Dynamics of Chinook Salmon Populations Within Idaho's Frank Church Wilderness: Implications for Persistence

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Abstract—Research was begun in 1995 to describe factors influencing the spatial dynamics and persistence of federally listed chinook salmon within the Frank Church River of No Return Wilderness. Results addressed two objectives: 1) description of chinook salmon redd distributions, and 2) comparison of index and total redd counts. Annual redd counts ranged from 20 to 661, and 99% of redds were constructed in tributaries. Redds were observed at elevations between 1,140 and 2,070 m, with a majority (56%) >1,900 m. The distribution of redds deviated from a random pattern and fluctuated with adult salmon numbers. At lower adult escapements, redds were clustered in specific areas of a few watersheds. At higher escapements, fish constructed additional redds near previous clusters and also outside of clusters and in watersheds that were previously not utilized. Index area counts averaged 63% of total counts.

The Columbia and Snake River basins historically supported large runs of chinook salmon (*Oncorhynchus tshawytscha*). Estimates of annual chinook salmon returns to the Columbia River prior to 1850 ranged to 6.4 million fish (Northwest Power Planning Council 1986). Despite several decades of habitat alteration and commercial harvest by the late 1880s, an estimated 1.5 million chinook salmon returned annually to the Snake River in that decade (Bevan and others 1994). Many native Americans depended on salmon as a subsistence and ceremonial resource (Northwest Power Planning Council 1986). Since European settlement, salmon and other anadromous species have continued to influence social and economic systems (Thurow and others 2000).

Today, chinook salmon and other anadromous fishes native to the Snake River are imperiled. All Snake River anadromous salmonids, including stream-type (spring and summer), and ocean-type (fall) chinook salmon, steelhead (*O. mykiss*), and sockeye salmon (*O. nerka*), are listed as threatened or endangered under the Endangered Species Act of 1973 (ESA). Coho salmon (*O. kisutch*) have been extirpated from the Snake River (Lee and others 1997). Pacific lamprey (*Lampetra tridentata*) have declined dramatically. Harrison (1995) reported that in the 1960s nearly 50,000 lamprey were counted at Ice Harbor Dam; less than 400 were counted in 1994.

Since European settlement of the Snake and Columbia river basins, a plethora of factors have contributed to declines in the distribution and abundance of chinook salmon. These include blocked access to historical habitat, passage mortality at dams and obstructions, freshwater and estuaries habitat degradation, overharvest, and interactions with hatchery-reared and nonnative fishes. Thurow and others (2000) reported that stream-type chinook salmon have been extirpated from more than 70% of their potential historical range, and strong populations remain in 1.2% of the current range in portions of the Columbia River and Klamath River basins east of the Cascade Crest. An estimated 12,452 km of potential historical habitat have been blocked and are no longer accessible to anadromous fish in the Snake and Columbia river basins (Northwest Power Planning Council 1986). Nehlsen and others (1991) identified habitat loss or degradation as a major problem for 90% of the 195 at-risk salmon and steelhead stocks they identified.

Although a variety of factors over many decades have influenced declines in Snake River anadromous fish, construction and operation of mainstem dams is considered the proximate cause of recent declines (Columbia Basin Fish and Wildlife Authority 1990). Smolt-to-adult return rates declined from more than 4% in 1968 (Raymond 1979) to less than 0.5% in the 1990s (Marmorek and others 1998). As a result of low flows in the migration corridor in 1973 and 1977, 95% of migrating smolts never reaching the ocean (Raymond 1979). The influence of passage mortality was further illustrated by Huntington and others (1996) and Lee and others (1997), who reported that no healthy or strong populations of anadromous fish were found in the central Idaho wilderness, even though it contains some of the Pacific Northwest's highest quality spawning and rearing habitat.

In response to declining populations and ESA requirements, agencies have adopted policies that attempt to conserve and restore remaining chinook salmon populations. These have included measures to maintain genetic integrity of remaining wild stocks, reduce passage mortality by improving conditions in the migration corridor, reduce the effects of exotics, restrict sport and commercial harvest, and adopt measures to conserve or restore remaining critical habitat. The conventional approach to managing critical habitat focused on conserving or restoring the quality of remaining habitats–that is, conserving and restoring those habitats considered necessary for chinook salmon to complete their complex life cycle from an incubating egg to a mature fish depositing eggs in natal spawning areas.

While conservation of the quality of critical habitats is essential, there is growing concern that the size and spacing

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of habitats also needs to be considered (Krohn 1992). Simberloff (1988) suggested that effective conservation may require maintaining or restoring a critical amount or mosaic of habitat, as well as habitat of certain quality. Recent papers support the hypothesis that conservation of declining salmonid stocks may require attention to spatial concepts (Frissell and others 1993; Rieman and McIntyre 1993). In an empirical study of larger scale processes, Rieman and McIntyre (1995) reported that habitat area influenced the distribution of disjunct populations of bull trout (*Salvelinus confluentus*) and suggested that larger-scale spatial processes may be important to salmonid persistence. The relevance of these concepts to declining populations of chinook salmon is unknown.

