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Responses to ISRP Comments by the Oregon Department of Fish and Wildlife
Project ID's: 30018, Salmonid Population and Habitat Monitoring in the Oregon Portion of the Columbia Estuary and, **31034,** Salmonid Population and Habitat Monitoring in the Oregon Portion of the Lower Columbia Province

Dear ISRP Members:

Enclosed are ODFW's responses to the comments the ISRP provided on project #30018 and 31034 for the Lower Columbia and Columbia Estuary Provincial reviews. We appreciate your efforts and the critical technical review provided. If you have additional questions or need additional information regarding these proposals, please contact Steve Jacobs (541.757.4263 x261, jacobss@fsl.orst.edu) or Bruce McIntosh (541.757.4263m x230, Bruce.McIntosh@orst.edu).

Task 1:

Is any biological data collected on the juveniles enumerated?

The only biological data collected from snorkel surveys for juvenile fishes is the delineation of zero aged trout (< 90 mm fork length) from age 1+ steelhead and cutthroat (≥ 90mm fork length).

What is the basis of the sampling protocol?

Because it is too costly (and probably inefficient) to conduct a complete census in each monitoring area, it is important to design a monitoring system that will produce estimates that statistically represent each area. Scientific sample surveys are designed to meet this need. The fundamental feature of surveys is that a representative sample of the target resource (streams) is selected, using randomization to avoid bias in the selection process. Measurements made on the sample, such as the number of coho juveniles at each reach selected as part of the sample of reaches, are used to make inferences about the resource as a whole. If the appropriate design principles are followed, the results derived from measurements on the sample produce an accurate representation of the entire resource, e.g., the average density of juvenile coho in the Oregon North Coast Monitoring Area.

Developing an efficient monitoring system often entails balancing conflicting goals. Monitoring design requirements to optimize our ability to estimate status differ from design requirements to optimize our ability to estimate trends. To estimate status, the larger the sample the better. For example, we could monitor 100 different sites each year for five years, giving us a total sample size of 500 for that period of time. For trend detection, it is best to revisit sites each year, consequently, in the above example, we would revisit the 100 sites visited the first year in each of the subsequent four years, yielding a total sample of 100 sites over the 5-year period. A variety of ways have been developed to balance the requirements for both status estimation and trend detection. One of the most promising is a rotating panel design which entails sampling a new set of sites each year over a particular cycle, say three years, then repeating the cycle by revisiting the first year's sites during the first year of the second cycle, and so on. Various versions of a rotating panel design allow for visiting a subset of sites every year, revisiting some sites on longer cycles, or incorporating new sites each year along with the revisit schedule.

We have developed a rotating panel sample design for monitoring salmonid habitat and population indicators for the Oregon Plan. In this design, there are 14 panels (the vertical columns); rows indicate years, with row 1 the first year of the monitoring plan. The first panel consists of a set of sites visited every year (S0). The last panel consists of a set of new sites selected each year from the pool of sites not selected for any of the other panels (S4). Between these "bookend" panels are three sets of panels that make up a three-year rotating design, patterned after the three-year coho spawning cycle. These three sets are grouped as blocks. S10 , S20, and S30 consist of a set of sites that would

Year	S_0	S_{10}	S_{11}	S_{12}	S_{13}	S_{20}	S_{21}	S_{22}	S_{23}	S_{30}	S_{31}	S_{32}	S_{33}	S_4
1	■	■	■											■
2	■					■	■							■
3	■									■	■			■
4	■	■		■										■
5	■					■		■						■
6	■									■		■		■
7	■	■			■									■
8	■					■			■					■
9	■									■			■	■
10	■	■	■											■
11	■					■	■							■
12	■									■	■			■
13	■	■		■										■
14	■					■		■						■
15	■									■		■		■
16	■	■			■									■
17	■					■			■					■
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25	■	■			■									■
26	■					■			■					■
27	■									■			■	■

be visited every three years, with S10 sites visited the first year, S20 sites the second year, and S30 sites the third year, then every three years thereafter. Within each of these three-year panels is an additional set of sites that would be visited on a nine-year cycle (i.e. S11, S12, S13, S21, S22, S23, S31, S32 and S33).

