THE OREGON PLAN *for Salmon and Watersheds*





Population Health Goals and Assessment Methods for Steelhead in the Klamath Mountains Province

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Oregon Plan for Salmon and Watersheds

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INTRODUCTION

On March 13, 1998, the National Marine Fisheries Service (NMFS) announced that steelhead in the Klamath Mountain Province (KMP) of southern Oregon and northern California would be protected by special conservation plans designed in cooperation with the states of Oregon and California. The steelhead supplement to the Oregon Plan for Salmon and Watersheds (OPSW) is intended to maintain wild steelhead populations in Oregon at sustainable and productive levels that will provide substantial environmental, cultural, and economic benefits. Similarly, a Memorandum of Agreement between NMFS and the California Department of Fish and Game (CDFG) established the terms and conditions for the improved conservation and management of steelhead on the northern coast of California.

Section ODFWIA1S of the OPSW commits the Oregon Department of Fish and Wildlife (ODFW) to work with NMFS to establish "Population Health Goals" for wild steelhead in Oregon. Section 7 of the Memorandum of Agreement between NMFS and CDFG requires that a monitoring program be developed in order to assess the health of steelhead on the north coast of California. The purpose of this document is to propose population health goals for wild steelhead populations in the Oregon portion of the KMP and to propose a monitoring program designed to characterize the status of KMP steelhead in relation to population health goals. Potential or ongoing monitoring activities conducted by private parties or government agencies are not discussed unless directly relevant to monitoring proposed for KMP steelhead.

The State of Oregon is in the process of developing a program to monitor the status of salmonid populations, and their habitats, along the coast of Oregon (ODFW 1998). Many elements of this program will be useful for monitoring the status of steelhead in the KMP. Integration of the two monitoring programs should result in a more effective use of public funds and also should ensure that data is gathered and stored so as to be available for wide-spread use.

ODFW considered a number of measures that have been used to describe the status, or health, of animal populations. Six goals were eventually chosen because they appeared to be the most appropriate and practical means by which to judge whether wild steelhead populations in the KMP attain sustainable and productive levels as called for in the OPSW. Health goals may be modified in the future as additional information, assessment criteria, or monitoring technology, becomes available.

ODFW believes that monitoring will result in improved assessment and management of steelhead resources. However, ODFW also believes that monitoring results need to be interpreted with care. Attainment of all of the proposed goals should indicate that the populations are generally healthy. Similarly, failure to attain any of the goals should raise immediate concern about the status of the populations. However, should some goals be attained, while others are not, the status of the resource will likely remain open to interpretation.

PROPOSED HEALTH GOALS FOR KMP STEELHEAD POPULATIONS IN OREGON

ODFW presently recognizes 16 populations of wild steelhead in the KMP (ODFW 1995). Criteria used to segregate these populations were primarily based on known differences in life history parameters and on the premise that anadromous fish populations are adapted to specific river basins. In contrast, analyses of genetic material has yet to reveal significant differences between any of the populations (Busby et al. 1994).

Primary differences in life history parameters have been identified for wild KMP steelhead. Summer steelhead and winter steelhead differ in time of return as adults, tendency to return to fresh water on a false spawning migration (the “half-pounder” run), age at ocean entry, growth rate and migration patterns of juveniles in fresh water (ODFW 1990, ODFW 1994). As a result of these differences, separate health goals seem warranted for summer and winter steelhead populations. Winter steelhead inhabit streams throughout the KMP, while summer steelhead are found only in the Rogue River Basin. However, the distribution of summer and winter steelhead overlap in major areas of the Rogue River Basin (Everest 1973) and as juveniles of the respective races cannot be differentiated, some population health goals will apply to both races.

Proposed health goals encompass some of the key elements associated with steelhead life history including quality and quantity of habitat (Goal 1), densities of juvenile fish (Goal 2), distribution of juvenile fish (Goal 3), production rates of juvenile fish that migrate downstream (Goal 4), abundance of adult fish (Goal 5), and life history diversity (Goal 6). ODFW believes that proposed monitoring associated with these goals can be used to characterize the status of wild steelhead in the Oregon portion of the KMP.

Goals one through three apply to steelhead throughout the KMP. Goals four through six apply primarily to summer steelhead for two reasons. First, fishery management agencies are more concerned about summer steelhead as compared to winter steelhead, at least in the KMP. Second, more biological data is available for summer steelhead as compared to winter steelhead. These data made it possible to develop quantitative goals that can be assessed with commonly accepted sampling methods.

Goal 1

Characteristics of fresh water habitat in areas accessible to steelhead should become more similar to ODFW benchmarks of habitat quality established for streams in western Oregon.

Stream habitat used by KMP steelhead exhibits a diversity that may exceed even the diversity of life history patterns among the fish. Juvenile steelhead can be found in large rivers with minimum flows that exceed 1,000 cfs (ODFW 1994) and can also be found in small first order streams that can become intermittent before the end of May (Satterthwaite et al. 1996). In general terms, streams with diverse types of habitat, relatively clean gravel, and acceptable water temperatures during summer, are capable of supporting large numbers of juvenile steelhead.

ODFW is presently monitoring stream habitat as part of the OPSW. About 50 sample sites will be monitored annually in each of the five Gene Conservation Groups identified for coho salmon along the coast of Oregon (ODFW 1998). Within Oregon, boundaries of the Southern Gene Conservation Group of coho salmon are similar to the boundaries of the KMP.

Sampling sites for coho salmon are currently selected with the GIS-based Environmental Monitoring and Assessment Program (EMAP) developed by the Environmental Protection Agency. EMAP selects sample sites at random within each template by laying a grid of templates over a digital map of the resource to be surveyed. For each Gene Conservation Group of coho salmon, EMAP generates a series of overlapping monitoring sites for habitat conditions, spawner abundance, and juvenile abundance in all first, second, and third order streams on a 1:100,000 USGS stream layer.

