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FSP Technical Report

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Dedicated to the acquisition, compilation, dissemination, and application of knowledge about managed ecological resources in Northern California.

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Regional Juvenile Coho Salmon Abundance Survey

Introduction

In the summer of 1999, the Forest Science Project (FSP) completed a juvenile coho salmon (*Oncorhynchus kisutch*) abundance survey in the Mad River-Redwood Creek Hydrologic Unit (HUC) with the cooperation and assistance of National Marine Fisheries Service (NMFS), Redwood National and State Parks, Cal Trout and the Fish, Farm, and Forest Communities Forum (FFFC), Humboldt State University's (HSU) Fisheries Department, HSU Fisheries Cooperative (HSU-Coop), Simpson Timber Company (Simpson), Pacific Lumber Company (PALCO), and Natural Resources Management Corporation (NRM). This was the first year of a multi-year study. The FSP cooperators have indicated a desire to participate in this study for at least ten years. The goal of the study within any given year is to estimate the total number of juvenile coho salmon within a defined sampling universe. However, any single annual estimate has limited value. The long-term objective of the project is to provide information that can assist in projecting the future viability of coho salmon.

Coho salmon in the Southern Oregon Northern Coastal California (SONCC) evolutionary significant unit (ESU) have been listed as a threatened species under the Endangered Species Act (ESA). NMFS has been assigned responsibility for listed coho salmon under the ESA. NMFS has decided that it must take an active leadership role to assure that necessary data are collected on ESA-listed salmonids in California. Time-series data for juvenile abundance has been described as "very desirable" at a "low cost" by NMFS (Prager et al., 1999). This survey is specifically designed to provide NMFS the time- series data that can be used to project the future viability of coho salmon.

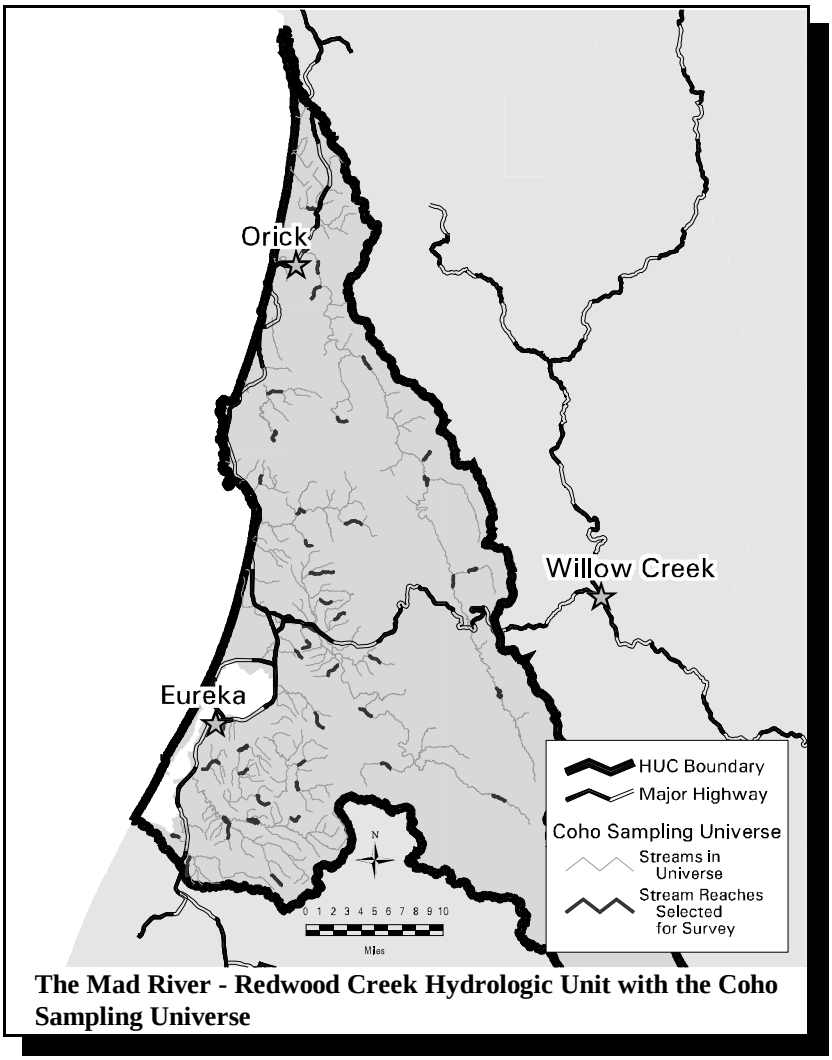
To estimate juvenile coho salmon abundance, FSP utilized a regional sampling design developed by Drs. Scott Overton and Trent McDonald (1998). A Bureau of Reclamation grant acquired by FFFC and administered by Cal Trout funded Overton, and later McDonald, to develop a design for estimating juvenile salmon abundance on a regional scale. The report was reviewed by NMFS and other state and federal agencies, as well as academia.