This fairly complicated looking design is flexible and meets several needs. The allocation of sampling effort can be adjusted across panels, although an initial suggestion is that equal effort be allocated to each. Only shaded panels would be visited the year indicated. The total number of sites each year is the sum allocated to each of the panels, and is used for that year's status estimate. For example, during year 1, 25 sites could be allocated to each panel (i.e. 25 S0, 25 S10, 25 S11, and 25 S4) for the Oregon North Coast monitoring area, for a sample size of 100 to estimate the number of coho spawners. The sites visited every year (S0) provide good trend detection capability; with this allocation of sampling effort, 25 sites would be visited each year. Trend detection capability is augmented by the sets of sites making up the rotating panels (three-year and nine-year cycles). Finally, the new sets of sites (S4) allow an expansion of the sampling effort by adding sites that would not be considered in the basic fixed and rotating panel design, improving overall representation of the resource of interest, and allowing for a buffer in the event that budgets change. Sample sites could be added or deleted from S4 without markedly disturbing the trend detection capability of the basic design.

This design also provides flexibility in allocating sample sizes for different indicators over different geographic areas within a monitoring area. For example, the initial requirement is that coho spawner densities will be estimated with the greatest number of sites, followed by juveniles, then habitat. An added complication is that the spawners occupy a more restricted set of stream miles than do the juveniles, and physical habitat inventories are needed over additional stream miles not occupied by adult and juvenile coho. Furthermore, monitoring designs should be flexible should the need arise for additional indicators (biological integrity, steelhead, etc.). This design layout is compatible with the need for variable sample sizes and spatial extent for a variety of indicators.

Why is abundance of coho identified separately from the other salmonids?

Because observation probabilities are relatively high and constant for juvenile coho from site to site, we can monitor trend AND status for them using snorkeling methods. For steelhead, however, observation probabilities are too variable to allow us to assign density estimates to sites. All we can do with the juvenile steelhead data is provide information on population trends. For further detail, see attached memo from Jeff Rodgers.

Task 2:
Is any biological data collected during these steelhead monitoring programs?

We examine all carcasses for fin clips, determine sex and sample scales, however we recover very few steelhead carcasses. Based on our research on the coast, surveyors are able to identify the presence of fin-marks on about 30% of the live steelhead observed on spawning surveys. We have evaluated this technique for coho spawners and found it accurate to assess hatchery-wild ratios. We plan to also use this approach on the Columbia to assess hatchery-wild ratios.

Population status will be indexed through cumulative redd counts and time between surveys is presumably set based on the visible "life expectancy" of redds. How was the frequency of surveys established, how variable is the life of a redd within a stream and between streams? Should the visible life of a redd be calibrated in each geographic area or is there data to support using a fixed period between Provinces?

We have examined redd longevity in coastal stream basins over the last four years. Generally, we have found that a minimum of 90% of the redds are visible 7 days after initial observation and approximately 80% of the redds remain visible 14 days after initial observation. Based on these findings, our protocol for the coast is to conduct surveys on a seven-day interval for population estimates and on a 14-day interval for index purposes. We propose applying the same protocol to the lower Columbia, and additionally, assessing redd longevity through redd marking and repeated visits to validate the protocol.

Task 3:
same comments as for Task 2, except replace coho stream life for steelhead redd life expectancy.

In computing Area-Under-the-curve estimates of coho spawner abundance we use a value of 11.3 days as the average survey life span of coho spawners. This value comes from the following publication: Perin C.J and J.R. Irvine 1990. A review of survey life estimates as they apply to the area-under-the-curve method for estimating spawning escapement of pacific salmon. Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1733. We have not directly validated this value but have used it as a component of deriving survey-based estimates in calibration studies. The results of these studies were presented at the proposal briefing and showed survey-based estimates to be comparable to mark-recapture estimates.

More information on coho assessments was presented at the briefing but nothing is included in the proposal.

Related questions to those above include:
How was the number of sites selected?

For juvenile fish and stream habitat sampling it is a legacy of what could be accomplished in our coastal program with the amount of resource allocated. Based on information collected on the coast, for coho we are obtaining 95% confidence intervals of about 40% for rearing density and 25% for frequency of occurrence (% of pools at a site that are occupied). For stream habitat variables (pools, substrate, woody debris, shade) coefficients of variation were generally between 50 and 200% thus giving 95% confidence intervals that, as a percent of the mean, ranged from 13-54% for sample sizes of 50 sites.

