Coenen

MEMORANDUM

Oregon Department of Fish and Wildlife

Date: October 3, 2000

To: Distribution

From: Steve King

Subject: Willamette Spring Chinook FMEP

Attached is the completed Willamette spring chinook FMEP including Ray Beamesderfer's risk assessment.

I sent out a draft for internal review several weeks back. Lance Kruzic of NMFS also received the earlier draft. We have incorporated all comments received, including NMFS', into this draft.

Today I passed the document to Lance Kruzic of NMFS. He will now post an announcement on the Federal Register that the document is available for public review. After the public review comment period of approximately 30 days is complete, we will work together with NMFS to address public comments.

I expect the FMEP will be adopted by letter of concurrence from NMFS by January 1, 2001.

I wish to recognize Ray Beamesderfer's fine efforts to produce this document for us. I believe it is solid and meets all of ODFW's objectives for Willamette spring chinook fishery management and provides the ESA coverage the fishery needs.

SK:smb
Attachment
c: Steve Williams
Neal Coenen
Kay Brown
Roy Elicker
Ray Temple
Bob Hooton
Mark Chilcote
Tim Whitesel
Peter Dratch
Burnie Bohn
Guy Norman
Chuck Tracy
Sam Sharr
Mike Burner
Shijie Zhou
Tony Nigro
Ron Boyce
Christine Mallette
Pat Frazier
Kevleen Melcher
Paul Hirose
Curt Melcher
Dave Ward
Chris Wheaton
Jim Muck
Craig Foster
Steve Smith
Steve Mamoyac
Wayne Hunt
Gary Galovich
Jeff Ziller
Mark Wade
Rick Klumph
Tom Nickelson
Bob Lindsay
<u>w/o attachment</u>
Lance Kruzic (NMFS-Ptld)
Ray Beamesderfer (S.P. Cramer & Assoc.)

FISHERIES MANAGEMENT AND EVALUATION PLAN

Upper Willamette River Spring Chinook in Freshwater Fisheries of the Willamette Basin and Lower Columbia River Mainstem

Prepared by

Oregon Department of Fish and Wildlife
2501 Southwest First Avenue
Portland, Oregon 97201

October 2, 2000

Title: ***Fishery Management and Evaluation Plan - Upper Willamette River Spring Chinook in Freshwater Fisheries of the Willamette Basin and Lower Columbia River Mainstem***

Responsible Management Agency:

Agency:	***Oregon Department of Fish and Wildlife***
Primary Contact:	***Steven D. King***
Address:	***2501 S. W. First Ave. Portland, Oregon 97201***
Telephone:	***(503) 872-5252 x5391***
Fax Number:	***(503) 872-5632***
Email Address:	**steve.d.king@state.or.us**

Date Completed: ***October 2, 2000***

SECTION 1. FISHERIES MANAGEMENT

1.1) General objectives of the FMEP.

The objective of this Fish Management and Evaluation Plan (FMEP) is to harvest known, hatchery origin spring chinook and other fish species in a manner that does not jeopardize the survival and recovery of listed spring chinook in the Upper Willamette River (UWR) Evolutionarily Significant Unit (ESU). This FMEP includes all freshwater sport and commercial fisheries which affect or could potentially affect upper Willamette River spring chinook salmon in the Willamette Basin and lower Columbia River. The primary focus is on fisheries which target unlisted hatchery spring chinook but this plan also considers the potential of other fisheries to affect this threatened ESU. Freshwater impacts are considered in light of expected ocean fishery impacts.

1.1.1) List of the "Performance Indicators" for the management objectives.

Performance indicators include fish population indicators by which we assess the status of populations in the listed ESU to determine trends in abundance, risk thresholds, and the impacts of management actions including fisheries. The primary fish population indicators for listed Willamette spring chinook are spawning escapement estimates based on Leaburg Dam counts (McKenzie River population), North Fork Dam counts (Clackamas River population), and spawning area redd counts (North Santiam River population). Supplemental fish population performance indicators include adult and jack counts at Willamette Falls, juvenile abundance indices from collection facilities at North Fork Dam (Clackamas), and spawning ground redd count indices in the McKenzie and Clackamas rivers.

Performance indicators also include fishery indicators for monitoring fishery performance and regulating impacts within prescribed limits. The primary fishery indicators for Willamette spring chinook sport fisheries are statistical catch and handle estimates in stratified, random, roving creel surveys conducted in the lower and upper Willamette mainstem and Clackamas River. Statistical creel surveys will also be conducted in the North Santiam and McKenzie rivers, providing funding is available, as fisheries are converted or reopened for adipose fin-clipped spring chinook. Secondary fishery indicators include catch rate, fishing effort, and catch composition (size, age, mark rates, coded-wire tags

(CWT), etc.) associated with statistical creel survey and spot check programs, and annual catch record card data from voluntary harvest tag returns by anglers. Fishery indicators for commercial fisheries include total landings which are solicited in phone surveys and reported on fish receiving tickets. Commercial fishery catch composition is also obtained by subsampling a portion of the catch at commercial fish buyer sites.

1.1.2) Description of the relationship and consistency of harvest management with artificial propagation programs.

An estimated 85-95% of current spring chinook returns to the Willamette Basin are fish that were spawned, reared, and released from hatcheries. Wild spring chinook historically spawned in the Clackamas River and in nearly all east side tributaries upstream from Willamette Falls. Dams constructed from 1952-1968 on all major east-side tributaries upstream from Willamette Falls block over 400 stream miles including at least half of the important spawning or rearing areas for spring chinook. Dam passage, flow, and temperature effects also reduce productivity of spring chinook populations in all remaining natural spawning areas including the Clackamas, McKenzie, and North Santiam rivers.

Five large hatcheries were built or modernized to mitigate for lost or reduced runs caused by these dams. The hatcheries currently release about 5 million spring chinook smolts per year. The four hatcheries upstream from Willamette Falls (Marion Forks, South Santiam, McKenzie, and Willamette) are predominately funded by the U. S. Army Corps of Engineers. Clackamas Hatchery is funded by Portland General Electric, the City of Portland, the State of Oregon, and the National Marine Fisheries Service. Hatchery programs historically released spring chinook directly from the facilities and in natural production areas such as the upper McKenzie and Clackamas basins. Hatchery stocks were often transferred among hatcheries to meet production goals. Only a subsample of releases were marked to provide information on survival rates, hatchery practices, and fishery contribution.

Concurrent with heightened concerns for wild fish populations, hatchery practices have been revised to minimize wild fish impacts. Hatchery fish are no longer released in natural production areas. For instance, no hatchery spring chinook have been outplanted into the upper Clackamas since 1985 and in the upper McKenzie since 1990. Hatchery releases are now localized to sites where straying into natural production areas is minimized and fishery opportunities are optimized.

In addition, all hatchery-reared fish are now externally marked with an adipose fin clip which distinguishes them from wild fish. Marking will allow fisheries to take hatchery fish while releasing wild fish and will allow removal of hatchery fish straying into wild production areas. The expanded hatchery fish marking program was phased in beginning in 1997 with the 1996 brood. Over 40% of the 1996 brood year smolts were adipose fin-clipped with over 90% of the Marion Forks and McKenzie hatchery production adipose fin-clipped. Almost 100% of 1997 brood year smolts were adipose fin-clipped. Unclipped hatchery releases are now restricted to experimental CWT tagged groups used to estimate the net effect of selective fisheries in freshwater and the ocean (double index tagging).

Selective spring chinook fisheries for adipose fin-clipped hatchery fish will be phased in as returns of adipose fin-clipped hatchery fish allow. Inaugural selective fisheries in the lower Willamette and North Santiam rivers were set in 2000 when significant numbers of adipose fin-clipped 4-year old fish began to return. Fisheries will continue to transition to 100% selectivity in year 2002 when all returning hatchery spring chinook will be adipose fin-clipped (except 6-year olds). Hatchery fish marking will also allow selective fisheries to reopen in 2001 in the McKenzie River where the spring chinook fishery was restricted to fin-marked fish only in 1995 and 1996, and closed from 1997 to 2000. Selective fisheries for hatchery fish in tributaries will reduce the numbers of hatchery spring chinook available to potentially stray into natural production areas.

Willamette Basin spring chinook hatchery programs are addressed by a final biological opinion issued by the National Marine Fisheries Service (NMFS) on July 14, 2000. This opinion found that UWR spring chinook will not be jeopardized by hatchery operations which continue to mark hatchery fish, take advantage of 100% hatchery marking to exclude hatchery fish from natural production areas, maintain locally-adapted hatchery stocks, and limit numbers and release locations of hatchery fish to reduce adverse ecological effects.

Other Willamette Basin hatchery programs release steelhead, resident trout, and coho salmon. These programs contribute to fishing opportunities for these species and all have been substantially modified to address wild fish concerns. For instance, most releases of catchable trout in running waters where fisheries might incidentally catch spring chinook smolts have been eliminated. Similarly, hatchery coho, fall chinook, and winter steelhead releases above Willamette Falls have been eliminated because these species were not native or could affect the native stocks. The NMFS biological opinion on hatchery operations found that operations of these other hatchery programs will not jeopardize the continued existence of listed ESU's in the basin.

1.1.3) General description of the relationship between the FMEP objectives and Federal tribal trust obligations.

Willamette spring chinook are not subject to Federal tribal trust obligations. Lower Columbia River sport and commercial fisheries for salmon during winter and early spring affect primarily Willamette and other lower river spring chinook stocks but also take some upriver spring chinook. For lower Columbia River sport and commercial fisheries during winter and spring, this fishery management plan addresses only Willamette spring chinook impacts. Upriver spring chinook are subject to Federal tribal trust obligations and impacts on upriver spring chinook stocks are jointly managed by the four Columbia River treaty Indian tribes, the federal government, and the states of Oregon, Washington, and Idaho under continuing court jurisdiction in *U. S. v. Oregon*. That process is addressed in a separate consultation described in more detail in following sections.

Willamette Basin fisheries are not subject to treaty Indian fisheries. During some years with significant hatchery returns (1994-1996 and 1998), annual agreements have been reached between the Oregon Department of Fish and Wildlife and four Columbia River treaty tribes (Warms Springs, Yakama, Nez Perce, and Umatilla) to conduct dip net fisheries for spring chinook at Willamette Falls. By stipulation of these agreements, no stated or implied treaty Indian fishing rights are established in the Willamette Basin. Catches were 759 in 1994 when low flows provided early access to fishing platforms below Willamette Falls. Catches in other years ranged from 0 to 29. Impacts of any such future fisheries are included within those addressed by this FMEP.

1.2) Fishery management area(s).

1.2.1) Description of the geographic boundaries of the management area of this FMEP.

This management plan includes all freshwater fisheries which affect or could potentially affect upper Willamette River spring chinook salmon in the lower Columbia River and the Willamette Basin. Included are all freshwater fisheries managed under the sole jurisdiction of the state of Oregon occurring within the boundaries of the Willamette Basin including the Clackamas River basin, the mainstem Willamette River to its mouth at the Columbia River and Multnomah Channel to it's mouth at the Columbia River (Figure 1). Also included are the Willamette spring chinook impacts in lower Columbia River mainstem sport and commercial fisheries during winter and spring (January-May) between the Columbia River mouth and the Willamette River mouth. This plan includes both Willamette Basin and lower Columbia fisheries affecting or potentially affecting UWR spring chinook because these fisheries are addressed jointly in management and catch allocation processes and the impacts in one area cannot be considered independent of the other.

Lower Columbia River mainstem sport and commercial fisheries which affect upriver spring chinook destined for areas upstream from Bonneville Dam are also regulated by *U. S. v. Oregon* management processes involving the states of Oregon, Washington, and Idaho, the Federal government, and the Columbia River treaty Indian tribes. Impacts on upriver spring chinook by Columbia River mainstem sport and commercial fisheries during winter and spring are addressed under a Section 7 consultation process.

Ocean fisheries which affect listed UWR spring chinook include Southeast Alaska and Canadian troll fisheries which are regulated by Pacific Salmon Commission processes. Because of their early run timing, significant numbers of listed UWR spring chinook are seldom taken in Oregon and Washington coastal sport and commercial fisheries regulated by Pacific Fishery Management Council processes. Ocean fishery impacts are addressed by a Section 7 process although impacts of those fisheries on UWR spring chinook are considered in the cumulative risk assessment for Willamette Basin fisheries.

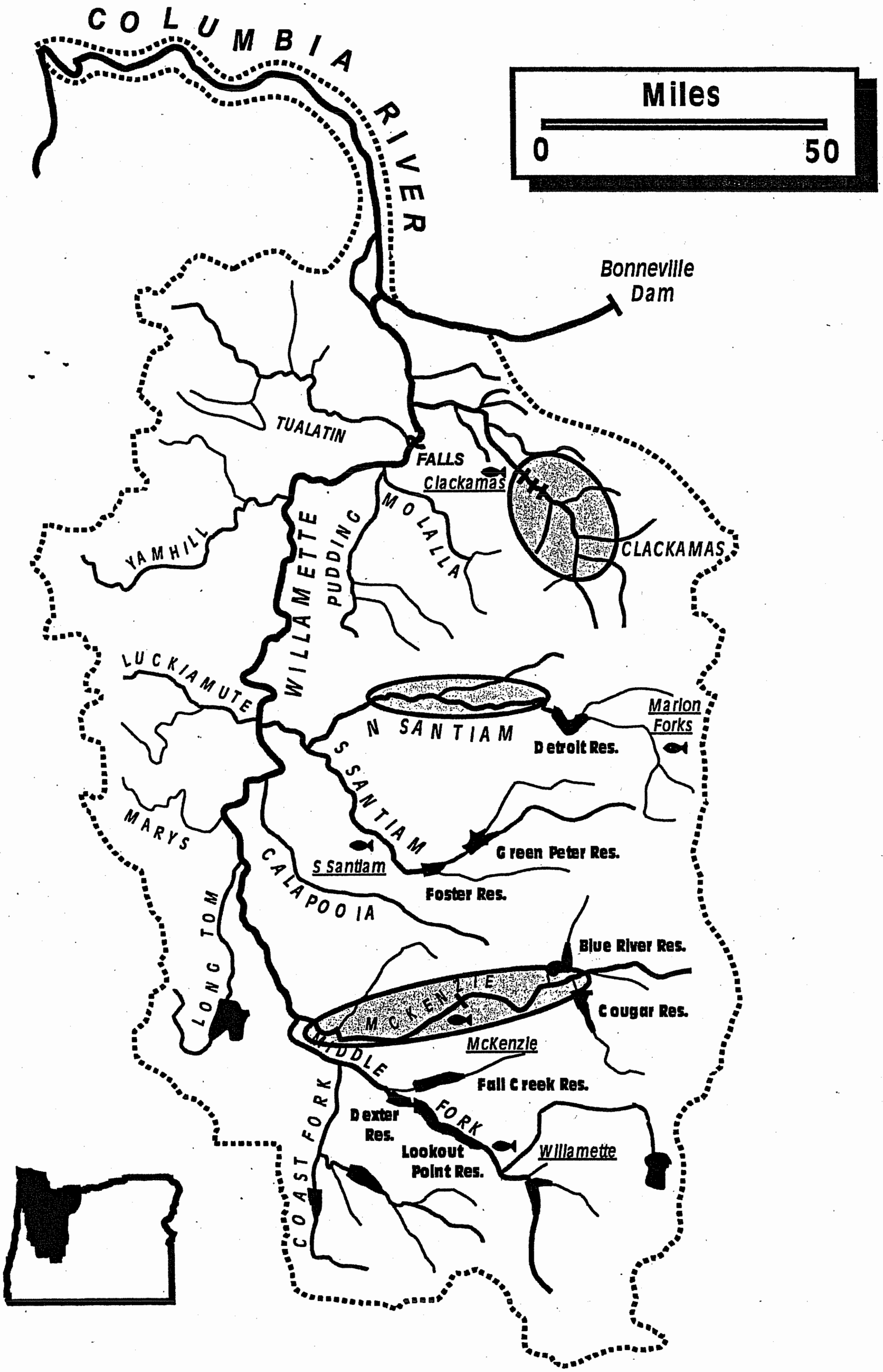


Figure 1. Geographic boundaries of the management area of this FMEP (dotted line) and locations of the 3 listed wild populations of upper Willamette River spring chinook salmon (shaded circles).

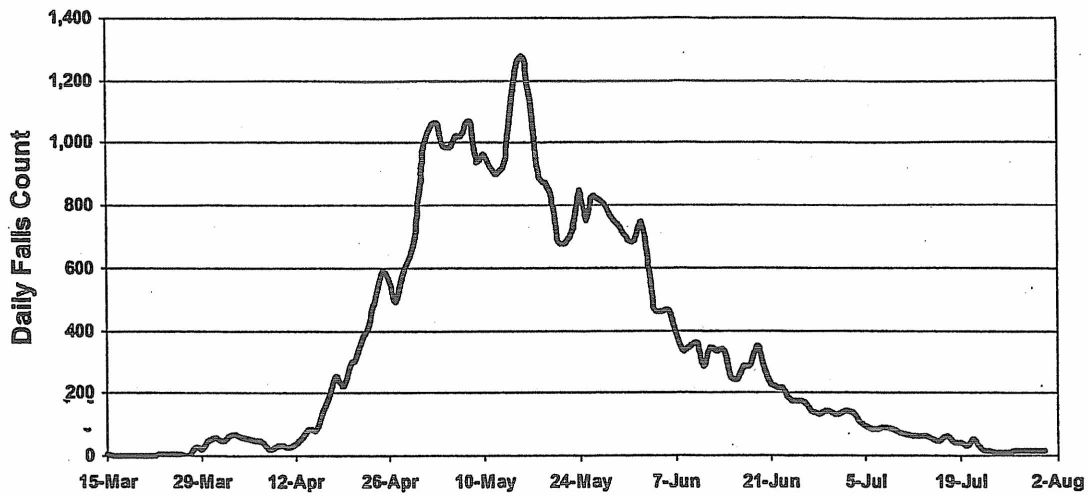


Figure 2. Recent 10-year average passage timing of spring chinook at Willamette Falls.

1.2.2) Description of the time periods in which fisheries occur within the management area.

Fisheries occur within the management area throughout the period of freshwater residence by adult and juvenile UWR spring chinook. Fisheries targeting adult spring chinook occur primarily around the peak of the freshwater migration and gradually follow the fish upriver from March through July. Fisheries targeting other species occur year-round. No fisheries target juvenile spring chinook.

Adult UWR spring chinook return to freshwater earlier than other Columbia basin chinook, with returns beginning around the first of January, increasing to peak numbers in late March, and entry tapering off by mid-May. Fish begin entering the Willamette Basin in significant numbers in March. Migration of adults through Multnomah Channel and the Willamette mainstem downstream from Willamette Falls peaks in late April or early May and is mostly complete by July (Figure 2). Significant numbers of spring chinook begin entering the lower Clackamas River in April. Spring chinook begin passing the Clackamas River dams in May but peak passage into spawning areas does not occur until September. Adults pass Leaburg Dam on the McKenzie River from May through mid October with peak passage in late May or early June and a smaller peak in September. Spawning occurs primarily in September and October.

Willamette spring chinook have a life history pattern that includes traits from both ocean- and stream-type life histories (NMFS 2000c). Smolt emigrations occur in fall as young of the year and in spring as age-1 fish. Many of the fall migrants may continue to rear in freshwater until the following spring before migrating to the ocean.

Fisheries and time periods are listed in Table 1 and described in more detail below. Sport fishery descriptions and dates are as prescribed in current sport fishing regulations with proposed or anticipated changes in the 2001-2004 public angling regulation process. Commercial fishery descriptions and dates reflect past practice and future expectations.

Table 1. Significant fisheries occurring within the Willamette spring chinook Management Area.

Fishery	Area	Typical open dates	Peak period	Effect[1]
		Sport		
Spring chinook	Lower Columbia R.	Jan 1 – Mar 31 [3]	Mar	A
	Columbia R. select areas	Year-round	Feb – Apr	A[2]
	Lower Willamette R.	Year-round [3]	Mar – May	A
	Upper Willamette R.	Apr 1 – Oct 31 [3]	Apr – Jun	A
	Lower Clackamas R.	Year-round [3]	May – Jul	A
	Santiam R.	Jan 1 – Aug 15 [3]	Jun – Jul	A
	McKenzie R.	Closed until 2001	Jun – Jul	A
	Middle Fork Willamette R.	Year-round	Jun – Jul	A[2]
Winter steelhead	Lower Columbia R.	Jan 1 – Mar 31 [3]	Nov – Mar	B
	Lower Willamette R.	Year-round [3]	Nov – Mar	B
	Clackamas R.	Year-round [3]	Nov – Mar	B
	Santiam R.	Year-round [3]	Jan – Feb	D
Summer steelhead	Lower Columbia R.	May 16 – Dec 31	May – Aug	B
	Lower Willamette R.	Year-round [3]	Mar – Jun	B
	Upper Willamette R.	Apr 1 – Oct 31 [3]	Jun – Aug	B
	Clackamas R.	Year-round [3]	May – Sep	B
	Santiam R.	Year-round	Apr – Aug	B
	McKenzie R.	Year-round	May – Oct	B
Shad	Lower Columbia R.	Year-round	May – Jul	B
	Lower Willamette R.	Year-round	May – Jul	B
Sturgeon	Lower Columbia R.	Year-round [3]	Year-round	D
	Lower Willamette R.	Year-round	Mar – Jun	D
	Upper Willamette R.	Year-round	Jun – Sep	D
Resident trout	Lower Columbia R.	Jan 1 – Mar 31, May 27-Dec 31	None	C
	Lower Willamette R.	May 27 – Oct 31	None	C
	Upper Willamette R.	Year-round or Apr 22 – Oct 31	None	C
	Upper Clackamas R.	May 27 – Oct 31	May – Aug	C
	Santiam R.	May 27 – Oct 31	May – Aug	C
	McKenzie R.	Year-round or Apr 22 – Oct 31	May – Aug	C
	Middle Fork Willamette R.	April 22 – Oct 31	May – Aug	C[2]
	Standing waters	Year-round	Year-round	D[2]
Warmwater species	Lower Columbia River	Year-round	Jun – Aug	D
	Willamette mainstem	Year-round	Jun – Aug	D
	Standing waters	Year-round	May – Sep	D[2]
Coho salmon	Lower Willamette R.	Sep 1 – Oct 31	Sep – Oct	D
	Clackamas R.	Sep 1 – Oct 31	Sep – Oct	D
	Eagle Creek	Sep 1 – Nov 30	Sep – Nov	D
		Commercial / Other		
Spring chinook	Lower Columbia River	Determined annually	Feb – Mar	A
	Columbia R. select areas	Determined annually	Feb – Jun	A
Sturgeon	Lower Columbia River	Determined annually	Year-round	B
Smelt	Lower Columbia River	Determined annually	Dec – Mar	D
Lamprey	Willamette Falls	Jun 1 – Aug 31	July	D

[1] A = spring chinook target fishery, B = potential for incidental encounter of spring chinook adults, C = limited potential for incidental encounter of spring chinook juveniles, D = spring chinook not encountered.
[2] Wild spring chinook not present in system.
[3] Regulations sometimes modified based on year-specific expectations and goals.

Sport spring chinook fishery - lower Columbia River: In the lower Columbia River, Willamette fish mix with other Columbia and Snake basin spring chinook stocks. Significant numbers of primarily hatchery fish are produced in Washington tributaries of the lower Columbia River including the Cowlitz, Kalama, and Lewis rivers. A large but predominately hatchery run is also produced upstream from Bonneville Dam. The upriver run includes endangered upper Columbia River spring chinook and threatened Snake River spring chinook. The spring chinook sport fishery from the Columbia River mouth to the I-5 Bridge is open under permanent regulations from January 1 through March 31. During most recent years, the fishery has closed effective March 11 to protect upriver spring chinook which typically begin to show after that date. The fishery has also been extended into April when impacts on upriver spring chinook allow. The states of Washington and Oregon individually set regulations concerning sport fisheries in the mainstem Columbia River. However, the regulations are normally identical.

Sport spring chinook fishery - Columbia River Select Areas: Small sport fisheries for spring chinook occur in "Select Areas" of the lower Columbia River including Youngs Bay, Blind Slough, and Tongue Point (Figure 3). Select Areas are off-channel bays and sloughs where terminal fisheries are conducted for hatchery salmon which were reared and released from net pens, primarily to provide commercial fishing opportunities. Select areas are open to sport fishing under permanent regulations for the entire year to maximize opportunity on returns from net-pen release programs. Impacts to non-local chinook are expected to be minimal. The fishery is small (< 1,000 angler trips per year in the spring).

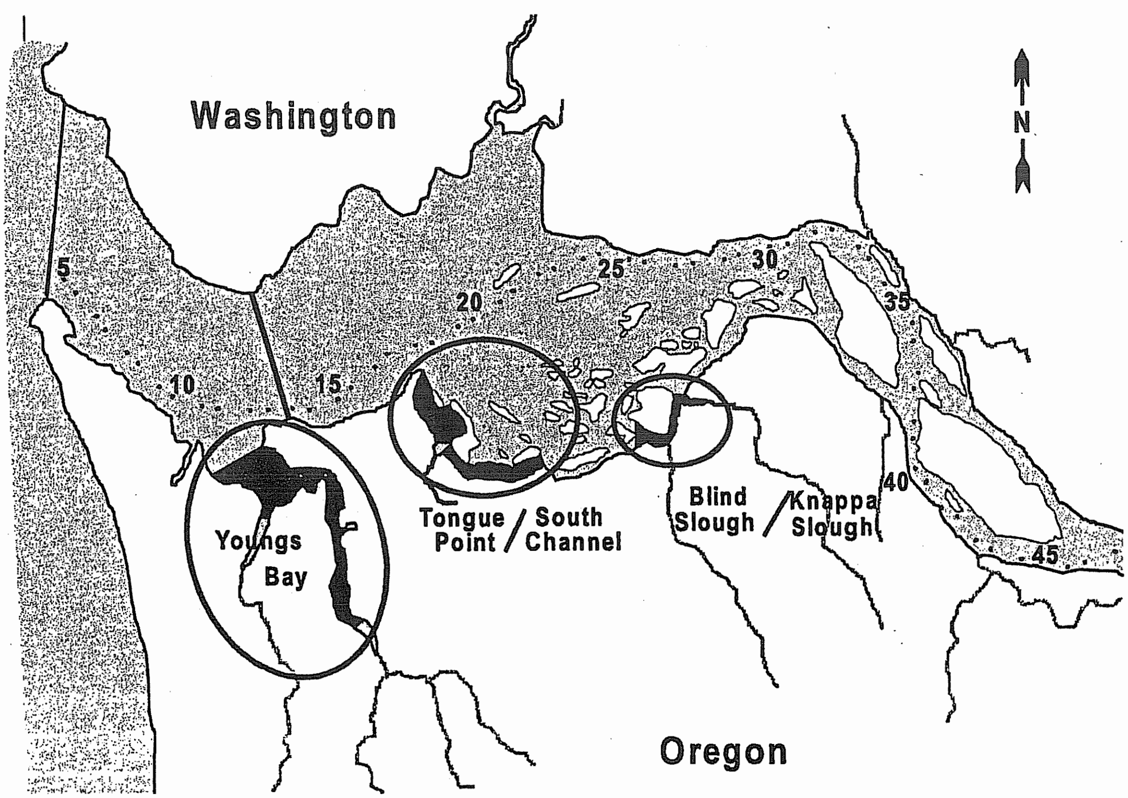


Figure 3. Spring season select area fishery sites.

Sport spring chinook fishery – Willamette Basin: Fisheries for spring chinook salmon can occur in Multnomah Channel and the lower Willamette River upstream to Willamette Falls, lower Clackamas River from the mouth to River Mill Dam, upper Willamette River from the Falls to the mouth of the McKenzie River, Molalla River, Santiam River and Forks, McKenzie River, and the Middle Fork of the Willamette River. Fisheries in the Willamette mainstem below and above the Falls, the lower Clackamas River, the lower mainstem and North Fork of the Santiam River, and the lower McKenzie River may incidentally intercept wild spring chinook. Chinook fisheries are open year-round or reopen under permanent regulations on January 1 in most areas and commence as fish begin entering the area beginning with Multnomah Channel and the lower Willamette River in February and March. Fisheries in tributaries near spawning areas typically close in August to protect spawners.

Sport winter steelhead fisheries: Fisheries for winter steelhead occur in the Willamette Basin from November through May. Fisheries are restricted to adipose fin-clipped hatchery steelhead and occur primarily in the lower Willamette River, lower Clackamas River, and Eagle Creek. Fisheries for hatchery winter steelhead upstream of Willamette Falls have been eliminated as hatchery winter steelhead are no longer released in the upper basin. Fisheries targeting winter steelhead are concentrated from December through February when spring chinook are not present. However, winter steelhead are taken incidental to spring chinook salmon fisheries in the lower Willamette mainstem from February through May. Steelhead fisheries are typically closed with spring chinook fisheries to avoid incidental spring chinook catch.

Sport summer steelhead fisheries: Fisheries for summer steelhead occur in the lower Willamette mainstem, upper Willamette mainstem, lower Clackamas, Santiam, Middle Fork Willamette, and McKenzie rivers. Summer steelhead are not native to the Willamette Basin but hatchery fish are released in areas where winter steelhead are not present. Summer steelhead enter fisheries from March through October and most of the catch occurs from May through August. Spring chinook adults may be encountered by summer steelhead anglers as both are present at the same time. The Columbia River from the mouth to the I-5 Bridge does not open to angling for hatchery steelhead until May 16 which is after the vast majority of Willamette spring chinook have passed upstream.

Sport shad fisheries: Significant shad fisheries occur in the lower Willamette River from May through July. The fishery is concentrated at Oregon City downstream from Willamette Falls and in Multnomah Channel. The shad fishery in the Oregon City area is sampled with a statistical creel survey and angler trips average about 11,000 per year. The Multnomah Channel fishery is minor in comparison to the Oregon City fishery. The onset of the shad run coincides with the tail end of the spring chinook run through the Oregon City area and small numbers of adult spring chinook are hooked in the shad fishery. These impacts are considered with target spring chinook fishery impacts. Shad fishing gear is much lighter than salmon gear which reduces the landing rate but some adult spring chinook are landed. Hatchery spring chinook predominate in the late run time period because wild adults tend to migrate upstream earlier. Shad fisheries also occur in the Columbia River mainstem but do not affect Willamette spring chinook because the vast majority of the run has already passed upriver. The recreational shad fishery is open year-round with no bag limits.

Sport sturgeon fisheries: Significant sturgeon fisheries occur in the lower Columbia and Willamette rivers. Sturgeon are also present in the Willamette mainstem above the falls as far upriver as Dexter on the Willamette Middle Fork and sporadic sturgeon effort is present. The fishery is generally open year-round and legal sturgeon retention sizes are 42 to 60 inches. Sturgeon anglers fish with bait on the bottom and use very large hooks to catch these large fish. In the lower Columbia River significant effort occurs year-round. In the lower Willamette River, effort is concentrated from March through June. Most sturgeon fishing in the Willamette River is from boats near Willamette Falls and near the mouth although a significant bank fishery occurs at Oregon City. Sturgeon fisheries in the Columbia and Willamette are sampled with a statistical creel survey. Angler trips average about 200,000 per year in the lower Columbia mainstem and 6,000 per year in the lower Willamette River. Most sturgeon fishing occurs after spring chinook have passed upstream. Spring chinook impacts in sturgeon fisheries are zero.

Sport resident trout fisheries: Fisheries for resident trout occur in tributaries and standing waters throughout the Willamette Basin. Plants of hatchery reared trout for put-and-take fisheries are now largely restricted to standing waters and streams without anadromous fish to avoid impacts on steelhead and salmon smolts and on resident trout populations. Many of these plants and fisheries now occur above or in the same reservoirs whose dams block historic salmon migrations.