In 1995, scientists at the Rocky Mountain Research Station initiated research to describe factors influencing the spatial dynamics of declining populations of chinook salmon. The central hypothesis states that habitat area, habitat quality, or habitat context (location in relation to other populations) influences the occurrence of spawning chinook salmon. If the hypothesis is true, recolonization and persistence of chinook salmon populations may be strongly influenced by the spatial geometry of remaining habitats. The hypothesis is being tested by describing the distribution of chinook salmon redds and potential spawning areas in a large, relatively undisturbed wilderness basin. Although a suite of objectives are being addressed, this paper reports results addressing two objectives: 1) describe the temporal and spatial distribution of chinook salmon redds and 2) compare index and non-index area redd counts. This research represents the first comprehensive survey of redds in the study area and provides information on the temporal and spatial dynamics of chinook salmon in a large wilderness watershed. In addition to addressing larger scale spatial questions about persistence, this research provides an estimate of the total number of redds constructed in the study area, enabling managers to estimate total adult escapement.

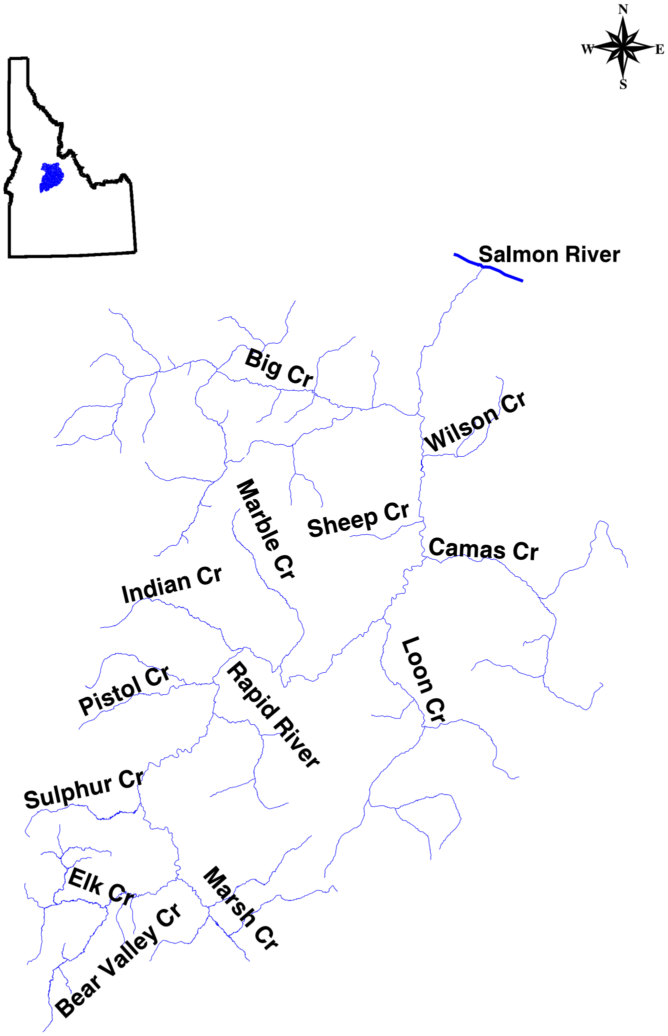

Figure 1—Potential chinook salmon spawning tributaries in the Middle Fork Salmon River drainage, Idaho.

Study Area

The Middle Fork Salmon River (MFSR), a National Wild and Scenic River, drains about 7,330 km^2 of a remote area of central Idaho. For most of its length, the river flows through the Frank Church River of No Return Wilderness (FC-RONRW). The MFSR drainage provides critical habitat for six ESA listed species: bald eagle (*Haliaeetus leucocephalus*), peregrine falcon (*Falco peregrines*), grey wolf (*Canis lupus*), chinook salmon, steelhead, and bull trout. From its origin at the confluence of Bear Valley and Marsh Creeks, the MFSR flows north-northwest for 171 km through the Salmon River mountains and joins the Salmon River 92 km downstream from Salmon, Idaho (fig. 1). Twelve major streams and hundreds of smaller ones are tributary to the river. Human access in the lower 156 km of the main river and most tributaries is limited to a few airstrips, float craft, or by trail. From 1930-1980, a majority of the region was managed in "Primitive Area" status (US Forest Service 1998). In 1980, the Central Idaho Wilderness Act established the 906,136 hectare wilderness that remains the largest contiguous wilderness in the lower 48 states and the largest in the National Forest system. The Gospel Hump and Selway-Bitterroot wilderness area border the FC-RONRW and together comprise nearly 1.6 million hectares (US Forest Service 1998). In 1984, the current name was adopted in honor of the late Senator Frank Church's efforts to secure wilderness designation.