To implement the regional sampling design, the area of interest first must be defined and the streams broken up into segments with endpoints that are easily identified in the field. The segments are then arranged in a sampling frame in a manner that will insure good spatial coverage during sample selection. A generalized systematic sample with a random start is then taken from the arranged segments. Each selected segment is then surveyed (if possible) using methods developed by Hankin and Reeves (1988) and modified more recently by Hankin (prepubl.) to estimate the total number of juvenile coho in the selected segments. The method relies primarily on snorkel dives to enumerate juvenile coho salmon abundance with occasional electrofishing required.

Sampling Frame Development

Define Area of Interest

The first step in developing the sampling frame was to define the sampling universe or the area of interest. The Mad River-Redwood Creek Hydrologic Unit (Mad-Redwood HUC) was selected as the area of interest. The Mad-Redwood HUC includes all streams that drain into Humboldt Bay and all streams that drain into the Pacific Ocean north to, but not including, the Klamath River. Also included in the HUC are all tributaries to the aforementioned streams. Discussions with numerous fishery biologists revealed that if a stream was not on a USGS 1:100,000 scale topographic map, then the stream probably did not provide suitable coho salmon habitat (this assumption was verified at a later step in the process). The FSP utilized GIS in sample frame development and found that the information in 1:100,000 scale hydrography was inadequate for additional frame development. The FSP has an interim 1:24,000 channel-routed, center-lined hydrography network that was suitable for use in this project.



The Mad River - Redwood Creek Hydrologic Unit with the Coho Sampling Universe

The 1:24,000 GIS coverage has approximately 2200 miles of single-line stream routes. Routes represent a stream from mouth to headwater. The 1:24,000 coverage was overlaid on a 1:100,000 digital line graph (DLG). Any 1:24,000 segment that was not represented on the 1:100,000 DLG was removed from the sampling universe. Approximately 1500 miles of 1:24,000 streams remained in the sampling universe after the overlay process was completed.

Exclusions

The next step in defining the sampling universe was to convene a meeting of local fisheries biologists familiar with coho salmon distribution to rule out stream reaches where it was known that coho would not be present. There were representatives from various state and federal agencies (NMFS, U.S. Fish and Wildlife Service, USDA Forest Service, Bureau of Land Management, U.S. Geological Survey, National Park Service, and CA Department of Fish and Game), HSU Coop, Yurok Tribal Fisheries, Humboldt Fish Action Council, Humboldt State University, and private timber industry (Simpson Timber Company and Pacific Lumber Company). The biologists at the meeting confirmed that, in their opinion, no significant coho stream was omitted from the universe by using only streams represented on 1:100,000 hydrography. Next, the experts indicated on hardcopy USGS 1:100,000 and 1:24,000 topographic maps streams that they knew have coho salmon and, more importantly, existence of migration barriers they knew coho could not pass. Each barrier was marked on the map, with notation

as to the nature of the barrier. The barrier notation was initialed by the fisheries biologist.

