Males as Vectors to Hatchery/Wild Spawning Interactions And the Reshaping of Wild Steelhead/Rainbow Populations Through Fishery Management

by Bill McMillan

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PREFACE

The primary purpose of this paper is to provide evidence to a hypothesis: the temporal breadth for potential spawning is so broad for male steelhead/rainbow (*Salmon mykiss* in Russia, *Onchorynchus mykiss* in North America) that it is impractical and perhaps impossible to effectively manage for temporal isolation of wild and hatchery steelhead when they cohabit mutual spawning areas. It is proposed that if this hypothesis is correct, then there has been a reshaping of wild steelhead/rainbow populations through fishery management in North America when and where management has been based on the assumption that wild and hatchery steelhead can be temporally isolated from spawning together.

This is not a paper aimed at scientific publication, thus a Preface and not an Abstract. One purpose is to convey the importance of personal observations as the generator of science and most other human thought. Another purpose is to suggest that what science does **not** know is just as important a mechanism for driving the protection of resources as what **is** known within the often perceived limitations of a 95% confidence level.

This is a paper trying to reach across borders: international borders, interstate borders, borders between science and philosophy and science and history, borders between hobby-science and professional-science, and the borders separating the accumulation of fish knowledge through angling as opposed to the accumulation of fish knowledge through fishery science. Part of the intent of this paper is to break down these borders in order to stimulate an interplay of knowledge and ideas that has often been prevented in the past with an ultimate diminishment of effective human understanding of problems and their potential solutions.

This paper was primarily written in 1997, but the implications of the hypothesis to steelhead management largely remain unchanged. Although salmon/steelhead restoration moneys since that time have increasingly included habitat purchases (as suggested), steelhead hatchery programs continue being funded with little or no mechanisms provided to effectively separate hatchery/wild spawning interactions. And while newer literature has become available since the writing of this paper, the basic evidence has not been refuted by anything new that I have read, and some of it has only been further confirmed.

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"If females provide the essential nutriment for embryonic or larval growth, we might ask why males exist at all. Why bother with sex if one parent can supply the essential provisioning? The answer to this old dilemma seems to lie in the nature of Darwin's world. If natural selection propels evolution by preserving favored variants from a spectrum randomly distributed about an average value, then an absence of variation derails the process — for natural selection makes nothing directly and can only choose among alternatives presented. If all offspring were the Xeroxed copies of a single parent, they would present no genetic variation (except for rare new mutations) and selection could not operate effectively. Sex generates an enormous array of variation by mixing the genetic material of two creatures in each offspring. If only for this reason, we shall have males to kick around for some time."

Stephen Jay Gould from
<u>Hens Teeth and Horse's Hooves.</u>

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REDISCOVERING STEELHEAD

In August of 1995, I was driving across the arid expanse of eastern Oregon and Washington enroute to Seattle. My mind was wandering with the clouds. Each individual shape was in continual change, from one into another, in its transport across the sky. All life is change. What cannot change dies. The process of life does not wait. There was a message in the clouds about the silent invisible process that determines creation, and continuity or extinction.

The next day I was to fly to Russia's Kamchatka Peninsula with the Wild Salmon Center as part of a joint Russian/American scientific expedition exploring steelhead there. In over 40 years of fishing for, living with, and studying steelhead, I thought I understood their past, their present, and a future that held little optimism for them. I had no notion of what to expect of Kamchatka — what it might teach me of steelhead, of human beings, and of myself. I only knew that I needed to go there ... take a last look at one of the remaining wild places.

My ignorance provided a blank slate, and the events that occurred there led me to see in a way I never had. Kamchatka was a confrontation with my own limitations. I came to understand how human lives are perpetually limited by the subjectivity of the way in which we each see.

<u>Limitations to Seeing</u>:

The human mind seems to work best when it focuses on a particular subject. Much of science is based on that ability to focus. The danger in that intensity of focus is that peripherals may go unnoticed.

The human mind is attracted to patterns and nature seems to work in patterns. It would seem, then, that the human mind should be able to understand the workings of nature. But the trap lies in focus. A focused mind tends to simplify — to ignore peripherals. It's a built-in trap to misunderstand nature — to see very well an isolated pattern, while unable to see that it is but a small component in the weave of the fabric that contains it.

When focused on a pattern, any differences may appear to be an aberration or an isolated anomaly. But, in fact, these very differences may be the connective edge to a larger weave, as yet unperceived, or so broken as to be unrecognizable.

The remaining anadromous fish populations along the West Coast of North America south of Canada are remnants — tattered, torn and isolated shreds of the original fabric. How to put it together again? By focusing on the *breadth* of the remaining differences, the "aberrations" and "anomalies," rather than on the remaining patterns. Adaptability depends upon a maximized breadth of differences so that the fabric remains alive in the alternation of dominant patterns from one to another within it. Survival is the measure of an animal's capacity to respond to an ever-changing environment imposed on it. Survival is transformation.

A Voyage to Kamchatka:

One of the few places remaining on the North Pacific Rim where a significant geographic area still exists with much of the wild salmonid "fabric" still intact is Russia's Kamchatka Peninsula. It provides an opportunity not unlike what Charles Darwin had in his voyage on the H.M.S. Beagle with arrival to the Galapagos Islands in 1835.

Kamchatkan steelhead/rainbow were first mentioned in A Description of the Land of Kamchatka (Krasheninnikov 1755), whose work Pallas had cited in 1811 when describing steelhead under the name of *Salmo purpuratus* (Derzhavin 1929). But findings now suggest that the steelhead/rainbow (*Salmo mykiss* in Russia and *Oncorhynchus mykiss* in North America) may not only have been first described in Kamchatka, but that the species may actually have originated there prior to eventual dispersal along the west coast of North America (Savviatova et al. 1997).

The appearances and characteristics of Kamchatkan steelhead/rainbow are varied. A group from the Sedanka River appears to have characteristics similar to the more primitive examples of both North American "redband trout" (varied subspecies of *O. mykiss*) and cutthroat (particularly *O. clarki lewisi*), and yet are different from all known examples described for both of those. It is not yet known if the "Sedanka trouts" are but one intermediary species, or two or more separate species. At this point it is not being discounted that primitive Kamchatkan forms of either, or both, *Salmo mykiss* and *Salmo clarki* might "belong to relict populations of the species which have diverged less from one another than the American ones, and that northeast Asia was the place where evolution of the whole group began." (Savviatova et al. 1997)

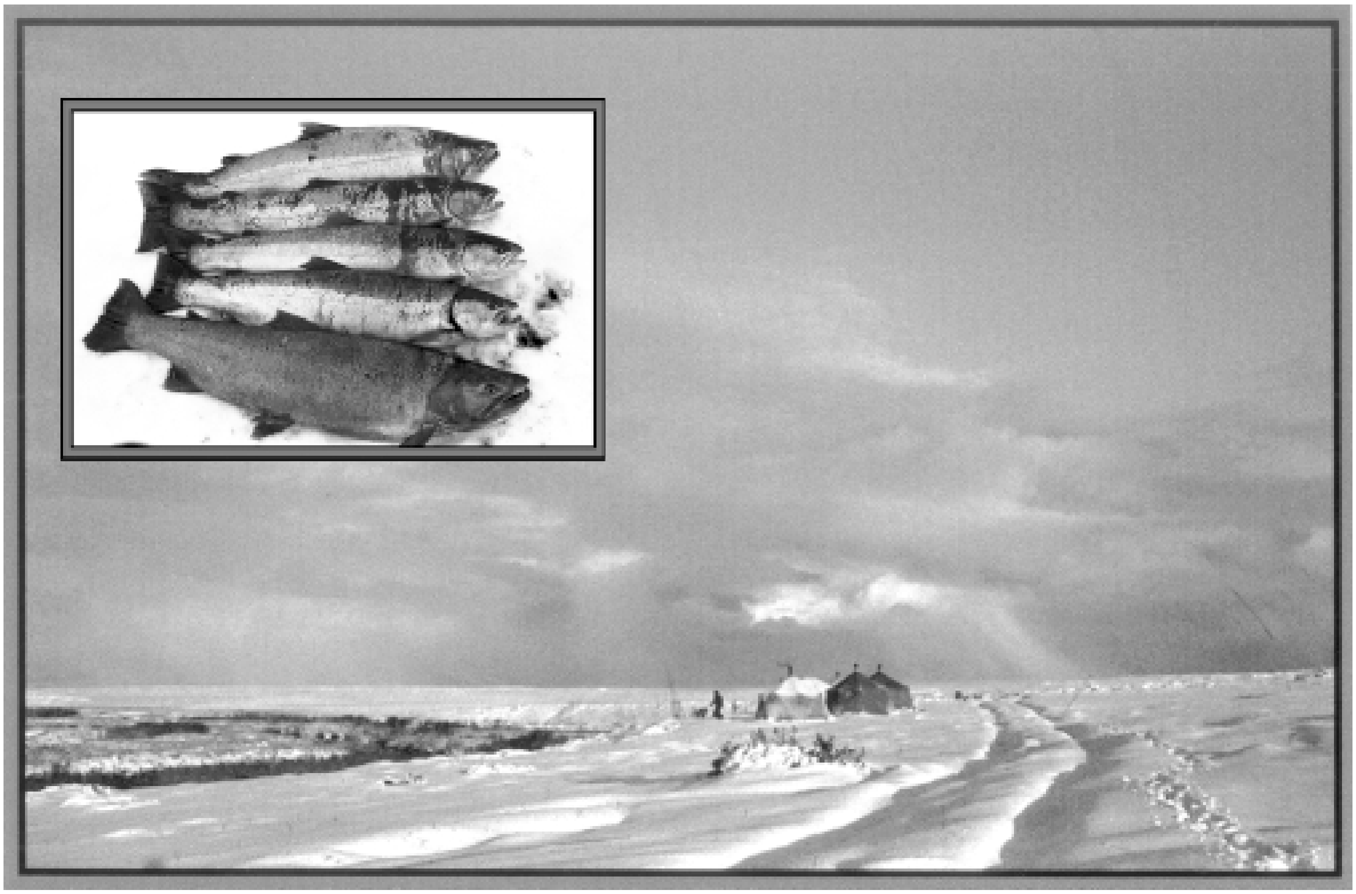
My experience of Russia's Kamchatka Peninsula was that of a vast and silent expanse where fishery discoveries might occur at any moment. The limitations of having tried to understand salmonids of the northwestern United States through the rivers and creeks of a country impacted by 150 years of aggressive resource exploitation became immediately clear. Kamchatka is a place where the filters of human uses that obscure the desire to understand are reduced, and where the scientific quest for essential truths is less inhibited by volumes of accumulated misinformation drawn from tattered resources.

Two Kvachina River Steelhead:

It was on my second trip to Kamchatka that observations of advanced sexual maturation of two male steelhead triggered a flood of distant memories with sudden relevance:

On October 29, 1996, as two Russian ichthyologists from Moscow State University were sorting five steelhead from a gill-net set on the Kvachina River on the Kamchatka Peninsula, I decided to photograph them at their work. As they began their detailed measurements, samplings and dissections, the red gill plates and dusky belly of a large male stood out in my view finder. His dark coloration was in sharp contrast to the other two males and two females with snow white bellies, silver sides and black backs.

the Sea of Okhotsk. Three feet of snow had banked against the windward side of our tents. River water temperatures had been running 32-35 degrees F. for a week. A mile downstream slush ice created an impassable blockage to our jet-motored raft all the way to the low tide point.



Photos by Bill McMillan

The Wild Salmon Center's Russian/American Steelhead Expedition Camp on Kamchatka's Kvachina River, October, 1996. Inset photograph: Five Kvachina River steelhead from a gill net catch in October, 1996. Note the sexually mature male at the bottom of the photograph.

Reminded of several similar wild male winter run steelhead I caught while fishing Washington's Washougal River in late November and early December of the 1960s and 1970s, also in the company of pure silver cohorts, I knelt down and squeezed his flanks. A liquid line of sperm oozed from his vent — just like the wild males on the Washougal from times past.

It was one of our last days on the Kvachina River. Our encampment was at the uppermost tidal reach about ten river miles from

The Russian biologists were excited. The net-catch provided the first evidence since they were last described 25 years ago of Kamchatkan steelhead sometimes known as The Ice Travelers: steelhead that make entry into Kamchatkan rivers coinciding with ice-up. It is thought that these steelhead continue to migrate under the ice during the early stages of Siberian winters (Savvaitova et al. 1973) — thus the romantic name. Valerey Maximov, a Moscow State University ichthyologist on the earlier expeditions, had been particularly interested by the movement of these steelhead during such extreme conditions. He had died two years earlier, and would not witness refinding them.

That night brought a sudden thaw. Likely the last before the long winter. Everyone was scrambling to be ready for the next morning's flight out. The helicopter may not have another chance for several days — or even weeks. The biologists each had their stories of 20-40 day waits.

Despite the rush, the gill net was pulled for one last time after a short set in ice-free water near camp. With a peripheral glance at the lone catch, a silver-bright male steelhead lying in the bottom of the boat, I noticed a slight trail of white sperm from the vent. From outward appearances I would never have guessed the advanced maturation. Despite the hurry, I decided to bring it to Sergei Maximov's attention. I had not wanted to disrupt his biological work the day before. He recognized the importance, tapped the shoulder of Kirill Kuzishchin, and together they knelt down and compressed the steelhead's flanks for more evidence of the early sexual maturation.

Sergei looked up at me. "Yes, Bill. Thank you."

The "yes" meant it was indeed important as a component to their understanding the full complexity of the differences in steelhead. The "thank you" was not only a means of being polite, but gratitude for reconfirming his innate trust in his deceased father's previous observations of these steelhead. The Ice Travelers were no longer a single observation made so long ago it began to seem a possible myth.

Understanding What Was Seen:

It was through data Valerey Maximov, Ksenya Savviatova, and other Russian scientists collected that 22% of the male steelhead on the Kvachina River were found at full sexual maturation during the mid-September through late October collection period in 1972. In the neighboring Snatolvayam River a remarkable 76% of the males were found at full sexual maturation in that same time period and year. By contrast, no females were at such complete levels of sexual maturation on either river, although 59% of Kvachina females hovered between the III-IV level, as did 13% of the Snatolvayam females (III is considered nearly mature, IV is fully mature, V is active spawning and VI is a spawned-out kelt). This difference in maturation time between males and females was described as common to Kamchatkan steelhead. The larger males were typically the ripest. Yet spawning for all was presumed to be on the wane of peak flows after ice-out from early May to mid-June coinciding with the beginning rise in water temperatures (Savvaitova et al. 1973).

In Kamchatka it would appear that a significant proportion of male steelhead can effectively spawn from mid-October to at least mid-May (when peak spawning activity with females was recorded on the Utholok River and thought to be similar on the Snatolvayam and likely the Kvachina) and perhaps as late as mid-June (the end of recorded spawning activity on the Utholok River) — a 7-8 month span of time.

What is not known, due to the winter cover of ice, is the possibility that steelhead spawning may occur prior to ice-out. There is presently no evidence to suggest that, although 1972 was a somewhat earlier spawning year on the Utholok River and there is speculation that steelhead spawning migration from deep holes to the spawning grounds might have occurred just prior to ice-out that year — perhaps as early as late April, although netting could not take place until May 10th due to ice-out conditions (Savvaitova et al. 1973).

1971 was a more typical year. Initial spawning migration did not occur until almost the complete ebb of ice-out water volumes on May 24th (as sampled in nets). The migration peak appeared more directly related to a sudden two-degree rise in water temperature to 3 degrees C. than to water volume (Savvaitova et al. 1973). But the only measures of that movement have been netting, spawning redd observations, and visual observations of native people to the area. This is possible only after the ice cover has broken up.

It would seem unlikely that actual spawning would take place beneath the ice in water that is 0 degrees C. However, it is probable that warmer springs occur in parts of the watershed. Earlier spawning might take place in those areas, but it has not been documented.

If early spawning does occur in spring-fed areas of Kamchatka, it would not be inconsistent with similar examples of early-maturation/ fall-spawning in typically spring-spawning salmonids as observed in North America. Robert Behnke (1992) has written: "Spring-spawning trout normally enter the fall-winter period with gonads at an advanced state of maturity, thus they are ready to spawn as soon as water temperatures rise." He then cites an example of two cutthroat collected from a spawning redd on a spring-fed tributary to the Snake River above Shoshone Falls on November 19th. He postulates that the movement from the colder Snake River into the warmer tributary (with a constant 9 degree C. temperature) prompted the "remarkably early" spawning.

Hatcheries have often manipulated water temperatures as a means of affecting spawning maturation. Adult steelhead held in ponds with a water supply several degrees warmer than the creek, spring or river that is the usual water source has been a standard hatchery practice in Washington for many years to accelerate the time of maturation (Royal 1972).

Another fact of Kamchatka is active volcanism that includes explosive mountains and geothermal water sources. The former are irregular eruptions of unpredictable timing; the latter are typically more constant sources although earthquakes or mountain volcanic activity can suddenly open or close geothermal water sources too. Female egg development could be accelerated by such regular, or irregular occurrences. The males are perpetually prepared for such possibilities.

But there is an additional natural retardant to further maturation of Kamchatkan female steelhead that might negate water temperature benefits from volcanic, geothermal or spring sources from early November through early February. The rivers of the Kamchatkan steelhead study are 56-59 degrees N latitude. Winter days are short and nearly non-existent in parts of December/January. This lack of light is further compounded by the cover of ice and snow on the rivers.

Light has been shown to be another determinant of steelhead maturation rate. Because of cold winter water as the source to Skamania Hatchery on the North Fork Washougal River, in order to stimulate earlier maturation and subsequent earlier egg-take from summer steelhead held there, lights were turned on over the holding ponds after sunset (Millenbach 1972). Presumably, lack of light would have an opposite effect by retarding maturation.

<u>Accepting What Cannot Be Understood by Preserving It</u>:

It remains possible that early spawning is entirely absent at this point in time on Kamchatka. If Kamchatkan steelhead have effectively adapted around severe winter conditions with an interactive male/female spawning timing presently documented only from early May to mid-June (and nowhere suggested as any longer than April through June on any Kamchatkan river), then what's the adaptive value of males that are ready to spawn by mid-October?

The fact is, it is not important that we understand why. No individual human, nor any human culture has existed or will exist long enough to know the complete answer. It is only important that we recognize and protect what Kamchatkan conditions have effectively selected for in the long-term as evidenced by the entire breadth of visible, or otherwise distinguishable traits.

and continuing survival of the animal through altered "norms" in ocean migration routes, river entry timing, gonad maturation, spawning timing, water temperature tolerances, body shapes, juvenile migration patterns, and etc., etc. Without maximal breadth of those differences, the animal is increasingly likely to vanish over time.

Photo by Bill McMillan

The Kvachina River on Russia's Kamchatka Peninsula. Many Kamchatkan rivers are intact and largely unaltered. They provide opportunities to study anadromous fish populations as they once may have been in the northwestern United States.

The residual remnants of long-term adaptation are the seeming aberrations and anomalies of the split-second in genetic time that is the present. Following "catastrophic" events, aberrations and anomalies can be rapidly selected as the more adaptive "norm." When El Ninos, Mt. St. Helens events, and/or inland droughts become common occurrences, aberrations and anomalies become the mechanisms to adaptation

THE COMPLEX "FABRIC" OF SALMONID ECOSYSTEMS IN KAMCHATKA

The anadromous fish of the Kamchatka Peninsula provide the intact example of what the "fabric" of the anadromous fish population complex once might have been in the northwestern United States. It's a fabric built on diversity, abundance and the beneficial interactions of the varied fish species and stocks in their adaptations to differing habitat niches and to each other.

Pacific salmon with overlapping return timings mutually create localized freshwater ecosystems built on their own maximized abundance perhaps because of, rather than in spite of, volcanic origin rivers carrying heavy silt loads in Kamchatka. Among the benefactor species of this "*Oncorhynchus* ecology" are steelhead/rainbow (*S. mykiss* in Russia), two char (*Salvelinus*) and perhaps a primitive cutthroat (*S. clarki* in Russia) that has yet to be classified.

Without experiencing Kamchatkan rivers, it is difficult to convey the notion that volcanically "degraded" rivers may not be a limitation to anadromous fish abundance, but actually may have initiated an evolutionary process that has resulted in what might be termed "suspended" or "floating" self-creative ecosystems that are detached from, and minimally dependent upon, the innate productive qualities of volcanic origin rivers themselves except for open access into them and cold, unpolluted, flowing water.

The lower sections of these rivers consist of long reaches of gravel mixed with immense quantities of fine sediments. But the varied mounds of pink, chum, and chinook salmon redds are everywhere as testimony that mud-impacted gravel supports fish. It would appear that intense spawning redd competition and the repetitive superimposition of redds may actually create mounds of ever-cleaner gravel for each succeeding spawner. Thus, reasonably clean spawning gravel is dependent upon sacrificial "inefficiency" through maximized competition on the spawning gravel in the appearance of wasteful mayhem. Clean gravel appears secondary to the primary necessity of maximized salmon abundance in order to create their own conditions for success.