Elevations range from >3,150 m in adjacent mountains to 1,550 m at the rivers' confluence. The topography has high relief. The geology of the area is highly variable and dominated by Challis Volcanics (Eocene age) and intrusions of the Casto Pluton phase (Tertiary age) of the Idaho Batholith (Minshall and others 1981). The climate is semiarid, with most precipitation falling as snow. Climate varies markedly with elevation; precipitation ranges from 38-50 cm in lower valleys to 76-100 cm at higher elevations (Minshall and others 1981). Maximum daily air temperatures range from -30 to >33 °C. Vegetation also varies by elevation, with sagebrush (*Artemsia* sp), grasses and shrubs common in lower elevations and on south-facing slopes. Various conifers including ponderosa pine (*Pinus ponderosa*), Douglas fir

(*Pseudotsuga menziesii*), subalpine fir (*Abies lasiocarpa*) and whitebark pine (*Pinus albicaulis*) populate higher elevations. Riparian vegetation includes alder (*Alnus* sp), aspen (*Populus tremuloides*), water birch (*Betula occidentalis*), cottonwood (*Populus balsam fera*) and willow (*Salix* sp) (Minshall and others 1981).

Native Americans inhabited the area and utilized its salmon resources for at least 10,000 years (Knudson and others 1982). Euroamericans first described the drainage in 1824, when Alexander Ross traveled along Marsh Creek. The MFSR was a major production area for chinook salmon in the Columbia River Basin. Chapman (1940) reported that "the Middle Fork of the Salmon possesses immense spawning areas for spring chinook which to my knowledge are not surpassed or even reached in quantity or quality any place else in the Columbia River drainage."

The drainage supports 15 native fishes including seven salmonid taxa: bull trout, westslope cutthroat trout (*Oncorhynchus clarki lewisi*), redband trout (*O. mykiss* ssp.), mountain whitefish (*Prosopium williamsoni*), steelhead and spring and summer chinook salmon forms (Thurow 1985). Columbia River basin chinook salmon have traditionally been described as spring, summer and fall races—separated primarily by their time of passage over Bonneville Dam (Matthews and Waples 1991). Spring chinook salmon cross Bonneville Dam from March to May, summers from June to July, and falls from August to September (Burner 1951). Healey (1991) categorized juvenile chinook salmon that migrate seaward after one or more years as stream-type and those that migrate as subyearlings as ocean-type. I adopted these definitions to characterize chinook salmon stocks in the study area. Within the MFSR, stream-type chinook salmon include spring- and summer-run fish (Fulton 1968; Gebhards 1959; Idaho Department of Fish and Game 1992; Parkhurst 1950).

Importance of the Wilderness Study Area

The wilderness study area was selected for four reasons. First, remaining chinook salmon stocks are wild and indigenous, unaltered by hatchery supplementation. Consequently, the ability of the salmon population to respond to the quality and quantity of the available habitat has not been altered. Hatchery programs could confound a spatial analysis by influencing population levels in two ways: 1) hatchery supplementation may erode genetic diversity and alter coadapted gene complexes characteristic of locally adapted stocks (Reisenbichler 1997; Waples and Do 1994), resulting in a loss of both fitness (such as growth, survival, and reproduction) and genetic variability important to long-term stability and adaptation in varying environments, 2) in degraded habitats, hatchery programs that rely on smolts could inflate the salmon population that would be present if recruitment were supported solely by the amount and quality of freshwater habitat. Wild, indigenous, stream-type chinook salmon populations like those in the MFSR are rare; Thurow and others (2000) reported their presence in 4% of the potential historical range and 15% of the current range in the Columbia River basin and portions of the Klamath River basin.

Second, most of the MFSR drainage has been relatively undisturbed by anthropogenic influences, so habitat quality has not been substantially altered. Although a majority of the MFSR drainage and its aquatic habitat is in a relatively pristine state, past anthropogenic activity has degraded habitat in some areas. Livestock grazing has degraded riparian and in-stream habitat in reaches of the Bear Valley, Camas and Marsh Creek drainages, and historical mining activities altered habitat in the reaches of the Bear Valley, Camas, Loon and Marble Creek drainages. Because past perturbations have largely been eliminated since wilderness designation, and with the additional land-use constraints since ESA listing of stocks, much of the degraded habitat is recovering. Numerous studies describe the negative effects of land-use activities on freshwater habitat conditions and link habitat conditions to survival and productivity of anadromous fish (Meehan 1991; Murphy 1995; National Research Council 1986). Widespread degradation of habitat would be expected to confound a spatial analysis of freshwater habitat by influencing fish distribution and abundance.

Third, few introduced species are present within the range of chinook salmon in the MFSR. Only brook trout (*Salvelinus fontinalis*) have been observed within known chinook salmon spawning and rearing areas (Thurow 1985). Introduction of other nonnative salmonids, including forms of rainbow trout and cutthroat trout, golden trout (*O. aguabonita*), and arctic grayling (*Thymallis arcticus*), have been confined to formerly fishless high-elevation lakes. Predation, competition and genetic introgression from nonnative species can influence the status of salmon populations (Thurow and others 2000). In degraded habitats, introduced species may pose an even larger risk to native species (Hobbs and Huenneke 1992).