Finally, gradients were estimated using 30-m digital elevation models (DEMs) for the entire stream network. It is known that coho generally utilize low gradient streams for spawning. However, due to the error in estimation of gradients using 30-m DEMs, and not wanting to risk omitting potentially good coho habitat, a high gradient was used to make omission decisions at this step. Wherever the majority of a segment was greater than 10% from a point up to the headwater, that segment was removed from the sampling universe; a high gradient reach would not be omitted if potentially suitable habitat (i.e., low gradient reaches) occurred upstream. The GIS-estimated gradients for several tributaries were compared to data reported by Anderson (1988) and Brown (1988). Our GIS-derived estimates were similar to their reported values. Moreover, GIS-derived high gradient segments were indicated as having no coho in their surveys. Thus, our $10% exclusion did not appear to remove any stream segments that were potentially coho bearing.

After removal of stream segments from both the exclusion meeting and the GIS-based gradient exclusion, there were 559 miles of 1:24,000 streams in the sampling universe. Stream segments above barriers identified at the exclusion meeting and by the GIS-based gradient procedure were removed simultaneously in GIS. Therefore, miles excluded from each exclusionary action have not been calculated.

Segment Delineation

The sampling universe was divided into sample units (stream segments) that had endpoints that field crews could easily identify. Confluences with 1:24,000-scale tributaries were used as the primary identifiable endpoint features for segment delineation. The 1:24,000 GIS coverage allowed us to estimate distance from the mouth of every 1:100,000 stream to its confluence with a 1:24,000 tributary for all streams in the sampling universe. The target length for the segments was one mile, with a tolerance range between 0.75 and 2.25 miles, although a few smaller segments were retained in the sampling universe (a minimum of 0.65 miles).

The majority of between-tributary segments were much shorter than the required minimum 0.75 miles. Therefore, an S-PLUS™ program was written that "walked up" every stream, constructing one-mile segments by piecing together shorter segments. Several segments delineated by the first run of the S-PLUS™ program were too large because there were no 1:24,000-scale tributary endpoints at appropriate intervals. For these long segments, approximately 10 of them, digital raster graphs (DRGs) of 1:24,000 USGS topographic maps were used to identify features, usually road crossings, that the field crew could easily locate. These extra point features were then used to mark endpoints, slicing the longer segments into lengths that fell within the tolerance range.

There were five segments longer than 2.25 miles (ranging from 2.27 to 3.03 miles) left in the sampling frame. Three of the segments were at the lowest end of the Mad River, one was at the lower end of Redwood Creek, and one was the entire length of Tom Creek, a tributary to Big Lagoon. The four low-end reaches are in areas that are known to have long habitat unit lengths; thus, there will be relatively few habitat units per mile for surveying. The sampling protocol for estimating abundance within a stream segment does not work properly if there are too few habitat units. We left these segments long in order to increase the number of habitat units in those stream segments. Coho salmon probably cannot use all, if any, of Tom Creek. The upstream limit for coho habitat in Tom Creek has not yet been determined. If Tom Creek were split into two segments the upper segment would more than likely have no coho. Thus, the actual length of a sample segment in Tom Creek would probably be well within the acceptable range, if not too short, for the survey.

There were a number of entire streams that were too short to meet the minimum required length. These pieces have been set aside from the sampling universe. However, a significant number of coho might be found in these small streams. It is hoped that these units will be incorporated into a separate sampling universe, which will be sampled using a different single-stream survey protocol.

In the end, there were 452 segments for the 1999 survey with an average length of 1.23 miles (range of 0.65 to 3.03 miles). From these 452 segments, 44 were selected using an equal probable generalized systematic sampling algorithm with a random start. The average length of the 44 sample segments was 1.15 miles (range of 0.65 to 2.1 miles) with a total of 50.65 miles of stream segments selected for field surveys.

Implementation

Why the Mad/Redwood HUC?

