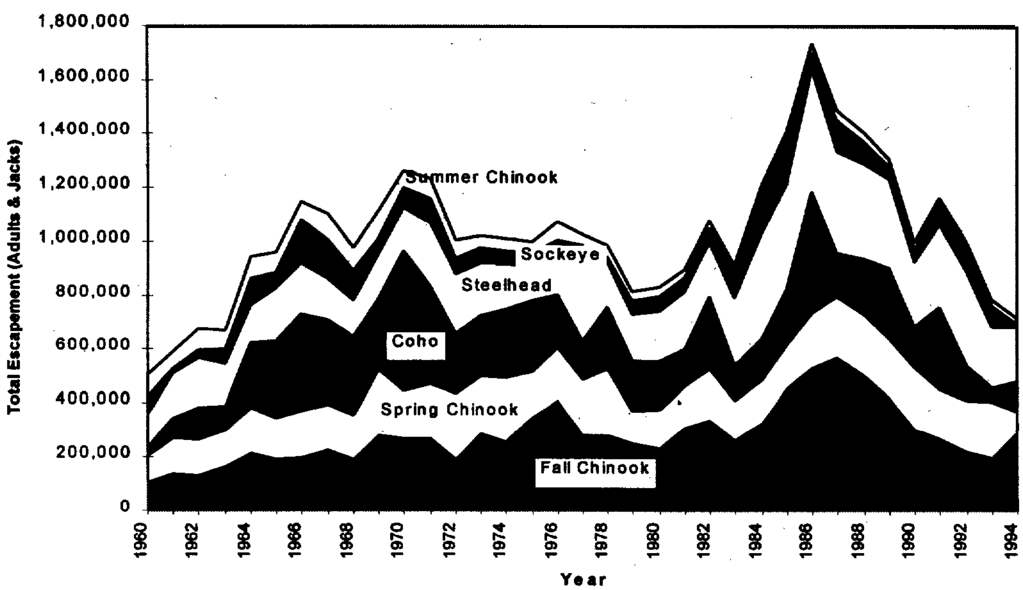


Figure 3. Estimate of total escapement (adults and jacks) by species/run (PSMFC 1995 and ODFW, WDFW 1995).

3. Upstream Survival Rates

Adult upstream survival rates have been estimated for various stretches of the system by members of the U.S. vs. Oregon Technical Advisory Committee (Table 1, personal communication, Ray Beamesderfer, report in progress). Using dam counts, harvest estimates, and estimates of numbers of fish returning to tributaries between dams, it is possible to estimate adult survival between dams. These survival rates are also known as conversion rates and they vary substantially from year to year and have a significant impact on adult escapement. For Snake River spring chinook stocks, the adult conversion rate for the river section from Bonneville Dam to Lower Granite Dam has averaged only about 60% since 1979.

Table 1. Estimates of upstream adult survival (conversion) rates for Spring Chinook for the Lower Columbia and Snake River Reaches.

Year	BON-MCN	MCN Pool	IHR-LGR	Total BON-LGR
79	0.51	0.86	0.83	0.37
80	0.42	1.01	0.69	0.29
81	0.61	1.13	0.88	0.61
82	0.49	1.00	0.88	0.43
83	0.75	0.84	0.81	0.50
84	0.66	1.01	0.83	0.55
85	0.85	1.09	0.82	0.76
86	0.81	0.97	0.84	0.66
87	0.85	0.93	0.94	0.74
88	0.79	1.04	0.89	0.73
89	0.63	1.00	0.82	0.51
90	0.79	0.89	0.88	0.62
91	0.66	1.05	0.69	0.48
92	0.85	1.03	0.87	0.76
93	0.81	1.13	0.87	0.80
94	0.77	1.04	0.91	0.73
Averages				
1979-94	0.70	1.00	0.84	0.60
1990-94	0.77	1.06	0.83	0.69

4. Natural Spawning

Comprehensive estimates of **the total number** of natural spawners are not available in the Columbia River Basin at this time. The reasons for this are both institutional (different management agencies have differing monitoring and estimation techniques), and geographic (spawning in the Columbia River Basin occurring in thousands of stream miles for long time periods making it unfeasible to count all of the spawners in all of the streams). Data for many individual populations are available, however, and are shown in the example population section of this report.

While estimates of total spawners are not consistent between management agencies or stocks of fish, these estimates hold the best promise for monitoring overall natural spawning trends. Idaho Department of Fish and Game and Oregon Department of Fish and Wildlife, for example, have been counting spring chinook redds in Snake River drainage subbasins since the late 1950's . (Figure 4). In 1994, index areas in 44 streams were surveyed averaging only 3 redds per stream, the lowest level since surveys began.

As the StreamNet data compilation process becomes more sophisticated, it may prove advisable to establish key indicator streams throughout the Basin that would be surveyed in a pre-defined, consistent manner in order to provide more accurate estimates of spawning populations, life stage survival, and production basin-wide.

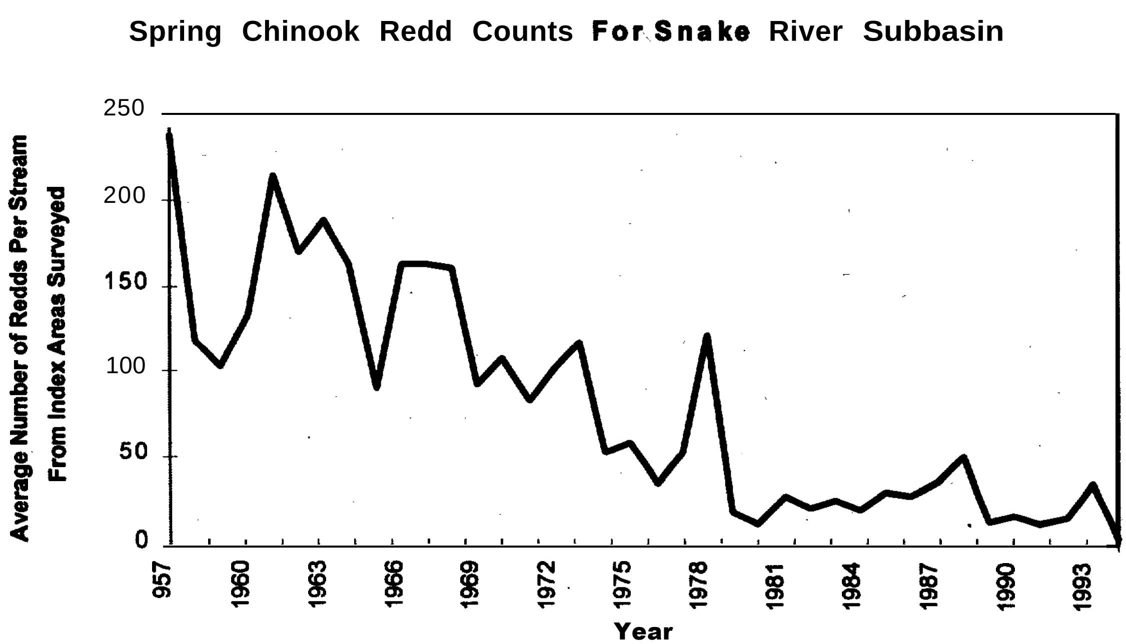


Figure 4. Average number of spring chinook redds **from** index areas per stream in Snake River subbasins, **1957-1** 994 (PSMFC 1995)

5. Hatchery Rack

The majority of hatchery rack returns occur in the region below Bonneville Dam (Figure 5). This is predictable given that the majority of the Basin's hatcheries are in this region, as are the majority of hatchery releases:

Hatchery returns by species and run are shown in Figure 6. Coho comprise the majority of returns in most years but have declined substantially in the last five years. Fall chinook make up the next most abundant returns followed by spring chinook and summer steelhead.

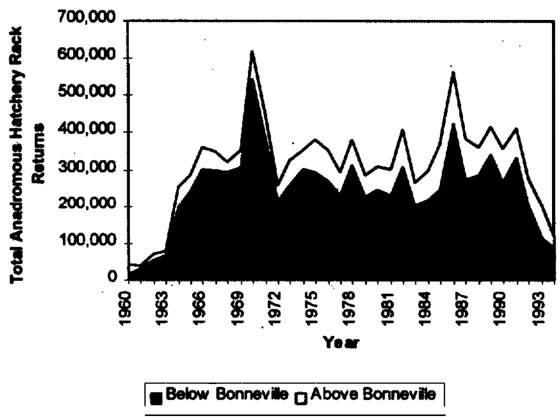


Figure 5. Total hatchery rack returns above and below Bonneville Dam. Data from the 1960's and 1970's is incomplete for some hatcheries. Hatchery rack returns do not necessarily reflect total hatchery production or performance (PSMFC 1995).

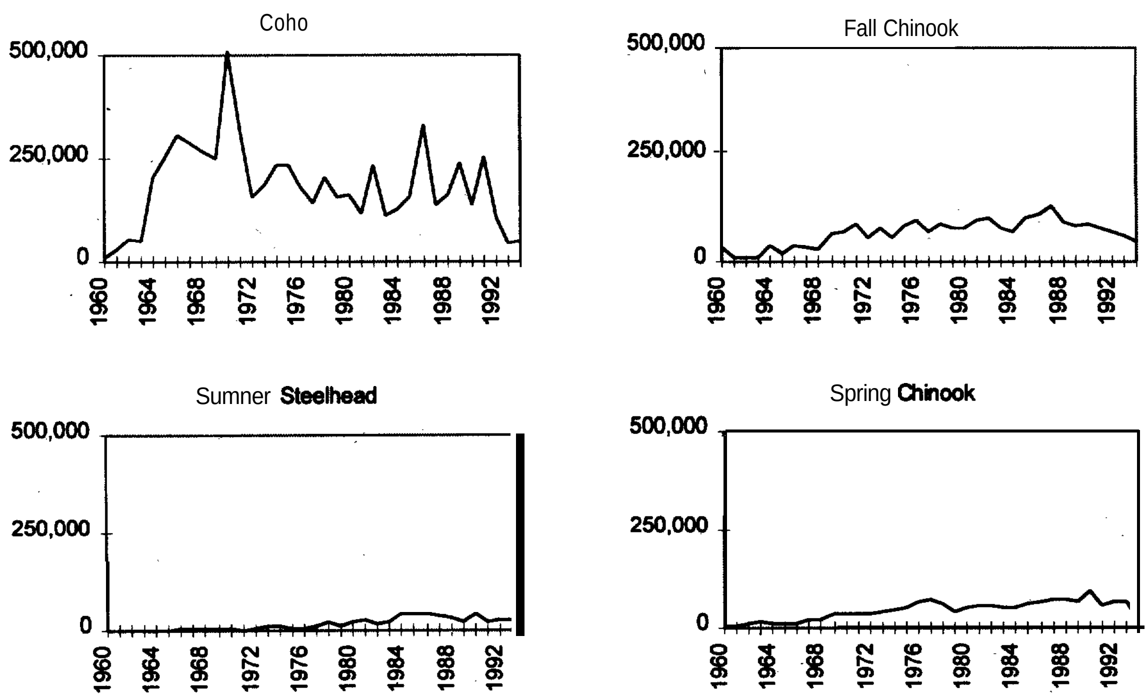


Figure 6. Total hatchery rack returns by species and run. Some years may be incomplete (PSMFC 1995).

B. Juveniles

1. Abundance

Detailed information on migrant abundance, condition, and behavior is provided by the Smolt Monitoring Program (SMP) whose primary objective is to provide up-to-date information for management of a water budget and spill agreement. The SMP is administered by the Fish Passage Center and conducted by federal agencies, state agencies, and Indian tribes (FPC 1995). Chinook salmon and hatchery-reared juveniles comprised the majority of the almost 1.5 million migrants- sampled at various sites in 1994 (Tables 2 and 3).

Table 2. Number of juvenile salmon and steelhead captured in river traps or sampled in dam collection facilities by the 1994 smolt monitoring program (FPC 1995). Percent of passage index sampled is in parentheses.

Location	Chinook 1	Chinook 0	Sockeye	Coho	Steelhead	Total
Salmon R. trap	43,672	0	17	0	7,947	51,636
Clear-water R. trap	34,136	31	0	0	6,414	40,581
Snake R. trap	23,819	58	0	0	35,101	58,978
Imnaha R. trap	53,582	0	0	0	36,826	90,408
Gr. Ronde R. trap	3,270	208	0	0	6,995	10,473
LGR Dam	37,286 (2)	2,468 (36)	1,446 (5)	0	98,936 (2)	140,136 (2)
LGS Dam	49,350 (5)	1,782 (37)	991 (5)	0	50,564 (4)	102,687 (5)
LMN Dam	109,774 (10)	2,250 (33)	637 (14)	0	68,118 (11)	180,779 (10)
RIS Dam	8,471 (69)	10,777 (75)	8,676 (66)	0	9,846 (64)	37,770 (68)
MCN Dam	64,746 (2)	267,524 (5)	14,232 (2)	5,719 (2)	18,109 (3)	370,330 (4)
JDA Dam	34,071 (8)	75,164 (6)	7,260 (8)	11,385 (8).	22,058 (8)	149,938 (7)
BON Dam	34,362 (4)	125,954 (4)	2,954 (3)	22,378 (4)	7,711 (4)	193,359 (4)
1994 **total**	496,539	486,216	**36,213**	39,482	368,625	**1,427,056**

A passage index of juvenile salmonid abundance is estimated based on number collected in juvenile diversion systems at dams with a correction for the proportion of flow which is spilled rather than passed through the powerhouse. (This index thus represents an underestimate of total juvenile abundance because it does not account for fish that pass through the turbines.) Annual passage indices varied substantially among years, species, and dams (Figure 7) depending on hatchery releases, natural production, number transported, and survival rates of migrants.

Table 3. Percentage of wild juvenile salmon and steelhead captured in river traps or sampled in dam collection facilities by the 1994 smolt monitoring program (FPC 1995).

Location	Age 1 chinook	Age 0 chinook	Sock-eye	Steel-head	Total
Salmon R. trap	11			7	10
Clearwater R. trap	4	100	0	28	8
Snake R. trap	10	100	0	10	8
Imnaha R. trap	12		0	1 3	13
Gr. Ronde R. trap	28	100	0	19	21
LGR Dam	29	100	100	10	18
LGS Dam	21	100	100	18	21
LMN Dam	12	100	100	13	14
RIS Dam	--[a]	--[a]	96	33	--[a]
MCN Dam	--[a]	--[a]	94	17	--[a]
JDA Dam	--[a]	--[a]	97	34	--[a]
BON Dam	--[a]	95	96	48	--[a]

[a] *All hatchery fish could not be distinguished because of unmarked releases in the mid-Columbia.*

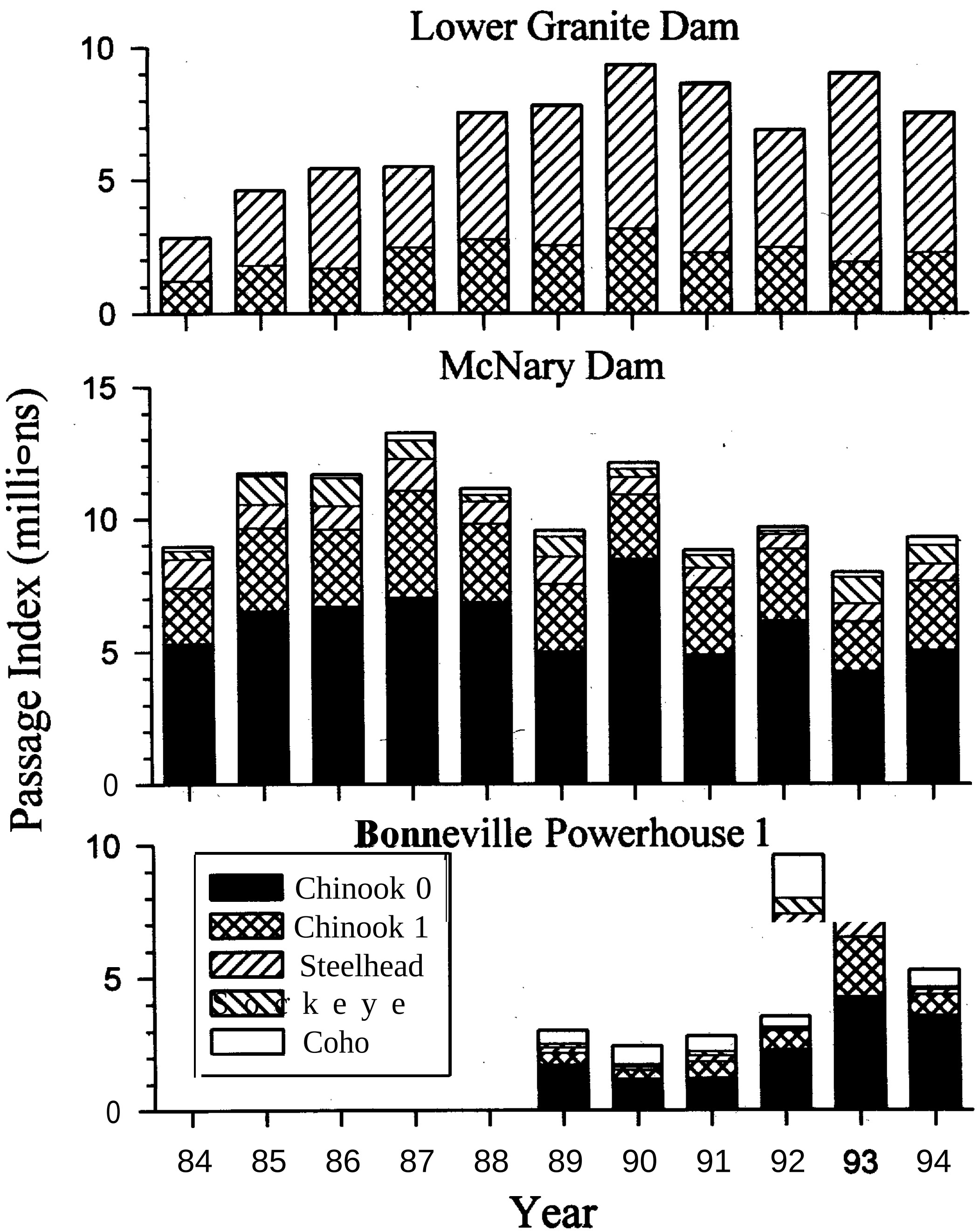


Figure 7. Passage indices of juveniles at selected dams, 1984-94.

2. Migration Timing

Peak migration periods are May through June for steelhead, sockeye, coho, and age 1 chinook juveniles and June through July for age 0 chinook juveniles. Migration timing at most sites was roughly comparable between 1994 with the average for the previous three years (Figure 8).

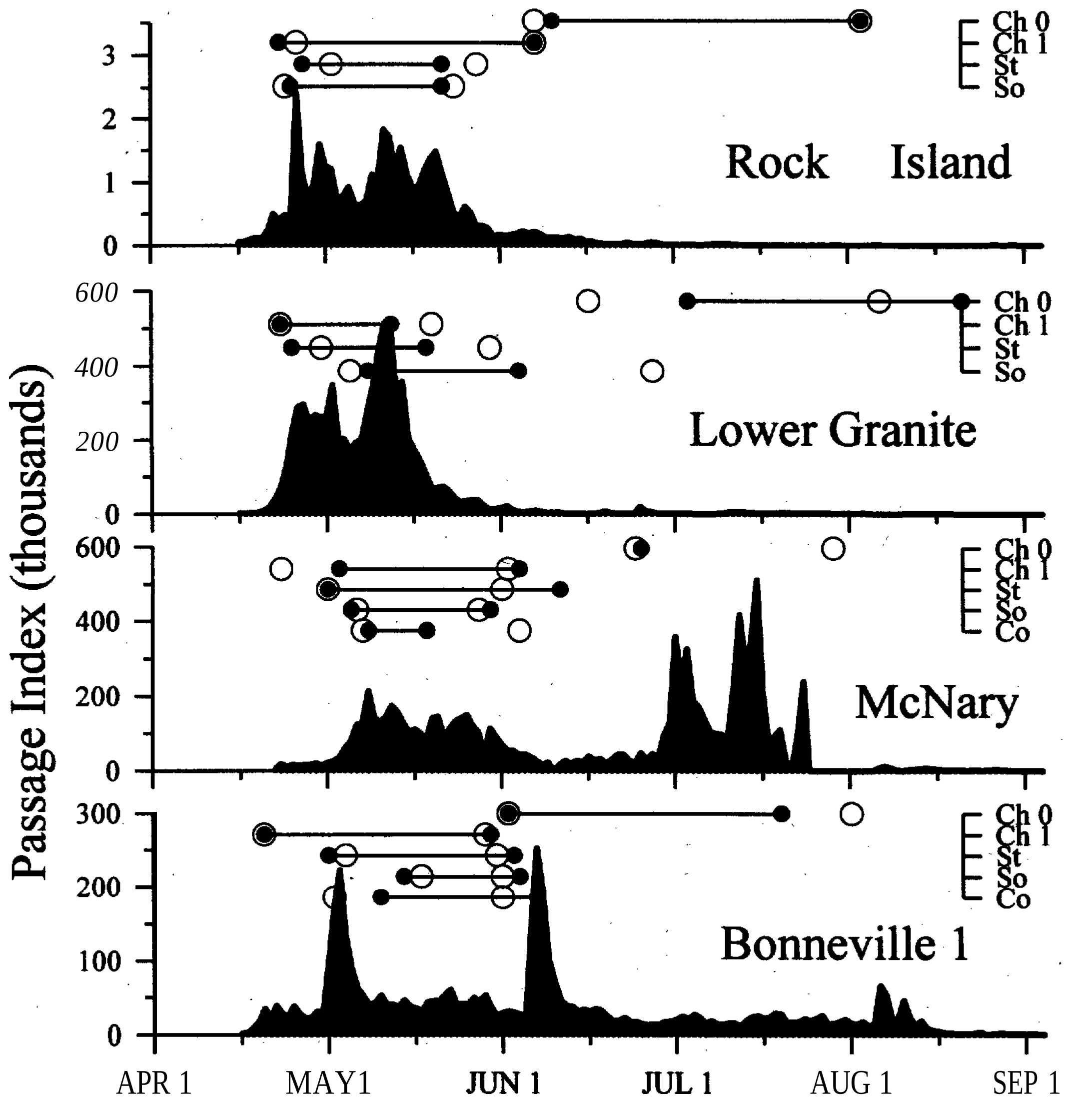


Figure 8. Migration timing of juvenile salmon and **steelhead** (all species, hatchery, and **natural** pooled) at selected dams during 1994 (FPC 1995). Dots connected with lines indicate 10% and 90% passage dates by species for 1994. Open circles indicate average 10% and 90% dates by species averaged for 199 l-93.

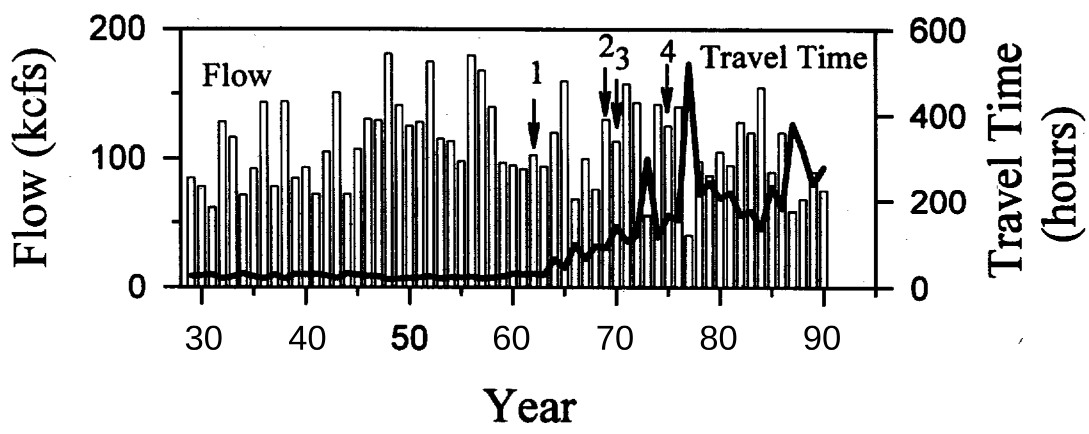


Figure 9. Water particle travel time and flow in the lower Snake River during the spring period (April 15-June 15) from 1929 to 1990 (Columbia Basin Indian Tribes and the State and Federal Fish and Wildlife Agencies 1993). Arrows indicate years of dam completion.

3. Travel Time

Migration speed is often considered an index of survival rate with shorter travel times corresponding to higher survival rates although the strength of this relationship is a question of considerable debate. Smolt travel time is closely correlated with water particle travel time. Water particle travel time in the Columbia and Snake river mainstems increased with dam construction which has increased the cross-sectional area of the river and decreased flow. Average water particle travel time through the Snake River has increased ten-fold since 1962 while average discharge has been reduced by less than half (Figure 9). Travel times for summer migrants such as subyearling chinook are typically longer than those of spring migrants including yearling chinook and steelhead (Table 4). Travel times also vary between hatchery and wild fish and seasonally in relation to changes in flow and degree of smoltification (FPC 1995).

Table 4. Approximate average travel times (days) in 1994 for juvenile salmon and steelhead based on PIT tag observations (pooled estimates for hatchery and wild fish derived from FPC 1995).

From	To	Miles	Dams	Chinook 0	Chinook 1	Sockeye	Steelhead
Whitebird	Lo. Granite	134	1		*12.3*		*6.9*
Lewiston	Lo. Granite	*32*	1		*6.9*		*3.7*
L. Granite	McNary	140	4		13.5		11.6
Rock Island	McNary	161	4	24.5	13.9	10.9	10.4

4. Fish Passage Efficiency

Fish passage efficiency or FPE refers to the proportion of juvenile migrants which pass a dam by means other than turbines. Passage mortality is generally thought to be reduced by increasing passage efficiency to avoid turbines which impose an approximate 10.1 5% mortality rate per dam. Passage efficiency is improved by increasing the proportion of river flow which is passed over spillways and by increasing the proportion of fish which are diverted from turbines by bypass systems such as submersible traveling screens. Fish guidance efficiency **(FGE)** refers to the proportion of migrants which pass via the powerhouse but are diverted from turbines by the bypass systems. Passage efficiency and guidance efficiency are affected by stage of smoltification which varies seasonally. Benefits of improving FPE with high spill rates are controversial because of the resulting gas supersaturation which can also be lethal to fish. Passage efficiencies in 1994 generally fell below the 70 or 80% levels typically recommended by state, tribal, and federal fishery management agencies (Figure 10).

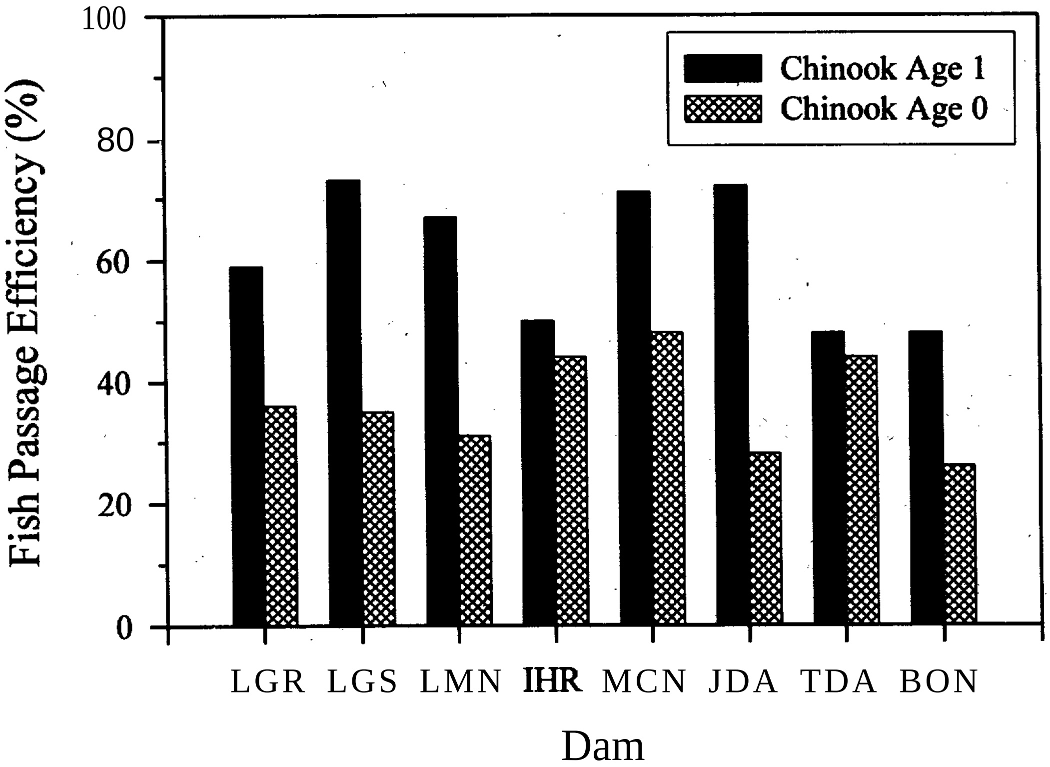


Figure 10. Fish passage efficiency based on 1994 conditions (FPC 1995). Values for spring chinook are averages for April 1 - June 20 in the Snake River and April 1 - June 30 in the lower Columbia River. Values for fall chinook are averages for June 21 - August 31 in the Snake and July 1 - August 3 1 in the lower Columbia.