Significant trout fisheries where spring chinook are present include the upper Clackamas, McKenzie, and Santiam rivers but impacts on spring chinook are negligible. Age 0 spring chinook parr are too small to be vulnerable to trout fisheries. Smolts are protected by a series of closed season, size, and gear restrictions. Trout season openers in running waters where salmon and steelhead are present are postponed until late April or May after smolts have passed. Catch and release regulations or minimum size limits are also in effect in tributaries where wild trout, steelhead, and salmon populations might be affected.

Creel survey data confirms that catch of spring chinook is very low in trout fisheries. For instance, a 1988 statistical creel survey program in the upper Clackamas basin from the season opener on April 23 until May 27, estimated that only 100 spring chinook smolts were caught in 37,500 angler trips for a total of 104,000 hours. Catch of hatchery trout totaled 21,000. Approximately 53% of the angler trips were made in North Fork Reservoir with the remainder in the free-flowing river upstream. Regulations in this area have subsequently been changed. The trout season opener has been delayed until late May (May 27 in 2000) and trout retention is allowed only in North Fork Reservoir. Catch and release regulations have been implemented in the upper Clackamas River and tributaries.

Sport warmwater fisheries: Significant fisheries occur in the Columbia River mainstem, Multnomah Channel, Willamette River mainstem, and lower sections of some large tributaries for warmwater game species including largemouth bass, smallmouth bass, channel catfish, crappie, bluegill, and walleye. Warmwater fisheries also occur in standing waters throughout the basin. Spring chinook impacts in warmwater fisheries are nil. In the Columbia River, warmwater fisheries focus on off-channel, near-shore, and deep-water benthic areas where juvenile salmonids are not common. In the Willamette River and it's tributaries, warmwater fisheries are concentrated in backwaters and sloughs which are not hospitable rearing areas for juvenile salmonids. Spring chinook are not present in standing waters where warmwater fisheries occur. Fisheries are also most active during warm summer months after spring migrant juvenile chinook have left the system and before fall migrant juvenile chinook disperse downstream from rearing areas. Since warmwater species potentially prey on and compete with juvenile spring chinook, warmwater fisheries could actually provide some marginal benefit for listed salmon if the warmwater catch were significant.

Sport coho salmon fisheries: Fisheries for adipose fin-clipped hatchery coho salmon destined for Eagle Creek National Fish Hatchery occur in the lower Clackamas River and Eagle Creek from September to November of some years. These coho fisheries do not encounter adult spring chinook which have all passed into upstream spawning areas or have died by this time. Juvenile spring chinook are rare in the lower Clackamas River and Eagle Creek during this time and are not vulnerable to the fishing gear used for adult coho.

Commercial spring chinook fisheries: Winter commercial salmon fisheries occur from the Columbia River mouth upstream to Kelley Point near the mouth of the Willamette River. These fisheries currently target a small allocation of Willamette spring chinook and are severely constrained by limitations on impacts to listed upriver spring chinook stocks. Since 1968, the general management time frame for the winter season has been February 15 to March 10. The gear is restricted to an 8-inch minimum mesh size to avoid incidental handle of winter steelhead.

Commercial spring chinook fishery - Select Areas. These terminal fisheries occur with 8" minimum mesh size gill nets during the spring in Youngs Bay, Tongue Point, and Blind Slough. Fisheries are for Willamette stock spring chinook which have been reared and released from a cooperative county, state, and industry-supported net-pen research program with a goal of 100% harvest of returning adults. The Youngs Bay program has operated since 1990 with a fishing area that extends from the Highway 101 Bridge upstream to the confluence of the Youngs and Klaskanine rivers. The fishery traditionally occurred during late-April through mid-June. However, beginning in 1998, a successful experimental, limited, full-fleet fishery began in mid-February through early-March targeting returning age-5 chinook. The net pen program was expanded in 1995 to include the Tongue Point basin and Blind Slough, where the first fisheries were set in 1998 during late-April to early-June. In 1999, the Tongue Point fishing area was expanded to include South Channel, and the Blind Slough fishing area was expanded to include Knappa Slough from the mouth of Blind Slough to the east end of Minaker Island. Effort in select areas is relatively small with as many as 75 commercial fishers expected to fish at least once, but only 30 expected to participate on a regular basis. Impacts on non-local chinook stocks are small. Any impacts on wild Willamette spring chinook are lumped in this plan with impacts in the lower Columbia River mainstem spring chinook commercial fishery.

Commercial sturgeon fisheries: Winter commercial sturgeon fisheries occur in January and February. The fishery occurs between the Columbia River mouth and Beacon Rock but most effort occurs upstream from the Willamette River. Gill net mesh size is restricted to 9-inch minimum and 9 3/4-inch maximum to avoid non-legal sturgeon and other species including spring chinook. Fishing periods during January and February provide commercial access to a harvestable sturgeon population with minimal impact on salmonid runs. Any impacts of this fishery on Willamette spring chinook are considered with those of the commercial salmon fishery.

Commercial smelt fisheries: Under permanent regulations, the commercial smelt fishery operates seven days per week from December 1 through March 31. However, the season has been reduced or replaced with a test fishery since 1995 because of recent poor returns. The fishery occurs in the lower mainstem Columbia River and Washington tributaries. Gear includes small otter trawls, gill nets with a maximum of two-inch mesh size, and hand dip nets. This fishery does not affect spring chinook adults or juveniles. The few adults present during this time easily avoid the gear. Juvenile spring chinook are not present at the times and places of the smelt fishery.

Lamprey fisheries: A small fishery occurs for lamprey at the base of Willamette Falls from June 1 through August 31. Lamprey are taken for bait, biological specimens, or food. Subsistence uses are primarily by Native Americans. Lamprey may be collected by hand or hand powered tools from a rocky area on the East side of the river below the Falls during daylight hours. The fishery is monitored using free permits. This fishery does not affect spring chinook. Lamprey are able to ascend small trickles and damp spots and hold in pools at the Falls which spring chinook cannot reach as spring flows subside.

1.3) Listed salmon and steelhead affected within the Fishery Management Area specified in section 1.2.

Listed salmon and steelhead present in Willamette Basin include upper Willamette River spring chinook (threatened effective May 24, 1999), upper Willamette River steelhead (threatened effective May 24, 1999), and lower Columbia River steelhead (threatened effective May 18, 1998). The presence of naturally spawning fall chinook salmon in the lower Clackamas River is unclear but if present, these fish would be included in the lower Columbia River chinook salmon ESU (threatened effective May 24, 1999). Listed salmon and steelhead present in the lower Columbia River during the winter/spring time period considered by this plan also include Snake River spring/summer chinook (threatened effective May 22, 1992) and upper Columbia spring chinook (endangered effective May 24, 1999).

This plan considers fishery impacts solely on listed upper Willamette River spring chinook. This ESU includes all naturally spawned populations of spring-run chinook upstream from Willamette Falls and in the Clackamas River. Significant natural populations occur in the Clackamas, McKenzie, and possibly North Santiam rivers. Wild spring chinook are commingled with spring chinook released at hatcheries located on the Clackamas, N. Fork Santiam, S. Fork Santiam, McKenzie, and Middle Fork Willamette rivers. The NMFS designated these 5 hatchery stocks as part of the ESU but not essential for recovery, and not listed. These hatchery stocks were deemed to represent a resource of native genetic material and are available to support recovery efforts.

Fishery impacts in the lower Columbia River on all listed stocks not including upper Willamette spring chinook are addressed by other plans or consultation processes. Fishery impacts in the Willamette Basin on listed upper Willamette River steelhead, lower Columbia River steelhead, and lower Columbia River chinook salmon are considered in separate Fish Management and Evaluation Plans prepared by the Oregon Department of Fish and Wildlife. The upper Willamette River steelhead ESU includes native winter-run populations from Willamette Falls to and including the Calapooia River. Naturally-spawning steelhead populations from the Willamette River mouth to Willamette Falls including the Clackamas River are included in the lower Columbia River steelhead ESU.

1.3.1) Description of "critical" and "viable" thresholds for each population (or management unit) consistent with the concepts in the document "Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units."

NMFS defines population performance in terms of abundance, productivity, spatial structure, and diversity and provides guidelines for each (McElhany et al. 2000). NMFS identifies abundance guidelines for critical and viable population thresholds. Critical thresholds are those below which populations are at relatively high risk of extinction. Critical population size guidelines are reached if a population is low enough to be subject to risks from: 1) depensatory processes, 2) genetic effects of inbreeding depression or fixation of deleterious mutations, 3) demographic stochasticity, or 3) uncertainty in status evaluations. If a population meets one critical threshold, it would be considered to be at a critically low level. Viability thresholds are those above which populations have negligible risk of extinction due to local factors. Viable population size guidelines are reached when a population is large enough to: 1) survive normal environmental variation, 2) allow compensatory processes to provide resilience to perturbation, 3) maintain genetic diversity, 4) provide important ecological functions, and 5) not risk effects of uncertainty in status evaluations. A population must meet all viability population guidelines to be considered viable.

Productivity or population growth rate guidelines are reached when a population's productivity is such that: 1) abundance can be maintained above the viable level, 2) viability is independent of hatchery subsidy, 3) viability is maintained even during poor ocean conditions, 4) declines in abundance are not sustained, 5) life history traits are not in flux, and 6) conclusions are independent of uncertainty in parameter estimates. Spatial structure guidelines are reached when: 1) number of habitat patches is stable or increasing, 2) stray rates are stable, 3) marginally suitable habitat patches are preserved, 4) refuge source populations are preserved, and 5) uncertainty is taken into account. Diversity guidelines are reached when: 1) variation in life history, morphological, and genetic traits is maintained, 2) natural dispersal processes are maintained, 3) ecological variation is maintained, and 4) effects of uncertainty are considered.

This fishery management plan focuses primarily on abundance and productivity which are the two key performance features most directly affected by fishery impacts of the scale we propose. Spatial structure is generally a function of habitat size and distribution. Proposed fisheries do not affect habitat. The small fishery impact rates proposed also will not reduce population sizes to levels where spatial effects are exacerbated. Diversity concerns for UWR spring chinook are primarily related to the effects of natural spawning by hatchery fish. The small proposed fishery impact rates on wild fish are not expected to exert sufficient selection pressure on any single characteristic to affect diversity. See section 2.1.2 for a more detailed discussion of why the harvest regime is not likely to result in changes to biological characteristics of the affected ESU's.

The NMFS provides limited guidance on fish numbers corresponding to critical and viability thresholds. They discuss hypothetical risks related to genetic processes effective at annual spawning population ranging from 50 to several thousand individuals. They also suggest that spawner numbers of 200-250 to 1,100-1,375 per year might be considered "safe" for spring-summer chinook (McElhany et al. 2000).

Based on review of the conservation biology literature and discussions in McElhany et al. (2000), we defined a critical threshold of 300 spawners per year for the Clackamas and North Santiam spring chinook populations and 600 spawners per year for the McKenzie spring chinook population. Spawner numbers of 300 or greater appear sufficient to avoid detrimental short term genetic effects. A critical threshold of 300 spawners per year is also consistent with minimum guidelines defined by State Wild Fish Management and Wild Fish Gene Resource Conservation Policies (OAR 635-07-52 and OAR 635-07-538). The McKenzie spring chinook critical threshold was increased from 300 to 600 to provide an added safety factor for this key remnant population and to reflect the greater size of the available spring chinook habitat in the McKenzie River than in the Clackamas and North Santiam rivers.

We also defined critical productivity indicators based on cohort replacement rate and abrupt declines in run size of a wild population. We defined a critical replacement rate to be the short term average replacement rate (3-year avg. spawners per spawner) projected to result in less than the critical threshold number of spawners within 3 years. Periodic poor cohorts are inevitable but an extended sequence of poor survival should trigger consideration of more conservative management strategies and this consideration should be tied to fish numbers. Poor cohort survivals are expected at very large escapements because the available habitat is overseeded. Poor replacement rates under these conditions should not trigger a conservative management response. Fishery closures after critical low escapement levels are reached provide limited benefits because too few fish are affected at low run sizes to substantially increase escapement. However, more conservative fishery management during extended declines in abundance such as those associated with poor ocean productivity cycles might help reduce the depth of decline and help avoid critical low population sizes where the damage is already done. For added protection, we also defined a critical productivity threshold corresponding to an abrupt decline in escapement. We defined abrupt as greater than a 50% decline relative to the recent year average. This indicator would flag significant declines in survival conditions which might warrant preemptive management actions in anticipation of a continuing downward trend.

Definition of an appropriate viability threshold depends largely on the capacity and productivity of the available habitat and the corresponding population size where compensatory population processes begin to provide resilience. Habitat capacity and productivity for wild Willamette River spring chinook salmon under current conditions are unknown. These parameters can be estimated from time series data of spawners and recruits but we lack suitable historic population data independent of hatchery effects. Changes in hatchery practices and the institution of appropriate monitoring programs will provide the necessary information in the future but preliminary estimates of productivity and capacity will require a minimum of 5 to 10 years of age-specific escapement data.

ODFW subbasin plans have defined interim escapement goals for the McKenzie and Clackamas subbasins based on optimistic assumptions of full seeding capacity but these goals are difficult to reconcile with observed spawning escapement levels. The interim Willamette Basin Plan escapement goal for the McKenzie River above Leaburg Dam is 3,000-5,000 spawners. Pristine production may have been as high as 10,000 to 40,000, although substantial habitat improvements would be required to again achieve pristine production levels (NMFS 2000c). Leaburg Dam counts since 1970 include many hatchery fish and reached 7,000 fish but generally ranged from 1,500 to 4,000. The interim escapement goal in the Clackamas subbasin plan is 2,900. However, historic wild run sizes were generally stable at 400 to 800 fish over North Fork Dam before Clackamas Hatchery operations and the development of a significant lower Clackamas River fishery.

The NMFS' Viable Salmonid Populations guidelines include multiple cautions about the effects of uncertainty in population assessments and also recommend an adaptive management approach for reducing uncertainty (McElhany et al. 2000). Based on the limitations of the available data and these recommendations, we defined interim population viability standards based on a generally increasing population trend and the expected escapements sufficient to identify population capacity and productivity with an effective monitoring plan. Prospects for observing the large escapements needed to plumb the limits of subbasin capacity were evaluated with a population viability analysis which estimated the likelihood of observing large escapements under the proposed fishing plan and normal variation in survival. This analysis is summarized in Section 2.1 and is detailed in Appendix C.

Long term viability thresholds would include an <u>average</u> spawner abundance greater than 50% of subbasin capacity where capacity is defined based on the smaller of replacement spawner abundance (i.e. the intersection of the stock-recruitment curve and the 1:1 replacement line) or spawner number at maximum recruitment (see Appendix C). We base this threshold on average rather than minimum abundance because we readily recognize the inherent variability in salmon population dynamics. Long term viability thresholds also include a productivity standard equivalent to a long term average replacement rate of 1.0 (i.e. a stable population size).

Table 2. List of the natural fish populations, "Viable Salmonid Population" thresholds, and associated hatchery stocks for natural populations of upper Willamette spring chinook.

			Hatchery Stock	
Population	**Critical Thresholds**	**Viable Thresholds**	**Associated**	**Essential for recovery?**
McKenzie	*Abundance*: 600 spawning adults/year *Productivity*: Short term avg. replacement rate (3-year avg. spawners per spawner) projected to result in less than critical threshold number of spawners within 3 years (or) Abrupt declines in escapement (>50% in one year) relative to recent year average)	<u>Interim</u> Abundance: periodic escapements sufficiently large to estimate capacity & productivity Productivity: generally increasing trend <u>Long term</u> Abundance: average spawner numbers >50% of basin capacity defined under interim strategy Productivity: long term avg. replacement rate =1	McKenzie [1]	No
Clackamas	*Abundance*: 300 spawning adults/year *Productivity*: Short term avg. replacement rate (3-year avg. spawners per spawner) projected to result in less than critical threshold number of spawners within 3 years (or) Abrupt declines in escapement (>50% in one year) relative to recent year average)	<u>Interim</u> Abundance: periodic escapements sufficiently large to estimate capacity & productivity Productivity: generally increasing trend <u>Long term</u> Abundance: average spawner numbers >50% of basin capacity defined under interim strategy Productivity: long term avg. replacement rate =1	Clackamas [1]	No
North Santiam	*Abundance*: 300 spawning adults/year *Productivity*: Short term avg. replacement rate (3-year avg. spawners per spawner) projected to result in less than critical threshold number of spawners within 3 years (or) Abrupt declines in escapement (>50% in one year) relative to recent year average)	<u>Interim</u> *Abundance*: periodic escapements sufficiently large to estimate capacity & productivity *Productivity*: generally increasing trend <u>Long term</u> *Abundance*: average spawner numbers >50% of basin capacity defined under interim strategy *Productivity*: long term avg. replacement rate =1	N. Santiam [1]	No

[1]*Each wild population is associated with a subbasin hatchery stock. All other Willamette Basin hatchery stocks are commingled during a portion of the freshwater migration.*

1.3.2) Description of the current status of each population (or management unit) relative to its "Viable Salmonid Population thresholds" described above. Include abundance and/or escapement estimates for as many years as possible.

Five major basins historically produced upper Willamette spring chinook including the Clackamas, North Santiam, South Santiam, McKenzie, and Middle Fork Willamette. Dams on the South Fork Santiam and Middle Fork Willamette eliminated wild spring chinook from those systems. Although there is still natural spawning in the South Santiam and Middle Fork, habitat quality is such that there is probably little resulting production and spawners are likely of hatchery origin (NMFS 2000b). The available habitat in the North Fork Santiam and McKenzie rivers was reduced to one quarter and two thirds, respectively of its original capacity and dam operations have reduced habitat quality in those areas due to thermal and flow effects (NMFS 2000b).

The McKenzie, Clackamas, and North Santiam rivers are the primary basins that continue to support natural production and the McKenzie is considered to be the most important of these (NMFS 2000b). Brief summaries of the current status of each of the three listed natural UWR spring chinook populations follow. A more detailed review of their status and the available data may be found in Appendix B.

The Clackamas and McKenzie wild populations appear to exceed critical and interim viability thresholds for abundance and productivity during recent years. The North Santiam population likely does not meet critical and interim viability thresholds for abundance and productivity because of habitat rather than fishery limitations. Significant factors in the NMFS decision to list upper Willamette spring chinook as threatened included the presence of only two significant populations (McKenzie and the Clackamas) and the influence of hatchery-produced fish on those wild populations. This ESU thus would not meet spatial structure and diversity guidelines for population viability defined by the NMFS. The interaction of variable natural survival rates and high fishing rates can combine to reduce spatial structure and diversity of wild salmon populations under certain conditions. However, the spatial structure and diversity of Willamette wild spring chinook populations will be determined by habitat quality, quantity, and connectivity. The effects of the low fishing rates identified in this plan on spatial structure and diversity of the wild spring chinook populations are expected to be insignificant over the long term as long as abundance and productivity guidelines are met. Spatial structure and diversity guidelines will not be achieved by fishery regulation. Spatial structure guidelines must be addressed primarily by habitat measures. Diversity guidelines for Willamette spring chinook must be addressed by hatchery measures.

McKenzie River: Recent wild spawning escapements in the McKenzie River exceed critical and interim viable thresholds for abundance and productivity. The McKenzie River historically produced 40% of the spring chinook above Willamette Falls and it may now account for half the production potential in the basin. An estimated 80% of the spawning by wild McKenzie River spring chinook occurs upstream from Leaburg Dam. Leaburg Dam fish counts before 1994 were directly affected by releases of hatchery spring chinook upstream from the dam (Figure 4). Since 1994, counts have ranged from 1,176 to an expected 2,700 in 2000. Leaburg counts of wild fish have increased from 825 to over 2,000 from 1994 to 2000 with a steadily increasing trend. Over that period, wild percentages in the Leaburg escapement have increased from 54% to 70-80%. No quantitative estimates of wild population productivity can be derived from historic data because of the confounding effects of hatchery outplants. However, the increasing trend in wild numbers suggests that this population may be reproducing at a rate greater than replacement.

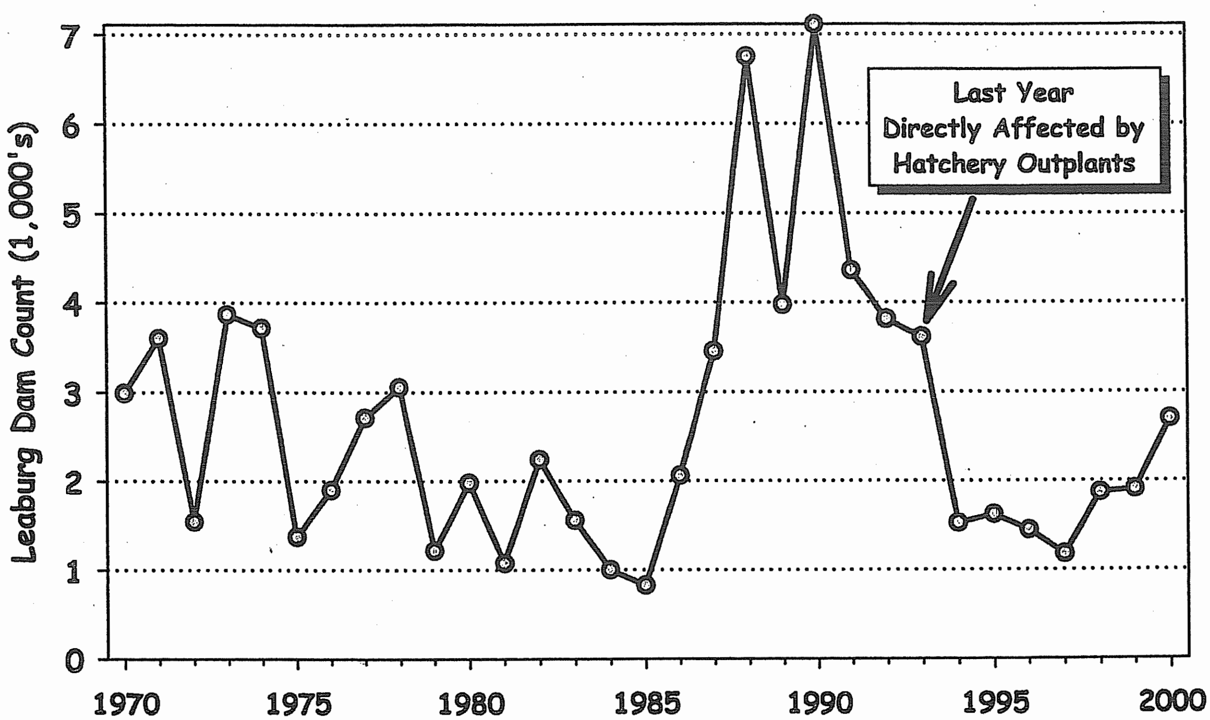


Figure 4. Spring chinook escapement into spawning areas of the McKenzie River.

Clackamas River: Recent wild spawning escapements in the Clackamas River exceed critical and viable thresholds for abundance and productivity. The Clackamas River currently accounts for about 20% of the production in the Willamette Basin. Most wild spring chinook spawn in the upper basin above the 3 dam complex located between river miles 23 and 30. Redd surveys conducted from 1996 through 1999 indicate spawning is widely distributed with about 75% in a 40 mile stretch of the mainstem upstream from the head of North Fork Reservoir, 15% in large tributaries of the upper mainstem, and 10% in the lower basin.

Counts at the uppermost dam (North Fork) provide an index of spawning escapement. Wild populations of spring chinook recolonized the upper Clackamas basin above the second dam (Faraday) after passage was reestablished in 1939 following a 22-year interruption. Counts of wild spring chinook averaged about 500 until 1981 when a large influx of hatchery fish from the newly built Clackamas Hatchery strayed past the hatchery and over North Fork Dam (Figure 5). Dam counts declined from a hatchery-influenced peak of 4,659 in 1991 to vary between 900 and an expected 1,800 in 2000.

Hatchery and wild fish cannot be distinguished until 2002 when all returning hatchery fish will have marks. However, it is thought reasonable to assume that escapement of naturally produced spring chinook in the Clackamas has ranged from about 500 to 1,500 fish during 1994-1999. North Fork Dam counts have followed a generally increasing trend from 1996 to 2000 and have increased in 3 of those 4 years. Relatively stable wild escapements from 1960 to 1980 and recent comparable wild escapements suggest that this population has maintained a replacement rate near 1.0 for an extended period of time.

Comparisons of juvenile production with brood year spawner number suggest that escapements greater than 1,000-1,500 adults will not produce significantly more juveniles on average. A Ricker stock recruitment curve fit to North Fork Dam adult and juvenile index counts indicates that "full seeding" occurs around 2,700 adults and that an adult spawner number of 1,350 equivalent to 50% of the full seeding level would provide 83% of the maximum juvenile production level (Figure 6). These results would suggest that an appropriate long term viability threshold for abundance in the upper Clackamas basin would be about 1,350 spawners if similar patterns hold when hatchery fish are excluded from spawning areas. Recent North Fork Dam counts are within this range if predominately comprised of wild fish.

North Santiam River: Recent wild spawning escapements in the North Santiam River likely do not meet critical and viable thresholds for abundance and productivity and will continue to fall short regardless of fishery management actions. Over 70% of the historic spawning area for spring chinook in the North Santiam basin was blocked by Detroit and Big Cliff dams since 1953. The remaining habitat is adversely affected by warm water and flow regulation.

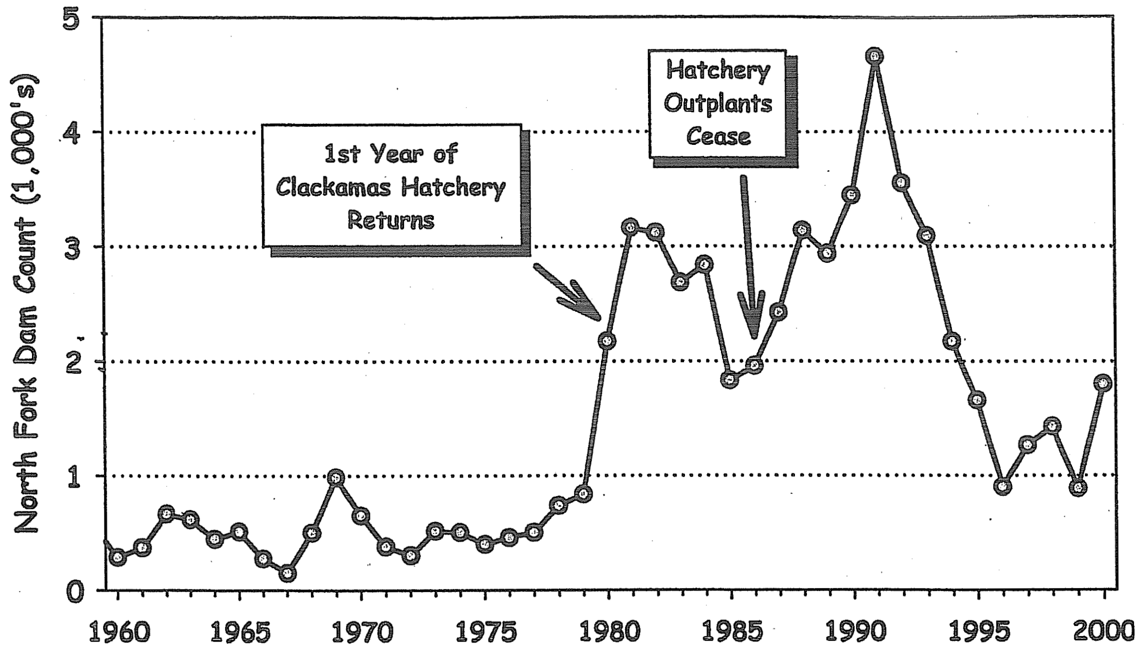


Figure 5. Spring chinook escapement into spawning areas of the Clackamas River.

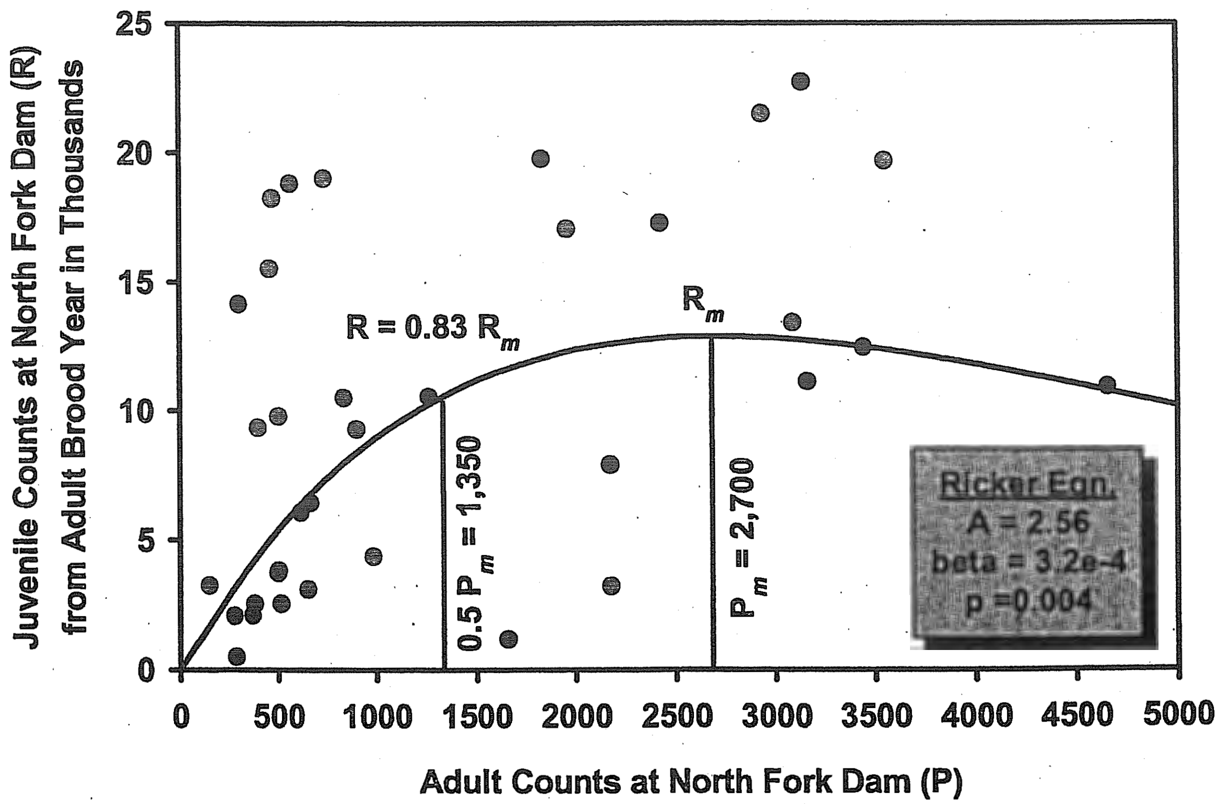


Figure 6. Relationship of adult spring chinook counts over North Fork Dam from 1958-1997 with juvenile outmigration index for offspring of those adults. Brood years where hatchery releases upstream from North Fork Dam inflated juvenile indices (1964-1965 and 1982-1984) are omitted.

Spawning still occurs in the North Fork mainstem and its Little North Fork tributary. Indices of spawning escapement are provided by redd counts. Redd counts have ranged from 137 to 226 from 1996-1999 (see Appendix B). Corresponding spawner numbers are likely in the 300 to 500 range although it is unclear how many of the spawners are stray hatchery fish. Fishway traps operated in 1994 and 1997-99 indicated that only 0% to 3% of the North Fork run originated from naturally-spawned fish.

It is unclear if a self-sustaining natural run of spring chinook remains in the Santiam system or if spawners consist solely of stray hatchery fish. The NMFS (2000c) notes that blockage of the North Santiam by Detroit Dam greatly limits the immediate prospects for recovery in this system. The hatchery program may be important to help maintain population levels.