Only a portion of the randomly selected sites need to be surveyed annually. Remaining sites will be surveyed on three and nine year rotational schedules that reflect the three year life cycle of coho salmon and provide the flexibility to add or delete areas of potential sampling as more accurate information on the distribution of coho salmon becomes available (ODFW 1998).

EMAP sampling protocol can be used to select sampling sites to monitor the habitat conditions in areas used by KMP steelhead. Delineation of steelhead distribution in KMP streams and a decision on an appropriate rotational schedule will be needed to randomly select sampling sites. As with coho salmon, only first, second, and third order streams should be sampled to overlap sampling for habitat conditions with sampling for juvenile abundance (Goal 2) and for juvenile distribution (Goal 3).

Habitat conditions at randomly selected sampling sites should be estimated using standardized survey procedures adopted by ODFW (Moore et al. 1997). All habitat units are surveyed within a 0.5 km length of the first order streams and within a 1.0 km length of second and third order streams (ODFW 1998). Within these chosen stream lengths, survey data are obtained from 20-40 habitat units.

ODFW surveys of each habitat unit produce data for about 50 parameters of aquatic and riparian habitat (ODFW 1998). Key parameters from the surveys can be summarized and compiled into a database, one record per site, that is identical in format to the aquatic habitat database currently maintained by ODFW. The status of key habitat features can then be: (1) estimated annually for KMP streams, (2) analyzed for trends over time, and (3) compared to benchmarks of habitat quality developed by ODFW for streams in western Oregon (**APPENDIX A**).

However, while habitat requirements of steelhead have been established to some degree, important questions remain to be answered including identification of the carrying capacity of different types of habitat for juvenile steelhead of various age classes at different times of the year. Extensive work with juvenile steelhead has not yet lead to a limiting factors model analogous to the one built for coastal coho salmon in Oregon.

This problem is even more pronounced for summer steelhead in the KMP because small intermittent streams compose some of the primary habitat for this race of fish. Summer steelhead in the KMP are presently of much greater concern to fishery management agencies, at least as compared to winter steelhead in the KMP. Assessments of population health, that rely solely on data obtained during habitat surveys, would minimize the importance of small streams for the production of summer steelhead. As a result, estimates of juvenile production are needed to appropriately interpret the findings from habitat surveys conducted in small streams used by spawning summer steelhead.

Proposed Monitoring Associated with Goal 1

Activity 1.1. Estimate the distribution of steelhead in KMP streams and record the data in GIS files. Update GIS files annually as more accurate information becomes available.

Activity 1.2. Estimate the habitat parameters of KMP streams annually at 48 sites chosen randomly annually with EMAP and survey with standardized methods adopted by ODFW (Moore et al. 1997). Incorporate a three year rotational schedule to aid in choice of sampling sites. Estimate flow during surveys.

Analysis 1.2.1. Estimate the mean and 95% confidence interval associated with each habitat parameter collected for KMP streams.

Analysis 1.2.2. Determine if the habitat goal of meeting ODFW benchmarks for streams in western Oregon (**APPENDIX A**) falls within the 95% confidence intervals estimated in **Analysis 1.2.1**.

Analysis 1.2.3. Determine if the habitat goal was met by assessing whether the temporal trends in habitat parameters, relative to ODFW benchmarks for streams in western Oregon (**APPENDIX A**), are significantly greater than zero.

Activity 1.3. Estimate the habitat parameters of non-randomly chosen streams where the production of summer steelhead fry will be estimated annually (**Goal 4**). These surveys should be conducted every four years and habitat conditions should be estimated for the entire area where steelhead fry are resident. Proximal to the trap site in each stream, monitor water temperature and estimate flow while the traps are operational.

Analysis 1.3.1. Estimate the mean and variance associated with each habitat parameter collected for nursery streams of summer steelhead.

Analysis 1.3.2. Determine if the habitat goal was met by assessing whether the temporal trends in habitat parameters, relative to ODFW benchmarks for streams in western Oregon (**APPENDIX A**), is significantly greater than zero.

Goal 2

During late summer and autumn, the mean density of trout fry should be at least 0.50 fish per m^2 and the mean density of age ≥ 1+ steelhead should be at least 0.10 (0.05 in riffles) fish per m^2.

Streams have a finite capacity to rear juvenile salmonids. Carrying capacity is affected by flow, water quality, habitat complexity, stream productivity, predation, and intra- and inter-specific competition. Various models have been developed to estimate the production potential of trout streams, but reliable models have yet to be developed for juvenile steelhead.

Densities of rearing steelhead have been estimated for numerous streams in the Pacific Northwest and for introduced populations in tributaries of the Great Lakes (**APPENDIX B**). Published values range widely, but some generalizations were apparent. Densities of subyearling steelhead in late summer and autumn usually ranged between 0.2 and 0.5 fish per m^2, and rarely exceeded 1.0 fish per m^2 (**APPENDIX B**). For age ≥ 1+ steelhead, densities in late summer and autumn usually ranged between 0.05 and 0.1 fish per m^2, and rarely exceeded 0.2 fish per m^2 (**APPENDIX B**).

However, juvenile steelhead are non-randomly distributed in streams (Gibbons et al. 1985; Roper et al. 1994). Density estimates from coastal streams of Oregon indicated that densities of age ≥ 1+ steelhead were significantly lower in riffles as compared to other types of habitat (Table 3 in **APPENDIX B**). Densities of age ≥ 1+ steelhead exceeded 0.05 fish per m^2 in only 15% of the riffles that were sampled. This density was incorporated into the health goal as riffles are a primary habitat type in KMP streams.