The long, mud-bottomed sections of the lower Kamchatkan rivers visited appeared deficient in another way. Although aquatic insects were not specifically analyzed for abundance or species during the Russian-American scientific expedition, the more common North American aquatic insects such as Mayflies (*Ephemeroptra*), Stoneflies (*Plecoptera*) and Caddisflies (*Trichoptera*) did not appear numerous. However, the stream bottom of these lower river reaches was profusely populated by what appeared to be a small, shrimp-like crustacean from 1/4"-3/4" in length. They are still in the process of being identified by the Russian scientists. They appear to be the first-line attack mechanism for breaking down spent fish carcasses, and they may prey on buried salmon eggs. But they would also appear to provide a remarkably abundant forage for rearing salmonids in place of aquatic insects. Along with carcass parts, these small crustaceans are forage products of, and for, salmonid abundance. Like the self-creative quality of the spawning gravel, they are detached from the innate river quality. In this "suspended" ecosystem, life appears to support itself like some nomadic Gypsy camp that can inhabit most anyplace as long as the sheer numbers and the complexity of living and dying organisms (of species and within species) is present and has access to unpolluted moving water.

The present management formula most often used for determining salmon escapement in North America, maximum sustained yield (MSY), would appear to have no valid function in Kamchatka unless the design was salmon extinction. Anadromous salmonids of Kamchatka appear to be dependent upon "MSA" (maximum sustained abundance). Perhaps salmon are everywhere, and Kamchatka is not unique.

Steelhead/rainbow are classified *Salmo mykiss* by Russian ichthyologists. They do not feel that a sufficient case has been built to put them in the genus *Onchorhynchus* (personal communication with Professor K.A. Savvaitova from Moscow State University in September, 1995). But it is clear in Kamchatka that steelhead/rainbow are benefactors of *Onchorhynchus* abundance. Because of steelheads' characteristic dependence on use of the freshwater environment for extended rearing, they and char may benefit most from carcasses, egg deposition, and the small crustacean provided by salmon abundance in the lower rivers. Steelhead/rainbow migrations to and from lower river and estuarine sections is prevalent in Kamchatka (Savvaitova et al. 1973; 1996; and 1997). With the exception of Klamath and Rogue River "half-pounders," this life history characteristic is generally not recognized in North America. Perhaps it was more common in eras of salmon abundance.

In Kamchatka, steelhead/rainbow life history diversity is broad and necessary to take advantage of each and every habitat advantage that is available. Nowhere is it more evident that the adaptive edge for the community of *Oncorhynchus* is built on abundance, while the adaptive edge of *S. mykiss* is built entirely on diversity that is capable of taking advantage of *Oncorhynchus* abundance or any other benefits provided by local or more distant environments. If *Oncorhynchus* is a more mystical creature of population enormity with a "suspended" self-creative quality for adaptation, then *S. mykiss* is a more practical creature of a more individualistic nature entirely connected to the opportunities of its environmental options through adaptive diversity.

CONNECTING OBSERVATIONS FROM TWO CONTINENTS: ASIA AND NORTH AMERICA

My returns from Kamchatka stimulated inevitable comparisons between Asian steelhead (which I had observed and studied for a few months), and the North American steelhead that I had observed and studied for 40 years. Inevitably, the Washougal River, a Washington tributary to the lower Columbia that I had lived on for 26 years, whose banks and tributaries I had walked in spawning surveys for 18 years, and whose pools and rapids I had snorkel counted for 9 years, provided the most immediate recall of data from which to make comparisons, draw conclusions, and from which to recreate a hypothesis that I had neglected to take any further in the mid-1980s.

A Male Steelhead Hypothesis Takes Initial Form:

On March 25, 1985, while walking Winkler Creek, a tributary to the Washougal River at River Mile 9, I found what appeared to be a wild female steelhead (no missing fins) spawning with two males that had missing dorsal fins, as is characteristic of many hatchery steelhead (personal field notes). [This was one year prior to all hatchery adults returning with adipose fin clips on the Washougal. However, stubbed dorsal fins were found in 88% of Kalama River hatchery steelhead (Crawford et al. 1978). Dorsal stubbing was presumed to be a similar indicator of hatchery steelhead origin on the Washougal River.]

75 feet downstream, Winkler Creek emptied into the Washougal. At the mouth, yet a third male was advancing into the smaller stream's freshet. It seemed remarkable that this fish could swim against the concentrated current. Sores spotted its body. One eye was surrounded in the white mess of fungus. Its movements were slow, deliberate, and yet, nevertheless, driven upstream for the active redd.

Although I could not determine if he had a missing dorsal fin or not, this third male registered vividly in my mind because of his juxtaposition with the two better-conditioned hatchery males vigorously spawning with the wild female. It emphasized that steelhead, unlike Pacific salmon, do not necessarily die shortly after spawning. And while female steelhead expend their eggs in a single spawning, males are potentially capable of generating sperm through repeated spawnings.

I made a number of tributary walks on the Washougal River in late March and April, 1985. It was purely the accident of needing moderate exercise to recover from a hernia operation. I lingered and watched with less hurry than on most spawning surveys. Due to the leisure, maybe I was more inclined to mentally explore what was observed.

On March 26, 1985, in a quarter-mile search of an unnamed tributary that some call "Slough Creek" (River Mile 8), I found one steelhead spawning pair — both wild (no missing fins). The male was large for the small size of the creek and was distinctively colored (personal field notes).

On April 2, 1985 (seven days later), I returned to "Slough Creek." No active spawning was found, but I did see the same distinctively sized and colored male as observed actively spawning on March 26th. He seemed to be waiting for other females to arrive and gave every appearance of being a vital, strong and reproductively capable fish (personal field notes).

A hypothesis began to take form. It was something simple and elemental in the general understanding of the differences between being male and female:

Because of the prolonged time span for potential male spawning, it may be virtually impossible to temporally isolate hatchery from wild steelhead on the spawning grounds while preserving the diversity of wild steelhead spawning timings necessary for effective adaptation to differing habitat niches, variations in annual weather conditions, or longer term climatic fluctuations.

However, March 15th is the date that Washington Department of Fish and Wildlife (1994[b]) has chosen to determine hatchery from wild steelhead spawning as a blanket management tool for Washington steelhead streams. Spawning activity on, or prior to, March 15th is assumed that of hatchery steelhead in Washington, and spawning activity thereafter is assumed that of wild steelhead. The assumption that hatchery steelhead are effectively isolated from spawning with wild steelhead is fundamental to

Photo by Bill McMillan

A wild male steelhead encourages a female beneath him to continue spawning activity on Slough Creek on the Washougal River (March 26, 1985).

Washington's steelhead management. If March 15th is not an effective criteria for determining the separation of hatchery from wild steelhead spawning, Washington's steelhead management plans fall apart unless hatchery and wild steelhead are effectively isolated from spawning together by some other mechanism.

If genetic diversity of wild steelhead (one aspect of which is breadth of spawning timing) is a fisheries management goal, or if reduced diversity is considered a risk to long-term wild steelhead/rainbow survival as a species in the broader interests of science and other facets of human culture, then male steelhead, in particular, would seem to be a particular problem. If their potential spawning timing is longer than for females, then hatchery selection for early spawning females may not temporally isolate hatchery males from wild females, nor wild males from hatchery females.

A resulting failure to temporally isolate hatchery and wild steelhead would perpetually introduce hatchery steelhead characteristics that reduce spawning success in riverine environments (as demonstrated by Chilcote et al. (1986), Leider et al. (1990), and Hulett et al. (1995)) into wild steelhead/rainbow populations on an annual basis. Due to the resulting high mortality of hatchery/wild steelhead crosses, evidence of such crosses may never show up through genetic evaluations — the steelhead carrying the genetic evidence of such wild/hatchery crosses having largely died before maturity. Those time periods when hatchery/wild spawning interactions most overlap might result in an eventual gap in wild steelhead entry times, wild steelhead spawning times, and in wild steelhead numbers to fill those habitat niches in which that specific spawning timing may be critical to survival.

<u>The Male Steelhead Hypothesis Takes the Form of a Wider Story</u>:

Lacking direct means to test the suspicion about the part that male steelhead play in extending the likelihood of hatchery/wild steelhead spawning interactions, it wasn't until a fishing experience eight years later that I began to see the potential magnitude of the implications. These implications then took the form of a larger story that subsequent experiences and a search for more evidence would have to confirm:

On an angling tip from a friend, I hiked to the hatchery tributary's junction with the main Washougal River on March 1, 1993. As he said, steelhead were spread in visible "rafts" through a 200-foot section of water. After two hours of fishing I hooked five but only managed to bring one to hand for examination — an adipose clipped male. All of those hooked or seen appeared to be dark-colored males and all likely hatchery. Hatchery females had been done and gone for nearly two weeks (personal field notes). [Over the next two weeks I did not fish. But ending with a freshet of high water on March 15th that made the river unfishable for a week thereafter, my friend returned three times to the same piece of water near the hatchery tributary. I asked him to record the sex and origin of what he caught. He landed 12 steelhead. All were dark hatchery males (personal field notes).]

Satisfied that I was going to catch nothing but ripe hatchery males from the water near the hatchery tributary that day, I returned to my cabin to fish a favorite run. Just before dark I caught and released a large wild female. Despite her bright silver sides, her swollen belly and distended vent indicated she would be spawning within a few days. It wasn't until reaching the cabin door that I remembered the gauntlet of hatchery males that she would have to pass through a half-mile upstream.

She was the only wild steelhead I was to catch all winter. What few wild males that had been waiting may have spent themselves in the previous month's spree with plentiful and mature hatchery females. Even if they had not, through sheer numbers she was left primarily to the horde of lingering hatchery males. Some would hound and follow her to wherever she was destined. The hatchery males had no other options; nor did the wild female. It was the destiny that modern steelhead management has created — a component of the spiral to depletion of wild steelhead.

What has happened was built on a flawed supposition: sufficient spawn timing differences between wild and hatchery steelhead exist to minimize crosses between the two. The error in that supposition has been based on the fallacy that the potential spawning timing of hatchery and wild steelhead holds the same for males as for females.

<u>Developing the Supportive Evidence</u>:

The objective of the supportive evidence will be to disprove the validity of using March 15th, or any other static return timing or spawning timing date, as an effective tool from which to identify, and then manage for, wild steelhead.

The evidence will attempt to show that male steelhead, in particular, do not fit within spawning timing frames that can provide temporal isolation between hatchery and wild steelhead. Due to steelhead management that has been largely based on temporal spawning isolation between hatchery and wild steelhead, as has occurred in Washington, to some extent in Oregon, and perhaps elsewhere in North America, wild steelhead/rainbow depletions in both numbers and diversity have occurred in those habitat areas where there are no barriers to separate wild and hatchery steelhead. As a result, many wild steelhead/rainbow populations in North America where this management strategy has been used may have been "reshaped" from their historic characteristics with a weakened potential for adaptation. This is at the crux of the extended hypothesis for this paper.

The Kamchatka steelhead findings magnify the implications of the hypothesis created for North American steelhead. What I saw in Kamchatka, and learned from the scientists there, dramatically increases the potential range of consideration for wild males, in particular, to interact with hatchery females during spawning activities on North American rivers. Kamchatka provided an unexpected beginning of supportive evidence that the sexual maturity of male steelhead is prolonged as compared to females. The Kamchatka evidence is of particular value because steelhead there have not been influenced by hatchery introductions nor have there been major alterations in the riverine environments due to modern agro-industrial colonization.

There is also a considerable range of supporting evidence from North American sources. The North American evidence, and further evidence from Kamchatka that supports the breadth of the hypothesis will be covered in the following major groupings:

1) Examples of male and female sexual maturation periods for steelhead/rainbow in North America.

2) Wild steelhead spawning timing breadth and spawning timing peaks with mainstem timing compared to tributary timing.

3) Hatchery steelhead spawning breadth and spawning peaks on Gobar Creek of the Kalama River.

4) The importance of steelhead entry time and spawning diversity.

5) The wild-male/hatchery-female connection.

6) Resident and estuarine life histories: A continuing male link to steelhead.

7) Steelhead management as a determinant of the composition of origins and diversity of steelhead populations.

CREATING A COMMON GROUND FOR EXAMINING THE INFORMATION THAT FOLLOWS

March 15th will be a comparative date used for analyzing much of the spawning timing and return timing data provided in this paper. It is a timeline that the State of Washington developed and uses for basing hatchery/wild assessments of data in steelhead management decisions (DeShazo 1985; Washington Department of Wildlife 1994[b]). Mid-March has also been used as a more generalized time frame for identifying wild from hatchery steelhead spawning in Oregon streams (Oregon Department of Fish and Wildlife 1995; Troop and Wicker 1996), although the development of local broodstock from wild populations began in 1990 on some Oregon coastal systems in order to address the problems of Alsea Hatchery stock steelhead impacting wild populations and to meet wild fish and genetic management policies (Oregon Department of Fish and Wildlife 1995).

Much of this paper will focus on varied references to spawning terms. Some of the past problems in the study of anadromous salmonids have stemmed from loose use of the term "spawning time." This is particularly the case when considering salmonids that can have protracted periods of: entry time to major spawning rivers; time of sexual development to full maturation or ripeness; time of ripeness to actual completion of spawning that may include differences for each sex; entry time to actual spawning grounds after time of major river entry; and the actual spawning activity itself as evidenced by redds constructed in the gravel with egg deposition and fertilization. In the case of some Pacific salmon in shorter rivers, particularly pink (*Oncorhynchus gorbuscha*) and chum (*Oncorhynchus keta*) salmon, these events may be so compressed that "spawning time" is assumed to mean a blurring together of everything happening at once.

However, in the case of steelhead/rainbow (*S. mykiss* or *O. mykiss* depending on Asian or North American reference), the time of initial river entry to the time of actual egg deposition/fertilization may be a full year. As an example, summer-run steelhead historically commenced Washougal River entry in the month of March, and in some years there would be angling catches of a lead entry as early as February (McMillan 1984[a]; and 1984[b]). These fish would spawn from January to May of the following year (McMillan 1984[b]). Somewhere between those time periods of entry and spawning, males and females would come to sexual maturation in their own times — by sex, by genetic variation, by variation in annual conditions, by specific area of the watershed destination, and etc., etc.

In order to reduce potential misunderstandings in terminology, a glossary follows identifying the meaning I have intended for varied spawning terms.

Glossary of Spawning Terms:

Egg deposition: when eggs are being deposited by females as evidenced by construction of redds.

Period of ripeness: that spread of time when gonads (male or female) become sexually mature until the complete expenditure of sperm or eggs.

Period of sexual maturation: the same as for period of ripeness.

Potential spawning timing: that period of time when a male or female can potentially spawn as evidenced by gonads that are sexually mature and continuing until complete expenditure of sperm or eggs; essentially the same as period of sexual maturation and period of sexual ripeness.

Ripe: that point in time where male and/or female gonads are at full maturation and the fish is capable of successfully expending sperm or eggs.

Sexually mature: the same as for ripe.

Spawning time: when females are actively constructing redds and depositing eggs, and males are in the activity of cohabiting with females for purposes of egg fertilization.

Spawning timing: that period of time when females and/or males are actively depositing eggs and fertilizing them.

EXAMPLES OF MALE AND FEMALE SEXUAL MATURATION PERIODS FOR STEELHEAD/RAINBOW IN NORTH AMERICA

A Columbia River Example:

The Kamchatka Peninsula holds no monopoly on steelhead diversity. In fact, Kamchatka is at the extreme northern range of rainbow/steelhead distribution along the Pacific Rim. The habitat/climate mix for steelhead/rainbow is not as complex there as in the more varied niches found in the center of the steelhead/rainbow distributional range — particularly that of the Columbia River with its many tributaries and geologic, geographic and climatic breadth of watershed areas. Adaptation is a response to habitat. Diversity is the response to complex habitats.

Historically the Columbia River system had greater diversity of steelhead than presently remains. Those that returned to British Columbia, Nevada, upper Snake River, upper Cowlitz River, upper North Fork Lewis River, and upper Deschutes River are among the destinations blocked by dams, with resulting steelhead extinctions. What diversity they may have represented we can never entirely know. But one piece of information from American Food and Game Fishes (Jordan and Evermann 1902) suggests an historic component of Columbia River steelhead diversity that is hauntingly reminiscent of the widely split dates between sexual maturity and actual spawning timing observed in a significant proportion of Kamchatkan male steelhead:

"The spawning season of the steelhead seems to be a prolonged one and varying greatly with the locality. In the headwaters of the Salmon River, Idaho, where there are important spawning beds, spawning takes place in May and early June. In Payette River they spawn a fortnight earlier, and in the shorter tributaries of Snake River from April 15 to May 10. Still lower down the Columbia basin they probably spawn increasingly earlier. Of 4,179 steelheads examined during the last week in September, and the first half of October, at The Dalles, Oregon, 1,531 were males and 2,648 females; 476 males and 900 females were well developed, and probably would have spawned in 4 to 6 weeks. The remaining 2,803 apparently would not have spawned until the next spring."

This reference would indicate that 31% of the male steelhead and 34% of the female steelhead passing Celilo Falls at The Dalles from September to mid-October were ripe by mid-November to early December. Mid-November to mid-June would be a seven-month span for potential spawning, both male and female, on the Columbia upstream of Celilo.

The question is: Did both males and females continue to mature, as suggested by Jordan and Everman? A seven-month span for full male maturation compares closely with that found for Kamchatkan male steelhead. But the earliest evidence cited for actual spawning on the upper Columbia occurred on the Payette River around April 15th and lasted into early June on the Salmon River. This was a two-month span of known egg deposition by females on the historic upper Columbia that is nearly identical to that for females on Kamchatkan rivers — but far less than the seven months suggested as a possible span of female ripeness based on the level of development on passage at Celilo Falls.

Perhaps upper Columbia female maturation remained delayed like in Kamchatka. Long cold winters are common in the upper Columbia and Snake rivers. At this point in history, all that is known is that a significant number of steelhead passing Celilo Falls on the Columbia River in the late 19th Century were at a more advanced state of sexual maturation than is presently documented. It tells us that a component of the upper Columbia steelhead population may presently be missing, or that it still exists undocumented and unrecognized.

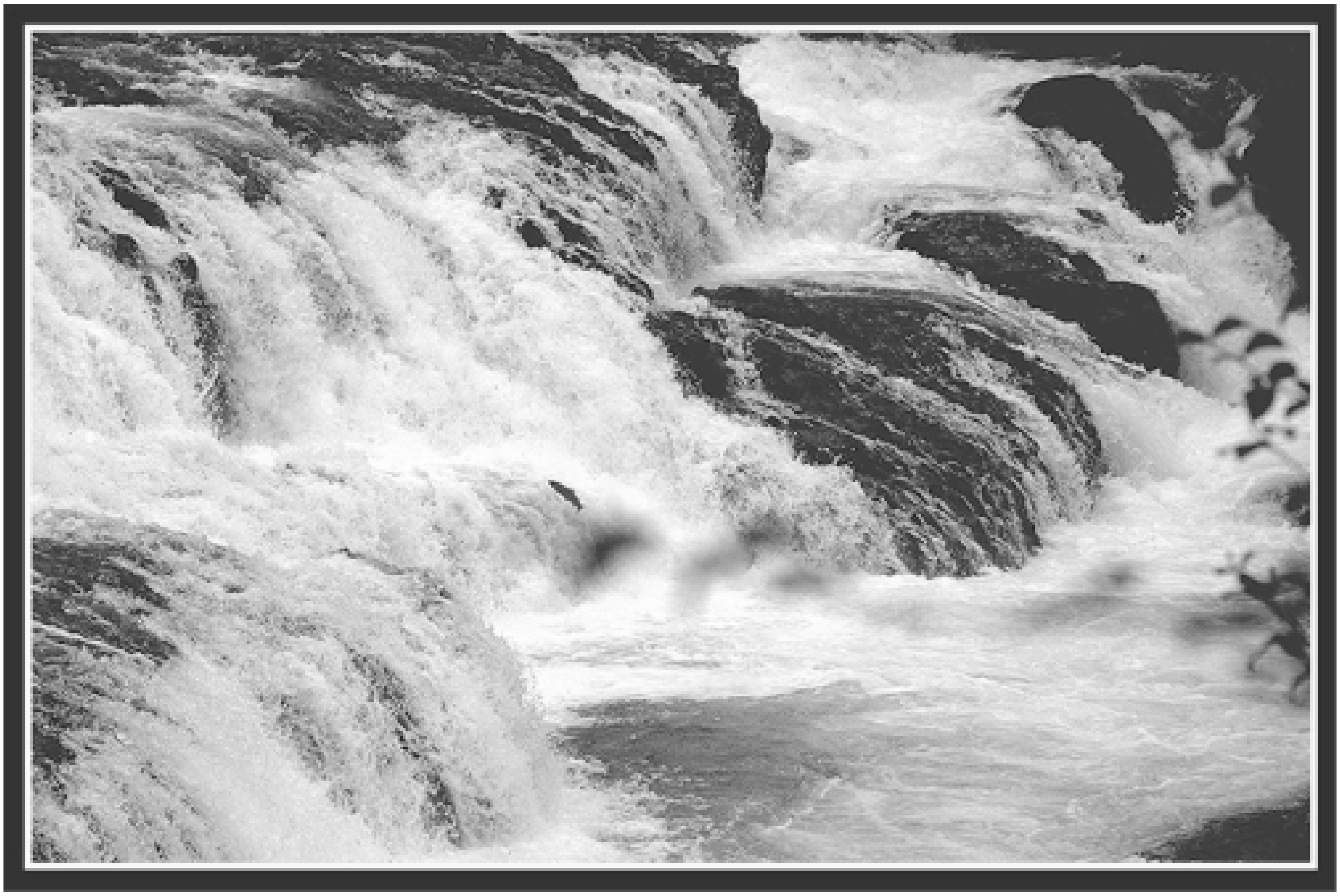
A Washougal River Example:

The Washougal River enters the lower Columbia at River Mile 121. The mainstem Washougal is approximately 30 miles long. As a means of learning more about its wild steelhead, I began doing spawning surveys in the more pristine upper reaches in 1979 and began snorkel surveys there in 1985 (McMillan 1983; 1984[a]; 1985; 1986[a]; 1986[b]; 1987; 1988[a]; 1990; 1991; and personal field notes).