1.4) Harvest Regime

This FMEP is primarily focused on spring chinook target fisheries where virtually all of the fishery impact occurs. Many hatchery releases of summer steelhead and catchable trout have been discontinued to eliminate potential fishery conflicts with listed adults and smolts. Management of fisheries for species other than spring chinook including trout, shad, and warmwater fisheries has been tailored to essentially eliminate impacts on wild spring chinook adults and juveniles. Many fisheries for other species with measurable impacts on UWR spring chinook have been closed. Some impacts on adult salmon occur in shad and summer steelhead fisheries but these impacts are considered as part of the allowed impacts in hatchery spring chinook target fisheries.

Willamette spring chinook management is based on a subbasin plan adopted by the Oregon Fish and Wildlife Commission (OFWC) following a lengthy public process. A revision of the spring chinook chapters of the plan was adopted in 1998 in part to address the ODFW Wild Fish Policy which provides increased protection for wild fish (ODFW 1998). The revised plan is scheduled to sunset in 2002 and was intended to bridge a period of transition for Willamette spring chinook sport fisheries to full selective fisheries for adipose fin-clipped hatchery fish. Release requirements for the unclipped wild fish in selective fisheries will reduce sport fishery impacts to very low levels.

Prior to revision, the Willamette plan provided for combined Columbia and lower Willamette River harvests intended to provide a minimum aggregate escapement goal at Willamette Falls of 30,000 to 45,000 depending on the aggregate run size. This goal was based primarily on hatchery escapement and fishery sharing needs. The current plan substantially reduces harvest rates to protect wild fish. The current plan identifies harvest rates in mainstem Columbia River and lower Willamette River fisheries which vary from 0% at aggregate runs of less than 30,000 to 40% or more at aggregate runs greater than 90,000. The aggregate approach affords protection to both hatchery and wild escapements because return rates are highly correlated.

The OFWC has adopted more conservative fishing rates than those identified in the current plan for 1998, 1999, and 2000 to ensure an increasing trend in wild fish escapement. More conservative rates are again likely to be adopted in 2001. A portion of the wild fish impacts in 2000 were reserved for a trial implementation in the lower Willamette mainstem of a selective fishery for adipose fin-clipped hatchery spring chinook in the latter part of the chinook run. Year 2000 was the first where adipose fin-clipped fish comprised a significant portion of the run. Large-scale marking of hatchery spring chinook in the Willamette Basin began with the 1996 brood year. Willamette spring chinook return primarily at age 4 and 5 with smaller numbers of age 3 jacks and age 6 adults. A substantial fraction of the 4-year old fish and almost all of the 3-year old fish returning in 2000 were adipose fin-clipped. In 2001, many of the age 5 fish and virtually all of the age 3 and 4 fish will be clipped. In 2002, all returning hatchery adults except 6-year olds will be clipped.

1.4.1) Provide escapement objectives and/or maximum exploitation rates for each population (or management unit) based on its status.

The current goal of Willamette Basin fishery management for spring chinook is to limit fishery impacts on wild fish to levels which ensure the survival and rebuilding of these populations. We estimate that average impact rates equivalent to an annual average of 15% or less in combined freshwater fisheries in the Willamette Basin and lower Columbia River will achieve this goal <u>even under the most pessimistic assumptions</u> of wild stock productivity based on a population viability analysis and expectations for fisheries in the ocean (Appendix C). This risk assessment explicitly considers the effects of data uncertainty and errors, in addition to the effects of variability in natural mortality rates. A variety of fishing strategies provide equivalent benefits to the 15% fixed rate strategy. For instance, variable rate strategies where fishing rates are less than 15% on low runs and greater than 15% on large runs can be tailored with similar or greater protection and recovery benefits to the fixed rate strategy. Similarly, larger rates can be absorbed in some years if balanced by smaller rates in others. These alternative strategies can be used to provide flexibility in optimizing fishery benefits, during the transition period to selective fisheries for instance.

Significant reductions in fishing rates below 15% do not appreciably affect wild escapement or long term survival and recovery probabilities because fishing no longer affects significant numbers of wild fish, especially at low wild run sizes. A harvest rate-based strategy implicitly recognizes variable run sizes and reduces the number of fish harvested at low run sizes. This strategy is thus effective over a wide range of run size which might be expected in the foreseeable future. The population viability modeling indicates that a harvest rate-based fishery strategy based on low fishing rates can be a more effective alternative to a strategy based on fixed escapement goals.

The 100% hatchery marking program which began with the 1997 brood year, will allow full implementation of selective fisheries for hatchery fish beginning in 2002 when all returning age classes of hatchery fish are adipose fin-clipped (except 6-year olds which comprise a very small fraction of the return). Wild fish impacts in selective fisheries will result only from handling mortality of wild fish released and from an expected very low rate of noncompliance with wild release requirements (Table 3). Selective fisheries will eliminate mortality from retention of wild fish and reduce fishery impacts to substantially less than the 15% maximum annual rate. For instance, expected freshwater fishery impacts beginning in 2002 will average 8.7%, 10.3%, and 10.5% for the McKenzie, Clackamas, and North Santiam populations, respectively (Table 4).

Table 3. Projected future harvest rates of Willamette spring chinook in selective sport fisheries.

Sport	Years	Handle rate[2]		C & R[3]	Non	C&R mortality		Non comp. mort		Repeat capture rate		Repeat capture mort		Total impacts	
fishery	included[1]	Avg	Max	mort rate	Comp.[4]	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
Expected Impacts															
L. Columbia	85-94	3.0%	6.7%	8.6%	2.0%	0.25%	0.56%	0.1%	0.1%	0.1%	0.4%	0.01%	0.04%	0.3%	0.7%
L. Willamette	86-95	25.9%	34.5%	8.6%	2.0%	2.18%	2.91%	0.5%	0.7%	6.4%	11.4%	0.55%	0.98%	3.3%	4.6%
Clackamas	90-99	27.5%	41.1%	8.6%	2.0%	2.32%	3.46%	0.5%	0.8%	7.3%	16.2%	0.62%	1.39%	3.5%	5.7%
McKenzie	85-94	13.7%	21.6%	8.6%	2.0%	1.16%	1.82%	0.3%	0.4%	1.8%	4.5%	0.16%	0.38%	1.6%	2.6%
Santiam		25.0%	25.0%	8.6%	2.0%	2.11%	2.11%	0.5%	0.5%	6.0%	6.0%	0.52%	0.52%	3.1%	3.1%
Sensitivity Analysis to Greater and Lesser Catch and Release Mortality Rates															
L. Columbia	85-94	3.0%	6.7%	12.9%	2.0%	0.38%	0.85%	0.1%	0.1%	0.1%	0.4%	0.01%	0.06%	0.4%	1.0%
L. Willamette	86-95	25.9%	34.5%	12.9%	2.0%	3.27%	4.36%	0.5%	0.7%	6.4%	11.4%	0.83%	1.47%	4.6%	6.5%
Clackamas	90-99	27.5%	41.1%	12.9%	2.0%	3.47%	5.19%	0.5%	0.8%	7.3%	16.2%	0.94%	2.09%	5.0%	8.1%
McKenzie	85-94	13.7%	21.6%	12.9%	2.0%	1.73%	2.73%	0.3%	0.4%	1.8%	4.5%	0.23%	0.58%	2.2%	3.7%
Santiam		25.0%	25.0%	12.9%	2.0%	3.16%	3.16%	0.5%	0.5%	6.0%	6.0%	0.77%	0.77%	4.4%	4.4%
L. Columbia	85-94	3.0%	6.7%	4.3%	2.0%	0.13%	0.28%	0.1%	0.1%	0.1%	0.4%	0.00%	0.02%	0.2%	0.4%
L. Willamette	86-95	25.9%	34.5%	4.3%	2.0%	1.09%	1.45%	0.5%	0.7%	6.4%	11.4%	0.28%	0.49%	1.9%	2.6%
Clackamas	90-99	27.5%	41.1%	4.3%	2.0%	1.16%	1.73%	0.5%	0.8%	7.3%	16.2%	0.31%	0.70%	2.0%	3.2%
McKenzie	85-94	13.7%	21.6%	4.3%	2.0%	0.58%	0.91%	0.3%	0.4%	1.8%	4.5%	0.08%	0.19%	0.9%	1.5%
Santiam		25.0%	25.0%	4.3%	2.0%	1.05%	1.05%	0.5%	0.5%	6.0%	6.0%	0.26%	0.26%	1.8%	1.8%

[1] *Most recent 10-years representing expected future fishery.*
[2] *Handle rate relative to escapement to that fishery. (Corresponds to catch / run size).*
[3] *Catch and release mortality rate relative based on Schroeder et al. (1999) research study results. Expected rate is 8.6%. Sensitivity analysis based on arbitrary 50% increase and decrease of average value.*
[4] *Expected non-compliance (% of landed unmarked catch that is illegally retained). Similar to ocean modeling estimates.*

Table 4. Freshwater fishery impact rates on wild Willamette River spring chinook.

						2002 & beyond	
	1981-97	1998	1999	2000[1]	2001	Avg.	Max.
Spring chinook fishery							
L. Col. commercial[2]	6.8%	0.0%	0.0%	0.6%	--[3]	4.0%	11.5%
L. Col. sport	2.5%	0.1%	0.0%	0.4%	--[3]	0.3%	0.7%
L. Willamette sport	21.7%	6.3%	10.2%	14.0%	--[3]	3.1%	4.0%
Clackamas	22.9%	16.5%	22.8%	13.6%	--[3]	3.2%	4.8%
U. Willamette sport	1.2%	0.6%	0.9%	1.2%	--[3]	0.3%	0.4%
North Santiam	16.5%	22.7%	21.7%	2.0%	--[3]	2.8%[4]	2.5%[4]
McKenzie	5.1%	0.0%	0.0%	0.0%	--[3]	1.0%	1.5%
Other fisheries					<0.1%	<0.1%	<0.1%
Totals by population							
McKenzie	37.3%	7.0%	11.1%	16.1%	≤20%[5]	8.7%	18.1%
Clackamas	54.0%	22.8%	33.0%	28.2%	≤20%[5]	10.3%	20.3%
N. Santiam	48.8%	29.6%	32.8%	18.0%	≤20%[5]	10.5%	19.2%

[1] *Preliminary*
[2] *Includes mainstem salmon/sturgeon fisheries and Oregon "Select Area" terminal fisheries.*
[3] *To be determined by Oregon Fish and Wildlife Commission consistent with prescribed population-specific impact limits based on run size, run composition, and allocation goals.*
[4] *Santiam impacts are based on an average expected handle of 25%. This results in greatest impacts at larger escapements to Santiam basin when downstream fisheries are less.*
[5] *Derived from quantitative population risk assessment.*

Tables 3 and 4 describe expected average annual impact rates based on average handle rates observed in historic fisheries. Maximum annual rates are also identified based on maximum handle rates observed in historic fisheries. Maximum rates result in years of optimum fishing conditions and maximum effort. Years of high rates are balanced by years of low rates such that actual annual impacts fluctuate about the average. The risk assessment results indicate that annual impacts such as the maximum depicted rates are acceptable as long as years with high rates are balanced by years with low rates. It will thus not be necessary to manage fisheries for the average rate in each individual year.

Sensitivity analyses were also conducted to evaluate the effects of alternative catch and release mortality rate assumptions. Sensitivity analyses indicate that: 1) fishery impacts remain under the 15% maximum average annual rate goal even if incidental handling impacts are substantially greater than expected and 2) fishery impact rates may be much less than the 15% maximum average annual rate goal if incidental handling impacts are less than expected. Ongoing double index tagging experiments will help identify actual catch and release impacts when selective fisheries are fully implemented.

Selective fisheries will maximize fishery opportunities and seasons for adult hatchery spring chinook and eliminate the need for time and area closures to limit fishery impacts on the wild fish. Fisheries in the Willamette mainstem, Clackamas, and Santiam rivers can reopen to seven days per week and continue without risk of inseason closures based on harvest quotas geared toward wild fish protection. The spring chinook sport fishery in the lower McKenzie River can reopen to target on hatchery spring chinook.

During the one remaining year (2001) until all returning hatchery fish are adipose fin-clipped, the OFWC will likely consider a combination of time and area closures, and selective fisheries consistent with the maximum harvest rate goal. Risk assessment results indicate that year 2001 fishing rates of up to 20% will not appreciably affect wild population survival and recovery prospects where future rates are further reduced by selective fishery implementation. Population-specific impacts of 20% in 2001 would be substantially less than past rates for the Clackamas and North Santiam populations. A 20% rate for one year on the McKenzie population would be slightly greater than in recent years but considerably less than historic rates. Continuing increases in McKenzie wild fish numbers during recent years provide the flexibility to fish at up to 20% in 2001 without risk to the wild population, if desired to smooth transition to selective fisheries in 2002.

Expected run size and mark rate will be key considerations in selecting an appropriate harvest level and regulations consistent with this harvest level. For instance, a large proportion of age 4 fish in the return will allow for more effective implementation of the selective fishery because all of the age 4 hatchery fish are adipose fin-clipped. If the age 5 component is expected to be significant, the OFWC can consider some non-selective fishing periods and areas to access the hatchery return, especially early in the year when age 5 fish predominate.

1.4.2) Description of how the fisheries will be managed to conserve the weakest population or management unit.

The 15% equivalent average harvest rate guideline was applied to all populations although it was based on the most pessimistic combination of assumptions of underlying stock productivity and conversion mortality. Conversion losses are significant in the upper Willamette mainstem. The Clackamas and North Santiam river populations are likely subject to lower adult conversion mortality rates than the McKenzie fish which have the longest distance to travel from the ocean to spawning areas. The maximum conversion loss rate was used in all risk assessment simulations. Application of the weak stock constraints to all populations should provide an added safety factor to buffer the Clackamas and Santiam populations.

1.4.3) Demonstrate that the harvest regime is consistent with the conservation and recovery of commingled natural-origin populations in areas where artificially propagated fish predominate.

The selective fishery strategy is geared to minimize wild fish impacts while removing the maximum share of the harvestable surplus of hatchery fish which can be obtained for a given wild impact. Fisheries occur in areas where hatchery fish comprise 80% or more of the run at recent wild run sizes.

1.5) Annual Implementation of the Fisheries

Current practice in establishing each year's specific regulations for Willamette spring chinook seasons involves a four month public process by the Oregon Fish and Wildlife Commission. This preseason process is followed by active inseason management of the fishery on a weekly or even daily basis. This process provides a high degree of adaptive management for spring chinook where annual fisheries can be tailored to the specific expectations for each year's run and the fishery can be fine tuned as the run unfolds. The extended preseason process will be similar for establishing year 2001 fisheries but is likely to be streamlined in future years when selective sport fisheries will eliminate the need for quota and closed-season management of sport fisheries.

Preseason process: The preseason process begins in November with an information briefing to the Commission on expectations and issues for the following year. During November, final data on the previous year's run size and composition becomes available as spawning is completed in October, scale samples are aged, and coded-wire tags are read. During early December, a forecast of the following year's run and composition is completed based on age-specific data from the prior year and a series of statistical sibling regressions. The OFWC reviews this information at their December meeting and establishes a process and schedule for the coming year.

During early January, the ODFW sends letters to interested public and key constituent groups which detail expectations and issues. Letters extend invitations to the January OFWC meeting and a series of public meetings to review regulatory alternatives. In addition, the ODFW staff holds an informational briefing for representatives of key constituent groups such as the Northwest Sportfishing Industry Association, Northwest Steelheaders, Oregon Trout, Trout Unlimited, and the Native Fish Society. At their January meeting, the OFWC considers appropriate fishing levels for the year based on run size and composition relative to escapement and wild fish protection needs. The OFWC also allocates fishery shares at this time among different areas and between sport and Columbia River commercial fisheries.

In February, the ODFW staff has been holding 2 to 3 public meetings in different areas to review season options consistent with OFWC direction and to obtain public input. Letters are subsequently sent to interested public with ODFW staff recommendations synthesized from the public meetings and with invitations to the February OFWC meeting where public testimony is heard and the spring chinook seasons for that year are adopted.

Columbia River Processes: The process for setting Willamette Basin fisheries is closely related and concurrent with the process for establishing sport and commercial seasons in the lower Columbia River. Commercial seasons in concurrent Oregon and Washington waters of the Columbia River are regulated by a joint Oregon and Washington regulatory body (the Columbia River Compact) in a series of public hearings which begin in January for winter fisheries. The ODFW and WDFW directors or their delegates comprise the Compact and act consistent with delegated authority by the respective state commissions. Columbia River seasons are also regulated by the *U. S. v. Oregon* process which dictates sharing of Columbia River fish runs between Indian and non-Indian fisheries. Impacts on upriver spring chinook and steelhead in Columbia River fisheries are not subject to this FMEP and are addressed by Section 7 consultations for *U. S. v. Oregon* fisheries.

Permanent Regulation Process: This process addresses regulations for other Willamette Basin fisheries addressed by this FMEP (trout, warmwater, shad, sturgeon, etc.). Permanent rules are developed in a state-wide angling regulation process which is currently conducted at 4-year intervals. A 1996 public involvement process established angling regulations from 1997 through 2000. The public process for 2001 through 2004 regulations began in September 1999 and will be completed later this year. The public process involved 1) solicitation of proposals for regulation changes from ODFW staff, Oregon State Police (OSP), and the public, 2) categorization of proposals for substance and opportunity by a Regulation Review Board which includes representatives from the public, ODFW, OSP, OFWC, and the Oregon Governor's office, 3) review of proposals in a series of 7 public meetings held around the state, and 4) review and adoption of rules by the OFWC at public commission meetings in August and September. New sport regulation pamphlets will be prepared and printed in October and November and new regulations will take effect on January 1, 2001.

The OFWC also considers interim-year changes which address conservation needs, correct errors and inadvertent restrictions, provide clarification, or capitalize on non-controversial opportunities. Fishery descriptions and regulations described in section 1.2.2 include descriptions of any pertinent changes or considerations identified in the current regulation review. Any affects of regulation changes on listed UWR spring chinook will be consistent with limitations described in this FMEP.

Recent regulations: Recent regulations have involved a series of very conservative seasons to provide some limited fishing opportunity while protecting wild fish during the transition to selective sport fisheries. In 2000 for instance, the OFWC adopted fisheries consistent with a 15% impact in combined Columbia and lower Willamette river sport and commercial fisheries. Impacts were allocated 2% to lower Columbia River commercial fisheries (1,200 fish at the preseason run forecast of 59,900), 2% to lower Columbia River sport fisheries (1,200 fish), and 11% to Willamette River sport fisheries below the Falls. The goal for the upper Willamette mainstem sport fishery was equal catch opportunity to the lower river fishery. Opportunity has typically been defined as days of fishing effort when significant numbers of fish have passed into the fishery area from Willamette Falls. Effort in the upper Willamette mainstem is much less than in the lower river and impacts are typically 10% or less of the lower river. The year 2000 goal for the lower Clackamas and North Santiam River fisheries was to reduce wild fish impacts by over one half relative to the unrestricted fishery of recent years. The McKenzie River sport fishery remained closed.

The year 2000 seasons corresponding to prescribed impact limits included a combination of daily closures, season closures based on catch quotas, daily and season bag limitations, and a trial selective fishery. The Mainstem Willamette River below the Falls was open 7 days per week for salmon and steelhead through March 19. The daily limit was two salmon or adipose fin-clipped steelhead and annual limit was the statewide regulation of 20 adult salmon or steelhead per year. From March 20 through April 15 and on April 22, the lower Willamette was open each Monday, Wednesday, Saturday, and a special fishing day (Friday April 14). The daily limit was one adult or jack salmon and one adipose fin-clipped steelhead, or two adipose fin-clipped steelhead per day. The annual limit was 5 adult or jack salmon for the combined restrictive seasons for the Lower Willamette, Upper Willamette, and Clackamas rivers. Any chinook caught before March 20 in the lower Willamette and May 1 in the Clackamas did not count on the season limit. Beginning May 1, the lower Willamette reopened with modified regulations to allow a selective fishery for adipose fin-clipped spring chinook and steelhead, 7 days per week.

The mainstem Willamette River from the falls to the mouth of McKenzie River opened April 1 on each Monday, Wednesday, Saturday, and the special fishing day (Friday April 14) with daily limits of 1 adult or jack salmon and 1 adipose fin-clipped steelhead, or 2 adipose fin-clipped steelhead per day. The annual limit was 5 adult or jack salmon for the combined restrictive seasons for the lower Willamette, upper Willamette, and Clackamas rivers.

The Clackamas River from the Highway 99E Bridge to North Fork Dam was open 7 days per week for salmon and steelhead with a 2 salmon or adipose fin-clipped steelhead daily limit and the standard annual limit through April 30. From May 1 through July 31 it was open each Monday, Wednesday, and Saturday with a daily limit of 1 adult or jack salmon and one adipose fin-clipped steelhead, or two adipose fin-clipped steelhead per day. The 5 salmon restrictive season limit applied.

The North Santiam River from the mouth to Big Cliff Dam was open 7 days per week for salmon and steelhead with a 2 salmon or adipose fin-clipped steelhead daily limit and the standard annual limit through April 30. From May 1 through August 15 it remained open 7 days per week but retained spring chinook and steelhead must have a healed adipose fin clip. Normal catch limits of two adult fish per day and 20 per year apply.

Commercial fishing seasons in 2000 were conducted approximately 3 days per week in January and February. January commercial fisheries primarily targeted sturgeon while February fisheries were focused on salmon. The commercial catch quota of 1,200 Willamette spring chinook was not achieved because the fishery was limited by impacts on listed Snake River spring chinook salmon. Sport seasons in joint state waters of the Columbia River are implemented in a public process by joint state action also as per delegated authority of the state commissions.

The year 2000 sport fishery in the Columbia River between the mouth and I-5 Bridge was open 7 days per week with normal limits of 2 adult salmon or adipose fin-clipped steelhead per day and 20 per year until 1,200 Willamette spring chinook are caught. The season closed March 16 because the sport fishery, like the commercial fishery, was limited by impacts on Snake River wild spring chinook.

<u>2002 and beyond:</u> The annual spring chinook fishery regulation process is expected to be considerably streamlined beginning with year 2002 when all sport fisheries will be selective for marked hatchery fish. Permanent rules will allow retention of only adipose fin-clipped chinook salmon and will require immediate release of fish without adipose fin-clips. Seasons are as described in Table 1. New rules have already been adopted in the McKenzie and North Santiam rivers for 2001 and are pending in other areas. Unless wild populations fall below critical thresholds or scheduled periodic reviews of this plan are due, annual fishery implementation is likely to be limited to presentation of the annual forecast, routine fishery and escapement monitoring, and dissemination of

inseason and post season updates. Annual implementation of Columbia River mainstem fisheries will continue to depend on *U. S. v. Oregon* processes and the status of other Columbia and Snake river stocks.

SECTION 2. EFFECTS ON ESA-LISTED SALMONIDS

2.1) Description of the biologically-based rationale demonstrating that the fisheries management strategies will not appreciably reduce the likelihood of survival and recovery of the affected ESU(s) in the wild.

Fishing rates identified in this plan do not appreciably reduce the likelihood of survival and-recovery of wild Willamette River spring chinook. This assessment was based on direct estimates of survival and recovery likelihoods with a quantitative Population Viability Analysis (PVA). This analysis is summarized below and described in more detail in Appendix C. Population Viability Analysis is a widely used and useful tool for evaluating specific harvest actions where used in conjunction with a Viable Salmonid Population concept as described by the NMFS to identify abundance levels necessary for long-term survival (McElhany et al. 2000).

Population Viability Analysis is a type of risk assessment model which provides a systematic, biological basis for estimating sustainable fishing levels. It estimates extinction risks and recovery prospects at different fishing levels by simulating the salmon life cycle into the future. Extinction risks are based on the frequency of numbers falling below a critical threshold (e. g. 300 spawners). Recovery prospects are based on future population size and normal variation in future population size as compared with rebuilding or recovery goals.

Risk-based modeling is the preferred approach for identifying the long term effects of management actions because it considers data uncertainty (in things like run forecasts) and normal variation in fish numbers due to chance and environmental variability. Simple trend analysis based on annual escapement comparisons may lead to management errors. For instance, increasing fish numbers during good ocean conditions may mask the need for habitat improvements to ensure stock persistence when ocean conditions inevitably go through another down cycle. Conversely, fishing may be reduced more than is necessary in an attempt to maintain an ever-increasing trend when natural cycles guarantee that this goal is not attainable.

Model results depend on population productivity which is the relative number of offspring produced by a given number of spawners. Extinction risk is typically defined solely in terms of fish numbers: too few spawners result in a spiral toward extinction. Recovery is typically defined in terms of fish numbers and population productivity. Above low threshold numbers, population productivity is much more important than absolute spawner numbers. Productive populations have a higher average population size, rebuild quickly after poor ocean cycles, and can easily sustain incidental harvest impacts. A small, productive population will fare much better over the long term than a large, unproductive one. Productivity is related to habitat quality and recovery ultimately depends on habitat improvements.

The PVA for wild Willamette spring chinook indicates that impacts of 15% in combined freshwater fisheries meet stock protection and restoration standards for wild populations even under worst case assumptions for wild stock productivity (Table 5). Impacts of 20% in 2001 would also meet stock and restoration standards when benefits of future selective fisheries are considered. Risk assessment modeling was based on the McKenzie River population which we believe to be the most sensitive population as a result of adult conversion mortalities in the upper Willamette mainstem. The Clackamas River population is not subject to this loss. The North Santiam population travels a shorter distance than the McKenzie population, hence, conversion mortality is likely to be less.

Table 5. Results of a quantitative Population Viability Analysis risk assessment of fishing impacts on wild Willamette River spring chinook based on worst case estimates of population productivity and capacity.

	Quasi-extinction risk [1]	Large Run Probability [2]	"Recovery" Probability [3]
Standard [4]	**≤1%**	**≥10%**	**≥50%**
Old Plan (1981-1997)	31%	< 0.1%	< 0.1%
15% average annual rate [5]	< 0.1%	15%	50%
Expected selective fishery	< 0.1%	20%	63%

[1] *Quasi-extinction risk based on the frequency of wild escapement of less than 300 fish within 30 years.*
[2] *Large run probability based on frequency exceeding 75% of replacement abundance within 30 years.*
[3] *Based on last 8-year average run size exceeding 50% of basin capacity.*
[4] *Standards are recommended as benchmarks for comparative purposes.*
[5] *Based on average ocean fishing rate of 12% and average 15% impact rate in all freshwater fisheries beginning in 2001.*

These risk assessment results are conservative because the model was based on worst-case productivity assumptions. Low productivity rates for other Columbia basin spring chinook were used because we lack information on the productivity of Willamette populations. Actual productivity is probably greater and productivity is also likely to increase in the future especially if wild stock benefit from reduced hatchery influences.

Rebuilding potential was evaluated based on the chances of observing large run sizes. Realistic numerical recovery goals cannot be identified because wild carrying capacity is unknown. Monitoring of the production from large run sizes will allow us to identify basin carrying capacity and stock productivity at a later date. Even if habitat capacity and full seeding levels were known, annual fishing plans should be based on long term fishery impact reduction goals rather than annual attempts to meet "full seeding" escapement goals. The sustainability modeling shows that: 1) full habitat seeding in every year is not realistic given normal population variability even in the absence of fishing, and 2) variable harvest rate strategies which allow fishing at runs less than full seeding can provide similar stock recovery benefits.

2.1.1) Description of which fisheries affect each population (or management unit).

Each of the three population units (Clackamas, McKenzie, and North Santiam rivers) are potentially affected by spring chinook target fisheries in the Willamette River mainstem, spring chinook target fisheries in the lower mainstems of the respective tributaries, and selected fisheries for other species in the Willamette mainstem and the tributaries (Table 6).

2.1.2) Assessment of how the harvest regime will not likely result in changes to the biological characteristics of the affected ESU's.

Low harvest impact rates which will result from implementation of selective fisheries for adipose fin-clipped hatchery spring chinook will substantially reduce the potential for fishing-related changes in biological characteristics of wild spring chinook. Fishing impact rates are small and spread over the breadth of the run so that no subcomponent of the wild stock will be selectively harvested at a rate substantially larger than any other portion of the run. No significant harvest differential will occur for different size, age, or timed portion of the run. In addition, low fishing rates for wild fish will result in increased numbers of wild spawners even in periods of poor freshwater migration and ocean survival conditions. Larger populations will be less subject to genetic risks and loss of diversity associated with small population sizes. Finally, increased harvest rates of hatchery fish in selective fisheries should benefit wild stock integrity and diversity by removing a greater fraction of the hatchery fish which could potentially stray into wild production areas.

Table 6. Fisheries potentially affecting each population of wild Willamette River spring chinook.

Fishery	Area	Clackamas	N. Santiam	McKenzie
Spring chinook	Lower Columbia R. sport	X	X	X
	Lower Columbia R. commercial	X	X	X
	Columbia R. select area sport	X	X	X
	Columbia R. select area commercial	X	X	X
	Lower Willamette R. sport	X	X	X
	Upper Willamette R. sport		X	X
	Clackamas R. sport	X		
	Santiam R. sport		X	
	McKenzie R. sport			X
Winter steelhead	Lower Columbia R. sport	X	X	X
	Lower Willamette R. sport	X	X	X
	Clackamas R. sport	X		
Summer steelhead	Lower Columbia R. sport	X	X	X
	Lower Willamette R. sport	X	X	X
	Upper Willamette R. sport		X	X
	Clackamas R. sport	X		
	Santiam R. sport		X	
	McKenzie R. sport			X
Shad	Lower Columbia R. sport	X	X	X
	Lower Willamette R. sport	X	X	X
Sturgeon	Lower Columbia R. commercial	X	X	X
Resident trout	Clackamas R. sport	X		
	Santiam R. sport		X	
	McKenzie R. sport			X

2.1.3) **Comparison of harvest impacts in previous years and the harvest impacts anticipated to occur under the harvest regime in this FMEP.**

Current impact rates in aggregate freshwater fisheries are substantially reduced from historic levels and will be reduced even further by future fisheries. With the advent of full selective fisheries in 2002, expected wild fish impacts in all freshwater sport fisheries are expected to average 4.7%, 6.3%, and 6.5% for the McKenzie, Clackamas, and N. Santiam populations, respectively (Table 4). Total freshwater impacts are expected to average 8.7%, 10.3%, and 10.5% including limited commercial fishery expectations of 4% consistent with continued Snake and upper Columbia river spring chinook constraints. These population-specific impacts are approximately one quarter the 1981-1997 average on these populations and approximately one half the average during the 1998-2001 transition period to selective fisheries (Table 4). Impacts in lower Columbia and Willamette sport and commercial fisheries will be reduced from annual averages in the 30-50% range from 1970-1995 to an annual average of less than 8% beginning in 2002 (Figure 7).