Reliable estimates of steelhead densities can be difficult to obtain. ODFW research has found that, unlike coho salmon, the number of steelhead counted by snorkelers are not highly correlated to population estimates produced by either mark-recapture methods or successive removal methods (ODFW 1998). Counts of juvenile steelhead within pools can also vary widely between snorkelers. Thus, underwater counts of fish may not result in reliable density estimates, particularly for fry, and that different sampling methods should be implemented. It seems important to develop reliable estimates of fry densities because survival rates between the fry and yearling life history stages can vary greatly between years.

Alternative estimation procedures include the mark-recapture method and the multiple pass-removal method, both of which require the use of electrofishing gear. As electrofishing is presently not permitted by NMFS in KMP streams, a section 10 permit will be needed. Other difficulties with this approach include (1) cutthroat fry cannot be effectively differentiated from steelhead fry and (2) the production of a large number of steelhead fry does not necessarily mean that a large number of steelhead smolts will be produced. However, areas to be sampled can be randomly selected and should result in estimates that are applicable to the entire KMP.

The EMAP sampling protocol can be used to select sampling sites to monitor the densities of juvenile steelhead in KMP streams. Delineation of steelhead distribution in KMP streams will be needed to randomly select sampling sites. As with coho salmon, only first, second, and third order streams should be sampled in order to overlap sampling for habitat parameters (**Goal 2**) and fish distribution (**Goal 3**) with sampling for juvenile abundance.

Proposed Monitoring Associated with Goal 2

Activity 2.1. Identify those areas of KMP streams accessible to adult steelhead. Record the data in GIS files and update files annually as more accurate information becomes available (same as **Activity 1.1.**).

Activity 2.2. Estimate the mean density of subyearling trout and age $\geq$ 1+ juvenile steelhead resident in KMP streams. About 50 sampling sites will be selected randomly using EMAP and will be linked with the habitat surveys described in **Goal 1**. At each sampling site, fish densities will be estimated in four randomly selected riffles and four randomly selected units for other types of habitat.

Fish numbers will be estimated using the multiple-pass removal method in riffles or other habitat units that are small enough to preclude snorkeling. Fish numbers at remaining sites will be estimated with two methods. First, fish will be counted by snorkelers. After units are snorkeled, fish numbers will be estimated by either the multiple-pass removal method or by the mark-recapture method. The largest estimate will be assumed to be the most accurate estimate of the number of fish present.

Density estimates may be biased by the presence of cutthroat trout or resident rainbow trout. Estimates of fry densities will be excluded from analyses if cutthroat trout compose more than 25% of the age $\geq$ 1+ trout seen or captured at that specific sampling site. Similarly, density estimates will be excluded from analyses if resident rainbow trout compose more than 25% of the age $\geq$ 1+ trout seen or captured at that specific sampling site. Rainbow trout longer than 25 cm (fork length) will be assumed to be resident fish rather than juvenile steelhead.

Analysis 2.2.1. Estimate the mean densities of trout fry and age $\geq$ 1+ steelhead, and the associated 95% confidence intervals.

Analysis 2.2.2. Determine if the density goal of 0.5 trout fry per m^2 falls within the 95% confidence interval estimated from **Analysis 2.2.1**.

Analysis 2.2.3. Determine if the density goal of 0.1 age ≥ 1+ steelhead per m^2 falls within the 95% confidence interval estimated from **Analysis 2.2.1**.

Analysis 2.2.4. Determine if the density goal of 0.05 age ≥ 1+ steelhead per m^2 in riffles falls within the 95% confidence interval estimated from **Analysis 2.2.1**.

Analysis 2.2.5. Determine if the density trends (fish density versus time) differ significantly from zero.

Goal 3

Juvenile steelhead should be present in at least 80% of sites accessible to spawners, or the percentage of sites inhabited by juvenile steelhead should increase through time.

Steelhead are widely distributed in the KMP. It is probable that the distribution of juvenile steelhead in fresh water varies between years due to variations in spawner abundance and streamflow during the time period when adult fish migrate within spawning streams. Barriers to upstream migration are not always readily apparent (Satterthwaite et al. 1995) and can function differentially in years of varied water yields.

However, ODFW records suggest that juvenile steelhead are usually present in areas that are accessible to spawning adults. Absence of juvenile steelhead probably indicates that a barrier is present downstream, or if a barrier is absent, then the stream or the population has been exposed to some type of catastrophic event. Contraction of the rearing distribution of steelhead throughout the KMP would then likely be aligned with a significant decrease in the amount of appropriate habitat.

The probable linkage between the presence of steelhead and the quality of habitat suggests that steelhead distribution can be sampled concomitantly with habitat. Sampling sites chosen randomly with EMAP for habitat monitoring (Goal 1) and for monitoring of the density of juvenile steelhead (Goal 2) can also be sampled to determine whether juvenile steelhead are present. These random samples can be used to characterize the distribution of juvenile steelhead within the KMP.

Proposed Monitoring Associated with Goal 3

Activity 3.1. Identify those areas of KMP streams accessible to adult steelhead. Record the data in GIS files and update files annually as more accurate information becomes available (same as **Activity 1.1.**).

Activity 3.2. Use the results from sampling for **Activity 2.2.** to determine the presence or absence of steelhead.

Analysis 3.2.1. Estimate the percentage of sites inhabited by juvenile steelhead and the associated 95% confidence interval.

Analysis 3.2.2. Determine if the distribution goal of 80% habitation falls within the 95% confidence interval estimated in **Analysis 3.2.1**.

Analysis 3.2.3. Determine if the trend in distribution (percentage of sites inhabited versus time) differs significantly from zero.

Goal 4

Mean production rates in intermittent streams used by spawning summer steelhead should be a minimum of 7,000 trout fry per kilometer.

In the early 1970’s, the Oregon Game Commission found that summer steelhead in the Rogue River Basin most often spawned in small tributary streams, many of which became intermittent or dry in summer, and that those streams produced between 40,000 and 110,000 steelhead fry that migrated to the Rogue River for summer residence (Everest 1973, Faudskar 1980). In addition, some steelhead fry failed to migrate from these small streams (Everest 1973).