5. Juvenile Transportation Program

In an attempt to avoid passage mortality through the mainstem Columbia and Snake rivers, over 15 million juvenile salmon and steelhead were collected in 1993 (Figure 11) at Lower Granite, Little Goose, Lower Monumental, and McNary dams and transported by barge or truck to release sites downstream from Bonneville Dam (Hurson et al. 1995). Fish are collected out of turbine intake bypass systems where they are diverted with screens. Transportation began on an experimental basis in 1968 and has been conducted by the U. S. Army Corps of Engineers since 1981 (BPA et al. 1994, Harmon et al. 1995). Comparisons of the relative number of transported and non-transported marked fish observed in fisheries, hatcheries, and other sample sites have been used as an index of transportation benefits (Harmon et al. 1995) but interpretation of this information is extremely controversial (Mundy et al. 1994).

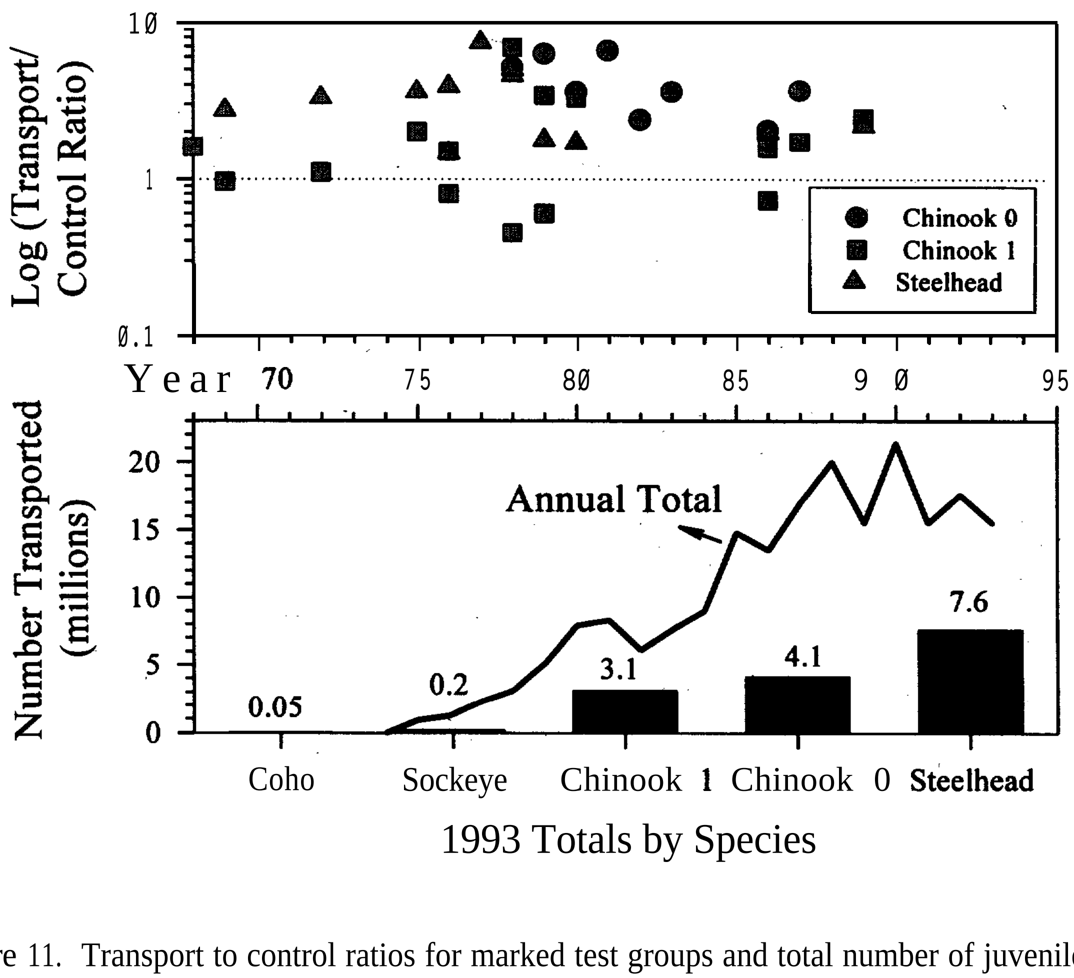


Figure 11. Transport to control ratios for marked test groups and total number of juvenile fish transported from dams to lower Columbia River release sites, 1968-93, with species breakdown for 1993 (Hurson et al. 1995, Mundy et al. 1994). Transport to control ratios are averages for species and release dam by year for values summarized in Mundy et al. 1994. The dotted line indicates equal survival of transported and control groups.

6. **Survival**

During 1993 and 1994, the National Marine Fisheries Service (NMFS) and the University of Washington (UW) tested methods for estimating survival probabilities of individual yearling chinook salmon and steelehad in the Snake River using passive integrated transponder (PIT) tags (Table 5, Iwamoto et al. 1994; Muir et al. 1995). These probabilities (Table 6) are related but not equivalent to survival rates (K. Steinhorst, University of Idaho, unpublished). Survival estimates remain controversial with unresolved questions related to the validity of statistical assumptions; inferences to other river reaches, river conditions, and portions of the outmigration including saltwater entry; and impacts of associated fish capture and handling.

Table 5. Number of salmonids captured by purse seine in Lower Granite Reservoir or handled at Lower Granite, Little Goose, or Lower Monumental dams for NMFS/UW survival studies. Percent wild is in parentheses where known.

	1993	1994
Juveniles	96,486 (15)	272,375 (13)
Sockeye	2	70
Chinook	49,042 (19)	142,620 (12)
Steelhead	47,442 (11)	129,685 (15)
Adults		
Steelhead	116	50

Table 6. Average survival probabilities estimated for individual PIT-tagged fish in the Snake River. Number of release groups is in parentheses. Refer to Iwamoto et al. (1994) and Muir et al. (1995) for release dates, number marked, etc.

From	To	Year	Hatchery chinook	Wild chinook	Hatchery steelhead
Misqually John	Lo. Granite tailrace	1993	0.902 (7)		
Silcott Island	Lo. Granite tailrace	1994	0.922 (10)	0.923 (1)	0.904 (9)
Lo. Granite tailrace	Lit. Goose tailrace	1993	0.862 (7)		
		1994	0.794 (10)	0.827 (1)	0.784 (9)
Lit. Goose tailrace	Lo. Mon. tailrace	1994	0.891 (10)	0.944 (1)	0.831 (9)
Silcott Island	Lo. Mon. tailrace	1994	0.659 (10)	0.728 (1)	0.598 (9)

Minimum survival estimates were also produced by radiotelemetry studies on hatchery chinook salmon juveniles used in evaluation of the transportation program (Schreck et al. 1994). Up to 70% of radio-tagged smolts transported from Lower Granite Dam and released downstream from Bonneville Dam were detected 160 km downstream from the release site. These estimates are conservative because not all fish retain tags and not all tags are detected.

7. Mainstem Predator Control

Predation by northern squawfish is a significant problem for migrating salmon and steelhead juveniles. Efforts to control northern squawfish by, fishing have been underway in the Columbia and Snake mainstems since 1990 (Willis and Young 1995). Squawfish are harvested by agency employees who electrofish, angle, and gillnet at dams and hatchery release sites, and by recreational anglers who are paid rewards for each squawfish turned in to check stations., In 1994, 14 check stations were operated 7 days a week from May 1 through September 25 (Figure 12). Registered anglers logged 40,800 days of effort and averaged 3.2 fish per day (Smith et al. 1995). Over 700,000 fish were removed from 1990 through 1994. In 1994, exploitation rate (% of the population harvested) increased to 13% from a program low of 9% in 1993 (Table 7). The 1994 exploitation rate was within the **10-20%** annual goal for the program.

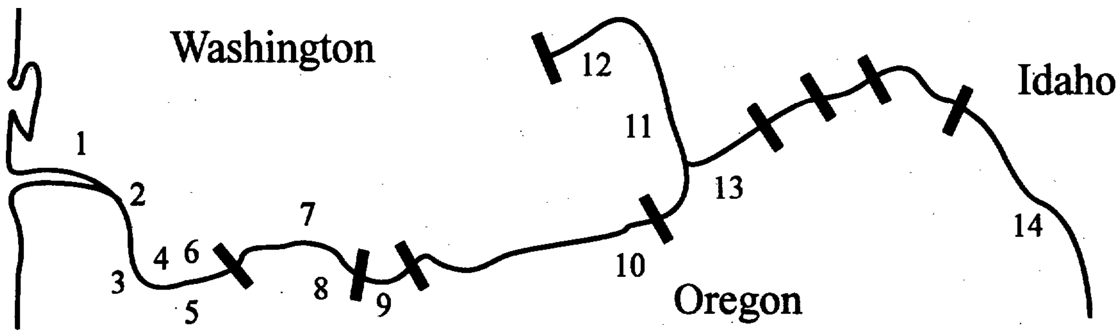


Figure 12. Locations of **squawfish** sport reward fishery registration stations in 1995. 1 = Cathlamet Marina, 2 = Kalama Marina, 3 = Gleason Ramp, 4 = Wahsougal Ramp, 5 = The Fishery, 6 = Hamilton Island, 7 = Bingen Marina, 8 = The Dalles Ramp, 9 = Giles French Ramp, 10 = Umatilla Marina, 1 1 = Columbia Point Park, 12 = Vernita Bridge, 13 = Hood Park, 14 = Greenbelt Ramp.

Table 7. Number and exploitation rate (percentage of population of northern squawfish 250 mm and larger) removed by the squawfish management program. Index values describe relative magnitude of predation in each area relative to John Day Reservoir (Ward et al. 1994).

Area	km	Index	1990	1991	1992	1993	1994	Total
Lower Columbia	224	7.3	1,963	60,260	86,453	53,785	76,167	278,628
Bonneville Res.	74	0.9	4,460	26,981	24,609	15,709	24,304	96,063
The Dalles Res.	38	1.7	2,205	41,180	33,797	14,258	18,370	109,810
John Day Res.	123	1.0	10,425	13,684	11,148	6,456	4,709	46,422
McNary Res.	98	0.5	1,345	8,624	21,069	19,176	21,404	71,618
Lower Snake	242	0.3	0	44,968	40,471	14,120	10,713	110,272
Total	799	11.7	20,398	195,697	217,547	123,504	155,667	712,813
Exploitation (%)				11	12	9	13	

C. Population Trend Summary

1. Natural

Using adult abundance information we looked at general trends in escapement (adult returns) throughout the region. Only those trends with at least 15 years of data having at least one data point in the 1990's were used. We divided the average of the last five years of each trend by the average of the first five years of the trend to get the trend value. Values near one indicated little change, less than one indicated declines in abundance, and greater than one indicated increases in abundance. We performed two analyses, one for indicators of natural spawning escapement and one for hatchery rack escapement. The results of the natural trends are shown in Figure 13. The results of this exercise are fairly consistent for all chinook stocks, with those in the lower and mid Columbia regions doing better than those in the Snake. Summer steelhead however, are doing slightly better in the Snake than in the Lower Columbia. Coho populations below Bonneville (not shown) were nearly all in decline (95% in the **<0.75** category).

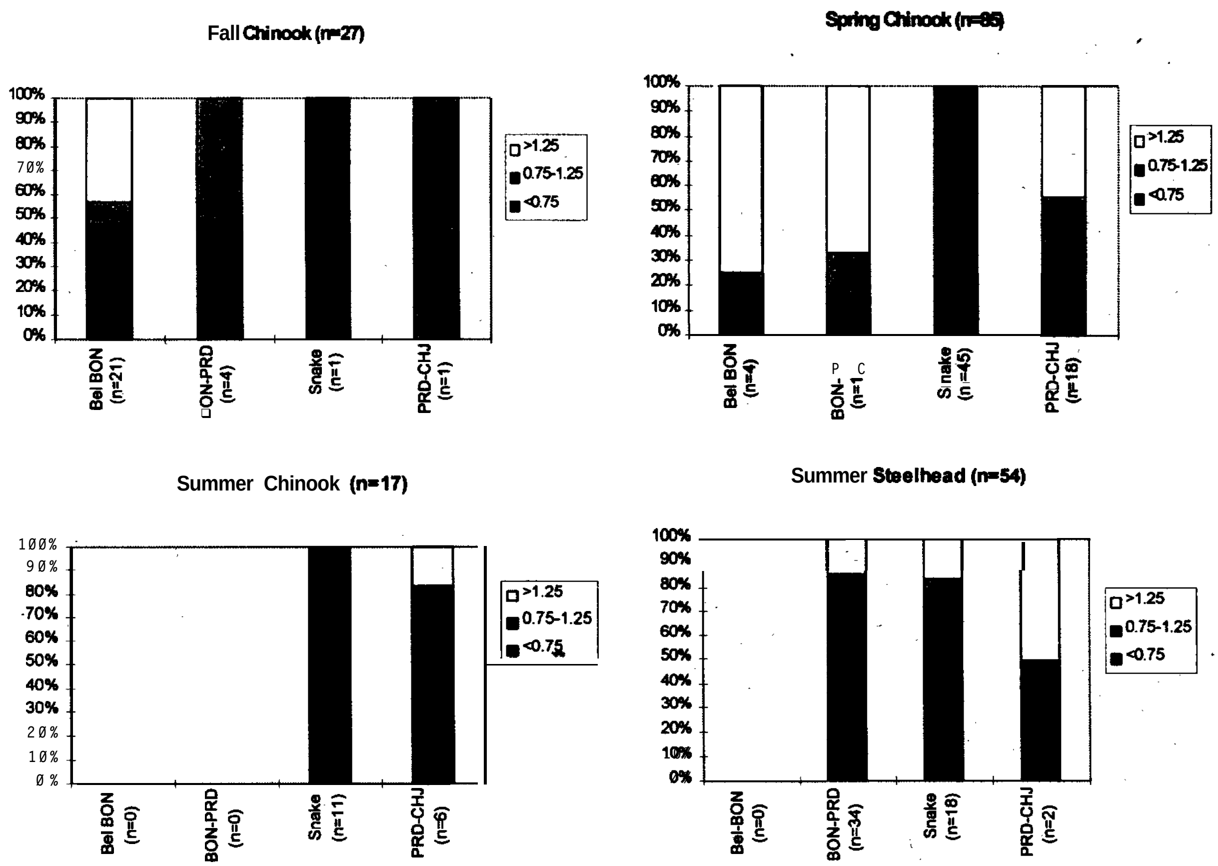


Figure 13. Percentage of natural spawning index ratios (average of ending five years divided by average of beginning five years) falling in three categories by region (trend analysis from data in PSMFC 1995). Black bars indicate a decrease in the number of spawners.

2. Hatchery

Hatchery stocks exhibit similar behavior to natural stocks (Figure 14). Chinook stocks are generally performing better in the Columbia River as compared to the Snake River, while steelhead stocks exhibit the converse pattern.

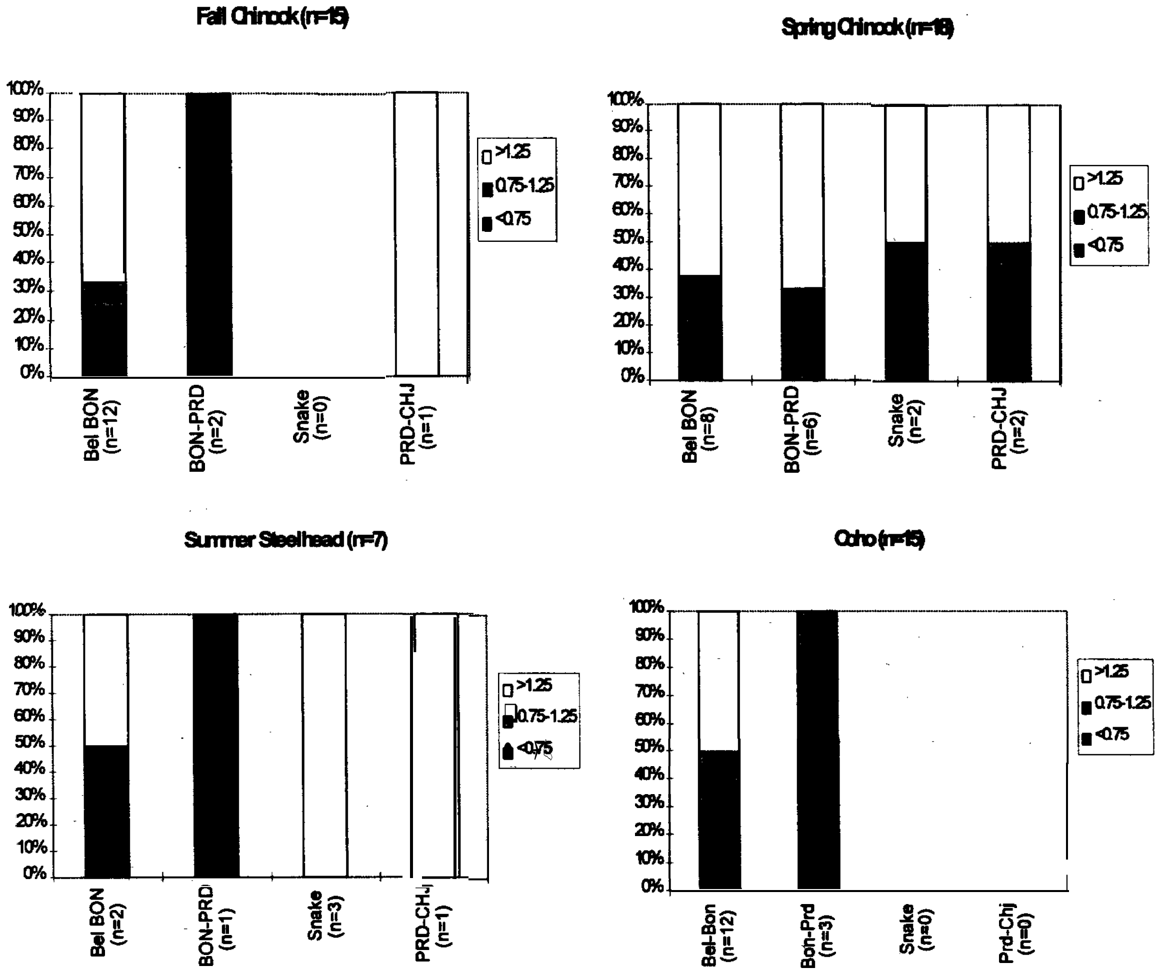


Figure 14. Percentage of hatchery rack return index ratios (average of ending five years divided by average of beginning five years) falling in three categories by region (trend analysis from data in PSMFC 1995). Black bars indicate a decrease in the number of adults returning to the hatcheries.

2. Ocean Distribution

Salmon and Steelhead travel great distances during the ocean phases of their life history. Generalized ocean migration patterns are shown in figures 15-17 (CDFO).

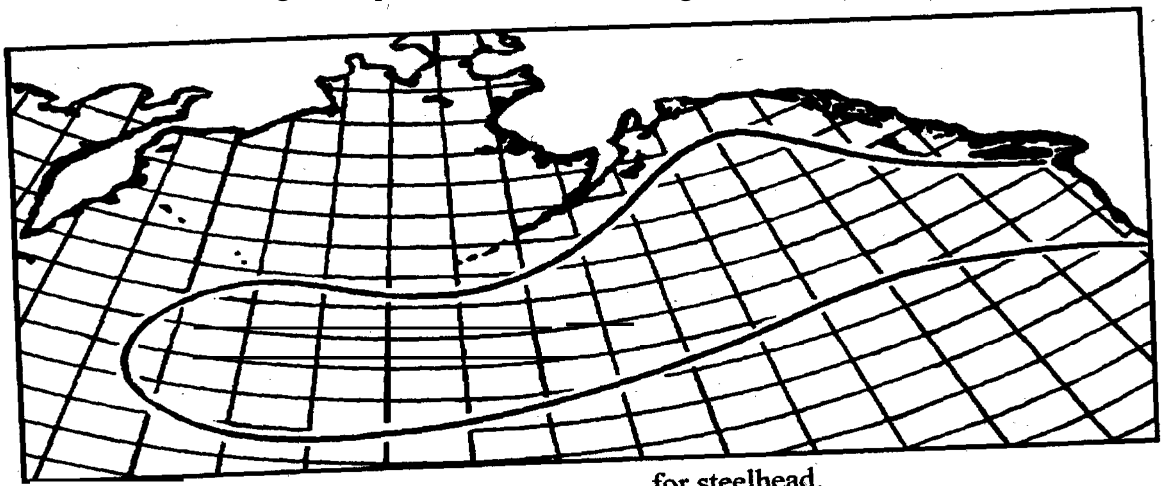


Figure 15. Generalized ocean migration patterns for steelhead.

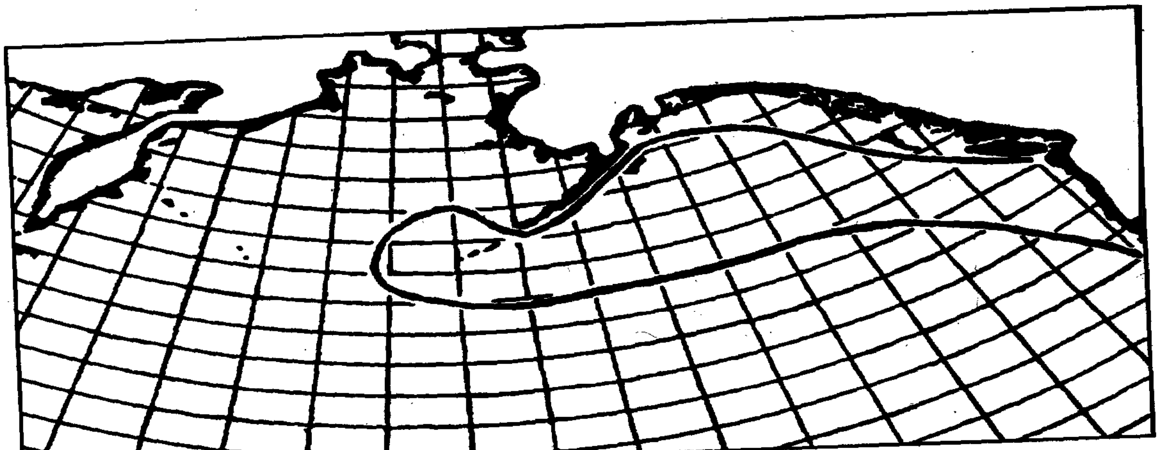


Figure 16. Generalized ocean migration patterns for chinook.

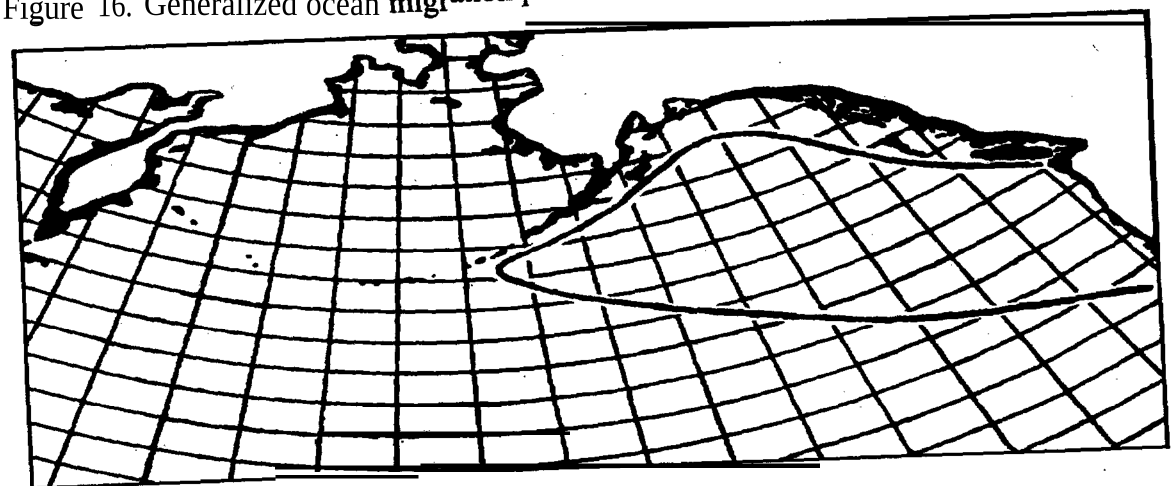


Figure 17. Generalized ocean migration patterns for coho.

3. Freshwater Distribution and Population Summary

Salmon and steelhead stocks utilize thousands of miles of streams throughout the Columbia River Basin (Table 8). Chinook and summer steelhead stocks generally inhabit all major portions of the Basin that are currently accessible (Figures **18-20).** Winter steelhead and coho are confined primarily to areas below Bonneville Dam (Figures **21-22),** although some remnant coho populations do 'exist in the Columbia Basin above Priest Rapids dam.

Table 8. Stock distribution data by Columbia River region in miles (PSMFC 1995, from Subbasin Planning 1989, based on mileages from **1:250,000** scale). Mileages do not include mainstem (Columbia or Snake river) use except for fall chinook in the Snake River.

Species/Run	Columbia River Region	Utilized By Stock	Spawning & Rearing	Rearing Only	Migration Only
Coho	Below Bonneville	2538	1498	814	226
	Bonneville-Priest Rap	1268	210	1057	*0*
	Snake River	0	0	0	*0*
	Priest - Chief Joe	297	172	125	*0*
Fall Chinook	Below Bonneville	1189	749	416	24
	Bonneville-Priest Rap	829	372	457	0
	Snake River	412	264	148	0
	Priest - Chief Joe	168	18	150	0
Spring Chinook	Below Bonneville	1422	715	583	124
	Bonneville-Priest Rap	1750	614	840	296
	Snake River	3766	2367	797	603
	Priest - Chief Joe	428	186	134	108
Summer Chinook	Below Bonneville	148	0	148	0
	Bonneville-Priest Rap	312	63	249	0
	Snake River	1080	445	533	102
	Priest - Chief Joe	312	141	148	23
Summer Steelhead	Below Bonneville	1672	902	613	158
	Bonneville-Priest Rap	4734	3278	940	517
	Snake River	7532	5934	763	835
	Priest - Chief Joe	581	391	167	23
Winter Steelehad	Below Bonneville	3155	1997	915	243
	Bonneville-Priest Rap	358	258	99	1
	Snake River	0	0	0	0
	Priest - Chief Joe	0	0	0	0

The Stock Summary Reports (Hymer et al. 1992, Kiefer et al. 1992, Olsen et al. 1992) identify 287 populations of anadromous fish within the Columbia River, Basin (Table 9). These populations are discreet species/run groups of fish that inhabit a particular drainage basin and do not necessarily represent genetically unique stocks. Natural (including wild) runs make up 45% of these stocks while the remaining 55% are hatchery or mixed runs. Detailed run timing information is shown in Table 10.

Table 9. Number of natural and hatchery/mixed stocks identified in the Stock Summary Reports.

Columbia River Region	Natural	Hatchery / Mixed	Total
Below Bonneville.	65	79	144
Bonneville to Priest Rapids	274	35	62
Snake River	34	32	66
Priest Rapids to Chief Joseph	4	11	15
Total	130	157	287

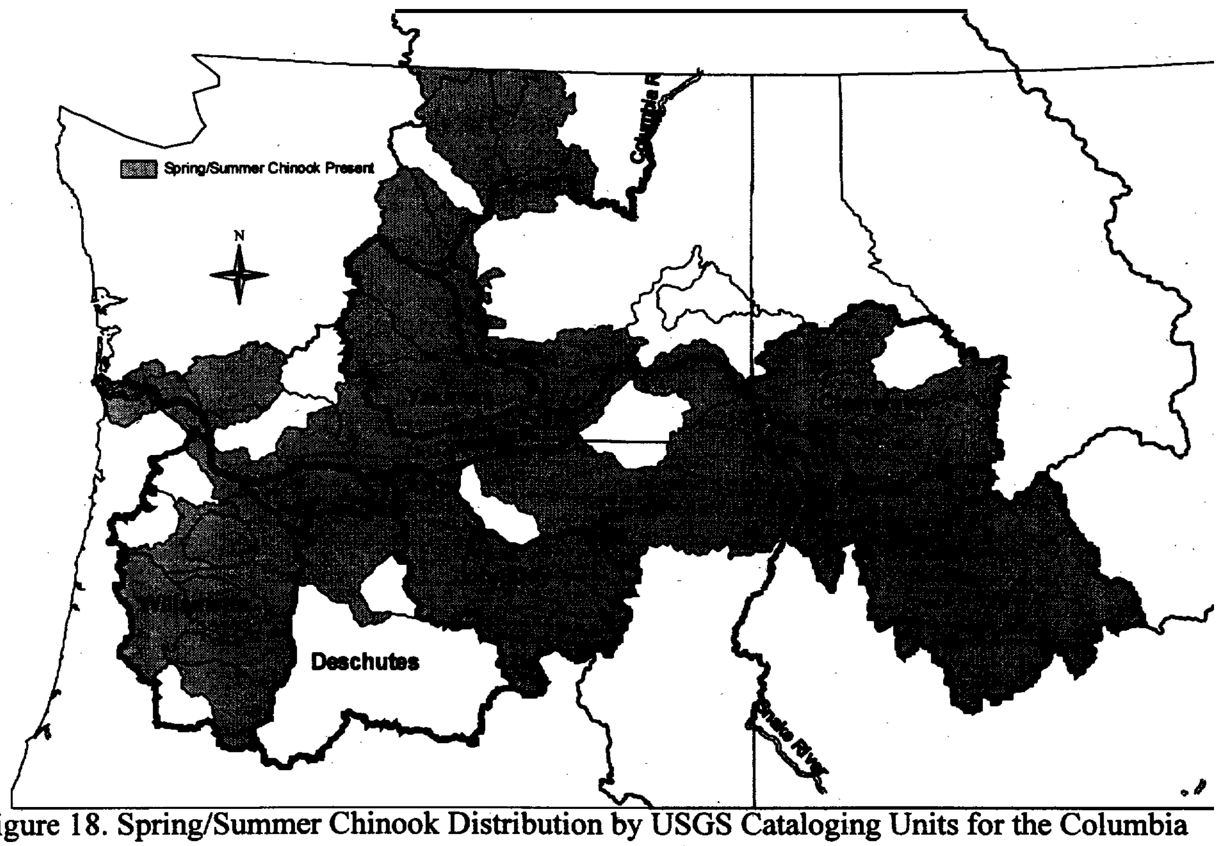


Figure 18. Spring/Summer Chinook Distribution by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on 1989 Subbasin Planning Presence / Absence Data).