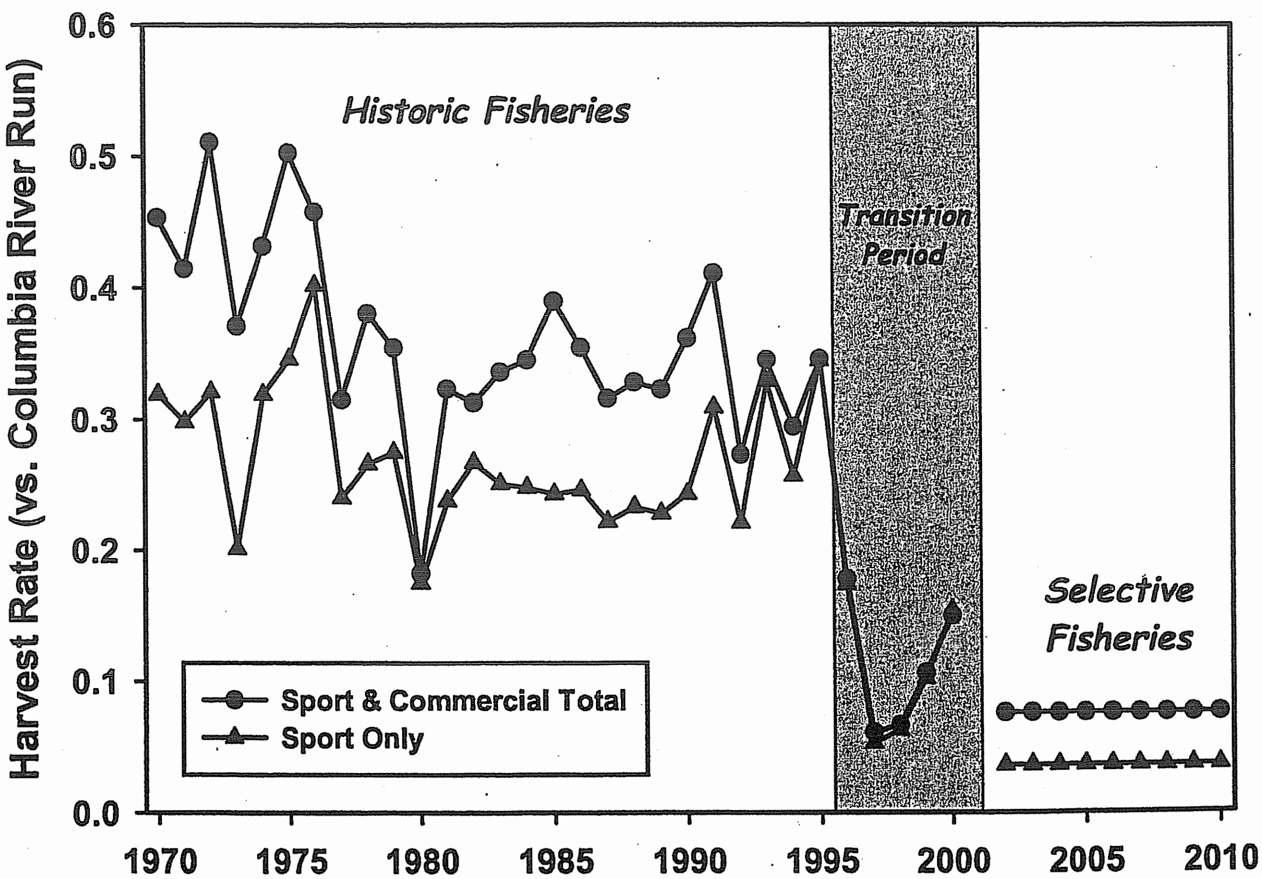


Figure 7. Historic and expected freshwater fishery impact rates on wild Willamette spring chinook in lower Willamette and Columbia River mainstem fisheries.

2.1.4) Description of additional fishery impacts not addressed within this FMEP for the listed ESUs specified in section 1.3. Account for harvest impacts in previous year and the impacts expected in the future.

Unlike most other stocks of Columbia basin spring chinook, Willamette spring chinook are subject to significant catches in ocean fisheries. Ocean distribution is consistent with an ocean-type life history with the majority of the catch occurring off the coasts of British Columbia and southeast Alaska (NMFS 2000b). UWR spring chinook are a far north migrating stock which are caught primarily in southeast Alaska (SEAK) and north central British Columbia (NCBC) fisheries (NMFS 2000c, PSC 1999). Because they are an early returning stock, they tend to be missed by more southerly ocean fisheries off the west coast of Vancouver Island and the Washington coast. The ocean fishery impact rate on Willamette spring chinook averaged 22% for 1975-1983 brood years, 14% for 1984-1989 brood years, and 9% for 1990-1993 brood years. These impact rates include all sources of fishery mortality from retention, hook and release, and drop off. Future rates in the abundance-based management strategy included in the recently completed amendments to the Pacific Salmon Treaty are expected to increase from the recent average but to be less than the higher rates of the 1970's and 1980's.

SECTION 3. MONITORING AND EVALUATION

3.1) Description of the specific monitoring of the "Performance Indicators" listed in section 1.1.3.

Performance indicators for Willamette spring chinook include fish population indicators and fishery indicators. Independent estimates or indices of numbers are available annually for each wild population. Primary fish population indicators for wild Willamette spring chinook are spawning escapement estimates from Leaburg Dam counts on the McKenzie River, North Fork Dam counts on the Clackamas River, and spawning area redd counts in the Santiam River. Secondary fish population indicators include Willamette Falls counts and juvenile passage indices.

Leaburg Dam and fish passage facilities on the McKenzie River (Appendix B Figure 3) are operated by the Eugene Water and Electric Board. Salmon and steelhead ascending the fish ladder are counted at a window with a video recording system. Fish are also trapped in the ladder beginning in June to remove adipose fin-clipped fish for the McKenzie Hatchery. Unclipped fish are passed into natural production areas upstream from the dam. Institution of 100% marking of hatchery spring chinook will allow all hatchery chinook to be removed when these adipose fin-clipped fish are fully recruited. The ODFW also counts redds and samples carcasses in the McKenzie River downstream of Leaburg Dam to estimate spawner numbers and hatchery:wild fractions. The 5 mile river section downstream from Leaburg Dam is surveyed by boat several times during September and October and the entire 39 miles to the mouth of the McKenzie is surveyed once by helicopter in October. A carcass recovery program is also being initiated in the upper McKenzie River to estimate age composition and brood year of origin so that recruitment rates and wild stock productivity can be estimated. Carcass recoveries rather than Leaburg trap samples are used to minimize handling at the trap.

North Fork Dam and passage facilities on the Clackamas River (Appendix B Figure 1) are operated by Portland General Electric (PGE). Adult counts are made at a mechanical counter at River Mill Dam, at the North Fork Ladder fish trap, and at a camera-equipped automatic counter in the North Fork Ladder above the trap (Boettcher and Cramer 1997). Escapement to North Fork Dam is the total of fish trap and ladder counts. Salmon and steelhead enter the fish ladder downstream from Faraday Diversion Dam and exit upstream from North Fork Dam unless diverted into the trap. Until recently, the trap was only operated from June through early October when spring chinook were present or under special circumstances. Since 1995, the ladder has been blocked and all fish trapped from December through April to keep hatchery fish from entering the upper river. Hatchery steelhead and adipose fin-clipped spring chinook are removed and unclipped spring chinook and wild steelhead are trucked upstream and released. Institution of 100% marking of hatchery spring chinook will allow all hatchery chinook to be removed when these adipose fin-clipped fish are fully recruited. PGE biologists also count redds between River Mill and Faraday projects to estimate numbers of spawners which do not pass North Fork Dam.

North Santiam River spawning escapement indices are based on redd counts in key production areas (Appendix B Figure 2) because no counting facility exists downstream from the spawning area. Spawning survey index areas and dates in the North Fork mainstem from Stayton to Minto and the Little North Fork were selected based on an extensive survey of potential spawning areas and timing in 1996-1998. The redd index is based on peak counts, hence represents a minimum estimate of the total redds in the system.

An adult spring chinook counting program has also been initiated in the Santiam River near Stayton at fishway traps at lower Bennett Dam, upper Bennett Dam, and the associated power canal. Traps have been operated from April through September in 1994 and 1997-present. Clipped and unclipped adults are counted and natural production has been inferred from the relative mark rates at the trap and in the hatchery. This trapping will provide a more accurate index of natural production in the system when all returning hatchery adults are adipose fin-clipped.

Spring chinook counts at Willamette Falls provide valuable information on combined hatchery and wild escapement into the upper basin which in conjunction with estimates of wild escapement and hatchery rack returns yields estimates of adult conversion rate. The fish ladder and counting facility at Willamette Falls is operated by the ODFW. Spring chinook counts have been made each year since 1946. Salmon and steelhead are now counted 24 hours per day, 365 days per year (Foster 1998). Counts are made with a video recording system and are read daily (except weekends) during the spring chinook migration. Counts thus provide real time information on fish numbers which allows managers to make inseason fishery adjustments in some years where actual returns are more or less than initially projected.

Downstream migrant counts at Clackamas Dam collection facilities provide indices of wild juvenile numbers and when compared with spawner numbers of stock productivity. Counts of juveniles are made at the North Fork Fish Ladder by PGE. Attraction water at the North Fork Dam forebay guides juvenile downstream migrants into the ladder (Boettcher and Cramer 1997). Fish descending the ladder are screened into a downstream migrant pipeline where they can be diverted into a holding tank for sampling or bypassed through a pipe which carries them 6 miles downstream to the Clackamas River at the River Mill Dam tailrace. Sample rates vary with time of year with daily counts being made during peak migration months of April, May, and June. Counts are made 5 days per week in March and November, and 2 to 5 times per week during the rest of the year. Total numbers of fish diverted by species are estimated based on the sample rate. These counts include only the portion of migrants that are diverted into the collection system and do not include fish which pass through dam turbines and the spillway. North Fork juvenile counts are thus minimum estimates of juvenile migrant numbers but are considered an index of total numbers where collection efficiency varies about an average value. Juvenile migrants are also counted at a separate bypass system at River Mill Dam.

Fishery performance indicators provide information on total run size, catch, and catch composition. This information is used inseason for adjusting fisheries consistent with prescribed impact levels. Annual monitoring and reporting on the spring chinook recreational fishery began in 1946 below Willamette Falls and in 1979 in the lower Clackamas River. Stratified, random, roving creel surveys are conducted in the lower Willamette and Clackamas rivers from March until July. This survey includes fisheries for spring chinook, steelhead, sturgeon, and shad. The methodology for estimating total effort and catch was standardized in 1974 with a sampling plan developed by the Survey Research Center of Oregon State University. Total effort determined by periodic aerial surveys is combined with systematic angler interview data at major fishing sites to develop statistical estimates of recreational angler pressure and success.

The angler survey is stratified by four areas: 1) a 6 mile upper section from Willamette Falls to the railroad bridge at Lake Oswego, 2) a 16 mile middle section from the railroad bridge to the St. Johns Bridge, 3) a lower section which includes 4 miles of the Willamette River from St. Johns Bridge to the mouth and 22 miles of Multnomah Channel to its mouth at St. Helens, and 4) the lower 23 miles of the Clackamas River from the mouth to River Mill Dam. Aerial counts of boats conducted on weekends and weekdays are expanded to total effort estimates based on daily pressure curves developed from more frequent counts from viewpoints on the ground. Boat and bank anglers are contacted at moorages, boat ramps, and bank fishing areas in each of the sections and interviewed for trip length and numbers of fish caught and released. The catch is inspected and individual fish data on size and marks are collected. Scale samples are collected for aging and snouts are taken from fish with coded-wire tags. Snouts are also voluntarily returned by some anglers. The interview sample rate typically averages 20% or more of all anglers. More detailed descriptions of fishery survey methods and results can be found in annual reports such as Foster (1998).

Fisheries in the Willamette River mainstem from the falls to the McKenzie River are monitored with periodic spot checks and interviews of anglers. Spot checks involve index counts of anglers in key fishing areas and boat trailers at launch sites. Spot checks also involve interviews of anglers at launch sites and voluntary reports. Total effort and catch is not monitored inseason because this fishery is much smaller than in the lower Willamette River. Total catch and effort are estimated to be less than 10% of the downstream fishery. Total annual catch estimates are available from returns of angler catch record cards which are issued with the fishing license. Anglers are required to immediately record every salmon retained, catch record cards are returned at the end of the year, and total catches in each area are tabulated. Catch record cards are typically returned at about a 25% rate and this subsample is expanded for the total number of licenses issued with corrections for differential return rates by anglers which did and did not catch fish. Catch record cards provide a useful index of total annual catches and generally appear to overestimate total catch relative to statistical angler survey estimates.

Historic data on spring chinook salmon fisheries in the Santiam and McKenzie rivers is available from catch record cards, spot checks, and some statistical creel surveys. Statistical creel surveys are planned for implementation in the North Santiam and McKenzie rivers as fisheries are reopened to adipose fin-clipped spring chinook when the majority of the hatchery return can be distinguished with adipose fin clips.

Fishery catch data when combined with fish ladder counts provides estimates of the aggregate Willamette spring chinook run into the Columbia River, Willamette River, Clackamas River, and upper Willamette Basin. These run size estimates and estimated harvest are the basis of fishery harvest rate estimates. Fishery surveys in the lower Willamette (and Columbia Rivers) are structured to provide real-time data for use in quota tracking and inseason fishery adjustments. For instance, angler interview data is immediately recorded in the field on hand-held data loggers from which data can be downloaded daily to provide catch summaries. This real-time analysis allows fishery managers to respond immediately to variation in fishing effort and catch rate or run size developments. Fishery catches can typically be regulated within several hundred fish of catch limits and fishery impacts on hatchery and wild fish can typically be regulated within less than 1% of the desired level.

Commercial fishery landings are estimated inseason by contacting wholesale buyers regarding their purchases. The number of active buyers is small and all are contacted for daily accounting of the catch. Landings are verified post-season from fish landing tickets. All fish buyers are required to complete and return fish receiving tickets for all purchases as a condition of their license. The commercial catch is subsampled inseason at fish buying sites to gather biological data including CWT recoveries and Visual Stock Identification (VSI) to distinguish Willamette and upriver spring chinook stocks. Mainstem commercial fisheries for salmon and sturgeon are sampled at a minimum 20% rate although greater sample rates are typical for recent small fisheries. A minimum of 50% of the catch is sampled in the Youngs Bay select area fishery. Nearly the entire catch in Tongue Point and Blind Slough select areas is sampled.

3.2) Description of other monitoring and evaluation not included in the Performance Indicators (section 3.1) which provides additional information useful for fisheries management.

In addition to routine monitoring and evaluation activities described in above, the ODFW also collects or uses information from a variety of sources related to the status of listed UWR spring chinook and the implementation of fisheries which might affect them. Since 1996, the ODFW has conducted a research study aimed at key population and fishery issues for Willamette Basin spring chinook. This study has made detailed investigations of the distribution and abundance of natural spawners and the mortality associated with a catch and release fishery (Lindsay et al. 1997, 1998; Schroeder et al. 1999).

Additional information on fishery impacts in combined ocean and freshwater selective fisheries will also be available based on double index tagging studies of hatchery spring chinook. Double index tagging compares the return rate of marked groups of fish from which the adipose fin has and has not been removed. The difference results from selective fishery impacts in ocean and freshwater fisheries which are restricted to adipose-fin clipped fish retention only. Analyses of coded-wire tag recoveries will also provide information on fishery contributions and exploitation rates for Willamette spring chinook. A recently completed study of coded-wire tag recovery rates will help reduce biases in fishery expansion factors (Zhou and Zimmerman 2000).

Finally, extensive monitoring and evaluation is conducted for Willamette spring chinook hatcheries. This program inventories production and returns, tracks straying, monitors fish health, and relates return rates to hatchery practices.

3.3) Public Outreach

The popularity of the Willamette spring chinook sport fisheries and the high visibility afforded by their proximity to metropolitan areas in the Willamette Valley result in intense public interest and participation in the annual management processes for these species. The ODFW conducts extensive public involvement and outreach activities related to spring chinook salmon fishery management and recovery. The annual fishery regulation process involving a series of public meetings, information mailouts, press releases, and public hearings was described in detail in section 1.5. Anglers are keenly aware of and accustomed to abrupt inseason management changes including closures and reopenings with short notice. Permanent regulations are detailed in published pamphlets of fishing regulations. Annual regulation and inseason changes are widely publicized with press releases, phone calls or faxes of action notices to key constituents, and signs posted at fishery access points. The ODFW also operates an information line, a tape-recorded hotline, and an Internet web page where timely information is available.

In addition to fishery-related outreach efforts, the state of Oregon including the ODFW is conducting a broad-based watershed recovery effort called the Willamette Restoration Initiative (WRI). The WRI is a new effort seeking to promote, integrate, and coordinate efforts to protect and restore the health of the watershed. Designed as a public/private partnership, the Initiative works closely with state and federal agencies, while bringing a new focus to exploring the restoration interests and capabilities of businesses, landowners, non-profit organizations, local governments, and watershed councils in the basin. One of the first tasks of the Initiative has been to help guide the development of the "Willamette chapter" of the Oregon Plan for Salmon and Watersheds.

3.4) Enforcement

Sport fishing regulations in Oregon are enforced by the Fish and Wildlife Division of the Oregon State Police working in close partnership with the Oregon Department of Fish and Wildlife. The OSP and ODFW work together to develop enforceable regulations to achieve fish and wildlife resource management goals. The Fish and Wildlife Enforcement Division of the OSP currently includes 128 Supervisors and Troopers including 105 assigned to general fish, wildlife, and natural resources law enforcement, and 13 Troopers assigned specifically to protection of anadromous fish and their habitat under the "Oregon Plan for Salmon and Watersheds." Another 6 Troopers are assigned to commercial fish enforcement. Permanent staff are also supplemented with cadets. Enforcement activities in the Willamette Basin are conducted from offices in Portland, McMinnville, Salem, Albany, and Springfield.

ODFW and OSP work together to facilitate enforcement of resource management goals through an annual cooperative enforcement planning process where local Troopers meet yearly with local biologists to set enforcement priorities by species. Troopers then develop tactical plans to address priority issues and gain desired compliance levels to protect resources and meet management goals. The results of each tactical plan are quantified and compared to the compliance level considered necessary to meet management goals. Compliance is typically estimated based on the percentage of angler contacts where no violations are noted. Tactical plans are adjusted if necessary based on compliance assessments to make the best use of limited resources in manpower and equipment to achieve the goals.

Willamette spring chinook fisheries are assigned a high priority for enforcement and are intensively monitored. Officers are assigned to work all open fishing days during restrictive seasons with additional checks during closed periods. Officers conduct bank and boat patrols to check and assist anglers. Covert surveillance is also made in locations where complaints on violators have been received. In addition to regular patrols, sport fishing industry groups funded 2 additional senior troopers for the 1 month period of the 2000 selective fishery to help ensure the success of that trial fishery. Troopers worked an average of 360 person hours per year for 1998-2000, contacted an average of 1,100 anglers per year, and observed salmon regulation compliance rates of 97% or 98% in every year. During 2000, citations associated with noncompliance were 53% for no angling license, 14% for fishing with two lines, 10% for salmon angling closed season, 8% for failure to validate salmon/steelhead tag, 3% each for unlawful take of salmon and steelhead, and 8% for other wildlife and marine violations. Compliance with catch and release requirements for unclipped fish during the trial 2000 selective fishery was 100%.

Regular OSP patrols are supplemented with a volunteer program which was initiated in 1997 in response to very restrictive regulations adopted for wild fish protection. The action plan incorporates volunteers to assist wildlife officers in the detection and apprehension of violators, assist the public with the restrictive regulations, and promote voluntary compliance. Volunteer teams of 2 persons are assigned to work all open fishing days during restrictive seasons and are in radio contact of officers. Volunteers wear uniforms when working boat ramps or other areas where they have direct contact with the public and provide added coverage during early morning and late afternoon shifts. Volunteers worked an average of 500 person hours per year for 1998-2000, contacted an average of 2,100 anglers per year, and observed salmon compliance rates of 96% to 99%.

An action plan is also typically implemented for lower Columbia River commercial and sport fisheries. Commercial seasons are monitored by boat patrol and inspection of the landed catch at fish wholesalers. Boat and bank patrols are made during open and closed sport seasons. In 2000 for instance, patrols totaled 323 person hours, checked

358 anglers (primarily fishing for species other than salmon since because seasons were brief), and cited 2 people for angling closed season.

3.5) Schedule and process for reviewing and modifying fisheries management.

3.5.1) Description of the process and schedule that will be used on a regular basis (e.g. annually) to evaluate the fisheries, and revise management assumptions and targets if necessary.

The annual spring chinook fishery review process described in detail in Section 1.5 will continue to be employed to evaluate fisheries and revise management assumptions and targets as needed. It is anticipated that the annual fishery review process will be most rigorous in 2001 and will become more routine beginning in 2002 when selective fisheries are fully implemented and fishery impacts on wild UWR spring chinook are reduced to low incidental levels. To ensure that fish population and fishery management is meeting the goals described in this plan, annual monitoring will include wild fish escapement numbers and/or indices, cohort replacement rates, projected future wild and hatchery numbers based on age composition of recent returns, fishery harvest of hatchery fish and handle of wild fish, fishery effort, fishery catch per unit effort, mark rates in the fishery and escapement areas, and projected fishery impacts on wild fish.

One key question will be whether catch and release mortality rates are as expected. Actual impacts when selective fisheries are implemented will be compared with expected impacts to ensure that fishery management is meeting wild fish protection objectives. Estimates of actual catch and release impacts will be based on observed fish handle rates and will be verified using double index tagging results from hatchery fish. If average annual impact rates exceed the 15% average impact standard, additional fishery restrictions will be implemented to reduce impacts to prescribed levels. Additional fishery restrictions will likely first be implemented in wild fish tributaries where maximum wild fish protection is afforded relative to numbers of hatchery fish accessed. Additional restrictions in mainstem Willamette and mainstem Columbia river fisheries will be added as needed to meet wild fish protection goals. Fishery restrictions may involve a combination of time and area closures, reduced bag limits, and quotas as necessary.

A second key question is whether wild populations are above or below critical abundance and productivity thresholds. In years where McKenzie and Clackamas river thresholds are not achieved, additional fishery limitations will be implemented to reduce fishery impacts on these wild populations. The Santiam population is not subjected to this standard because habitat limitations preclude meeting thresholds even in the absence of fishing. Tributary fisheries in affected tributaries will be closed in years where thresholds are not reached. Closures of the Clackamas and McKenzie river tributary fisheries are projected to reduce fishing impacts by 30% and 10%, respectively. Additional restrictions in mainstem Willamette and mainstem Columbia river fisheries will be implemented based on the specifics of the problem, the effects of tributary closures, and the benefits of additional closures. Mainstem fishery impacts will be reduced when either the McKenzie or Clackamas wild populations fall below critical thresholds and lesser restrictions are not sufficient to exceed thresholds. Mainstem fishery restrictions may involve a combination of time and area closures, reduced bag limits, and quotas as necessary.

3.5.2) Description of the process and schedule that will occur to evaluate whether the FMEP is accomplishing the stated objectives. The conditions under which revisions to the FMEP will be made and how the revisions will likely be accomplished should be included.

This FMEP is intended to remain in effect indefinitely. Wild population status and fishery performance will continue to be assessed by the Oregon Department of Fish and Wildlife on an annual basis. The Oregon Department of Fish and Wildlife will conduct a comprehensive review of this plan in 2004 (after 3 years of selective fishery implementation) to evaluate whether fisheries and wild populations are performing as expected. Comprehensive reviews will be repeated by the Oregon Department of Fish and Wildlife at 5-year intervals thereafter until such time as the wild stocks are recovered and delisted. Consultations between the Oregon Department of Fish and Wildlife and the National Marine Fisheries Service regarding management of fisheries impacting listed UWR spring chinook will be reinitiated only if significant changes in the status or designation of UWR spring chinook, projected benefits of selective sport fishery implementation, habitat conditions, management processes, or other unforeseen developments necessitate revision.

SECTION 4. CONSISTENCY OF FMEP WITH PLANS AND CONDITIONS SET WITHIN ANY FEDERAL COURT PROCEEDINGS

Actions and objectives contained in this proposed FMEP related to upper Willamette spring chinook do not directly impact Federal tribal trust resources. Tribal trust resources do not exist for Willamette spring chinook salmon in the Willamette Basin. There are no existing court orders with continuing jurisdiction over tribal harvest allocations that are relevant to the implementation of the proposed FMEP with respect to UWR spring chinook.

REFERENCES

Foster, C. A. 1998. 1997 Willamette spring chinook salmon run, fisheries, and passage at Willamette Falls. Oregon Department of Fish and Wildlife Report. Clackamas, Oregon.

Boettcher, J., and D. Cramer. 1997. Fish counting procedures for North Fork complex and Bull Run. Pages 143 to 149 in Fisheries Partnerships in Action, Clackamas River Subbasin, Oregon. 1996 Accomplishments Report for the Clackamas River Fisheries Work Group. Portland, Oregon.

Cramer, S. P., C. F. Willis, D. Cramer, M. Smith, T. Downey, and R. Montagne. 1996. Status of Willamette River spring chinook salmon in regards to the Federal Endangered Species Act, Part 2. Report by S. P. Cramer and Associates to the National Marine Fisheries Service on behalf of Portland General Electric Company and Eugene Water and Electric Board. Gresham, Oregon.

Lindsay, R. B., K. R. Kenaston, R. K. Schroeder, J. T. Grimes, M. G. Wade, K. Homolka, and L. Borgerson. 1997. Spring chinook salmon in the Willamette and Sandy Rivers. Fish

Research Project Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

Lindsay, R. B., R. K. Schroeder, and K. R. Kenaston. 1998. Spring chinook salmon in the Willamette and Sandy Rivers. Fish Research Project Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42. Seattle, Washington.

NMFS (National Marine Fisheries Service). 2000a. Biological opinion on impacts from the collection, rearing, and release of salmonids associated with artificial propagation programs in the upper Willamette spring chinook and winter steelhead evolutionarily significant units. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2000b. Biological opinion on impacts of Treaty Indian and non-Indian year 2000 winter, spring, and summer season fisheries in the Columbia River basin, on salmon and steelhead listed under the Endangered Species Act. Seattle, Washington.

NMFS (National Marine Fisheries Service). 2000c. Draft biological opinion on impacts of Pacific Salmon Treaty fisheries on salmon and steelhead listed under the Endangered Species Act. Seattle, Washington.

ODFW (Oregon Department of Fish and Wildlife). 1998. Spring chinook chapters. Willamette Basin Fish Management Plan. Portland, Oregon.

ODFW and WDFW (Oregon Department of Fish and Wildlife and Washington Department of Fish and Wildlife). 1998. Status report on Columbia River fish runs and fisheries, 1938-1997. Clackamas, Oregon, and Vancouver, Washington.

PSC (Pacific Salmon Commission). 1999. Joint chinook technical committee 1995 and 1996 annual report TCCINOOK(99)-2. Vancouver, B. C.

Schroeder, R. K., K. R. Kenaston, and R. B. Lindsay. 1999. Spring chinook salmon in the Willamette and Sandy Rivers. Fish Research Project Annual Progress Report. Oregon Department of Fish and Wildlife. Portland, Oregon.

Willis, C. F., S. P. Cramer, D. Cramer, M. Smith, T. Downey, and R. Montagne. 1996. Status of Willamette River spring chinook salmon in regards to the Federal Endangered Species Act, Part 1. Report by S. P. Cramer and Associates to the National Marine Fisheries Service on behalf of Portland General Electric Company and Eugene Water and Electric Board. Gresham, Oregon.

Zhou, S., and M. Zimmerman. 2000. Estimation of Willamette River CWT spring chinook in freshwater harvest and escapement. Oregon Department of Fish and Wildlife Information Report 2000-01. Portland, Oregon.

Appendix A

Past Spring Chinook Fishery Impacts

Appendix Table A-1. Estimated run sizes and catches of Willamette spring chinook salmon, 1970-2000.

Run	Estimated run sizes					Catch										
	Columbia	Willam	Willam	Clack	McKenzie	Select	LCR	LCR	LWR	LWR	Clack		UWR		Lower
year	River	River	Falls	River	River	Comm	Comm	Sport	Sport	Indian	Sport	Total	mains.	Santiam	McKenzie
1970	65,500	53,500	34,200	1,600	4,787	0	8,800	3,200	17,700	0	100	29,800		1,582	
1971	80,911	67,411	44,569	2,200	6,323	0	9,400	4,100	20,042	0	200	33,742		1,320	
1972	58,362	47,062	26,154	2,200	3,770	0	11,100	200	18,508	0	200	30,008		597	
1973	70,685	54,485	41,960	2,200	7,938	0	12,000	4,200	10,025	0	200	26,425		698	
1974	82,430	71,830	44,530	2,200	7,840	0	9,300	1,300	25,000	0	200	35,800		698	
1975	40,775	32,775	19,079	1,100	3,392	0	6,400	1,600	12,496	0	100	20,596		489	
1976	45,109	40,809	22,154	2,200	4,275	0	2,500	1,800	16,355	0	200	20,855		181	
1977	64,399	58,099	40,012	4,000	9,127	0	4,800	1,500	13,987	0	1,000	21,287		1,720	
1978	83,300	71,400	47,512	4,000	8,142	0	9,500	2,400	19,788	0	1,000	32,688	671	877	
1979	49,198	44,598	26,623	5,026	3,018	0	3,900	700	12,849	0	1,226	18,675	237	387	
1980	43,333	42,433	26,973	8,465	4,154	0	300	600	6,995	0	3,165	11,060	484	853	
1981	56,271	48,571	30,057	8,034	3,624	0	4,800	2,900	10,480	0	2,334	20,514	428	1,090	
1982	77,964	72,464	46,195	7,263	5,413	0	3,600	1,900	18,905	0	2,463	26,868	508	1,520	
1983	62,249	55,149	30,589	10,432	3,377	0	5,300	1,800	13,828	0	4,532	25,460	370	724	206
1984	84,240	74,540	43,452	11,288	4,739	0	8,200	1,500	19,400	0	4,300	33,400	532	1,033	567
1985	68,090	57,090	34,533	6,617	4,930	0	10,000	1,000	15,540	0	2,478	29,018	224	1,635	459
1986	73,552	62,452	39,155	7,897	5,567	0	8,000	3,100	15,000	0	3,900	30,000	289	1,625	354
1987	93,593	82,893	54,832	8,689	7,370	0	8,800	1,900	18,872	0	3,186	32,758	524	3,512	1,339
1988	118,112	103,951	70,451	8,687	12,637	0	11,261	2,900	24,613	0	2,720	41,494	952	3,937	1,133
1989	114,929	102,025	69,180	8,440	10,025	0	10,904	2,000	24,205	0	2,900	40,009	1,012	3,478	1,730
1990	130,588	106,354	71,273	11,470	12,854	0	15,504	8,730	23,011	0	4,710	51,955	1,253	4,345	1,387
1991	109,929	95,272	52,516	11,857	11,553	0	11,183	3,474	30,499	0	3,834	48,990	1,036	3,634	1,922
1992	75,007	68,045	42,004	11,534	8,976	0	3,866	3,096	13,508	0	2,697	23,167	639	4,363	1,195
1993	65,934	63,923	31,966	10,814	8,160	220	833	958	20,743	0	2,963	25,717	627	4,226	1,761
1994	49,580	47,209	26,102	7,490	2,992	56	1,044	1,271	11,458	759	1,541	16,129	287	2,190	439
1995	42,564	42,550	20,592	6,647	3,162	14	0	0	14,681	29	1,708	16,432	541	1,885	75
1996	34,756	34,632	21,605	5,918	3,640	33	91	0	6,056	12	1,869	8,061	1,484	1,899	244
1997	35,302	35,030	26,885	5,819	3,105	189	83	0	1,886	0	1,732	3,890	464	2,175	0
1998	45,139	44,963	34,461	7,367	3,992	117	12	47	2,818	0	1,302	4,296	819	2,762	0
1999	54,202	53,942	40,410	7,444	4,557	247	13	0	5,507	0	1,890	7,657			0
2000[1]	58,000	57,456	37,594	7,400			339	205	8,701	0	1,179				0

[1] *Preliminary*

Appendix Table A-2. Estimated harvest rates of Willamette spring chinook salmon, 1970-2000.