In 1995, ODFW found that an average of 28% of the trout fry (steelhead and cutthroat trout) remained in nine small streams of the Rogue River basin that became intermittent or completely dried up. Production rates in the streams unaffected by dams varied between 2,000 and 12,000 trout fry per kilometer and averaged about 7,000 trout fry per kilometer (Satterthwaite et al. 1995). Assuming that the findings represent a reasonable average for intermittent streams in the basin, this production rate was chosen as a population health goal.

Estimates of total production require that traps be installed and that upstream areas be electrofished to estimate the number of fry that fail to migrate. As electrofishing is presently not permitted by NMFS in KMP streams, a section 10 permit will be needed. Other difficulties with this approach include (1) cutthroat fry cannot be effectively differentiated from steelhead fry, (2) the production of large numbers of steelhead fry does not necessarily mean that large numbers of steelhead smolts will be produced, and (3) it seems unlikely that a sufficient number of streams can be randomly sampled so that results can be used to make unbiased inferences relevant to all intermittent streams used by summer steelhead.

Proposed Monitoring Associated with Goal 4

Activity 4.1. Estimate the number of trout fry that migrate from six intermittent streams historically used by spawning summer steelhead (Everest 1973). Use weir traps to capture juvenile migrants and assume that all trout fry are the progeny of summer steelhead. Streams to be sampled should be spread as evenly as possible throughout habitat used by spawning summer steelhead.

Activity 4.2. Estimate the number of trout fry that fail to migrate from trapped streams using methods described by Jones et al. (1998).

Analysis 4.2.1. Combine the findings from **Activity 4.1** and **Activity 4.2** to estimate the mean production rate of trout fry and the associated 95% confidence interval.

Analysis 4.2.2. Determine if the production rate goal of 7,000 fry per kilometer falls within the 95% confidence interval estimated from **Analysis 4.2.1**.

Goal 5

Annual returns to Gold Ray Dam should be a minimum of 4,000 wild summer steelhead and 4,000 wild winter steelhead, while annual returns to the Rogue River should be a minimum of 10,000 wild late-run adult summer steelhead.

The abundance of adult steelhead in KMP streams has been monitored consistently only at two sites, both in the Rogue River. Because of pronounced differences in life history, abundance trends of adult steelhead may not covary between populations in the Rogue River Basin and populations in other river basins of the KMP. Consequently, current monitoring of adult steelhead does not necessarily allow for inferences to be drawn about abundance trends of adult steelhead in the entire KMP.

Other measures of population health would need to be developed if health goals are to be developed for adult steelhead in the entire KMP. Such measures could include redd counts, counts of spawning or holding adults, construction of temporary counting stations, mark-recapture experiments, or hydroacoustic surveys.

ODFW has initiated an evaluation of whether survey counts of spawners or redd counts can provide reliable estimates of spawning escapement for steelhead in coastal streams (ODFW 1998). Results from this project will likely not be available in the proximal future. Even if project findings indicate that reliable inferences can be drawn from spawning surveys for steelhead, results may not be applicable to summer steelhead in KMP streams. Female summer steelhead in KMP streams average 46 centimeters in length on their first spawning migration (ODFW 1994), can spend less than two days in spawning streams (Everest 1973), and excavate small redds that can be very difficult to locate or identify.

In addition, generic spawning escapement goals have yet to be established for steelhead and would likely vary depending on the life history strategy of the population to be monitored. For example, small tributaries of the Rogue River serve as nursery streams for summer steelhead (Everest 1973). While it may be possible to estimate the number of spawners needed to seed these small streams, it will likely not be possible to estimate the number of spawners needed to seed the downstream rearing habitat in the Rogue River.

However, data from ongoing efforts to monitor the abundance of wild steelhead in the Rogue River appears to be of value, especially since returns of summer steelhead are estimated at both sites. The passage of summer steelhead (early-run and late-run varieties) and winter steelhead has been estimated at Gold Ray Dam (river kilometer 202) since 1942. Numbers of half-pounders and late-run adult summer steelhead that pass Huntley Park (river kilometer 10) have been estimated since 1976 (ODFW 1994).

Stock-recruitment relationships developed for wild steelhead that passed Gold Ray Dam from 1974 through 1997 (Chilcote 1998) suggested that returns of about 4,000 wild summer steelhead and about 4,000 wild winter steelhead would be appropriate return goals. Each return goal of 4,000 fish represent the lower values of the 95% confidence intervals associated with estimates of the equilibrium abundance of each population (Chilcote 1998). Equilibrium abundance represents the average maximum number of spawners that a population can maintain based on habitat capacity and natural mortality as estimated by a Ricker stock-recruitment curve.

In addition, ODFW (1994) recommended that the harvest of half-pounders be managed so that a minimum of 10,000 wild late-run adult summer steelhead would pass Huntley Park. This recommendation was developed from a comparison of a fry abundance index with the numbers of parents estimated to have passed Huntley Park during the previous year, although only eight years of data composed the analysis (ODFW 1994).

Proposed Monitoring Associated with Goal 5

Activity 5.1. Enumerate the number of wild and hatchery steelhead that daily pass Gold Ray Dam. Adults will be classified as winter steelhead, early-run summer steelhead, or late-run summer steelhead.

Analysis 5.1.1. Determine if annual return goals were met.

Analysis 5.1.2. Determine whether the abundance trends (returns versus time) differ significantly from zero.

Activity 5.2. Estimate the number of wild and hatchery late-run steelhead that pass Huntley Park as described by ODFW (1994). Steelhead shorter than 41 cm (fork length) will be classified as half-pounders, while longer fish will be classified as adults.

Analysis 5.2.1. Determine if the annual return goal was met.

Analysis 5.2.2. Determine whether the abundance trend (returns versus time) differ significantly from zero.