Fourth, the large area provides an opportunity for a large sample size. About 650 km of tributaries and 170 km of the mainstem are accessible to chinook salmon (Mallet 1974; Thurow 1985). This increases the likelihood of a sample size large enough to complete a robust spatial analysis.

Methods

The importance of spatial concepts to persistence of chinook salmon was initially tested by describing the distribution of chinook salmon redds within the Middle Fork Salmon River drainage. First, I selected areas with the potential to support spawning fish. Second, areas were annually surveyed to count chinook salmon redds. A global positioning system (GPS), was used to spatially locate salmon redds which were mapped using a geographic information system (GIS). Redd elevations and the linear distance of redd distribution along streams were calculated and compared among years with different spawning escapements. Finally, I annually compared redd counts in index areas with total counts.

Selection of Study Streams

Chinook salmon require access to and specific microhabitat conditions in spawning locations. Consequently, not all areas of the MFSR have the potential to support redds. I selected potential study streams by reviewing past redd surveys, reviewing anecdotal accounts of redds and spawners, contacting biologists familiar with the drainage and reviewing records of juvenile chinook salmon occurrence. Existing information suggests that a total of 12 tributaries and about 145 km (headwaters to Big Creek) of the mainstem MFSR have the potential to support spawning populations of chinook salmon. Chinook salmon redds were counted in the MFSR beginning in 1947, and counts have been consistently completed in six MFSR tributaries since 1957 (Hassemer 1993). Redd counts in 1953 documented chinook salmon spawning in the mainstem MFSR and the Bear Valley, Big, Camas, Indian, Loon, Marble, Marsh, Rapid River and Sulphur Creek drainages (Hauck 1954). Gebhards (1959) reviewed historical information and also reported chinook salmon spawning in the Pistol and Wilson Creek drainages. Juvenile chinook salmon and suitable chinook salmon spawning habitats were observed by Thurow (1985) in 10 of the 11 streams listed above. Despite no record of chinook salmon spawning, I included Sheep Creek as a potential spawning stream because it is accessible and supports suitable spawning habitat. These 12 tributaries and the mainstem MFSR total more than 800 km of accessible habitat. The remaining tributaries to the MFSR were judged to be too steep or too small to support spawning chinook salmon (Gebhards 1959; Ball 1995).

Redd Counts

From 1995-1998, annual redd counts were completed in each of the 12 streams and in the reaches of the mainstem MFSR described above. I flew all of the accessible stream reaches in the survey area and observed redds from a low-flying helicopter. All flights were conducted after chinook salmon had completed spawning and while redds were still visible. Based on IDFG index area surveys (Hassemer 1993), interviews with biologists who survey MFSR index areas, and my own observations, chinook salmon typically complete spawning by September 8. All redd count flights were completed from September 8-14 1995-1998. We completed surveys between 0900 and 1800 hours to increase the likelihood of direct overhead sunlight. Flights required about 40 hours of aerial census time per year.

During counts, the pilot maintained the slowest airspeed possible and hovered the helicopter (a turbo Hiller Saloy) at an altitude ranging from 15 to 50 m above the streambed, depending on the terrain and presence of trees and cliffs. As the primary observer, I wore polarized sunglasses and searched for the characteristics pit and tailspill morphology of chinook salmon redds (Burner 1951) in potential spawning areas.

Redd dimensions illustrate the area of disturbed gravel I was searching for: Burner (1951) reported an average area of 3.3 m^2 for 184 spring chinook salmon redds, and King and Thurow (1991) reported an average area of 4.7 m^2 for 30 summer chinook salmon redds. Redd dimensions tend to be proportional to the length of spawning fish (Burner 1951; Crisp and Carling 1989; Ottaway and others 1981) and MFSR chinook salmon are of similar size to those studied by King and Thurow (1991).

After observing a redd, I immediately recorded its position with a global positioning system (GPS) mounted in the ship. For ease of recording, I used a data dictionary and recorded redds as point features in a GPS file. One of the benefits of the helicopter was the ease with which it could be used to resurvey an area. For example, if I wanted a second look, the pilot hovered the craft and re-flew the area in question.

Some portions of the study area were not adequately surveyed from a helicopter. Narrow streams with a large amount of tree canopy and shading were particularly difficult. I recorded the areas where I was unable to complete aerial surveys. Crews returned to the areas where aerial counts were incomplete and completed ground-based redd surveys. During ground surveys, two observers wore polarized sunglasses, walked parallel on adjacent stream banks and recorded redd locations with a portable GPS unit. Both mainstem stream reaches and side channels were surveyed.

Comparison of Index and Total Counts

I compared annual redd counts in seven index areas with total counts in the drainage. Index area counts were completed in low-gradient reaches and completed during the “peak” spawning period, typically in August (Hassemer 1993). Total counts were derived by summing the results of the September aerial and ground-based surveys described above.