The FSP has a 1:24,000 channel-routed hydrography layer in development for the Mad/Redwood hydrologic unit that, although being a work in progress, has enough information to be utilized for this project. Without this type of GIS data, it would be impossible to automate the segment delineation step; segment delineation then becomes a manual, labor intensive process.

The Mad/Redwood HUC is composed of a diversity of landowners and land stewards. Such a cadastral diversity was considered an excellent test of how effectively state and federal land stewards and private landowners could be brought together on a large regional-scale project.

There are two coho ESUs in California: the Central California Coho ESU at approximately 4,150 mi^2 and the Southern Oregon Northern California Coastal Coho ESU at approximately 18,090 mi^2 (www.nwr.noaa.gov/1salmon/salmesa/cohoswit.htm). NMFS requires information that can be used to assess coho populations across entire ESUs. It is impossible to gather data at an ESU-wide scale without involving multiple public and private parties. Approximately 24% of the miles of streams in the Mad/Redwood HUC flow through public lands, such as Redwood National and State Parks, and the BLM's Headwaters Forest. Nearly 40% of the stream miles traverse large industrial property. The majority of the remaining watercourses flow across numerous small non-industrial private landowner properties. The success of this regional survey can be largely attributed to the cooperation between the many organizations and landowners in the Mad-Redwood HUC.

Landowner Contact

With the assistance of Natural Resources Management Corporation, property ownership and contact information was identified using county assessor office records on CD-ROM. County assessor maps do not always match the USGS topographic maps used for the survey, making the task of identifying the sample segment on the assessor map difficult. For example, on the Jacoby Creek segment, one endpoint was incorrectly identified, causing several private landowners to be inadvertently contacted.

Before a field crew visited a sample segment, the landowners along the segment were contacted about one month in advance to obtain access permission. If we failed to contact a landowner, that property was not surveyed. Of all the private landowners contacted during the Summer 1999 survey, there were no denied access responses. Many sample segments had single ownership, but there were as many as 10 landowners on a single surveyed stream. During the 1999 field season, a total of 12 small non-industrial private landowners were contacted. Ten of those were on Jacoby Creek. Only one Jacoby Creek landowner did not respond in time for the survey and the stream section passing through that property was not surveyed (0.11 mi. out of the 1.3 mi. Jacoby Creek segment).

Permits

To handle coho, an ESA-listed threatened species, both state and federal permits are required. Large industrial landowners involved in the survey had their own permits for sampling on their property, but streams falling on other lands required surveying as well. For the federal Section 10 permit, FSP worked under the permit of Dr. Walt Duffy, Director of the California Fisheries Cooperative located at Humboldt State University (HSU-Coop). FSP state permits were expedited with the assistance of Larry Preston and Harvey Reading, both from California Department of Fish and Game. FSP is currently working on obtaining a federal permit for future work.

Reconnaissance

Nine drawn sample segments seemed unlikely to have suitable coho habitat. A two-person crew from the HSU-Coop was sent into the field to assess these nine segments. Because of this reconnaissance, seven of the nine segments were deemed unsuitable for surveying. Six of the seven were not suitable for coho and assigned an abundance value of zero. The other segment was a potential health hazard to surveyors and was assigned a NULL value (an inaccessible unit).

Three additional selected sample segments were identified as dry channels by biologists familiar with those streams. One more was identified as non-surveyable in the office. In total, 11 segments totaling 12.5 miles were not surveyed because pre-survey work indicated that it was not possible to survey these segments. Nine of the segments were assigned zero coho counts. The pre-survey work took

less than two days, saving a great amount of time and money.

Field Packets

The FSP assembled field packets for all field crews. Each packet contained field data collection forms, color maps, and a written description on how to get to the site. The data forms were composites of forms submitted to FSP by Simpson Timber Company and NMFS. Consistent field forms insured that data entry would be easier when the data from several different crews were entered in FSP's centralized database.