Goal 6

Fish with half-pounder life histories should compose at least 95% of the late-run adult summer steelhead in the Rogue River.

Steelhead in the KMP have more diverse life histories as compared to counterparts in other areas along the coast of North America because of the unusual false spawning run made by “half-pounders” in the Klamath River and in the Rogue River. Little is known about the life history of steelhead in KMP streams with the exception of the Rogue River.

Life history parameters could be estimated from scale samples collected from winter steelhead captured by anglers in the 1980s and in the 1990s. Scale samples archived by ODFW include 540 fish from the Winchuck River, 1,336 fish from the Chetco River, 114 fish from the Pistol River, 62 fish from Hunter Creek, and 208 fish from the Elk River. However, it may be difficult to identify the origin of the fish that compose the samples because ODFW did not mark all hatchery fish with fin clips until the 1990s. Given the incidence of age one smolts in at least some populations of winter steelhead in the area (ODFW 1990), it remains unknown as to whether scale samples can be used to segregate wild and hatchery fish.

Estimation of life history composition of adult steelhead can necessitate that fish be randomly sampled during the entire period of fresh water return. Research has shown that recreational fisheries in the Rogue River non-randomly select anadromous salmonids of differing life history (Cramer et al. 1985, ODFW 1990, ODFW 1994). Thus, sampling with electrofishing gear, seines, or traps would likely be needed to ensure that life history parameters were randomly sampled.

It might be possible randomly sample adult steelhead throughout the KMP by using EMAP to select sampling sites where scale samples could be collected from fish proximal to spawning areas. However, any sampling design should take into account differences in spawning times among the KMP populations. Characterization of the life history of steelhead in the coastal streams is of value, but an appropriate strategy to pursue remains unknown as of this time. Background information is a prerequisite for the establishment of some life history goal that can be used to evaluate the health of steelhead in small coastal streams in the KMP.

In contrast, much is known about the life history of steelhead in the Rogue River. ODFW (1990) identified 14 life history patterns among winter steelhead sampled near the mouth of the Rogue River during four years in the late 1970s and early 1980s. In addition, the life history composition of the run varied greatly among years and that some winter steelhead had previously returned to freshwater as half-pounders (ODFW 1990).

The life history of summer steelhead in the Rogue River is also diverse. ODFW (1994) identified 15 life history patterns among late-run adults sampled near the mouth of the Rogue River during 1975-91.

As with winter steelhead, the life history composition of the run varied greatly among return years and among brood years (ODFW 1994).

However, a half-pounder return was the predominate life history pattern among late-run adults. Fish with a half-pounder life history composed an average composed an average of 95% of the wild late-run adult summer steelhead that returned to the Rogue River in 1976-91 (ODFW 1994). Given that the half-pounders are almost unique to the KMP, and that only two rivers within the KMP produce half-pounders, maintenance of this unusual life history should be of primary importance to ensure diversity among steelhead populations in the KMP and among steelhead throughout the range of the species.

Proposed Monitoring Associated with Goal 6

Activity 6.1. Estimate the proportion of half-pounder life histories among late-run adult summer steelhead in the Rogue River. Life history patterns will be determined from circuli patterns on scales taken from wild adult steelhead captured at Huntley Park (ODFW 1994). Scale samples should be taken from about 200 randomly selected fish.

Analysis 6.1.1. Estimate the percentage of half-pounder life-histories among wild late-run adults and the associated 95% confidence interval.

Analysis 6.1.2. Determine if the life history goal of 95% half-pounders falls within the 95% confidence interval estimated in **Analysis 6.1.1**.

Analysis 6.1.3. Determine if the life history trend (proportion of adults with the half-pounder life history versus time) differs significantly from zero.

REFERENCES

Busby, P.J., T.C. Wainwright, and R.S. Waples. 1994. Status review for Klamath Mountains Province steelhead. National Oceanic and Atmospheric Administration, Technical Memorandum NMFS-NWFSC-19, Springfield, Virginia.

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

Cramer, S.P., T.D. Satterthwaite, R.R. Boyce, and B.P. McPherson. 1985. Lost Creek Dam fisheries evaluation phase I completion report. Volume I. Impacts of Lost Creek Dam on the biology of anadromous salmonids in the Rogue River. Oregon Department of Fish and Wildlife, Fish Research Project DACW57-77-C-0027, Portland.

Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Commission, Fishery Research Report 7, Corvallis, Oregon.

Faudskar, J.D. 1980. Ecology of underyearling summer steelhead trout in intermittent streams tributary to the Rogue River. Master’s thesis. Oregon State University, Corvallis.

Gibbons, R.G., P.K.J. Hahn, and T.H. Johnson. 1985. Methodology for determining MSH steelhead spawning escapement requirements. Washington Department of Game, Fisheries Management Division, Report 85-11, Olympia.

Jones, K.K., J.M. Dambacher, B.G. Lovatt, A.G. Talabere, and W. Bowers. 1998. Status of Lahontan cutthroat trout in the Coyote Lake Basin, southeast Oregon. North American Journal of Fisheries Management 18:308-317.

Moore, K.M.S., K.K. Jones and J.M. Dambacher. 1997. Methods for Stream Habitat Surveys. Information Report 97-4. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1990. Effects of Lost Creek Dam on winter steelhead in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department of Fish and Wildlife). 1994. Effects of Lost Creek Dam on summer steelhead in the Rogue River. Phase II completion report. Oregon Department of Fish and Wildlife, Fish Research Project DACW 57-77-C-0033, Completion Report, Portland.

ODFW (Oregon Department Of Fish and Wildlife). 1995. Biennial report on the status of wild fish in Oregon. Oregon Department of Fish and Wildlife, Portland.

ODFW (Oregon Department Of Fish and Wildlife). 1998. ODFW coastal salmonid population and habitat monitoring program. Oregon Department of Fish and Wildlife, Portland.