For adult sampling, sample size was based on precision targets and sensitivity analysis of coastal sampling data. The ODFW recovery plan for Lower Columbia River coho lists six population complexes. Assuming a similar variance structure to that observed on the coast, the proposed sample size will provide a relative 95% confidence interval of ± 30% for abundance estimates of each of these population complexes. Proposed sample sizes for steelhead redd surveys are targeted to provide relative 95% confidence intervals of ± 30% for abundance estimates of each ESU. These targets were determined using coastal redd data.

How will EMAP be used to select the actual sites?

The EMAP procedure is well documented in the following publications: Messer, et al.1991; Larsen et al. 1991; Stevens and Olsen 1999 and Firman and Jacobs 2001. As proposed for application in the Lower Columbia, EMAP uses a three-stage process to choose sampling areas: Frame development, site selection and site verification. Frame development involves developing GIS coverage's of the specific resources to be samples (adult coho spawners, steelhead redds, juveniles or stream habitat). Frames are developed by modifying 1:100,000 USGS stream network maps to display the extent of the specific resource in question. For example, in the case of adult coho spawners, we would start with ODFW's stream layer coverage and edit it to remove spawning habitat above dams with counting stations, portions of streams that are inaccessible and stream reaches known to be devoid of spawning gravel. Conversely, streams known to support coho spawning but do not appear on 1:100,000 resolution maps may be added. Upon completion this coverage would represent an electronic map of our best estimate of the potential spawning habitat that is downstream from counting stations and is accessible for spawning surveys. The second stage involves generating a random point coverage on this stream layer that corresponds to the sample size specified by the precision target (Stevens and Olsen 1999). The specifics of this process are fairly complex but it provides a random sample of points that are spatially-balanced across the sampling frame. The final stage involves sample reach allocation and site verification. Reach allocation involves assigning a target stream reach to each sample point. For spawners we use the U. S. EPA river reach file as a cataloging system and we select stream reaches to conform to this structure. Site verifications involve visiting each site prior to the actual sampling season to determine access, acquire landowner permission assess habitat suitability and compile detailed location descriptions.

References

Firman, J.C., and S.E. Jacobs. 2001. A survey design for integrated monitoring of salmonids. First Int. Symp. On GIS in Fishery Science.

Larsen, D.P., Stevens, D.L., Selle, A.R., and Paulsen, S.G. 1991. Environmental Monitoring and Assessment Program, EMAP-Surface Waters: A Northeast Lakes Pilot. Lake Reserve Management, 7: 1-11.

Messer, J.J., Linthurst, R.A., and Overton, W.S. 1991. An EPA program for monitoring ecological status and trends. Environmental Monitoring and Assessment, 17: 67-78.

Stevens D.L. and A.R. Olsen. 1999. Spatially restricted surveys over time for aquatic resources. Journal of Agricultural and Environmental Statistics, 4:415-428.

Which rivers will be sampled?

All river systems draining Oregon and empting into the Columbia River from the mouth of the Columbia through Hood River that are accessible to anadromous salmonids will be sampled, excluding the Willamette Basin above Willamette Falls. For adult monitoring we will also exclude portions of watersheds above counting stations.

What will be the frequency of sampling?

The total number of candidate sites for each year is divided equally into four visitation intervals: 1) sites that are visited annually; 2) sites that are visited every three years; 3) sites that are visited every nine years; and 4) sites that are visited once. The repeat visitation sites help to provide for better trend detection, while the single visitation sites enable us to incorporate changes in known fish distribution into our sampling universe.

What are the methods for sampling habitat and juveniles?

Juvenile surveys

A 2-4-person snorkel crew will count the number of juvenile salmonids at each 1,000-meter long sample reach. The number of snorkelers employed will be based on what is needed to effectively cover the pool being snorkeled on a single upstream pass. To reduce problems associated with snorkeling in shallow or fast water habitat, only pools $\geq$ 6 m^2 in surface area and $\geq$ 40 cm deep will be snorkeled. We will measure the maximum depth, length, and width of all snorkeled pools.

Snorkel methodology involves a single upstream pass through each pool. Counts of the number of juvenile coho, cutthroat, steelhead, unknown trout, and chinook will be recorded for each pool. After snorkeling, the underwater visibility of each pool during the snorkel count will be ranked on a scale of 0 to 3 where: 0 = not snorkelable due to extremely high hiding cover or zero water visibility; 1 = high amount of hiding cover or poor water clarity; 2 = moderate amount of hiding cover or moderate water clarity neither of which were thought to impede accurate fish counts; and 3 = little hiding cover and good water clarity. Only pools with a visibility rank of two or three will be used in data analysis. To provide information on the percentage of pools containing juvenile salmonids at sites where no pools can be snorkeled due to poor water visibility, electrofishing will be conducted using Smith-Root model 12-B backpack electrofishers following NMFS electrofishing guidelines. Electrofishing will be conducted by making a single pass upstream in each pool that meets the size and depth criteria for conducting snorkel surveys. No block nets will be used for this sampling.