Color maps created using USGS 1:24,000 DRG's in ARCPLOT, identifying the reach endpoints, were included in the field packets. Color maps, along with a written description, enabled crews to identify the correct stream and locate the entire segment length that was selected for the survey.

Pre-survey Field Workshops

To ensure that all field crews were deployed into the field using the same sampling protocol, two pre-survey workshops were held at Redwood National and State Parks in Orick, CA. For both workshops, the morning sessions were in a classroom setting, and the afternoon sessions were dive sessions in Prairie Creek.

Morning sessions: For the first workshop morning session lectures were given by Phillip Buttolph, HSU's Dive Safety Officer, on diving safety issues, HSU Fisheries Department professor Dr. David Hankin on single-stream snorkel surveys, and HSU Fisheries Department professor Dr. Terry Roelofs on fish species and age-class identification. The lectures were followed by an open forum where divers shared their experiences with snorkel and electrofishing surveys. A written test was administered to the group to make sure there was a thorough understanding of the survey protocol.

In a second morning session that took place two weeks later, a "final" protocol was distributed to the group. Each step of the protocol was discussed in detail. Some changes were made in the protocol based on comments from field personnel. The modifications reduced the chance of errors in the field. The changes did not adversely affect the objectives of the study. Also discussed in the session were the results of the tests that were administered at the previous workshop.

Afternoon sessions: Both afternoon sessions were hands-on field training. The group moved to the Prairie Creek amphitheater, where all aspects of the survey were discussed. The method for habitat typing was discussed, defining what constitutes a habitat break, what is the difference between a run and a riffle, and how units are marked for snorkeling or electrofishing. Next, divers entered the Prairie Creek and counted fish. Dr. Roelofs helped individuals identify juvenile coho salmon from other salmonids. There were a number of experienced fish surveyors at the workshop and they were able to share their techniques, not with just the less experienced, but with each other as well.

For large regional surveys such as this to be successful, it is critical that the various field crews are deployed using the same protocol. As a result of the workshops, multiple crews were able to survey many different stream reaches in a consistent manner.

Field Crews

There were a total of five crews that supplied data for the project: two crews from Simpson, one HSU/FSP crew, one PALCO/HSU crew, and one HSU-Coop crew. Table 1 shows the number of streams and the number of stream miles each team habitat typed and fish surveyed.

Table 1. Number of Sample Reaches and Length Habitat Typed and Fish Surveyed by Each Crew.

Crew	Activity	Number	Length (miles)
Simpson	Habitat typed	6	4.2
	Fish surveys	5	5.0
HSU-FSP	Habitat typed	7	5.6
	Fish surveys	2	2.6
HSU/PALCO	Habitat typed	4	4.9
	Fish surveys	4	4.9
HSU-COOP	Habitat typed	1	0.9
	Fish surveys	1	0.9

NOTE: Simpson crews performed fish surveys on more miles than were habitat typed because they conducted a fish survey on a long reach that was habitat typed by the HSU-FSP crew. The Simpson crew also habitat typed two short segments that were not suitable for fish surveys using the Modified Hankin-Reeves Protocol.

Stream Segment Sampling

Selected stream segments were sampled using the modified Hankin and Reeves single-stream sampling approach. The methodology requires that all fish have a chance to be observed and that fish are not double counted. Three significant problems were encountered that made it impossible to survey a number of stream segments: some segments (1) were too wide and/or too deep requiring more than two divers to cover a stream cross section, (2) had poor water visibility making it impossible to see all fish in the habitat unit, and (3) were too short downstream from migration barriers, having inadequate lengths that were discovered only after surveys had begun.

Six segments were too large to effectively survey using the prescribed survey method. However, there is adequate information available to assign these six segments a fish count of zero. These segments have been surveyed either for this project or for summer steelhead surveys and only one juvenile coho was observed in the entire mainstems of both Redwood Creek and Mad River (Matt House, pers. comm.; David Anderson, pers. comm.).

Three segments were too short downstream from migration barriers to meet the segment-length criterion that was established at the outset of segment delineation. These were not discovered until the crew arrived at the stream segment.