The Washougal's wild summer steelhead population has been in decline since the 1950s (McMillan 1984[a]; and 1987; Rawding 1997). Escapement estimates for this population prior to the early 1950s were 1,000-1,500 summer steelhead (McMillan 1984[a]; 1984[b]; and 1987). This did not include the estimated annual sport harvest of 400-500 summer run steelhead for that era (Lavier 1973). The five-year minimal escapement average for 1992-1996 as determined by snorkel counts was 79 wild summer steelhead (Rawding 1997). This minimal escapement figure is 5%-8% of total escapement prior to the early 1950s. It includes no legal harvest. Wild-steelhead-release regulations were implemented on the Washougal River beginning in 1986 (McMillan 1986[a]).

The dramatically reduced numbers of wild summer steelhead returning to the Washougal River have likely affected diversity. However, patterns of data recorded into the mid-1980s continued to demonstrate two adult return peaks (April/May and September/October) during the March to November river-entry time of steelhead destined for the upper Washougal (McMillan 1984[a]; 1987; and 1988[a]); and spawning surveys into the mid-1980s continued to show wide ranges of spawning timing (McMillan 1983; 1984[a]; and 1986[a]). This is due to the varied isolative niches created by a maze of waterfalls on the upper Washougal and several of its tributaries. Complex adult entry times and spawning timings are required for anadromous fish to enter these niches and successfully spawn. Spring and fall entry times, dependent upon the specific niche, appear to be the best adaptations to do so (McMillan 1984[a]; 1984[b]; and 1988[a]). Without broad steelhead diversity, these habitat niches would be void of anadromous fish. Now they nearly are, with remnant-level wild steelhead returns to the Washougal River.

The Washougal River also has a wild winter steelhead population. The winter-run is as complex in spawning timing and river-entry times as the summer-run. Most return to the lower and mid-Washougal River and tributaries, but some winter steelhead share habitat niches with summer steelhead on the upper Washougal (McMillan 1984[a]; 1984[b]; and 1987). Sometimes there appear to be significant temporal separations between spawning peaks in wild winter steelhead and wild summer steelhead in the upper Washougal (McMillan 1988[a]), but generally there seems to be considerable overlap with more subtle differences between the spawning peaks (McMillan 1984[b]). Without actually capturing spawning adults for identification, differences in summer and winter steelhead spawning timing on the upper Washougal require considerable subjectivity based on long-term observations.



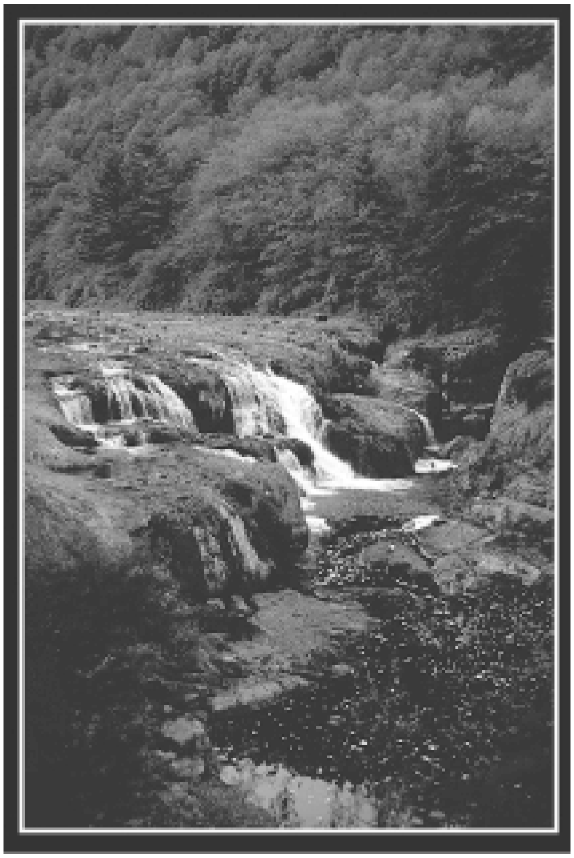
Photoby Bill McMillan

Dougan Falls in a typical May flow when wild steelhead passage is common. Similar flows occur in late April and early June, and then again from mid-September through October.

The Washougal River also has returns of both winter and summer hatchery steelhead. The hatchery winter steelhead released into the Washougal originated from Chambers Creek on southern Puget Sound. They have been selected for early return time and early spawning (Crawford 1979; DeShazo 1985). The hatchery summer steelhead released into the Washougal originated primarily from summer steelhead trapped on the North Fork (also called West Fork) Washougal River, although some Klickitat River summer steelhead were also taken for brood (Crawford 1979). Skamania stock steelhead have been selected for: early spawning (Millenbach 1973; Randolph 1986); large adult size with reduced life history traits and eventual elimination of one-salt adults (McMillan 1984[a]; and 1987; Randolph 1986); and attempts toward recreating early return timing (McMillan 1987).

The Skamania Hatchery is located on the North Fork (also known as West Fork) of the Washougal which enters the mainstem at River Mile 13. Both winter and summer hatchery adults return there, but they also stray in varying degrees throughout the watershed as found in spawning and snorkel surveys previously referenced. Outplanting of both hatchery stocks have also been made into varied sections of the mainstem Washougal River (personal communication with Mark Chilcote of Washington Department of Game, June 5, 1987).

Dougan Falls (River Mile 21) has proven to be significant for wild Washougal steelhead. It's a vital isolative barrier that presently denies entry to most hatchery steelhead. This has been determined by snorkel counts which identify wild steelhead with adipose fins from hatchery steelhead without adipose fins. (Those whose adipose fins cannot be seen are counted as unknowns.) Steelhead snorkel counted directly



Dougan Falls as it looks from July into September, when it typically denies steelhead passage and when most hatchery summer steelhead arrive there.

Dougan Falls in a full winter freshet, which can occur from November through February. High flow velocities over the lip of the falls commonly deny steelhead passage in winter.

Photos by Bill McMillan

Dougan Falls in a full winter freeze, which can occur from late November through January and last for up to three weeks. Even without ice, winter water temperatures are typically too low to provide passage.

below Dougan Falls have ranged from 5%-40% hatchery origin at differing times of the year and during differing years. So early steelhead spawning must always be suspect there regarding hatchery or wild determinations of redd origins. But only 0%-4% of the steelhead above Dougan Falls were found to be of hatchery origin depending on the year (McMillan 1988[a]). Therefore, redds found above Dougan Falls have a 96%+ probability being those of wild steelhead.

Electrophoretic analysis of Washougal River summer steelhead also shows no genetic evidence of interbreeding between hatchery and wild fish (Phelps et al. 1994). Although it will later be suggested that this does not necessarily mean there has been no spawning between hatchery and wild steelhead, combined with the field evidence provided by spawning and snorkel surveys on the Washougal River, it is apparent that above Dougan Falls very few hatchery and wild steelhead presently spawn together.

That may not have always been the case when Skamania hatchery stock summer steelhead had characteristics more similar to the wild Washougal steelhead they originated from. Prior to varied selective factors at Skamania Hatchery in the 1960s and 1970s, Skamania hatchery stock steelhead had a return time and range of sizes and ages that were better adapted to upper Washougal River entry (McMillan 1984[a]; and 1987). Be that as it may, present factors limiting wild steelhead recovery in the upper Washougal probably aren't due to hatchery/wild spawning interactions above Dougan Falls (below Dougan Falls is an entirely different case), and the wild steelhead that presently return above there likely portray spawning characteristics of steelhead native to the upper Washougal drainage.

Given this background, the following differences in steelhead sexual maturation times were found on the Washougal River:

WASHOUGAL RIVER WILD FEMALES

Several times in the month of January (the earliest being January 9, 1987), fresh inactive redds were found at one mainstem pool approximately one mile upstream of Dougan Falls (McMillan 1983; 1986[a]; and 1990). Perhaps warming springs upwell from the river bed stimulating early maturation and spawning of females. Whatever the reason, it has proven unique in its regular evidence of early spawning in a river section where most steelhead (96%+) are wild.

The latest spawning evidence of a wild female steelhead was found in the upper Washougal on July 22, 1979. Remnants of a steelhead carcass were found about one mile up Stebbins Creek, whose entry to the Washougal is three miles above Dougan Falls. 200 feet upstream of the carcass a redd was found with green algae beginning to grow on it (McMillan 1983). The algaed redd and carcass remnants were arbitrarily given a spawning date of ten days earlier (July 12th), as was done on all older redds observed on the upper Washougal.

Washougal River Potential Range for Wild Females to Spawn: The observed range for wild females to potentially spawn was January 9th to July 12th — six months.

WASHOUGAL RIVER WILD MALES

The earliest wild male steelhead in ripe condition (as evidenced by sperm) that I recorded from the Washougal was a winter run sport caught on November 29, 1977 (personal field notes). I remember several other wild winter male steelhead sport caught from late November through December that were at a similar stage of early maturity, but the information was not recorded.

The latest wild male observed that may have been capable of fertilizing eggs was found 1/8th mile upstream of the old redd/carcass previously described in Stebbins Creek on July 22, 1979. The male was dark and skinny, but that it had not dropped out of the small creek suggested it was still capable of spawning (McMillan 1983).

Washougal River Potential Range for Wild Males to Spawn: The observed range for wild male steelhead to potentially spawn was November 29th to July 22nd — eight months.

[With the tools available it was not possible to determine the potential spawning breadth for individual male steelhead on the Washougal (from initial ripeness to completion). It probably is not as long as that of some individual Kamchatkan male steelhead. This is primarily because Washougal males have opportunities to spawn repeatedly with earlier maturing females (including those of hatchery origin). However, because some wild males have been observed to be sexually mature at the end of November while the earliest evidence of observed wild spawning has been January or February (depending on year), some individual wild males on the Washougal would appear to be sexually mature for at least two months and longer may be possible.]

WASHOUGAL RIVER HATCHERY FEMALES

The earliest steelhead spawning evidence I know of for the Washougal River were several redds found with active spawning near my cabin 1/4 mile downstream from the hatchery tributary on December 20, 1991. Although the origin of the steelhead could not be determined in the high flows, that they were redds of hatchery females is highly probable (personal field notes).

The latest hatchery female spawning evidence was observed between March 13, and March 19, 1985 (personal field notes). I noted a great deal of spawning activity on those two dates as an aside to fishing. That most of it occurred within 1/2 mile of the steelhead hatchery tributary on the mainstem Washougal strongly suggested that many of the redds were those of hatchery steelhead.

Washougal River Potential Range for Hatchery Females to Spawn: The observed range for hatchery female steelhead to potentially spawn was December 20th to March 19th — three months.

WASHOUGAL RIVER HATCHERY MALES

The earliest hatchery male steelhead that I recorded in ripe condition (as evidenced by sperm) on the Washougal was caught November 29, 1967, and contained the primary wing feathers of an American Dipper (*Cinclus mexicanus*) in its stomach (personal field notes).

The latest evidence of hatchery male steelhead actively spawning was observed on a tributary of the mid-Washougal, Winkler Creek, on March 25, 1985. What appeared to be a wild winter run female was accompanied on the redd by two hatchery males with missing dorsal fins (McMillan 1986[a]). This was a year prior to subsequent hatchery adult returns with clipped adipose fins on the Washougal, but missing dorsal fins remained a common indicator of hatchery steelhead origin.

On April 16, 1985, there was evidence of yet another hatchery male steelhead consideration. I sport caught a 16"-17" adipose-clipped male. It was skinny and had recently spawned, but it did not appear to have gone to the sea. It appeared to be a hatchery smolt that had residualized from the first group of adipose clipped smolts released from Skamania Hatchery on the Washougal River in the spring of 1984 (personal field notes).

Washougal River Potential Range for Hatchery Males to Spawn: The observed range for hatchery male steelhead to potentially spawn was November 29th to March 25th — four months. [If the residual smolt that lived to maturation and spawning just prior to April 16 is counted, the range was 4.5 months.]

[As with the wild Washougal males, I do not know the potential spawning breadth (from initial ripeness to spawning completion) for individual hatchery male steelhead. But the two hatchery males observed spawning with a wild female on Winkler Creek (March 25, 1985) may well have been ripe in late December, as has been my common angling experience with hatchery-origin males in Washington. A three-month potential for some individual hatchery males to spawn would seem entirely possible.]

<u>A Siuslaw River Example</u>:

The Siuslaw River is part of Oregon's "Mid and North Coast" gene conservation area for steelhead (Oregon Department of Fish and Wildlife 1995). The climate and non-glacial origins of Oregon's mid and north coast rivers are not dissimilar from the climate and origins of many rivers and streams located on the southern Washington coast and lower Columbia River. In other words, these Oregon steelhead stocks have adapted around spawning timing factors such as river flow patterns and temperatures that are similar for some Washington steelhead stocks.

Characteristics of steelhead — for hatchery and wild, for male and female, for mainstems and tributaries — will be compared throughout this paper that reflect broad similarities whether from the Siuslaw and Necanicum rivers in Oregon, or the Washougal, Kalama, and Clearwater rivers in Washington. This in no way diminishes the unique differences that exist in steelhead. Rather, it emphasizes the importance of including the broadest peripheral possibilities if the widely ranging peaks in the annual variables of entry and spawning times are to be captured within the development of management patterns.

BACKGROUND ON HATCHERY STEELHEAD RELEASED INTO THE SIUSLAW RIVER

Siuslaw hatchery steelhead are from non-native Alsea River stock. Like the Chambers Creek Hatchery stock of winter-run steelhead in Washington, the Alsea Hatchery stock of winter-run steelhead has been broadly dispersed into most Oregon coastal streams (Oregon Department of Fish and Wildlife 1995). Unlike the Chambers Creek Hatchery stock, the Alsea Hatchery stock has not been specifically selected for early return and early spawning (personal communication with Bob Hooton of Oregon Department Fish and Wildlife Fish Division, January 9, 1998).

Despite no specific selection for early return time and early spawning of Alsea Hatchery stock steelhead, they have been characterized in both management and research literature as having earlier spawning and earlier returns than wild steelhead stocks: In the Biennial Report on the Status of Wild Fish in Oregon (Oregon Department of Fish and Wildlife 1995), which is used as a tool for implementing Oregon's Wild Fish Management Policy, the Alsea Hatchery stock is described as spawning in January and February, while most wild Umpqua basin populations spawn in March-May. It is added, however, that hatchery winter steelhead have been observed spawning with wild North Umpqua summer steelhead.

Alsea Hatchery steelhead were also described in a report from ODFW's Research and Development Section as entering spawning areas mostly in January and February on Oregon's Necanicum River, with a noticeable break in spawn timing between wild and hatchery steelhead occurring the week of March 11th (Troop and Wicker 1996). This is despite the observation from the same report that hatchery steelhead were captured from redds in the Necanicum system for 14 of the 17 weeks studied, and wild steelhead were captured for 15 of the 17 weeks studied.

These references indicate that Alsea Hatchery stock steelhead appear to share spawning timing characteristics with Washington's Chambers Creek Hatchery stock steelhead, and that similar management and research assumptions have sometimes been made in Oregon, as in Washington, regarding temporal separations in spawning timing between these hatchery stocks and wild stocks, despite evidence to the contrary.

However, the Siuslaw studies represent a changing emphasis in Oregon. More accurate steelhead spawning information has been collected regarding escapement levels for hatchery steelhead relative to varied broodstock origins and wild steelhead escapement levels as created in the standards of the Oregon Wild Fish Management Policy (Lindsay et al. 1991).

SIUSLAW RIVER RESEARCH COMPARING HATCHERY/WILD AND MALE/FEMALE STEELHEAD SPAWNING TIMING

Steelhead entering several Siuslaw River tributaries in the winters of 1990-91, 1991-92 and 1992-93 were trapped throughout the full spawning season (Lindsay et al. 1991; 1992; and 1993). Each steelhead was identified as to sex; scale samples were taken to determine age and origin (wild or hatchery); and each was marked prior to release or held in tubes for broodstock use. The goal of the research project was to provide managers with recommendations to decrease the risk of detrimental effects of steelhead hatchery programs on the genetic characteristics of wild steelhead (Lindsay et al. 1991).

The Siuslaw reports equate spawning tributary entry as the initiation of spawning timing. This is substantiated from the capture of 10 hatchery steelhead from redds on Turner Creek after being tagged at the weir (Linsay et al. 1991). Females were found on redds an average of 1.8 days after tagging at the weir and males 7.3 days after tagging. So entry into the spawning tributaries was accurate within an average of 43 hours of actual initiation of spawning for those females recaptured. Although males took more than five days longer to initiate spawning activity after entry, they may have been sexually ripe on passage at the weirs and fully capable of spawning — although that was not described or noted in the reports.

Raw data from the Siuslaw reports were broken out to better identify spawning timing specifics in a letter and figures provided by Ken Kenaston (1997) of Oregon Department of Fish and Wildlife's Fish Division. In Figure 1 he breaks out the data for steelhead trapped on entry to (and sometimes exit from) Whittaker and West Fork Indian creeks on the Siuslaw River in 1991-92 and 1992-93. The data is separated so spawning entry/exit in December to March 15th can be compared to spawning entry/exit from March 16th into June. Spawned out kelts exiting these tributaries were included as part of the spawning escapement passed through the traps. Evidently they were not counted on entry, which could be determined by presence or absence of tags, although that is not clarified.

SIUSLAW RIVER WILD FEMALES

The earliest wild female steelhead entering a Siuslaw tributary for spawning was December 28, 1992 (Linsay et al. 1993). The latest wild females exiting a Siuslaw tributary after spawning were captured in West Fork Indian Creek in June, 1992 (no specific date from Figure 1).

Of the 126 wild females (entering and exiting combined) captured in the Siuslaw tributaries in Figure 1, 41 (33%) spawned March 15th or earlier. They represented 56% of the total female steelhead population in that time period. They spawned with a male population that was 65% hatchery and 35% wild.

After March 15th, 85 (67%) of the wild females were captured. They represented 92% of the total female population in that time period. They spawned with a male population that was 41% hatchery and 59% wild.

Siuslaw River Potential Range for Wild Females to Spawn: December 28th into June — 5.5-6 months.

SIUSLAW RIVER WILD MALES

The earliest wild male steelhead entering a Siuslaw tributary for spawning was also December 28, 1992 from Greenleaf Creek (Lindsay et al. 1993). The latest wild males exiting a Siuslaw tributary after spawning were in West Fork Indian Creek in June, 1992 (no specific day from Figure 1).

Of the 137 wild males (entering and exiting combined) captured in the Siuslaw tributaries in Figure 1, 35 (26%) spawned March 15th or earlier. They represented 35% of the total male steelhead population in that time period. They spawned with a female population that was 44% hatchery and 56% wild.

After March 15th, 102 (74%) of the wild males were captured. They represented 59% of the total male steelhead population in that time period. They spawned with a female population that was 8% hatchery and 92% wild.

Siuslaw River Potential Range for Wild Males to Spawn: December 28th into June — 5.5-6 months. [There is no indication in the Siuslaw reports how long prior to spawning tributary entry wild males might have been sexually ripe.]

SIUSLAW RIVER HATCHERY FEMALES

The first hatchery female trapped entering a Siuslaw spawning tributary was December 19, 1991 in Greenleaf Creek (Lindsay et al. 1992), and the last entering female was a single steel-

Figure 1

Summary of upstream-bound steelhead trapped in two spawning tributaries in the Siuslaw basin, 1992 and 1993. Numbers in parentheses are those steelhead captured from pools immediately above weirs and represent primarily spawned-out fish. Information from Oregon Department of Fish and Wildlife.