Roper, B.B., D.L. Scarnecchia, and T.J. La-Marr. 1994. Summer distribution of and habitat use by chinook salmon and steelhead within a major basin of the South Umpqua River, Oregon. Transactions of the American Fisheries Society 123:298-308.

Satterthwaite, T.D., R.R. Leffler, and B.L. Bellerud. 1996. Evaluation of the effects of Elk Creek Dam on migratory salmonids. Oregon Department of Fish and Wildlife, Fish Research Project (unnumbered), Annual Progress Report, Portland.

APPENDIX A

ODFW BENCHMARKS OF HABITAT QUALITY FOR STREAMS OF WESTERN OREGON[a]

POOLS

Area (of total stream)	>35%
Frequency (channel widths between pools)	5-8
Residual depth (average maximum pool depth - average riffle depth)	
Small streams (<7m in width)	>0.5m
Medium streams (≥7m and ≤15m in width)	
Low gradient (slope <3%)	>0.6m
High gradient (slope >3%)	>1.0m
Large streams (>15m in width)	>1.5m
Frequency of complex (wood complexity rating >3) pools	>2.5/km

RIFFLES

Width/depth ratio (of active channel)	<10
Gravel (area within riffles)	≥35%
Fines (silt, sand, and organic material)	
For substrate of volcanic origin (area within riffles)	<8%
For substrate of sedimentary origin (area within riffles)	<10%
For stream gradient <1.5% (area within riffles)	<12%

SHADE (Reach Average)

Stream width < 12m	>70%
Stream width > 12m	>60%

LARGE (Minimum 15cm x 3m) WOODY DEBRIS

Number/100m of stream	>20 pieces
Volume (m^3)/100m of stream	>30 m^3
"Key" (minimum 60cm x 10m) pieces/100m of stream	>3 pieces

RIPARIAN CONIFERS

Number >20" dbh/1000 ft of stream	>300 trees
Number >35" dbh/1000 ft of stream	>200 trees

a *As described in*: Moore, K.M.S. 1997. Habitat benchmarks. Unpublished manuscript. Oregon Department of Fish and Wildlife, Portland.

APPENDIX B

LITERATURE REVIEW RELATED TO THE DENSITY OF JUVENILE STEELHEAD IN STREAMS

Defense of feeding territories is a common behavior among salmonids resident in streams. Aggressive interactions may then partially determine the maximum density of salmonids in streams. Grant and Kramer (1990) used data published from laboratory and field studies, and found a positive relationship between territory size and the size of individual salmonids. Further evaluation indicated that the model could be used to predict maximum densities of salmonids in shallow habitats such as riffles or raceways. Their model predicted maximum densities of 3 fish/m^2 when fish average 8 cm in length and 0.7 fish/m^2 when fish average 14 cm in length. These lengths approximate the mean lengths of juvenile steelhead in Oregon coastal stream during late summer or early autumn.

However, because a multitude of physical and biological factors act to limit the number of juvenile steelhead in streams, a review of published estimates of rearing densities may provide more appropriate insight as to the capacity of streams to rear juvenile steelhead.

Ward and Slaney (1993) estimated that the densities of steelhead fry one month after emergence averaged 0.34 fish per m^2 and ranged between 0.11 and 0.92 fish per m^2 during 1976-1982 in the Keogh River, British Columbia. A density of 0.3 fry per m^2 is considered to be about the average density of steelhead fry in coastal streams of British Columbia (cited by Hume and Parkinson (1987).

Burns (1971) estimated summer densities of subyearling trout in three small coastal streams of northern California during 1965-67. Densities ranged between 0.07 and 0.14 fish per m^2 in Godwood Creek and ranged between 0.60 and 0.92 fish per m^2 in the South Fork of Yeager Creek. Burns (1971) found that densities of subyearling trout decreased over the course of the season in North Casper Creek. In the three years of sampling densities ranged between 0.81 and 1.61 fish per m^2 in June, while densities in October ranged between 0.47 and 0.52 fish per m^2.

Johnson and Kucera (1985) also found that densities of subyearling steelhead decreased between early summer and autumn in three tributaries of the Clearwater River, Idaho. October densities in these three streams ranged between 0.27 and 1.00 fish per m^2.

Hume and Parkinson (1987) planted steelhead fry of hatchery origin in sections of Lynn Creek, British Columbia, at densities of 0.13 to 2.10 fry per m^2. Fry were planted in July or August and the densities of remaining fish were estimated in late September or early October. They found that densities of subyearling steelhead increased with stocking rate. However, regardless of stocking rate, autumn densities of subyearlings were less than 0.6 fry per m^2 in 31 of 32 sample sites. In 34 of 37 sample sites, the autumn densities of older juvenile steelhead were less than 0.2 fish per m^2.

Wentworth and LaBar (1984) planted steelhead fry of hatchery origin in sections of Lewis Creek, Vermont, at densities of 0.84 to 1.76 fry per m^2. Fry were planted in May and the densities of remaining fish were estimated in October. They found that, regardless of stocking rate, autumn densities of subyearlings ranged between 0.13 and 0.78 fish per m^2.

Seelbach (1993) estimated that autumn densities of subyearling steelhead in the Little Manistee River, Michigan, averaged 0.23 fish per m^2 and densities of age ≥ 1+ steelhead averaged 0.07 fish per m^2 during 1981-84. There was little variation in the annual densities of age ≥ 1+ steelhead. Seelbach (1993) also referenced densities of juvenile steelhead in other Great Lakes streams. Densities of subyearling steelhead ranged between 0.01 and 2.30 fish per m^2, while densities of age ≥ 1+ steelhead ranged between 0.02 and 0.37 fish per m^2.