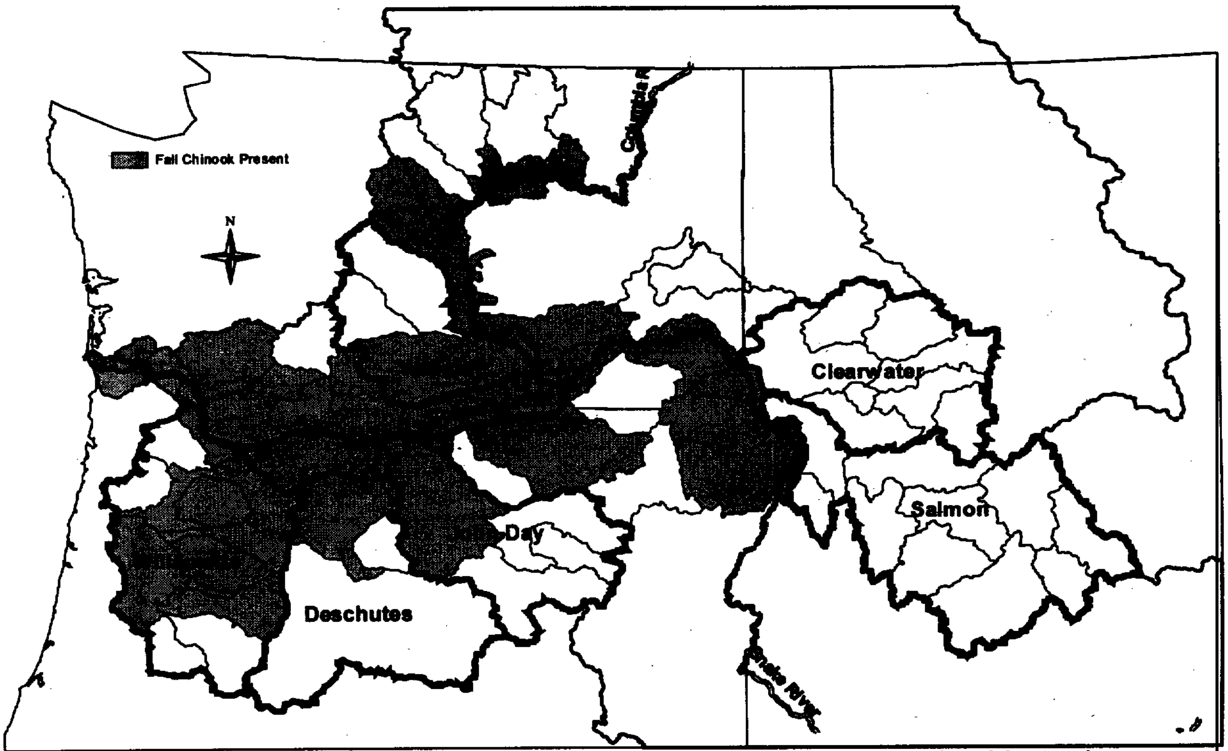


Figure 19. Fall Chinook Distribution by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on 1989 Subbasin Planning Presence / Absence Data).

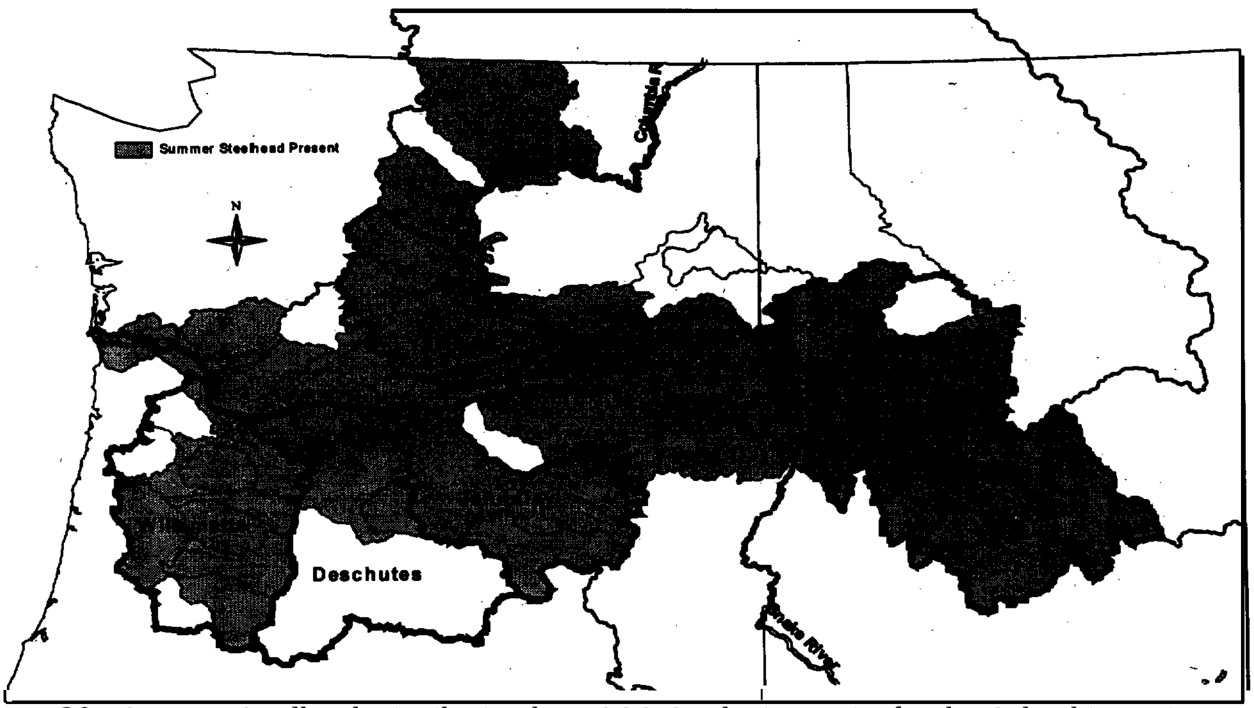


Figure 20. Summer Steelhead Distribution by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on 1989 Subbasin Planning Presence / Absence Data).

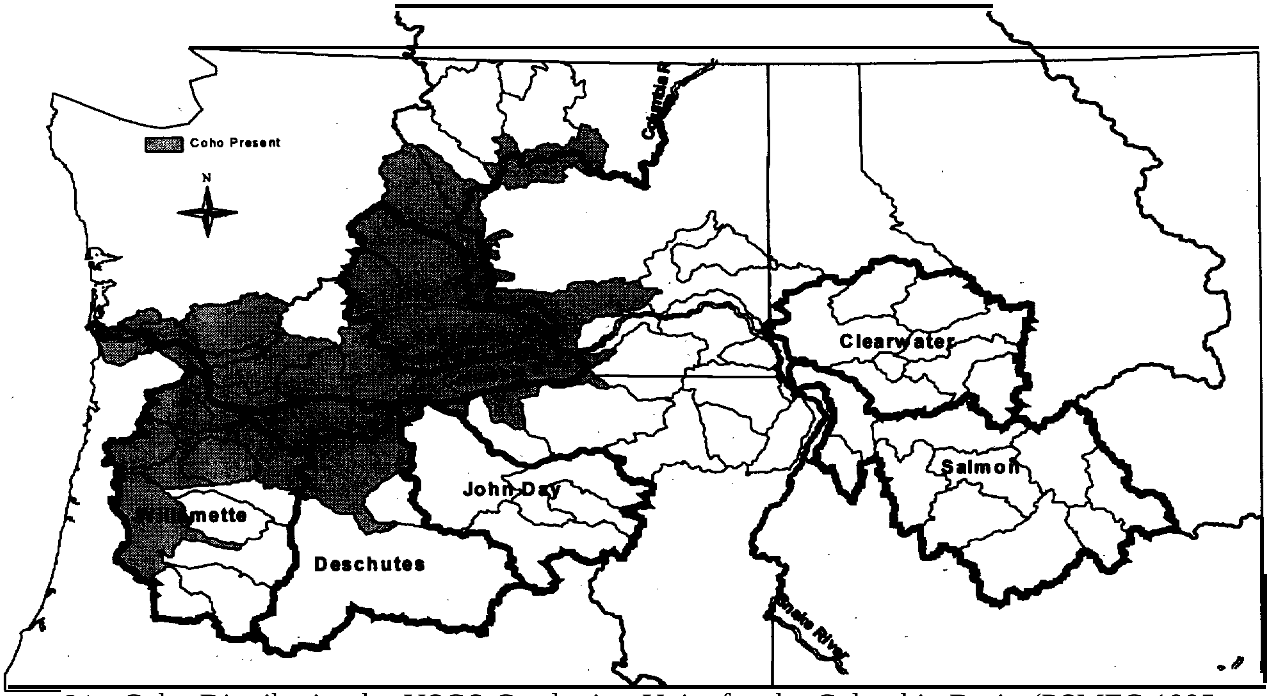
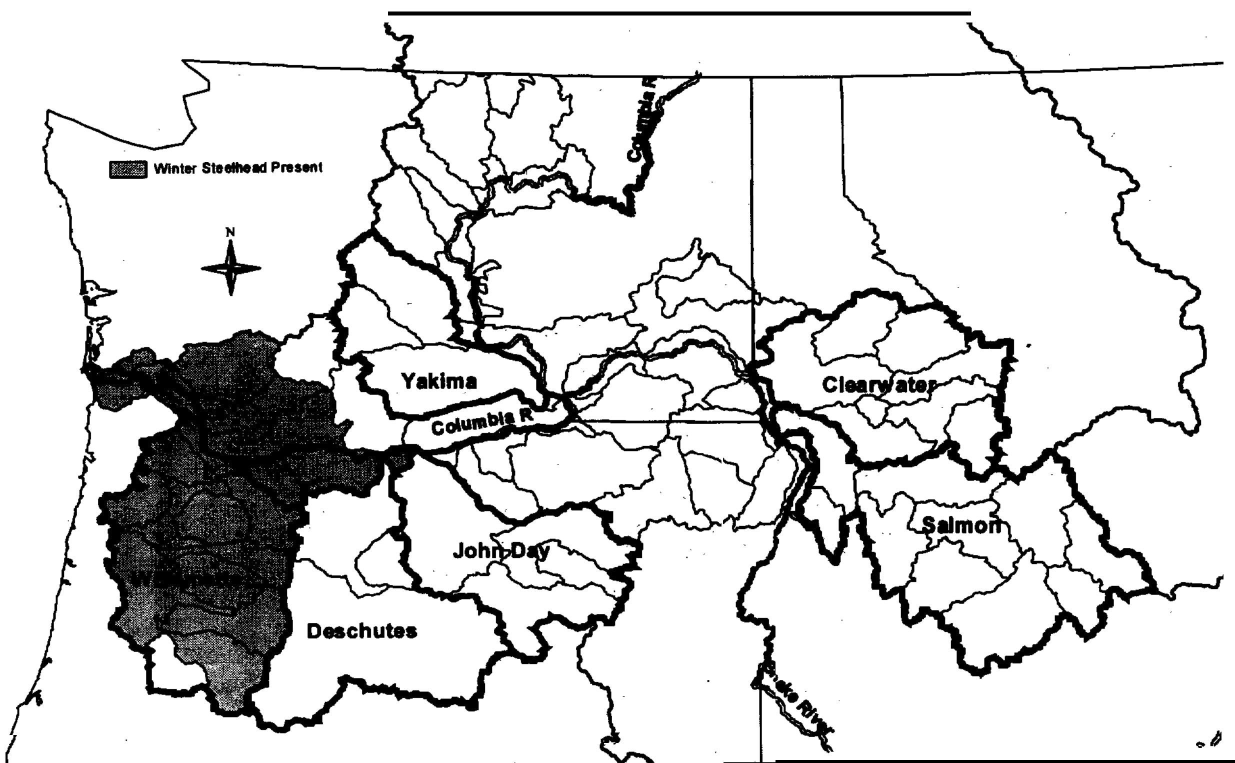


Figure 21. Coho Distribution by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on 1989 Subbasin Planning Presence / Absence Data).



F'igure 22. Winter Steelhead Distribution by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on 1989 Subbasin Planning Presence / Absence Data).

Table 10. Number of runs and life history information by species, run, and Columbia River Region. Format for dates is mm/dd/Yr_x, where Yr_x represents the year of the life history relative to adult immigration (year 1).

Species/Run	Columbia River Region	Production Type	# Runs	Adult Immigration	Spawning	Egg\Alevin Incubation	Emergence	Rearing	Juvenile Emigration
Chum	Below Bonneville	Hatchery/Mixed	3	10/15/Yr1-12/31/Yr1	11/15/Yr1-12/15/Yr1	-	3/15/Yr2-4/15/Yr2	-	-
Chum	Below Bonneville	Natural	1	10/15/Yr1-11/30/Yr1	-	-	-	-	-
Coho	Below Bonneville	Hatchery/Mixed	10	8/1/Yr1-1/31/Yr2	10/15/Yr1-11/15/Yr1	-	-	-	-
Coho	Below Bonneville	Natural	8	8/1/Yr1-2/15/Yr2	8/15/Yr1-12/31/Yr1	8/15/Yr1-3/15/Yr2	1/15/Yr2-3/31/Yr2	1/15/Yr2-7/31/Yr3	3/1/Yr3-7/31/Yr3
Coho	Bonneville-Priest Rap	Hatchery/Mixed	5	9/1/Yr1-1/15/Yr2	10/15/Yr1-12/15/Yr1	10/15/Yr1-3/15/Yr2	1/15/Yr2-5/15/Yr2	3/15/Yr2-5/31/Yr3	2/1/Yr3-6/30/Yr3
Coho	Bonneville-Priest Rap	Natural	3	9/1/Yr1-10/31/Yr1	10/1/Yr1-11/30/Yr1	-	-	-	-
Coho	Snake	Hatchery/Mixed	1	-	-	-	-	-	-
Coho	Snake	Natural	1	9/15/Yr1-11/15/Yr1	11/15/Yr1-12/15/Yr1	11/15/Yr1-4/15/Yr2	2/15/Yr2-4/15/Yr2	2/15/Yr2-5/15/Yr3	9/15/Yr2-6/15/Yr3
Coho (N Type - Late)	Below Bonneville	Hatchery/Mixed	6	9/1/Yr1-10/31/Yr1	11/15/Yr1-3/31/Yr2	-	1/1/Yr2-4/30/Yr2	-	-
Coho (N Type - Late)	Below Bonneville	Natural	2	9/15/Yr1-3/31/Yr2	11/1/Yr1-3/31/Yr2	11/1/Yr1-5/15/Yr2	1/1/Yr2-5/31/Yr2	1/1/Yr2-6/15/Yr3	10/1/Yr2-7/31/Yr3
Coho (N Type - Late)	Bonneville-Priest Rap	Hatchery/Mixed	2	9/15/Yr1-10/31/Yr1	9/15/Yr1-3/31/Yr2	-	1/15/Yr2-2/28/Yr2	-	-
Coho (S Type - Early)	Below Bonneville	Hatchery/Mixed	6	8/1/Yr1-9/30/Yr1	10/15/Yr1-10/15/Yr1	-	1/1/Yr2-4/30/Yr2	-	-
Coho (S Type - Early)	Below Bonneville	Natural	4	8/1/Yr1-12/31/Yr1	9/1/Yr1-12/31/Yr1	9/15/Yr1-4/30/Yr2	11/15/Yr1-4/30/Yr2	11/15/Yr1-7/31/Yr3	3/1/Yr3-7/31/Yr3
Coho (S Type - Early)	Bonneville-Priest Rap	Hatchery/Mixed	2	8/15/Yr1-11/15/Yr1	9/15/Yr1-11/15/Yr1	-	1/15/Yr2-2/28/Yr2	-	-
Fall Chinook	Below Bonneville	Hatchery/Mixed	15	8/1/Yr1-11/30/Yr1	9/15/Yr1-1/31/Yr2	9/15/Yr1-4/15/Yr2	12/1/Yr1-8/15/Yr2	3/1/Yr2-8/31/Yr2	4/15/Yr2-12/31/Yr2
Fall Chinook	Below Bonneville	Natural	9	8/1/Yr1-2/15/Yr2	8/15/Yr1-2/15/Yr2	8/15/Yr1-5/15/Yr2	11/1/Yr1-6/30/Yr2	11/15/Yr1-9/15/Yr2	3/15/Yr2-9/15/Yr2
Fall Chinook	Bonneville-Priest Rap	Hatchery/Mixed	3	8/1/Yr1-11/30/Yr1	9/15/Yr1-10/31/Yr1	-	1/1/Yr2-3/31/Yr2	-	-
Fall Chinook	Bonneville-Priest Rap	Natural	4	6/15/Yr1-10/31/Yr1	10/1/Yr1-12/31/Yr1	11/1/Yr1-3/31/Yr2	1/1/Yr2-4/15/Yr2	2/1/Yr2-6/30/Yr2	5/1/Yr2-7/31/Yr2
Fall Chinook	Snake	Hatchery/Mixed	1	-	-	-	-	-	-
Fall Chinook	Snake	Natural	2	10/15/Yr1-11/30/Yr1	11/1/Yr1-12/31/Yr1	-	-	-	-
Fall Chinook	Priest Rap-Chief Joe	Hatchery/Mixed	2	8/15/Yr1-10/31/Yr1	10/15/Yr1-12/31/Yr1	-	12/15/Yr1-1/15/Yr2	-	3/15/Yr2-7/31/Yr2
Fall Chinook (Tule)	Below Bonneville	Hatchery/Mixed	1	8/15/Yr1-9/30/Yr1	-	-	-	-	-
Fall Chinook (Tule)	Below Bonneville	Natural	2	-	9/15/Yr1-10/15/Yr1	-	-	-	-
Fall Chinook (Tule)	Bonneville-Priest Rap	Hatchery/Mixed	3	8/1/Yr1-9/30/Yr1	9/1/Yr1-10/15/Yr1	9/1/Yr1-12/15/Yr1	12/1/Yr1-3/31/Yr2	12/15/Yr1-5/15/Yr2	5/15/Yr2-9/30/Yr2
Fall Chinook (URB)	Below Bonneville	Natural	1	8/1/Yr1-2/15/Yr2	11/15/Yr1-2/15/Yr2	11/15/Yr1-5/15/Yr2	5/1/Yr2-6/30/Yr2	5/15/Yr2-9/30/Yr2	5/15/Yr2-9/30/Yr2
Fall Chinook (URB)	Bonneville-Priest Rap	Hatchery/Mixed	3	8/1/Yr1-1/15/Yr2	10/15/Yr1-1/15/Yr2	10/15/Yr1-4/15/Yr2	1/15/Yr2-4/15/Yr2	-	2/15/Yr2-11/15/Yr2
Sockeye	Below Bonneville	Hatchery/Mixed	1	-	-	-	-	-	-
Sockeye	Below Bonneville	Natural	1	-	-	-	-	-	-
Sockeye	Bonneville-Priest Rap	Hatchery/Mixed	1	-	-	-	-	-	-
Sockeye	Bonneville-Priest Rap	Natural	1	7/1/Yr1-9/30/Yr1	9/15/Yr1-11/15/Yr1	11/1/Yr1-4/15/Yr2	3/15/Yr2-5/15/Yr2	6/1/Yr2-6/30/Yr2	3/1/Yr3-5/31/Yr3
Sockeye	Snake	Natural	2	6/1/Yr1-10/31/Yr1	10/1/Yr1-11/15/Yr1	10/1/Yr1-3/31/Yr2	4/1/Yr2-5/31/Yr2	4/1/Yr2-8/31/Yr3	4/1/Yr3-5/31/Yr3

Species/Run	Columbia River Region	Production Type	# Runs	Adult Immigration	Spawning	Egg\Alevin Incubation	Emergence	Rearing	Juvenile Emigration
Sockeye	Priest Rap-Chief Joe	Hatchery/Mixed	2	5/15/Yr1-8/31/Yr1	10/15/Yr1-10/15/Yr1	-	3/15/Yr2-4/30/Yr2	-	-
Spring Chinook	Below Bonneville	Hatchery/Mixed	13	1/1/Yr1-11/30/Yr1	8/15/Yr1-11/15/Yr1	8/15/Yr1-2/15/Yr2	11/1/Yr1-3/31/Yr2	11/15/Yr1-5/15/Yr3	11/1/Yr2-7/31/Yr3
Spring Chinook	Below Bonneville	Natural	9	1/1/Yr1-11/30/Yr1	8/1/Yr1-11/30/Yr1	9/15/Yr1-4/30/Yr2	11/15/Yr1-7/15/Yr2	2/1/Yr2-3/31/Yr3	3/1/Yr2-6/15/Yr4
Spring Chinook	Bonneville-Priest Rap	Hatchery/Mixed	8	3/1/Yr1-8/15/Yr1	8/1/Yr1-9/30/Yr1	8/15/Yr1-2/15/Yr2	12/15/Yr1-3/15/Yr2	1/15/Yr2-7/15/Yr3	9/15/Yr2-8/15/Yr3
Spring Chinook	Bonneville-Priest Rap	Natural	4	4/1/Yr1-6/30/Yr1	8/15/Yr1-9/30/Yr1	9/1/Yr1-3/31/Yr2	1/1/Yr2-5/31/Yr2	4/1/Yr2-5/31/Yr3	3/1/Yr3-6/30/Yr3
Spring Chinook	Snake	Hatchery/Mixed	13	2/15/Yr1-9/30/Yr1	6/15/Yr1-10/15/Yr1	7/1/Yr1-2/15/Yr2	9/15/Yr1-4/30/Yr2	9/15/Yr1-5/15/Yr3	8/15/Yr2-6/15/Yr3
Spring Chinook	Snake	Natural	10	3/15/Yr1-8/31/Yr1	7/15/Yr1-9/30/Yr1	7/15/Yr1-2/28/Yr2	11/15/Yr1-4/15/Yr2	12/1/Yr1-4/30/Yr3	2/1/Yr3-6/30/Yr3
Spring Chinook	Priest Rap-Chief Joe	Hatchery/Mixed	3	4/15/Yr1-7/31/Yr1	8/15/Yr1-9/30/Yr1	-	-	-	-
Summer Chinook	Below Bonneville	Hatchery/Mixed	1	-	-	-	-	-	-
Summer Chinook	Bonneville-Priest Rap	Hatchery/Mixed	1	-	-	-	-	-	-
Summer Chinook	Bonneville-Priest Rap	Natural	1	-	-	-	-	-	-
Summer Chinook	Snake	Hatchery/Mixed	3	5/1/Yr1-10/31/Yr1	8/1/Yr1-10/31/Yr1	7/15/Yr1-6/15/Yr2	10/15/Yr1-6/15/Yr2	10/15/Yr1-5/31/Yr3	2/15/Yr3-4/30/Yr3
Summer Chinook	Snake	Natural	4	5/15/Yr1-8/15/Yr1	8/15/Yr1-12/31/Yr1	8/15/Yr1-6/30/Yr2	3/1/Yr2-6/30/Yr2	3/1/Yr2-4/15/Yr3	3/1/Yr3-4/30/Yr3
Summer Chinook	Priest Rap-Chief Joe	Hatchery/Mixed	3	5/15/Yr1-9/30/Yr1	9/15/Yr1-11/30/Yr1	-	1/1/Yr2-4/30/Yr2	-	6/1/Yr2-7/31/Yr2
Summer StlHead	Below Bonneville	Hatchery/Mixed	11	3/1/Yr1-2/15/Yr2	11/15/Yr1-6/15/Yr2	11/15/Yr1-6/15/Yr2	1/15/Yr2-8/15/Yr2	6/1/Yr2-4/15/Yr3	3/15/Yr2-6/30/Yr4
Summer StlHead	Below Bonneville	Natural	10	3/1/Yr1-2/28/Yr2	2/1/Yr1-6/15/Yr2	11/15/Yr1-6/30/Yr2	12/1/Yr1-8/31/Yr2	-	5/1/Yr1-6/15/Yr3
Summer StlHead	Bonneville-Priest Rap	Hatchery/Mixed	4	4/15/Yr1-6/15/Yr2	3/15/Yr2-6/15/Yr2	3/15/Yr2-7/15/Yr2	5/15/Yr2-7/15/Yr2	5/15/Yr2-5/15/Yr3	3/15/Yr3-7/15/Yr3
Summer StlHead	Bonneville-Priest Rap	Natural	9	3/1/Yr1-6/30/Yr2	2/1/Yr1-6/15/Yr2	3/1/Yr2-8/15/Yr2	5/1/Yr2-8/31/Yr2	5/1/Yr2-7/31/Yr2	4/1/Yr1-5/31/Yr4
Summer StlHead	Snake	Hatchery/Mixed	13	1/15/Yr1-6/30/Yr2	3/1/Yr1-6/30/Yr2	2/15/Yr1-7/31/Yr2	4/1/Yr1-11/15/Yr2	4/1/Yr1-6/15/Yr3	2/15/Yr2-6/15/Yr3
Summer StlHead	Snake	Natural	13	6/15/Yr1-6/30/Yr2	4/1/Yr1-6/30/Yr2	2/15/Yr2-7/31/Yr2	4/15/Yr2-11/15/Yr2	7/15/Yr1-6/15/Yr3	4/15/Yr2-5/31/Yr4
Summer StlHead	Priest Rap-Chief Joe	Hatchery/Mixed	1	5/1/Yr1-10/31/Yr1	1/1/Yr2-3/31/Yr2	-	-	-	-
Summer StlHead	Priest Rap-Chief Joe	Natural	4	7/15/Yr1-11/30/Yr1	4/1/Yr1-6/30/Yr2	-	-	-	-
Summer StlHead (A Run)	Snake	Natural	1	9/1/Yr1-12/15/Yr1	2/1/Yr2-5/15/Yr2	3/1/Yr2-4/30/Yr2	4/15/Yr2-5/31/Yr2	-	3/1/Yr2-5/15/Yr2
Summer StlHead (B Run)	Snake	Hatchery/Mixed	1	1/1/Yr1-5/31/Yr1	2/1/Yr1-5/15/Yr1	3/1/Yr1-6/15/Yr1	3/15/Yr1-7/15/Yr1	7/15/Yr1-4/30/Yr2	4/1/Yr2-5/31/Yr2
Summer StlHead (B Run)	Snake	Natural	1	8/1/Yr1-5/31/Yr2	3/15/Yr2-6/15/Yr2	4/1/Yr2-6/15/Yr2	6/1/Yr2-7/31/Yr2	-	3/15/Yr3-6/15/Yr3
Winter StlHead	Below Bonneville	Hatchery/Mixed	12	2/1/Yr1-5/15/Yr2	4/15/Yr1-5/15/Yr2	1/1/Yr2-5/31/Yr2	2/15/Yr2-6/30/Yr2	2/15/Yr2-7/31/Yr3	2/15/Yr3-6/30/Yr4
Winter StlHead	Below Bonneville	Natural	16	1/1/Yr1-6/15/Yr2	2/1/Yr1-6/30/Yr2	1/15/Yr1-7/31/Yr2	3/1/Yr1-5/31/Yr3	3/1/Yr1-5/15/Yr4	4/15/Yr1-11/30/Yr3
Winter StlHead	Bonneville-Priest Rap	Hatchery/Mixed	3	-	-	-	-	-	-
Winter StlHead	Bonneville-Priest Rap	Natural	5	1/1/Yr1-12/31/Yr1	3/1/Yr1-6/30/Yr2	-	-	-	4/1/Yr1-5/31/Yr1

4. Habitat

A. Columbia River Basin Dam Development

Hydroelectric and other purpose dam development in the Columbia River Basin has been widespread and ongoing for over 100 years. There are at least 145 hydropower dams in the basin and over 900 other purpose dams greater than 10 ft. in height, (Table 11).

Dam development in the Columbia River Basin has affected anadromous fish production in a variety of ways including:, 1) complete loss of upstream habitat due to blockage, 2) direct mortality caused by the dams to both downstream and upstream migrants, and 3) indirect mortality caused by alteration of the environment (change in flow patterns and travel time, etc.).

Table 11. Number of hydropower and multipurpose dams in the Columbia Basin by region *(NID 1994 and BC Hydro 1996).*

Columbia River Region	Hydro Power	Non Hydro Power	Total
Below Bonneville	40	167	207
Bonneville to Priest Rapids	16	152	168
Snake River	42	310	352
Priest Rapids to Chief Joseph	10	54	64
Chief Joseph to Headwaters	37	168	205
Unknown Stream in Basin	0	68	68
Total	**145**	**919**	**1.064**

B. Mainstem

1. Hydropower Project Summary

Grand Coulee Dam on the Columbia (completed in 1941) and Hells Canyon Dam on the Snake (completed in 1967) completely blocked fish passage. There are currently 13 passage mainstem dams operated in Basin at this time (Table 12). The only truly free flowing section of the Columbia River that remains above Bonneville Dam is the Hanford Reach.