To provide some quality control of the snorkel data, and to provide information on temporal changes in abundance during the coarse of the sampling season, supervisory staff had a goal of resurveying a random sample of 10 to 20 percent of the sites surveyed in each monitoring area.

Habitat surveys

Channel-habitat and riparian surveys are conducted as described by Moore et al (1997) with some modifications. Modifications to the survey methods include: survey lengths of 500-1000 meters and measurement of all habitat unit lengths and widths (as opposed to estimation). Information is collected at two scales: the geomorphic reach or valley scale and the smaller channel habitat unit. Both of these scales are complementary and are used for analysis. Reach scale information includes an assessment of valley form, land use and dominant riparian vegetation. Habitat unit information includes assessments of substrate, slope, shade, wood pieces and bank stabilization. Riparian transects are completed at 5 locations along the length of the survey where individual trees are counted and described while understory and canopy closure is recorded. A separate two-person crew resamples Ten percent of the sites. Repeat surveys are randomly selected and are intended to assess within-season habitat variation and differences in estimates between survey crews.

Habitat surveys that are completed within the range and coho and that coincide with juvenile and spawning surveys are 1000 meters in length. Shorter surveys of 500 meters are conducted outside the know distribution of coho. At these sites, electrofishing surveys are completed with habitat surveys in order to assess fish presence. Electrofishing surveys are one-pass surveys of three fast-water and three slow-water habitat units.

How will juvenile abundance be determined?

For juvenile coho, three metrics will be used; 1) the percentage of sites where at least one juvenile coho was found; 2) the percentage of pools at a site that contained juvenile coho, and 3, average density. Results from coastal streams for metrics 2 and three may be found in attachment B.

For other salmonids, the first two metrics used for coho will be determined, as well as a third metric which is the average number of juveniles observed per site. Densities will not be determined because of the reasons outlined in the attached memo from Jeff Rodgers.

How will the sampling enable detection of trends in distribution and abundance?

Increases or decreases in density or average fish per site will allow for abundance trend detection. Changes in the frequency of occurrence metrics and mapping of the spatially explicit sample sites, will allow for analysis of distributional changes.

Will the sampling be adequate to detect range expansion due to habitat recovery?

This question implies that the intent of this sampling is to establish a direct link between fish populations and habitat recovery. This is not the intent of the proposal. The purpose of the sampling is to provide information on status and trends in fish populations and habitat conditions. From this information alone it will not be possible to establish a direct correlation between the two variables. The sampling will, however, be adequate to detect range expansions and habitat changes.

What exactly do the precision estimates mean?

Relative 95% confidence intervals, i.e. 95% of the time the true value lies within the specified proportion of the point estimate.

How will hatchery and wild spawners be differentiated? When the fish are alive or as carcasses?

Adipose fin clips on carcasses and live spawners for coho, Adipose fin clips on live spawners for steelhead.

How will the data be analyzed?

Fin mark ratios will be used to estimate hatchery-wild ratios of naturally spawning populations. These ratios will also be applied to abundance estimates to estimate the abundance of naturally produced adults. Fin mark data will be stratified temporally and spatially to reduce bias to the extent that this is compatible with maintaining adequate sample sizes.

In using the AUC technique, what value for stream life is used and why?

11.3 days. Best available estimate. See above.

Is stream life assumed to be constant? If so, why?

Yes. We don't have a practical means of estimating the variability.

Why are coastal cutthroat and chinook not included in the monitoring?

Methods are not appropriate. However we will include counts of these species in the course of our sampling.

Is the sampling intensity proposed in these provinces comparable to other provinces?

Yes, the proposed sampling intensity for adult, juvenile, and habitat monitoring is identical to what ODFW has implemented in coastal watersheds since 1997 and will implement in the Columbia Plateau in 2002.

OREGON Fish & Wildlife

MEMORANDUM

Department of Fish and Wildlife
Intra Departmental

Date: November 7, 2001

To: Bruce McIntosh

From: Jeff Rodgers

Subject: Summary of evaluation of the use of snorkeling and electrofishing for monitoring juvenile steelhead.