	Harvest rates (v Columbia River run)							Harvest rate subtotals				Harvest rates (v run to area)				
Run year	Select Comm	LCR Comm	LCR Sport	LWR Sport	LWR Indian	Clack Sport	Total	LCR total (v Col)	LWR total (v Col)	LCR & LWR sport (v Col)	LCR & LWR total (v Col)	LWR sport (v Will)	Clack total (v Clack)	U. Wll mains. (v Falls)	Santiam (v Falls)	Lower McKenzie (v McK)
1970	0.0%	13.4%	4.9%	27.0%	0.0%	0.2%	45.5%	18.3%	27.0%	31.9%	45.3%	33.1%	6.3%		4.6%	
1971	0.0%	11.6%	5.1%	24.8%	0.0%	0.2%	41.7%	16.7%	24.8%	29.8%	41.5%	29.7%	9.1%		3.0%	
1972	0.0%	19.0%	0.3%	31.7%	0.0%	0.3%	51.4%	19.4%	31.7%	32.1%	51.1%	39.3%	9.1%		2.3%	
1973	0.0%	17.0%	5.9%	14.2%	0.0%	0.3%	37.4%	22.9%	14.2%	20.1%	37.1%	18.4%	9.1%		1.7%	
1974	0.0%	11.3%	1.6%	30.3%	0.0%	0.2%	43.4%	12.9%	30.3%	31.9%	43.2%	34.8%	9.1%		1.6%	
1975	0.0%	15.7%	3.9%	30.6%	0.0%	0.2%	50.5%	19.6%	30.6%	34.6%	50.3%	38.1%	9.1%		2.6%	
1976	0.0%	5.5%	4.0%	36.3%	0.0%	0.4%	46.2%	9.5%	36.3%	40.2%	45.8%	40.1%	9.1%		0.8%	
1977	0.0%	7.5%	2.3%	21.7%	0.0%	1.6%	33.1%	9.8%	21.7%	24.0%	31.5%	24.1%	25.0%		4.3%	
1978	0.0%	11.4%	2.9%	23.8%	0.0%	1.2%	39.2%	14.3%	23.8%	26.6%	38.0%	27.7%	25.0%	1.4%	1.8%	
1979	0.0%	7.9%	1.4%	26.1%	0.0%	2.5%	38.0%	9.3%	26.1%	27.5%	35.5%	28.8%	24.4%	0.9%	1.5%	
1980	0.0%	0.7%	1.4%	16.1%	0.0%	7.3%	25.5%	2.1%	16.1%	17.5%	18.2%	16.5%	37.4%	1.8%	3.2%	
1981	0.0%	8.5%	5.2%	18.6%	0.0%	4.1%	36.5%	13.7%	18.6%	23.8%	32.3%	21.6%	29.1%	1.4%	3.6%	
1982	0.0%	4.6%	2.4%	24.2%	0.0%	3.2%	34.5%	7.1%	24.2%	26.7%	31.3%	26.1%	33.9%	1.1%	3.3%	
1983	0.0%	8.5%	2.9%	22.2%	0.0%	7.3%	40.9%	11.4%	22.2%	25.1%	33.6%	25.1%	43.4%	1.2%	2.4%	6.1%
1984	0.0%	9.7%	1.8%	23.0%	0.0%	5.1%	39.6%	11.5%	23.0%	24.8%	34.5%	26.0%	38.1%	1.2%	2.4%	12.0%
1985	0.0%	14.7%	1.5%	22.8%	0.0%	3.6%	42.6%	16.2%	22.8%	24.3%	39.0%	27.2%	37.4%	0.6%	4.7%	9.3%
1986	0.0%	10.9%	4.2%	20.4%	0.0%	5.3%	40.8%	15.1%	20.4%	24.6%	35.5%	24.0%	49.4%	0.7%	4.2%	6.4%
1987	0.0%	9.4%	2.0%	20.2%	0.0%	3.4%	35.0%	11.4%	20.2%	22.2%	31.6%	22.8%	36.7%	1.0%	6.4%	18.2%
1988	0.0%	9.5%	2.5%	20.8%	0.0%	2.3%	35.1%	12.0%	20.8%	23.3%	32.8%	23.7%	31.3%	1.4%	5.6%	9.0%
1989	0.0%	9.5%	1.7%	21.1%	0.0%	2.5%	34.8%	11.2%	21.1%	22.8%	32.3%	23.7%	34.4%	1.5%	5.0%	17.3%
1990	0.0%	11.9%	6.7%	17.6%	0.0%	3.6%	39.8%	18.6%	17.6%	24.3%	36.2%	21.6%	41.1%	1.8%	6.1%	10.8%
1991	0.0%	10.2%	3.2%	27.7%	0.0%	3.5%	44.6%	13.3%	27.7%	30.9%	41.1%	32.0%	32.3%	2.0%	6.9%	16.6%
1992	0.0%	5.2%	4.1%	18.0%	0.0%	3.6%	30.9%	9.3%	18.0%	22.1%	27.3%	19.9%	23.4%	1.5%	10.4%	13.3%
1993	0.3%	1.3%	1.5%	31.5%	0.0%	4.5%	39.0%	3.1%	31.5%	32.9%	34.5%	32.4%	27.4%	2.0%	13.2%	21.6%
1994	0.1%	2.1%	2.6%	23.1%	1.5%	3.1%	32.5%	4.8%	24.6%	25.7%	29.4%	24.3%	20.6%	1.1%	8.4%	14.7%
1995	0.0%	0.0%	0.0%	34.5%	0.1%	4.0%	38.6%	0.0%	34.6%	34.5%	34.6%	34.5%	25.7%	2.6%	9.2%	2.4%
1996	0.1%	0.3%	0.0%	17.4%	0.0%	5.4%	23.2%	0.4%	17.5%	17.4%	17.8%	17.5%	31.6%	6.9%	8.8%	6.7%
1997	0.5%	0.2%	0.0%	5.3%	0.0%	4.9%	11.0%	0.8%	5.3%	5.3%	6.1%	5.4%	29.8%	1.7%	8.1%	0.0%
1998	0.3%	0.0%	0.1%	6.2%	0.0%	2.9%	9.5%	0.4%	6.2%	6.3%	6.6%	6.3%	17.7%	2.4%	8.0%	0.0%
1999	0.5%	0.0%	0.0%	10.2%	0.0%	3.5%	14.1%	0.5%	10.2%	10.2%	10.6%	10.2%	25.4%			0.0%
2000[1]		0.6%	0.4%	15.0%	0.0%			0.9%	15.0%		15.9%	15.1%[2]	16.0%			0.0%

[1] Preliminary

[2] Wild fish impacts are less because of selective fishery implemented in 2000.

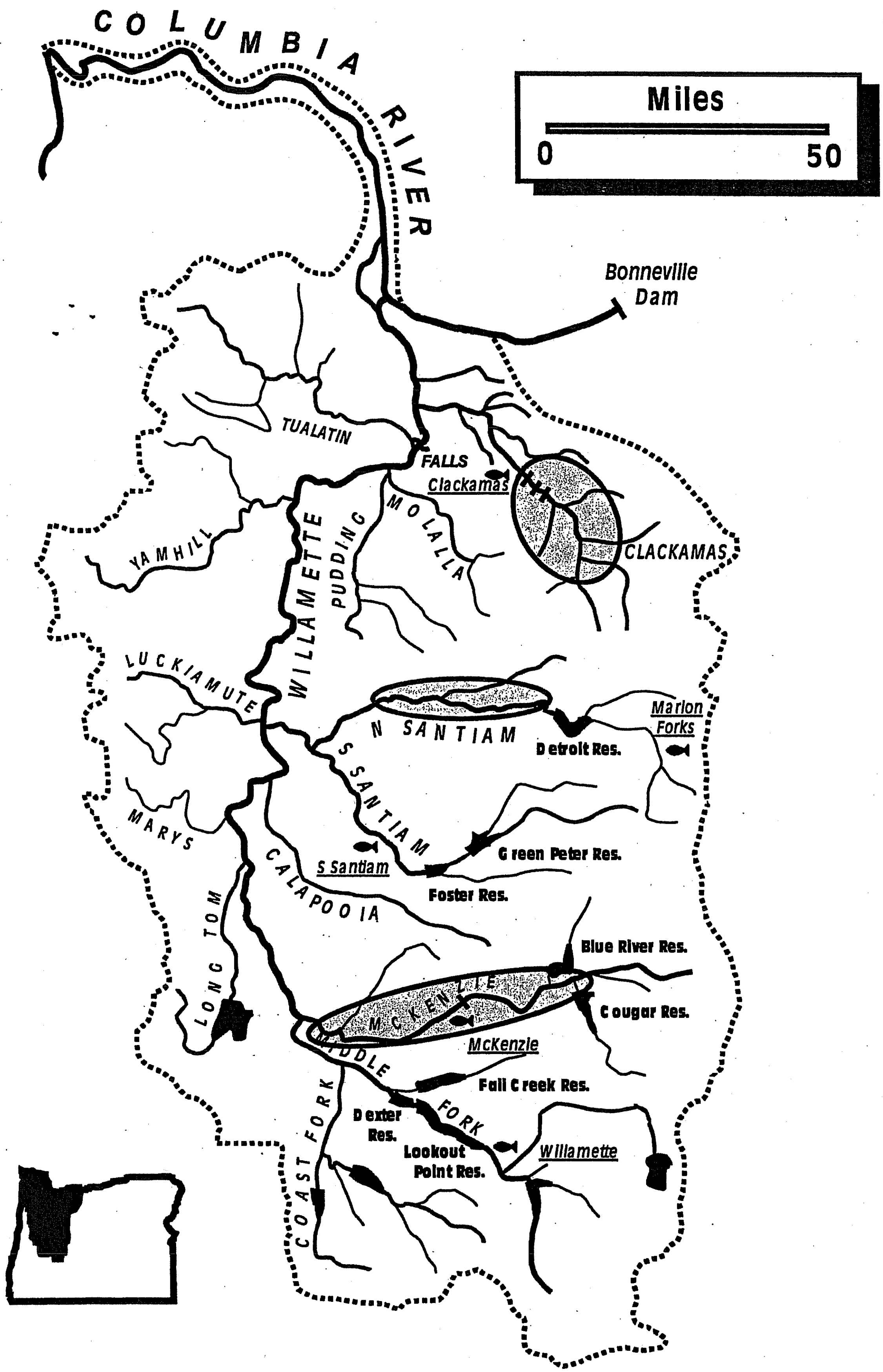
Appendix B

Status of Willamette River Natural Spring Chinook Populations

Steven D. King
Craig Foster
Steve Mamoyac
Mark Wade

Oregon Department of Fish and Wildlife
2501 Southwest First Avenue
Portland, Oregon 97201

February 2000



Natural Spawning Populations of Willamette River Spring Chinook Salmon

Clackamas River Basin

Available Habitat

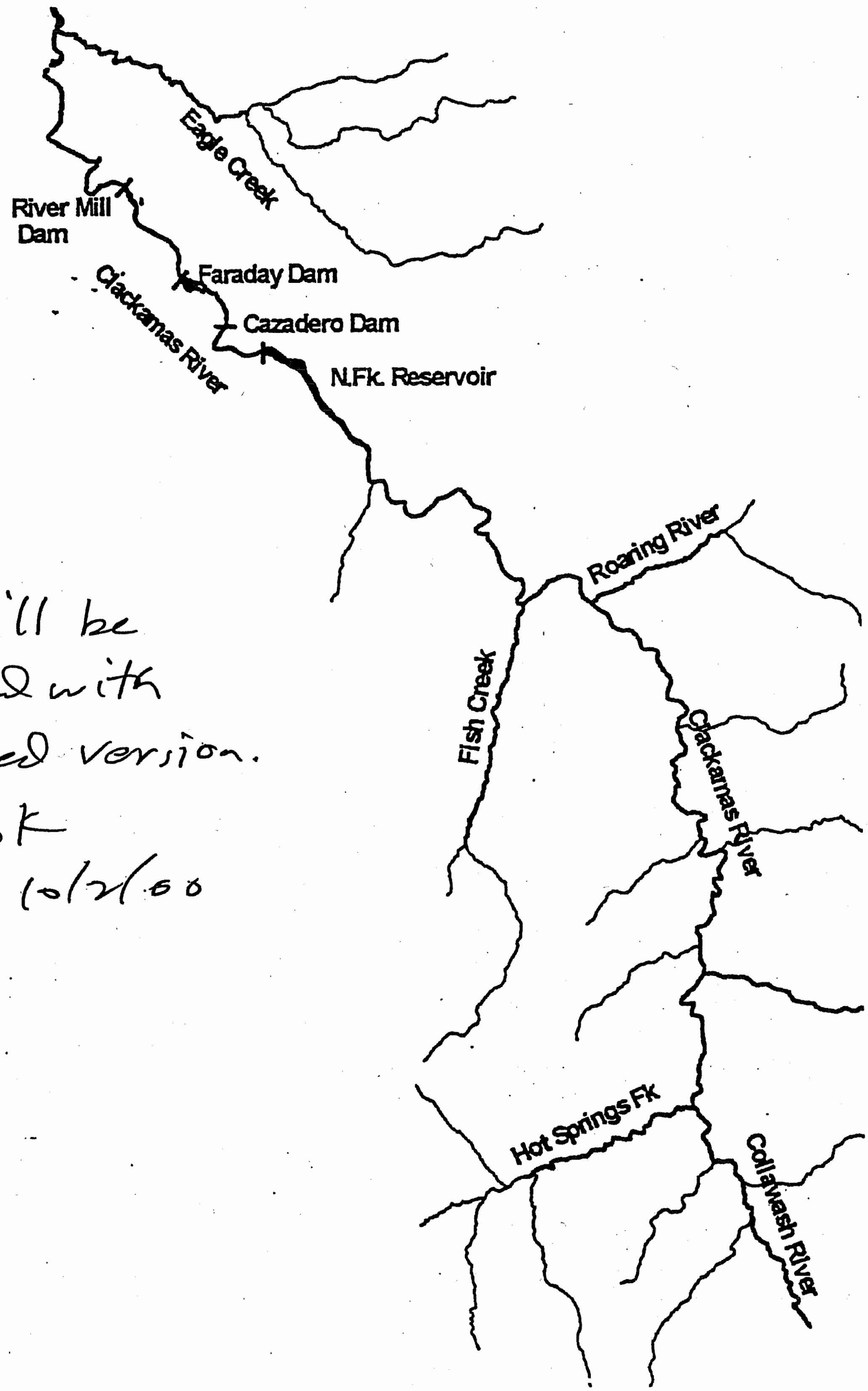
Historically, spawning by indigenous spring chinook occurred in the upper Clackamas basin in the mainstem and in tributaries including Eagle Creek, Fish Creek, Roaring River, and the Collawash River (Figure 1). Access to spawning areas was severely impeded or prevented by Faraday and River Mill dams from 1906-39. During this period, natural production of spring chinook was restricted to the lower 23 miles of the Clackamas and Eagle Creek. Passage into upriver spawning areas was restored in 1940 and counts of spring chinook past River Mill Dam in the early 1950's indicate recolonization of the upper basin. The source of the spring chinook that recolonized the upper Clackamas is not known. Most likely, it included some Clackamas fish that had persisted below Faraday Dam, plus strays that were deterred from their destination in upper Willamette tributaries by passage problems at Willamette Falls (located just above the mouth of the Clackamas) and pollution in the lower Willamette. Today, natural production habitat is thought to be relatively productive in at least the Clackamas mainstem and tributaries above North Fork Dam. Much of the Clackamas basin above the North Fork Dam is in National Forest management and substantial area is protected by Wild and Scenic River Designation. Juveniles primarily rear in the mainstem Clackamas River above North Fork Reservoir and in North Fork Reservoir. Rates of mortality caused by dams to downstream migrants are not well documented.

Natural Spawning

Intensive spawning ground surveys for spring chinook salmon were conducted in the Clackamas River basin from 1996 through 1998 to document timing, distribution, and abundance of natural spawning. A subset of the most heavily used areas was surveyed in 1999. Aerial surveys of spawning grounds were conducted annually from 1982 to 1995. However, these surveys may have limited value because test comparisons between aerial and ground surveys in 1996 and 1998 showed aerial surveys only accounted for about 24% of the total spring chinook redds in the upper Clackamas River basin.

The mainstem of the upper Clackamas River above North Fork Dam (RM 30) is the most important spawning area for spring chinook salmon accounting for an average of 85% of the redds in three years of intensive surveys (1996-98). Only 15% were accounted for in tributaries. Mean annual redd counts in the upper mainstem in 1996-99 were 236 (Table 1). Redds in the upper mainstem from Sisi Creek (RM 74) to the head of North Fork Reservoir (RM 33) are fairly uniformly distributed with the section from the mouth of the Collowash River (RM 57) to Cripple Creek (RM 48) usually containing the highest redd densities. Of the tributaries, the Collowash River is the most used by spring chinook in the basin. Spring chinook salmon generally begin spawning in the upper Clackamas in late August and finish near the end of October.

Spring chinook salmon also spawn in the lower Clackamas River below River Mill Dam (RM 23), but not as heavily as above North Fork Dam. The lower Clackamas River accounted for 11% of the total redds in the Clackamas basin in 1998 when both upper and lower sections were surveyed. Although fall chinook salmon also use the lower Clackamas River, spring chinook predominate in the area just below River Mill Dam.



Map will be replaced with improved version.
SK
10/2/00

Figure 1. The upper Clackamas River basin including natural production areas for spring chinook.

Table 1. Redd counts of spring chinook salmon in the Clackamas River, 1996-99.

Area	Redd Counts			
	1996	1997	1998	1999
Upper Clackamas:				
Main stem	159	302	323	161
Tributaries	23	74	57	16 a/
Lower Clackamas	--	--	48	--
Total	182	376	428	177

a/ Not all tributaries surveyed in 1996-98 were surveyed in 1999.

Natural Juvenile Production

Downstream passage of juvenile salmonids is routinely monitored at North Fork Dam. Naturally produced spring chinook juveniles are considered relatively abundant. Partial, unexpanded annual counts of downstream migrants (thought to be naturally produced) during 1959-99 ranged from about 1,000 to over 50,000 (Table 2). These data show a pattern of downstream migration by juvenile spring chinook similar to that observed at Leaburg Dam on the McKenzie River. Peaks in downstream movement occur in the spring and fall.

Return of Naturally Produced Adults

Natural production of salmonids, including spring chinook was severely constrained or eliminated in the Clackamas above Faraday Dam from 1906-39. Natural production in the upper basin was reestablished through colonization after 1939 when passage was provided at the Faraday Dam complex. Escapement of naturally produced adults above North Fork Dam averaged about 500 fish annually during the decade prior to large-scale introductions of upper Willamette hatchery fish to the basin. Counts of spring chinook over North Fork Dam increased substantially in 1980 after onset of the hatchery program. Escapement over North Fork Dam since 1990 has averaged about 2,300 fish annually (Table 3). Table 4 provides the total estimated return of spring chinook to the Clackamas River during 1979 to 1999.

Hatchery fish returns to the basin prior to 1998 were from releases of mostly unclipped hatchery fish above and below North Fork Dam. Starting in 1998, 100% of the hatchery production releases were adipose fin-clipped and released below River Mill Dam. No precise estimates of the number of wild fish passing North Fork Dam are available. However, it is thought reasonable to assume that escapement of naturally produced spring chinook to the Clackamas (primarily but not exclusively above North Fork Dam) has been somewhere in the range of 500 to 1,500 fish during 1994-99. This compares to the long-term average of 500 fish annually passing North Fork Dam prior to 1980.

Table 2. Unexpanded counts of downstream migrating wild juvenile spring chinook at North Fork Dam on the Clackamas River, 1959-99.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
1959			17	26	3,922	437	45	23	26	496	312	36	5,340
1960	58	155	100	223	14,310	2,467	32	7		250	3,306	936	21,844
1961	654	47	131	876	10,809	1,783	2		14	29	44	85	14,474
1962	66	32	23	112	71	8				86	234	363	995
1963	144	209	497	222	265	42	32	1	3	46	238	230	1,929
1964	516	118	171	906	3,921	259	21	61	71	115	488	782	7,429
1965 [1/]	4		900	2,022	1,337	262	21	3			45,088	18,531	68,168
1966 [1/]	19,941	16,289	31,183	15,489	19,427	3,942	558	17	198	495	2,625	2,112	112,276
1967 [1/]	1,787	1,266	41,690	111,269	48,193	8,038	246			135	199	160	212,983
1968	66	160	127	586	616	23			6	34	290	75	1,983
1969	23	141	717	521	1,092	333	20	5	14	109	175	340	3,490
1970	856	194	469	941	608	26	3	5	5	37	93	111	3,348
1971	342	386	746	716	1,236	658	26			140	340	175	4,765
1972	203	351	638	484	540	216	13		8	39	108	105	2,705
1973	108	128	158	1,407	466	10	3	1	14	37	420	211	2,963
1974	200	2,266	2,703	2,414	5,094	748	30	1	11	6	22	47	13,542
1975	58	23	38	385	1,805	127	29	96	170	330	647	710	4,418
1976	314	406	1,074	2,873	2,525	566	67	32	124	208	178	189	8,556
1977	32	7	31	1,864	6,210	399	62	12	83	770	1,882	1,015	12,367
1978	293	754	3,829	4,903	1,765	198	8	6				335	12,091
1979	7	53	187	307	2,705	186	35	27	310	1,292	1,483	1,154	7,746
1980	401	175	828	3,875	8,450	732	263	99	221	859	1,102	1,173	18,178
1981	271	911	1,425	2,695	1,495	142	99	49	30	232	651	828	8,828
1982	92	240	496	1,354	3,853	67	6	74	62	167	834	556	7,801
1983	363	404	546	1,910	5,088	693	422	380	636	3,344	9,333	1,644	24,763
1984	2,873	2,202	2,323	3,536	10,445	2,286	1,738	817	345	4,834	7,948	1,611	40,958
1985 [1/]	1,627	1,416	2,667	5,062	15,659	4,884	1,764	119	1,205	7,146	8,454	659	50,662
1986	2,293	3,796	5,976	6,064	5,750	1,805	424	96	163	1,042	3,079	914	31,402
1987	218	553	1,349	3,886	7,580	674	196	56	170	1,262	3,408	6,022	25,374
1988	694	459	858	1,173	2,515	172	268	75	50	228	1,938	601	9,031
1989	133	94	82	797	12,104	928	240	88	150	4,474	6,216	3,048	28,354
1990	578	240	716	1,687	4,249	1,003	270	36	63	145	4,726	2,241	15,954
1991	398	46	158	1,791	10,557	1,175	152	14	21	512	2,830	1,035	18,689
1992	114	67	141	1,903	4,905	909	8	0	0	186	2,838	760	11,831
1993	325	20	47	686	4,430	1,225	398	192	68	664	2,988	5,781	16,824
1994	1,282	59	136	4,167	4,085	168	82	6	30	210	2,186	136	12,547
1995	55	46	120	2,124	6,890	1,567	38	20	10	913	1,402	257	13,442
1996	12	0	164	383	44	6	6	16	44	89	108	39	911
1997	11	13	0	70	730	40	20	2	5	140	308	37	1,376
1998	6	2	6	909	5,839	999	1,024	50	106	4,464	2,448	212	16,065
1999	55	48	69	585	2,336	76	84	63	16	172	696	105	4,305

[1/] *Counts include some hatchery fish.*

Table 3. Spring chinook passage over Clackamas River dams, 1950-99.

	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Total		
Year	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Total
1950							3		123		21		20		3				170	0	170
1951 1/					5		147		180		6		29		4				371	0	371
1952					9		72		214		161		30		10				496	0	496
1953							24	14	199	63	228	24	76	5	4	1		1	531	108	639
1954							4	33	158	131	138	32	25	5	8	1			333	202	535
1955									130	53	115	23	51	5	28	2			324	83	407
1956																			0	0	0
1957																	25	1	25	1	26
1958 2/					10	1	33		129		39	6	143	69	28	12	5		387	88	475
1959	2				14		7	3	37	3	8		154	20	69	252			289	278	567
1960							11	16	45	28	21	2	88	27	16	33			181	106	287
1961							89	52	54	42		2	68	38	12	13			223	147	370
1962							117	17	122	27	81	25	207	25	43	2			570	96	666
1963					5	1	149	17	44	11	16	6	194	27	124	18	3	1	535	81	616
1964							11	10	75	50	77	16	140	25	42	2			345	103	448
1965					1	1	104	79	156	83	29	30	15	9	2	2			307	204	511
1966					1		1	4	83	30	32	9	70	10	31	6			218	59	277
1967						1	10	1	44	10	11	1	29	5	35				129	18	147
1968								3	196	57	116	28	75	5	21				408	93	501
1969							471	29	178	15	71	15	145	15	43	1	1		909	75	984
1970					4		245	18	199	32	38	19	60	7	30				576	76	652
1971							56	5	171	30	47	8	48	5	11				333	48	381
1972							4	1	41	35	40	43	69	25	36	9			190	113	303
1973			1		4	1	176	15	81	10	30	10	119	17	45	5			456	58	514
1974							1		162	24	89	10	146	16	52	4			450	54	504
1975							10	4	92	20	149	9	70	4	40	2			361	39	400
1976					6		79	2	139	11	53	11	114	3	41	1	1		433	28	461
1977			3		21	1	78	15	45	14	51	20	130	13	106	6	1		435	69	504
1978				1			52	43	30	78	49	61	176	122	109	16		2	416	323	739
1979							189	42	72	112	32	25	166	40	131	27	2		592	246	838

Table continued next page.

1/ Counts 1950-55 are from River Mill Dam. Jacks were not counted separately during 1950-52.

2/ Counts since 1958 are from North Fork Dam.

Table 3. Spring chinook passage over Clackamas River dams, 1950-99. (Continued)

	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Total		
Year	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Adults	Jacks	Total
1980					4		204	5	438	25	429	17	763	2	281		3	1	2,122	50	2,172
1981					41	3	456	42	437	70	483	24	1,101	22	467	16			2,985	177	3,162
1982					20		211	31	556	76	415	41	1,464	42	244	19			2,910	209	3,119
1983							327	15	145	12	313	17	1,639	30	172	13	2		2,598	87	2,685
1984					5		195	17	774	35	118	7	1,368	38	273	5			2,733	102	2,835
1985					5		195	22	491	62	221	33	649	14	132	9	1		1,694	140	1,834
1986			2		6		716	73	409	50	104	13	525	23	35	4			1,797	163	1,960
1987					15		983	21	481	47	171	21	519	14	113	30	10		2,292	133	2,425
1988					7		886	18	749	14	330	12	964	7	152		1		3,089	51	3,140
1989					18		857	32	602	25	381	18	815	9	180	1			2,853	85	2,938
1990			1		54		531	14	901	22	661	17	1035	3	205				3,388	56	3,444
1991					15		270	1	1,123	13	871	14	2,027	45	278	2			4,584	75	4,659
1992			8		304	3	868	13	792	17	248	6	1,266		27		1		3,514	39	3,553
1993					28		291	1	649	10	419	13	1,513	7	158		1		3,059	31	3,090
1994					150	1	436	5	403	5	268	1	780	1	124				2,161	13	2,174
1995					26		247	7	511	5	237	5	510	2	107	1	1		1,639	20	1,659
1996					3		182	2	215	2	76	4	343	7	69				888	15	903
1997					7		79		294		266	3	550		68				1,264	3	1,267
1998					8		190		384	23	166	13	496		148		3		1,395	36	1,431
1999							8		159	7	214	13	379	3	97	5	3		860	28	888

Table 4. Estimated return of spring chinook to the Clackamas River, 1979-99.

Year	L. Clackamas Sport Catch	North Fork Dam Count	Natural Spawn Bel. N. Fork Dam	Hatchery Return		Total Return
				Eagle Ck. NFH	Clackamas	
1979	1,226	838	159	2,803	0	5,026
1980	3,165	2,172	624	1,480	1,024	8,465
1981	2,334	3,162	654	812	1,065	8,027
1982	2,463	3,119	203	905	573	7,263
1983	4,532	2,685	770	522	1,923	10,432
1984	4,300	2,835	600	1,032	2,521	11,288
1985	2,478	1,834	635	726	944	6,617
1986	3,900	1,960	600	661	776	7,897
1987	3,186	2,425	868	1,338	1,005	8,822
1988	2,720	3,140	201	1,373	1,253	8,687
1989	2,900	2,938	600	1,137	865	8,440
1990	4,710	3,444	600	869	1,847	11,470
1991	3,834	4,659	500	88	2,776	11,857
1992	2,697	3,553	750	0	4,535	11,535
1993	2,963	3,090	200	0	4,635	10,888
1994	1,541	2,174	100	9	3,675	7,499
1995	1,708	1,659	150	19	3,112	6,648
1996	1,869	903	100	2	3,044	5,918
1997	1,732	1,267	150	0	2,670	5,819
1998	1,302	1,431	100	4	4,530	7,367
1999	1,890	888	100	4	4,562	7,444

North Santiam River Basin

Available Habitat

The availability of areas historically used for spawning by spring chinook in the North Santiam was severely reduced by construction of Detroit and Big Cliff dams in 1953 (Figure 2). Mattson (1948) estimated that over 70% of the spring chinook spawning in 1947 were located upstream from the site of these dams. Today, spawning and rearing habitat is still available below these dams downstream to Stayton, which Mattson noted as the extreme downstream location of spawning by spring chinook. This area, although accessible for spawning by spring chinook, may not be as suitable as it was historically because of the thermal effect of reservoir-released water on incubating eggs. An important spawning tributary, the Little North Fork, is still accessible and is thought to be quite suitable to spawning and rearing by spring chinook.

Natural Spawning

Spring chinook salmon spawn in the North Santiam River primarily above the town of Stayton, Oregon (RM 17). Fall chinook spawn mainly below Stayton. Recent spawning ground surveys have shown most natural spawning of spring chinook salmon occurs near the upper limit of their migration at Minto Dam (RM 44). Redd counts between Minto and Stayton have averaged 160 annually from 1996-1999 (Table 5). Aerial surveys in 1993 and 1994 counted about 165 redds annually above Stayton. However, comparisons of aerial counts of redds with those conducted on the ground in 1996 and 1997 showed that aerial counts only accounted for 26% of the redds actually present. If this relationship was true in 1993-94, redd counts in these years may have approached 630 annually, much higher than the counts observed in 1996-1999. Run sizes of spring chinook in 1993-94 were somewhat higher than those observed in 1996-99, and probably accounts for some of the difference between the two periods.

The Little North Fork Santiam River (RM 26) is the only tributary in the North Santiam basin that currently supports natural production of spring chinook salmon. However, redd counts in 1996-99 have been low, averaging only 15 redds annually (Table 5). No hatchery spring chinook are released into the Little North Fork.

Table 5. Redd counts of spring chinook salmon in the North Santiam River, 1996-99.

Area	Redd Counts			
	1996	1997	1998	1999
Mainstem North Santiam:				
Stayton to Minto	**137**	**134**	**155**	**215 a/**
Little North Fork of the Santiam	**0**	**10**	**39**	**11**
Total	**137**	**144**	**194**	**226**

a/ Counts adjusted for sections not surveyed, which accounted for 18% of the redds based on data in 1996-98.