Table 12. Project summary data for passable mainstem dams on the Columbia and Snake rivers. (USDOE et. al 1994).

Dam (Powerhouse)	Year Complete	Full Pool (ft)	Minimum Operating Pool (ft)	# Turbine Units	#Units with screens	MW Cap.	Pool Length (mi)
Bonneville (1)	1938	77	70	10	10	518	46
Bonneville (2)	1982			8	8	532	,
The Dalles	1960	160	155	14 (1960) 8 (1973)	0	1,780	24
John Day	1971	268	257	16	16	2,160	76
McNary	1957	340	335	14	14	980	61
Ice Harbor	1962	440	437	3 (1962) 3 (1975)	6	603	32
Lower Monumental	1970						29
Little Goose	1970	638	633	3 (1970) 3 (1978)	6	810	37
Lower Granite	1975	738	733	3 (1975) 3 (1978)	6	810	5
Priest Rapids	1959	83	18				18
Wanapum	1963	84	38				38
Rock Island	1933	54	21				21
Rocky Reach	1961	93	42				42
Wells	1967	72	29				29

2. **Long Term Change In Hydrograph**

Hydro-development, and the increased storage capacity that resulted from it, as well as irrigation has had a significant impact on seasonal flows in the Columbia River Basin. While the annual average flow of the Columbia has not changed significantly, spring and summer flows have been reduced (Figure 23) and winter flows increased. This reduction in spring and summer flows has been aggravated by lower than normal run-off in 8 of the last 10 years,

Reservoir storage capacity in the Columbia. River Basin has reached over 100 million acre feet (Figure 24). Total storage available increased over 50% in one year alone. (1973) with the completion of Libby Dam in Montana, Dworshak dam in Idaho, and the Mica Dam in British Columbia. Mica dam has an incredible storage capacity of over 23 million acre feet.

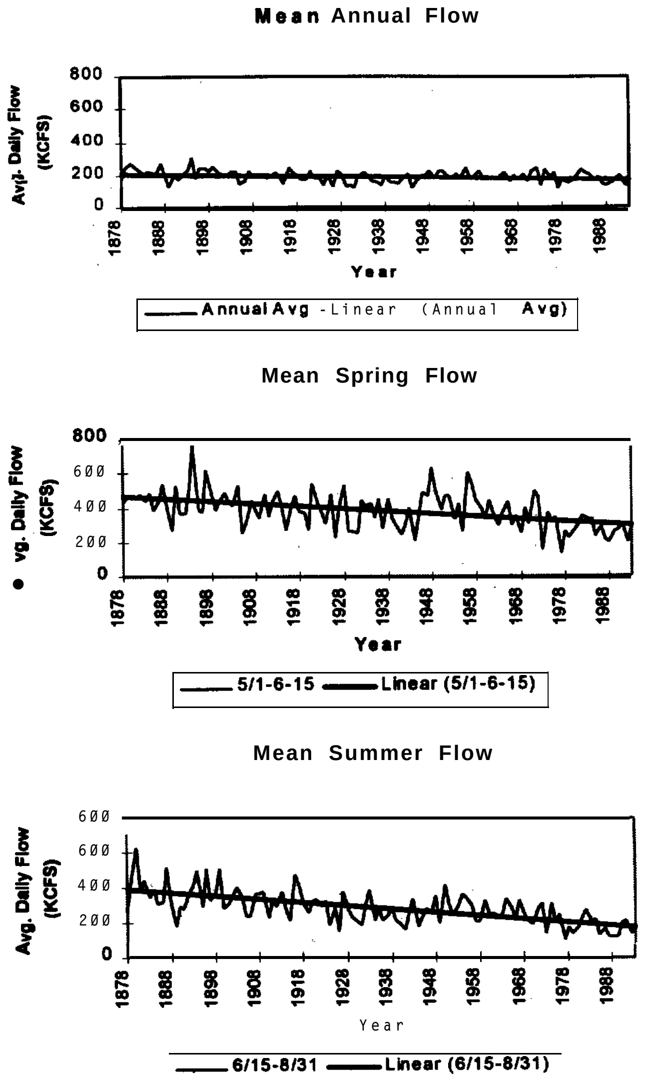


Figure 23. Average daily flows in the Columbia River at The Dalles for three time periods; Annual (top), Spring (middle), and Summer (bottom) (PSMFC 1996).

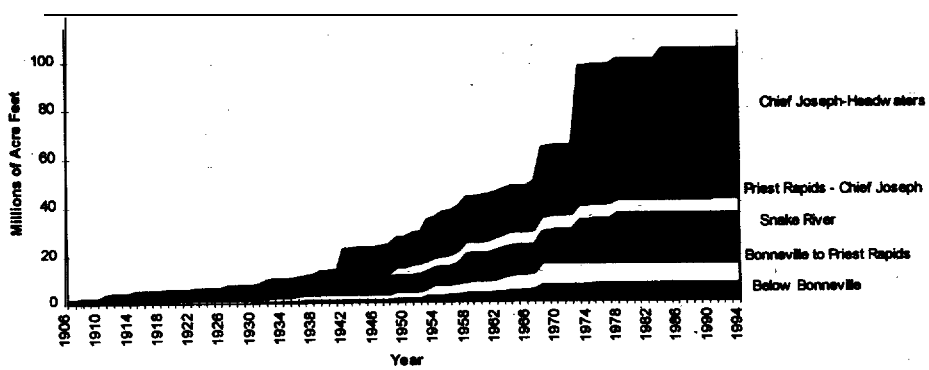


Figure 24. Cumulative storage capacity in the Columbia River Basin in millions of acre feet (PSMFC 1996).

3. Recent Flow And Spill Conditions

Table 13 shows daily average total project flows and percent spill for the spring period (April 16 to May 31 for all projects except the four lower Columbia dams (Bonneville, The Dalles, John Day, and McNary) and May 1 - June 15 for those projects). Summer flows and percent spill are shown in Table 14. The summer period was defined as June 1 through July 31st for upriver projects and June 16th through August 31st for the four lower Columbia dams.

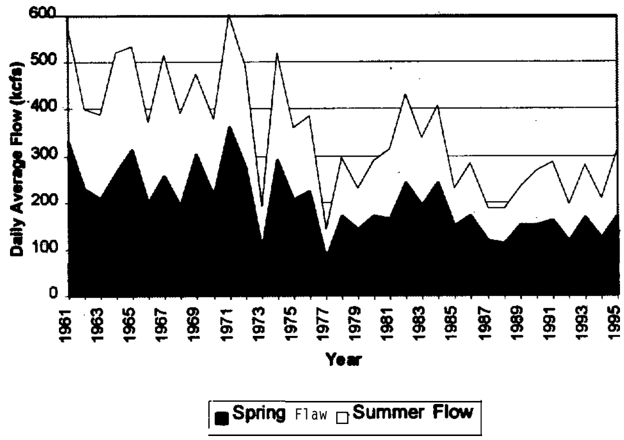
Table 13. Spring period average total flows (kcfs) and percent of that flow spilled by each project (PSMFC 1996).

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
BON	308-53%	319-58%	128-3%	251-42%	211-31%	251-41%	248-38%	351-41%	290-25%	335-41%	226-30%	250-40%	189-20%	175-13%	231-30%	243-33%	263-38%	194-50%	239-44%	193-45%	254-35%
TDA	284-21%	311-33%	122-0%	241-1%	203-0%	239-5%	242-12%	340-34%	275-20%	323-20%	214-8%	242-18%	183-0%	168-0%	223-6%	233-8%	257-13%	188-7%	232-26%	186-19%	236-54%
JDA	286-21%	323-24%	124-0%	250-2%	210-1%	247-7%	250-18%	356-33%	287-36%	339-28%	219-7%	249-17%	185-0%	170-1%	224-2%	236-7%	260-11%	187-2%	235-16%	189-4%	248-3%
MCN	277-22%	314-49%	123-1%	242-9%	195-5%	234-22%	237-19%	335-42%	273-37%	317-43%	211-4%	242-13%	182-10%	163-0%	214-5%	234-9%	254-23%	183-3%	224-19%	183-8%	241-39%
IHR	121-63%	131-44%	36-0%	94-12%	81-14%	97-23%	86-34%	141-47%	107-39%	155-41%	80-10%	98-30%	50-1%	56-0%	82-14%	67-13%	68-16%	48-33%	104-31%	63-32%	97-35%
LMN	121-53%	129-58%	37-0%	93-30%	83-4%	100-11%	88-35%	141-61%	106-43%	154-40%	82-18%	98-35%	52-14%	58-9%	82-33%	68-31%	69-36%	48-22%	103-23%	62-8%	97-16%
LGS	125-48%	135-60%	38-0%	94-12%	82-0%	98-0%	86-0%	143-28%	107-19%	155-29%	82-0%	98-5%	52-0%	58-0%	82-0%	67-0%	67-1%	48-0%	103-23%	62-24%	96-20%
LGR	120-73%	135-59%	37-0%	94-6%	81-3%	98-2%	87-9%	144-30%	107-14%	156-32%	80-1%	98-4%	51-0%	57-0%	81-0%	66-0%	67-0%	48-0%	103-13%	62-13%	97-12%
PRD	150-10%	172-13%	86-2%	138-3%	111-6%	130-12%	155-18%	190-56%	158-31%	152-28%	128-10%	136-15%	126-10%	106-9%	128-15%	165-21%	182-31%	138-17%	118-21%	123-12%	136-22%
RIS	144-46%	181-59%	85-17%	137-44%	109-8%	125-8%	146-11%	176-36%	150-23%	145-25%	124-8%	133-11%	123-12%	101-12%	124-15%	156-18%	172-18%	130-9%	111-18%	116-12%	127-10%
RRH	138-3%	166-9%	81-1%	132-3%	103-5%	120-10%	146-13%	177-32%	148-19%	145-12%	122-6%	129-7%	118-7%	94-6%	119-6%	153-10%	168-8%	126-5%	108-8%	113-11%	121-10%
WEL	138-4%	167-17%	81-1%	129-3%	105-5%	119-6%	143-10%	174-32%		142-21%	119-6%	127-7%	115-5%	95-5%	122-5%	158-15%	170-7%	125-6%	107-9%	112-5%	117-6%

Table 14. Summer period average total flows (kcfs) and percent of that flow spilled by each project (PSMFC 1996).

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
BON	200-32%	245-42%	101-1%	176-24%	128-4%	168-21%	221-27%	259-26%	202-21%	213-20%	120-7%	149-8%	114-0%	114-1%	112-5%	181-18%	193-26%	134-37%	155-44%	135-37%	194-45%
TDA	193-13%	235-20%	95-0%	168-0%	123-0%	163-4%	217-9%	253-30%	191-11%	206-12%	112-4%	146-4%	110-0%	110-0%	110-5%	180-6%	188-7%	127-4%	151-5%	130-9%	184-61%
JDA	194-14%	243-14%	97-0%	172-0%	125-0%	165-6%	222-17%	262-26%	197-21%	211-28%	111-0%	151-10%	109-1%	110-3%	108-6%	180-7%	190-9%	126-7%	150-7%	131-5%	190-3%
MCN	193-16%	243-27%	97-0%	168-0%	123-0%	165-15%	219-13%	253-34%	193-3%	206-25%	111-0%	147-1%	109-0%	109-0%	108-0%	180-7%	190-10%	125-0%	149-0%	129-2%	186-15%
IHR	116-61%	82-28%	28-0%	80-8%	50-2%	74-28%	77-61%	117-40%	97-36%	124-40%	49-6%	72-28%	23-0%	32-0%	51-7%	51-20%	56-14%	27-15%	76-24%	39-33%	89-40%
LMN	116-47%	81-42%	29-0%	81-28%	52-0%	75-19%	77-66%	118-50%	96-29%	125-37%	51-9%	72-31%	25-5%	34-2%	52-18%	53-35%	57-36%	27-24%	74-6%	38-6%	89-9%
LGS	120-49%	86-46%	31-0%	82-5%	51-0%	74-0%	76-11%	119-20%	97-16%	124-24%	51-0%	72-12%	25-0%	34-0%	52-0%	52-4%	56-0%	27-0%	74-6%	38-6%	88-11%
LGR	115-56%	85-46%	30-0%	81-4%	51-0%	74-4%	77-21%	119-22%	97-10%	125-26%	50-1%	72-12%	25-0%	33-0%	51-0%	51-0%	56-1%	27-0%	74-1%	39-10%	87-7%
PRD	142-9%	174-9%	76-0%	127-2%	98-0%	142-12%	221-26%	200-47%	143-22%	138-24%	93-1%	127-13%	102-3%	98-1%	94-3%	187-21%	179-29%	123-11%	116-4%	132-13%	143-10%
RIS	139-43%	180-59%	75-10%	124-35%	95-5%	137-8%	204-13%	187-21%	138-13%	133-10%	91-0%	124-14%	100-0%	94-0%	91-0%	177-17%	168-8%	116-3%	109-4%	125-3%	135-4%
RRH	129-7%	168-3%	72-0%	119-0%	92-0%	135-10%	211-21%	188-27%	137-13%	129-7%	89-0%	120-11%	98-2%	89-1%	86-0%	174-14%	164-10%	115-0%	108-1%	124-7%	133-4%
WEL	127-7%	163-15%	72-0%	113-0%	93-0%	133-4%	202-13%	182-20%	131-9%	124-14%	86-0%	119-8%	96-2%	89-4%	88-4%	176-26%	161-8%	114-5%	106-5%	123-4%	123-5%

Average project flow and spill rates vary dramatically from year to year based on run-off conditions, operational mandates, and storage capacity in the Columbia River Basin. We averaged the flow and spill at the dams existing in a given year between the Columbia River mouth and Snake River spawning grounds for spring and summer time periods (Figure 25). Both spring and summer flow and spill levels have decreased significantly since the early **1960's.** Flow reduction has been significantly influenced by the increased storage capacity developed in the Columbia River Basin during that period (Figure **24),** more than doubling from about 50 million acre feet in 1961 to over 105 million acre feet in 1995. Spill reductions have been influenced by reduced flows and by increased powerhouse capacity from additional turbine installations made at the **mainstem** dams.



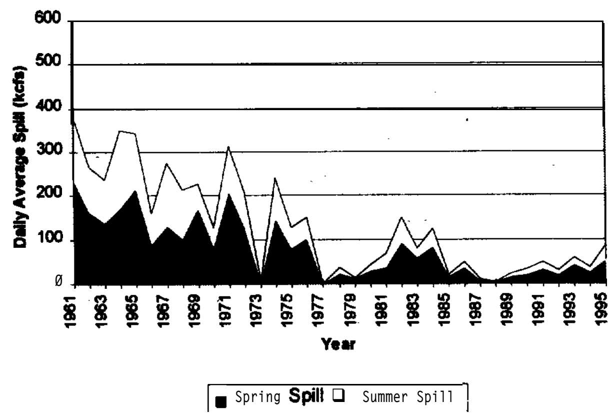


Figure 25. Daily average total flow (top) and spill (bottom) for the **mainstem** projects between the Columbia River mouth and Snake River spawning grounds **(PSMFC** 1996).

The average spring and summer spill levels of the **mainstem** dams between the Columbia River mouth and Snake River spawning grounds (expressed as a percentage of average total flow) declined through the **1960's** and **1970's.** Spill levels have steadily increased since 1988 (Figure **26),** though they are still far below those of the early **1960's.**

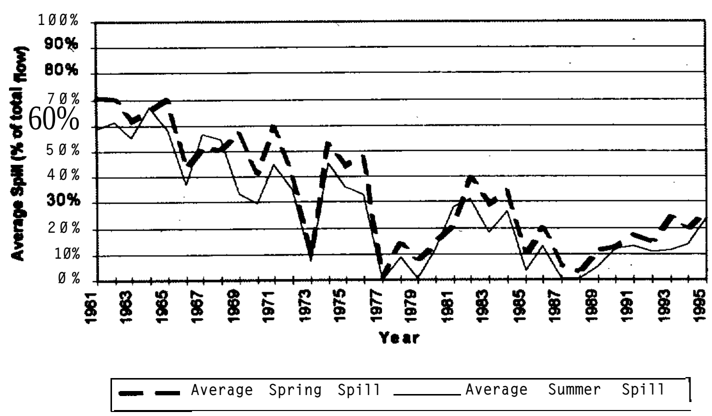


Figure 26. Average summer and spring spills expressed as percentage of total flow for the **mainstem** dams between the Columbia River mouth and Idaho spawning grounds.

C. Tributary

1. Habitat Lost Due To Hydro Development

Freshwater habitat for anadromous fish in the Columbia River Basin has been severely depleted by hydroelectric development. For the U. S. portion of the Columbia River Basin, we calculate that over 18,700 miles of historically accessible streams have been blocked by hydroelectric dams (based on 1:250,000 digital line file). This represents nearly 38% of the estimated

historical range of 49,300 miles. The allocation of this habitat loss varies widely throughout the Basin with the Snake River area sustaining the largest loss (Figure 27). Currently accessible habitat is approximately 30,600 miles (Figure 29) although a little over half of that habitat is actually in use by anadromous fish at this time (Figure 28).

As the figures indicate, while the Snake River Region has sustained the largest historical loss of habitat due to hydro development, it still represents the majority of available habitat in the U.S. portion of the Columbia River Basin. Note that Grand Coulee Dam blocked significant historic production areas in Canada. These losses are not reflected in the figures below.

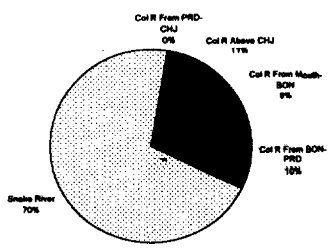


Figure 27. Allocation of 18,700 miles of historically accessible anadromous habitat blocked by hydro development in the U.S. portion of the Columbia River Basin (PSMFC 1996).

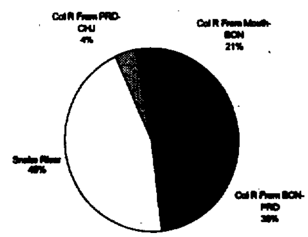


Figure 28. Allocation of 16,800 miles currently in use by salmon and steelhead in the U.S. portion of the Columbia River Basin (PSMFC 1996).

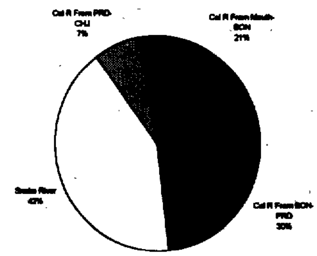


Figure 29. Allocation of the 30,600 miles of currently accessible anadromous habitat in the U.S. portion of the Columbia River Basin (PSMFC 1996).

2. Habitat Condition

In the late **1980's,** agencies and tribes participating in the Northwest Power Planning Council's **subbasin** planning process subjectively rated habitat quality for all currently utilized salmon and steelhead production areas in the Columbia River Basin. Habitat conditions were rated based on relative comparisons of the present fish producing potential of habitat within a given **subbasin** (not based on comparisons of habitat to that in other **subbasins.)** Excellent habitat was defined as that which would support the highest productivity for a species within a **subbasin.** Poor was the

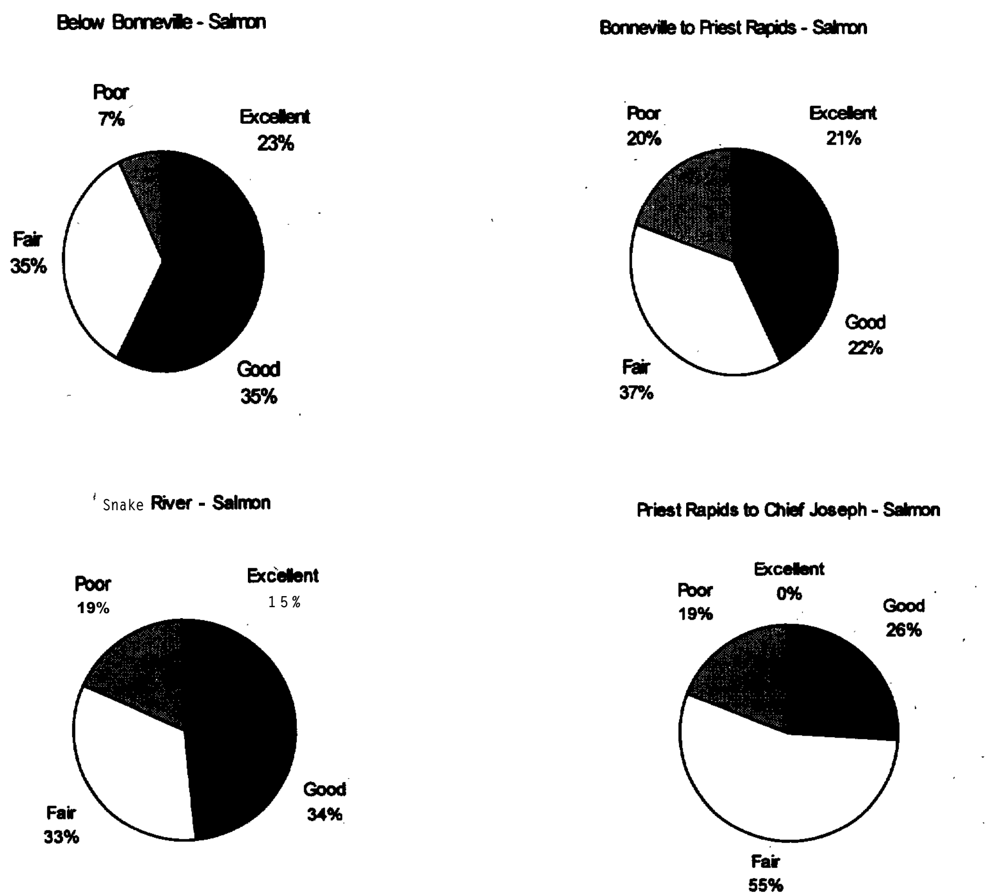


Figure 30. Percent of excellent, good, fair, and poor salmon habitat identified by **Subbasin** Planners by Columbia River Region **(PSMFC** 1995 **from Subbasin** Planning, 1989).

classification for habitat which would support the lowest level of productivity. Good and **fair** were used to describe habitats that were intermediate relative to the other two categories **(NWPPC** 1989). We summarized these habitat ratings for salmon and **steelhead** by Columbia River Region. Figure 30 shows the results for salmon. The area below Bonneville was the only region where more than half of the salmon habitat was rated as good or excellent.

Results for **steelhead** are shown in Figure 31. While the contrast between the Columbia River and Snake River regions for **salmon** was not that great, the picture is different for **steelhead.** While below Bonneville and the Snake regions were found to possess 60% or greater excellent or good habitat, only 25% of the Bonneville to Priest Rapids regions received excellent or good ratings.

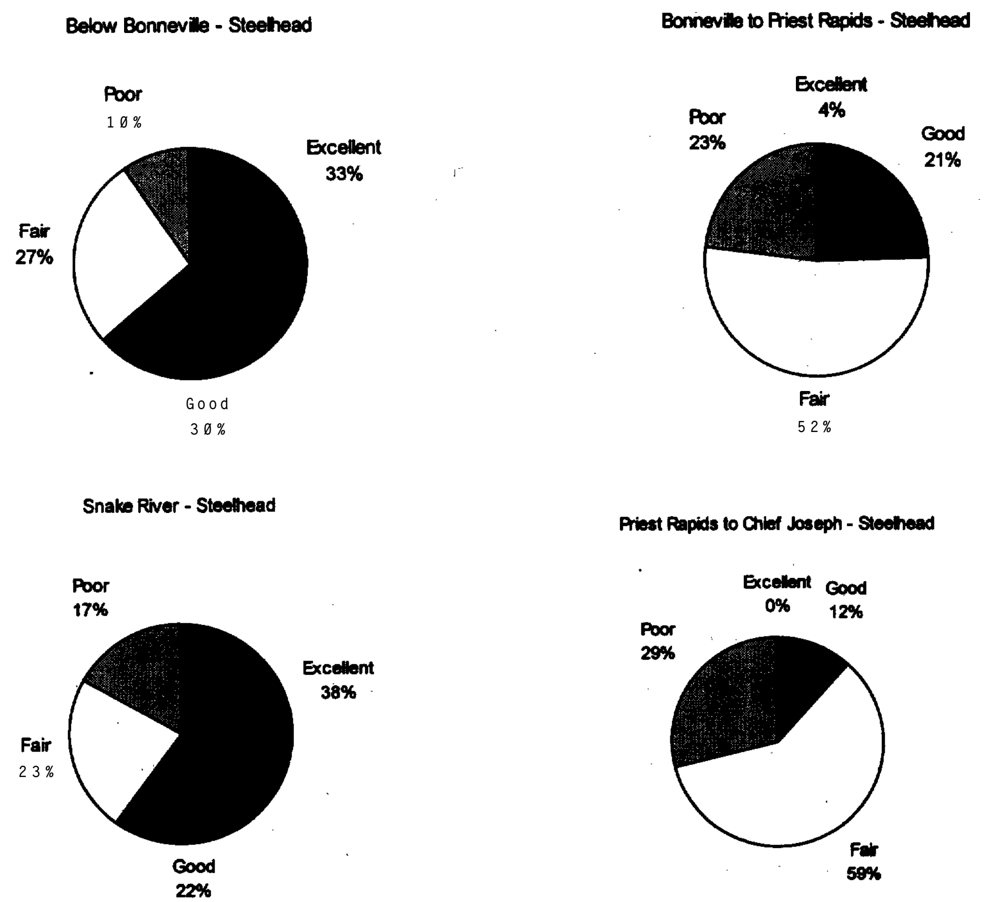


Figure 3 1. Percent of excellent, good, fair, and poor **steelhead** habitat identified by **Subbasin** Planners by Columbia River Region **(PSMFC** 1995 from **Subbasin** Planning, 1989).

3. Habitat Limiting Factors

While hydro development and harvest have played major roles in the decline of Columbia River salmon and **steelhead,** habitat degradation has also been significant. Sedimentation problems linked to poor land use practices, are prevalent throughout the Basin (Table **15). High instream** temperatures, loss of large woody debris, degraded **instream** and **streambank** conditions, loss of habitat due to channelization, and low flow levels have also reduced the productivity of many of the Basin's streams.

Table 15. Major habitat constraints by stock and region **(Subbasin Planning,** 1989). Values are expressed as percentages (total miles identified with constraints divided by total miles of spawning and/or rearing habitat).

Species/Run	Columbia River Region	Flow Levels Low	Gravel Quantity Low	High Temperature	In-stream Cover	Inter-specific Comp-etition	Pool-Riffle Ratio Low	Sedi-ments	Stream Bank De-graded
Coho	Below Bonneville	16.1%	7.6%	29.7%	2.6%	12.4%	9.2%	20.1%	2.7%
	Bonneville-Priest Rap	2.3%	0.4%	0.2%	4.6%	0.2%	5.1%	0.4%	0.2%
	Snake River •								
	Priest - Chief Joe	0.2%	0.8%		37.1%		3.5%	8.1%	
Fall Chinook	Below Bonneville	9.3%	6.8%	25.0%	1.4%	16.8%	0.5%	20.4%	15.7%
	Bonneville-Priest Rap	9.1%	7.7%		2.2%		5.7%	16.2%	5.6%
	Snake River	1.1%		4.4%	2.5%	2.5%	2.5%	22.4%	
	Priest - Chief Joe				10.7%		6.3%		
Spr Chinook	Below Bonneville	20.9%	8.9%	27.6%	3.3%	1 1.9%	2.8%	16.9%	4.1%
	Bonneville-Priest Rap	11.3%	9.8%	16.3%	10.6%	7.6%	10.2%	10.2%	14.4%
	Snake River	7.7%	2.0%	13.4%	5.4%		6.3%	20.4%	8.4%
	Priest - Chief Joe	41.3%	8.6%	0.8%	56.4%		12.7%	7.5%	
Sum Chinook	Below Bonneville *								
	Bonneville-Priest Rap *								
	Snake River	4.5%						25.5%	2.3%
	Priest - Chief Joe	8.6%	8.4%	21.1%	36.7%			24.8%	
Sum Stlhead	Below Bonneville	15.7%	13.8%	22.5%	9.7%	9.2%	5.8%	12.2%	2.8%
	Bonneville-Priest Rap	31.7%	12.4%	36.0%	17.9%	10.9%	16.0%	25.3%	40.1%
	Snake River	15.2%	2.9%	13.6%	6.2%	0.1%	9.1%	25.8%	. 13.5%
	Priest - Chief Joe	18.6%	6.8%	19.8%	28.0%		13.2%	7.5%	0.1%
Win Stlhead	Below Bonneville	14.2%	13.0%	20.6%	6.4%	12.1%	5.3%	15.3%	1.9%
	Bonneville-Priest Rap	37.4%	6.4%	18.7%	30.1%		40.3%	18.8%	13.0%
	Snake River *								
	Priest - Chief Joe *								

* **Species/run** is not found in this region

4. Habitat Changes

McIntosh et al. (1994) identified changes in fish habitat over a **50-year** period in selected Columbia Basin tributaries by comparing the frequency of large pools and coarse woody debris from two time periods based on surveys in 1934-42 and **1990-92** (Table 16). The frequency of large pools increased in managed and unmanaged watersheds of the mid-Columbia River, with the increase twice as great in unmanaged watersheds. Large pool frequency declined in managed watersheds of the Snake River, except for the Tucannon 'River where there was a significant increase. Coarse woody debris was generally more common in unmanaged than in managed areas. Large pools were identified as key rearing habitat for juveniles and resting habitat for adults. Coarse woody debris creates and maintains high-quality fish habitat by providing cover, enhancing pool development, and reducing erosion.