Results

Since 1995, annual redd counts have ranged from 20 to 661 (table 1). A total of 1,188 redds were observed from 1995 to 1998. Chinook salmon spawned in both mainstem reaches of the Middle Fork Salmon River and tributaries, with 98.9% of the redds observed in tributaries. With the exception of 1995, the Bear Valley and Marsh Creek drainages supported the largest number of redds, followed by varying numeric order in the Loon, Sulphur and Camas Creek drainages. I consider these minimum total counts because several areas were not completely counted in certain years. In 1995, intensive rainfall created turbid water conditions and prevented complete counts in the Camas and Loon Creek drainages and in the mainstem downstream from Loon Creek. In 1997, intensive rainfall created turbid water conditions and prevented complete counts in the mainstem downstream from Bernard Creek. In 1998, intensive rainfall created turbid water conditions and prevented complete counts in Loon Creek downstream from Cold Springs Creek and in the mainstem downstream from Loon Creek.

Redds were observed at elevations between 1,140 to 2,070 m (fig. 2). Most (56%) of the redds were observed in spawning areas above 1,900 m elevation in the Bear Valley and Marsh Creek drainages. The East Fork Mayfield Creek in the headwaters of the Loon Creek drainage also supported redds above 1,900 m. The Big, Camas, Loon and Sulphur Creek drainages supported redds in the 1,700-1,800 m range. The lowest elevation redds (<1,200 m) were consistently observed in lower reaches of the Big Creek drainage.

The distribution of redds deviated from a random pattern (figs. 3, 4, 5, and 6). Redd distribution also fluctuated with adult salmon numbers. At lower adult escapements, redds were clustered in specific areas of a few watersheds. At higher escapements, fish constructed additional redds near

Table 1—Chinook salmon redd counts in tributaries to and in the mainstem Middle Fork Salmon River, Idaho, 1995-1998.

Drainage	Stream	1995	1996	1997	1998	Totals
Bear Valley	Bear Valley	9	19	47	116	191
	Elk	0	17	106	112	235
Big	Big	9	8	44	38	99
	Monumental	0	0	8	18	26
Camas	Camas	0	5	26	65	96
Indian	Indian	1	0	5	4	10
Loon	Loon	0	5	51	71	127
Marble	Marble	0	1	21	13	35
Marsh	Marsh	0	8	41	61	110
	Beaver	0	1	8	32	41
	Capehorn	0	5	24	42	71
	Knapp	0	0	1	6	7
Pistol	Pistol	0	1	7	3	11
RR	RR	0	1	7	8	16
Sulphur	Sulphur	1	11	21	67	100
Mainstem MFSR	reaches	0	1	7	5	13
	Totals	20	83	424	661	1188

previous clusters and also outside of clusters and in watersheds that were previously not utilized.

Figure 7 and table 1 illustrate the change in the linear distribution of redds in some example drainages. Viewing mainstem Bear Valley Creek, for example, in 1995 nine redds were distributed along 14.8 km, compared with 19 redds along 24.8 km in 1996, 47 redds distributed along 40.7 km in 1997 and 116 redds distributed along 44.5 km in 1998.

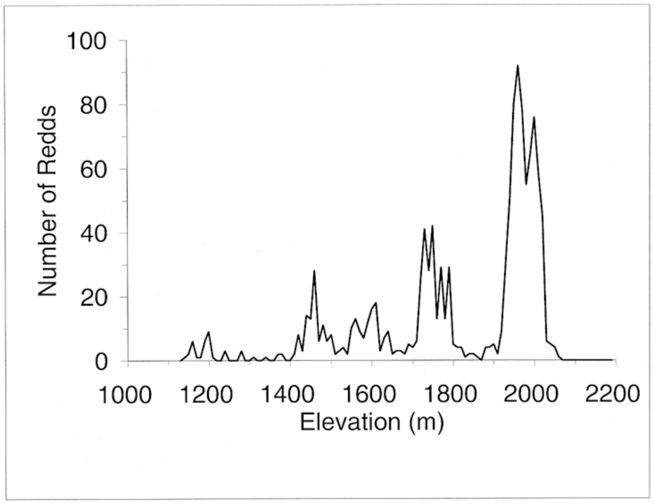

Figure 2—Elevation of 1,188 redds observed in the Middle Fork Salmon River, Idaho, 1995-1998.