Stream, time period	Wild male	Wild female	Hatchery male	Hatchery female
Whittaker 1991-1992:				
December	0	0	0	0
January	5	7	9	6
February	1	5	12	11
March 1-15	0	1	1	0
March 16-30	4 (1)	5	0 (6)	1
April	4	6 (1)	11	0
May	2 (2)	1	0	0 (1)
Whittaker 1992-1993:				
December	2	2	3	1
January	6	4	4	4
February	1	3	3	0
March 1-15	11	10	20	6
March 16-30	2	5	20	1
April	3	3	8	1
May	0	0	2	0
WF Indian Creek 1991-1992:				
December	0	0	0	0
January	0	1	1	0
February	0	0 (1)	2	1
March 1-15	2 (4)	3 (2)	2 (3)	0 (1)
March 16-30	4	10	2	0
April	16 (1)	10 (1)	1 (2)	0 (1)
May	2 (34)	2 (11)	0 (6)	0 (1)
June	0 (22)	0 (11)	0	0
WF Indian Creek 1992-1993:				
December	0	0	0	0
January	0	0	1	1
February	1	1	4	1
March 1-15	2	1	0	0
March 16-30	1	2	0	0
April	0	0 (1)	2	0
May	0 (4)	0 (16)	0 (8)	0 (1)
June	0	0	0 (2)	0

head in Whittaker Creek in April, 1992 (no specific date from Figure 1). The last hatchery females captured exiting spawning tributaries occurred in May of 1992 and 1993 in both Whittaker and West Fork Indian creeks (no specific dates from Figure 1).

Of the 39 hatchery females (entering and exiting combined) captured in Siuslaw tributaries in Figure 1, 32 (82%) spawned March 15th or earlier. They represented 53% of the total female steelhead population in that time period. They spawned with a male population that was 35% wild and 65% hatchery.

After March 15th, 7 (18%) of the hatchery females were captured. They represented 8% of the total female steelhead population in that time period. They spawned with a male population that was 59% wild and 41% hatchery.

Siuslaw River Potential Range for Hatchery Females to Spawn: December 19th into May — 4.5-5 months.

SIUSLAW RIVER HATCHERY MALES

The earliest hatchery male entering a Siuslaw spawning tributary was December 19, 1991 in Greenleaf Creek (Lindsay et al. 1993). The last entering males were in Whittaker Creek in May, 1993 (no specific date from Figure 1). The last hatchery males exiting a spawning tributary were in June, 1993 (no specific date from Figure 1) in West Fork Indian Creek.

Of the 135 hatchery males (entering and exiting combined) captured in Siuslaw tributaries in Figure 1, 65 (48%) spawned March 15th or earlier. They represented 65% of the total male steelhead population in that time period. They spawned with a female population that was 56% wild and 44% hatchery.

After March 15th, 70 (52%) of the hatchery males were captured. They represented 41% of the total male population. They spawned with a female population that was 92% wild and 8% hatchery.

Siuslaw River Potential Range for Hatchery Males to Spawn: December 19th into June — 5.5-6 months. [There is no indication in the Siuslaw reports how long prior to spawning tributary-entry hatchery males might have been sexually ripe.]

FURTHER DISCUSSION OF THE DATA FROM THE SIUSLAW RIVER

The data collected from Siuslaw tributaries suggest how hatchery steelhead spawning timing might be perceived as occurring primarily before March 15th with a temporal separation from that of wild steelhead and related management possibilities. Indeed, hatchery females composed only 8% of the total spawning population of females after March 15th.

However, the perception that a temporal separation in spawning timing exists based on hatchery females does not hold true in the examination of wild and hatchery male spawning timings and that of wild females. 52% of all hatchery males spawned after March 15th, but 92% of the available female population after March 15th was wild. Therefore, hatchery males after March 15th had little choice but to spawn with wild females. And on, or prior to March 15th, 33% of all wild females were spawning in Siuslaw tributaries. They spawned with a male population that was 65% hatchery.

In a letter that accompanied the figures, Kenaston (1997) warned that hatchery males spawning with wild females after March 15th wasn't the only consideration. He emphasized that wild steelhead spawning on, or prior to March 15th should not be ignored as initiating the time of wild and hatchery spawning overlaps. Figure 1 demonstrates that in both 1991-92 and 1992-93, the numbers of hatchery/wild, male/

female steelhead in Whittaker Creek present from December through March 15 are sufficient to create relatively equal potentials for hatchery and wild steelhead to intermix on the redds or to spawn with their own kind.

Another consideration regarding the spawning timing of Siuslaw steelhead was provided by Keneston (1997): "Looking at the figures showing timing you can clearly see that there is a lot of variation among years even within the same spawning tributary ... Obviously, generalizations about spawning timing are just generalizations and one should recognize the potential for substantial variation among years with concomitant variable periods of overlap with hatchery spawners."

As an example of the variables, in Figure 1 the comparative large escapement of hatchery males (30) to wild males (5) after March 15th in Whittaker Creek in 1992-93, contrasts to relatively few hatchery males (11) to wild males (77) escaping into West Fork Indian Creek in 1991-92. And in 1992-93, the escapement of hatchery males (12) into West Fork Indian Creek after March 15th was more than double that of wild males (5).

The use of weirs in the Siuslaw studies also provided an opportunity to determine the length of time steelhead lingered in tributaries in sexually ripe condition. It was noted by Lindsay et al. (1991) that of the 33 steelhead that were passed above weirs and later recaptured at the weirs as kelts on their downward migration in 1990-91, in general, males stayed upstream longer than females. Two wild males that were captured on entry to West Fork Indian Creek were recovered as kelts an average of 35 days later. No dates are given, but as an average between the two, it can be assumed that one of the males probably was in West Fork Indian Creek even longer. Whether such males spawned more than once was not discussed.

Further information from the Siuslaw included the capture of eight pairs of steelhead from eight redds on Siuslaw tributaries (Lindsay et al 1991). Three of the eight pairs contained a mix of hatchery and wild steelhead (38%). Two of these mixes were hatchery males with wild females (January 17 and 29, 1991), and one mix was that of a wild male with a hatchery female (January 30, 1991).

<u>Hatchery Resident Rainbow Trout Examples</u>:

Trotter (1997) found two papers providing length of ripeness periods for male rainbow trout at hatcheries. Scott et al. (1980) and Buyukhatipglu and Holtz (1984) found that good quality semen could be stripped from most individual hatchery males for more than four months. Some individual males produced semen from October through April (seven months) for the stock used by Buyukhatipoglu and Holtz and November through May (seven months) for the stock used by Scott et al.

Interestingly, both of these examples for periods of ripeness for individual hatchery male rainbows closely replicate the range that wild male steelhead are capable of spawning (as a population composite, if not necessarily as individuals) as suggested historically for the upper Columbia River (seven months) and as previously described for several Kamchatka rivers (eight months), the Washougal River (eight months), and the Siuslaw River (six months).

<u>A Cowlitz River Consideration:</u>

However, Trotter (1997) also found cause for warning regarding generalizations toward equating the length of time that male steelhead/rainbow can be spawned in hatcheries with the length of time they can actually spawn in the wild. In personal communication with Jack Tipping of Washington Department of Fish and Wildlife (April 15, 1997) he related that hatchery-origin steelhead were radio-tagged and then tracked in the river to see how their spawning behavior differed from hatchery-origin fish taken back into the hatchery for spawning. Fourteen of the radio-tagged fish were males. Each remained in the stream about a week before showing any apparent interest in spawning, and then participated in spawning for about two weeks more. After three weeks, all but one of these fish died and the single fish that survived left the river.

In contrast, hatchery males taken to Cowlitz Hatchery could be repeatedly spawned for up to two months before they quit producing sperm, and no mortalities occurred. It was conjectured that milt-stripping at the hatchery is less hard on the fish than natural spawning in a stream.

Nevertheless, it would seem that 2-3 weeks could provide ample opportunity for the hatchery males to interact with several females — potentially wild. It entirely depends on the watershed area where the hatchery male happens to end up and the origin of females available on reaching that particular individual destination. Spawning surveys clearly indicate that all hatchery steelhead do not uniformly return to hatcheries or specific release sites (Lindsay et al. 1991; 1992; and 1993; McMillan 1986[a]; 1990; and 1994). And studies indicate that successful hatchery/wild spawning occurs often enough in some rivers to show genetic alterations in succeeding generations of wild steelhead (Chilcote et al. 1986; Leider et al. 1986; and 1990; Phelps et al. 1994; Reisenbichler and Phelps 1989).

Comparing the Examples of Periods of Sexual Ripeness Differences:

Figure 2 demonstrates the period of sexual ripeness differences for steelhead from four of the rivers previously described and for the males of the two hatchery stocks of rainbow trout. These sexual ripeness periods are also compared to Washington Department of Fish and Wildlife's March 15th line of demarcation for determining hatchery from wild steelhead egg deposition on Washington streams.

WILD STEELHEAD SPAWNING TIMING BREADTH AND SPAWNING TIMING PEAKS WITH MAINSTEM TIMING COMPARED TO TRIBUTARY TIMING

Upper Washougal River Example:

Figure 3 demonstrates the wild steelhead redds that were counted on the upper Washougal River and its tributaries between 1979 and 1991 (McMillan 1983; 1986[a]; 1990; and 1991) as graphed in 5-8 day intervals from early January through mid-July. This represents the cumulative spawning timing of the wild summer and winter steelhead that share the Washougal River upstream of Dougan Falls (96%+ probability of being wild).

There was no consistent time regimen in the surveys made on the upper Washougal. Some years surveys had to be delayed until late February or early March due to heavy winter snow with limited access into the area. Some years surveys were as frequent as every two weeks. In other years surveys were three to four weeks apart. Old redds were noted and assumed constructed 10 days earlier than observed. Surveys in December and January on both the mainstem and tributaries were limited due to frequent high water volumes. Surveys after mid-May were comparatively rare. The number of surveys per tributary were not as numerous as for the mainstem. The strength of the surveys rests in the continuity of the same individual being the lead man in sighting and recording the redds for 13 consecutive years.

In all, 537 redds were counted on the upper Washougal and five of its tributaries (Stebbins, Timber, Silver, lower Prospector, and Meander creeks). 166 (31%) of the redds were found in tributaries and 371 (69%) were found in the mainstem. The actual percentage of tributary spawning was likely much higher due to fewer spawning surveys made per tributary than on the mainstem, and because every potential spawning tributary was not surveyed. Because of the effort

Figure 2

Periods of sexual ripeness for steelhead/rainbow by half-month intervals, in relation to Washington's March 15 line of demarcation.

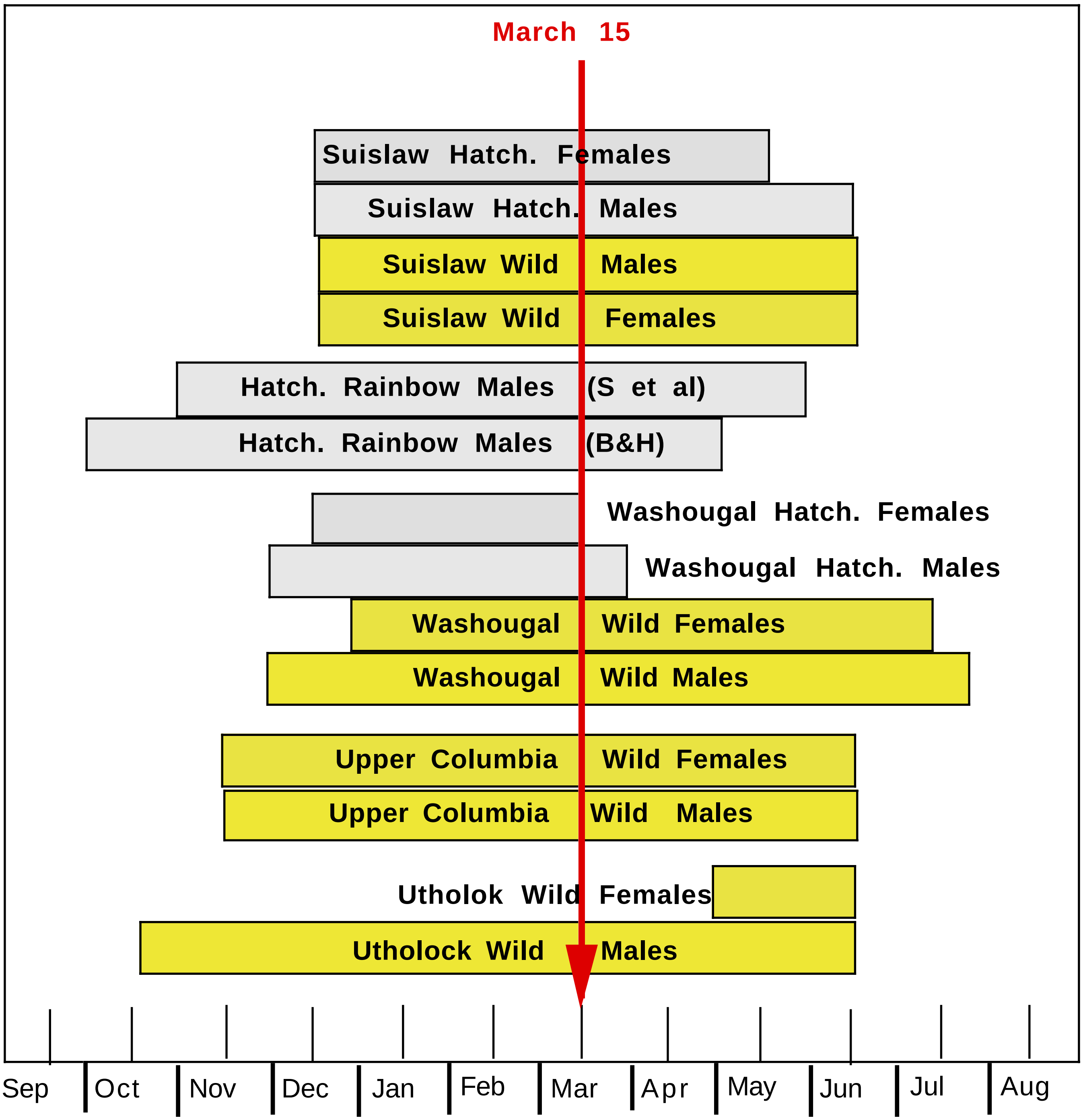


Figure 3

Wild steelhead redd counts on the upper Washougal River and five of its tributaries recorded in five-day intervals (1979-1991), in relation to Washington's March 15 line of demarcation. Information provided by Clark-Skamania Flyfishers.

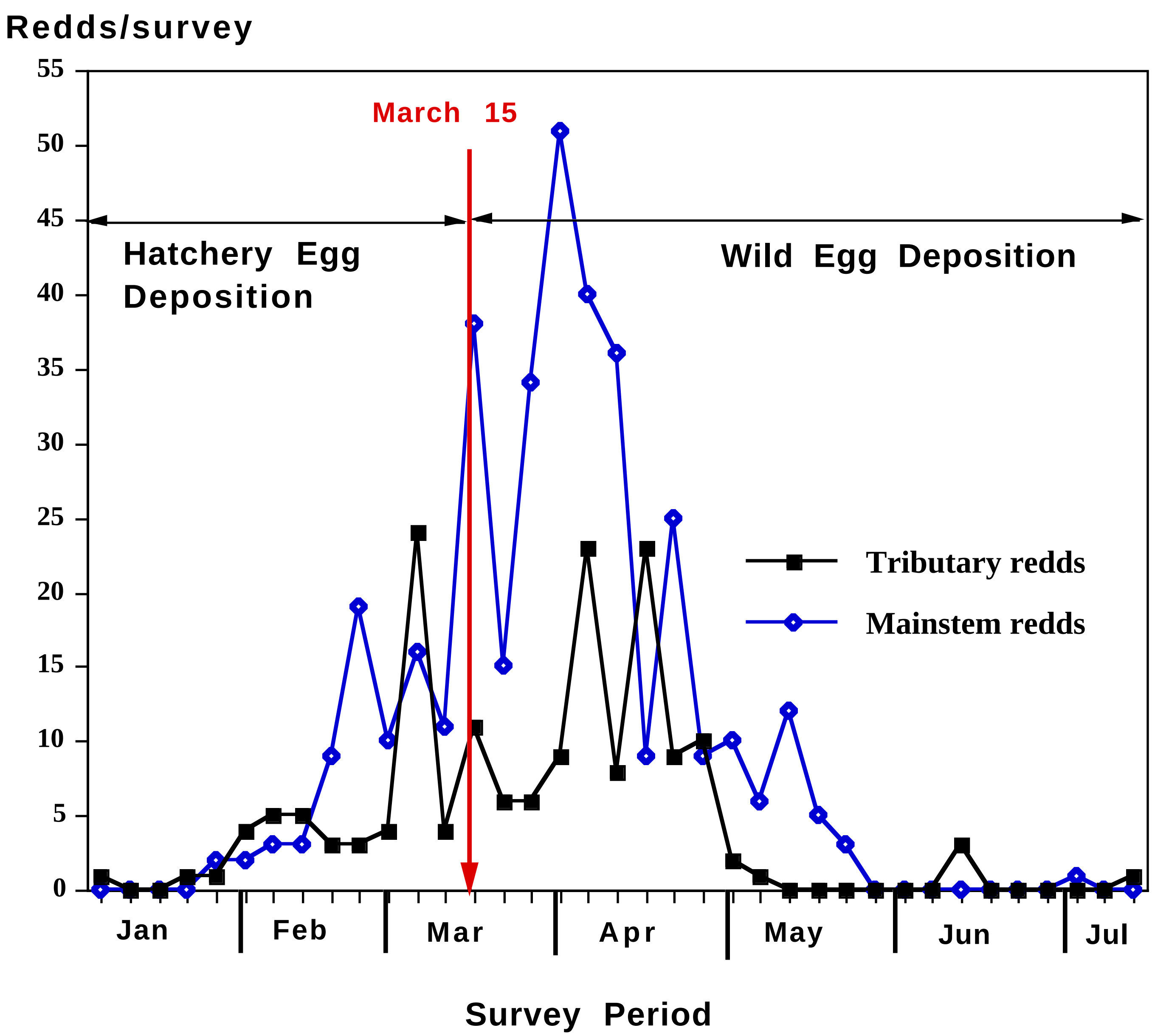
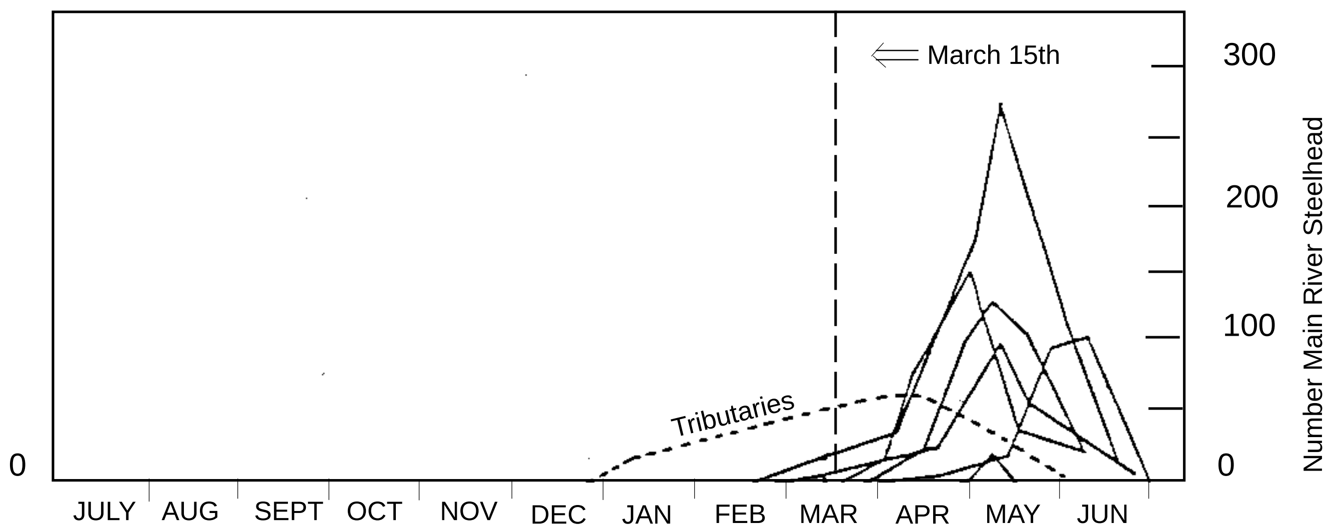


Figure 4

Clearwater River and tributaries' (Queets River system) steelhead redd counts from 1974 - 1978 compared to Washington's March 15 line of demarcation between wild and hatchery steelhead egg deposition. Information from graphs by C. J. Cederholm of the Washington Dept. of Natural Resources.



required to effectively survey smaller spawning tributaries, it is easy to neglect their importance to steelhead spawning. My personal spawning survey experiences on the Washougal River suggest that 50%, or more, of historic native populations of steelhead may have spawned in relatively small Washougal tributaries.

The upper Washougal redd counts (assumed 96%+ wild) were compared to Washington Department of Fish and Wildlife's March 15th dateline for separating hatchery steelhead egg deposition from wild steelhead egg deposition. 77 (21%) of the mainstem redds were found prior to March 15th, and 294 (79%) of the mainstem redds were found after March 15th.

There was a greater proportion of early redd construction in the upper Washougal tributaries. 54 (33%) of the tributary redds were found prior to March 15th, and 112 (67%) were constructed after March 15th.

Because very few hatchery steelhead escape into the upper Washougal River, it provides a useful example of wild steelhead spawning timing without the distraction of hatchery steelhead spawning that often obscures the true pattern of the breadth and complexity of wild steelhead spawning timing on other rivers (and including the Washougal River immediately downstream of Dougan Falls).