These data suggest a reduction in damaging land use practices in the **mid-**Columbia watersheds during the last **50** years and continuing effects of more recent activities in the Snake watersheds.

Table 16. **Historical** habitat changes in pool frequency and current abundance of coarse woody debris for select eastern Oregon and Washington **subbasins** from 1934-92.

Basin, **use**[a]	**Subbasin**	**Pools**[b]	**Wood**[c]
Columbia			
Managed	**Methow**	100%	69.2.
	Wenatchee	57%	26.7
	Yakima	111%	32.8
	Combined	89%	**??**
Unmanaged	**Methow**	240%	40.2
	Wenatchee	200%	72.5
	Yakima	144%	72.7
	Combined	195%	**66.1**
Snake			
Managed	**Asotin**	-33%	
	Grande Ronde	-66%	36.0
	Tucannon	171%	
	Combined	-19%	

[a] *Managed streams were used for timber, livestock, agriculture, or mining while unmanaged were wilderness or roadless areas*

[b] *Change in frequency*

[c] *Pieces per km at least 0.1 m in diameter and 2.0 m in length*

5. Diversions and Screens

A large-scale program to install new fish screens on unscreened irrigation diversions and to upgrade or replace existing fish screens has been under way since 199 1 in an attempt to improve survival of juvenile salmon and steelhead in Columbia and Snake river tributaries upstream from Bonneville Dam (FSOC 1996). With funding from the Federal Mitchell Act and from the Bonneville Power Administration, 163 screens have been constructed in 1991-94 to National Marine Fisheries Service's current design criteria. By 2002, fish screens will be installed at over 300 unscreened diversions and 602 old fish screens will be replaced or upgraded. To reduce fish passage delay and fish screen operation and maintenance costs, irrigation ditches are also being consolidated or replaced with pumps or groundwater wells.. Finally, this program also is screening irrigation pump intakes and is upgrading fish ladders of tributary obstructions.

Table 17. Gravity diversion screens constructed or replaced in Columbia River Basin tributaries, 1985- 1994 (Hawkes, Columbia Basin Fish and Wildlife Authority, personal communication). Totals include sites eliminated by consolidation or conversion to ground water. Totals do not include intake pump screens or fishways constructed or replaced by this project.

Year	Idaho	Oregon	Washington	Total
1985	0	0	4	4
1986	0	0	2	2
1987	0	16	2	18
1988	0	0	4	4
1989	0	4	5	9
1990	0	1	3	4
1991	1	0	0	1
1992	7	12	6	25
1993	15	25	12	52
1994	18	50	17	85
1995-2002[a]	435	412	99	946

[a]*To be completed*

D. Ocean Conditions

1. Upwelling Index

Ocean conditions are **highly** variable and can have a significant impact on production and survival of anadromous fish. Coastal upwelling conditions are generally thought to **influence** early ocean smolt survival with higher levels of upwelling associated with more favorable fish conditions. Figure 32 shows the mean March - September upwelling anomaly for sites off the Oregon and Washington coasts. Values greater than 0 represent greater than average levels of upwelling while negative values represent less than average. In 7 of the last 10 years upwelling has been below normal.

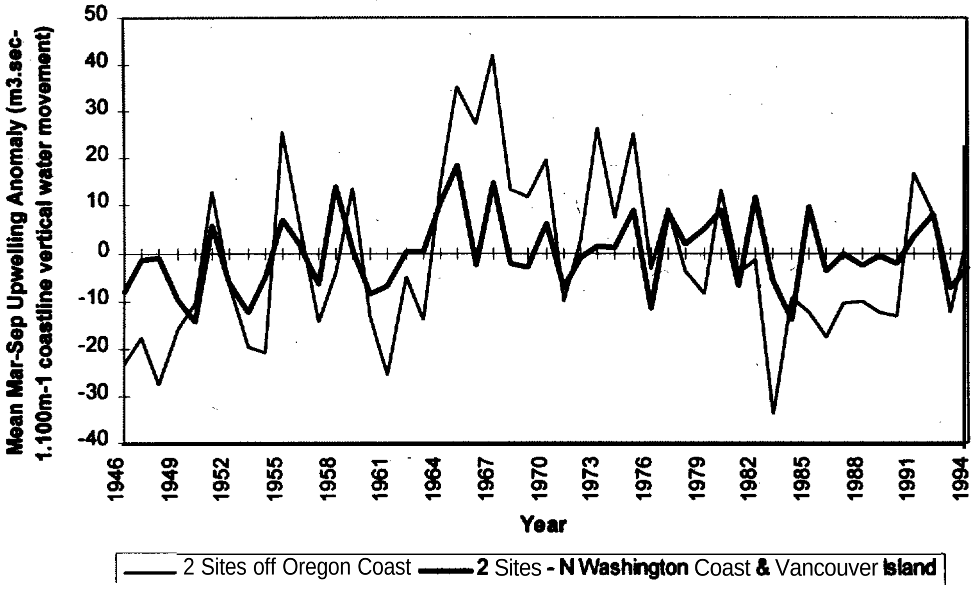


Figure 32. **Upwelling** anomalies-difference between current year and **1948-1967** average for four coastal locations. Positive values represent stronger upwelling than normal, negative values. represent **weaker** (PSMFC 1996).

2. Southern Oscillation Index

Another commonly accepted measure of ocean conditions is the Southern Oscillation **Index-SOI** which is related to El **Niño** events. The El **Niño/Southern** Oscillation **(ENSO)** phenomenon is an atmosphere-ocean coupling across the **central** tropical Pacific Ocean which influences climate in many regions of the Earth. Values of the **SOI** that are less than minus one are generally thought to be related to El **Niño** events; the lower the **SOI,** the stronger the event. Much of the North American continent is **influenced** to some extent by the **ENSO** phenomenon and fish production in the Pacific is also **affected.** Again, the **SOI** indicates that ocean conditions have been less than **optimal** in the majority of years since 1977 (Figure 33).

3. **Sea Surface Temperatures**

Another general indicator of ocean conditions is sea surface temperature (Figure 34). Again, the data is highly variable but shows a general tendency for increasing temperatures in southerly coastal **areas,** a condition generally recognized as being unfavorable to the production and growth of anadromous species which inhabit these areas.

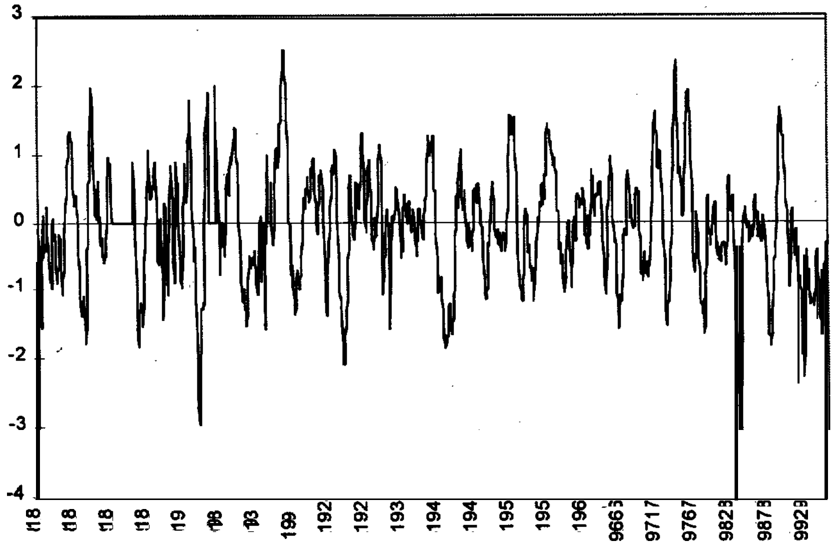


Figure 33. 5 month running means of the Southern Oscillation Index. Negative values less than -1 represent the onset on El **Niño** events (Sevilleta LTER 1995).

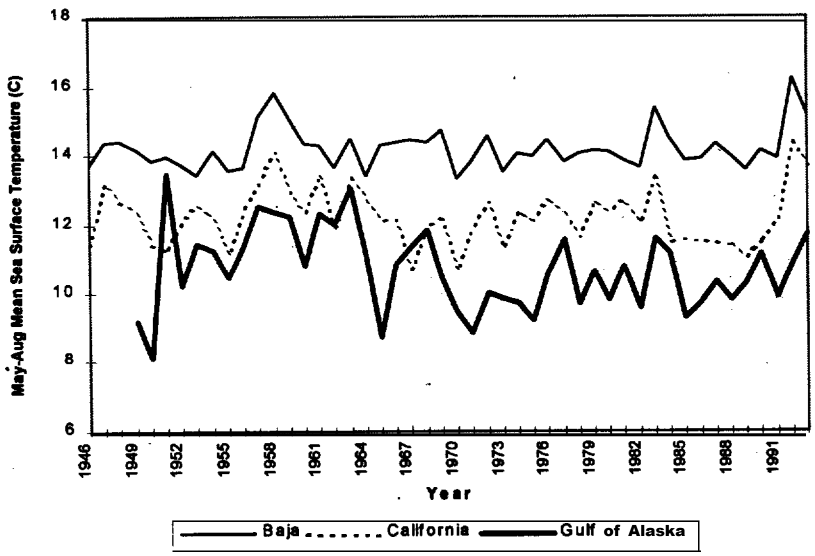


Figure 34. Average May-August sea **surface temperatures** at three near shore ocean sites.

5. Hatchery Production

A. Hatchery Distribution

Hatchery releases have been widespread and numerous in the Columbia River Basin. Only a few watersheds in the Columbia which have not received hatchery plants since 1975 (Figures 37-42). Notable areas that have not received plants during that time include the John Day Basin and portions of the Salmon River Basin. Hatcheries releasing fish in the Columbia Basin since 1980 are listed in Table 18 by management agency.

Table 18. Hatcheries which have released fish into the Columbia River Basin since 1980, by management agency (PSMFC, 1996).

Agency	Hatchery	Agency	Hatchery	Agency	Hatchery
IDFG	CLEARWATER	ODFW	ROARING RIVER	WDFW	COTTONWOOD POND
IDFG	CROOKED RIVER TRAP	ODFW	ROUND BUTTE	WDFW	COWLITZ SALMON
IDFG	HAYDEN CREEK	ODFW	SANDY	WDFW	CURL LAKE
IDFG	MACKAY	ODFW	SF KLASKANINE POND	WDFW	DAYTON POND
IDFG	MAGIC VALLEY	ODFW	SOUTH SANTIAM	WDFW	EASTBANK
IDFG	MCCALL	ODFW	STAYTON PD	WDFW	ELOKOMIN
IDFG	NIAGARA SPRINGS	ODFW	TROJAN PD	WDFW	GRAYS RIVER
IDFG	OXBOW	ODFW	UMATILLA	WDFW	KALAMA FALLS
IDFG	PAHSIMEROI	ODFW	VANDERVELDT PONDS	WDFW	KLICKITAT
IDFG	POWELL SATELLITE	ODFW	WAHKEENA PD	WDFW	LEWIS RIVER
IDFG	RAPID RIVER	ODFW	WALLOWA	WDFW	LOWER KALAMA
IDFG	RED RIVER POND	ODFW	WILLAMETTE	WDFW	LYONS FERRY SALMON
IDFG	SAWTOOTH	USFWS	ABERNATHY SCTC	WDFW	METHOW
ODFW	BIG CANYON	USFWS	BIG WHITE SALMON POND	WDFW	PRIEST RAPIDS
ODFW	BIG CREEK	USFWS	CARSON NFH	WDFW	RINGOLD SALMON POND
ODFW	BONNEVILLE	USFWS	DWORSHAK NFH	WDFW	ROCKY REACH
ODFW	CASCADE	USFWS	EAGLE CREEK NFH	WDFW	SIMILKAMEEN POND
ODFW	CLACKAMAS	USFWS	ENTIAT NFH	WDFW	SKAMANIA
ODFW	DEXTER PD	USFWS	HAGERMAN NFH	WDFW	SPEELYAI
ODFW	GNAT CREEK	USFWS	KOOSKIA NFH	WDFW	TOUTLE
ODFW	IRRIGON	USFWS	LEAVENWORTH NFH	WDFW	WASHOUGAL
ODFW	KLASKANINE	USFWS	LITTLE WHITE SALMON NFH	WDFW	WELLS SALMON
ODFW	LEABURG	USFWS	SPRING CREEK NFH	WDFW	WELLS TROUT
ODFW	LOOKINGGLASS	USFWS	WARM SPRINGS NFH	WDFW	WENATCHEE NET PENS
ODFW	MARION FORKS	USFWS	WILLARD NFH	WDFW	WEYCO POND (GRAYS R)
ODFW	MCKENZIE	USFWS	WINTHROP NFH	WDFW COOP	SEA RESOURCES
ODFW	OAK SPRINGS	WDFW	BEAVER CREEK	YIN	NILE SPRINGS PONDS
		WDFW	CARLTON POND		

B. Total Hatchery Releases

Average annual hatchery releases into the Columbia River Basin have exceeded 185 million fish since 1980. During this time, the region below Bonneville Dam has received, on average, about 60% of all hatchery plants. The Bonneville to Priest Rapids Region of the basin has received about **26%,** the Snake River Region about **9%,** and the area above Priest Rapids has received about 4% of all hatchery releases (Figure 35). Releases in 1994 were about 25% lower than releases in the years 1990 through *1992.*

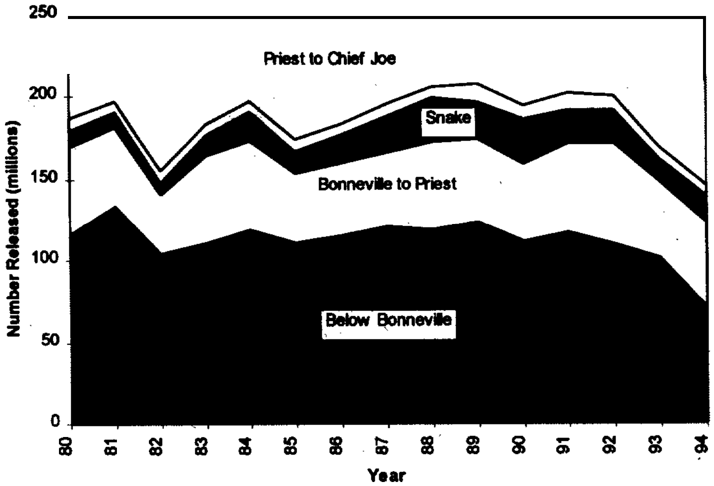


Figure 35. Total hatchery releases (all species, in millions) by Columbia River region since 1980 (PSMFC 1995, based on data provided by the Regional Mark Processing Center **(RMPC)).**

Since 1980, fall chinook account for the majority of hatchery releases (Figure **36),** with 53% of the total releases, followed by coho with 22% of the releases, spring chinook with **18%,** and summer steelhead with 5%. Releases of coho in 1994 were down more than 40% from **1990** levels while spring chinook and summer steelhead releases in 1994 were both down more than 33% from totals in 1990.

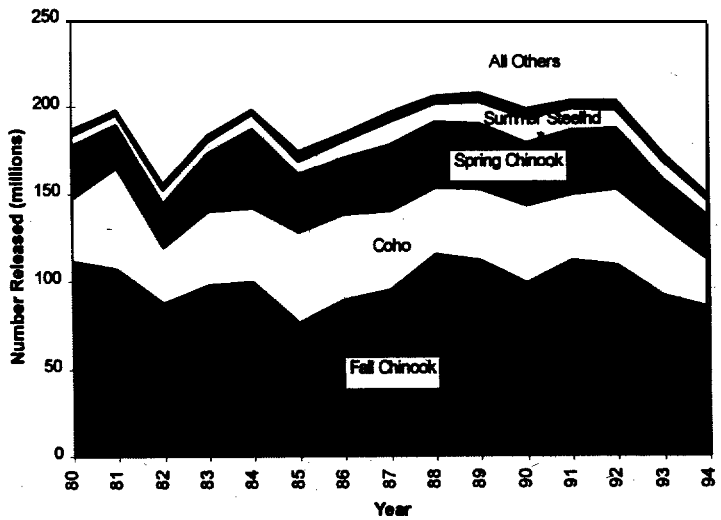


Figure 36. Total hatchery releases (millions) by species and run in the Columbia **River Basin** since 1980 (PSMFC 1995).

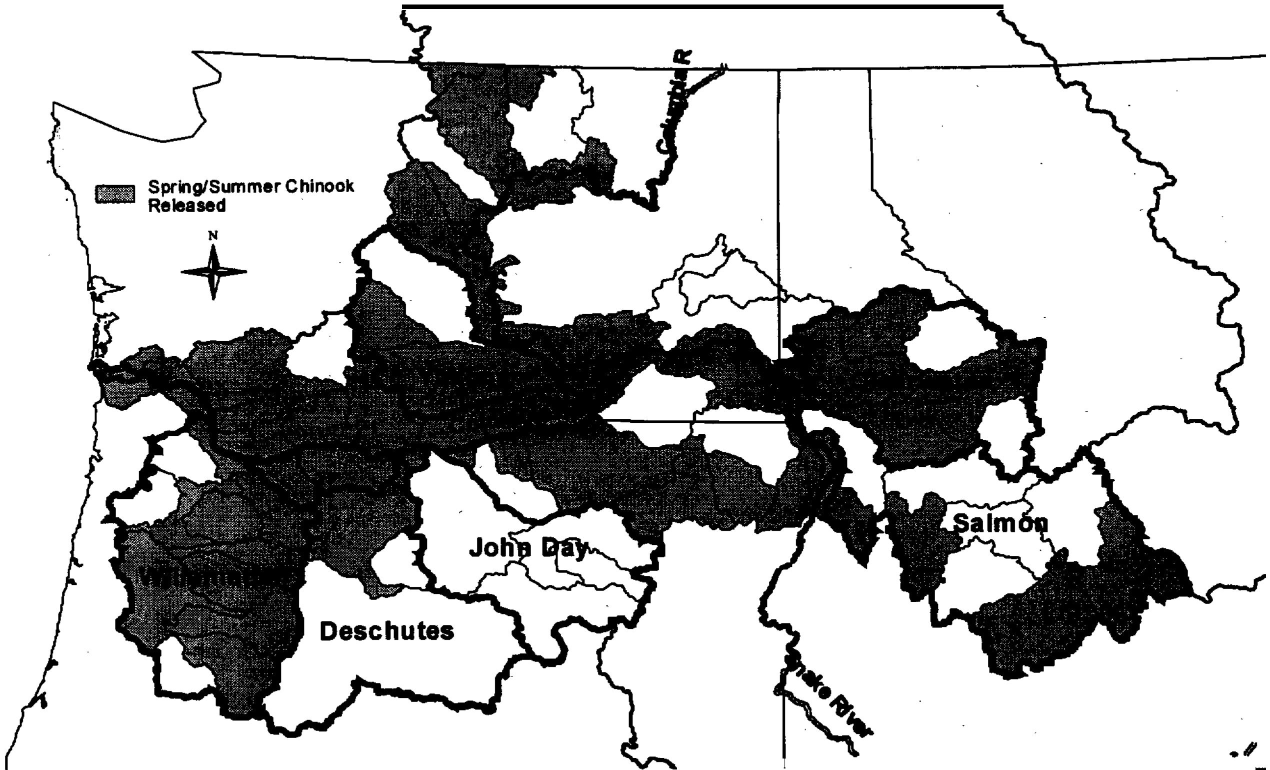


Figure 37. Hatchery spring/summer chinook releases by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

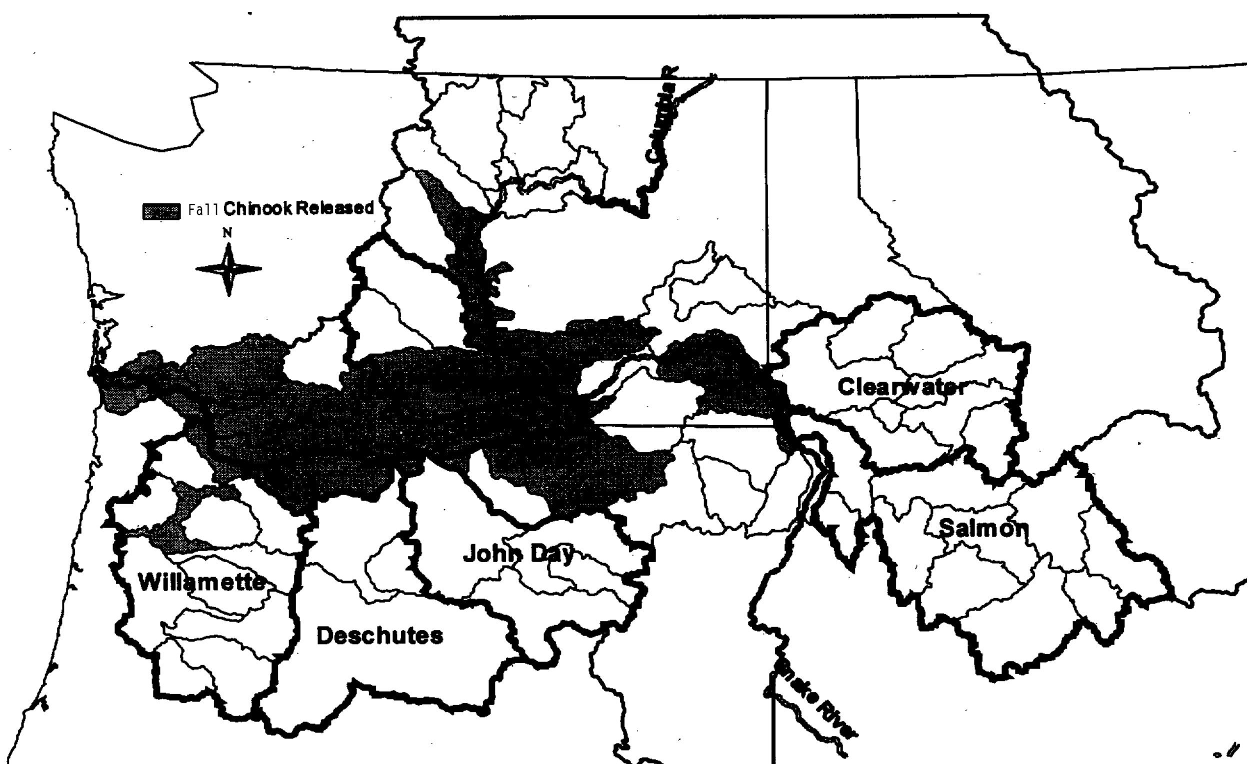


Figure 38. Hatchery fall chinook releases by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

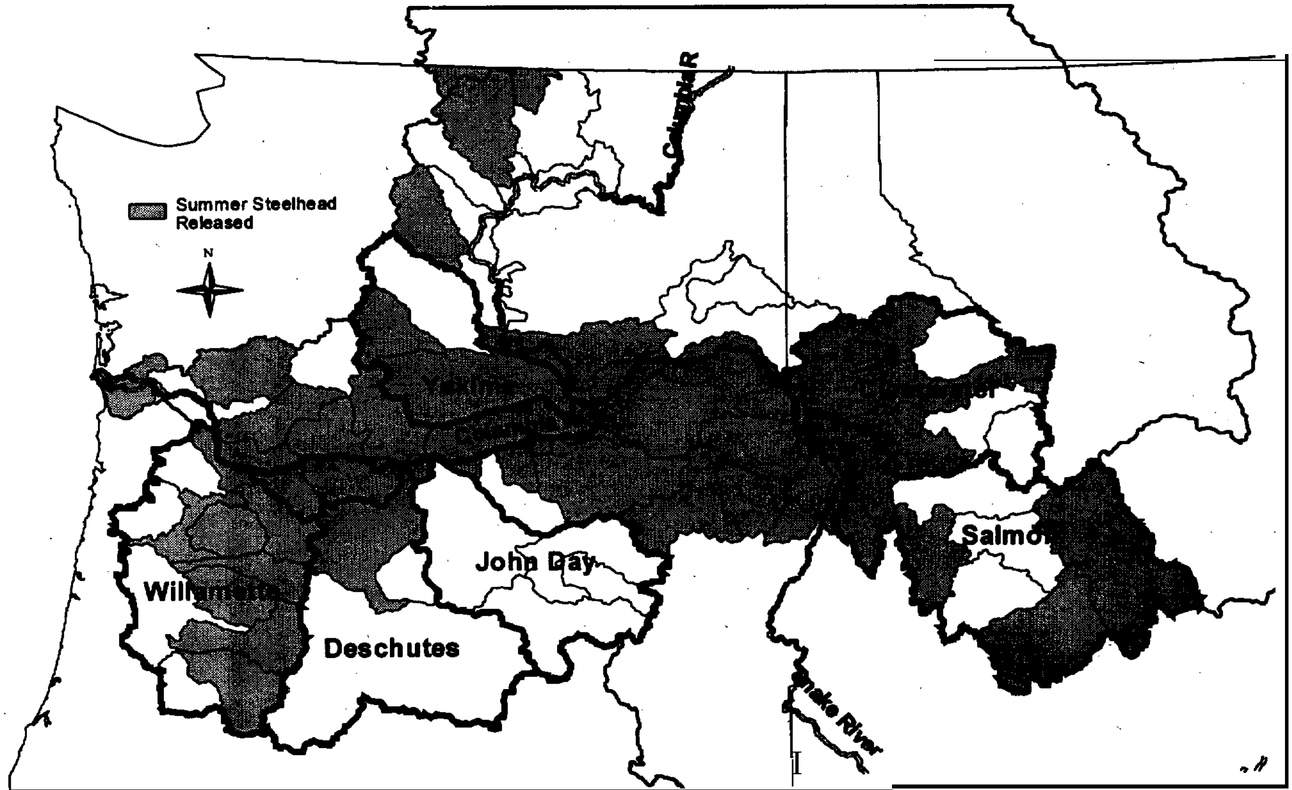


Figure 39. Hatchery summer **steelhead** releases by USGS Ca**taloging** Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

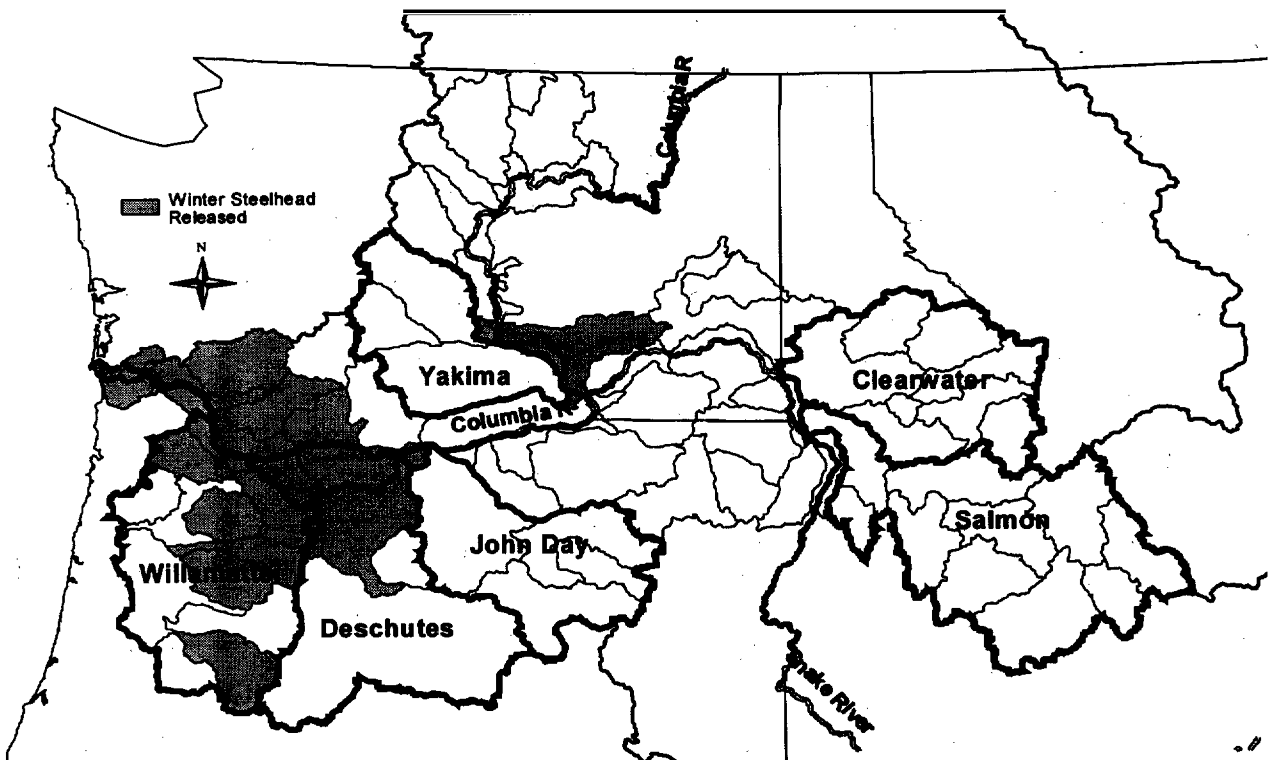


Figure 40. Hatchery winter steelhead releases by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