Eight selected segments could not be surveyed due to poor visibility. Attempts were made to survey two of these segments and it became obvious that, although a few 0+ coho were observed, many fish could go undetected. Abundance estimates from these observations were impossible. Thus, these eight segments were assigned NULL values and were treated as inaccessible units.

One unit was not surveyed due to potential health risk. This segment flowed through a wooded section of Eureka CA where obvious signs of indigent habitation were observed. There was a fowl smell in the air and the area was clearly unsanitary. The reconnaissance team stated that they would be uncomfortable entering this stream. This also was assigned a NULL value. No assessment has been made to the potential this site has for rearing coho salmon.

Twelve additional units were either not surveyed or the survey was aborted: there was no possibility of coho occupying these segments. These segments were either completely dry, mostly dry, beyond migration barriers, or the gradient was too high. Field visits were performed on the mostly dry and high-gradient segments to verify the lack of coho habitat. These 12 segments were assigned zeros without snorkel surveys.

Five segments were not sampled due to time expiring on the predefined sampling season. These segments were assigned NULL values.

For the actual field surveys, 20 segments were habitat typed and 13 were fish surveyed. One segment that was fish surveyed was in the mainstem of Redwood Creek where the stream was too large to effectively survey. However, no 0+ coho were observed and there were probably none present. Two segments had poor visibility and could not be enumerated. One surveyed segment was too short, but in the context of the Overton/McDonald regional survey design, it may possible to be included in enumerating fish abundance for the region. This leaves nine segments that had a complete survey for a stream that was suitable for fish surveys.

A summary of the survey suitability for each selected segment and information regarding work done in the reaches can be found in Table 2. The table reports whether a segment was habitat typed and whether there was a fish survey performed. Also indicated in the table are units that did not require full field surveys. These reaches were identified as non-coho bearing or a health risk to divers during reconnaissance and non-coho bearing or non-surveyable by biologists in the office. There were five segments lacking fish surveys because of time constraints, nine segments that had fish surveys that were suitable for surveys, six segments that were too large (cross sectional area) to survey given the available field protocol, three segments that were too short due to migration barriers in the segment to survey given the available field protocol, 12 segments that have zero juvenile coho population sizes determined by means other than snorkel surveys, eight segments that could not be fish surveyed due to low observation probability (poor visibility) given the available field protocol, and the one segment that was determined to be too large of a health risk to the field crew.

Quality Assurance/Quality Control

Training is an important and primary step in a quality assurance / quality control (QA/QC) program. Divers participated in a training workshop at Redwood National and State Parks before the start of the field season. Lectures, discussions, and field training took place at the workshop. Divers were

Table 2. Reaches that were selected for surveying identified by the segment number and the stream name that contained the segment.