Clearwater River Example:

The range of steelhead spawning timing on the Washougal River may be wider than on most rivers, or perhaps the survey effort merely took place over a more extended range of time than elsewhere. But the Washougal is not a lone example. Wide spawning times for other wild steelhead populations in Washington have been observed.

Spawning surveys on the Olympic Peninsula's Clearwater River (Queets River watershed) and five of its tributaries were conducted prior to introductions of tribal hatchery steelhead (Cederholm 1984). Although the spawning peak varied annually and in watershed areas, the range remained the same for both the main river and its tributaries — a six-month span from January to June.

The spawning peaks on the Clearwater system typically occurred earliest in tributaries, latest in the mainstem. As can be seen in Figure 4, a significant proportion of tributary spawning falls within the theoretical egg deposition time of hatchery steelhead (prior to March 15th) as determined by Washington Department of Fish and Wildlife (1994[b]). The data was not broken out in a way that precise redd numbers and percentages relative to March 15th could be accurately determined for the tributaries, but on the mainstem just 2% of the redds were found on, or prior to, March 15th. [As was noted for the tributaries surveyed on the Washougal River, a map of the Clearwater River would indicate that the five tributaries surveyed represent but a portion of the tributaries available for potential steelhead spawning. Therefore, Figure 4 should not be used as an indicator of the amount of tributary spawning as compared to the amount of mainstem spawning that occurs on the Clearwater River. It is merely a comparison of differing spawning timings between the two.]

How much earlier wild male steelhead might have been sexually ripe on the Clearwater River was not suggested by Cederholm. But clearly, males and females were both spawning over the six-month spawning period found for Clearwater tributaries as well as the mainstem.

<u>The Magnitude of Tributary Spawning</u>:

Tributaries are difficult to effectively survey for steelhead spawning. Smaller tributaries are canopied in a way that they do not lend to aerial surveys, if in fact, it were economically feasible to do so from the standpoint of flight hours and fuel costs. Foot surveys are generally the only practical way they can be done. However, manpower is generally insufficient for managing agencies to effectively cover all steelhead spawning tributaries through the minimal six-month season of typical wild steelhead spawning timing. Therefore, at this point in time, the magnitude of tributary spawning is largely unknown.

That the magnitude of tributary spawning by steelhead is not known creates a substantial management risk for wild steelhead. As previously indicated, my personal experience in 18 years of Washougal River spawning surveys was that 50% or more of historic native steelhead may have spawned in smaller tributaries. How can wild steelhead be managed for, without knowing where 50% or more of the population historically spawned, when it spawned there, and why it spawned there?

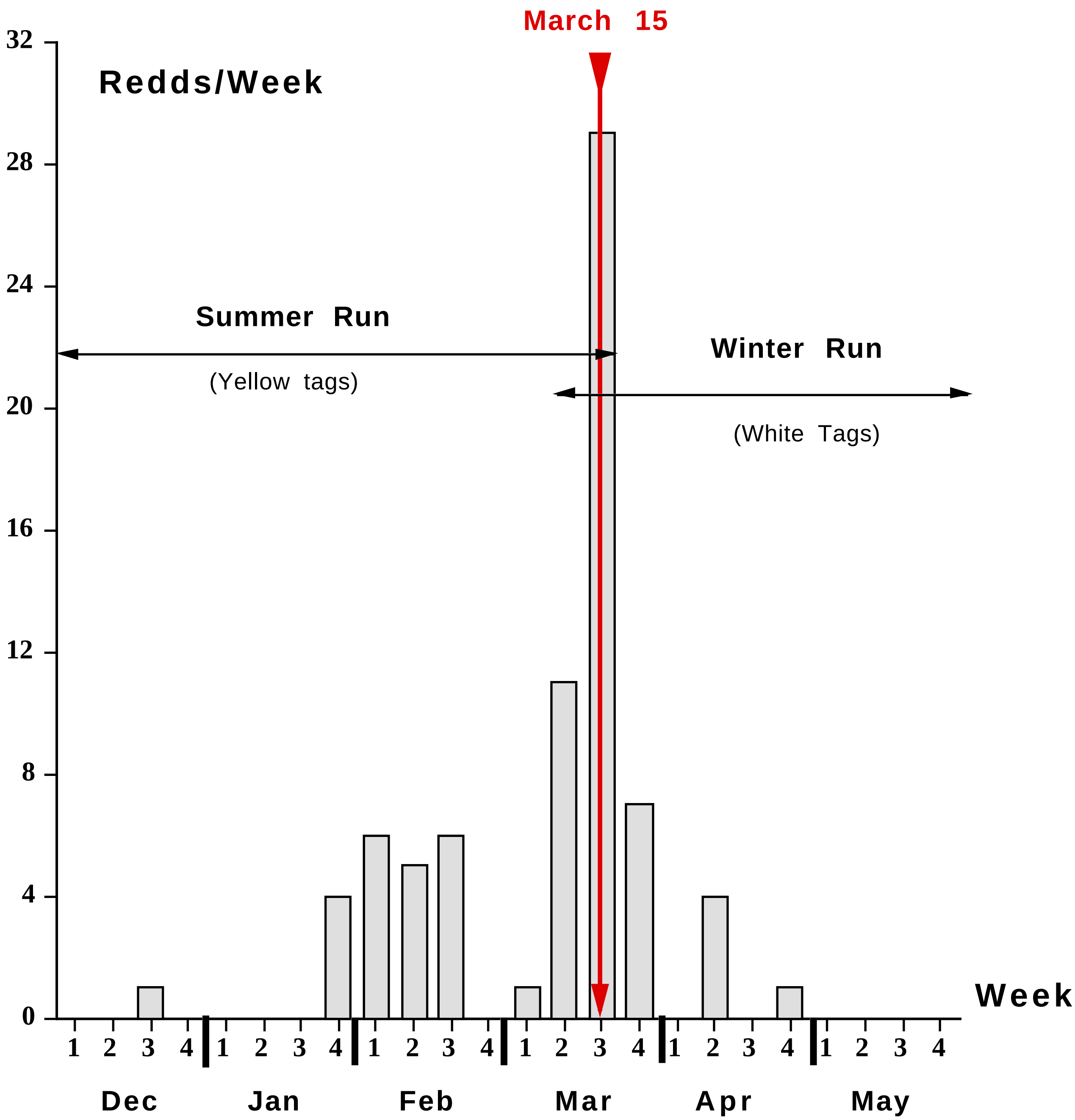
HATCHERY STEELHEAD SPAWNING BREADTH AND SPAWNING PEAKS ON GOBAR CREEK OF THE KALAMA RIVER

The Kalama River, like the Washougal River, is a Washington tributary to the lower Columbia. The Kalama River Steelhead Investigations (Crawford et al. 1978) made spawning surveys of Gobar Creek (River Mile 19.5) and other upper Kalama tributaries from December 1976 into June of 1977. Wild steelhead spawning was not as well documented as hatchery spawning due to no identifying tags being placed on wild steelhead. But hatchery steelhead in their passage through traps at Kalama Falls Salmon Hatchery were sampled, recorded and tagged — summer-runs with visible yellow Floy tags and hatchery winter-runs with visible white Floy tags. Steelhead were later counted on spawning redds in Gobar Creek and the visible tag colors noted to determine if redds were constructed by winter-runs or summer-runs (Figure 5).

Altogether, 74 hatchery steelhead redds were counted on Gobar Creek. 48 (65%) of those redds were constructed prior to March 15th, and 26 (35%) were constructed after March

Figure 5

Number of new redds counted per survey week of hatchery summer and winter steelhead on a tributary of the upper Kalama River in 1976/77. Information from the Washington State Department of Game, with the March 15th timeline added for comparative purposes.



15th. The combined peak of redds counted for summer and winter hatchery steelhead occurred between March 11-March 18. The first hatchery steelhead redd was constructed December 21, 1976, and the last hatchery steelhead redd constructed was April 19, 1977 (four months).

This mixture of summer-run and winter-run hatchery steelhead spawning in the natural environment of the Kalama River and its tributaries is similar to what occurs on the Washougal River and its tributaries downstream of Dougan Falls. Because both rivers are tributaries of the lower Columbia, the Gobar Creek redd counts for hatchery steelhead (Figure 5) provide a useful comparison to the redd counts of wild steelhead on the upper Washougal River, particularly in tributaries (Figure 3). The overlaps in time of egg deposition between hatchery and wild female steelhead may similarly occur on other rivers in the state where both summer and winter hatchery steelhead return.

THE IMPORTANCE OF STEELHEAD ENTRY TIME AND SPAWNING DIVERSITY

A Panther Creek Example:

Panther Creek (entering at River Mile 4.3) is one of two major tributaries to southwest Washington's Wind River. It provides an example of differing habitats selecting for differing steelhead traits. In the early and mid-1980s, the then Washington Department of Game's spawning surveys on the Wind River system demonstrated that the other major tributary, Trout Creek (River Mile 10), was hosting over one-half of the wild steelhead spawning found on Wind River in some years (Lucas and Pointer, 1987). By contrast, very little wild steelhead spawning had been found on Panther Creek. This was despite historic evidence that Panther Creek had once been a major spawning tributary (Bryant 1949) that may have been comparable to Trout Creek.

In order to avoid counting the redds of hatchery steelhead that spawn in the wild, the state's spawning surveys of Wind River began in mid-March as was consistent with Washington's March 15th timeline assumptions for separating wild from hatchery spawning. But on the upper Washougal River, where hatchery steelhead are rare, independent spawning surveys found 21% of mainstem spawning and 33% of tributary spawning by wild steelhead occurred between early January and mid-March (McMillan 1983; 1984[a]; 1986[a]; 1990; and 1991). Obviously, if no early counts are made, no early evidence of wild steelhead spawning will be found nor the specific habitat niches that may depend on early timing for maximized spawning success.

In the winter of 1987/88, an article in Vancouver, Washington's Columbian newspaper indicated that the adjacent tributary to Panther Creek on Wind River, Bear Creek (also River Mile 4.3), was a major overwintering area for deer. Studies found that deer traveled great distances to take advantage of unusually abundant winter forage stimulated by Bear Creek's south-facing exposure (the specific article date is no longer remembered).

On reading the article, it seemed possible, due to Panther Creek's neighboring south-facing exposure, that like the land in Bear Creek's drainage, the water in Panther Creek may be somewhat warmer and stimulate earlier steelhead spawning than the more northward-facing slope of lower Trout Creek. Perhaps the mid-March and later spawning surveys were missing an earlier spawning peak on Panther Creek. On examining previous Wind River data it did, in fact, appear that per given date Panther Creek was running warmer than Trout Creek (Lucas and Nawa 1986; Lucas and Pointer 1987).

On February 18, 1988, two of us from the Clark-Skamania Flyfishers surveyed Panther Creek and three smaller creeks for water temperature comparisons. There was considerable snow on the ground, and we were limited in how far we could walk without special equipment. The three smaller tributaries were running 38-39 degrees F. Panther Creek was running 41 degrees F. (McMillan 1988[b]; and 1990).

We found no evidence of steelhead redds on the smaller creeks, but on Panther Creek we found eight fresh redds. One was occupied by three steelhead (McMillan 1988[b]; and 1990). Although we could not identify the origin of the three steelhead, a subsequent snorkel survey of Panther Creek in September, 1988 found 17 steelhead: four hatchery (23.5%), nine wild (53%), and four unknown (23.5%) (Weinheimer 1988). Another snorkel survey recorded by Dan Rawding (1994) of Washington Department of Fish and Wildlife found no hatchery, eight wild (67%), and four unknown (33%) summer steelhead on Panther Creek in August, 1994. For the two years of snorkel surveys, four steelhead were hatchery (19%) and seventeen were wild (81%) of the 21 that could be identified.

Four more spawning surveys were made on Panther Creek in 1988 by Washington Department of Wildlife's co-regional fish biologist in southwest Washington at the time, John Weinheimer (1988). 23 more redds were counted for a total of 31 redds found between February 18 and March 18 (86% of total redds counted in 1988). Only four redds were counted after March 18th (14% of total redds counted in 1988).

The proportion of wild steelhead returning to Panther Creek appears high (81%) as compared to hatchery steelhead (19%). Despite that, early spawning predominates (86%). This suggests that wild steelhead in Panther Creek spawn early (at a time previously considered predominantly a hatchery steelhead spawning period). But overall numbers of steelhead spawning in Panther Creek, while much higher in 1988 due to the earlier counts, were still proportionally less than half of the redds counted on Trout Creek for the same year.

Some proportion of the Panther Creek early spawning redds must be presumed to be those of hatchery females (14% of Panther Creek steelhead snorkel counted were hatchery) that spawn with both wild and hatchery males. And evidence cited in this paper supports the likelihood of hatchery males lingering to spawn with wild females past the time period of hatchery female egg deposition.

Perhaps historic suppositions of Panther Creek's equal productivity to Trout Creek were in error. Or perhaps there have been unequal changes to their respective habitats, although logging impacts to Trout Creek in the 1960s suggest Trout Creek as the more impacted drainage for salmonid production (McMillan 1987).

Or has it something to do with differences in hatchery steelhead escapement patterns to each of these tributaries?

In 1991 a trap was put at the top of the fish ladders at Hemlock Lake Dam on Trout Creek. It has indicated almost no movement of hatchery steelhead into Trout Creek (Washington Department of Fish and Wildlife 1994[b]). The limitations to passage created by the dam and primitive fish ladder have likely been helpful for insulating Trout Creek from hatchery steelhead entry (McMillan 1987) since its construction in 1936 (Wieman 1994) or 1941 (Bryant 1949).

The Trout Creek trap was put into place to accurately count escaping wild steelhead and to remove whatever hatchery steelhead may enter it as an attempt to create a wild steelhead genetic preserve upstream. However, coinciding with the trap placement there was a crash in steelhead escapement to Trout Creek (Washington Department of Fish and Wildlife 1994[b]). It is not known if the trap itself is related to that. Changes in trap design have since occurred.

Panther Creek has no similar artificial barrier to hatchery steelhead entry. Hatchery steelhead escapement into Panther Creek may have been greater than it presently is. Between 1961 and 1981, annual releases of hatchery summer steelhead averaged 77,000 smolts on Wind River (McMillan 1987). Since 1983, the annual release of hatchery summer steelhead has averaged about 20,000 smolts on Wind River.

Despite hatchery escapement into the wild and related spawning interactions, Wind River (maybe even Panther Creek) appears to still have a genetically distinct stock of wild summer steelhead (Phelps et al. 1994). But what has been the cost in numbers to that genetically distinct wild population after 35 years of hatchery/wild spawning crosses that may have survived so poorly that there is no genetic evidence such spawnings ever occurred?

A Rogue River Example:

On the Rogue River in southern Oregon it was found that early spawning/early juvenile outmigration on small intermittent tributaries was both typical and vital to the summer steelhead there (Oregon State Game Commission Research Division 1973):

"The efficiency with which summer steelhead successfully reproduce in intermittent streams is remarkable. Adults enter streams as soon as flow levels are sufficient, usually in December. Spawning occurs in December, January and February, fry emerge in April and May and most fry migrate in May and June, often only a few days before the streams become intermittent. The sequence of spawning, incubation, emergence and migration is so restricted in time that any deviation in natural flow patterns in these streams could seriously impair their capacity to produce summer steelhead ...."

It could also be said that skewing the adult return to a later spawning timing would equally impair the Rogue River's capacity to produce summer steelhead.

Steelhead production from intermittent tributary streams is not limited to the Rogue River. Whether in rain forests or deserts, all rivers have intermittent tributaries. Early spawning steelhead are vital if such streams are to produce juveniles that outmigrate prior to going dry.

Washougal River Examples:

Spawning surveys on a mid-Washougal tributary, Winkler Creek (River Mile 9), have found considerable January and February spawning activity (McMillan 1986[a]; and 1990). But it is difficult to sort out wild from hatchery fish in the freshet conditions commonly chosen for creek spawning at that time. The combined straying of both summer and winter hatchery steelhead released into the Washougal River may occur in this tributary. What few steelhead that it has been possible to identify prior to March were of hatchery origin (missing adipose and/or dorsal fins).

Water temperatures on Winkler Creek have been found to be 2-3 degrees F. warmer than the main Washougal River (McMillan 1986[a]). Like Panther Creek, it is a south facing drainage. It is entirely possible that some early wild winter steelhead still spawn in Winkler Creek. They may have been historically common there prior to hatchery steelhead introductions to the Washougal. If so, wild steelhead have been heavily impacted by hatchery/wild spawning interactions — likely but one example of many on Washougal tributaries downstream of Dougan Falls.

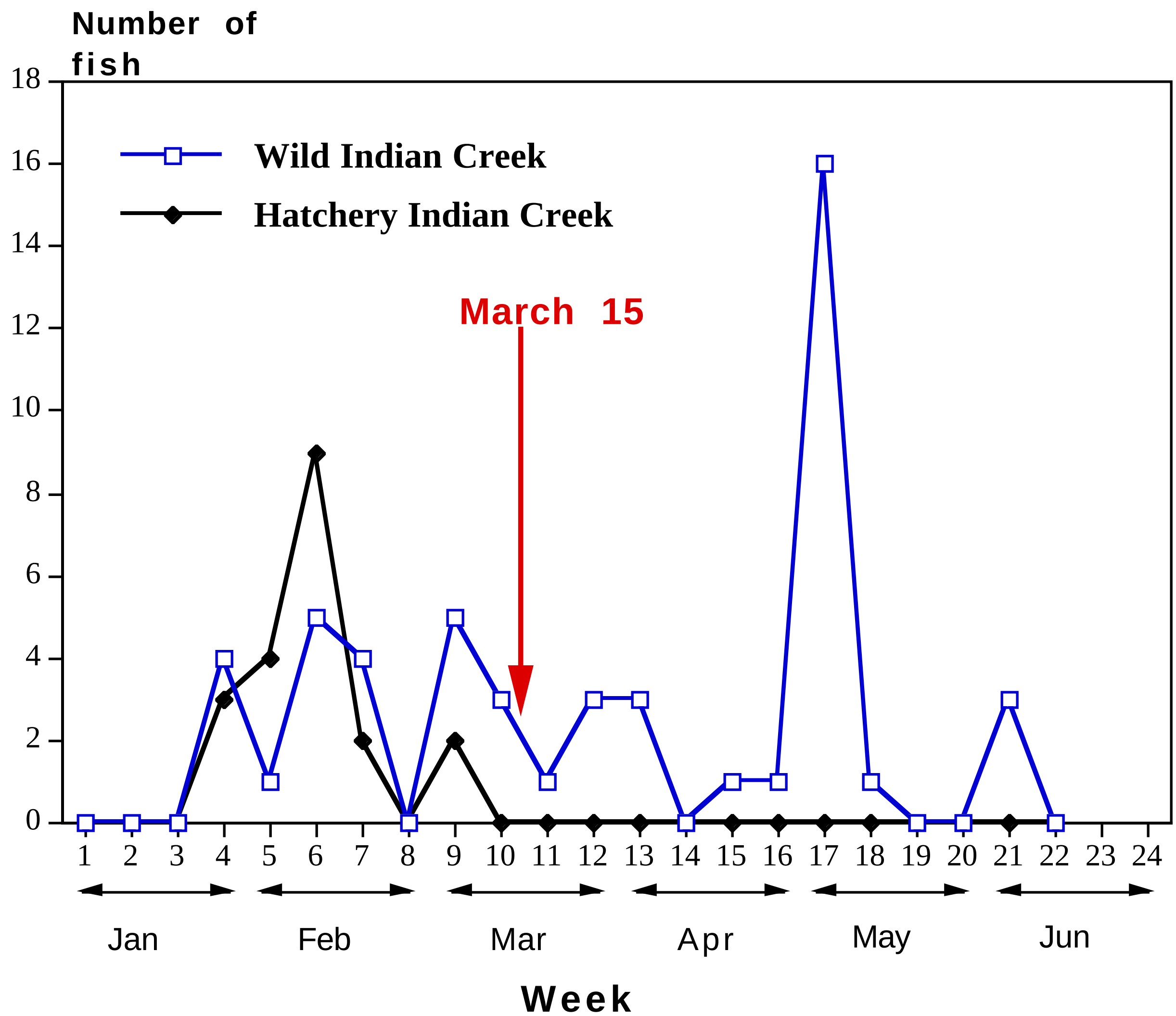
Timber Creek (River Mile 26) is a major wild steelhead spawning tributary of the upper Washougal River. In the driest years it goes intermittent in August and September. A tributary of it, "Dry Fork" as identified in spawning surveys, goes dry most summers by late July. Steelhead redds in "Dry Fork" have never been found later than February. In Timber Creek they have been found from early February to mid-April (McMillan 1983; 1986[a]; 1990; and 1991). "Dry Fork," like Rogue River tributaries, may depend on early spawning for fry emergence and outmigration prior to going dry.

Siuslaw River:

Siuslaw River steelhead on the mid-

Figure 6a

Temporal distribution of catch of wild and of hatchery adult steelhead in traps on West Fork Indian Creek in 1991. Information provided by Oregon Dept. of Fish and Wildlife.