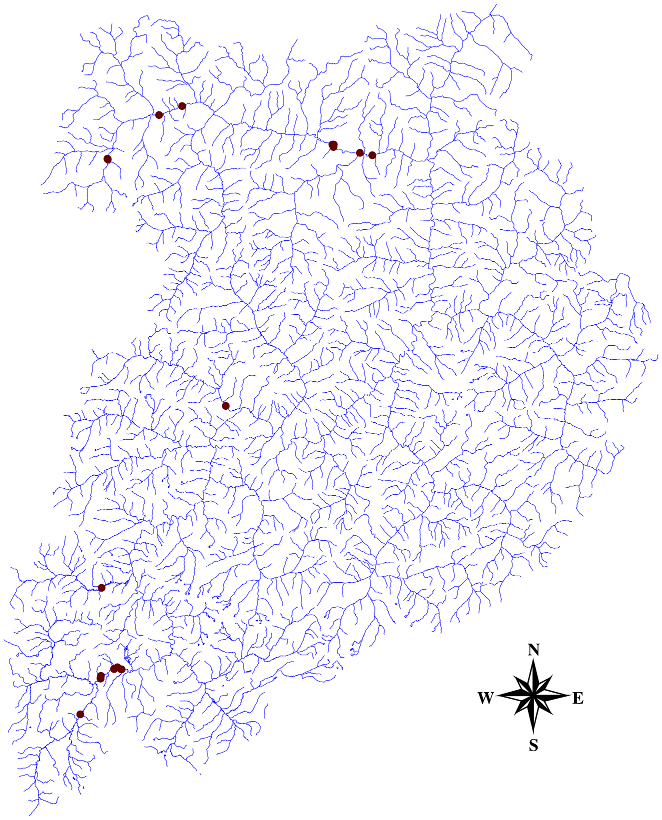

Figure 3—Distribution of chinook salmon redds in the Middle Fork Salmon River, Idaho, 1995.

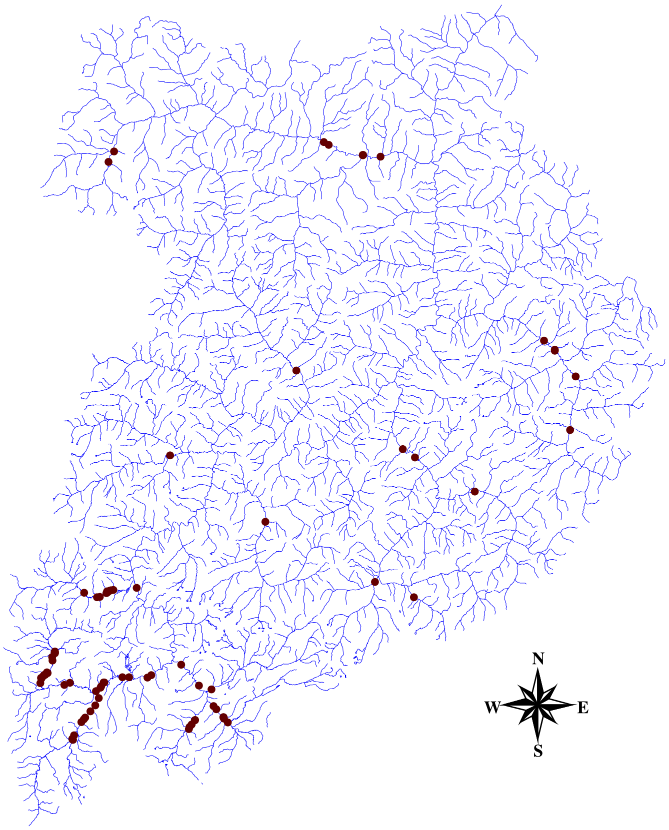

Figure 4—Distribution of chinook salmon redds in the Middle Fork Salmon River, Idaho, 1996.

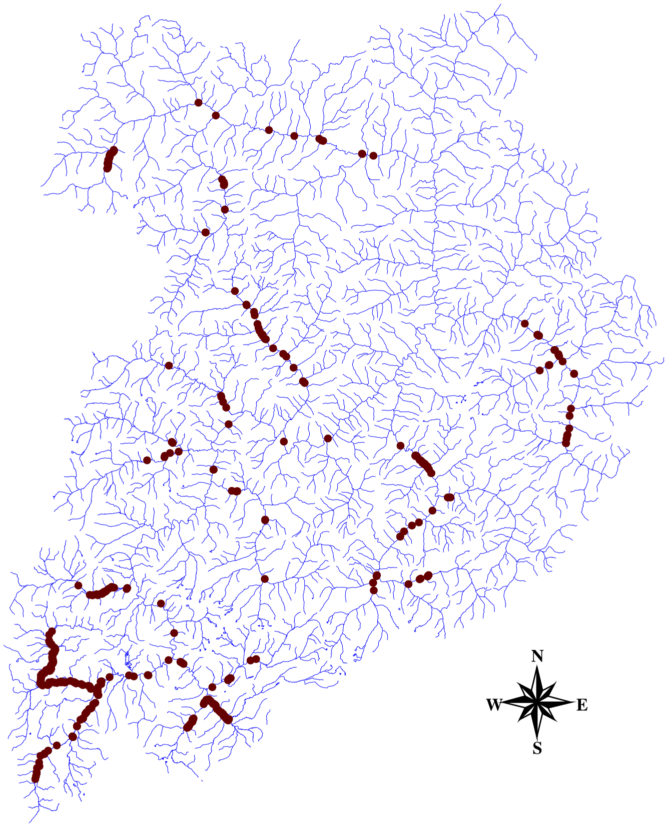

Figure 5—Distribution of chinook salmon redds in the Middle Fork Salmon River, Idaho, 1997.