Map will be replaced with improved version SK 10/3/00

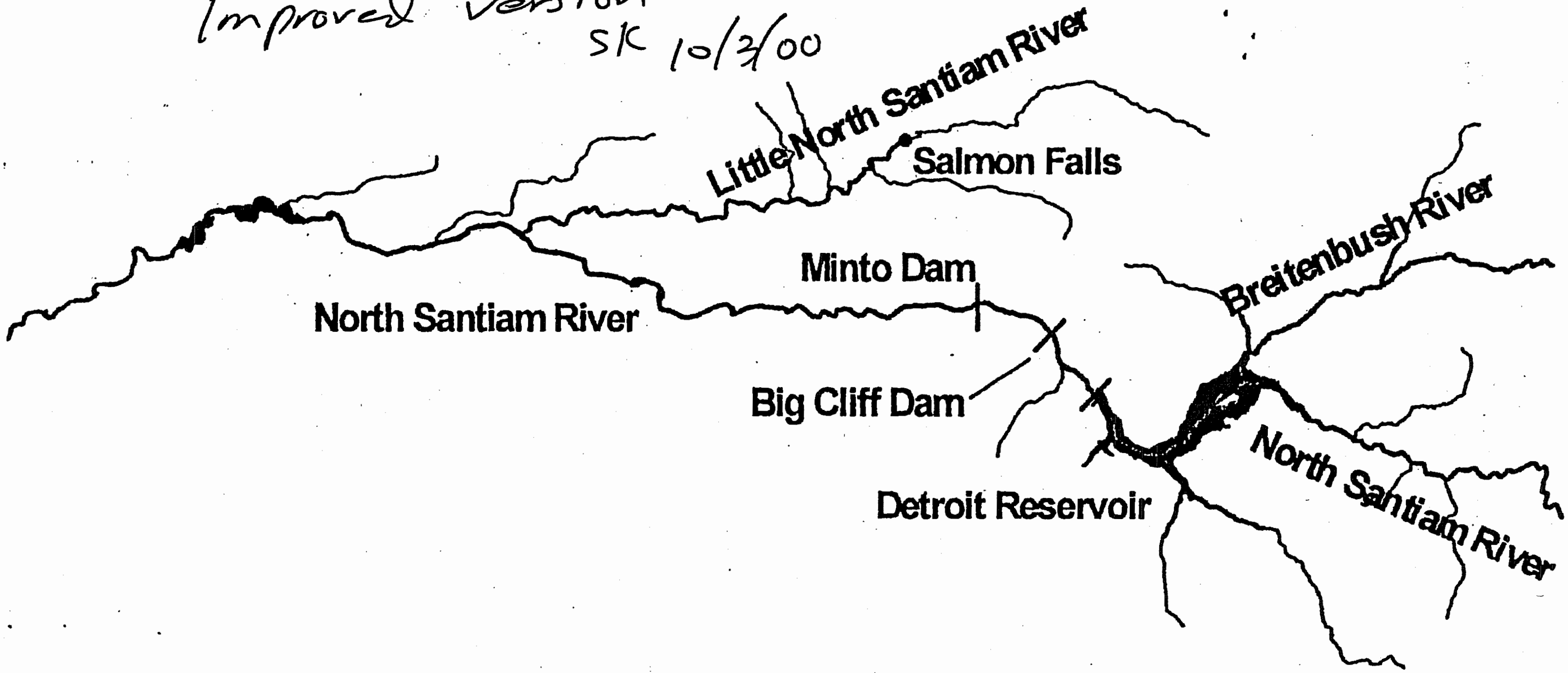


Figure 2. The North Santiam River basin including natural production areas for spring chinook.

Natural Juvenile Production

In 1989 and 1990 the ODFW Research Section operated several downstream migrant traps in the Santiam Water Control District's hydroelectric/irrigation canal on the North Santiam River. The objective of this study was to document the seasonal presence or absence of fish in the canal to develop fish protection criteria. Staff documented that naturally produced juvenile spring chinook salmon could be found migrating through the canal during all months of the year as either fry, fingerlings, or smolts. Staff estimated the total number of fry (35-40 mm) migrating through the canal from January 1 to April 1 in 1989 by expanding trap catches for unsampled days and known trapping efficiency of fry. Estimates, based on two methods, were 96,100 and 101,600 fry. Since the percentage of river diverted into the canal ranged from 9-60% during this period, staff suspect that substantially more fry migrated down the river past the entrance to the canal. In addition, visual surveys during recent years have noted the occurrence of rearing juveniles in the Little North Fork and in the mainstem North Santiam below Big Cliff Dam.

Return of Naturally Produced Adults

In 1994 and 1997-2000 the Research Section installed and operated fish traps in fishways located near Stayton Island on the North Santiam River. These traps were situated on the primary paths of upstream migration and operated three to four days per week from March to mid-October. Using daily trap catches to estimate passage on unsampled days, staff calculated that adult spring chinook passage through the Stayton complex averaged 2,556 fish (range: 2,161-3,351) for this period.

The majority of Willamette River spring chinook adults (>95%) return at ages 4 and 5. Hatchery releases corresponding to the aforementioned adult return/ trapping years were adipose fin-clipped and coded-wire tagged at an average of 6.77%. In 1994, when staff expanded the number of adipose fin-clipped fish observed in Department traps to account for unclipped hatchery fish, staff estimated that virtually all the adults passing Stayton Island were of hatchery origin. Based on this analysis it appears the naturally produced portion of the North Santiam run was insignificant in 1994. Analysis of 1997, 1998, and 1999 mark returns indicated that a small portion of the run in each of these years was naturally produced. The estimated run which originated from natural production was 2%, 1%, and 3% for the years 1997, 1998, and 1999, respectively. Sampling to date indicates that by far the greatest proportion of the adult run of spring chinook entering the North Santiam in recent years has consisted of hatchery fish.

McKenzie River Basin

Available Habitat

Considerable habitat suitable to support natural spawning and rearing by spring chinook exists today in the McKenzie basin. Dams on the mainstem McKenzie River (Trailbridge) and on tributaries to the McKenzie (Blue River and South Fork) have eliminated some historic spawning areas (Figure 3). Also, Blue River and Cougar dams adversely affect natural production because of the thermal effects of reservoir-released water that accelerate incubation, hatching, and emergence of juveniles. The Mohawk River supported spring chinook historically but may not currently be suitable for natural production. Mattson (1948) reported that the principal spawning areas were found from the mouth to Hendricks Bridge and in the Walterville Canal. Based on recent, incomplete spawning ground surveys, the principal areas used for spawning appear to be above Leaburg Dam.

Map will be replaced w/ improved version
s/c 10/3/00

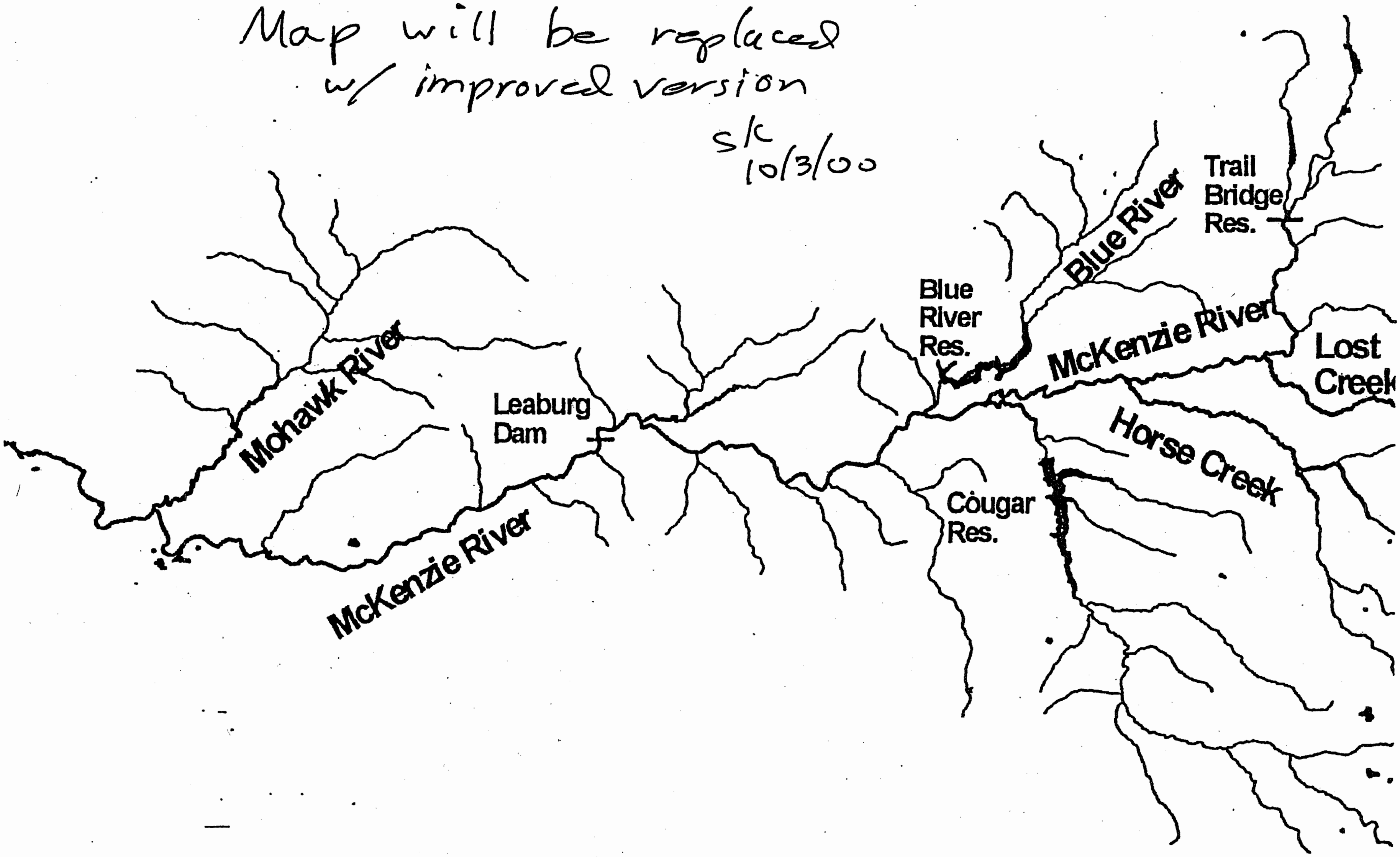


Figure 3. The upper McKenzie River subbasin including natural production areas for spring chinook.

The reasons for this possible change in distribution of spawners are not known. Prior to 1958, the McKenzie was often racked near Hendricks Bridge and a trap was operated at Leaburg to facilitate collection of eggs for hatchery programs. Both actions could have reduced escapement to the upper river. Also, spawning by hatchery fall chinook may have inflated redd counts in the lower river during 1969-78. Although the majority of the traditional spawning and rearing areas formerly used by spring chinook are still accessible, the contemporary productive capacity of these habitats are not known. The McKenzie is thought to presently contain substantial high quality spawning and rearing habitat for natural production of spring chinook.

Natural Spawning

Natural spawning by spring chinook in the McKenzie is not comprehensively sampled. Annual passage of adults upstream over Leaburg Dam has been estimated since 1970 and has ranged from 800 to 7,200 annually (Table 6). Annual observations of redds below Leaburg have been recorded since 1965. These data indicate that spawning by spring chinook occurs both below and above Leaburg, but is primarily above Leaburg.

Extensive surveys of spawning areas in 1992 noted the earliest initiation of spawning on the last day of August. As was noted by Mattson (1948) spawning generally progressed downstream through time. Peak spawning was apparently around the third week of September in 1992, although some spawning activity was noted into the second week of October.

Natural Juvenile Production

Some monitoring of juveniles migrating downstream past Leaburg has occurred since 1985. During the period 1985-92, the number of juveniles that moved downstream past Leaburg Dam was estimated at between about 100,000 and 1.5 million. Production of higher numbers of naturally produced juveniles was generally associated with escapement of higher numbers of adult hatchery and wild spring chinook past Leaburg Dam (Figure 5).

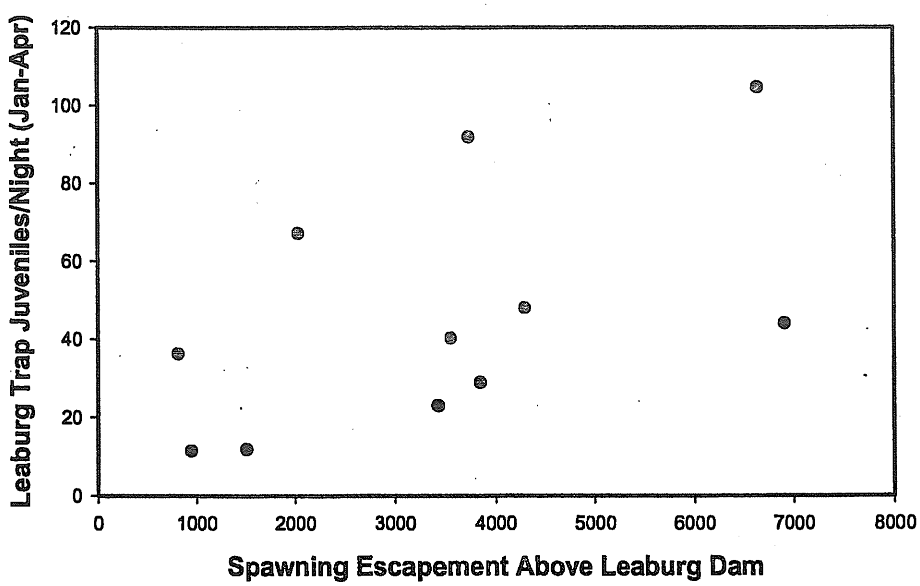


Figure 5. Presmolt passage index versus upstream adult escapement at Leaburg Dam, 1984-1994 brood years.

Table 6. Estimated return of spring chinook to the McKenzie River, 1970-99.

Run Year	Leaburg Dam Count	McKenzie Hatchery Return	Sport Catch: Above Leaburg Dam	Sport Catch: Below Leaburg Dam	Sport Catch: Total	Est. Natural Spawn Below Leaburg Dam[1/]: Redds	Est. Natural Spawn Below Leaburg Dam[1/]: No. Fish	Total Return
1970	2,991	20	--		525	278	1,251	4,787
1971	3,602	232	--		621	415	1,868	6,323
1972	1,547	301	--		1,125	177	797	3,770
1973	3,870	56	--		1,510	556	2,502	7,938
1974	3,717	0	--		1,022	689	3,101	7,840
1975	1,374	0	--		461	346	1,557	3,392
1976	1,899	396	--		139	409	1,841	4,275
1977	2,714	1,517	--		1,071	850	3,825	9,127
1978	3,058	1,464	--		924	599	2,696	8,142
1979	1,219	798	--		303	155	698	3,018
1980	1,980	807	--		381	219	986	4,154
1981	1,078	784	--		493	282	1,269	3,624
1982	2,241	1,460	--		627	241	1,085	5,413
1983	1,561	821	15	206	221	172	774	3,377
1984	1,000	1,901	51	567	618	271	1,220	4,739
1985	825	1,923	8	459	467	381	1,715	4,930
1986	2,061	1,705	29	354	383	315	1,418	5,567
1987	3,455	1,593	29	1,339	1,368	212	954	7,370
1988	6,753	2,487	86	1,133	1,219	484	2,178	12,637
1989	3,981	3,154	134	1,730	1,864	228	1,026	10,025
1990	7,226	3,206	315	1,387	1,702	160	720	12,854
1991	4,359	4,483	64	1,922	1,986	161	725	11,553
1992	3,816	3,407	81	1,195	1,276	106	477	8,976
1993	3,629	2,051	80	1,761	1,841	142	639	8,160
1994	1,526	701	13	486	499	59	266	2,992
1995	1,622	1,135	24	84	108[2/]	66	297	3,162
1996	1,445	1,573	58	244	302[2/]	71	320	3,640
1997	1,176	1,524	0	0	0[3/]	90	405	3,105
1998	1,874	1,690	0	0	0[3/]	95	428	3,992
1999	1,909	2,279	0	0	0[3/]	82	369	4,557
1970-99 Average	2,650	1,449	58	757	769	277	1,247	6,114
1994-99 Average	1,592	1,484	16	136	152	77	347	3,574

1/ Estimated Natural Spawn below Leaburg Dam = No. of Redds below Leaburg Dam X 4.5 Fish/Redd.
2/ Adipose fin-clipped hatchery fish only allowed to be retained.
3/ Closed season.

Return of Naturally Produced Adults

Annual estimates of the number of adults passing Leaburg Dam are available for an extended period. Probably, these data represent mostly naturally produced adults until the mid-1960s. Estimates of spring chinook passage over Leaburg Dam were conducted twice in the 1950s. Passage of spring chinook (thought to be essentially all wild fish) in 1958 and 1959, respectively, was estimated to be about 13,000 and 9,000 fish (Willis 1960). With the achievement of a successful hatchery program, however, counts at Leaburg included both hatchery and naturally produced fish in unknown proportions. Estimates of the number of naturally produced spring chinook migrating past Leaburg Dam are available since 1994. The estimated number of wild fish passing Leaburg during 1994-99 range from 825 to 1,415 with a modest improvement in the numbers during this time period (Table 7). Considering that some wild spring chinook spawned below Leaburg, the number of wild spring chinook that escaped into the McKenzie is thought to be in the neighborhood of 1,000-1,600 fish during the 1994-99 period.

Table 7. Spring chinook counts at Leaburg Dam on the McKenzie River, 1994-99.

	Wild		Hatchery		
Year	Number	Percent	Number	Percent	Total
1994	825	54	701	46	1,526
1995	933	58	689	42	1,622
1996	1,105	76	340	24	1,445
1997	991	84	185	16	1,176
1998	1,415	76	459	24	1,874
1999	1,383	72	526	28	1,909

References

Mattson, C. R. 1948. Spawning ground studies of Willamette River spring chinook salmon. Research Briefs. Fish Commission of Oregon, vol. 2 no. 2. Portland, Oregon.

Willis, R. A., M. D. Collins, and R. E. Sams. 1960. Environmental survey report pertaining to salmon and steelhead in certain rivers of eastern Oregon and the Willamette River and its tributaries. Part II. Survey reports of the Willamette River and its tributaries. Fish Commission of Oregon, Research Division, Clackamas.

Appendix C

Fishery Risk Assessment for Willamette River Natural Spring Chinook Populations

Raymond C. P. Beamesderfer

Oregon Department of Fish and Wildlife
2501 Southwest First Avenue
Portland, Oregon 97201

S. P. Cramer & Associates, Inc.
19190 South Creek Lane
Oregon City, OR 97045

September 1, 2000

Conservation Risks of Mixed Stock Fisheries for Wild Spring Chinook Salmon from Oregon's McKenzie River based on a Population Viability Analysis

RAYMOND C. P. BEAMESDERFER[1]

Oregon Department of Fish and Wildlife
17330 Southeast Evelyn Street, Clackamas, Oregon 97015, USA

Abstract.- Extinction risks and recovery potential associated with different fishing strategies were estimated for a wild spring chinook salmon population from the McKenzie River using a stochastic, age-structured, life-cycle model. The model included a stock-recruitment relationship, normal variability in mortality rates, parameter uncertainty, ocean and freshwater fisheries, and hatchery and wild components of the Willamette Basin run. Sensitivity analyses were used to explore the effects of parameter uncertainty. Fixed escapement, fixed harvest rate, and variable harvest rate strategies were compared to a no-fishing option to weigh risks to the wild population. Strategies included historic and revised harvest management plans for accessing surplus hatchery fish mixed with the wild return. This population viability analysis indicates that quasi-extinction risk for the McKenzie River wild population is reduced from 31% under historic fishing strategies to 5% or less by a revised management plan and to less than 0.1% under a planned selective fishery for adipose fin-clipped hatchery fish. The current management plan does not provide for substantial increases in average wild escapement over current levels nor does it provide for periodic large escapements which could be used to explore stock productivity and habitat capacity. Fishing options equivalent to a 15% fixed rate are necessary to provide substantial assurance of periodic large runs under most productivity assumptions. The low wild fish impact of selective sport fisheries for fin marked hatchery chinook salmon (5%) will provide sufficient impacts for continued implementation of a limited commercial fishery in the lower Columbia River while still meeting wild stock protection and recovery goals. Several alternatives to the 15% fixed-rate strategy provide similar stock protection and rebuilding benefits but fishery benefits are optimized by an abundance-based approach where harvest rates vary with run size. Extinction risks are largely independent of stock size at average escapements of 800 or greater. Thus, it is not necessary to manage for "full seeding" every year to ensure the longevity of the wild McKenzie River spring chinook population. Therefore, fishery managers have the flexibility to manage for mixed stock (hatchery and wild) fishery benefits as long as sufficient buffer is provided for chance variation dropping wild stock abundance below a critical level. Population viability standards equivalent to 50% of the habitat capacity based on the smaller of replacement spawner abundance or spawner number at maximum recruitment easily exceed the ESA recovery standard of not endangered with extinction or likely to become endangered within the foreseeable future.

[1] Current address: S. P. Cramer and Associates, 19190 South Creek Lane, Oregon City, Oregon 97045, beamer@ccwebster.net.

Introduction

The widespread failure of the traditional stock-recruitment approach to protect and rebuild weak, sensitive, and endangered salmon populations requires adoption of a new paradigm for salmon fishery management. Traditional management has relied on the simple fact that on average more spawners produce more recruits up to the capacity of the habitat. Harvest has typically been regulated to maintain spawning escapement within the range where the greatest harvestable yield can be obtained from a stock which consists of an aggregate of populations. However, the traditional approach does not provide adequate protection for weak salmon populations which can't sustain the aggregate stock harvest rates, are subject to small-population risks which are not considered in traditional stock-recruitment models, and can be extirpated when normal environmental variation causes the weak population to "bottom out".

Protection of depleted, threatened, or endangered salmon populations requires a risk-based approach rather than a harvest or yield-based approach. Many populations would survive low levels if faced with average conditions but are at high risk of extirpation under extreme environmental fluctuations such as the periodic "El Ni□o's" which reduce ocean survival of many Oregon, Washington, and California salmon stocks. Accurate risk assessments require stochastic population models which can incorporate variability in survival rates and uncertainty in parameter estimates in addition to traditional stock-recruitment and other life cycle processes (Brown and Patil 1986). "Population Viability Analyses" based on stochastic population models are a widely-applied tool to assess risks of extinction and probabilities of recovery for threatened species (Burgman et al. 1993). Analyses have recently been applied to several salmonid populations including Snake River spring chinook salmon (Emlen 1995), Oregon coho salmon (Chilcote 1998a, Nickelson and Lawson 1998) and Oregon steelhead (Chilcote 1998b).

Population viability analyses provide a useful tool for systematically evaluating the effects of alternative fishing strategies. Even where healthy wild or hatchery populations provide large harvestable surpluses, restrictions on mixed stock fisheries are often necessary to protect weak populations. A wide variety of fishing restrictions and strategies have been considered or adopted to reduce impacts on depleted natural stocks. However, the technical basis for selecting appropriate fishing rates is often unclear. Restrictions are often scaled as a function of stakeholder concerns and constraints without a clear understanding if reductions are sufficient to protect and restore target populations. Conversely, complete closures of fisheries are often advocated without consideration of the marginal effects of conservative fishing rates. Tradeoffs are rarely weighed among fixed or variable, escapement-based or harvest rate-based fishing strategies and interactions with stock life history and productivity. The key questions remain, "how much fishing is too much?" and "are some fishing strategies better than others?"

Salmon fisheries in Oregon, Washington, and California have been severely reduced during the last 10 years as tighter harvest restrictions have not forestalled continuing population declines and many stocks were listed or proposed for listing under the Federal Endangered Species Act (ESA). Recovery plans or conservation management agreements have implemented a wide range of harvest limitations. For instance, allowable harvest rates on Snake River fall chinook salmon are 24.4% in the ocean and 31.3% in freshwater depending on run size. These rates were based on a 30% reduction from a 1988-93 base period prior to protection of this stock as an ESA-threatened species. Fisheries for ESA-endangered winter-run chinook salmon in California are limited to 50% of 1989-93 brood year rates based on an intent to increase mean brood replacement rate by 31%. Corresponding ocean fishery impacts on winter-run chinook salmon are approximately 26%. Harvest impacts on ESA-threatened Snake River spring chinook salmon are limited to 9%. Harvest impacts on ESA-threatened steelhead in the Columbia River were limited in 1998 to 12% of an early Group-A portion of the run and 17% of a late Group-B portion of the run. Harvest impacts on wild coastal Oregon coho (ESA-threatened) have been limited to an average of 11.2% from 1994 to 1999 and will be managed under the ESA for rates of 10 to 35% based on run size.

This paper uses a population viability analysis based on a stochastic salmon life cycle model to weigh the risks of several mixed-stock fishing strategies and to identify strategies which preserve and restore a wild population of spring chinook salmon in Oregon's McKenzie River while also providing access to abundant hatchery fish. The McKenzie River population is the only significant wild spring chinook population remaining in the upper Willamette basin but constitutes only 5-10% of the total Willamette River return. A series of flood control reservoirs have eliminated other wild populations historically present in most major east-side Willamette basin tributaries (Figure 1). Reservoirs also reduced production in downstream areas by altering flow and temperature regimes. Habitat losses upstream from Willamette Falls and hydropower facility impacts in another lower Willamette River tributaries were mitigated by construction of five hatcheries which release about 5 million smolts per year. Willamette spring chinook are subject to ocean commercial and sport interception fisheries, and freshwater commercial, sport, and tribal fisheries in interception and terminal areas.

Methods

Effects of fishing on the wild population were evaluated based on extinction risk and recovery potential. Extinction risk was described as the probability of declining below a small population threshold where the ability to rebound was in question because of depensatory population processes or genetic effects. Depensatory population processes include the inability to find mates at low spawner densities and predation (Hilborn and Walters 1992). Loss of genetic diversity and inbreeding depression associated with small effective population size can also be expected to reduce population "fitness" and productivity (Lande and Barrowclough 1987, Nelson and Soulé 1987, Lynch 1996).

A "critical population threshold" can be defined as the small population size which does not assure extinction but significantly heightens extinction risk (McElhany et al. 2000). We refer to this term as "Pc". A threshold of Pc = 300 spawners was used rather than an actual extinction level because recovery from single digit populations sizes was assumed to be to be unrealistic. Use of the critical population threshold thus provided a "quasi-extinction risk" which can be defined as a conservative estimate of extinction risk. The 300 spawner threshold was based on literature values for similar evaluations (Kapuscinski and Jacobson 1987, Waples 1990, Lynch 1996) and is also consistent with the statutory requirements of Oregon's Wild Fish Management Policy for protecting natural spawning populations. The appropriate threshold may be arguable but any level can be considered as a benchmark for describing relative changes associated with different fishing strategies.

Definition of a defensible numerical recovery goal for McKenzie River spring chinook is difficult because data on basin carrying capacity and productivity are lacking. Recovery also means different things to different people and an explicit biological description has not been established. Under the ESA, a population is considered recovered when it is not "endangered" or "threatened". An "endangered species" is one which is in danger of extinction throughout all or a significant portion of its range. A "threatened species" is one which is likely to become an endangered species within the foreseeable future. This minimalist definition of recovery has been variously extended by other authors to include factors other than extinction risks such as "full seeding" and ecosystem function (Cramer 2000, McElhany et al. 2000). McElhany et al. (2000) suggest that population viability guidelines consistent with recovery should include a population size sufficient for compensatory processes to provide resilience to environmental and anthropogenic perturbation.

We explored the use of 50% of the habitat capacity as a benchmark for measuring population recovery. We chose the 50% capacity standard because density-dependent processes rapidly reduce recruits per spawner above this point. Habitat capacity was defined based on the smaller of replacement spawner abundance or spawner number at maximum recruitment. We define this population viability standard as "Pv". For productive populations where maximum recruitment occurs at less than the replacement spawner level, Pv equals 50% of the spawner number at maximum recruitment (Figure 2). For unproductive populations where maximum recruitment occurs at greater than the replacement level, Pv equals 50% of the replacement spawner number. In subsequent analyses we also verify that this recovery standard is consistent with ESA definitions of recovery as a point where the population is not at risk of extinction. Recovery prospects were evaluated by comparing average spawner number for the last 8 years of simulations with the recovery benchmark (Pv). The eight-year average was used to describe the returns from several overlapping generations. We also estimated the probability of average spawner number during the last 8 simulation years exceeding the recovery threshold.

We also explored the use of large run size probabilities as a component of our recovery standard because we wished to estimate productivity and capacity of the wild population. Recruitment estimates over a wide range of spawning escapements needed so that future monitoring could accurately estimate stock-recruitment parameters. "Large" run sizes were defined as >75% of the replacement abundance.

Probabilities were calculated based on 1,000 iterations of a 30 year time period where initial population values were based on current numbers and future population values were calculated by the stochastic model using appropriate parameter estimates and variance terms. Thus, a 30% quasi-extinction risk indicates that the spawner population fell below 300 spawners on 30% of the 30,000 (30 years times 1,000 iterations) simulation observations. A 30% recovery probability indicates that 30% of the 1,000 iterations resulted in average populations for the last 8 years of the simulation which exceeded the recovery threshold.

Model Description

The population viability model consisted of a series of difference equations solved at annual intervals. Wild and hatchery fish numbers were tracked by year and cohort from smolt migration through ocean rearing, ocean and freshwater fisheries, and freshwater migration of adults back to the spawning grounds (Figure 3, Table 1). Wild smolt numbers were estimated from wild spawners based on a Ricker function. All density-dependent mortality was thus assumed to occur during the freshwater rearing stage. Depensation was applied to estimated recruits at spawner numbers under the critical threshold of 300, such that recruits per spawner declined from a maximum at 300 spawners defined by the Ricker function to zero at zero spawners. Hatchery smolt numbers were based on annual production levels for Willamette Basin hatcheries.

The model calculated survivors of freshwater migration reaching the ocean, survivors of ocean rearing to recruit to ocean fisheries, escapement from ocean fisheries to return to freshwater, escapement from various freshwater fisheries, and returns to wild spawning grounds and hatcheries. Adult recruits produced by each year-specific spawning cohort included adults returning at several ages. Willamette Basin spring chinook have stream-type life histories where juveniles generally smolt and migrate to the ocean at age 1 and return as 3 through 6 year-olds with most fish returning as 4- and 5-year olds. Thus, spawners in year 1 produced recruits which included 3-year olds in year 4, 4-year olds in year 5, 5-year olds in year 6, and 6-year olds in year 7. Fish returning to the Clackamas River which contributes to the total Willamette run were also included.

Parameter Estimation

Wild fish numbers. - Counts of wild spring chinook passing Leaburg Dam on the McKenzie River from 1995 to 2000 were used as starting values in simulations. Hatchery and wild fish could be distinguished only since 1994 and returns prior to 1994 were heavily influenced by releases of hatchery smolts upstream from Leaburg Dam which have since been discontinued. Counts from 1994-2000 have averaged 1,200 wild fish. Approximately 20% of McKenzie wild fish spawn downstream from Leaburg Dam, hence, the Leaburg wild count can be considered a minimum estimate of population size. This additional spawning more than offsets the effects of prespawning mortality in maintaining actual spawner numbers approximately equivalent to the Leaburg Dam count.

Stock-recruitment function. - The lack of an extended time series of age-specific return data precludes estimation of a stock-specific Ricker function for McKenzie River wild spring chinook. Therefore, risks were estimated for low, average, and high production cases based on observed stock productivities for other Columbia Basin stream-type chinook populations. Stock productivities were defined based on the Ricker function a-value which averaged 1.2 and ranged from 0.6 to 2.1 for 21 spring and summer chinook populations from 1974 to 1990 brood years (Schaller et al. 1999, author unpublished). Ricker a-values of 0.7 and 2.0 used for modeling (Figure 3) include approximately 90% of the observations for these 21 populations. The 1974 to 1990 brood year period reflects productivity under current ocean and freshwater migration conditions. Ricker a-values averaged 2.51 and ranged from 1.29 to 3.44 for 13 populations prior to 1970 when favorable ocean conditions and fewer Columbia and Snake river mainstem dams provided for greater salmon survival

Carrying capacity of the McKenzie River for naturally-produced spring chinook was similarly unknown. The wild population is generally assumed to be less than fully-seeded based on historic observations of larger run sizes although the effects of development and impoundment of several tributaries are unclear. A sensitivity analysis type of approach was also applied to the replacement spawner abundance (P_r) value of the Ricker function. Equilibrium values of 3,000 and 5,000 were used to represent cases where the habitat is moderately and greatly under-seeded (Figure 3).