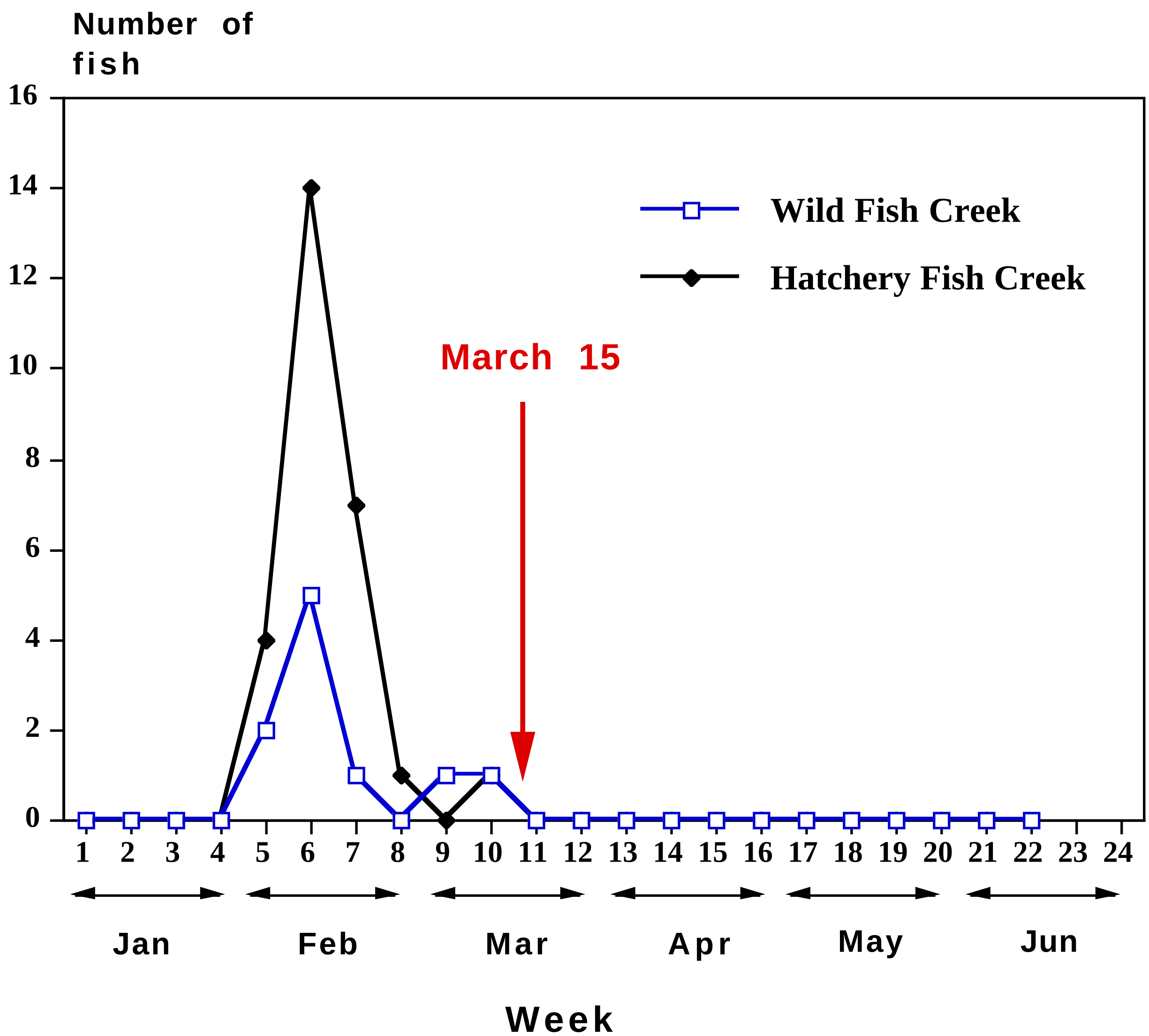


Oregon coast were trapped at weirs on two tributaries where early entry timing of wild steelhead was found by Lindsay et al. (1991). The entry timing peaks for hatchery steelhead (mid-February) and wild steelhead (early May) were different on West Fork Indian Creek, but the entry peaks were the same for hatchery and wild steelhead (mid-February) on Fish Creek (Figures 6a and 6b). Despite the differences in entry timing peaks for wild steelhead on the two tributaries (early May as opposed to mid-February), wild steelhead began entry at the same time as hatchery steelhead on both (January and early February).

It is apparent that early wild steelhead entry might be vital to Fish Creek, with 100% of the wild steelhead captured prior to March 15th. However, despite the graphic peak of wild steelhead entering West Fork Indian Creek after March 15th, 22 wild steelhead entered West Fork Indian Creek prior to March 15th, representing 42% of the total 52 wild steelhead captured.

Figure 6b

Temporal distribution of catch of wild and of hatchery adult steelhead in traps on Fish Creek in 1991. Information provided by Oregon Dept. of Fish and Wildlife.



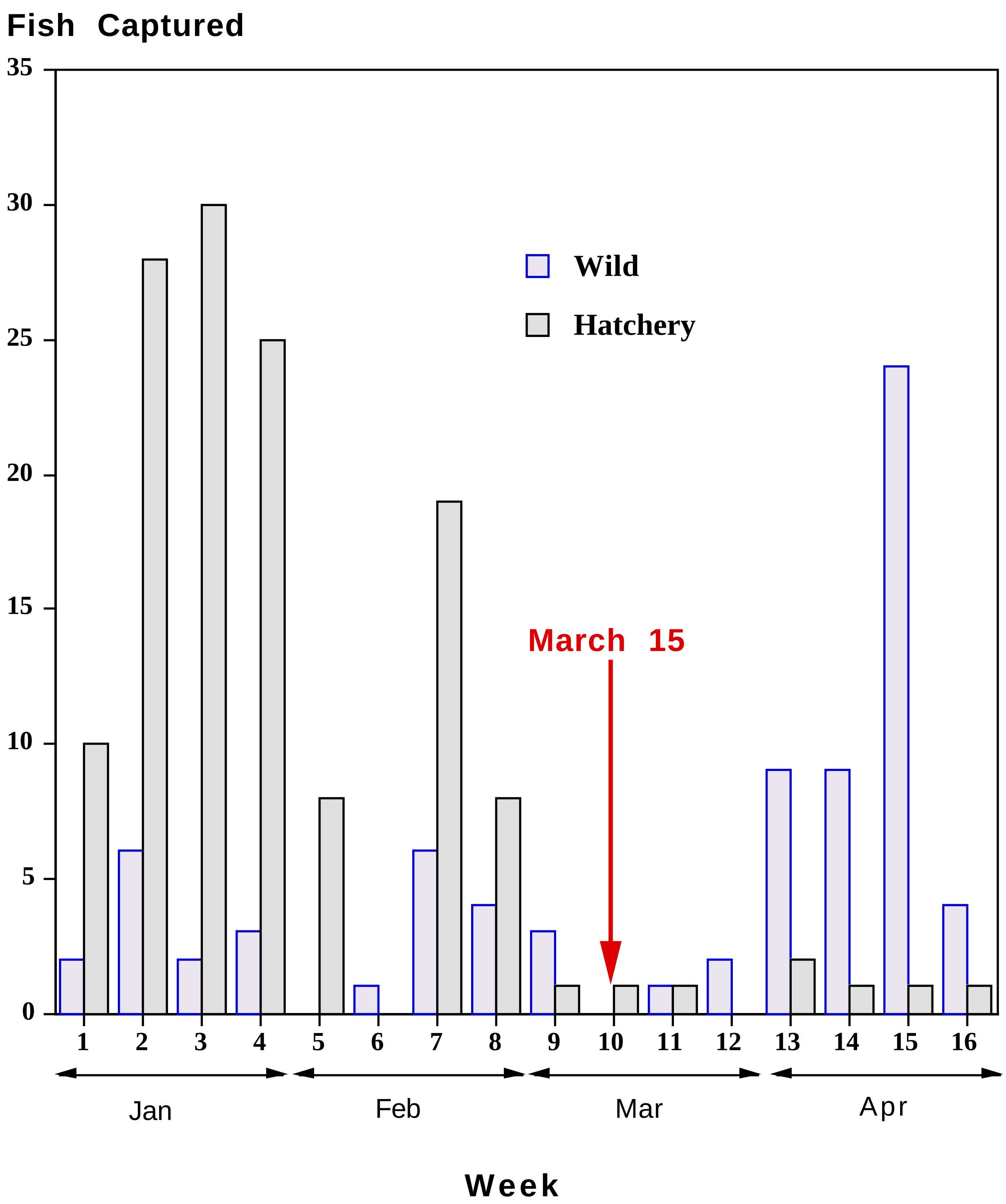
Necanicum River:

The Necanicum River is on Oregon's northern coast. Between January 3, 1996 and April 30, 1996, steelhead were captured off of redds on the Necanicum and a number of its tributaries with 30" diameter nylon mesh nets attached to four- and five-foot handles (Troop and Wicker 1996). The steelhead captured were identified as being wild if they had all of their fins or as being hatchery if they had a fin, or fins, missing.

Although the resulting information over the 17-week collection period may not represent the entire breadth of steelhead spawning time on the Necanicum, it does provide a good comparison of hatchery to wild spawning times for the survey period (Figure 7). While there was a break in spawning activity peaks between wild and hatchery fish the week of March 11th as noted by Troop and Wicker (1996), not unlike Washington Department of Fish and Wildlife's assumed March 15th line of demarcation between hatchery and wild spawning, there are

Figure 7

Fish captured (hatchery vs. wild) per week for all survey sections in the Necanicum River basin, January-April, 1996. Information provided by Oregon Dept. of Fish and Wildlife.



obvious and significant overlaps, particularly in wild fish spawning activity prior to that timeline.

It was noted in the results of the Necanicum study, that mainstem spawning was primarily that of wild steelhead (mid-March through April), but that tributary spawning was mainly accomplished by hatchery steelhead (January and February). Despite that generalization, Figure 7 displays a considerable spread of wild steelhead spawning prior to March 15th (the March 15th line has been added to the original graph).

In personal communication with Ken Kenaston of Oregon Department of Fish and Wildlife on February 11, 1998, regarding further discussion of the steelhead data from Oregon, he indicated steelhead spawning (whether hatchery or wild) seems to occur earlier on tributaries on the Oregon coast, while mainstem spawning is typically later and primarily that of wild steelhead. He further elaborated that early tributary spawning occurs in spite of sufficient water volumes in many of the tributaries for later entry of wild steelhead. He suggested that early spawning of wild steelhead in tributaries may be necessary for early emergence from the gravel prior to reduced tributary flows.

<u>What's the Selective Factor for Early Spawning on Clearwater River Tributaries</u>?

Panther Creek, Rogue River, Winkler Creek, "Dry Fork," Fish Creek, and Necanicum tributaries demonstrate some of the habitat niche variables that can select for wild steelhead spawning traits that may not fit broad generalizations such as those developed by Washington Department of Fish and Wildlife in the management of steelhead.

On examination of the data collected for the Clearwater River of the Queets system (Cederholm 1984), from 1978 to 1980, 38% of tributary spawning was prior to March 31st (the data was not broken out in a way to compare it to March 15th). By contrast, from 1973 to 1980, only 2% of mainstem Clearwater spawning was March 15th or earlier and only 10% on April 7th or earlier. Although variable between watershed areas and from year to year, the pattern was for an earlier tributary spawning peak than on the mainstem. Why?

On the Clearwater River, Cederholm (1984) found that mainstem wild steelhead spawning builds and peaks coinciding with the drop in peak winter flows. This would minimize the effects of stream bottom scour on steelhead eggs deposited in redds that are shallower than either chinook or coho redds. But the correlation did not hold so well for tributary spawning.

The answer as to why steelhead spawn earlier in Clearwater River tributaries is presently unknown. Nor are the reasons better known on most river systems. Does that mean managers should ignore protective standards for early wild steelhead spawning simply because its value is presently unknown? This has been the practical application of steelhead management in Washington State.

THE WILD-MALE/HATCHERY-FEMALE CONNECTION

Kamchatkan male steelhead often enter rivers in October sexually mature and ready to spawn, but most likely they will not spawn until May/June because that is when the females presently develop mature eggs ready for fertilization. There are presently few, if any, females to provide opportunities for early spawning.

But over the centuries climatic episodes have likely occurred in which May/June spawning is not advantageous. Down the center of the Kamchatka Peninsula is a mountainous spine with many active volcanoes. Changes in rivers may occur dramatically and rapidly, and geothermal water sources are common to some areas. Warmer water could potentially accelerate female egg development to a winter spawning period. But whatever the past patterns, Kamchatka's wild male steelhead are developmentally prepared for a broad range of spawning timing deviations.

Wild steelhead returning to the Washougal River are just as well prepared. The maturation time-spread for males to effectively spawn is eight months. For Kamchatkan males it is also eight months. Unlike Kamchatkan steelhead, the early-entry, early-maturing wild Washougal River males have early-maturing females to mate with. But downstream of Dougan Falls most of them are not wild.

<u>A Lower Washougal River Example Where Hatchery Steelhead Are Numerous</u>:

On January 22, 1991, I walked to the edge of the pool bordering my Washougal River cabin property (personal field notes). The water temperatures had been in the 30s ever since mid-December. It was the first day of warming.

My cabin was less than a half-mile downstream from the Skamania Hatchery tributary stream. What seemed to be hatchery steelhead were in spawning activity in several groups across the gravel tailing. I stood motionless. The closest pod of steelhead was just 10 feet away. There was no cover between me and the fish, yet the female dug her redd obliviously. She was adipose clipped, as were two of the males. The third male was substantially larger than the others. Perhaps three feet in length with red gills, golden back, and an adipose the size of a quarter, he was wild. He was nervous at the sight of me, but he wouldn't drift far from the female except in constant darts to the side to chase one or the other of the two hatchery males. I watched for twenty minutes.

On the drive to work the story pieced itself together. I understood what I saw. He was the dominant male in a pool with half a dozen mature hatchery females in varied stages of spawning that would be followed by others over the coming week. No hatchery male was a challenge, if only for his size. He would expend himself over the next several days, maybe even a week or more — sperm and energy gone after mating with multiple hatchery females all ripe at once. His gametes would have a low probability for perpetuating his genes through the resulting spawning crosses (Chilcote et al. 1986; Leider et al. 1990; Hulett et al. 1995). For 40 years the biggest and strongest of early return wild males have been shooting the works into the low percentage odds of combining genes with the earliest maturing females that are increasingly all hatchery.

[And when the wild females come to increasing maturation in February or March, with whom will they spawn? The most dominant of early-return wild males are done and gone — gametes lost on hatchery females. By sheer numbers, the hatchery males linger on (Bentzen 1997; McMillan 1994).]

<u>An Upper Washougal River Example Where Hatchery Steelhead Are Rare</u>:

Timber Creek is five miles upstream of Dougan Falls on the Washougal River. Very few hatchery steelhead have been counted upstream of Dougan Falls in snorkel counts from 1985-1996 (0%-4% of total steelhead counted each year). But on February 17, 1991, two hatchery females (missing adipose fins) were observed among the nine steelhead found that day in a survey of Timber Creek. Both were dropping downstream with spawning complete. Two abandoned redds were found above them. A third redd was in active use a quarter mile downstream. Only one of the other eight steelhead could be positively identified as to origin — a wild male with a full adipose. The wild male was found in the same stream vicinity as where the two hatchery females had been observed. He was in the company of yet another female of undetermined origin (McMillan 1991).

What was the origin of the male(s) that may have spawned with the two hatchery females? There is no knowing for sure, but the 96%+ probability is wild. And this is in a watershed area of the Washougal River where hatchery/wild spawning interactions are uncommon simply because very few hatchery steelhead typically return there. But as uncommon as they may be, with a minimum escapement average of only 79 steelhead into the upper Washougal over the past five years (Rawding 1997), any compromise in spawning success would seem to threaten the survival of a small wild steelhead population that may be struggling at 10% or less of historic population size.

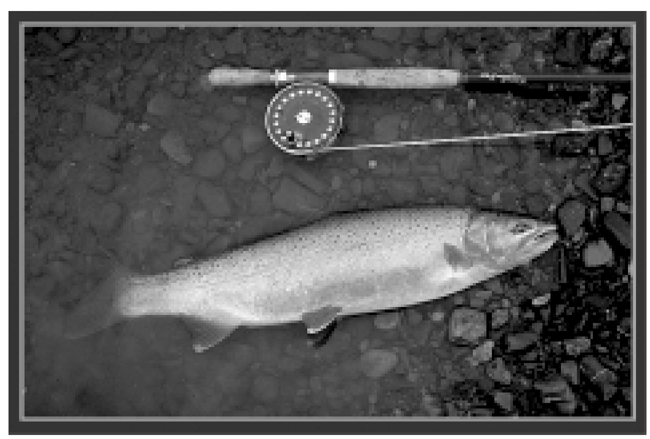
Resident rainbow life history type from Kamchatka's Utholok River.

RESIDENT AND ESTUARINE LIFE HISTORIES: A CONTINUING MALE LINK TO STEELHEAD

Kamchatkan Life History Complexity within Steelhead/Rainbow Populations:

Estuarine rainbow life history type from Kamchatka's Utholok River.

In Kamchatka there is a buffer to any potential loss of male steelhead. In fact, there appears to be a neat little design that is a part of the larger. In Kamchatka, resident river rainbow (mikizha is the Russian common name), estuarine rainbow (coastal), and steelhead (semga is the Russian common name) are a single genetic population as found on the Utholok River. They spawn together. The male/female proportional differences within these varied life history forms of rainbow even seem to be mathematically designed to spawn together: steelhead are represented by mostly female fish, 67.9%; the estuarine (coastal) group by male fish, 66.7%; while the river group is also predominantly male, 82% (Savvaitova et al. 1995).



Photos by Bill McMillan

Steelhead life history type from Kamchatka's Utholok River.

From the perspective of maximized adaptability, the mixing of these life history strategies makes great sense. Whatever curveball nature throws at Kamchatkan rainbows, whatever niche is most favorable at the time (river, estuary, or sea), the population can shift proportional numbers as natural selection favors the life history option coinciding with the most lucrative niche.

North American Examples of Life History Complexity within Steelhead/Rainbow Populations:

In Washington, resident, estuarine and/or half-pounder forms of wild rainbow have not been typically managed for — or even recognized — on anadromous rivers. On most rivers they likely coexisted with steelhead, and on some rivers, if not all, they may have been one genetic population, as on the Utholok River.

Estuary-run, half-pounder-sized steelhead (14"-20") were once a relatively common life history component on the Washougal River as evidenced in my personal sport catch beginning in the mid-1950s. But I have not seen one for many years. Most were males, and most seemed sexually mature. The Washougal "half-pounders" may have performed a similar role to the "coastal" (estuarine) male rainbows in the Utholok River steelhead/rainbow population where estuarine and resident males make up for the low percentage of adult male steelhead (Savvaitova et al. 1973). Whatever the case may once have been, that life history form may now be extinct on the Washougal and perhaps on other rivers where they may have been an historic component to steelhead/rainbow genetic diversity.

On Oregon's Rogue River, half-pounders are a dominant life history in the steelhead population. Most are immature males. However, although mature males made up only 3.6% of the half-pounders sampled 25 years ago, through sheer numbers they were estimated to contribute 4,000-6,000 mature spawning males for the years sampled (Everest 1973). Despite the deceptive percentages, in reality they were a significant component of the steelhead spawning population.

Snorkel surveys conducted on the Tolt River (Beardslee 1989-1996) initially found little evidence of half-pounder-sized steelhead. But coinciding with more restrictive angling regulations and reduced summer angling effort and distribution on the Tolt/Snoqualmie system beginning in the early 1990s, snorkel counts began to find an increasing number of this size-range steelhead (14"-20") beginning in 1991. They appear to move in and out of the system during the summer.

This is encouraging. Similar estuarine life history traits may be greatly depressed, but not necessarily extinct on other Washington rivers. It's another remaining shred from which to recreate a fabric of steelhead/rainbow adaptive diversity.

In some western Oregon rivers (Hood, Rogue, and Umpqua among them) resident rainbow are still known to be sympatric with steelhead (Oregon Dept. of Fish and Wildlife 1995). These same river drainages have additional isolated populations of resident rainbow.

In eastern Oregon it was found that "Biochemical and morphological phenograms do not show that resident populations of rainbow trout in the Deschutes River are more similar to each other than to steelhead populations." And it was found that nonanadromous populations have evolved there independently within the drainage, often from steelhead populations (Currens 1987).

Currens (1987) further states in the same paper: "The resident rainbow trout in the mainstem of the Deschutes River, known as "redsides" (Bond 1973), have traditionally been considered and are presently managed as a separate, resident race. However, spawning areas and times may overlap substantially with those for steelhead in some years. Male hatchery steelhead that do not migrate develop typical redside appearance and have been observed spawning with female steelhead (Fessler 1972)."

Snorkel surveys on the upper Washougal River (McMillan 1985; 1986[b]) and in the more inaccessible areas of Wind River Canyon (McMillan and Nawa 1985; McMillan 1988[b]) have found that resident riverine rainbow (more densely spotted than steelhead) are still present in mature breeding ages as estimated by their large size (15"- 22"). That they are still there is accident rather than any management plan.