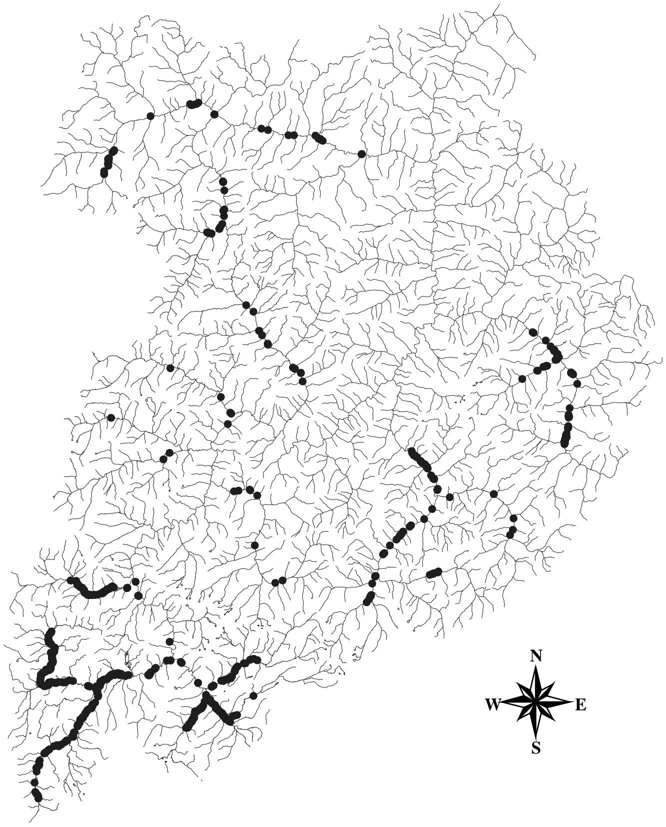

Figure 6—Distribution of chinook salmon redds in the Middle Fork Salmon River, Idaho, 1998.

I compared annual index area counts in seven streams with total annual redd counts. Index counts accounted for from 58% to 76% of the total redds counted within index areas (table 2). Index area counts averaged 63% of total counts in the entire study area (fig. 8).

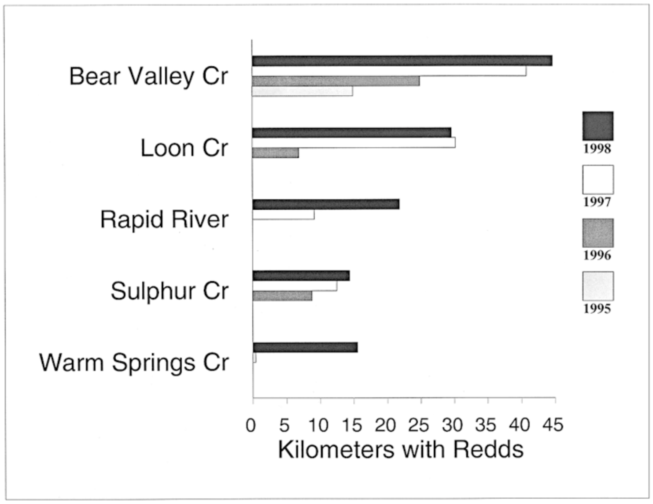

Figure 7—Kilometers of selected spawning tributaries supporting redds in the Middle Fork Salmon River, Idaho, 1995-1998.

Table 2—Chinook salmon redds counted in index and total surveys in tributaries to the Middle Fork Salmon River, Idaho, 1995-1998.

Drainage	Stream	Year surveyed	Number of redds observed Index survey	Total survey
Bear Valley	Bear Valley Cr.	1995	9	9
		1996	15	19
		1997	38	47
		1998	102	116
	Elk Cr.	1995	0	0
		1996	17	17
		1997	86	106
		1998	105	112
Big	Big, Monumental creeks	1995	2	9
		1996	1	8
		1997	33	52
		1998	15	56
Camas	Camas, West Fk Camas creeks	1995	No count	No count
		1996	1	5
		1997	7	26
		1998	16	65
Loon	Loon, Warm Springs, Mayfield creeks	1995	No count	No count
		1996	1	5
		1997	22	51
		1998	42	71
Marsh	Marsh, Capehorn, Beaver, Knapp creeks	1995	0	0
		1996	10	14
		1997	62	74
		1998	88	141
Sulphur	Sulphur Cr.	1995	0	1
		1996	13	11
		1997	15	21
		1998	47	67