Gibbons et al. (1985) reported densities of age ≥ 1+ steelhead from 13 streams and river basins sampled in western Washington between 1976 and 1984. Densities ranged between 0.01 and 0.20 fish per m^2. Mean densities averaged 0.07 fish per m^2 for streams that drained into Puget Sound, while densities averaged 0.03 fish per m^2 for streams that drained into the Pacific Ocean. Johnson et al. (1986) estimated that the densities of age ≥ 1+ steelhead in seven streams in southeast Alaska ranged between 0.01 and 0.31 fish per m^2 during summer.

Some information is available from coastal streams of Oregon. Roper et al. (1994) estimated the densities of subyearling and older steelhead in eight reaches of Jackson Creek, a tributary of the South Umpqua River, in the summer of 1989. They found that the densities of steelhead fry ranged between 0.09 and 0.23 fish per m^2, while the densities of older steelhead ranged between 0.05 and 0.18 fish per m^2. They also found that both age groups of steelhead were not distributed randomly within the stream and that habitat use differed between stream reaches.

The Salmonid Habitat Project of ODFW estimated the densities of juvenile steelhead and subyearling trout in numerous small streams along the central and north coast of Oregon in 1985-92. Different types of stream habitat were sampled each year during summer and during winter. In general, densities of juvenile steelhead and trout fry were greater in summer as compared to winter (Rodgers et al. 1990; Johnson et al. 1991; Solazzi et al. 1992).

Juvenile trout ≥ 9 cm in length were classified as steelhead or cutthroat trout that were age ≥ 1+. Only a portion of the trout of smaller sizes could be visually identified to species. However, most of the subyearling trout were probably steelhead because steelhead were the dominant species among older juvenile trout (Rodgers et al. 1990; Johnson et al. 1991; Solazzi et al. 1992).

Estimates of fish densities during summer were retrieved from project records and were analyzed. There were 1,375 density estimates for trout fry and there were 1,387 density estimates for juvenile steelhead. All of the data were collected from first, second, or third order streams. Fish densities were estimated by the removal method (Seber and LeCren 1967). These data were analyzed to characterize rearing densities and to determine if fish densities differed among types of aquatic habitat.

Densities of subyearling trout and juvenile steelhead exhibited a non-normal distribution (Table 1). Various types of transformations failed to produced normally distributed data, so the data was analyzed with non-parametric statistics.

Densities of subyearling trout ranged between 0 and 5.8 fish/m^2. More than 80% of the estimates were less than 0.50 fish/m^2 (Table 1). Densities of juvenile steelhead ranged between 0 and 1.4 fish/m^2. More than 80% of the estimates were less than 0.10 fish/m^2 (Table 1). It is important to note however, that sampling sites were primarily chosen to estimate densities of juvenile coho salmon, which tend to inhabit different types of streams as compared to steelhead. If sampling sites had been chosen randomly, project personnel believe that densities of juvenile steelhead would have been greater.

The project identified fourteen types of aquatic habitat in Oregon coastal streams. Sample sizes appeared sufficient in some years to compare fish densities in five types of habitat: lateral scour pools, mid-channel scour pools, glides, riffles, and rapids. Fish densities were compared only within years because variations in spawning escapement and winter survival rates were likely responsible for variations in fish production among years. Comparisons were made

Table 1. Densities of subyearling trout and juvenile steelhead as estimated in coastal streams of Oregon, 1985-92. Data includes all years of sampling and all habitat types.

Subyearling trout			Juvenile steelhead		
Fish/m^2	N	%	Fish/m^2	N	%
0.00-0.25	873	63.5	0.000-0.025	745	53.7
0.25-0.50	279	20.3	0.025-0.050	199	14.3
0.50-0.75	122	8.9	0.050-0.075	137	9.9
0.75-1.00	45	3.3	0.075-0.100	96	6.9
1.00-1.25	27	2.0	0.100-0.125	62	4.5
1.25-1.50	10	0.7	0.125-0.150	46	3.3
1.50-1.75	7	0.5	0.150-0.175	29	2.1
1.75-2.00	3	0.2	0.175-0.200	13	0.9
2.00	9	0.7	> 0.200	60	4.3
Total	1,375	100	Total	1,387	100

with a Kruskal-Wallis test, which is a single factor analysis of variance on ranks.

Results indicated that trout fry densities differed significantly among different types of aquatic habitat. However, differences were not significant in one of the five years and differences were not always consistent among different types of habitat. Trout fry densities were significantly lower in mid-channel pools during two of three years, were significantly lower in riffles during one of five years, and were significantly lower in rapids during one of five years (Table 2).

Table 2. Comparisons of trout fry densities within five types of aquatic habitat in Oregon coastal streams, 1988-92. Estimates are reported only for those groups were sample sizes exceeded 20. Within columns, densities with dissimilar superscripts differed significantly at $P \leq 0.05$ as determined by Dunn's test.

	Median density (fish per m^2)				
Habitat type	1988	1989	1990	1991	1992
lateral scour pool	0.21^{ab}	--	0.13^{a}	0.20^{ab}	0.18^{ab}
mid-channel scour pool	--	--	0.06^{b}	0.24^{a}	0.12^{b}
glide	0.36^{a}	0.32^{a}	0.13^{a}	0.25^{ab}	0.25^{a}
riffle	0.18^{b}	0.27^{a}	0.18^{a}	0.15^{ab}	0.18^{ab}
rapid	0.28^{ab}	0.18^{a}	0.23^{a}	0.18^{b}	0.22^{ab}

In contrast to trout fry, juvenile steelhead exhibited more pronounced preferences for certain types of habitat. In each of the five years, densities were lower in riffles as compared to other types of habitat (Table 3). Differences among other types of habitat types were also found, but the differences were not always consistent among different types of habitat. Densities of juvenile steelhead were significantly lower in glides as compared to pools during two of four years, and were significantly lower in rapids as compared to pools during one of four years (Table 3). These findings indicated that a population goal for the rearing density of juvenile steelhead would need to be sensitive to different types of habitat.