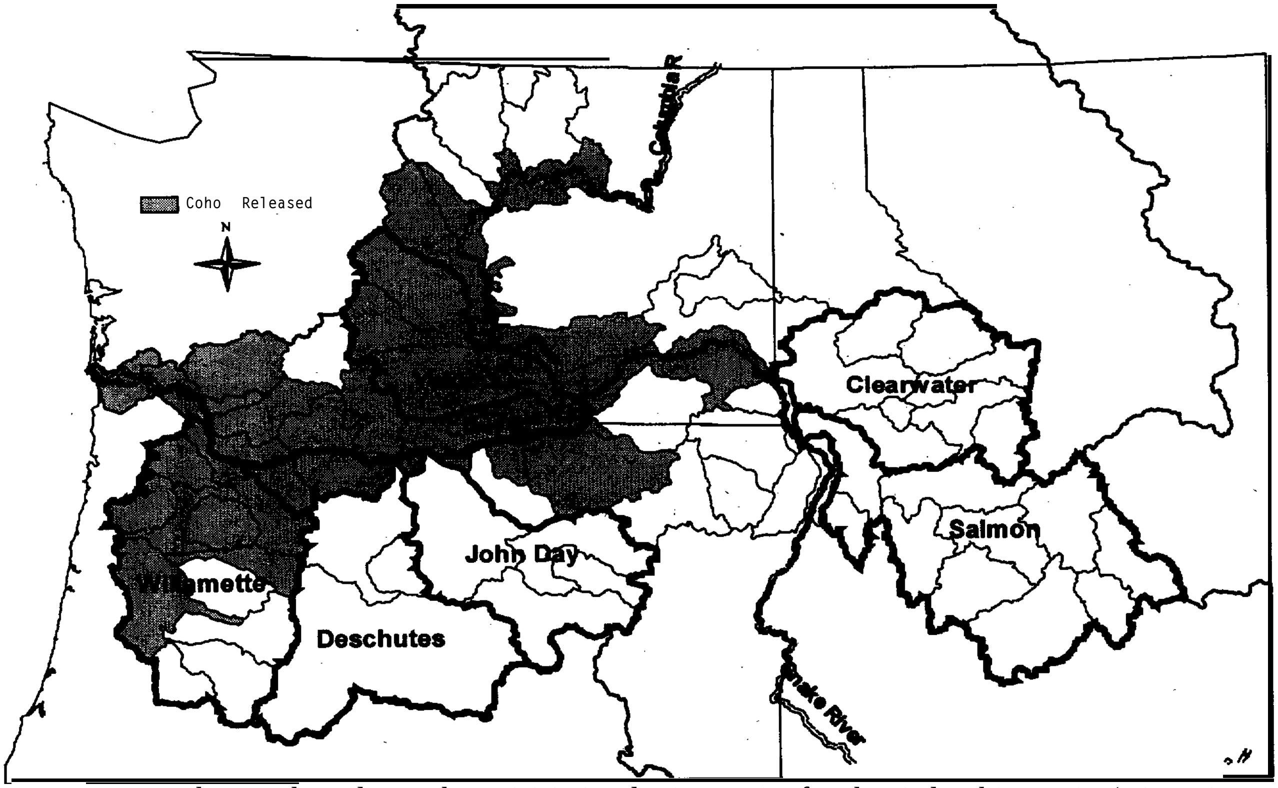


Figure 41. Hatchery coho releases by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

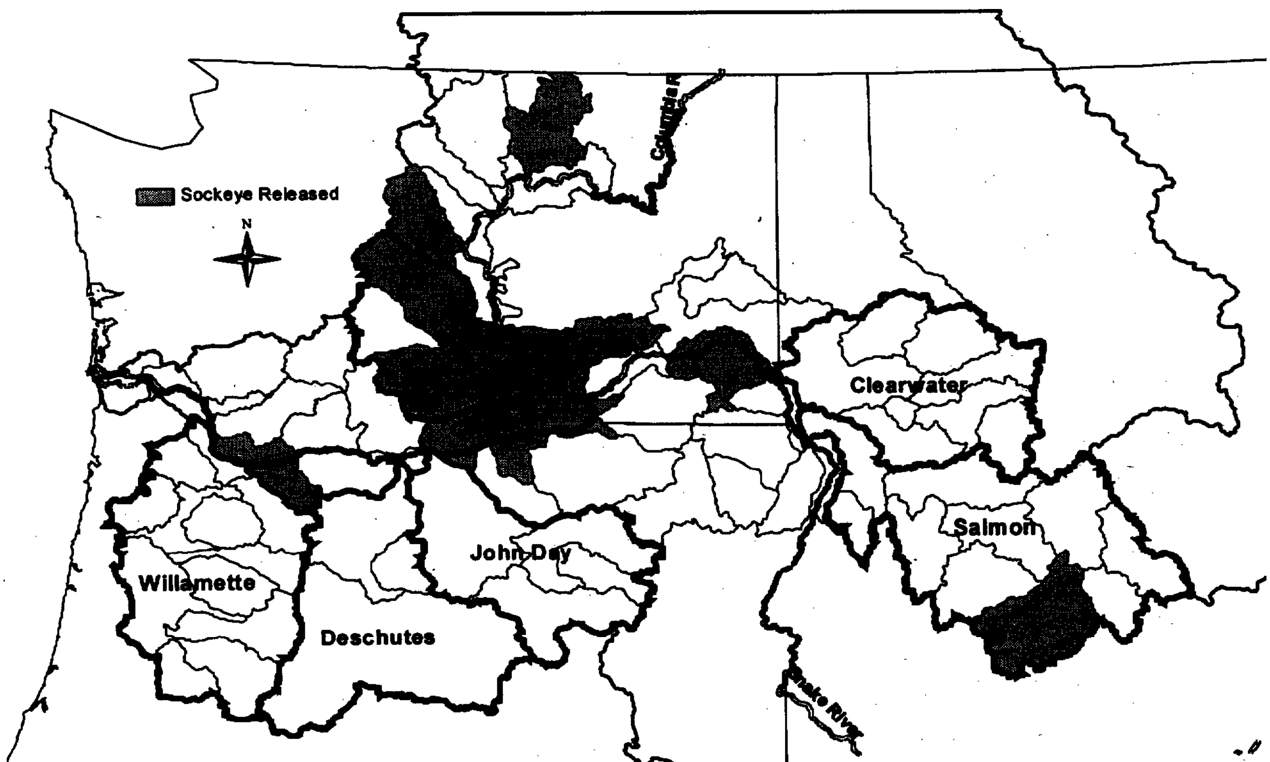
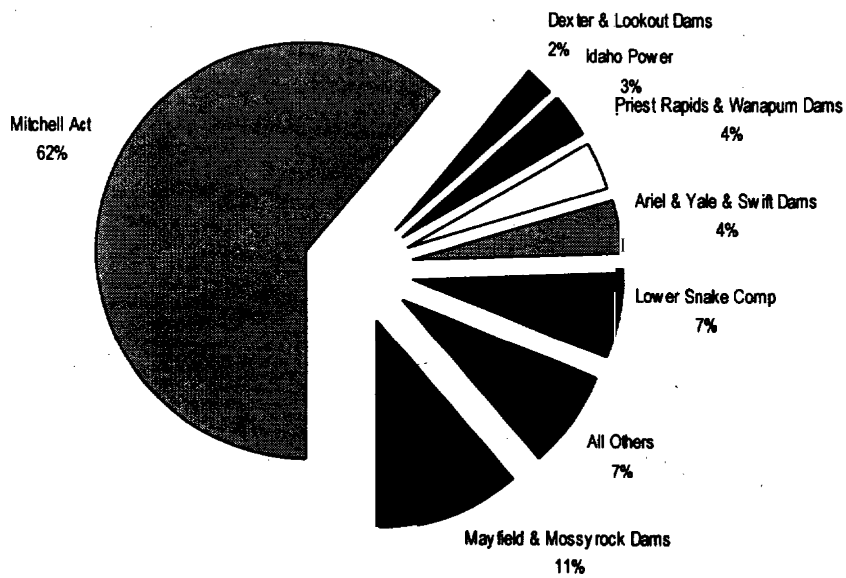


Figure 42. Hatchery sockeye releases by USGS Cataloging Units for the Columbia Basin (PSMFC 1995, based on data from the RMPC).

C. Hatchery Authorization-and Funding

The majority of hatchery releases in the Columbia River Basin have been authorized and funded either through federally mandated programs like the Mitchell Act and the Lower Snake River Compensation Program, or as part of specific dam mitigation programs. These two broad categories of authorization have been responsible for about 93%' of the total hatchery releases since 1980 (Figure 43).



E. Freshwater Coded Wire Tag Recoveries

Records of coded wire tag (CWT) recoveries are a useful index of the incidence of straying. Straying of hatchery fish varies by stock (Tables 19-2 1). Individual fish from some stocks such as Hood River chinook in the lower Columbia have been recovered as far away as the Snake River in Washington.

Table 19. Estimated number of fish with given tag code represented by CWT recoveries within the Columbia Basin for **chinook**, since 1973. Numbers in bold boxes represent recoveries of tagged fish in the subbasin of their release. Other numbers represent tagged fish recovered in a subbasin other than the one in which they were released (RMIS 1995).

Chinook Tag Recoveries since 1973 (n=401,349)

SUBBASIN OF RECOVERY --->	COL R, BELOW BON	GRAYS	ELOCHOMAN	COWLITZ	KALAMA	LEWIS	WILLAMETTE	WASHOUGAL	SANDY	COL R, BON TO PRD	WIND	BIG WHITE SALMON	LITTLE WHITE SALMON	HOOD	KLICKITAT	FIFTEENMILE	DESCHUTES	JOHN DAY	UMATILLA	WALLA WALLA	SNAKE, MAINSTEM	TUCANNON	CLEARWATER	GRANDE RONDE	SALMON	IMNAHA	COL R, PRD TO CHJ	YAKIMA	WENATCHEE	ENTIAT	OKANOGAN/SIMILKAMEEN
SUBBASIN OF RELEASE																															
COLUMBIA, BELOW BON	**43,115**	414	593	290	252	79	58	10	3	6,387	31	50	412	0	6		64		15		30	5					50	11	34	7	
GRAYS	4,241	**1,274**	514	2	14	4	2																				1				
ELOCHOMAN	633	14	**279**	6	40	10				1																					
COWLITZ	7,304	41	12	**85,297**	521	1,004	31			3					4												1				
KALAMA	2,330	50	13	319	**4,829**	549		3		37			1																		
LEWIS	1,976	1	5	180	111	**4,575**	24			1,370			1						8		6										
WILLAMETTE, ENTIRE	11,512	16	8	25	34	89	**40,809**	8	4	25			1				1				1		1	1	0						
WASHOUGAL	5,604	20	16	30	931	448	10	**5,179**	25	104			4								2										
SANDY																															
COLUMBIA, FRM BON TO PRD	15,721	236	44	89	5	3		1		**32,053**	14	205	38		1		38		22		14						234	40	92	11	
WIND	324				6					154	**3,556**		238				79											2			
BIG WHITE SALMON																															
LITTLE WHITE SALMON	2,275	6	3	6						1,900	39	619	**2,594**				3				8							4			
HOOD	8,587			25						3,699		50	745	**61**			12		25		304	41	2		2						
KLICKITAT	544	17	3	14		3				545			3		**4,942**		115		6		3		3				32	12			
FIFTEENMILE																															
DESCHUTES	1,184			8	45	5	36			378	10			1	3		**17,524**		18									51	6		
JOHN DAY																															
UMATILLA	3,512			1				43		5,002			1				3		**4,009**	1	460	23	12	4	1		2	0	1		
WALLA WALLA																															
SNAKE, MAINSTEM	5,332			19		3				6,933		30	2				5	1	1		**10,145**	169	2	59	2		1				
TUCANNON	32				4					4	4										127	**1,089**	1								
CLEARWATER	467						6			60	4		3		2		40		1		3		**1,993**		1			4	1		
GRANDE RONDE	437			6		2	5		1	152			2		2		32	1				3		**1,913**		6		2			
SALMON	686			7	4	20	15			314			1		1		131				3		6		**5,641**	2	4	16			
IMNAHA	55			17						18			3		7		57				1			6		**1,519**					
COLUMBIA, FRM PR TO CHJ	3,283			31	1					5,427							11										**2,404**	2	6		
YAKIMA	626			1			5			879			4				13				8						2	**11**	34		
WENATCHEE	480			3			6			102							4				0						41	15	**2,174**		
ENTIAT	16									11							2											4		**229**	
OKANOGAN/SIMILKAMEEN	52									81							0										148				
METHOW	82									54							1										143			1	

Table 20. Estimated number of fish with given tag code represented by CWT recoveries within the Columbia Basin for **steelhead** since 1973. Numbers in bold boxes represent recoveries of tagged fish in the subbasin of their release. Other numbers represent tagged fish recovered in a subbasin other than the one in which they were released (RMIS 1995).

Steelhead Tag Recoveries since 1973 (n=80,188)																															
SUBBASIN OF RECOVERY —>	COL R, BELOW BON	GRAYS	ELOCHOMAN	COWLITZ	KALAMA	LEWIS	WILLAMETTE	WASHOUGAL	SANDY	COL R, BON TO PRD	WIND	BIG WHITE SALMON	LITTLE WHITE SALMON	HOOD	KLICKITAT	FIFTEENMILE	DESCHUTES	JOHN DAY	UMATILLA	WALLA WALLA	SNAKE, MAINSTEM	TUCANNON	CLEARWATER	GRANDE RONDE	SALMON	IMNAHA	COL R, PRD TO CHJ	YAKIMA	WENATCHEE	ENTIAT	OKANOGAN/SIMILKAMEEN
SUBBASIN OF RELEASE																															
COLUMBIA, BELOW BON	**373**									7,217							166		5		32		1,373		48			3			
GRAYS																															
ELOCHOMAN	29																														
COWLITZ																															
KALAMA																															
LEWIS																															
WILLAMETTE, ENTIRE							**485**																								
WASHOUGAL	309									187							4														
SANDY																															
COLUMBIA, FRM BON TO PRD	73									**724**							11														
WIND	59									73							2		4												
BIG WHITE SALMON																															
LITTLE WHITE SALMON	7																														
HOOD										422							15						99								
KLICKITAT	154									95							49		4									1			
FIFTEENMILE																															
DESCHUTES										5							**66**														
JOHN DAY																															
UMATILLA	225									146							48	2	**1,005**				1								
WALLA WALLA	928									896							49	2	4		16		16								
SNAKE, MAINSTEM	1,324									3,148							149	9	9		**150**		279	550							
TUCANNON	771									1,200							39		3		86		144	8							
CLEARWATER	1,592									8,319							93	47	7		849		**11,485**		470						
GRANDE RONDE	1,765									3,943							780	15	36		421		24	**2,543**	31	5					
SALMON	2,308									8,569							914	30	9		421		77		**8,612**	1					
IMNAHA	436									509							92		8		43			1	14	**1,222**					
COLUMBIA, FRM PRD TO CHJ																															
YAKIMA	43									188							21		1									**3**			
WENATCHEE										95							2														
ENTIAT																															
OKANOGAN/SIMILKAMEEN	147									74							2														
METHOW	131									480							9														

Table 21. Estimated number of fish with given tag code represented by CWT recoveries within the Columbia Basin for **coho** since 1973. Numbers in bold boxes represent recoveries of tagged fish in the subbasin of their release. Other numbers represent tagged fish recovered in a subbasin other than the one in which they were released (RMIS 1995).

Coho Tag Recoveries since 1973 (n=279,752)																														
SUBBASIN OF RECOVERY --->	COL R. BELOW BON	GRAYS	ELOCHOMAN	COWLITZ	KALAMA	LEWIS	WILLAMETTE	WASHOUGAL	SANDY	COL R. BON TO PRD	WIND	BIG WHITE SALMON	LITTLE WHITE SALMON	HOOD	KLICKITAT	FIFTEENMILE	DESCHUTES	JOHN DAY	UMATILLA	WALLA WALLA	SNAKE, MAINSTEM	TUCANNON	CLEARWATER	GRANDE RONDE	SALMON	IMNAHA	COL R. PRD TO CHJ	YAKIMA	WENATCHEE	ENTIAT
SUBBASIN OF RELEASE																														
COLUMBIA, BELOW BON	**70,494**	32	53	58	15	34	1	9	4	2,612			6				1						3							
GRAYS	3,508	**6,413**	35	3																										
ELOCHOMAN	3,591	3	**1,659**																											
COWLITZ	19,518	42	215	**25,526**	28	12		4											1											
KALAMA	13,090			109	**5,494**	16			1	11																				
LEWIS	6,591			5	3	**7,704**		5		10																				
WILLAMETTE, ENTIRE	2,892		8	7		12	**2,469**			1			1																	
WASHOUGAL	14,889	2		26		0		**17,664**	2	94			1						1											
SANDY	30,038		3	66	1	12		1	**32,529**	72																				
COLUMBIA, FRM BON TO PRD																														
WIND																														
BIG WHITE SALMON																														
LITTLE WHITE SALMON	569									323			**2,456**																	
HOOD																														
KLICKITAT	3,451					12		6		491					**180**															
FIFTEENMILE																														
DESCHUTES																														
JOHN DAY																														
UMATILLA	1,628									530			2						**1,138**		1									
WALLA WALLA																														
SNAKE, MAINSTEM																														
TUCANNON																														
CLEARWATER																														
GRANDE RONDE																														
SALMON																														
IMNAHA																														
COLUMBIA, FRM PR TO CHJ	136							2		89																				
YAKIMA	768					12				244			3																	
WENATCHEE																														
ENTIAT																														
OKANOGAN/SIMILKAMEEN																														
METHOW																														

6. Harvest

*A. **Mainstem** Columbia*

Columbia River harvest is divided into 3 broad categories; sport, commercial, and tribal. Sport harvest is typically constrained to the lower river and estuary. Non-sport harvest is regulated by 6 defined areas or zones on the river; Zones 1 through 5 define the area from the mouth to Bonneville **Dam** and are typically reserved for non-Indian commercial fisheries. Zone 6 is defined as the area from Bonneville Dam to McNary Dam and is typically reserved for Indian harvest.

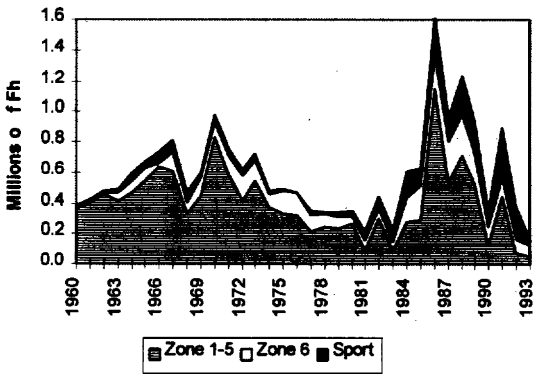


Figure 44. Total **mainstem** harvest by type (ODFW, WDFW, 1995).

Since 1960, harvest peaked in 1986 when 1.6 million fish were taken (Figure 44). Since 1986, harvest has dropped dramatically.

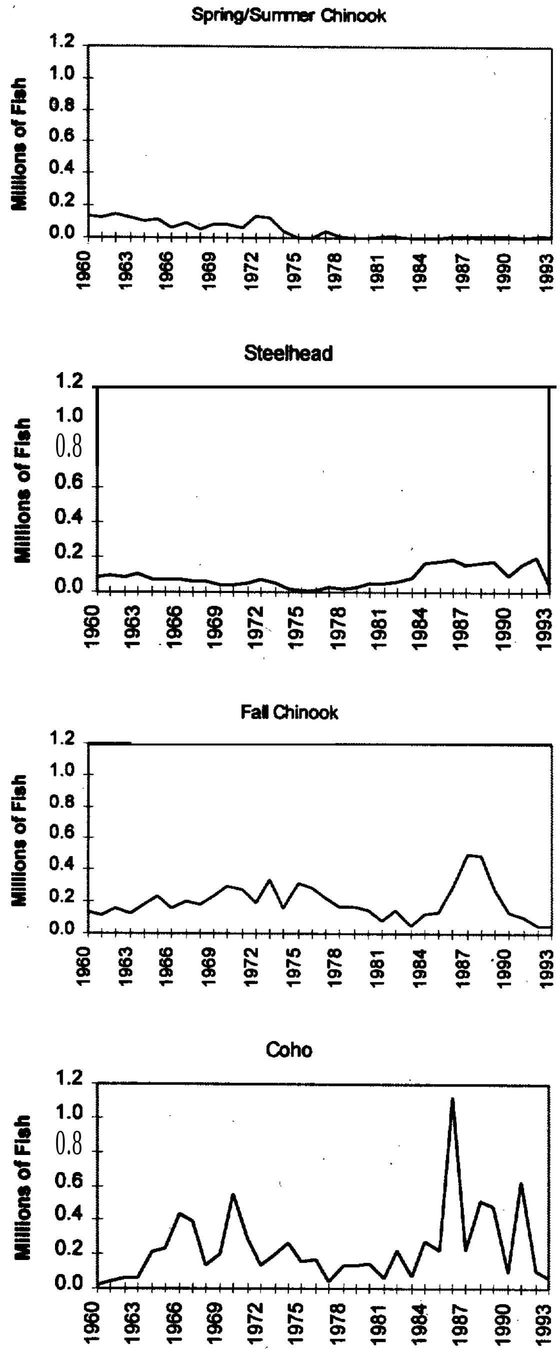


Figure 45. Total Columbia River harvest (including estuary) by species (ODFW, WDFW, 1995).

In most years, coho and fall chinook comprise the majority of harvest (Figure 45). Since 1960, coho harvest has averaged 36% of the total while fall chinook has averaged 35%. Steelhead harvest represents about 16% of the total, but the number of steelhead harvested has been increasing for the past 10 years. Spring/summer chinook harvest has averaged 9% of the total since 1960, but only 2% of the total harvest since 1974.

Average total harvest in the **mainstem** Columbia was around 550,000 in the 1960's and **1970's,** rose to around 720,000 in the **1980's,** and has declined to about 440,000 so far in the 1990's (Figure.46).

The allocation of that harvest has changed dramatically (Figure 46). The proportion of Columbia River harvest attributed to commercial fishing (zones l-5) has declined from over 80% in the 1960's to 40% in the 1990's. Sport harvest has increased five-fold from 7% in the 1960's to 37% in the 1990's. Tribal harvest increased markedly from the 1960's to the 1970's (1 **0%-21%)** but has remained about constant since that time.

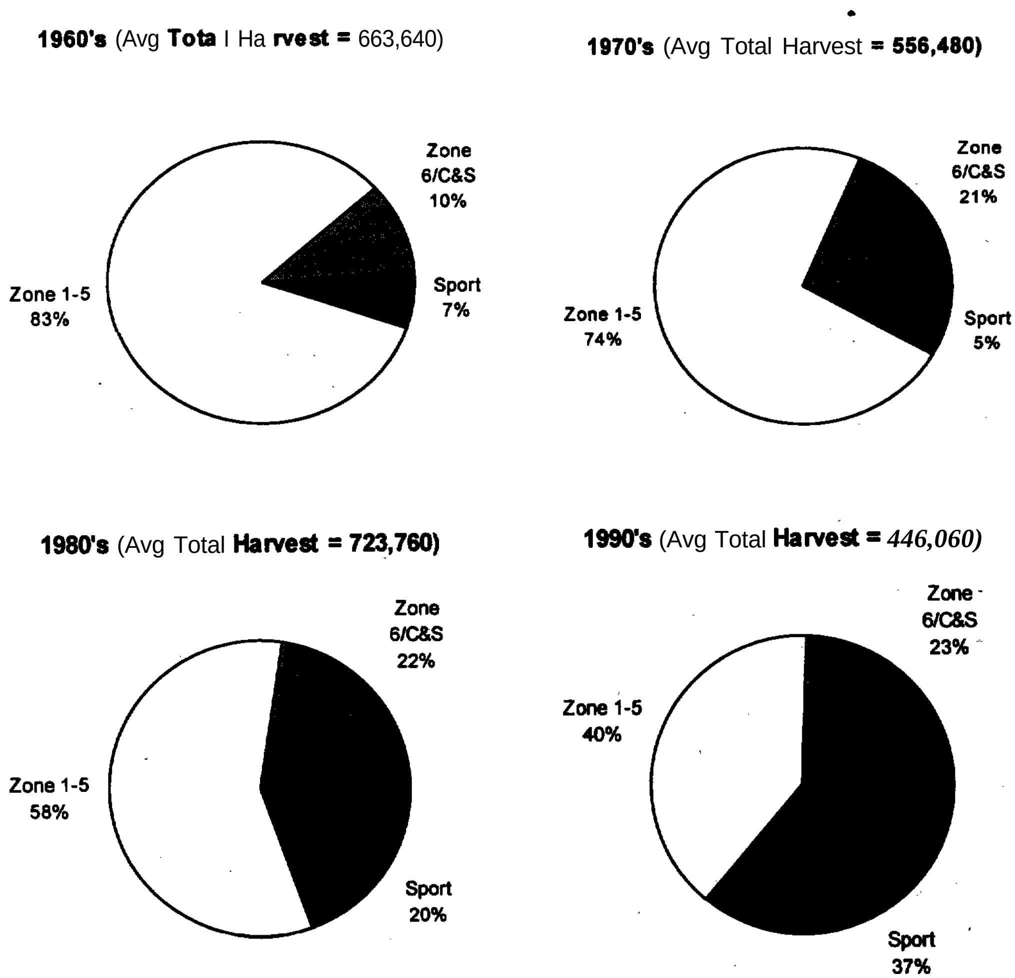


Figure 46. Average proportion of harvest (all species) for four time periods and three fisheries **(ODFW** and WDFW 1995). Total harvest values shown are in numbers of fish.

B. Tributary

Most harvest in tributaries is attributed to sport fishing. Sport harvest in the tributary systems is concentrated in subbasins below Bonneville Dam (Figure 47). Since 1975, sport harvest below Bonneville Dam has comprised, on average, nearly 71% of the total.

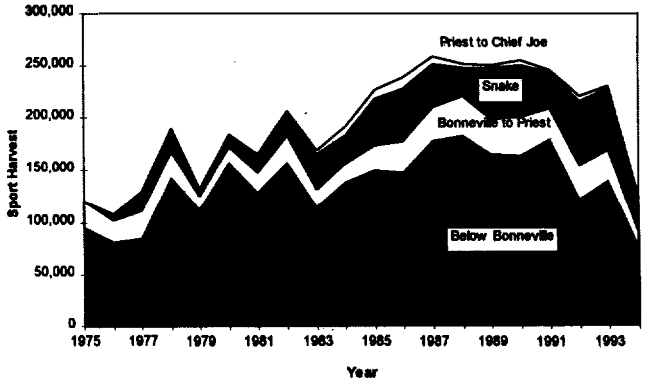


Figure 47. Tributary sport harvest of salmon and steelhead by Columbia River Region since 1975 (PSMFC 1996).

Species composition of the sport harvest is shown in Figure 48. Summer and winter steelhead comprise, on average, nearly 65% of the sport harvest in the Columbia River Basin. Spring chinook average about 24% of the catch while coho and fall chinook comprise about 7 and 3% respectively.

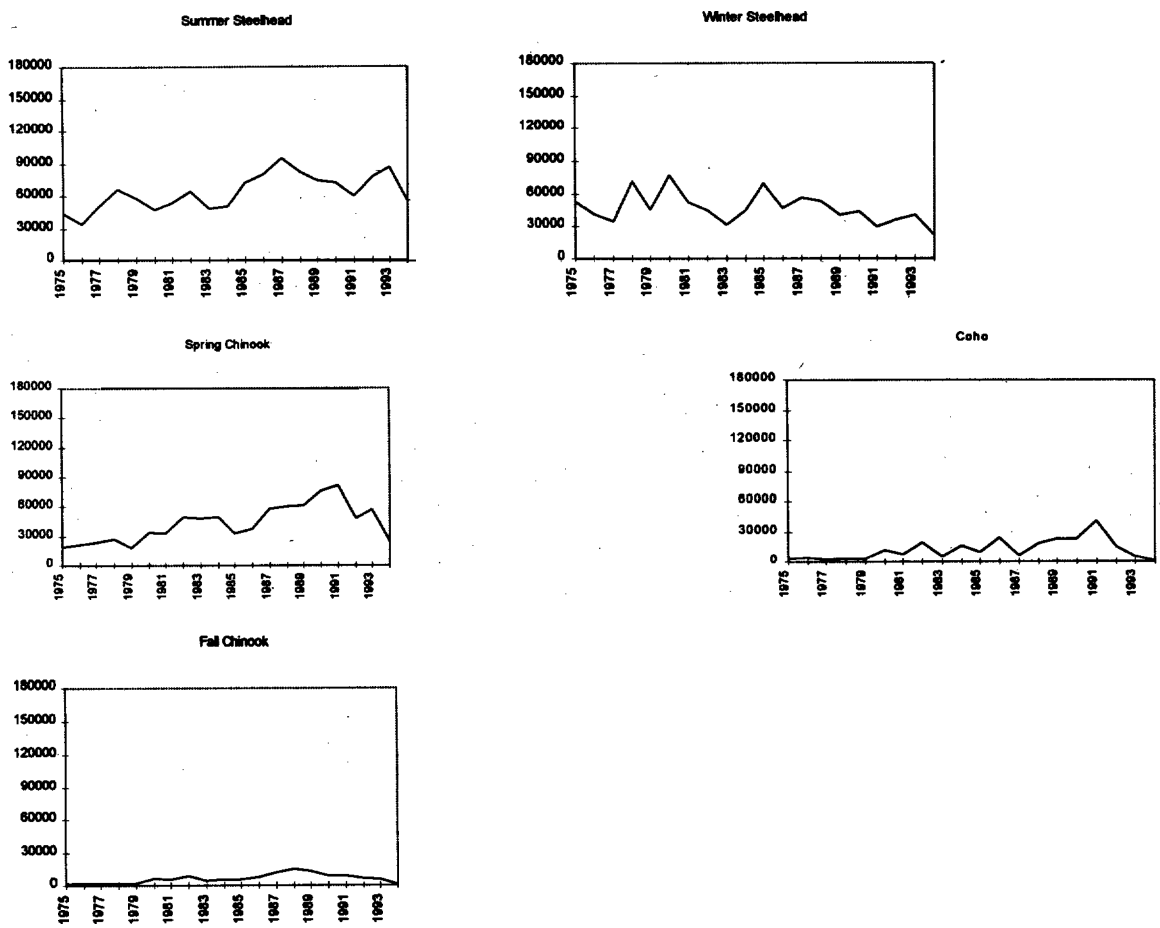


Figure 48. Total estimated sport harvest in Columbia River tributaries (PSMFC 1996).