As you requested, here is a summary of my evaluation of the use of snorkeling and electrofishing as tools to monitor juvenile steelhead populations.

Theoretical Narrative

Snorkeling strengths: Can collect lots of data over a broad geographic area for relatively low cost. Snorkel surveys can be conducted in stream segments that are too large to be cost effectively sampled with electrofishing gear. As a result, because the majority of juvenile steelhead in a river basin may reside in larger "nonwadeable" reaches, an often much larger proportion of the overall population of juvenile steelhead may be monitored by snorkeling. Because it is an observational sampling method, snorkeling does not have the potential for physical harm to fish populations that electrofishing does.

Electrofishing strengths: Can provide more precise and less biased data than snorkeling within the stream size range of its effectiveness. Provides positive species ID and ability to collect accurate size and age information. Electrofishing estimates can be conducted in both fastwater (riffle/rapid) and pool habitat, resulting in the ability to estimate the total abundance of juvenile steelhead in the sample reach.

Snorkeling weaknesses: Variable and often unknown percentages of the actual population of fish are observed due to differences between observers, variable hiding cover and water clarity, species identification problems, and the often recluse nature of juvenile steelhead. Counts for age 0+ trout can be particularly imprecise and biased because they often are found in shallow water along the stream margins and in pool tailouts that are difficult to snorkel. Extremely high imprecision and bias of snorkel counts in fast water habitat limit the use of snorkel surveys to pool habitat. As a result, snorkel counts can only be used as an index of abundance.

Electrofishing weaknesses: Relatively high cost per unit of sampling. Can cause direct mortality of fish. Cannot be cost effectively conducted in larger streams. As a result, in some river basins, only a small proportion of the overall population is being monitored.

The argument for why snorkeling is a better tool to use to monitor juvenile steelhead populations than electrofishing is based on the premise that in many instances a large proportion of the juvenile population resides in stream reaches larger than can be systematically and quantitatively be sampled with electrofishing gear. It is likely that differences in streamflow patterns from one year to the next affect distribution so it is unlikely that the proportion of juveniles rearing in the “wadeable” stream reaches is relatively constant from year to year. Unless there is some way of knowing what this proportion is, it may be false to assume that monitoring the population in wadeable streams provides information on the status of the overall population.

The argument for why electrofishing is a better tool than snorkeling is based on the fact that the proportion of the actual number of fish present that are observed by snorkelers is often unknown and quite variable. The types of analyses that are greatly affected by this fact are those that try to compare one sample site to another or that compare observed numbers or calculated densities to a benchmark. Uncalibrated snorkel data should not be used for these types of analyses.

So, how can snorkel counts be used to monitor juvenile steelhead populations? The key to this is the random sample design and it’s amelioration of the impact of unknown and variable observation probabilities. If we design a survey in an area the size of our Coho Gene Conservation Areas, each of the sites we select will have an unknown yet real observation probability associated with it. The average and variance of these sites observation probabilities represent the precision and bias associated with that years sampling information. Since the sites were selected at random, the precision and bias of any one years sampling effort should be roughly the same as another if there are no major changes from one year to the next that would systematically alter observation probabilities of a large subset of sample sites compared to previous years. As a result, snorkel surveys should be useful in tracking trends in juvenile steelhead populations.

One factor that might systematically alter observation probabilities is drastic changes in hiding cover that might be associated with habitat restoration. The effect of habitat restoration on observation probabilities is probably minimal since most restoration efforts are conducted in wadeable rather than nonwadeable stream reaches. Since the bulk of many populations live in the nonwadeable reaches, observation probabilities associated with the bulk of the population samples should not be systematically biased. In addition, across the complete range of steelhead distribution, the relative impact of habitat restoration on overall stream complexity and thus hiding cover is probably small.

Another factor that might systematically alter observation probabilities is the effect of different observers. This is a quality control issue that should be managed by training and resurveys that will allow quantification of observer bias. While observer bias does occur, past data indicates its effects on overall bias are relatively small in magnitude.

Empirical Narrative

We have ten years of data from Tenmile Creek, an ocean tributary situated in the Mid-Coast near Yachats. In this study, we monitor smolt numbers in the spring and conduct Hankin and Reeves population estimates and habitat surveys in the summer. We conduct population estimates and sampling for eight separate stream reaches in Tenmile Creek. These separate reaches are shown in figure 1.