The Salmonid Habitat Project of ODFW also estimated the summer densities of subyearling trout and juvenile steelhead in Cummins Creek and Tenmile Creek on the central coast of Oregon in 1991-98. Annual density estimates of trout fry in Cummins Creek averaged 0.14 fish per m^2 and ranged between 0.07 and 0.25 fish per m^2 (Table 4). Annual density estimates of juvenile steelhead in Cummins Creek averaged 0.06 fish per m^2 and ranged between 0.03 and 0.10 fish per m^2 (Table 4).

Table 3. Comparisons of juvenile steelhead densities within five types of aquatic habitat in Oregon coastal streams, 1988-92. Estimates are reported only for those groups were sample sizes exceeded 20. Within columns, densities with dissimilar superscripts differed significantly at $P \leq 0.05$ as determined by Dunn's test.

Habitat type	Median density (fish per m^2)				
	1988	1989	1990	1991	1992
lateral scour pool	0.018^{ab}	--	0.000^{ab}	0.036^{a}	0.058^{ab}
mid-channel scour pool	--	--	0.000^{ab}	0.075^{a}	0.092^{a}
glide	0.013^{ab}	0.024^{ab}	0.000^{b}	0.020^{ab}	0.031^{b}
riffle	0.000^{b}	0.017^{b}	0.000^{b}	0.000^{b}	0.013^{c}
rapid	0.051^{a}	0.059^{a}	0.029^{a}	0.021^{a}	0.031^{b}

Juvenile steelhead were more abundant in Tenmile Creek as compared to Cummins Creek. Mean densities of trout fry in Tenmile Creek ranged between 0.31 and 0.46 fish per m^2, while mean densities of juvenile steelhead ranged between 0.05 and 0.12 fish per m^2 (Table 4).

Table 4. Annual summer densities of subyearling trout and juvenile steelhead in two small streams on the central coast of Oregon, 1991-98.

	Mean (range) fish per m^2			
	Pools	Glides	Riffles	Entire stream
		SUBYEARLING TROUT		
Cummins Creek	0.13(0.06-0.24)	0.16(0.08-0.36)	0.14(0.08-0.24)	0.14(0.07-0.25)
Tenmile Creek	0.36(a)	0.46(a)	0.31(a)	(a)
		JUVENILE STEELHEAD		
Cummins Creek	0.09(0.05-0.15)	0.04(0.02-0.07)	0.04(0.02-0.07)	0.06(0.03-0.10)
Tenmile Creek	0.12(a)	0.06(a)	0.05(a)	(a)

[a] *Estimates not available*.

REFERENCES

Burns, J.W. 1971. The carrying capacity for juvenile salmonids in some northern California streams. California Fish and Game 57:44-57.

Gibbons, R.G., P.K.J. Hahn, and T.H. Johnson. 1985. Methodology for determining MSH steelhead spawning escapement requirements. Washington Department of Game, Fisheries Management Division, Report 85-11, Olympia.

Grant, J.W.A., and D.L. Kramer. 1990. Territory size as a predictor of the upper limit to population density of juvenile salmonids in streams. Canadian Journal of Fisheries and Aquatic Sciences 47:1724-1737.

Hume, J.M.B., and E.A. Parkinson. 1987. Effect of stocking density on the survival, growth, and dispersal of steelhead trout fry (Salmo gairdneri). Canadian Journal of Fisheries and Aquatic Sciences 44:271-281.

Johnson, J.H., and P.A. Kucera. 1985. Summer-autumn habitat utilization of subyearling steelhead trout in tributaries of the Clearwater River, Idaho. Canadian Journal of Zoology 63:2283-2290.

Johnson, S.L., J.D. Rodgers, and M.F. Solazzi. 1990. Development and evaluation of techniques to rehabilitate Oregon's wild salmonids. Oregon Department of Fish and Wildlife, Fish Research Project (unnumbered), Annual Progress Report, Portland.

Johnson, S.W., J. Heifetz, and K.V. Koski. 1986. Effects of logging on the abundance and seasonal distribution of juvenile steelhead in some southeastern Alaska streams. North American Journal of Fisheries Management 6:532-537.

Roper, B.B., D.L. Scarnecchia, and T.J. La-Marr. 1994. Summer distribution of and habitat use by chinook salmon and steelhead within a major basin of the South Umpqua River, Oregon. Transactions of the American Fisheries Society 123:298-308.

Rodgers, J.D., S.L. Johnson, and M.F. Solazzi. 1990. Development and evaluation of techniques to rehabilitate Oregon's wild salmonids. Oregon Department of Fish and Wildlife, Fish Research Project (unnumbered), Annual Progress Report, Portland.

Seber, G.A.F, and E.D. LeCren. 1967. Estimating population parameters from catches large relative to the populations. Journal of Animal Ecology 35:631-643.

Seelbach, P.W. 1993. Population biology of steelhead in a stable-flow, low-gradient tributary of Lake Michigan. Transactions of the American Fisheries Society 122:179-198.

Solazzi, M.F., J.D. Rodgers, and S.L. Johnson. 1990. Development and evaluation of techniques to rehabilitate Oregon's wild salmonids. Oregon Department of Fish and Wildlife, Fish Research Project (unnumbered), Annual Progress Report, Portland.

Ward, B.R., and P.A. Slaney. 1993. Egg-to-smolt survival and fry-to-smolt density dependence of Keogh River steelhead trout. Pages 209-217. In R.J. Gibson and R.E. Cutting [editors]. Production of juvenile Atlantic salmon Salmo salar, in natural waters. Canadian Special Publication of Fisheries and Aquatic Sciences, Number 118.

Wentworth, R.S., and G.W. LaBar. 1984. First year survival and growth of steelhead stocked as fry in Lewis Creek, Vermont. North American Journal of Fisheries Management 4:103-110.