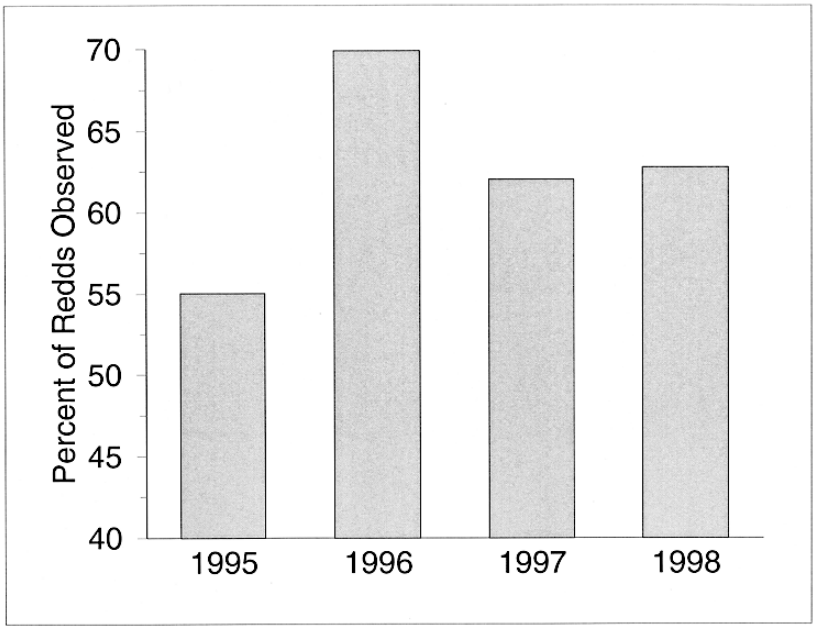

Figure 8—The percent of total chinook salmon redds in the Middle Fork Salmon River, Idaho, counted in index area surveys.

Conclusions

Redd counts from 1995-1998 suggest two main conclusions about the chinook salmon studied here. First, chinook salmon in the MFSR appear to retain a strong tendency to return to natal areas to spawn. Second, the distribution of redds outside of clusters and the change in linear distribution of redds in MFSR tributaries suggest that some chinook salmon may not return to natal areas but instead "stray" and spawn in non-natal habitats. Both features have important implications for the persistence of wild chinook salmon.

The clustering of redds in specific areas of the watersheds I studied supports the premise that most salmon retain high fidelity and "home" to natal areas. As Labelle (1992) observed, one of the distinguishing features of Pacific salmon is their ability to return to their natal streams to spawn and die. If redd clusters occur annually in the same areas, this would suggest that progeny from earlier spawning continue to return as adults and spawn in natal areas. The homing ability of chinook salmon was one of the premises for establishing "index" areas to monitor MFSR chinook salmon (Hassemer 1993). The ecological importance of this homing is partially linked to nutrient influx. As Larkin and Slaney (1997) observed, an adult salmon's body mass is almost entirely of marine origin. As a result, salmon secure the link between the marine and freshwater environment via the annual return of adults to natal areas, of which many, like the MFSR, are very oligotrophic. By returning to natal areas, adult salmon substantially contribute nutrients that may influence the growth and survival of juvenile salmon (Bilby and others 1996; Kline and others 1990), as well as contributing nutrients to terrestrial plants and animals.

Observations at higher escapements that more redds are distributed outside clusters and redds are distributed along longer distances in streams may indicate straying. Straying is the process by which new habitats are colonized (Labelle 1992) or the process by which populations that become extirpated may be refounded by adjacent populations (Hanski and Gilpin 1991). Although natural rates of straying have rarely been assessed, data suggest there is both a temporal and spatial pattern to straying. Straying appears to be related to proximity to the natal river (Labelle 1992; Quinn 1993), as well as the physical conditions in the watershed. Straying may also be related to demographic (older salmon stray more than younger salmon) (Quinn 1993) and density characteristics.

As noted in the introduction, the research results reported here begin to address two of several objectives of a larger research program. The 1995-1998 results can also be considered preliminary because of temporal variation. Returns of adult chinook salmon are influenced by a variety of factors, including migratory corridor (Raymond 1979) and ocean conditions (Lichatowich and Mobrand 1995). Therefore, adult escapements and corresponding redd counts will fluctuate annually. Because of this variation, it will be necessary to follow a minimum of one full generation of chinook salmon to adequately complete an analysis of spatial dynamics.. The age structure of spring and summer chinook salmon that spawn in the MFSR includes precocial males that mature after one or two years in freshwater, jacks that mature after two or three years in freshwater and 1 year in the ocean, and males and females that mature after two or three years in freshwater and two or three years in the ocean (Idaho Department of Fish and Game and others 1990). An occasional fish will spend four years in salt water. As a result of this variable age structure, the spawners in an individual year may range from one to seven years old. One generation would encompass seven years. Consequently, the data from 1995-1998 represent an initial step in addressing larger scale spatial questions about persistence.

As described above, the wilderness designation of the study area is critical to the completion of this research. Within the large FC-RONRW wilderness, the factors influencing the spatial dynamics of chinook salmon populations can be studied without the confounding effects of human activities. Further, designated wilderness and unroaded areas are important anchors for several native salmonids (Lee and others 1997) in addition to supporting some of the last remaining indigenous stocks of chinook salmon and steelhead (Thurow and others 2000). Although the declines in Snake River chinook salmon in recent years can be attributed primarily to mainstem dams, until passage problems are resolved, the resiliency and persistence of remaining chinook salmon populations will be largely dependent on the quality and diversity of remaining freshwater habitat (Lee and others 1997). The FC-RONRW will be key because it retains some of the highest quality salmon spawning and rearing habitat in the Columbia River Basin (Huntington and others 1996).

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