To conduct the Hankin and Reeves population estimates, we first survey the habitat, estimating the surface area of pools, riffle/rapids, and glides. We next snorkel one third of the pools in each stream and then conduct electrofishing in riffles/rapids and glides. By multiplying the average density of juvenile steelhead in riffle/rapids and glides by the total surface area of these habitats, we obtain an estimate of the total population of juvenile steelhead in these habitat types. We also electrofish a subset of the snorkeled pools to obtain a correction factor for the snorkel counts. By multiplying the raw snorkel counts by this correction factor and then multiplying by three, we obtain an estimate of the total number of juvenile steelhead in pools. We obtain an estimate of the total population of juvenile steelhead in the study stream or reach by summing the individual estimates for pools, riffle/rapids, and glides. The population estimates derived from this survey method provide the best approximation of the actual population of fish that can be obtained at the scale we are sampling.

From this dataset we can look at the relationship of basin-wide snorkel surveys and electroshocking in wadeable stream reaches to the overall population of juvenile steelhead. For this analysis, I considered reaches 1, 2, to be "nonwadeable", and reaches 3, 4 and the tributary streams as being wadeable.

Figure 2 shows there is a poor relationship between the density of 1+ steelhead juveniles in the wadeable reaches and the overall population of 1+ steelhead as estimated by the Hankin and Reeves sampling. Figure 3 shows that there is a significant correlation between the number of 1+ steelhead observed in basin-wide surveys and the total population estimated by the Hankin and Reeves sampling. There are probably four factors responsible for this result: 1) the proportion of 1+ steelhead rearing in the wadeable streams is variable from year to year (figure 4); 2) the majority of fish (68%) rear in the nonwadeable reaches; 3) the majority of fish rear in pools in the nonwadeable reaches (64%) whereas only 40% rear in pools in the wadeable reaches, and 4) the snorkel surveys are more comprehensive and thus provide larger sample sizes that provide more representative data for any given reach than the smaller sample sizes obtained by electrofishing.

<u>Conclusions</u>

Neither electrofishing in wadeable reaches or basin-wide snorkel surveys can provide information on the absolute abundance of juvenile steelhead populations. Snorkel surveys can provide information on trends in the population. Electrofishing can provide information on the use of tributary streams by juvenile steelhead but, because the abundance of populations in the tributary streams do not necessarily correlate with the overall population, electrofishing in wadeable stream reaches cannot be used to track overall population trends.

It is important to remember that the Tenmile Creek study was not designed specifically to look at this question. In addition, Tenmile Creek is a relatively small system. The results may vary in larger river systems. It is my feeling that the results may be even stronger in supporting the use of snorkel counts in larger river systems because an even higher proportion of the total population may reside in the nonwadeable reaches. As the Smith River study progresses, we will have more information on this subject.

In addition to the analysis described above, there is also information on the performance of snorkeling as a tool to detect trends in the abundance of juvenile steelhead from three other streams. The U.S. Forest Service PNW Laboratory found significant correlations between pool snorkel counts and smolt production from Fish Creek in the Clackamas drainage and Elk River on the south coast. Both of these watersheds are larger than Tenmile Creek. We found a significant correlation between pool snorkel counts and smolt production in Cummins Creek, a small ocean tributary near Tenmile Creek. To my knowledge, PNW has not done a similar analysis with electroshocking data (they may not have such information). I did not analyze the relationship between electroshocking data and smolt production in Cummins Creek because all of Cummins Creek is in wadeable stream reaches.