Natural survival rates. - Recruitment of wild adults to the spawning grounds for a given spawner number was based on the Ricker function. Recruits included all adults produced by a run-year spawner cohort for all age classes in which they returned. Recruitment was estimated in the absence of fishing, hence, fishing reduced the actual number of spawners. Observed natural mortality rates were used to partition survival into freshwater and ocean components and to estimate reproduction rate. Reproduction rate was defined as smolts per spawner (B) and was estimated such that:

$$R = R \cdot B\ (S_1 S_2, \ldots, S_n)$$

where

R = recruits,

B = smolt equivalent birth rate (smolts per spawner), and

$S_1 S_2, \ldots, S_n$ = Survival rates in the absence of fishing between smolt and adult spawner.

Thus,

$$B = 1/\ (S_1 S_2, \ldots, S_n)$$

Survival of juveniles during freshwater migration was assumed to be 100% in the absence of accurate data. However, the estimated numbers of wild smolts produced per spawner was randomly varied with an arbitrarily-selected 25% coefficient of variation to reflect variability in freshwater rearing survival conditions.

Average survival of smolts between ocean entry and recruitment to ocean fishing was estimated from hatchery smolt releases and combined wild and hatchery recruits to ocean fishing. Ocean recruits were total river mouth returns expanded for age-specific and year-specific total mortality rates in ocean fisheries. The aggregate wild and hatchery return was used because wild and hatchery fish could not historically be distinguished. The 1975 to 1993 brood year average rate of 1.67% was used to reflect productivity under current ocean and freshwater migration conditions (Figure 5). The estimate is based on the same period for which the range in stock-recruitment parameters was derived except 1974 brood year ocean harvest data were not available. This survival rate is a slight overestimate of the aggregate rate because no estimate of naturally-produced smolts is available. However, this may not introduce significant bias to simulations of the wild stock because survival rates are typically greater for wild than hatchery smolts.

Average natural mortality rates of adults at Willamette Falls were based on counts of carcasses downstream from the falls and systematic observations of sea lion predation. A minimum estimate of upstream survival rate between Willamette Falls and the spawning grounds was based on the proportion of fish counted at Willamette Falls ladder counts and subsequently observed upstream. Upstream observations included hatchery racks, Leaburg Dam, natural spawners in the McKenzie River downstream from Leaburg Dam, and estimated angler harvest upstream from Willamette Falls. This rate averaged 69.5% with a coefficient of variation of 11% from 1989 to 1998 where complete upriver harvest data was available from catch record cards returned by anglers (Figure 5). Data prior to 1989 (1983 brood years) was not included because changes in hatchery practices improved return of adults during the last ten years. This "conversion rate" is a minimum estimate of upstream survival because it does not account for natural spawning in tributaries other than the McKenzie River. Recent spawning ground surveys (Lindsay et al. 1997) suggest that these natural spawner account for less than 5% of the Willamette Falls count.

Approximate smolt-to-adult survival rates were randomly varied based on observed smolt to ocean recruit variability observed for 1975 to 1993 brood years. To capture apparent autocorrelation in smolt-to-adult survival rates, the value for the first year of each iteration was randomly selected from the 19-year time series of survival rates. Rates were then used in sequence for successive years until all 19 rates were used. Rates were selected from the start of the sequence after the 1993 rate was used to ensure that each year was weighted equally. A new starting rate was randomly selected after all 19 rates were used and the selection process was repeated. Hatchery and wild fish were subjected to the same pattern in ocean survival (i.e. when survival was good, it was good for both).

Maturation rates. - Proportions of a cohort returning at various ages were based on average proportions from estimated ocean recruits for 1985 to 1994 brood years. Average proportions were estimated from brood year rather than run year proportions. Complete cohort return data (through age 6) was available for brood years 1968 to 1994 but more recent returns included a greater proportion of age 5 fish, perhaps because of improvements in hatchery practices.

Ocean harvest rates. - Age-specific ocean harvest rate data were available for run years 1978-98 based on coded wire tag recoveries of hatchery Willamette spring chinook in ocean fisheries. Significant numbers of Willamette spring chinook are harvested in southeast Alaska and North Central British Columbia fisheries but avoid most Washington and Canada fisheries because of their early run timing. Ocean harvest rates were total mortality estimates which included reported catch and incidental mortality. Ocean harvest rates in future years were modeled at 12% per year with a 35% coefficient of variation based on the most recent 10 years of available ocean harvest rate data (1984 to 1993 brood years). Recent ocean harvest rates of 5-10% were less than the historic average, but future ocean fishing rates were assumed to rebound from recent levels. Age-specific harvest rates equivalent to the average rate were estimated using age-specific scalars based on recent 10-year average brood year data for which complete cohort data were available (1984 to 1993).

Model Calibration

The need for model calibration was examined by comparing the predicted average and standard deviation of total Columbia River run size in 30-year simulations with the actual average and standard deviation in run size from 1970 to 1998. Simulations of historic conditions were based on brood year 1975 to 1990 ocean fishing rates which averaged 18% with a coefficient of variation of 40% and freshwater harvest rates based on a Willamette Basin fish management plan in effect before 1998.

Fishing Strategies

Fishing strategies were compared to a no-fishing option to identify the relative effects of various alternatives (Figure 6). Harvest rates included all freshwater sport and commercial fisheries in the Willamette Basin and lower Columbia River. Total harvest rate on McKenzie-destined chinook was apportioned between the area from the Columbia River mouth and Willamette Falls and the area upstream from the falls based on 1992 to 1996 angler catch record card estimates of harvest in the McKenzie River and Willamette mainstem upstream from Willamette Falls and roving angler survey harvest estimates in the lower Willamette and Columbia river mainstems. Approximately one-tenth of the total impact occurred in the upstream area.

Alternative fishing strategies included past practice, the current state of Oregon spring chinook management plan, and a variety of fixed harvest rate and fixed escapement alternatives. Past practice and the current plan are variable harvest rate strategies where harvest rates are reduced at low run sizes. A Willamette Basin fish management plan in effect before 1998 managed for a 27,000 to 30,000 falls escapement minimum at runs less than 70,000 and increased escapement at larger run sizes (Figure 6). Current practice is based on a revised management plan which reduces harvest rates at runs between 30,000 and 90,000 Maximum harvest rates under the past and proposed plans were limited to historic maximum rates of 41.5% which reflect the inability of sport fisheries to catch surplus fish at large run sizes.

Fixed harvest rate strategies included 5%, 10%, 15%, 20%, and 40%. The 40% fixed rate is near the maximum freshwater rate observed since 1980 (45%). The 5% fixed rate is comparable to a expected incidental impact rate on wild fish in sport fisheries limited to marked hatchery fish. All five million hatchery fish were marked by removal of the adipose fin beginning with the 1997 brood and year 2002 sport fisheries are expected to be for marked hatchery fish only. A fixed escapement strategy was based on a 30,000 fish escapement goal for Willamette Falls which is the upriver escapement needed to provide fisheries and ensure adequate hatchery broodstock returns. This escapement would produce approximately 1,000 wild spawners to Leaburg Dam. A 50,000 fish escapement goal strategy was also evaluated. Finally, we also explored the effects of a fixed escapement goal equivalent to our proposed population viability standard of 50% of the spawners at habitat capacity. This numerical goal varied based on population productivity and capacity as defined by Ricker parameter values (Table 3).

Freshwater harvest rates were randomly varied about target values to reflect uncertainty in run size forecasts upon which harvest quotas are based. A coefficient of variation of 20% was equivalent to the estimated uncertainty in the 1999 run size forecast based on a series of cohort regression estimates.

Results

Simulation results were similar to actual run sizes when the model was parameterized with historic harvest and natural mortality rates. Total run size to freshwater ranged from 26,000 to 144,000 and averaged 79,000 with a variation coefficient of 40% in 100-year simulations (Figure 7). Actual run size ranged from 34,800 to 130,600 and averaged 69,700 with a variation coefficient of 37% during the 19-year period from 1970 to 1998. The use of autocorrelated natural survival rates in the ocean produced more variable results than were obtained with random normal variation (CV's of 40% versus 33%).

Model results suggest that the wild McKenzie River population was at a measurable, albeit significant risk (31%) of falling below 300 spawners under the old Willamette Plan fishing schedule if the stock were unproductive ($a = 0.7$) and the habitat capacity expressed as replacement spawner abundance (P_r) was near 3,000 (Table 4). The risk declined to only 0.2% if the habitat capacity was large ($P_r = 10{,}000$). The old plan provided little chance of seeing large escapements near the replacement abundance or average escapements exceeding 50% of the carrying capacity unless the stock was highly productive.

Willamette Plan revisions which reduce harvest rates at intermediate run sizes, substantially reduce the chances of falling below 300 spawners in any given year (Table 4). "Quasi-extinction risk" falls to 4% in the unproductive/low habitat capacity case and to 0.1% or less if the wild population is more productive or the habitat capacity is large. Unless stock productivity is large, the new harvest plan continues to provide little chance in any given year of seeing large run sizes which could be monitored to resolve questions of stock productivity and habitat carrying capacity. The revised Willamette Plan will also result in average escapements of less than 50% of the habitat capacity.

Freshwater harvest rate strategies equivalent to a fixed rate of 15% or less were necessary to minimize low-run-size risks, produce large run sizes, and maintain average escapements at or above 50% of the habitat capacity under conservative assumptions of productivity and habitat capacity. Equivalent rates reduce low run size risk to 0.1% or less while also ensuring a reasonable chance (>10%) of large escapements in some years, and a minimum assurance (50%) that average spawner number will exceed the population viability goal. For a productive population (a = 2.0), low run size risks did not exceed 3% even at extreme fishing options such as the fixed 30,000 falls escapement alternative.

Several different fishing strategies provided equivalent risks. For instance, the revised Willamette Plan which closed freshwater harvest at low run sizes and gradually increased harvest rate as run size increased, produced similar low and high run size probabilities as a flat harvest rate option of approximately 30% for all run sizes and as a fixed escapement option of just under 50,000 fish at Willamette Falls. However, different fishing strategies provided very different fishing opportunities. At low run sizes, the flat rate catches were too small to provide significant fishery benefits. The fixed escapement strategy provided sporadic fisheries which were closed during low to intermediate run years and produced large hatchery surpluses in intermediate to high run years. A mixed, abundance-based approach similar to the revised Willamette Plan generally optimized fishery benefits by foregoing harvest in low run size years in exchange for increased harvest rates in intermediate run size years.

The average future wild population size depended on the balance between stock productivity, habitat capacity, and fishing mortality rate. Higher stock productivity, higher habitat capacity, and lower fishing mortality produced higher average numbers (Table 4). In high productivity populations, high harvest rates on big runs actually increased average population size by avoiding the descending limb of the stock-recruitment function. Fishing strategies which reduced low run size frequency and increased large run size frequency also produced larger average population sizes. Extinction risk was 1% or less as long as equilibrium stock levels exceeded 800 spawners even under low productivity assumptions. All examples where "recovery" probability exceeded 5% within 30 years were accompanied by quasi-extinction risks of less than 1% (Figure 8).

Discussion

This risk assessment for the wild spring chinook salmon population in Oregon's McKenzie River indicates that small population size risks are substantially reduced but not eliminated by a newly-adopted harvest plan which is more conservative than the historic strategy. Under historic harvest rates which averaged 18% in the ocean and 40% in freshwater, the McKenzie wild population was at a 31% risk of falling below 300 spawners in some years based on worst case assumptions of population productivity and capacity. This finding is consistent with observed patterns of distribution of wild spring chinook salmon throughout the Willamette Basin. The McKenzie population persists while other apparently smaller and less productive populations in fragmented or degraded habitats appear to have been extirpated.

The wild McKenzie River population can sustain limited harvest but freshwater harvest rates greater than 15% do not provide for substantial increases in wild escapement over current levels. Target wild escapement and recovery goals cannot be identified for the McKenzie population because stock-specific production data under current conditions is not available. Escapements above Leaburg Dam prior to 1994 included returns of hatchery-reared fish which were released into natural production areas for brood years through 1988. Natural production levels could not be estimated from historic data because hatchery and wild fish could not be distinguished. Now that hatchery plants have been discontinued above Leaburg Dam and all returning hatchery fish are marked, future monitoring will provide information on the natural stock-recruitment relationship. Large escapements in at least some years would facilitate exploration of habitat capacity and stock productivity. The newly-adopted harvest plan does not provide a wide range of wild escapements over the long term.

Simulations suggest that fishing rates substantially greater than 15% can substantially reduce survival and recovery probabilities for unproductive wild populations; however, simulations also suggest that there would be little conservation benefit to reducing fishing rates to below 15%. At rates less than 15%, the fishing rate has a relatively minor affect on survival and recovery probabilities. Risks are not sensitive to low fishing rates at small population sizes because too few fish are affected to significantly impact the long term prospects of the depleted population. Sensitivity analyses suggest that this result is true regardless of population productivity and survival variability assumptions, although effects are more pronounced for smaller initial population sizes, less productive populations, and increased variation in natural mortality rates.

Model results suggest that planned selective fisheries for adipose fin-marked hatchery fish (with required release of unmarked wild fish) which would reduce fishery impact to less than 5%, will reduce small population risks to negligible levels and will provide for large wild escapements even under the most pessimistic of productivity assumptions. The low expected impact rates in selective fisheries would allow for continued commercial spring chinook fisheries in the lower Columbia River where combined average annual impacts do not exceed the 15%.

Simulations also suggest that a variety of fishing strategies provide similar stock protection and rebuilding benefits but that an "abundance-based" approach may optimize fishery benefits. The newly-adopted Willamette plan is an example of an abundance-based approach where fishing is curtailed at low run sizes and harvest rate increases with increasing run size. Fishery managers thus have significant flexibility to shape fisheries to access surplus hatchery fish and optimize allocation among user groups within the constraints posed by the weak stock. The key constraint is the need to provide sufficient buffer for the wild stock to prevent chance variation from dropping the population size below some critical threshold. It is not necessary to manage for "full seeding" in every or even any years to ensure the longevity of the wild McKenzie River spring chinook population.

The sensitivity of the model population to stock-recruitment parameters for productivity and habitat capacity confirms that population "health" must be defined in terms of both spawner escapement number and intrinsic population productivity. Clearly, a population with small annual spawning escapements is at risk. However, even a population with large average spawning escapements associated with a large habitat capacity and a high Ricker beta can be at risk if intrinsic productivity is too low to ensure spawner replacement. Emlen (1995) noted that manipulations of Ricker beta are likely to have little effect on persistence versus extinction, but considerable influence on population size. Many large-capacity but low-productivity populations such as Snake River fall chinook salmon are threatened or endangered while other low-capacity high-productivity populations such as Deschutes River spring chinook remain stable. Recovery efforts for weak stocks which increase intrinsic stock productivity pose a greater likelihood of long-term success than recovery efforts aimed merely at building up a large number of spawners to buffer against small population sizes. The productive stock rebounds quickly from low numbers whereas the unproductive stock remains depressed and vulnerable to further perturbations.

Productivity of the wild McKenzie River population has likely been depressed by past management practices including introductions of hatchery-origin fish in natural spawning areas and changes in flow and temperature regimes from tributary water storage reservoirs. Improvements in natural stock productivity like those expected with the elimination of hatchery releases in the McKenzie will significantly increase the likelihood of wild stock survival and rebuilding. Habitat improvement measures such as those that increase juvenile spawning and rearing success will have similar benefits.

A key assumption in the assessment of fishery risks involved productivity of the stock. Errors in estimates of natural survival rates through portions of the life cycle result in mispartitioning of the mortality schedule rather than large changes in absolute risk values. Nevertheless, the model works best in a comparative rather than absolute sense. Absolute estimates of probabilities are affected by errors in parameterization but the relative ranking of risks and benefits of the fishing alternatives does not change.

This population viability analysis provides a conservative assessment of numerical extinction risks because of several conservative assumptions including use of the population viability threshold of 300 as a quasi-extinction level rather than an actual extinction level. Simulations also assumed strong depensation in the stock-recruitment relationship at spawner numbers less than 300 when these factors may not become significant until much smaller numbers. The range of productivity estimates used to develop bounds for testing was drawn heavily from Columbia and Snake River populations which are heavily influenced by hydrosystem mortality to which the Willamette population is not exposed. Finally, simulations assume extended periods of poor average ocean survival like those prevalent since the mid-1970's, rather than the more favorable average patterns observed historically.

The conservative modeling approach is somewhat balanced by the difficulty of including large scale population and ecosystem processes. Several potentially significant processes could not be modeled because we lack the information for describing and parameterizing the functional relationships. For instance, large run sizes may provide opportunities for recolonization of other areas and the restoration of the historic metapopulation stock structure. Large run sizes might also improve productivity through nutrient enrichment or by providing greater opportunities for evolutionary genetic changes. The importance and benefits of such processes warrant further exploration but do not currently provide a firm basis for use in fishery management decisions. Managers should consider other avenues for investigating ecosystem processes such as direct experimentation.

Even with accurate stock productivity and carrying capacity data, development of an escapement or recovery goal can be fraught with value judgments regarding what constitutes an optimum level. Past management practices have identified a variety of potential target reference points such as maximum sustained yield, maximum production, and replacement spawner abundance (Caddy and McGarvey 1996). The weak stock management imperative suggests the need for a limit reference point that ensures survival of the stock or species. This paper used 300 spawners as a "critical population threshold" below which recovery of the population could not be assured.

Population viability standards equivalent to 50% of the habitat capacity easily exceed the ESA recovery standard of not endangered with extinction or likely to become endangered within the foreseeable future. Quasi-extinction risks were minimal in all simulations where the probabilities of the average escapement meeting the population viability standard even approached 50%. Our definition of habitat capacity was based on the smaller of replacement spawner abundance or spawner number at maximum recruitment. This definition rightly reflects the interaction of abundance and productivity on extinction and recovery risks. Because of their inherent resilience, more productive populations should be considered "recovered" at lower average population sizes than less productive populations.

Despite the lack of detailed data on wild stock productivity, this population viability analysis provides a systematic basis for capturing assumptions and considering management alternatives. Analyses have resolved several fundamental questions in debates over appropriate harvest rates including how often the population would fall below the 300 fish minimum conservation threshold (only if unproductive and high fishing levels) and whether new harvest plans provide for rebuilding even under pessimistic productivity assumptions (they don't). Where significant questions remain, the model provides testable hypotheses to assist in resolution. For instance, the model predicts rapid rebuilding under conditions of high productivity or significant underseeding relative to a 5,000 fish habitat capacity. If we don't see large increases under more conservative fishing rates, then we can reject some of the less realistic assumptions and focus on actions which more directly address limitations on stock productivity.

Acknowledgments

Steve King, Craig Foster, Pat Frazier, Don McIsaac, Curt Melcher, Tom Nickelson, Mark Wade, and Shijie Zhou, all of the Oregon Department of Fish and Wildlife, provided data, background information, and constructive comments on methods and draft manuscripts. Steve King was particularly supportive in encouraging the development of this approach and in applying it to Oregon salmon management.

References

Brown, B. E. and G. P. Patil. 1986. Risk analysis in the Georges Bank haddock fishery - a pragmatic example of dealing with uncertainty. North American Journal of Fisheries Management 6:183-191.

Burgman, M. A., S. Ferson, and H. R. Akçakaya. 1993. Risk assessment in conservation biology. Chapman and Hall, London.

Caddy, J., F., and R. McGarvey. 1996. Targets or limits for management of fisheries? North American Journal of Fisheries Management 16:479-487.

Chilcote, M. W. 1998a. Conservation status of lower Columbia River coho salmon. Oregon Department of Fish and Wildlife Information. Unpublished report. Portland.

Chilcote, M. W. 1998b. Conservation status of steelhead in Oregon. Oregon Department of Fish and Wildlife Information Report 98-3. Portland.

Emlen, J. M. 1995. Population viability of the Snake River chinook salmon (Oncorhynchus tshawytscha). Canadian Journal of Fisheries and Aquatic Sciences 52:1442-1448.

Hilborn, R., and C. J. Walters. 1992. Quantitative fisheries stock assessment: choice, dynamics, and uncertainty. Chapman and Hall, New York.

Kapuscinski, A. R., and L. D. Jacobson. 1987. Genetic guidelines for fisheries management. Sea Grant Research Report 17, St Paul, Minnesota.

Lande, R., and G. F. Barrowclough. 1987. Effective population size, genetic variation, and their use in population management. Pages 87 to 123 in M. Soulé, editor. Viable populations for conservation. Cambridge University Press, Cambridge.

Lindsay, R. B., K. R. Kenaston, R. K. Schroeder, J. T. Grimes, M. G. Wade, K. Homolka, and L. Borgerson. 1997. Spring chinook salmon in the Willamette and Sandy Rivers. Oregon Department of Fish and Wildlife Annual Research Project Report F-163-R-01, Portland.

Lindsay, R. B., R. K. Schroeder, and K. R. Kenaston. 1998. Spring chinook salmon in the Willamette and Sandy Rivers. Oregon Department of Fish and Wildlife Annual Research Project Report F-163-R-01, Portland.

Lynch, M. 1996. A quantitative-genetic perspective on conservation issues. Pages 471 to 501 in J. C. Avise and J. L. Hamrick, editors. Conservation genetics case histories from nature.

McElhany, P., M. H. Rucklelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Technical Memorandum NMFS-NWFSC-42. Seattle.

Nelson, K, and M. Soulé. 1987. Genetic conservation of exploited fishes. Pages 345 to 368 in N. Ryman and F Utter, editors. Population genetics and fishery management. University of Washington, Seattle.

Nickelson, T. E., and P. W. Lawson. 1998. Population viability of coho salmon, Oncorhynchus kisutch, in Oregon Coastal Basins: application of a habitat-based life-cycle model. Oregon Department of Fish and Wildlife. *In review for publication.*

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of the Fisheries Research Board of Canada 191.

Schaller, H. A., C. E. Petrosky, and O. P. Langness. 1999. Contrasting patterns of productivity and survival rates for stream-type chinook salmon (*Oncorhynchus tshawytscha*) populations. Canadian Journal of Fisheries and Aquatic Sciences 56:1031-1045.

Waples, R. S. 1990. Conservation genetics of pacific salmon. II. Effective population size and the rate of loss of genetic variability. Journal of Heredity 81:267-276.

Table 1. Definitions of initial-state and driving variables in a model of fishing risks for Willamette spring chinook salmon. The parameters p1, ..., p34 are defined in Table 2.

Variable	Definition	Equation number
o	Origin (H = hatchery, W = wild)	
y	Year (1, ..., N)	
x	Age (1, ..., 6)	
NJ_{Hy}	Number of juvenile hatchery fish released = p12 + VNJy	1
VNJy	Normal variation in hatchery release number $\sim N[0, (p12\ p13)^2]$	2
NJ_{Wxy}	Number of juvenile wild fish migrating to the ocean $= p9\ NS_{Wxy}\ EXP(p7(1 - NS_{Wxy}/p8))\ rB$	3
rB	Birth rate expressed as smolts per recruit = p10 + VrB	4
VrB	Normal variation in birth rate $\sim N[0, (p10\ p11)^2]$	5
MJ_{oxy}	Number of juvenile fish dying during migration $= NJ_{Wxy}(1 - p14)$	6
NO_{oxy}	Number of juvenile fish surviving freshwater migration ro reach the ocean $= NJ_{Wxy} - NO_{oxy}$	7
MO_{oxy}	Number dying of natural causes in the ocean $= NO_{oxy}(1 - rO)$	8
rO	Ocean survival rate = p15 + VrO	9
VrO	Normal variation in ocean survival rate $\sim N[0, (p15\ p16)^2]$	10
NR_{oxy}	Number recruiting to ocean fisheries $= [(p18, p19, p20, \text{or } p21)\ NO_{oxy}] - MO_{oxy}$	11
HO_{oxy}	Number harvested in ocean fisheries $= NR_{oxy}\ rOH_{xy}$	12
rOH_{xy}	Age-specific ocean harvest rate = (p24, p25, p26, or p27) (p22 + VrOH)	13
VrOH	Normal variation in ocean harvest rate $\sim N[0, (p22\ p23)^2]$	14
NC_{oxy}	Number surviving ocean fisheries to return to freshwater $= NR_{oxy} - HO_{oxy}$	15
HF_{oxy}	Number harvested in lower Columbia and Willamette river fisheries $= (NC_{oxy})(rHF)$	16
rHF	Harvest rate in lower Columbia and Willamette river fisheries = p30 + VrHF	17

VrHF	Normal variation in freshwater harvest rate $\sim N[0, (p30\ p31)^2]$	18
NT_{oxy}	Number turning off into Clackamas River $= p28\ (NC_{oxy} - HF_{oxy})$	19
MF_{oxy}	Number dying of natural causes and sea lion mortality downstream from Willamette Falls $= (NC_{oxy} - HF_{oxy} - NT_{oxy})(1 - p29)$	20
NF_{oxy}	Number surviving to pass over Willamette Falls fish ladder $= NC_{oxy} - HF_{oxy} - NT_{oxy} - MF_{oxy}$	21
HU_{oxy}	Number harvested in upper Willamette River sport fisheries $= (NF_{oxy})\ (rHF)\ (p32)$	22
MW_{oxy}	Number unaccounted fish above Willamette Falls $= (NF_{oxy} - HU_{oxy})\ (1 - rUC)$	23
rUC	Upstream surival or conversion rate $= p33 + VrUC$	24
VrUC	Normal variation in upstream survival rate $\sim N[0, (p33\ p34)^2]$	25
NS_{Wxy}	Number escaping to spawn in McKenzie River natural production areas $= (NF_{oxy} - HU_{oxy})\ (rUC)$	26

Table 2. Definitions and values of initial state variables and parameters used in equations (see Table 1) for a model of fishing risks for Willamette spring chinook salmon.

Symbol	Variable or parameter	Value
*p*1	Starting wild population year 1 - 6	933
*p*2	Starting wild population year 1 - 5	1,105
*p*3	Starting wild population year 1 - 4	991
*p*4	Starting wild population year 1 - 3	1,415
*p*5	Starting wild population year 1 - 2	1,383
*p*6	Starting wild population year 1 - 1	2,000
*p*7	Ricker a value	0.7, 1.2, or 2.0
*p*8	Ricker P_r	3,000 or 5,000
*p*9	Depensation at low run sizes	Strong
*p*10	Smolts / spawner	88.0
*p*11	Smolt / spawner CV	0.25
*p*12	Annual hatchery releases	5,300,000
*p*13	Annual hatchery releases CV	0.06
*p*14	Juvenile migration survival	1.00
*p*15	Smolt to adult survival	0.0167
*p*16	Smolt to adult survival CV	0.45
*p*17	Smolt to adult survival autocorrelated	Yes
*p*18	Maturation rate age 3	0.04
*p*19	Maturation rate age 4	0.43
*p*20	Maturation rate age 5	0.52
*p*21	Maturation rate age 6	0.01
*p*22	Ocean harvest rate	0.12
*p*23	Ocean harvest rate CV	0.35
*p*24	Ocean harvest age 3 scalar	0.24
*p*25	Ocean harvest age 4 scalar	0.85
*p*26	Ocean harvest age 5 scalar	1.15
*p*27	Ocean harvest age 6 scalar	1.33
*p*28	Clackamas turnoff	0.20
*p*29	Falls passage survival	0.979
*P*30	Freshwater harvest rate	Based on strategy
*p*31	Freshwater harvest rate CV	0.20
*p*32	Harvest rate proportion above Falls	0.10
*p*33	Upstream conversion survival	0.695
*p*34	Upstream conversion survival CV	0.11
Y	Years to run	30
I	Iterations	1,000

[a] *See Table 1.*

Table 3. Ricker equation stock-recruitment parameters (Ricker 1975) for hypothetical spring chinook populations used in simulations.

	Low Capacity			High Capacity		
Parameter	Low Productivity	Medium Productivity	High Productivity	Low Productivity	Medium Productivity	High Productivity
a	0.7	1.2	2	0.7	1.2	2
Pr	3,000	3,000	3,000	5,000	5,000	5,000
beta	0.00023	0.00040	0.00067	0.00014	0.00024	0.00040
alpha	2.01375	3.32012	7.38906	2.01375	3.32012	7.38906
Rm	3,175	3,054	4,078	5,292	5,089	6,796
Pm	4,286	2,500	1,500	7,143	4,167	2,500
Rs	1,996	2,523	3,887	3,326	4,205	6,478
Ps	1,362	1,256	1,082	2,269	2,093	1,804
Us	0.32	0.50	0.72	0.32	0.50	0.72
0.5*Pm	2,143	1,250	750	3,571	2,083	1,250
0.5 * Pr	1,500	1,500	1,500	2,500	2,500	2,500
"Pv"	1,500	1,250	750	2,500	2,083	1,250
"Rv"	2,129	2,517	3,361	3,548	4,195	5,602
"Uv"	0.295	0.503	0.777	0.295	0.503	0.777

Table 4. Effects of fishing on quasi-extinction risk based on the probability of fewer than 300 natural spawners, probability of returns exceeding 75% of the assumed replacement abundance (P_r), average spawner number in during the last 8 simulation years, and probability of last 8-year average run size exceeding 50% of basin capacity for low (a = 0.7), average (a = 1.2), and high (a = 2.0) productivity spring chinook stocks. Fishing options are sorted by increasing risk.