WASHOUGAL RIVER RESIDENT RAINBOWS: AN INTERBREEDING RELATIONSHIP OF MALES TO WILD AND HATCHERY STEELHEAD

An examination of the relationship between resident rainbow and steelhead has just begun in the State of Washington. Preliminary information thus far collected demonstrates that some resident rainbows sampled in Washington appear genetically the same as steelhead within the same drainage while others appear different (Crawford 1997).

On Dougan Creek of the upper Washougal River, a 12" trout was filmed during a television documentary as it spawned with two female steelhead on February 20, 1982 (McMillan 1983). On March 14, 1983 a lone 22"-range female steelhead was seen spawning with a dark male trout of 9"-10", also on Dougan Creek. No larger male was found in a search upstream and down (McMillan, 1983). As low as present escapement is on the Washougal, any contribution from resident rainbows may be an important factor in maintaining the remnant wild steelhead population in the absence of enough anadromous males to go around (McMillan 1988[c]).

Lower Washougal Resident Rainbows — A Near Absence of Identifiable Adults:

However, a 0.7 mile snorkel survey on the lower Washougal River on June 12, 1987 found no wild resident rainbow of a size readily distinguishable from rearing steelhead. Just seven wild resident rainbow or large juvenile steelhead (8"-10") were found; 71 hatchery steelhead smolts that appeared to have residualized (5"-12"); 200 wild rainbow/steelhead juveniles (3"-8"); one wild cutthroat juvenile (3"-8"); 2,325 juvenile coho and chinook (2"-5" and likely hatchery origin); 183 suckers; and one unidentified adult steelhead (McMillan, 1988[a]).

A two-mile snorkel survey of the lower Washougal River on June 2, 1986 gave almost identical results to the 1987 snorkel survey. The only major difference was a count of 171 whitefish which were present in that particular two-mile stretch. 21 wild resident rainbow or large juvenile steelhead (8"-12") were counted — none large enough to be clearly of spawning-age size, although some possibly were (McMillan 1986[b]).

This was not always the case. The last large resident rainbow I sport caught on the lower Washougal River was a 20-3/4" male released in September of 1979 (personal field notes). In the 1960s and 1970s I generally released two or three 14"-18" resident rainbows each year from the lower Washougal River as incidentals to steelhead fishing. They virtually disappeared by the late 1980s.

Upper Washougal Resident Rainbows — A Common Presence of Identifiable Adults :

Large resident rainbow of 14"-22" are commonly counted in snorkel surveys of the upper Washougal River. For comparison to the lower Washougal counts, on June 28, 1987 (McMillan 1988[a]), a 0.6 mile snorkel count of the upper Washougal River found: 80 resident rainbow (9"-20"); 514 rainbow/steelhead juveniles (3"-8"); four wild cutthroat (10"-16"); and 97 adult steelhead (24 wild, 1 hatchery, and 72 unidentified).

On June 1, 1986 (McMillan 1986[a]) a 0.6 mile count of the upper Washougal found similar results: 58 resident rainbow (9"-20"); 793 rainbow/steelhead juveniles (3"-8"); seven wild steelhead smolts (6"-10"); two wild cutthroat (7"-15"); and 16 adult steelhead (8-wild, 0-hatchery, and 8 unidentified). Resident spawning-age-size rainbow were clearly identifiable as a significant component to the upper Washougal wild rainbow/steelhead population.

Wild Washougal Resident Rainbows: Are The Males Vectors to Their Own Population Demise?

The upper Washougal River has a good population of apparent breeding-sized wild resident rainbow; the lower river does not. What are the differences between the upper and lower sections of the Washougal?

Wild steelhead and wild resident rainbow in the upper Washougal are isolated from most hatchery steelhead that could otherwise return and spawn there by Dougan Falls (McMillan 1985; 1986[b]; and 1988[a]). This is a consequence of river geography and geology.

Without Dougan Falls, hatchery/wild steelhead spawning interactions visually occur on the lower Washougal River (McMillan 1986[a]; 1990; and 1991) as previously described near my former cabin-home. There is nothing to prevent that.

Steelhead/rainbow spawning interactions have been observed several times on the smaller tributaries of the upper Washougal River (McMillan 1983; 1986[a]; and 1988[c]). It is more difficult to observe on the main river, where spawning often takes place 30'-100' away. Nevertheless, I have sometimes seen the flicker of small, dark residents among the spawning pods of steelhead, and occasionally have suspected larger residents that are difficult to discern from small steelhead if larger than 16". As has been observed in Kamchatka, I assume these are "dwarf males" that can effectively fertilize the eggs of female steelhead as described by Savvaitova et al. (1973).

There has been nothing to prevent wild "dwarf males" or large wild resident males from spawning with hatchery female steelhead on the lower Washougal. As demonstrated with the hatchery resident rainbows (Buyukhatipoglu et al. 1984; and Scott et al. 1980[a] and [b]), resident male rainbow apparently have as long a period for potential spawning as do steelhead. There would appear to be no reason why a hatchery/wild, steelhead/resident cross would have any better survival than a hatchery/wild cross between steelhead as found by Chilcote et al. (1986), Leider et al. (1990), and Hulett et al. (1995).

Is this part of the reason for the present absence of an identifiable wild adult resident rainbow population on the lower Washougal River — a 40-year history of wild resident males spawning with abundant hatchery female steelhead, with a continuous gradual loss in numbers due to lack of that interbreeding success? And has that loss of resident wild rainbows in the lower Washougal River contributed to the decline in genetic diversity and numbers of wild steelhead as an interactive component of a single wild steelhead/rainbow population?

OTHER CONTRIBUTING FACTORS TO THE LOSS OF WILD RESIDENT AND ESTUARINE RAINBOWS

Continuing Harvest:

Wild steelhead have had protective catch-and-release angling regulations on some rivers for more than 15 years in Washington (although results appear variable and with little assessment). But wild resident rainbow and estuary-run rainbow between 12"-20" have had no similar protective measures on westside anadromous river sections beyond a two-fish angling limit at best (the Toutle River system after the eruption of Mt. St. Helens is an exception). As management considerations, westside resident rainbow on most anadromous stream sections do not exist in either Washington or Oregon. As a reflection of that management indifference, they often do not exist as visible adult populations except in sanctuary areas to protect anadromous fish through angling closures or by the accident of angler inaccessibility in remote river reaches (McMillan 1988[b]).

Residualism of Hatchery Steelhead Smolts:

As previously demonstrated in the June snorkel surveys of the lower Washougal River, residualized hatchery steelhead smolts outnumbered the identifiable wild resident rainbows. In 1987, only seven wild rainbows of potential resident size (8"-10") were counted, compared to 71 residualized hatchery steelhead smolts (5"-12") (McMillan 1988[a]). In 1986, 21 wild rainbows of potential resident size (9"-12") were counted compared to 29 residualized hatchery steelhead smolts (6"-14") (McMillan 1986[b]).

It has been suggested for a long time that residualized hatchery steelhead smolts create direct competition to wild juvenile steelhead for food and space in rivers (Royal 1972). Certainly they create the same competition problems for wild resident rainbow.

THE LOSS OF WILD STEELHEAD DIVERSITY THROUGH THE LOSS OF RESIDENT AND ESTUARINE RAINBOW LIFE HISTORY FORMS

How might the loss of resident and estuarine rainbow life history forms affect steelhead? If resident rainbow, estuary-run rainbow, and steelhead are one interbreeding population as on Kamchatka's Utholok River (and suspected on other Kamchatka steelhead rivers), then two-thirds of the population's adaptive capacity may be contained within the resident and estuarine life history forms if each is equally important to the long-time survival of the population.

Can steelhead populations survive in the long term if they are largely missing two-thirds of their adaptive life history options? Is this another factor in some steelhead populations that have not responded to present management attempts to rebuild them? Is it possible to manage for steelhead restoration without effectively managing for rainbow (resident and estuarine) as an inclusive and interconnected population?

STEELHEAD MANAGEMENT AS A DETERMINANT OF THE COMPOSITION OF ORIGINS AND DIVERSITY OF STEELHEAD POPULATIONS

The examinations of hatchery/wild steelhead spawning interactions, the part males play in that, and the inter-relationships of the varied life histories of steelhead/rainbow as connected populations, are all inseparable from steelhead management. As discussed in the lead to this paper, the human mind tends to focus — to separate rather than to connect. We tend to see too small rather than large enough. Fisheries management is a part of the remaining "fabric" of North America's wild anadromous fish populations. It might even be said that fishery management has become the weaver of that "fabric."

STEELHEAD MANAGEMENT IN WASHINGTON STATE

To date, steelhead management in the State of Washington has primarily focused on maintaining temporal separation of wild and hatchery spawning timing (Leider et al. 1984; DeShazo 1985) as the means of conserving wild steelhead stocks in the State while providing hatchery steelhead for harvest (Hulett and Leider 1993; Washington Department of Fish and Wildlife 1993). The Washington Department of Fish and Wildlife's line of demarcation separating wild steelhead spawning from hatchery steelhead spawning has been determined to be March 15th (Washington Department of Fish and Wildlife 1994[b]) and has been used statewide.

Selection for early spawning of steelhead at hatcheries has been used since the 1950s. Although it was originally a tool for maximizing the growth of juveniles to smolt size in one year of hatchery rearing (Royal 1972), it is now more commonly cited as a conservation measure for maintaining temporal separations in wild and hatchery spawning. The policy goal has been to maintain long-term reproductive potential of wild stocks at a minimum of 90% of its natural level (Washington Department of Fish and Wildlife 1994[b]).

Washington Steelhead Management Results:

The results of Washington's steelhead management strategy (based on the assumption that hatchery steelhead spawn prior to March 15th and wild steelhead spawn after March 15th as a statewide management blanket) has been variable as measured by research attempting to detect genetic mixtures of steelhead on differing rivers:

The Kalama River's wild winter steelhead population shows little genetic evidence of hatchery steelhead heritage (Leider et al. 1986), but that is not the case with the Kalama's wild summer steelhead, where there is considerable evidence of hatchery heritage (Leider et al. 1986; Chilcote et al. 1986).

On the North Coast of Washington there appears to have been a reduction in genetic variation in wild winter steelhead stocks. It is suspected that 40 years of hatchery/wild spawning interactions have caused reduced genetic variability there when compared with British Columbia wild steelhead stocks just to the north (Reisenbichler and Phelps, 1989).

Hatchery steelhead contribution to present wild winter steelhead on the Cedar and the North Fork Stillaguamish rivers appears minimal, as with the present wild summer steelhead on Deer Creek, North Fork Skykomish, Wind and Washougal rivers (Phelps et al. 1994).

Moderate hatchery steelhead introgression was found in the wild winter steelhead of the Green, Raging and Pilchuck rivers, while a moderate-to-large extent of hatchery introgression was found for wild summer and winter steelhead on the Tolt and the wild winter steelhead of the mainstem Skykomish (Phelps et al. 1994).

To further confuse the picture, in a report to The Osprey (newsletter of the Steelhead Committee of the Federation of Fly Fishermen), Washington Department of Fish and Wildlife provided an update on steelhead genetic findings in the State (Crawford 1997). Comparing recent steelhead electrophoretic samplings with those collected 20 years ago, it was concluded that the amount of interbreeding between hatchery and wild steelhead has been at an insufficient level to increase similarity of hatchery and wild steelhead in most areas, although exceptions did exist.

However, the conclusion drawn by Crawford is not the only one the evidence suggests. Lack of electrophoretic evidence of hatchery/wild crosses does not necessarily mean that such matings were infrequent or did not take place at all. It could mean that such matings resulted in no survival in the form of progeny that return as adults.

This is precisely the maximized implication of what was found with Kalama River hatchery winter steelhead that spawned in the wild and resulted in zero returning adults four years later in 1993-94 by Hulett et al. (1995). What happens when hatchery steelhead which have zero survival when spawning in the wild, spawn with wild steelhead? This is a sobering consideration for all Washington rivers where hatchery plants have occurred for many years, where no barriers exist to separate hatchery from wild steelhead, but where no genetic evidence is found that hatchery/wild matings took place. It could be among the reasons for continuing wild steelhead depletions on rivers where hatchery steelhead continue to return while otherwise vigorous efforts have been applied to increase wild steelhead escapement.

That hatchery/wild matings occur has been observed on the lower Washougal River several times despite the difficulty of being able to observe missing fins as the only determinant there of hatchery origin (McMillan 1986[a]; and personal field notes). Crawford et al. (1978) found that two (33%) of the six redds from which all steelhead were effectively captured and identified as to origin on the Kalama River's Gobar Creek had a mixture of hatchery and wild participants. The timing of wild steelhead redds found on the upper Washougal River and its tributaries (Figure 3), Kalama River tributaries (Figure 5), and Queets River tributaries (Figure 4) all overlap substantially into the time period prior to March 15th that Washington Department of Fish and Wildlife considers hatchery steelhead spawning time. It seems unlikely that hatchery/wild spawning interactions would not occur, given this overlap in egg deposition times. The lengthy period of sexual ripeness for wild males further increases the range of likely hatchery/wild interactions.

If hatchery/wild matings do occur, as much of the evidence would suggest, then why the varied genetic evidence that such matings have actually occurred? It likely varies for each river, for each tributary, for each individual wild stock in its mating success/survival with the two primary hatchery stocks used in Washington (Chambers Creek Hatchery stock winter-runs; Skamania Hatchery stock summer-runs), and for differing historic epochs in which conditions (local and/or global) may alter hatchery/wild spawning success. In some instances there may be zero-to-negligible survival from such matings with no electrophoretically measured evidence it occurred, as previously suggested. Or it may mean that the sample size of juveniles and/or adults used for electrophoretic analysis was too small, or too limited in area, to find juveniles or adults from watershed areas where such matings are most likely to occur.

For instance, juveniles or adults sampled from the upper Washougal River should show little genetic evidence of hatchery/wild crosses because there is 96%+ probability that spawnings that occur there are of wild steelhead. But samples taken downstream of Dougan Falls on the Washougal should show some evidence of hatchery/wild spawning interactions in those areas where they most frequently occur — particularly within a mile each side of the hatchery tributary on the mainstem, within a mile radius each side of smolt release sites on the mainstem, and in the lower and mid-river tributaries. If genetic evidence of such matings is not found there, it should be suspect that there is minimal survival from hatchery/wild matings in those areas unless on-the-ground spawning surveys can factually demonstrate that no hatchery/wild interactions are occurring.

The false assumptions that can be drawn about use of spawning areas by hatchery and wild steelhead based on spawning surveys that don't begin until after March 15th have been previously demonstrated in the example of Wind River's Panther Creek. Without accurate knowledge of steelhead spawning use of watershed areas, it makes it difficult to collect samples for genetic determinations relative to spawning interactions. It also fosters myths rather than knowledge.

However, the genetic information collected in Washington does indicate that some wild steelhead show no evidence of genetic exchange with hatchery steelhead (as limited to the present tools used for analysis), and others have. It remains for most site-specific watershed areas to be identified where genetic exchanges between hatchery and wild steelhead have not occurred throughout the State.

But that is just a beginning, not an end, to the fundamental needs in the process of restoring wild steelhead/rainbow populations. It is not known if wild populations have been reduced due to a long-term, cumulative lack of spawning success through hatchery/wild matings, despite apparent lack of genetic exchange; and it is not known if overall diversity has been reduced due to chronically reduced population numbers (by comparing such values as spawning timing breadth, return timing breadth, juvenile outmigration timings, ocean migration routes, and etc. through a more holistic understanding of steelhead than electrophoretic sampling is capable of).

If steelhead diversity (and their inseparably related potential for adaptability) has been reduced due to reduced population size that is in part due to hatchery/wild spawning interactions, then insulating those watershed areas presently subject to hatchery/wild spawning interactions from further hatchery steelhead entry would necessarily be a part of the solution for restoring both wild population numbers and wild population diversity.

OTHER MANAGEMENT CONSEQUENCES IN WASHINGTON

Disappearance of Early-Return Wild Winter-Run Steelhead in Washington State:

Early-return/early-spawning steelhead are now so uncommon that some biologists believe the supposed early-return component of wild winter-run steelhead in Washington is a myth and always was. The official stance by Washington Department of Fish and Wildlife is more subdued, but nevertheless, Washington's wild steelhead policies have long defended the position that early return timing of hatchery steelhead is a useful barrier for preventing gene flow with later return wild steelhead (Leider et al. 1984) and that it is a good steelhead management tool (DeShazo 1985) regarding harvest decisions based on the assumption that very few early-return wild steelhead exist.

But the history of angling for early winter-run steelhead is solidly there in books like Fishing Guide To The Northwest edited by Ken McLeod (1944). A winter steelhead return timing in "late fall," December, January and/or February is specifically mentioned for 20 rivers or creeks. For the majority of the other westside steelhead streams (perhaps 100 in all) there is generally no description beyond a presence of steelhead in winter. However, under the identification print of a steelhead on page 35 it states: "Found in all coastal streams, principally from December 1 to April 1, also in some streams in summer months." This was fifteen years prior to releases of hatchery steelhead smolts in Washington whose parentage had been selected for early returns and early spawning.

Claude Kreider (1948) in his book Steelhead lists 19 winter steelhead rivers in western Washington. December and January are specifically mentioned as part of the winter steelhead timing for eight of them; February for three more; four of them simply state "winter" with no other specifics; and the remaining five are listed as "April peaking winter runs" on lower Columbia tributaries which probably included many early summer run steelhead in the supposed April peak which was confusing to many anglers of that era.

Enos Bradner (1950) in Northwest Angling lists 84 winter steelhead streams in Washington with thorough descriptions of the steelhead and the fishing. On 16 of these streams winter steelhead runs were said to begin in December (19%), 33 streams in January (39%), 8 streams in February (10%), 4 were called strictly "late return" (5%), and the remaining 23 were simply described as arriving in winter (27%). Because of the completeness of the descriptions for so many rivers, Bradner is a valuable historical source who found that 68% of Washington's streams had wild winter steelhead that commenced entry in February or earlier, and on 58% of the streams wild winter steelhead entry commenced entry in January or earlier.

Each of these books was written independent of the other. McLeod and Bradner were outdoor writers for rival newspapers in Seattle, and Kreider was a well-traveled California outdoor writer. It is evident that the majority of Washington's steelhead streams had enough winter steelhead present from December to February to expect sport fishing success before hatchery steelhead programs with early return/spawning came on line.

When I began winter steelhead fishing in the mid-1950s, Thanksgiving Day was considered the colloquial beginning for winter steelhead fishing in Washington. The legal fishing season for winter steelhead was typically December 1 through February, as defined in regulation pamphlets in the 1950s. In other words, most fishing effort was on early-return wild steelhead with fishing closures beginning March 1st. Some streams, or sections of streams, had "Late Season" extensions into March and April, but that was more often the exception than the rule. How quickly history is ignored.

<u>Kalama River</u>:

For somewhat later evidence, the Kalama River study (Crawford et al. 1978) sampled 1,099 winter-run steelhead between October 26, 1976 and June 8, 1977. Both hatchery and wild runs peaked in late April with a lesser peak between late February and early March.

It was noted in the Kalama study that 1976/77 was an unusual winter characterized by low water volumes and cold flows which may have delayed wild and hatchery winter steelhead returns and compressed their return and spawning times closer together than is usual. My personal field notes show similar information for the Washougal River that same winter. And subsequent winters in the 1980s and early 1990s were also sometimes characterized by low, cold flows. Such winters emphasize the problems of assuming the validity of any theoretical and arbitrary timeline for distinguishing between wild and hatchery return periods and spawning times. Despite the low, cold flows, wild winter steelhead returns to the Kalama River traps in 1976/77 were not inconsequential prior to March 15th.

<u>Washougal River</u>:

Between 1971 and 1984, I recorded the return time of the 45 wild winter-run steelhead from my personal catch on the Washougal River (Figure 9). 38% of these steelhead returned between November and the end of February, and 62% returned between March and the end of May (McMillan 1984[a]; and 1987). Again, although 38% is less than 62%, early return wild winter steelhead were not an inconsequential return component to the Washougal River.

<u>Quileute River System</u>:

Evidence collected to explore the possibility of an historic early component to the wild winter steelhead return on the Quileute River system found that 37% of the wild steelhead on the Quinault River are caught in tribal nets prior to the end of January and 25% on the Queets River (Washington Dept. of Fish and Wildlife 1996). There was no conclusion regarding what the early proportion of wild steelhead on the Quileute once was, although it suggests a similar proportion to the Quinault and the Queets was possible prior to the 1960s.

Old Washington Department of Game catch statistics indicate the Sol Duc River (Quileute tributary) had a December/January sport catch in 1956 and 1957 similar to the catch for the other winter months (McLachlan 1994). And the numbers of early return fish were sufficient to support the tribal net fishery prior to 1963 on the Quileute River just downstream (McLachlan 1994; Washington Dept. of Fish and Wildlife 1996). In addition, data from an early hatchery steelhead marking experiment in 1954-55 indicates a very high proportion of wild steelhead returning to the Sol Duc in December/January (Royal 1972; McLachlan 1994). But the numbers of December wild steelhead caught by anglers since 1961 on the Sol Duc have signifi-

Figure 8

Number of adult winter hatchery and wild steelhead trapped at lower Kalama River in 1976/77. Information from the Washington Department of Game.