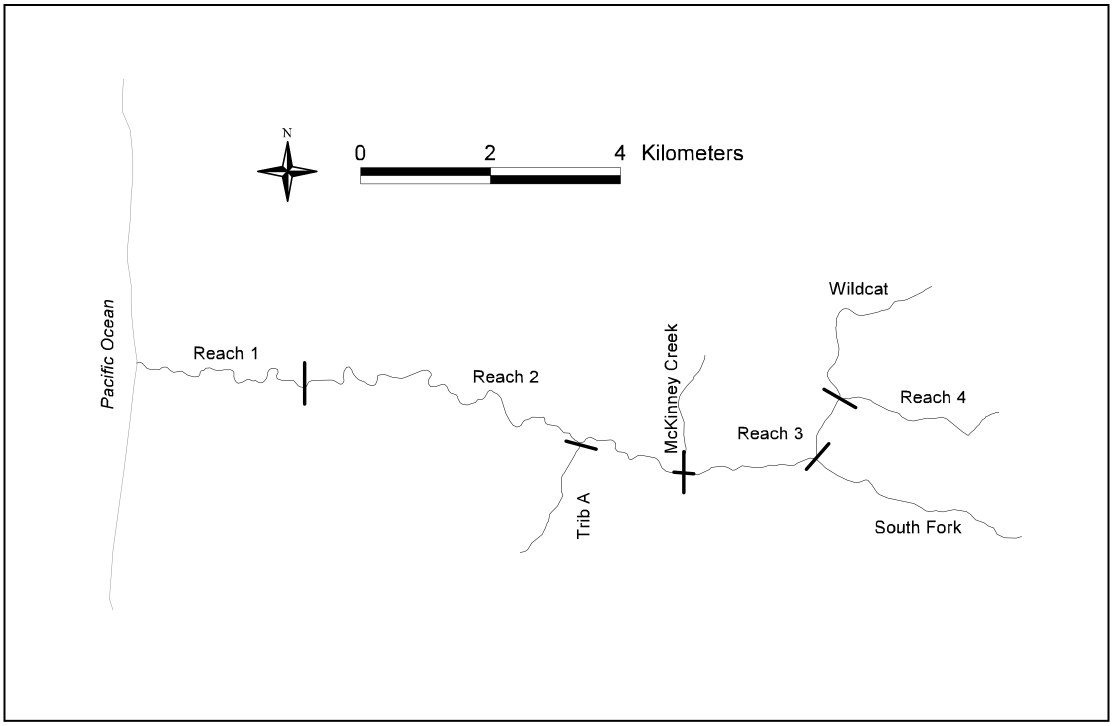


Figure 1. Location of eight sample reaches in Tenmile Creek.

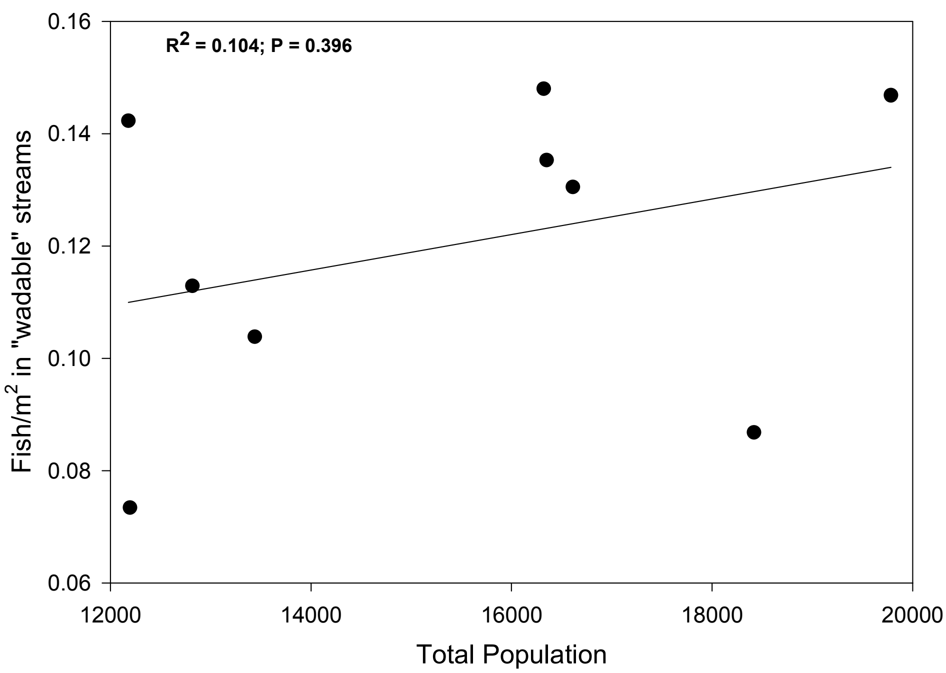


Figure 2. Relationship between the density of 1+ juvenile steelhead in pools in tributary streams as determined by electrofishing and the total population of 1+ steelhead in all reaches of Tenmile Creek. Each data point represents one sample year.