C. Ocean

Ocean salmon harvest is regulated by the respective states within 3 miles of shore and by the Pacific Fishery Management Council (PFMC) from 3 to 200 miles from shore (PFMC 1995). PFMC divides the Washington, Oregon, and California coast into four management areas of which only the northern-most, Cape Falcon to the Canada border, affects Columbia River stocks (Figure 49). Landings and fishing effort between Cape Falcon and Canada were much reduced in 1994 over previous years (Figure 50). Some Columbia River stocks are also intercepted in Canadian and Alaskan fisheries (Table 22). Ocean exploitation rates in recent U. S. and Canadian ocean fisheries average 46-58% for tule chinook stocks, 24-39% for upriver bright chinook stocks, 24% for Willamette spring chinook, and less than 5% for upriver spring and summer chinook (Table 23).

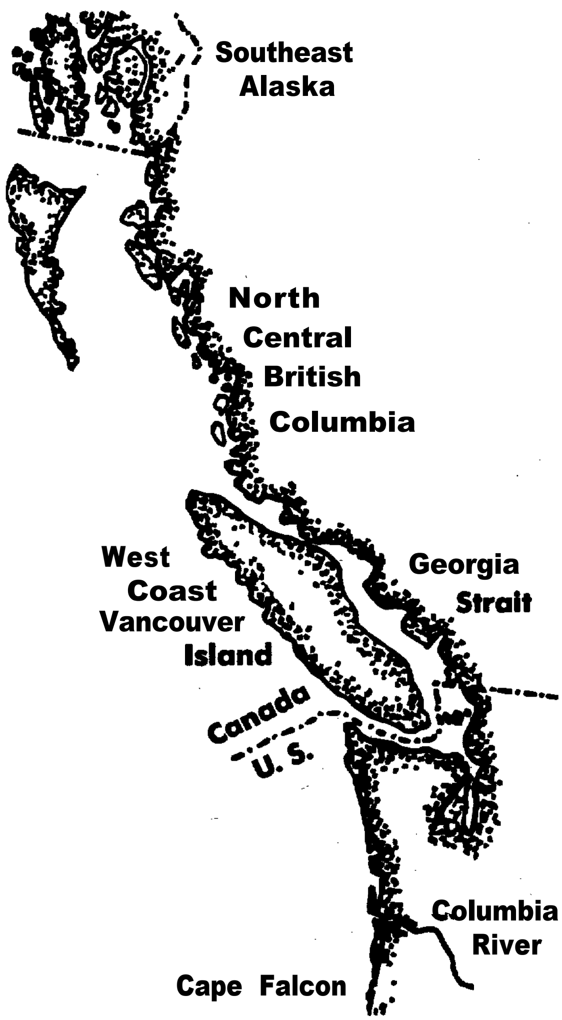


Figure 49. PFMC Ocean Salmon Harvest Management Areas.

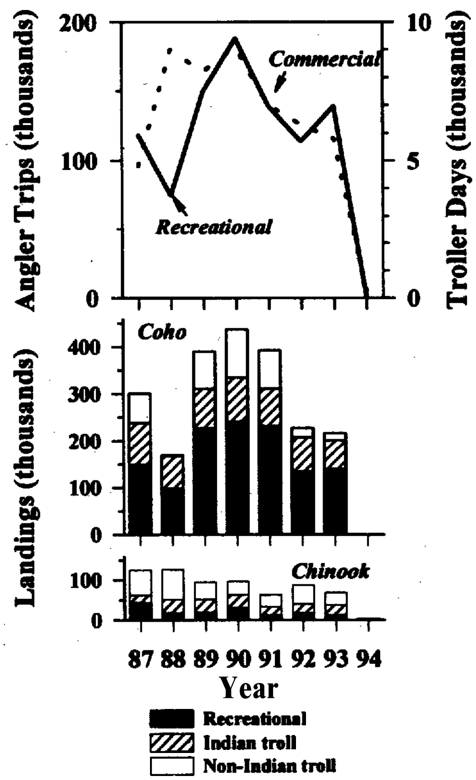


Figure 50. Annual landings of salmon and fishing effort in U. S. coastal waters 'north of Cape Falcon, Oregon (PFMC 1995).

Table 22. Distribution of catch in ocean fisheries (% of total) of Columbia Basin salmon and steelhead. Chinook salmon are denoted by age of juvenile migration (age 0 for fall chinook and age 1 for spring and summer chinook).

Fishery	Chinook 0 (tule)[1]	Chinook 0 (bright)[2]	Chinook 1 (spring)[3]	Chinook 1 (summer)[3]	Coho	Sockeye[5]	Steelhead
PFMC							
Recreational	16	12	<1	<1	--[4]	0	0
Troll	21	6	<1	<1	--[4]	0	0
PSC							
w. coast **Vanc.** Is. troll	31	18	<1	<1	--[4]	0	0
Georgia Strait troll	1	<1	<1	<1	--[4]	0	0
Canadian recreational	1	1	<1	<1	--[4]	0	0
N. C. British Columbia	4	13	<1	<1	0	0	0
S. E. Alaska	2	17	<1	<1	0	0	0

[1]Recent average for Cowlitz, Spring Creek, Bonneville, Stayton Pond indicator stocks (PSC 1994a).
[2]Recent average for Columbia River, Hanford wild Lewis wild and Lyons Ferry indicator stocks (PSC 1994a).
[3] Inference from PSC indicator stocks for Columbia basin excluding the Willamette (Bohn, Oregon Department of Fish and Wildlife, personal comunication).
[4]Fishery takes coho salmon in an unknown proportion. (PSC 1994b)
[5]McIsaac, Oregon Department of Fish and Wildlife, personal communication.

Table 23. Pacific Salmon Commission chinook salmon indicator stocks from the Columbia Basin and brood year exploitation rates (%) in combined U.S. and Canada ocean fisheries (PSC 1994b). Rates less than 5% are inferred from low tag recovery rates (Bohn, Oregon Department of Fish and Wildlife, personal communication).

Stock	1982	1983	1984	1985	1986	1987	1988	1989	Average
Cowlitz Fall Tule	46	37	40	48	43	39	47	66	46
Stayton Pond Tule	64	63	59	66	59	52	43	55	58
Spring Creek Fall Tule	42	38	50	56	48	52	43	57	48
Lewis Fall Bright (wild)	27	33	23	25	25	24	26	12	24
Upriver Fall Bright	36	42	40	39	42	32	41	37	39
Hanford Fall Bright (wild)					32	49	31	45	39
Lyons Ferry Fall Bright			38	‘37	46	25	27	30	34
Willamette Spring	24	36	25	16	21	19	21		24
Leavenworth Spring	<5	<5	<5	<5	<5	<5	<5	<5	<5
Rapid River Spring	<5	<5	<5	<5	<5	<5	<5	<5	<5
Sawtooth Spring	<5	<5	<5	<5	<5	<5	<5	<5	<5
McCall **Summer**	<5	<5	<5	<5	<5	<5	<5	<5	<5

D. Value

Economic values of salmon fisheries can be described by prices paid to commercial fishers for their landings (exvessel value) and total personal income associated with fisheries. Exvessel values in 1994 were only 24% of the 1981-93 average for combined commercial fisheries for salmon and steelhead in the U.S. controlled portion of the ocean and in the Columbia River (Table 24). Personal income values in 1994 were only 30% of the 1986-93 average for combined U.S. ocean salmon fisheries (Table 25).

Table 24. Exvessel values (nominal dollars in thousands) of salmon (coho and chinook) landed by non-Indian ocean troll (PFMC 1995) and salmon (chinook, coho, sockeye, chum) and steelhead landed by inriver fisheries (ODFW and WDFW 1995).

Year	Ocean California	Ocean Oregon	Ocean Washington	Inriver Non-Indian	Treaty all gears	Total
1981	14,322	9,573	5,921	1,831	1,107	32,754
1982	19,489	9,893	6,730	3,301	836	40,251
1983	4,608	2,296	1,465	891	482	9,742
1984	7,562	1,595	410	3,648	2,076	'15,291
1985	11,515	5,774	1,601	3,190	1,773	23,853
1986	15,112	7,954	1,175	9,263	2,082	35,586
1987	25,623	16,763	1,960	11,266	5,569	61,181
1988	41,927	21,536	2,337	19,724	7,892	93,416
1989	13,485	10,025	1,230	5,202	2,160	32,102
1990	12,056	6,641	1,648	2,781	2,356	25,482
1991	9,047	3,120	1,126	3,625	787	17,705
1992	4,505	2,712	1,299	889	778	10,183
1993	5,707	1,671	795	562	504	9,239
1994	5,934	689		534	437	7,594

Table 25. Estimates of coastal community and state personal income impacts (thousands in 1994 dollars) of the troll and recreational ocean salmon fisheries (PFMC 1995).

	Troll			Sport			
Year	Calif.	Oregon	Wash.	Calif.	Oregon	Wash.	Total
1986	46,636	22,852	3,182	17,284	11,797	8,989	110,740
1987	71,791	43,188	4,817	22,774	16,175	8,346	167,091
1988	112,460	51,830	5,447	21,047	16,066	5,419	212,269
1989	35,784	24,626	3,143	21,625	16,679	9,731	111,588
1990	29,880	14,904	3,745	20,008	15,388	11,832	95,757
1991	22,019	7,447	2,515	16,160	11,723	8,250	68,114
1992	10,423	5,857	2,731	10,698	9,880	7,017	46,606
1993	13,441	3,503	1,671	14,677	4,772	7,824	45,888
1994	13,866	1,401	30	14,990	1,410	0	31,697

7. Mitigation Efforts

A. Bonneville Power Administration

BPA is the primary parties involved with mitigation activities **in** the Columbia River Basin. **BPA's** fish protection, restoration, and enhancement projects in the Basin have totaled nearly $370 million from 1981-1993 with funding distributed throughout the Basin (Figure 51).

The types of projects funded and-the amount spent have changed dramatically since 1990 (Figure 52). Total spending for 1995 is over $80 million. dollars on over 200 projects.

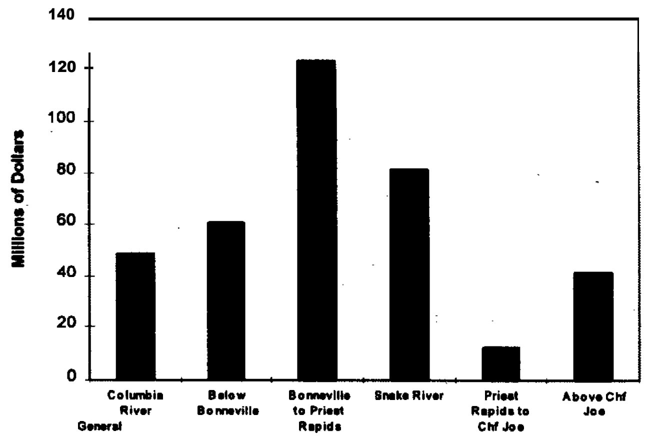


Figure 5 1. Total BPA obligations by region from 1981-1993 **(PSMFC** 1996, data provided by BPA)

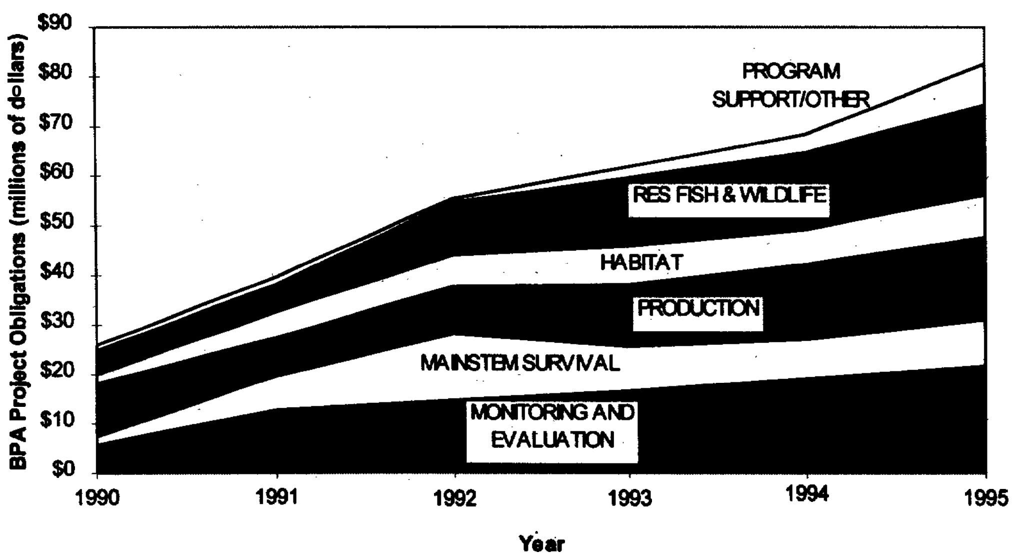


Figure 52. Total project dollars spent since 1990 by Bonneville Power Administration **(PSMFC** 1996, data provided by BPA).

B. U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers is another major player in anadromous fish mitigation activities in the Columbia Basin. Primary activities funded by the Corps include project modifications aimed at improving juvenile and adult fish passage, hatcheries (Lower Snake River Compensation Program), research, spillway **modifications,** and juvenile fish transportation. Through **fiscal** year 1987, the Corps has spent nearly $545 million in the Columbia Basin on fish mitigation measures (Figure 53, Mighetto 1994).

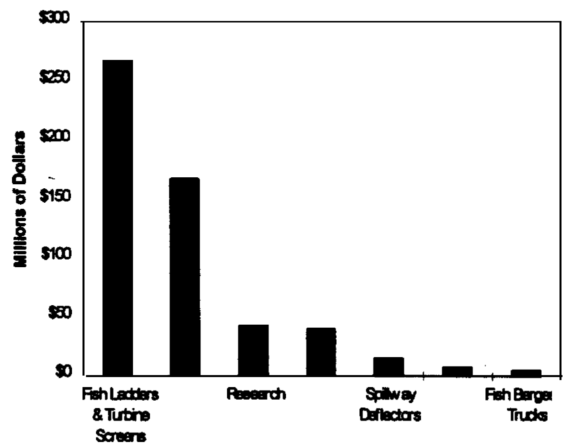


Figure 53. U.S. Army Corps of Engineers Lower Columbia / Snake Rivers Existing Fish Mitigation and Capital Costs Through Fiscal Year 1987.

Research activities have been funded by the Corps since 1953 with total research expenditures exceeding $63 million through 1993 (Figure 54, Mighetto 1994).

Corps expenditures for the operation, maintenance, and research operations for Lower Snake River Compensation Program (LSRCP) hatcheries currently exceed $12 million per year (Figure 55).

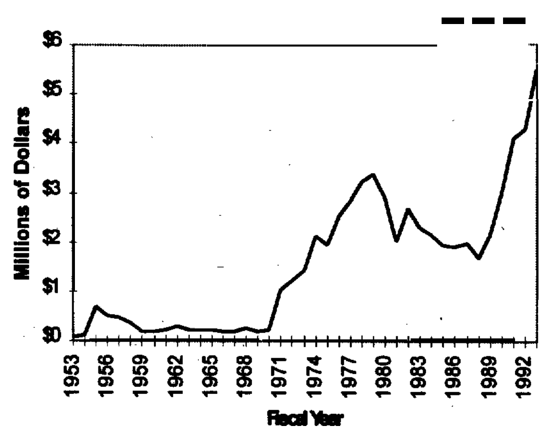


Figure 54. North Pacific Division, Corps of Engineers Fish Passage Development and Evaluation Program (FPDEP) Fisheries Research Expenditures.

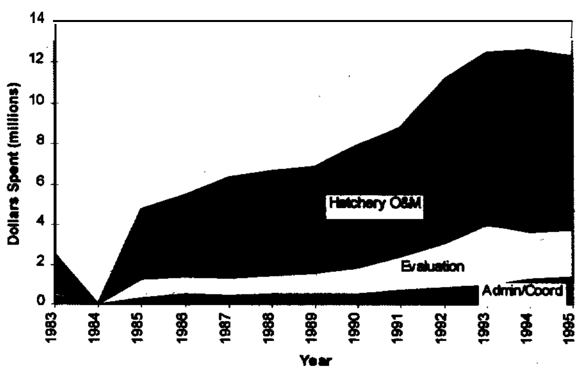


Figure 55. Lower Snake River Compensation Program **(LSRCP)** funding levels by major activity (Crateau 1996).

C. Mitchell Act

The Mitchell Act, passed by Congress in 1938, funds state and federal hatcheries on the lower Columbia River. Its objective was to offset the impacts to fish resulting from the construction of Bonneville and Grand Coulee Dams, as well as the effects of logging and pollution (Mighetto . 1994). Funds are also used to pay for large irrigation diversion screening programs. The Columbia River Fisheries Development Program (CRFDP) was authorized under the Mitchell Act in 1949 and is currently administered by the Environmental and Technical Services Division (ETSD) of the National Marine Fisheries Service (NMFS) in Portland. The CRFDP is a cooperative effort between NMFS and the Oregon Department of Fish and Wildlife (ODFW), the Washington Department of Fish and Wildlife (WDFW), Idaho Department of Fish and 'Game (IDFG), and the U.S. Fish and Wildlife Service (Delarm 1990). Between 1949 and 1989, the program has expended over $183 million dollars, primarily on the construction and operation of hatcheries (Figure 56). The program is currently authorized to expend approximately $10 million dollars per. year.

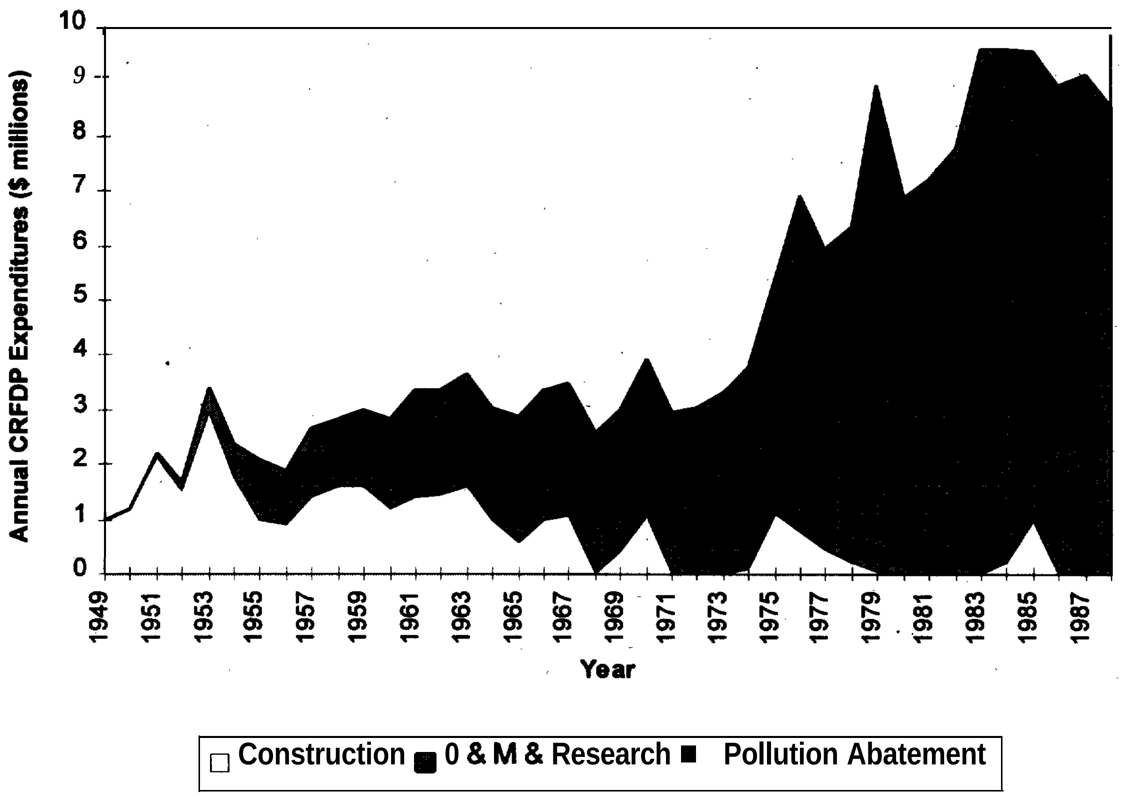


Figure 56. Funds expended by the Columbia River Fisheries Development Program from 1949 through 1988 (Delarm 1990).

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9. Example Populations

Example populations for which detailed information is presented were selected from areas where information was readily available (Figure 57). Future editions of this annual report will expand this section to include key populations **from** throughout the Basin including all index populations for listed endangered species.

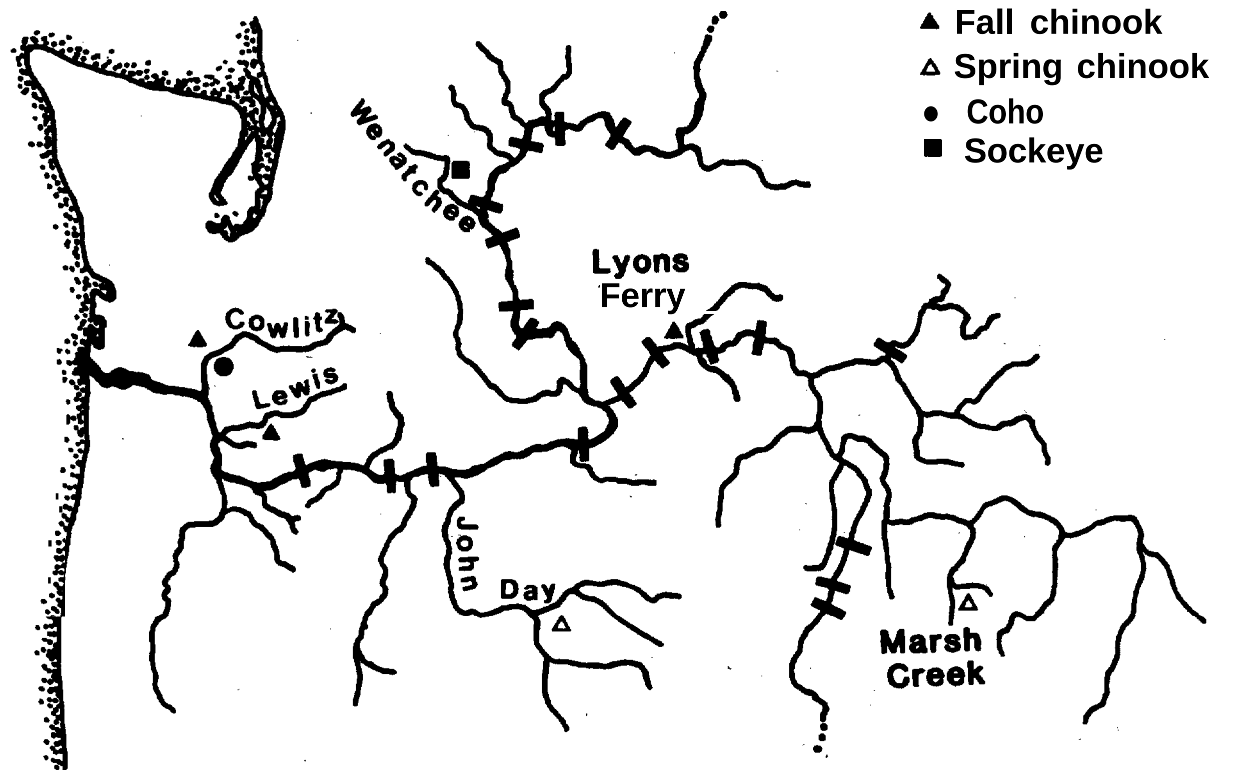
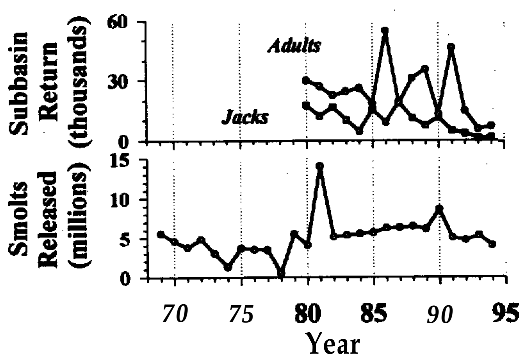


Figure 57. Locations of sample populations included in this report.

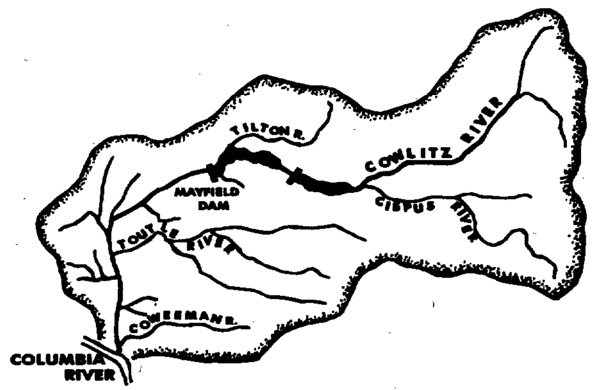
Cowlitz* *Hatchery Coho

Distribution: Presently, most Cowlitz River coho are of hatchery origin. Mayfield Dam has blocked tributaries above river mile (RM) 52 since 1968 but natural production still occurs in several small tributaries of the lower Cowlitz including Olequa, Lacamas, Ostrander, Blue, Otter, Brights, Mill, Arkansas, Foster, and Hill creeks. Adults are also released each year to spawn in the Tilton and upper Cowlitz rivers.

Abundance: The Washington Department of Fisheries estimated coho escapement at about 32,500 fish in 1951. Coho counts past Mayfield from 1961-66 averaged 24,579. Hatchery-produced returns averaged 24,997 adults and 9,723 jacks in 1980-94 with a peak of 54,685 adults in 1986 and 19,178 jacks in 1987. The Northwest Power Planning Council's model estimated smolt production capacity of 123,123 for the lower Cowlitz River, 131,318 for Tilton River and Winston Creek, and 155,018 for above Cowlitz Falls.

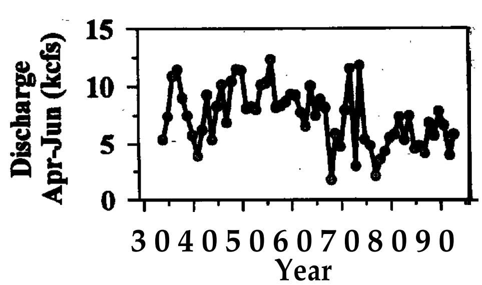


Hatchery Production: Hatchery coho have been planted in the subbasin since at least 1915, from the Tilton River Hatchery which operated downstream of Morton until 1921. A salmon hatchery also operated in the upper Cowlitz near the mouth of the Clear Fork until it was abandoned in 1949 because of low water temperatures. Cowlitz Hatchery, completed in 1967, produces about 4.8 million yearling smolts annually. More than 15,700 coho were also released upstream from the Cowlitz Hatchery annually to spawn naturally from 1967 through 1971.



Harvest: Coded-wire tag recoveries of the 1982 brood late coho revealed that most of the ocean catch occurred in Washington (26%) and Oregon (11%) followed by British Columbia (7%) and California (0.1%). Columbia River fisheries accounted for an additional 37% of the total harvest. Escapement. was 20% overall. Harvest rates have averaged 79% and 85% for Type-S and N stocks, respectively, between 1983 and 1987. Harvest of Type-S coho is occasionally constrained by fall chinook. Harvest of Type-N coho is rarely constrained by weak stocks.

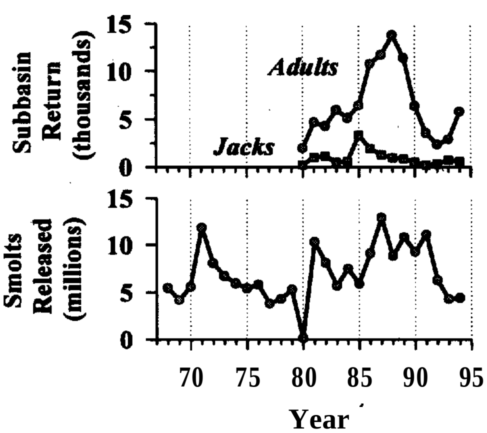
Habitat: The Mt. St. Helens eruption in 1980 severely affected spawning areas downstream from the mouth of the Toutle River at RM 20. Habitat quality has also been significantly degraded- by land use and development. Spring flows have been generally less than average since 1975.