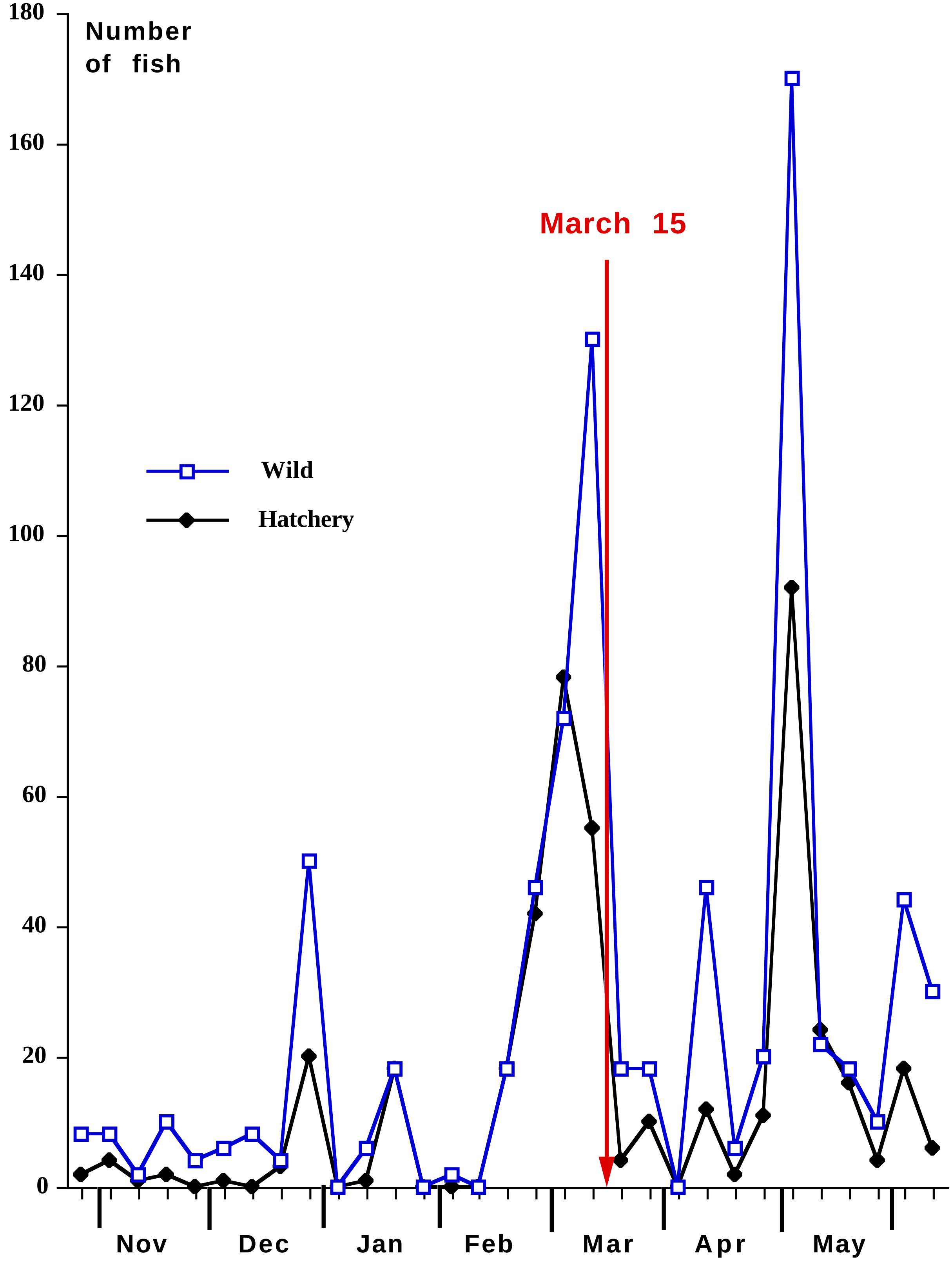
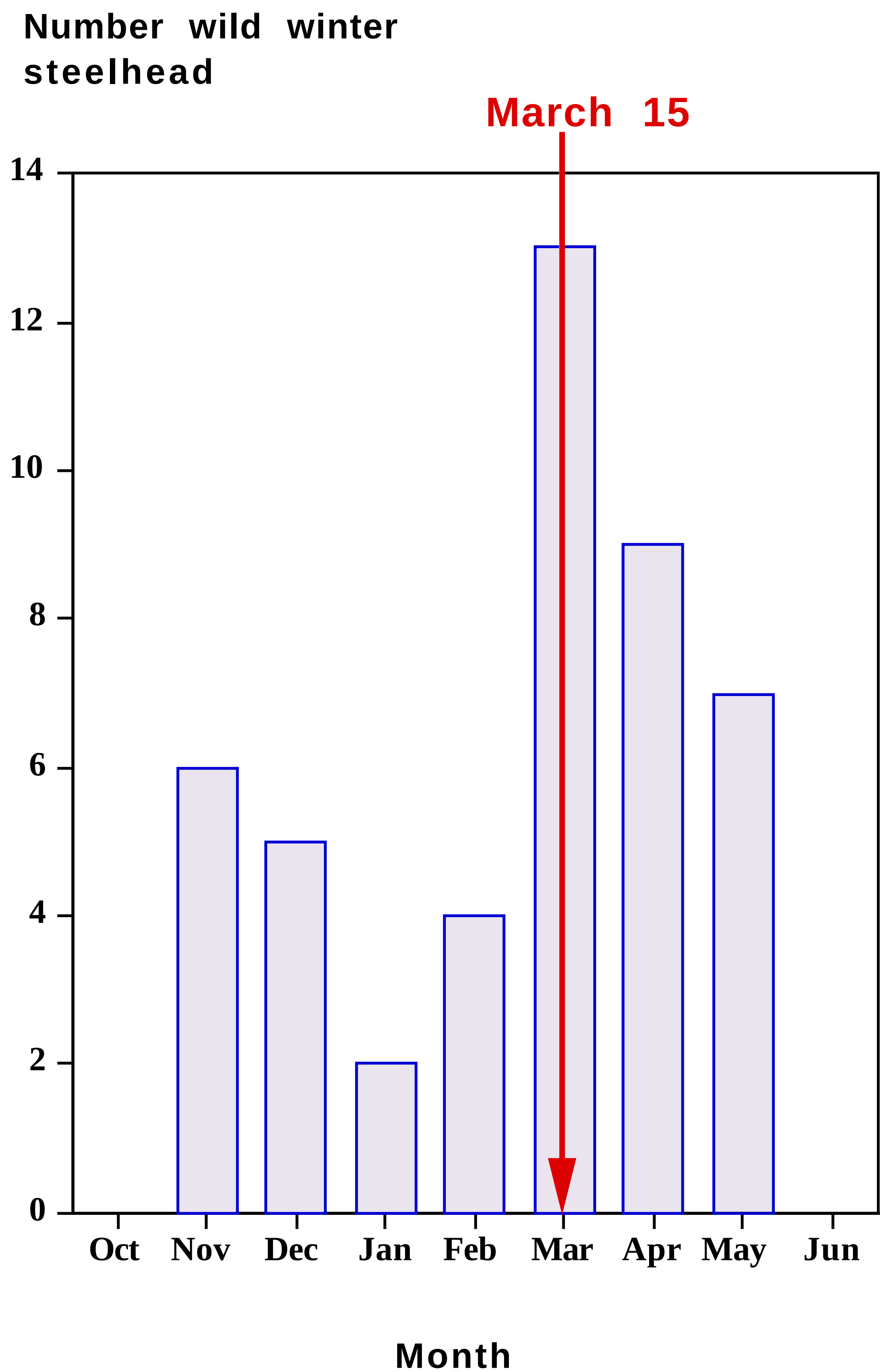


Figure 9

Wild winter run steelhead catch frequency per month on the Washougal River (1971-1984). Information provided by the Clark-Skamania Flyfishers.



cantly declined (Washington Dept. of Fish and Wildlife 1996).

If wild winter steelhead in Washington no longer return with sufficient numbers to manage for them in the early winter time frame, it is indicative of a pervasive loss of wild steelhead return time diversity in the State. It has probably resulted in a pervasive loss of early spawning timing associated with that early return group. But it has not entirely disappeared. As previously shown, it is still common enough to be measurable on some rivers, particularly in the smaller tributaries where early spawning may be important due to water volumes, water temperatures, the need for early juvenile outmigration, or as yet undetermined reasons.

How Did the Early Wild Winter Steelhead in Washington Disappear?

During the 1993-94 return cycle on the Kalama River it was found that the reproductive success of hatchery winter run steelhead that spawned in the wild four years earlier was essentially zero (Hulett et al 1995). Crosses between Skamania Hatchery summer steelhead with wild Kalama River summer steelhead showed an 86% reduction in productive capacity compared to wild/wild spawning pairs (Leider et al. 1990). With these kinds of low to non-existent reproductive examples in the wild, it is easier to understand what has happened in the 40 years of hatchery interactions.

Washington steelhead managers feel that the shift to later return and spawning timing for wild steelhead, as well as a considerable level of hatchery/wild spawner overlap in Washington, is an acceptable sequence of events. In the FEIS for proposed Grandy Creek hatchery on the Skagit River (Washington Department of Wildlife 1994[a]), it is reported that Chambers Creek hatchery stock steelhead exhibit 40% of spawner overlap with wild winter steelhead, i.e., 40% of hatchery females have not yet begun spawning by the time the wild run begins spawning in February (p. 43, appendix A-6 FEIS). Evidently this percentage is acceptable to Washington Department of Fish and Wildlife. The FEIS was written in order for the State to build the hatchery.

One of the few recorded pieces of evidence I found demonstrating that male steelhead (both wild and hatchery) are the link to hatchery/wild interactions in Washington was given in a court testimony provided as evidence to deny construction of Grandy Creek hatchery (Bentzen 1997). He warns that "40% of hatchery females minus fishing mortality and hatchery taking will be available to spawn with Grandy Creek wild males. Because males are not gamete limited,

Mature Skagit River wild male steelhead released on February 5, 2000. Will he spawn with a wild female or a hatchery female?

Photos by Bill McMillan

Freshly arrived Skagit River hatchery female steelhead killed on February 7, 2000. She was caught in the same pool as the wild male caught two days earlier. Who will her hatchery cohorts spawn with?

they tend to stay in freshwater longer than females, and therefore have greater opportunities to reproduce than do females. If the hatchery males remain in freshwater until there are no more females to spawn with, 100%, minus fishing mortality and hatchery taking, of the Chambers Creek males would then be present when the wild winter steelhead population returns to spawn ....”

Bentzen continues, “Some level of gene flow from Chambers Creek stock to wild Skagit winter steelhead has therefore been occurring ever since hatchery supplementation began in the Skagit drainage.” This factor was not considered in the FEIS.

Washington is but one example where North American fishery managers have taken liberal risks with a public resource, and there is every indication they will continue to do so.

WHAT YOU SPEND IS WHAT YOU GET

The bottom line is most wild anadromous salmonid populations, steelhead included, have either gone extinct or are otherwise not doing well in the western continental United States (Nehlsen et al. 1991).

Fishery management agencies determine where and how fishery moneys are spent.

Those fishery moneys did not create dams, graze cattle and cut old growth trees from riparian areas, or build homes with fertilized lawns and asphalt driveways along rivers and creeks. But most fishery management moneys in the Northwest United States have been spent on hatcheries and the baggage related to hatcheries. Hatchery-related barriers that deny wild fish access to historic habitat, harvest pressures due to mixed stock fisheries, spread of diseases originating from hatcheries, hatchery/wild juvenile interactions, and hatchery/wild spawning interactions are all contributive to the loss of wild anadromous fish.

Fishery management agencies can still decide to spend moneys in ways that solve fishery problems, rather than in ways that contribute to fishery problems. Because of fishery management’s focus on hatcheries, hatcheries may actually be the dominant problem all wild anadromous fish presently face — not necessarily by the hatcheries themselves, or due to hatchery/wild spawning crosses, or due to other hatchery baggage, but by the simple fact that funding of hatcheries has largely robbed the potential for funding the more fundamental and primary issues for preserving and restoring wild fish populations.

A graph on the front page of the July 27, 1997 Portland Oregonian newspaper (“$3 Billion Later, Columbia Basin Salmon Dwindle”) demonstrated that as federal spending on the Columbia River dramatically increased between 1981 and 1996 with the intent of doubling the anadromous fish returns from 2.5 million in 1987 to 5 million, instead the anadromous Columbia River return in 1996 was less than one million. 75% of those fish were hatchery origin, which is where most of the money was spent.

Both professional science and species management are driven by money. What you spend is what you get. Where we have spent anadromous fish-related money reflects where we are at: a systemic curve to depletion/extinction of wild West Coast anadromous salmonids in the lower continental United States.

I was a member of the Washington Department of Wildlife’s Fishery Policy Task Force from its inception in 1989 until 1993. To understand a large part of the plight of wild steelhead in the State took little more than a look at the bookkeeping of the primary managing agency for steelhead: $26 million (the dominant single investment for the entire breadth of department spending) was spent on the steelhead hatchery program; the most I could find that could be cumulatively called wild trout/steelhead management was no more than $1.5 million (personal notes taken at Policy Task Force meetings on examining the previous Washington Department of Wildlife budget in 1990).

Shortly after discovering that discouraging discrepancy, I spent several hours trying to determine the spending on hatcheries in the states of Oregon, Washington and Idaho. My best estimate was that the combined federal fish, federal power, private power, state fish, and tribal fish agencies spend one-half to one billion dollars annually on anadromous salmonid hatcheries in these states and in the human man-hours to operate, research, maintain, promote and defend them. But it was merely a guess based on a projection of Washington Department of Wildlife hatchery spending to agencies that were smaller, larger or equal. However, more concrete numbers have been provided by recent press reports:

The July 27, 1997 issue of the Portland Oregonian reported that Bonneville Power Administration alone spent $338 million in 1996 (plus an additional $100 million in lost revenue to provide improved passage flows to benefit both wild and hatchery fish) just on Columbia River salmon projects. The largest proportion of that $338 million was hatchery-driven. Just one man, a part time consultant for the Yakama Tribe's hatchery program, was paid $375,000 between 1989-1994.

The November 30, 1997 issue of The Seattle Times reported that just under $1 billion a year is being spent in Washington State to save anadromous fish. It's a composite of state, federal, BPA, private utility, city, county, and Native-American funding sources. Most of it goes to hatcheries, management (much of that hatchery related), and moving fish around dams. But in recent years, fishery moneys are finally beginning to go to watershed and water quality preservation, and to habitat purchase and protection. The $1 billion reported for Washington did not include the shared Columbia River fish programs of Oregon and Idaho, nor did it include every possible agency in Washington State that may have provided some sort of fishery funding.

If fishery moneys spent over the past 40 years had been habitat driven rather than hatchery/harvest driven, how many miles of rivers with 200-foot-wide corridors on each bank could have been purchased or leased? How many water rights purchased or leased? And how would wild anadromous salmonids be faring without competition and genetic introgression from hatchery salmonids? And what if fishery managers decided to reverse the trend? What if they spent a billion dollars a year among the three states on solving two of the three H's (habitat and harvest) and eliminated the third (hatcheries)? What if they started now?

IN RUSSIA: STEELHEAD MANAGEMENT WITHOUT MONEY

The Russian ichthyologists from Moscow State University who have studied Kamchatka steelhead for 30 years carefully record the differences in steelhead. It is the breadth of differences that provides adaptability to differing or varying environmental niches. The Russians take extensive measurements of the morphometric characteristics of each steelhead killed for study. (Although the majority of steelhead used for data collection in recent years have been released alive after more limited measurements and the taking of tissue and scale samples.) And now, 25 years after they were begun, the tedious morphometric characteristic measurements have begun to pay off with results that have disturbing implications — perhaps even more for North America than for Russia.

On all three rivers of primary study over the past 25 years (Utholok, Kvachina and Snatolvayam), steelhead have shown a significant decrease in number of spinal vertebrae. On two of these rivers, where the population size has remained undiminished in that time, the vertebrae counts have decreased the most. On the third river, the Utholok, where the anadromous *Salmo mykiss* population has significantly dropped in numbers due to illegal commercial netting (although still a remarkably abundant steelhead population by present North American standards), the vertebrae count has not decreased as much as on the other two rivers.

Although the vertebrae count for Utholok steelhead has not reduced as much as on the other two rivers, the reduced numbers of Utholok anadromous steelhead have resulted in other significant changes that have not occurred on the two rivers where the steelhead numbers did not decline: the dorsal fin has reduced in height; the previous population structure has been disturbed so that the size and role of groups more closely tied to fresh water life histories have increased; individual fish have appeared who go to sea for several months and return to the river while sexually immature; the proportion of females in the anadromous group has increased; female resident riverine fish, previously absent, have appeared; and the number of repeat spawners has increased noticeably (Savvaitova et al. 1997).

It was concluded from this that while the steelhead populations from all three rivers were originally very similar, with the decrease in anadromous steelhead numbers on the Utholok, its interactive steelhead/rainbow population is now significantly different from the others.

Interestingly, where the population remained numerous (the Kvachina and Snatolvayam), the steelhead vertebrae counts decreased the most. Increased vertebrae counts had been previously described in other literature as a consequence of raised temperatures in the spawning redds at the time of incubation of the eggs (Taning 1952). The source of the suspected temperature change on the Kamchatka rivers studied is not presently known, although changed conditions at the spawning grounds, change in spawning time, or warming of the global climate are among the suggestions. But whatever the source, it is felt that the reduced vertebrae counts are indicative of an adaptive process in all three steelhead populations. This adaptation to temperature change is occurring more rapidly on the two rivers where population numbers remain high. In other words, with population numbers high, steelhead appear to be more adaptive.

Where the anadromous population has been reduced, the entire *S. mykiss* population is in active change in several ways as a reaction to the depleted survival in the anadromous life history. And the anadromous population appears to be adapting less rapidly (as evidenced through vertebrae counts) to temperature change due to the depletion in numbers.

The Russian scientists are worried that if these factors creating change in the steelhead populations continue, it could damage their inborn homeostasis (Savvaitova 1997).

If Kamchatkan steelhead (still appearing remarkably numerous) are struggling to maintain adaptive equilibrium within their populations as perceived necessary for their effective long-term survival, what has happened to North American steelhead populations that now number in dozens or a few hundred where once there were thousands?

In 1983 Russian ichthyologists convinced the then Soviet government that increased netting activities (often illegal poaching) from their own country and other nations, as well as a changing ocean environment, were sufficient cause to list steelhead in The Red Book of the RSFSR Animals (1983) due to the lack of scientific data from which to effectively monitor the steelhead returning to Kamchatka rivers. As a consequence, it has been illegal since 1983 for any but the native people of Kamchatka (who net relatively few steelhead on most rivers examined) to fish for steelhead in any way (net, rod and reel, or otherwise), unless a part of verified data collection in the company of Russian scientists.

A Russian Red Book listing is roughly equivalent to a U.S. Endangered Species Act listing, except there appears to be less time lag and less "constipation" in the process from scientific identity of an animal-threatening problem to rapid implementation through government action.

Because of lack of moneys, the collection of scientific data that may, or may not, eventually justify taking steelhead off The Red Book did not begin until the fall of 1994. At that time a joint expedition of Russian scientists and an American based group of fly fishermen (The Wild Salmon Center) came to a mutual long-term agreement to study the distribution and the diversity of Russia's steelhead on the Kamchatka Peninsula (Savviatova et al. 1996; and 1997).

The Russian ichthyologists responsible for The Red Book listing of Kamchatka's steelhead seem remarkably bold and united by American standards. Perhaps it's simply that Russian icthyologists have no moneys available to do anything but protect the resource, and that in Russia there is no steelhead fishery management bureaucracy to filter the science through.

The Russian ichthyologists reacted decisively in 1983 (18 years ago) with the first hint that there might be a steelhead problem. The American scientific community did not react until three members of the AFS Endangered Species Committee authored the paper, "Pacific Salmon at the Crossroads: Stocks at Risk from California, Oregon, Idaho and Washington" (Nehlsen et al. 1991). But even today, 10 years later, there have been no Draconian measures taken that reflect anything like the crisis it is. And particularly disturbing, there is still no unity among the fish scientists to change that, and certainly little evidence of a desire to do so by the fishery managers.

When might the Russians have listed Southern California's steelhead in The Red Book? Or Snake River/Upper Columbia steelhead? Or Washougal River steelhead? Or on the entire West Coast?

No data in Russia **is** a problem; in the United States, no data has often been equated as **no** problem. In fact, the best thing that ever happened for wild steelhead in the State of Washington may have stemmed from the Boldt Decision. For the first time, and only through the force of court order, Washington Department of Game began to collect meaningful data on wild steelhead escapement from which to manage and divide the State's steelhead resources.

In the United States, the lawyers and judges of the legal system have proven to be the most effective, and often the only, agents of leadership demonstrating an ability to effectively mandate planning intended to protect natural resources from the final outcome of managed depletion. Unfortunately, the use of the legal process is typically so delayed through the conflict of natural resource users, managers, and scientists, that the resources themselves are often reduced to a level from which they may never recover.

In Russia, the process to protect steelhead at least has the horse in front of the cart — a scientific community that bases actions as much on what it does **not** know as on what it does.

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