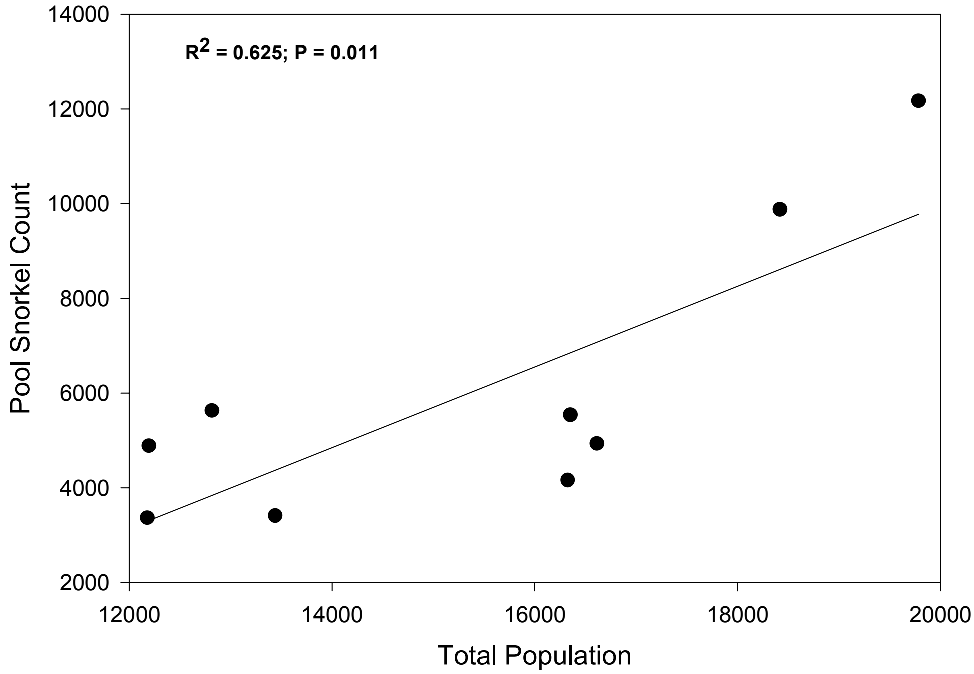
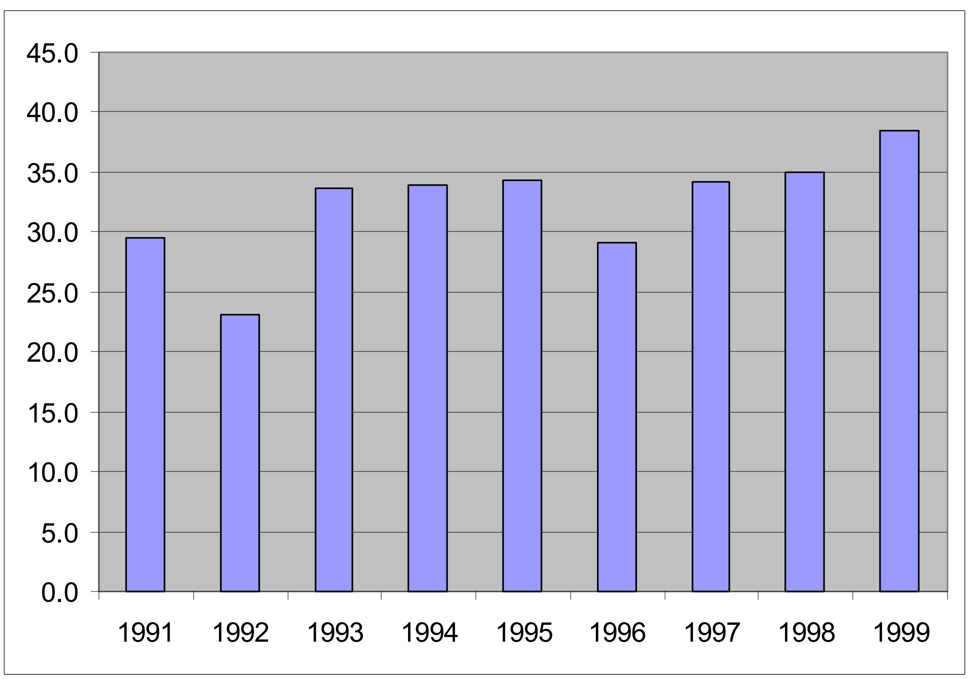


Figure 3. Relationship between basin-wide snorkel counts in pools for 1+ juvenile steelhead and the total population of 1+ juvenile steelhead in Tenmile Creek. Each data point represents one sample year.



Percentage of the total population of juvenile steelhead in Tenmile Creek that resided in wadeable stream reaches, 1991-1999.