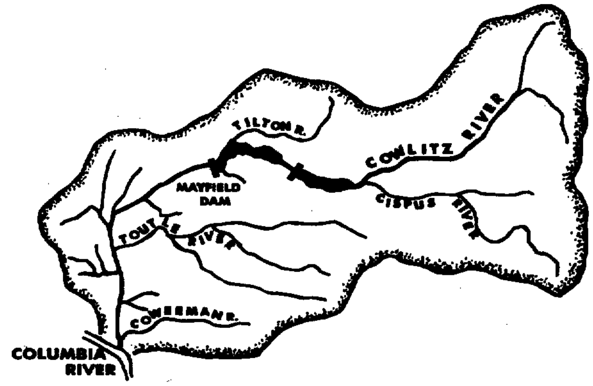
Cowlitz Fall Chinook

Distribution: Fall chinook historically occurred from near the mouth to upper tributaries including the Ohanapecosh and Tilton rivers. Completion of Mayfield Dam at RM 52 in 1968 blocked fish migration into upper Cowlitz River tributaries and eliminated 37% of spawning areas based on redd count distribution. Fall chinook continue to spawn naturally in the Cowlitz mainstem with most spawning occurring between the Cowlitz salmon (RM 52) and Cowlitz trout hatcheries (RM 41.3)

Abundance: In 1951, an estimated 10,900 fall chinook returned to the Cowlitz mainstem, plus 500 to the Tilton River. Run size declined to an average of 5,992 adults and 2,543 jacks at Mayfield Dam in 1961-66. Hatchery produced returns averaged 6,470 adults and 935 jacks in 1980-94 building to peaks of 13,798 adults in 1988 and 3,348 jacks in 1985. Numbers of naturally-spawned fish in the basin averaged 3,876 adults and 254 jacks in 1981-94.



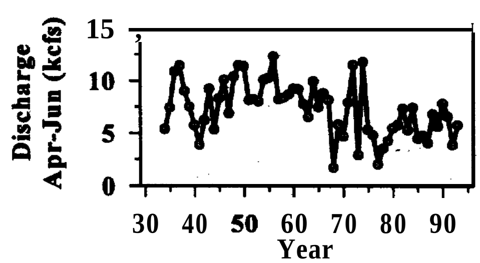
Hatchery Production: The Cowlitz Salmon hatchery was completed in 1967 to mitigate for upstream habitat losses. Fall chinook broodstock are collected from the Cowlitz Salmon Hatchery barrier dam except for some of the fish planted in 1968 (Toutle),



1971 (Kalama), and 1981 (Big Creek, Kalama, Bonneville). Hatchery and natural fall chinook are not separated during broodstock collection and both also spawn naturally. Cowlitz Salmon Hatchery mitigation goals include 8,300 fall chinook. Original hatchery designs called for 10 million fall chinook juveniles (66,400 lb.).

Harvest: Coded-wire tag recoveries of 1985-86 brood in the ocean catch were mostly in Washington **(18%)** and British Columbia **(14%),** followed by Oregon (11%) and Alaska (3%). Columbia River fisheries accounted for an additional 24% of the total harvest. Escapement was 3 1%.

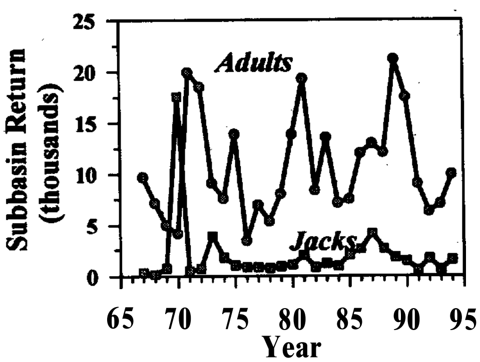
Habitat: The Mt. St. Helens eruption in 1980 severely affected spawning areas downstream from the Toutle River mouth at RM 20. Habitat quality has also been significantly degraded by land use and development. Spring flows have been generally less than average. since 1975.



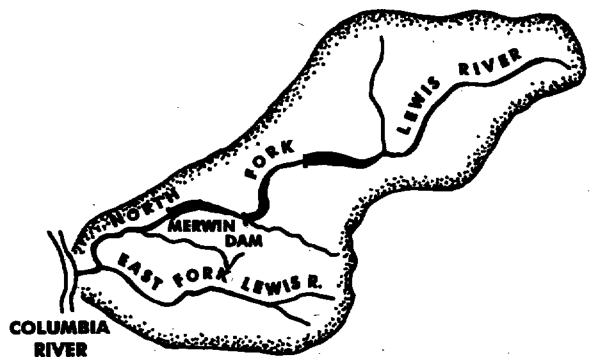
Lewis Fall Chinook

Distribution: Fall chinook historically occurred 'from near the mouth to the upper tributaries. With the construction of Merwin Dam in 193 1, the majority of the spawning reaches became inaccessible. Fall chinook continue to spawn naturally in the North Fork Lewis River with most spawning occurring between the Lewis River Hatchery (RM 12) to Merwin Dam (RM 16).

Abundance: Current fall chinook production is entirely natural in the North and East Fork Lewis rivers. Natural spawning escapement in the North Fork Lewis River from 1967-94 return years averaged 10,974 adults and 2,045 jacks, with a peak of 21,199 adults in 1989 and 17,596 jacks in.1970. The number of wild juvenile fall chinook that migrated from the North Fork Lewis River between 1977-87 (excluding 1980 and 1981) has averaged 2,786,667 and ranged from a low of 1,540,000 for the 1986 brood and a peak of 4,650,000 for the 1983 brood (estimates are based on simple Peterson recapture method using coded wire tags recovered from adult returns).



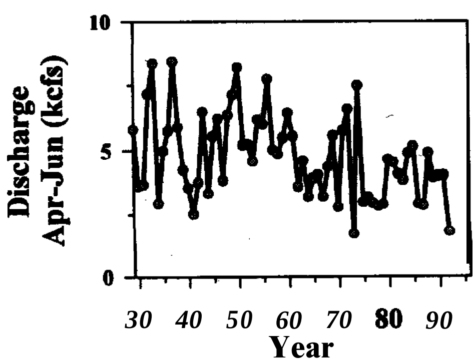
Hatchery Production: North Fork Lewis River hatchery production of fall chinook have been inconsistent in terms of numbers and types of releases. Some release



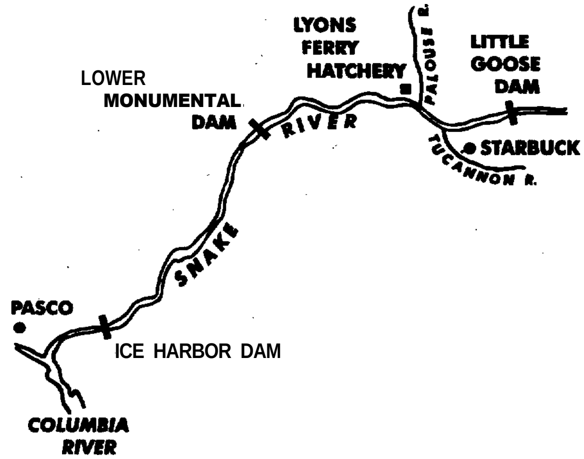
groups were for experimental rather than production purposes. Since 1971, progeny releases from adults collected at Merwin Dam did not exceed 550,000 fingerlings and typically ranged from 50,000 to 150,000 fish. Most of those releases were offspring of an early spawning segment of the run. No fall chinook have been planted since 1985.

Harvest: A harvest profile of Lewis River wild fall chinook based on coded-wire tag recoveries of the 1985-1986 brood fall chinook revealed that most of the ocean catch occurred in British Columbia (14% percent) and Washington (5%), followed by Alaska (4%) and Oregon (3%). Columbia River fisheries accounted for an additional 13% of the total harvest. Escapement was 62% overall.

Habitat: Habitat quality has been significantly degraded by land use, -development, and dams since the mid-1900's. Spring flows have generally decreased during the last 60 years.

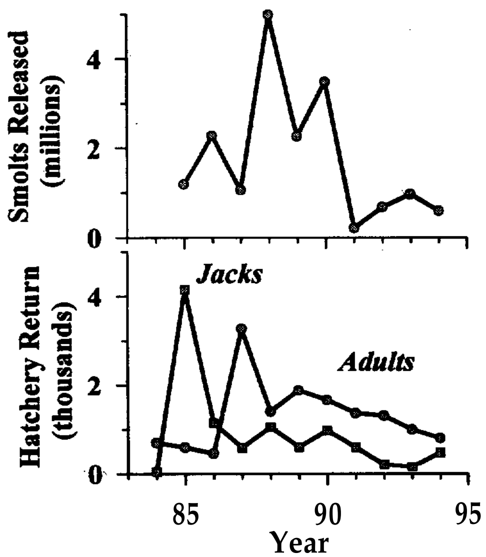


Lyons Ferry Fall Chinook



Distribution: The Lyons Ferry Hatchery is located at the confluence of the Palouse River with the lower Snake River at RM 56.2. Fall chinook salmon are hatched and reared at the Lyons Ferry facility and either released on station or barged downstream and released.

Abundance: Hatchery produced returns averaged 1,3 12 adults and 9 13 jacks in 1984-94 -building to a peak of 3,267 adults in 1987 and 4,160 jacks in 1985.



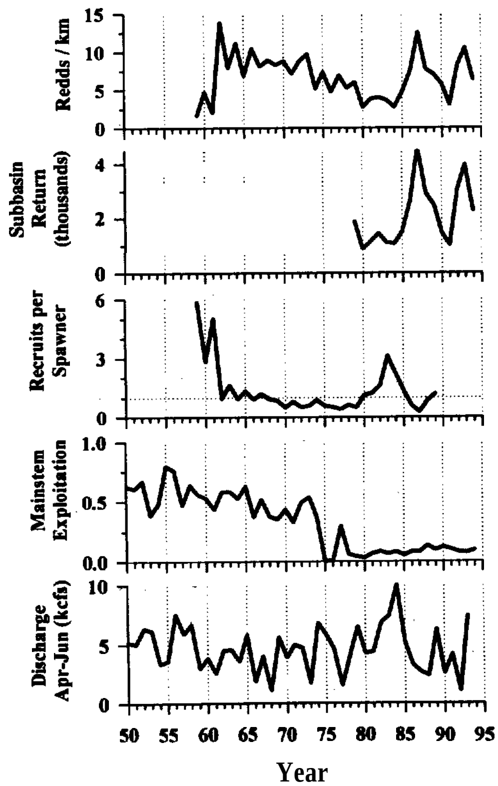
Hatchery Production: The objectives of the Lyons Ferry Fish Hatchery under the Lower Snake River Compensation Plan are to compensate for the losses of 18,300 fall chinook, Snake River stock. The facility has a single pass well water system through the incubators, two adult holding ponds, and 28 raceways. Design capacity is 101,800 pounds of fall chinook. Adult fall chinook salmon return to the fish ladder at the Lyons Ferry facility for brood stocks. Numbers of fall chinook salmon returning to the Lyons Ferry Fish Hatchery ladder are increasing. On-station releases since 1985 are returning as adults. As of 1987, voluntary returns to the hatchery 'have been the primary source of brood stock. Prior to completion of the Lyons Ferry Fish Hatchery, a portion of the Snake River stock fall chinook salmon adults were collected and reared at the Kalama Falls Fish Hatchery on the lower Columbia River as part of the Snake River Fall Chinook Egg Bank Program. When the Lyons Ferry facility was completed, eyed eggs were transported from the Kalama Falls Fish Hatchery to Lyons Ferry for rearing and subsequent release. Hatchery staff transported 219,800 1984 brood eggs, 1 ,182,000 1985 brood eggs, and 749,355 1986 brood eggs from Kalama Falls Fish Hatchery.

Harvest: **Ocean** commercial and recreational fisheries from Alaska to Washington, in addition to Columbia River treaty, non-treaty and sport fisheries all harvest a portion of the Snake River fall chinook.

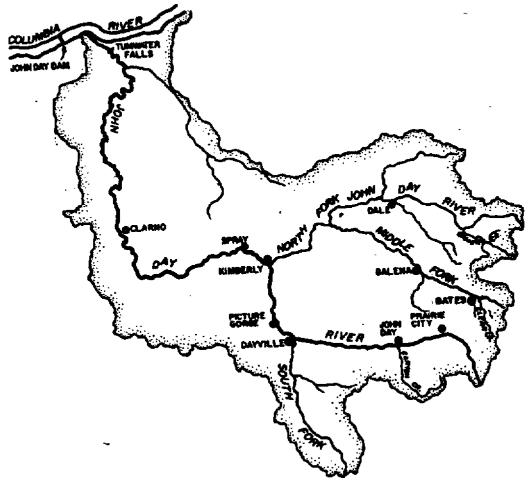
John Day Spring Chinook

Distribution: Current natural spawning areas include portions of the upper mainstem, middle fork mainstem, north fork mainstem, and Granite Creek which is a tributary of the North Fork (Lindsay et al. 1986).

Abundance: Average redd counts in index areas ranged between 2.6 per km in 1959 and 22.2 per km in 1962 (Lindsey et al. 1986). Escapement to the subbasin averaged 2,100 adults and jacks during 1979-94 (TAC 1994). Recruit per spawner ratios (to spawning grounds) remained below replacement levels for an extended period during the 1970's (Petrosky et al. 1996).



Hatchery production: Hatchery-reared spring chinook salmon have never been released into the John Day River subbasin (ODFW et al. 1990).



Harvest: John Day spring chinook are taken in ocean and Columbia River mainstem sport, commercial, and tribal fisheries. Ocean exploitation rates rarely exceed 5%. Mainstem exploitation rates for. spring chinook including the John Day population have declined from an average of 52% during 1950-74 to an average of 8% from 1975-94 as fisheries were curtailed to protect weak stocks (ODFW and WDFW 1995). Small numbers (O-41 per year) have also been harvested in the basin by the Umatilla Tribe since 1986. Sport fisheries for spring chinook in the subbasin have been closed since 1978.

Habitat: Average spring discharge has ranged from 1 to 10 kcfs over the last 40 years. Spawning and rearing habitat for spring chinook has been degraded and fragmented by extensive water withdrawal, grazing, mining, and logging (Lindsay et al. 1986, OWRD 1986, Wissmar et al. 1994). Habitat quality remains high in wilderness areas of the north fork mainstem and Granite Creek. High summer water temperatures (>25°C) limit fish production in the upper mainstem and middle fork, which flow mainly through agricultural lands. Screens are currently maintained on several hundred water diversions. Significant habitat improvement efforts began on federal lands in 1973 and on private lands in 1984.

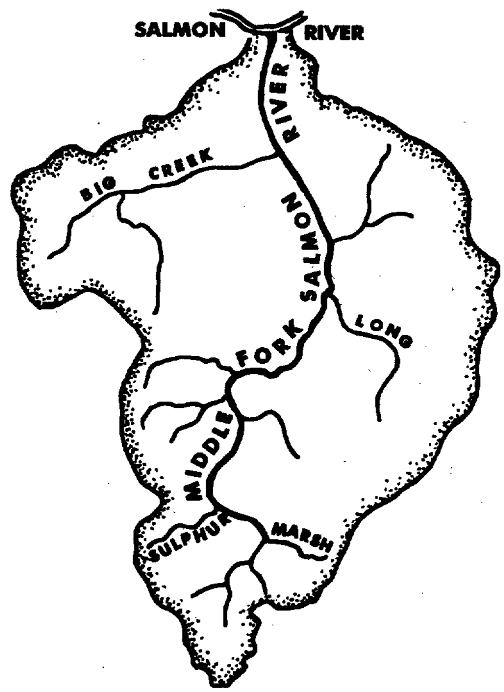
Marsh Creek Spring Chinook

Distribution: Spring chinook occur in 28 tributaries throughout the Middle Fork Salmon River (MFSR) drainage (Mallet 1974). In the Marsh Creek drainage, they spawn in Marsh, Beaver, Cape Horn and Knapp creeks (Elms-Co&rum, et al. in press).

Abundance: Spawning escapements for the Marsh Creek drainage during 1957- 1969 ranged from 180 to 1,290 adults (Petrosky et al. 1996). Estimated recruits to the Columbia River mouth from these brood years ranged from 1,236 to 6,620. As with other Snake River stocks, the population productivity declined and became more variable following construction of the lower Snake River dams (Petrosky and Schaller 1992). Recent spawning escapements (brood years 1975-1994) were much reduced, ranging from 16 to 491; no redds were found in the Marsh Creek drainage during the 1995 spawning ground survey (IDFG unpublished data).

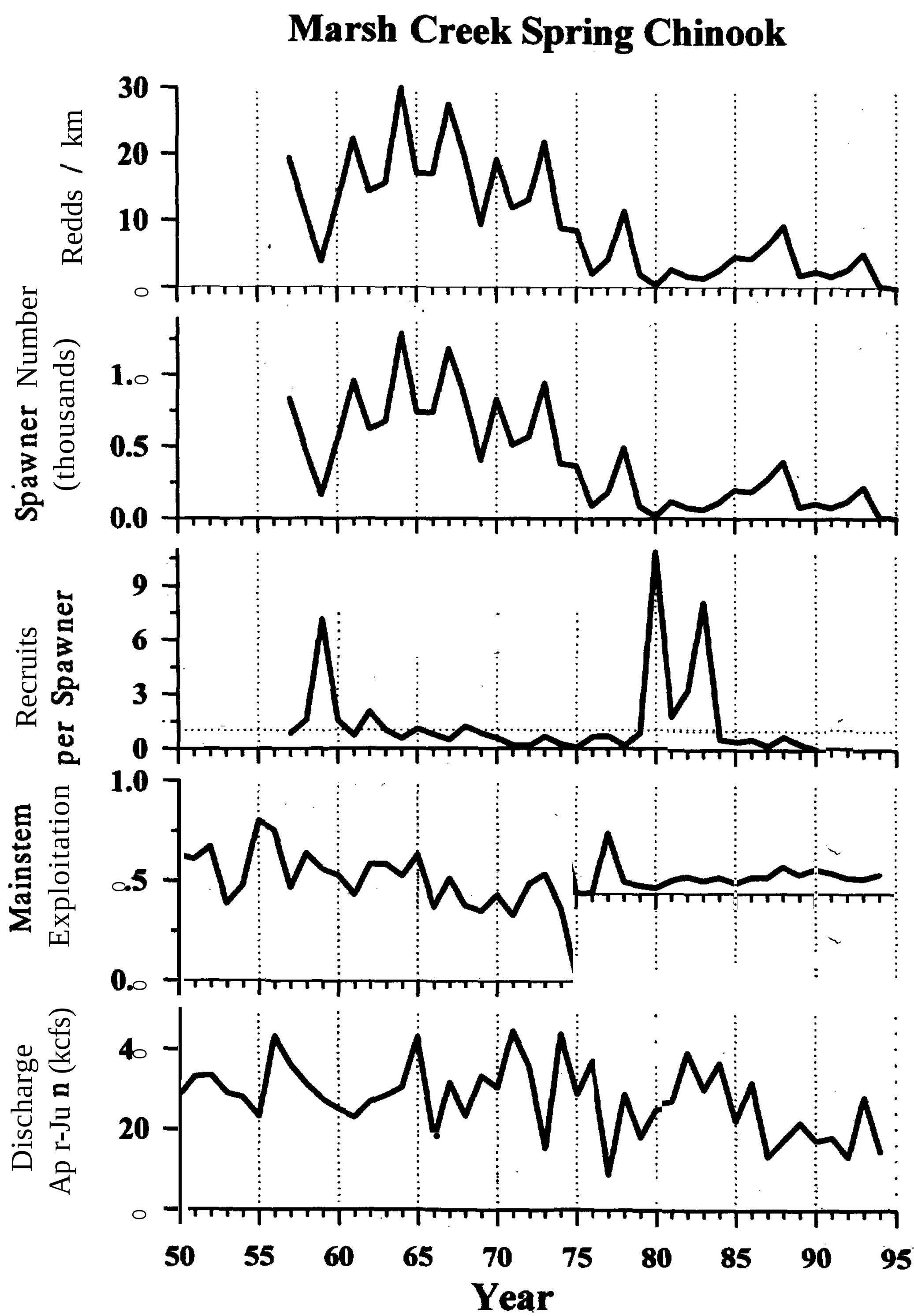
Hatchery Production: The entire MFSR is managed for wild, native spring and summer chinook and steelhead (Kiefer et al. 1992). Only one experimental release of hatchery chinook has been made into the MFSR drainage (Matthews and Waples 1991; 22,000 nonindiginous spring chinook fry into Cape Horn Creek in 1975 by University of Idaho).

Harvest: MFSR spring chinook are currently taken in ocean and Columbia river mainstem sport, commercial and tribal fisheries. Ocean exploitation rates are less than 5%. Mainstem exploitation rates for spring chinook including MFSR populations have declined from an average of 52% during 1950-74 to an average of 8% from 1975-94 as fisheries were curtailed to protect weak stocks (ODFW and WDFW 1995).



On average, 24% of Idaho's salmon sport harvest, 1959-1978, came from the MFSR drainage (Homer and Bjornn 1981). Maximum annual sport harvest in the MFSR was 3,851 spring chinook in 1955-1958 (Gebhards 1959 cited in Thurow 1985). Sport harvest ranged from 349 to 1,906 and averaged 1,003 fish in 1969-1978 (Howell et al. 1985). The MFSR has been closed to sport harvest of chinook since 1978.

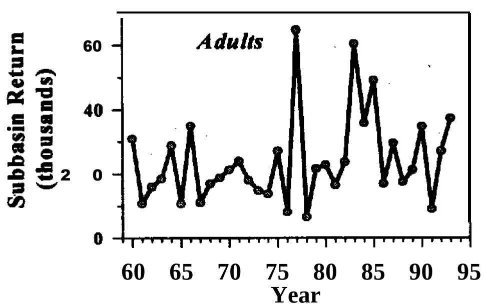
Habitat: The MFSR drains 2,830 square miles of central Idaho (Kiefer et al. 1992). Most of the drainage, including the mainstem, is within the Frank Church River of No. Return Wilderness Area. The rugged topography and wilderness designation has preserved high quality habitat, except in some headwater streams. Summer water temperatures are suitable for salmonid rearing throughout the drainage. Major irrigation diversions are absent. Cattle grazing has historically degraded a portion of mainstem Marsh Creek (OEA 1987); cattle were excluded from the drainage in 1993.


Marsh Creek Spring Chinook
Redds / km
0
10
20
30
Spawner Number (thousands)
0.0
0.5
1.0
Recruits per Spawner
0
3
6
9
Mainstem Exploitation
0.0
0.5
1.0
Discharge Apr-Jun (kcfs)
0
20
40
50
55
60
65
70
75
80
85
90
95
Year

Wenatchee Sockeye

Distribution: Sockeye spawn in the lower 3.5 miles of the Little Wenatchee, the lower 5 miles of the White River at the upper end of Lake Wenatchee (RM 59), and in the Napeequa River (a tributary to the White River). In the 1960's, production also occurred in Nason Creek.

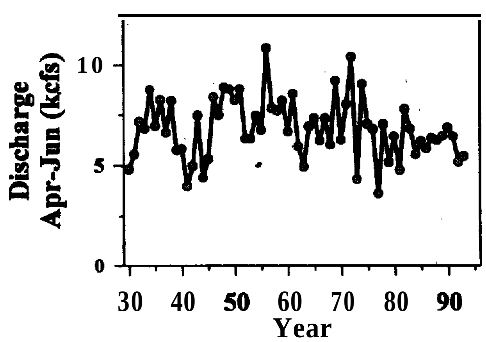
Abundance: The Wenatchee River sockeye natural spawn escapement from 1960-93 return years averaged 24,824 with a low return of 6,600 in 1978 and a peak of 64,600 for the 1977 return.



Hatchery Production: Beginning in 1939, and continuing until 1943, sockeye were trapped at Rock Island Dam for relocation to three national fish hatcheries (Leavenworth, Entiat, and Winthrop). Releases of sockeye smolts occurred from 1941 through 1969, with all three Grand Coulee Fish Maintenance' Project hatcheries contributing to the Wenatchee River Basin. The Leavenworth facility continued to rear sockeye up until 1969 when it was decided to abandon sockeye propagation due to a number of factors, including losses from IHN. Mullan (1986) contends that the effects of artificial propagation of sockeye salmon in the Columbia River were not inconsequential, indicating that hatchery production composed as much as 98% of the return in some years. Wenatchee sockeye are presently managed on a natural stock basis.

Harvest: Sockeye are not harvested in significant numbers in ocean fisheries. Limited non-treaty and treaty commercial gillnet fisheries, as well as subsistence net fisheries and the Lake Wenatchee sport fishery, all harvest a portion of the Lake Wenatchee origin sockeye. No commercial season has occurred since 1988.

Habitat: Habitat quality has been significantly degraded by land use and development in the basin.



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Glossary

coded wire tag recovery: Coded wire tags are laser etched metallic wires implanted into the snouts of many hatchery fish. The coding on the tag indicates the hatchery from which the fish was released as well as the year the fish was released. These tags are subsequently recovered and read to create a database of where individual tags were recovered.

emigration: Migration from freshwater to the ocean.

escapement: The number of salmon and steelhead that return to a specific point of measurement after all natural mortality and harvest have occurred. Natural spawning escapement (or spawner escapement) refers to fish that return to spawn without human intervention in rivers, streams or lakes. Hatchery rack escapement refers to hatchery-produced fish that return from the ocean to collection points at the hatchery of origin.

exploitation rate: The total rate of harvest of a given stock or run of fish.

habitat: The environment in which an organism normally lives and grows. Habitat factors of particular relevance to salmon and steelhead include, but are not necessarily limited to, water temperature, flow, instream cover (including large woody debris), substrate, pools, shading, and bank angle and stability.

immigration: Migration from the ocean to freshwater.

jack: Sexually mature male salmon or steelhead that return to freshwater one or more years earlier than is customary for a particular species or stock.

juvenile: Fish from one year of age until sexual maturity.

outmigration: Downstream migration of fish through the river system to the ocean.

PIT tags: Passive Integrated Transponder tags are used for identifying individual salmon for monitoring and research purposes. Each miniaturized tag consists of an integrated microchip that is programmed to include specific fish information. The tag is inserted into the body cavity of the fish and decoded at selected monitoring sites.

smolt: A juvenile salmon or steelhead migrating to the ocean and undergoing physiological changes to adapt its body from a freshwater to a saltwater existence.

stock: The fish spawning in a particular lake, stream, or series of streams at a particular season, which fish to a substantial degree do not interbreed with any group spawning in a different place, or in the same place at a different season.

Southern Oscillation Index (SOI): An oceanographic indicator of environmental conditions that, allows for the prediction of global climate events such as El Nino.

tailrace: That portion of a stream immediately downstream of a release from a dam, penstock, or other man-made water discharge device. The area is typically characterized by higher than normal velocity and turbulence.

time series: A sequence of years during which records of a consistent form are collected in order to determine a trend.

trend: The directional change in a time series data set. Population trends identify trends in the abundance of a particular stock, population, or other fish grouping.

upwelling: The movement to the surface of ocean bottom waters in areas near the continental shelf. These waters are typically rich in nutrients.

yearling: One-year-old fish.

wild population: Fish that have completed their entire life cycle in the natural environment and maintained successful natural reproduction with little or no supplementation from hatcheries or other culture facilities. A natural population is similar but may contain fish of hatchery or mixed parentage.

Appendix A. Data Dictionary

Table 1. Fisheries Data Dictionary for the September, 1995 version of the Columbia River CIS Distributed System

	Adult Abundance				Harvest				Juve.	Hatchery		Dist.
	Dam/ Weir Counts	Redd Counts	Peak/ Index Spawn Counts	Est. of Spawng Pop.	FW Sport Harvest	FW Comm. / Tribal Harvest	Marine Sport	Marine Comm.	Juvenile Abund.	Returns	Releases	Dist Data
Idaho	C4	C4	NS	NS	C4	S	NA	NA	S	C3	C4*	C9
Oregon In Col Basin	C4	P	P	P	C3	S	NA	NA	NS	C3	C4**	C9
Washington In Col Basin	C4	NS	P	P	P	S	NA	NA	NS	C3	C4***	C9
Oregon Outside Basin	P	NS	P	P	P	S	C3	S	NS	C3	S	C6
Washington Outside. Basin	P	NS	P	P	P	S	S	S	NS	P	S	C6

C3 = Complete through 1993
C4 = Complete through 1994 (Mainstem dam counts go back to 1960)
C4* = Complete from 1975 through 1994
C4** = Complete from 1975 through 1994 for everything except untagged, unassociated releases prior to 1982
C4*** = Complete from 1975 through 1994 for everything except untagged, unassociated steelhead
C6 = Distribution only as of 1986, data available from Regional Data Manager, currently not included in DS
C9 = Distribution, smolt production potential, and habitat quality as of 1989
NA = Not Applicable
NS = Not submitted or Not Collected
P = Partially Complete (Not all years or all streams have complete data, at this time)
S = Slated for next release

Table 2. Non-Fisheries Data Dictionary for the September, 1995 version of the Columbia River CIS Distributed System

Shaded columns indicate data that are not currently available in the Distributed System, but can be obtained through requests to the Regional Data Manager at PSMFC

	Dams Facilities	Hatchery Facilities	Tributary Flow Data	Tributary Temp. Data	Mainstem Dam Flow Data	Nearshore Ocean Upwelling Indices	Sea Surface Temp. and Pressure
Idaho	C	Ca	C3	C3	C3*		
Oregon In Col Basin	C	Ca	C3	C3	C3*		
Washington In Col Basin	C	Ca	C3	C3	C3*		
Oregon Outside Basin	P	P	S	S	NA	C5	C2
Washington Outside Basin	P	P	S	S	NA	C5	C2

C = Complete for hydropower and larger, non-hydropower dams
Ca = Complete for anadromous fish production facilities
C2 = Complete temperature, pressure, and wind speed from 1854 - 1992, entire Pacific Ocean
C3 = Complete through 1993 for all USGS gauging stations, data available from Regional Data Manager
C3* = Daily Flow and spill data by project from 1960- 1993
C5 = Monthly Mean data for 11 west coast stations from 1946-1995
NA = Not Applicable
P = Partially Complete (Not all years or all streams have complete data at this time)
S = Slated for next release