	$P_r = 3{,}000$			$P_r = 5{,}000$		
Fishing Option	*a = 0.7*	*a = 1.2*	*a = 2.0*	*a = 0.7*	*a = 1.2*	*a = 2.0*
		Quasi-extinction risk				
No inriver fishing	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Harvest rate fixed at 5%	<0.001	<0.001	0.004	<0.001	<0.001	<0.001
Harvest rate fixed at 10%	<0.001	<0.001	0.003	<0.001	<0.001	<0.001
Harvest rate fixed at 15%	<0.001	<0.001	0.002	<0.001	<0.001	<0.001
Harvest rate fixed at 20%	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Falls esc. fixed at 50,000	0.008	0.001	<0.001	0.002	<0.001	<0.001
Revised Willamette Plan	0.039	0.001	<0.001	0.009	<0.001	<0.001
Harvest rate fixed at 40%	0.050	0.001	<0.001	0.013	<0.001	<0.001
Old Willamette Plan	0.314	0.013	0.002	0.197	0.004	0.002
Falls esc. fixed at 30,000	0.437	0.071	0.022	0.358	0.038	0.021
		Large run size probability				
No inriver fishing	0.346	0.464	0.513	0.294	0.433	0.510
Harvest rate fixed at 5%	0.303	0.429	0.503	0.248	0.394	0.502
Harvest rate fixed at 10%	0.258	0.393	0.493	0.197	0.363	0.491
Harvest rate fixed at 15%	0.210	0.357	0.481	0.147	0.325	0.478
Harvest rate fixed at 20%	0.160	0.313	0.464	0.104	0.277	0.461
Harvest rate fixed at 40%	0.022	0.145	0.346	0.004	0.122	0.335
Falls esc. fixed at 50,000	0.008	0.111	0.387	0.001	0.073	0.347
Revised Willamette Plan	0.004	0.052	0.251	<0.001	0.032	0.224
Old Willamette Plan	0.001	0.120	0.155	<0.001	0.006	0.146
Falls esc. fixed at 30,000	<0.001	0.003	0.082	<0.001	0.001	0.064
		Average spawner number in years 22 to 30				
No inriver fishing	2,290	2,440	2,490	3,800	4,250	4,180
Harvest rate fixed at 5%	2,070	2,390	2,480	3,470	3,990	4,090
Harvest rate fixed at 10%	1,920	2,290	2,350	3,060	3,810	3,950
Harvest rate fixed at 15%	1,700	2,190	2,360	2,760	3,660	3,890
Harvest rate fixed at 20%	1,490	2,010	2,290	2,400	3,320	3,770
Falls esc. fixed at 50,000	860	1,590	2,080	1,310	2,580	3,400
Harvest rate fixed at 40%	660	1,390	1,940	980	2,340	3,200
Revised Willamette Plan	540	1,280	1,890	780	2,080	3,070
Old Willamette Plan	200	820	1,570	300	1,320	2,600
Falls esc. fixed at 30,000	100	550	1,220	150	840	1,920
		Probability of "recovery" within 30 years				
No inriver fishing	0.85	0.98	1.00	0.84	0.99	1.00
Harvest rate fixed at 5%	0.73	0.98	1.00	0.72	0.99	1.00
Harvest rate fixed at 10%	0.65	0.98	1.00	0.63	0.97	1.00
Harvest rate fixed at 15%	0.52	0.96	1.00	0.50	0.95	1.00
Harvest rate fixed at 20%	0.41	0.92	1.00	0.38	0.92	1.00
Falls esc. fixed at 50,000	0.01	0.88	1.00	0.01	0.86	1.00
Harvest rate fixed at 40%	0.02	0.51	1.00	<0.01	0.48	1.00
Revised Willamette Plan	<0.01	0.50	1.00	<0.01	0.45	1.00
Old Willamette Plan	<0.01	0.04	0.99	<0.01	0.03	1.00
Falls esc. fixed at 30,000	<0.01	<0.01	0.88	<0.01	<0.01	0.85

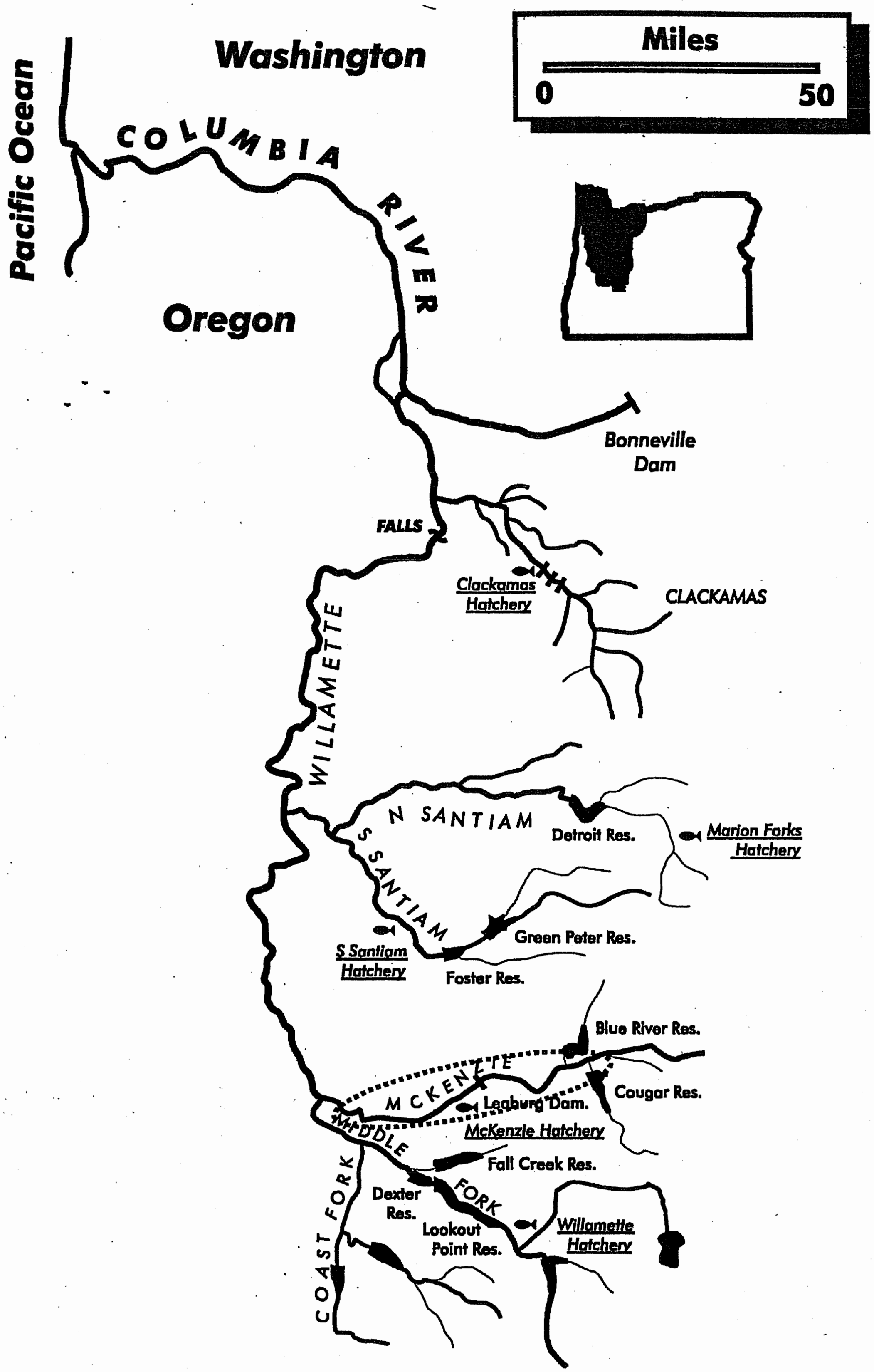


Figure 1. Willamette River basin spring chinook production areas. McKenzie River natural production area is circled.

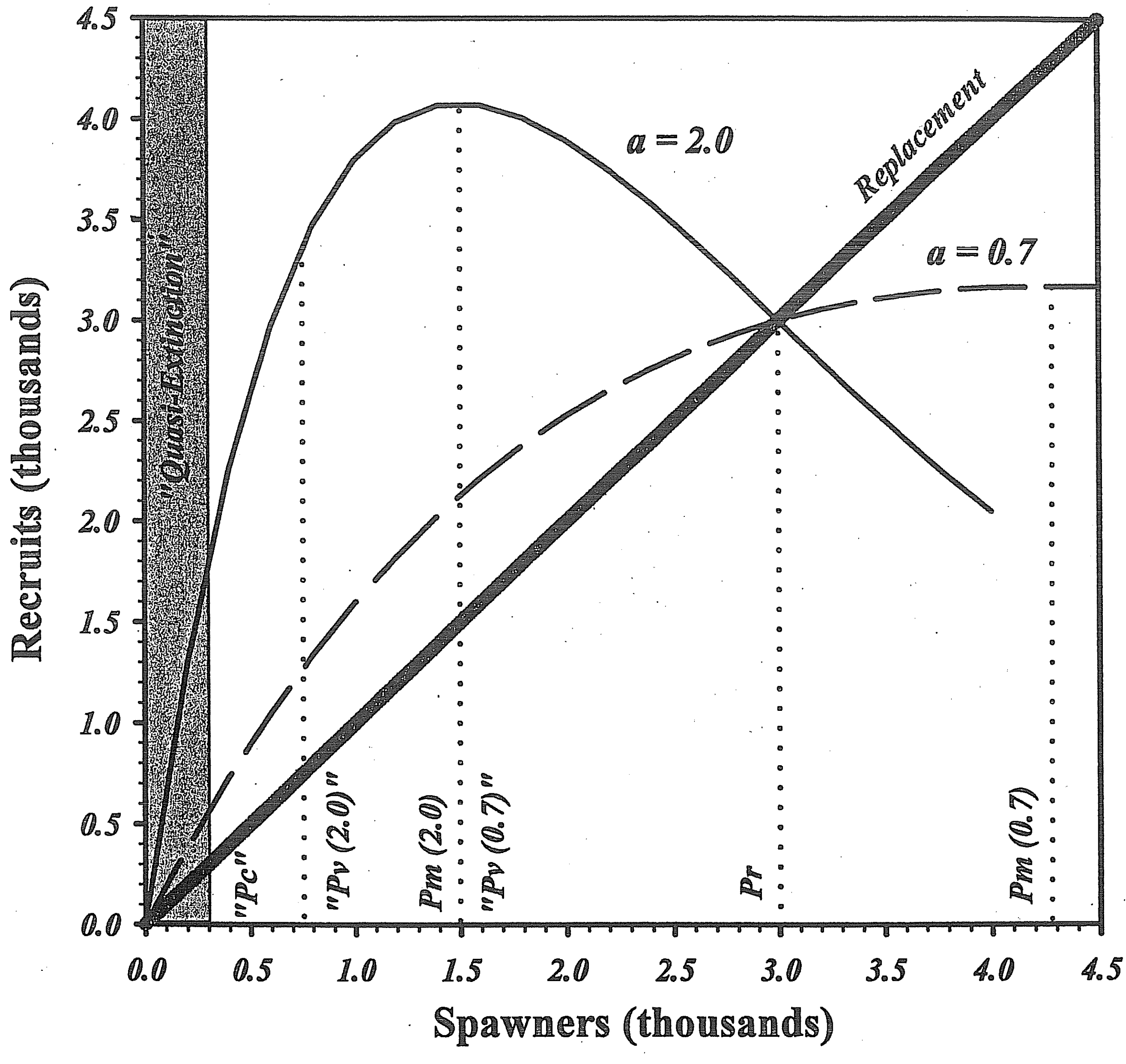


Figure 2. Hypothetical Ricker stock-recruitment relationship for productive (a = 2.0) and unproductive (a = 0.7) populations depicting spawner numbers at replacement (Pr), maximum recruitment (Pm), proposed critical population size ("Pc"), and proposed population viability thresholds ("Pv").

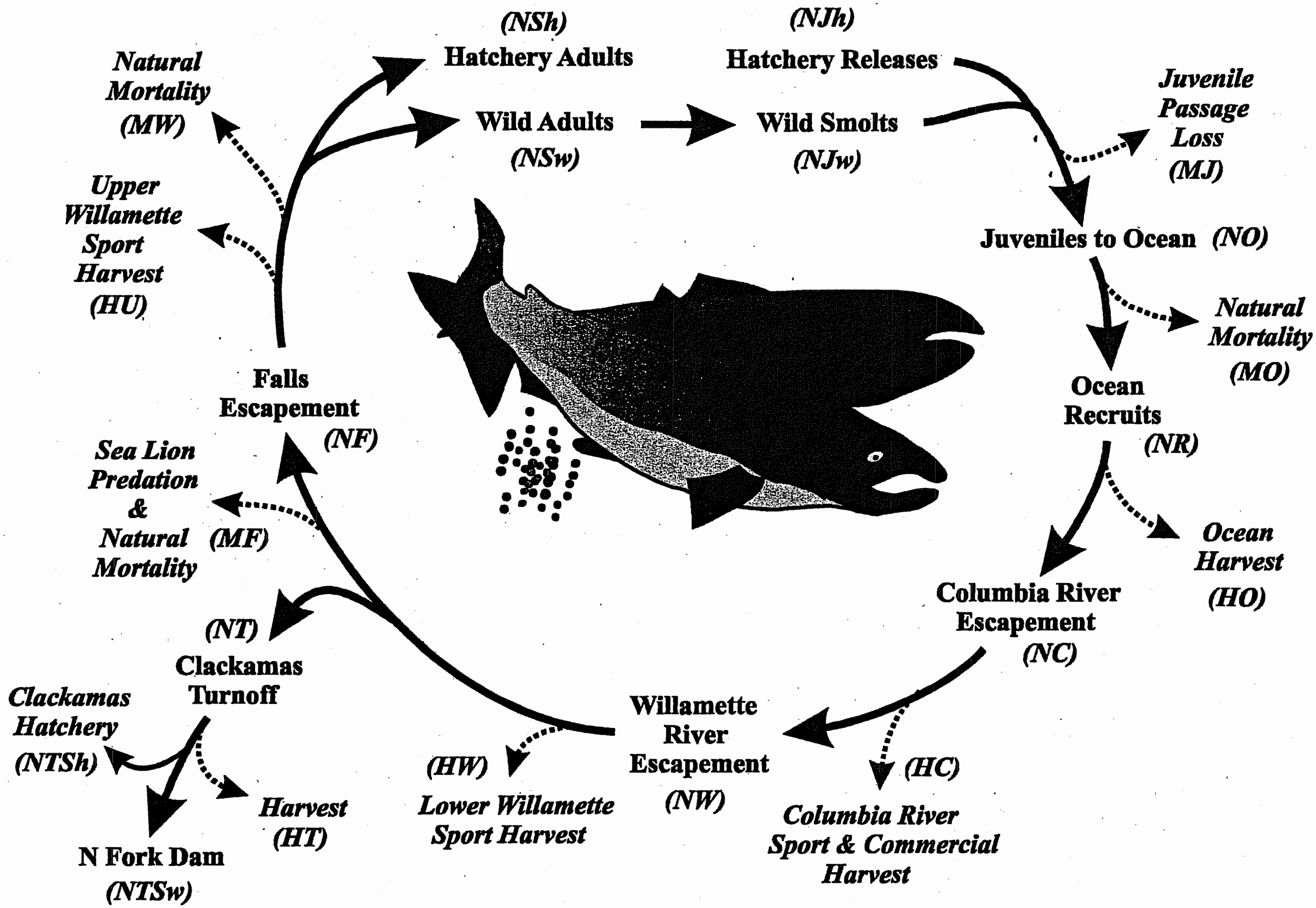


Figure 3. Conceptual model of Willamette spring chinook salmon life cycle including state variable denotations.

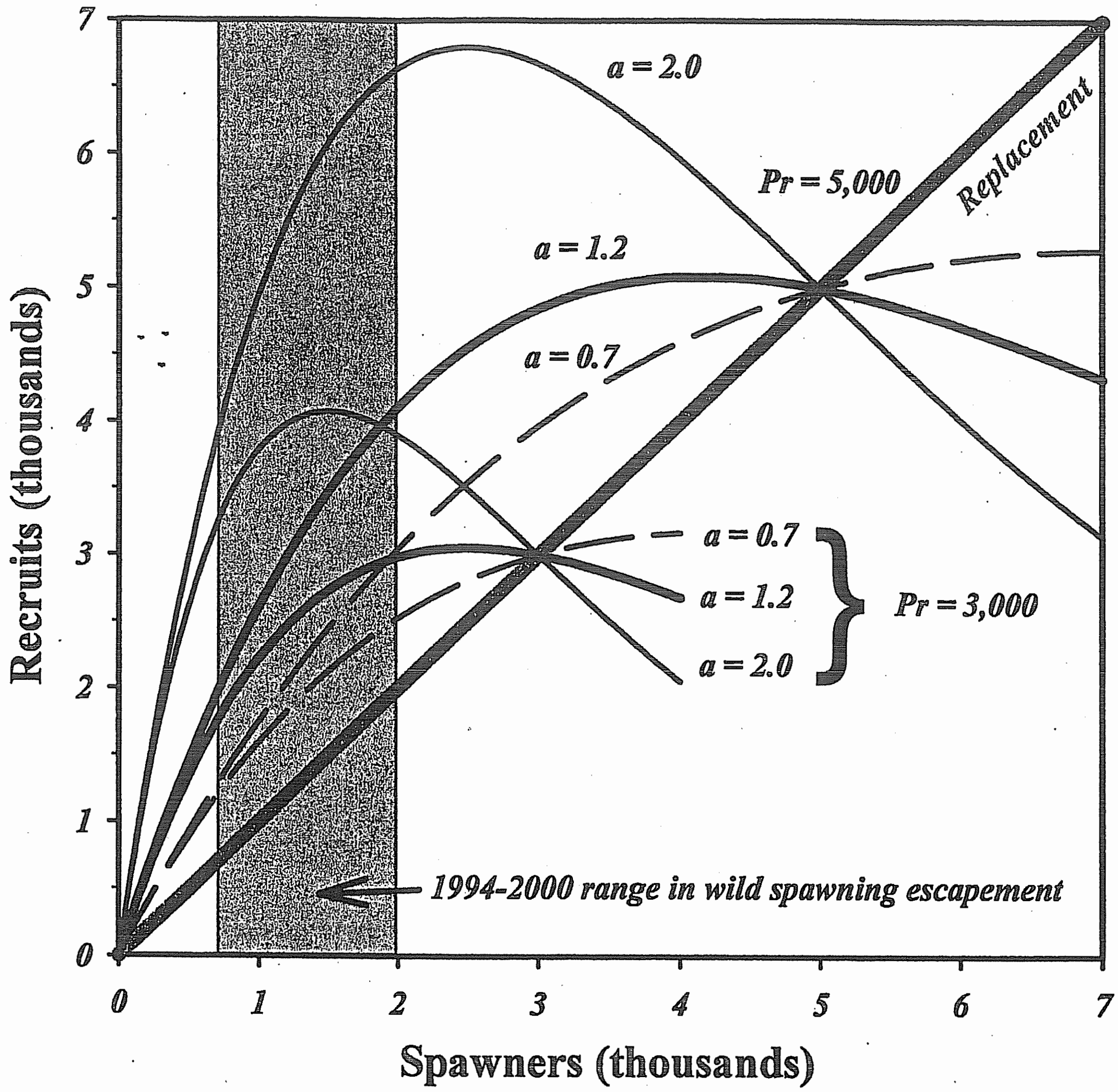


Figure 4. Ricker spawner-recruit functions for which fishing effects were evaluated.

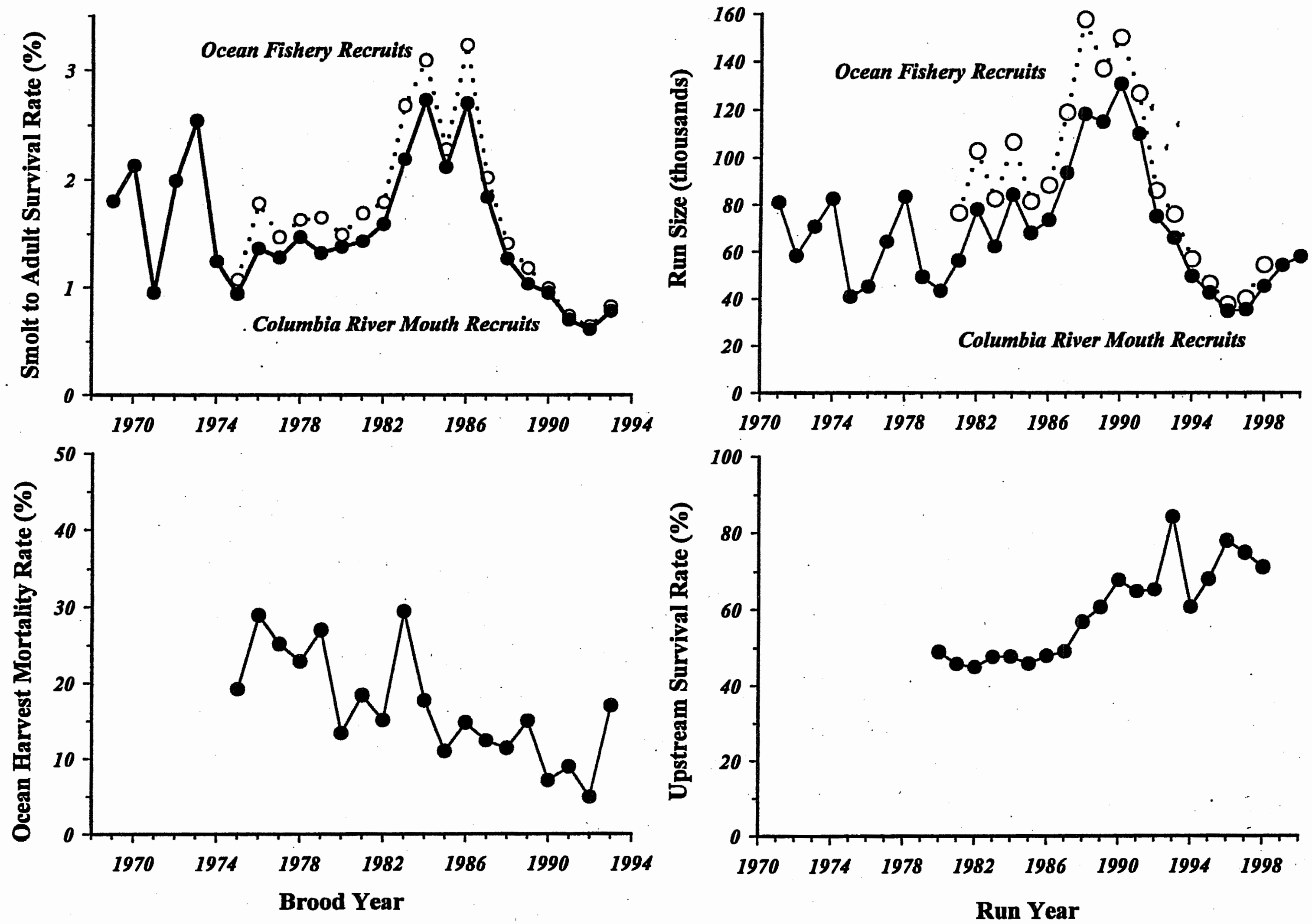


Figure 5. Annual numbers, survival rates, and mortality rates for Willamette River spring chinook used as the basis for population simulations.

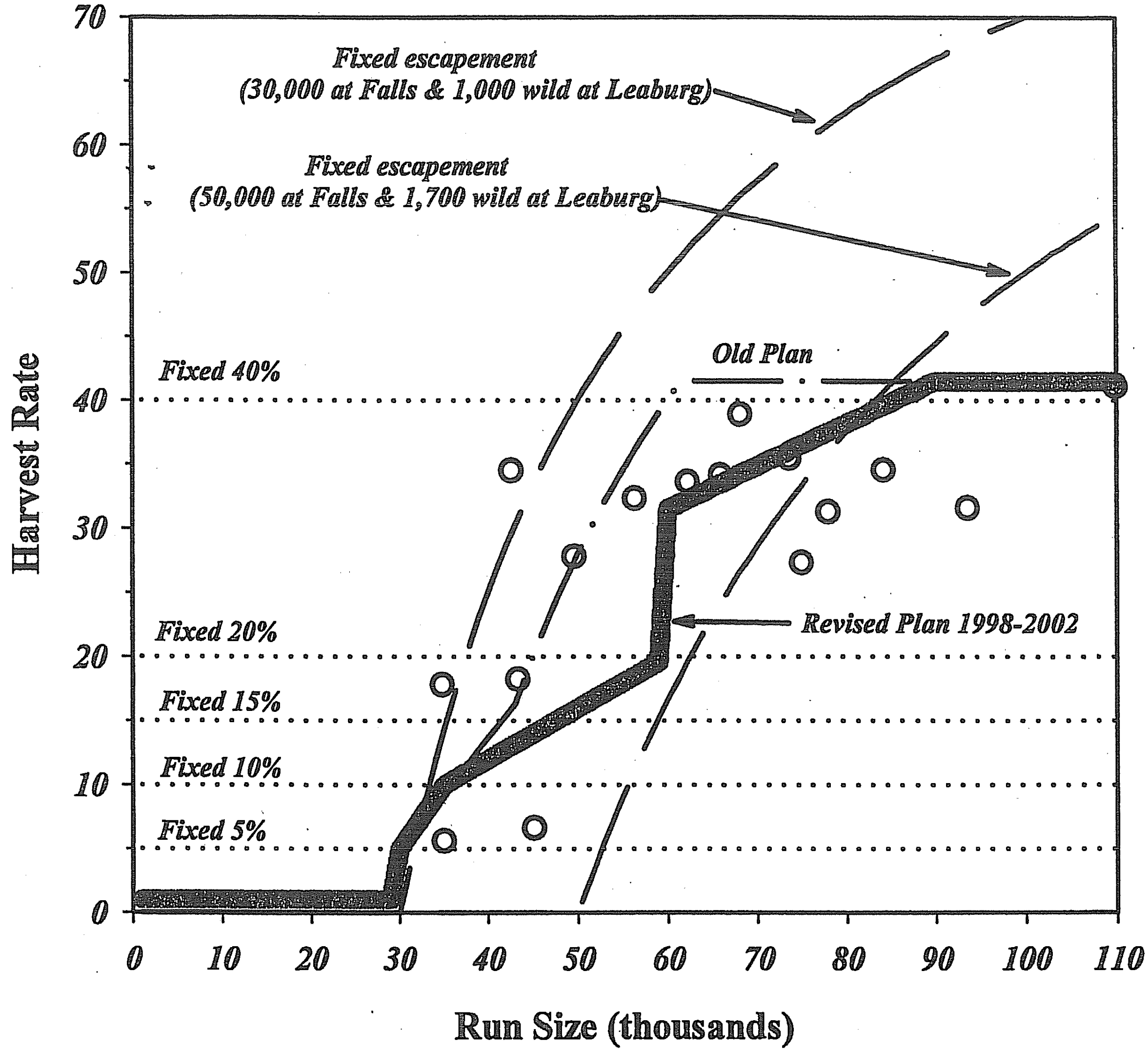


Figure 6. Fishing rate alternatives. Circles denote actual 1980-98 fishing rates at corresponding run sizes.

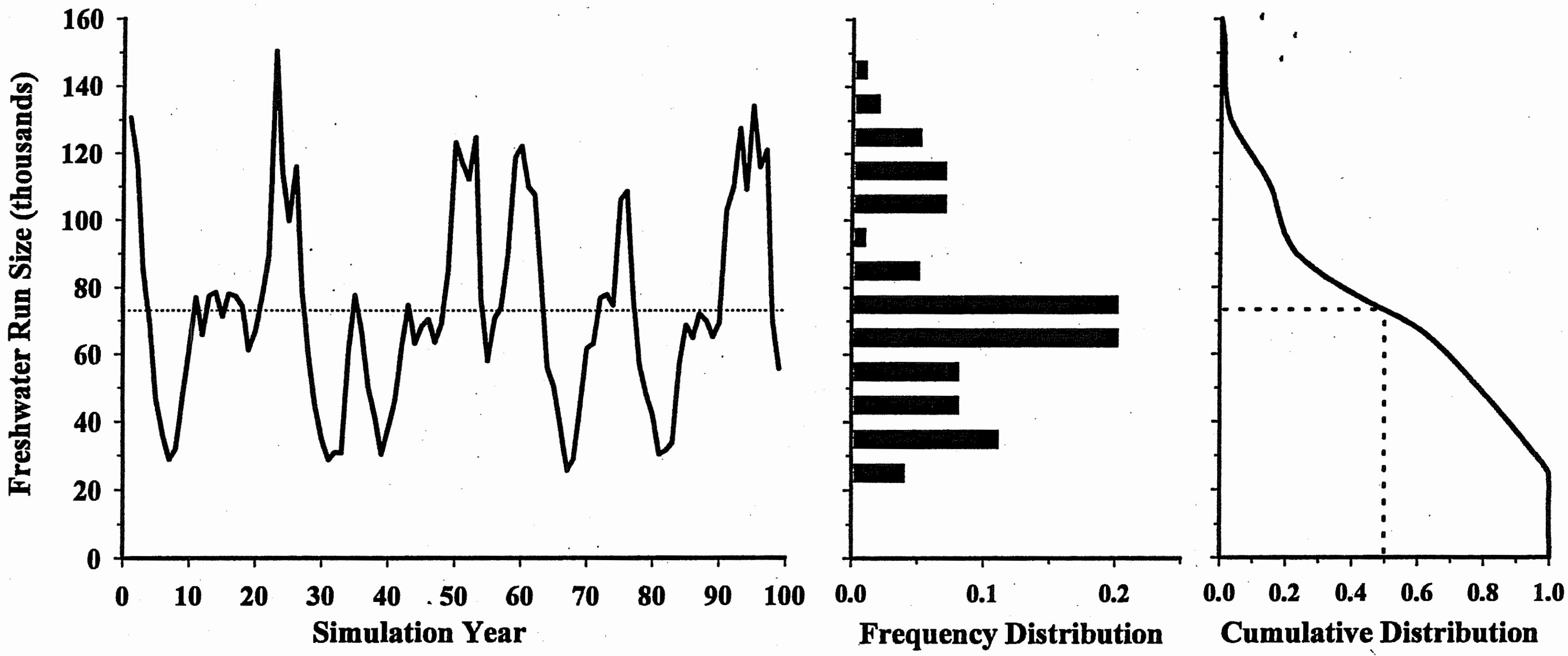


Figure 7. Simulated total freshwater run size (hatchery and wild combined) under 1970 to 1998 natural and fishing mortality conditions for 100-year period.

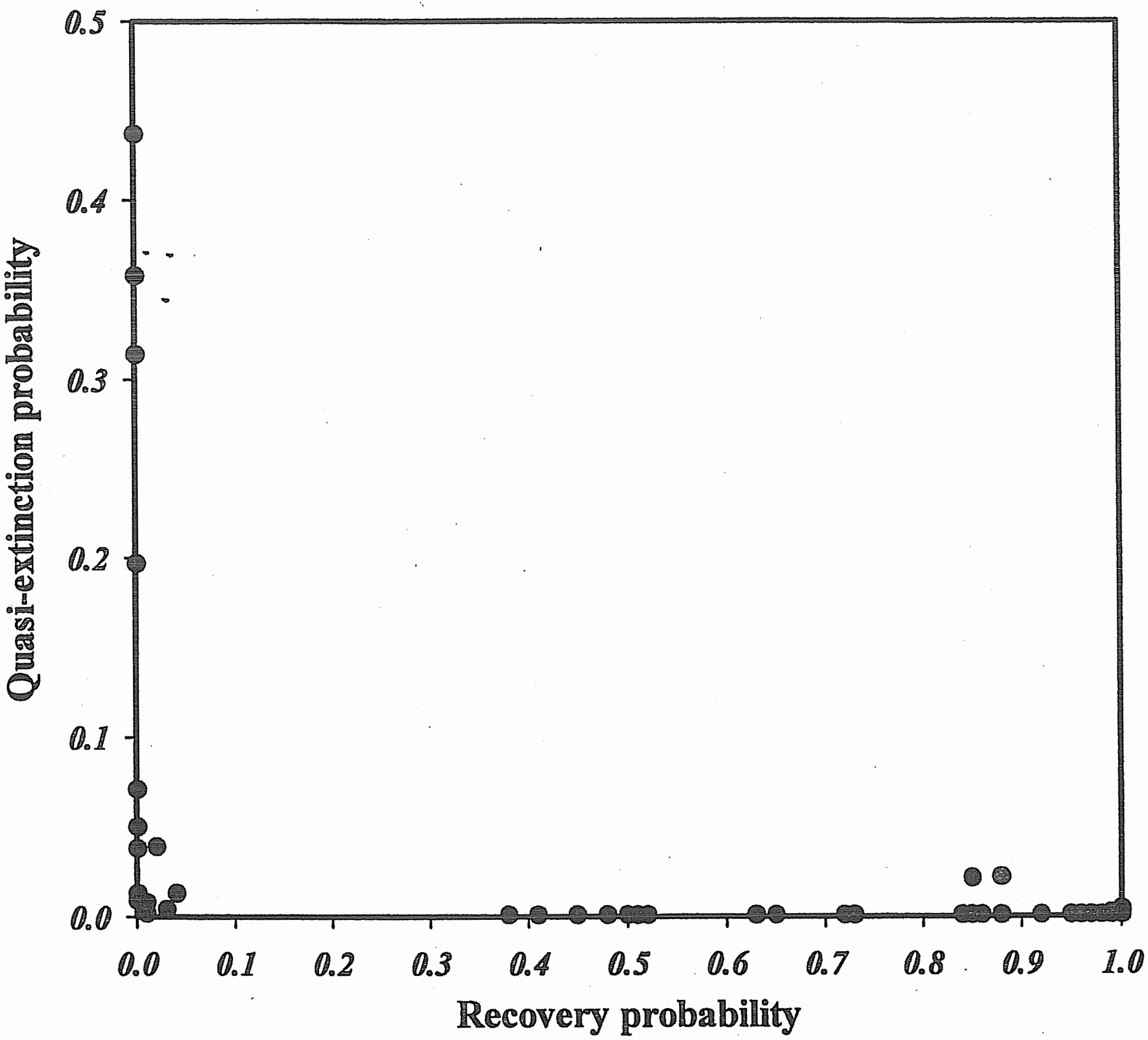


Figure 8. Relationship of "recovery" probability and quasi-extinction risk for examples detailed in Table 4.