Segment Number	Stream Name	GIS Length (Miles)	Habitat Typed	Fish Survey	Reconn only	Class
15	Jacoby Creek	1.5	Y	-	-	n
25	Redwood Creek	1.0	Y	-	-	1
35	Redwood Creek	1.2	Y	-	-	1
46	Redwood Creek	1.0	Y	Y	-	1
56	Redwood Creek	1.0	-	-	-	1
66	Redwood Creek	1.3	-	-	-	3
76	Prairie Creek	2.1	Y	Y	-	4
88	Skunk Cabbage Creek	1.0	-	-	-	4
99	Streelow Creek	0.8	Y	Y	-	0
111	Elam Creek	1.3	Y	Y	-	2
122	Bridge Creek	1.0	Y	-	-	3
133	Garrett Creek	1.0	-	-	-	n
143	Minor Creek	0.9	-	-	-	n
154	Janes Creek	0.8	-	-	Y	3
164	Little River	1.0	Y	Y	-	0
174	SF Little River	0.8	Y	-	-	3
184	Upper SF Little River	1.5	Y	Y	-	0
196	Pitcher Creek	1.2	Y	Y	-	0
207	Maple Creek (Big Lagoon)	1.1	Y	Y	-	0
217	NF Luffenholtz Creek	0.7	-	-	Y	3
227	Mad River	1.2	-	-	Y	1
237	Mad River	1.2	-	-	-	1
248	Warren Creek	1.2	-	-	Y	3
258	Grassy Creek	1.0	-	-	-	2
268	Unnamed Lindsay Cr Trib	2.0	-	-	-	2
278	Mill Creek	1.1	-	-	Y	3
289	Quarry Creek	1.2	-	-	Y	3
299	Hatchery Creek	1.0	Y	Y	-	0
310	Black Creek	1.0	-	-	-	n
320	Boulder Creek	1.2	-	-	-	n
330	Freshwater Creek	0.9	Y	Y	-	0
340	Ryan Creek	1.2	-	-	-	4
350	Guptil Gulch	0.9	Y	-	-	4
360	Unnamed Ryan Cr Trib	1.4	Y	-	-	4
370	Cloney Gulch	0.6	Y	Y	-	0
380	Cooper Gulch	1.3	-	-	Y	5
393	North Fork Elk River	1.6	Y	Y	-	0
404	Martin Slough	1.7	-	-	Y	4
415	South Fork Elk River	1.6	-	-	-	4
426	Tom Gulch	0.9	Y	Y	-	4
437	Little SF Elk River	1.1	-	-	-	3
449	M^{c}Whinney Creek	0.9	-	-	Y	3
461	Salmon Creek	0.8	-	-	Y	3
471	Deering Gulch	1.6	-	-	Y	3

Note: "Y" under the "Habitat Typed" or "Fish Survey" columns indicates that the segment was habitat typed or that fish data were collected, respectively. The "Reconn only" column indicates segments that minimal work was done to determine that either the reach was non-coho bearing or that it could not be surveyed. The classification codes in last column are defined in Table 3.

Table 3. Classification code (Class) definitions for Table 2.

Class	Description	Count	GIS Length (miles)
n	No fish survey due to time constraints	5	5.6
0	Valid fish survey	9	9.7
1	Too large (cross-section) for fish survey	6	6.5
2	Too short before migration barrier	3	4.3
3	Non-coho bearing reach (most are dry channels)	12	12.5
4	Observation probability too low (poor visibility)	8	10.9
5	Health risk to field crew	1	1.3

NOTE: The number of occurrences for each class is given along with the total GIS estimated length.

tested in both the field and the classroom. The workshop provided the first calibration check on the measurement system (i.e., the crews). Continuing calibration checks are important for assuring that the measurement system has not drifted (i.e., crews have departed from the protocol).

Field audits were performed two weeks after deployment of dive crews into the field. Field audits provided continuing calibration checks to determine whether the crews were still in adherence to protocol. Field audits were performed by Chris Moyer (USDA Forest Service, Corvallis, OR), one of the foremost experts in stream surveys using the Modified Hankin and Reeves protocol. Mr. Moyer filed a report documenting the quality of dive team work. The PALCO team did not start until after Moyer completed the field audits. A copy of the field audit report prepared by Mr. Moyer is available upon request.

Field forms were reviewed as quickly as they were submitted, often the day of the survey. Only one error was detected in this process. The error was corrected before the team resumed the survey.

Data entry forms were developed in Microsoft Access™ to facilitate data entry and to catch possible data entry errors. Further data integrity checks were done in S-PLUS™ before data analysis. One additional data recording error was uncovered at this step. This error was only in recording a habitat unit identification number which did not affect analysis.

For the most part, field crews did an excellent job. One crew that was unable to attend the workshop electrofished more units that they should have under the protocol, although the required habitat units were correctly sampled. The error required the crew to work longer hours, but did not reduce the quality of the survey. Such errors, however, can adversely affect cost and unnecessarily increase handling of fish.

Sampling Design and Protocol Challenges

There were three main reasons why a number of reaches could not effectively be surveyed using the Modified Hankin and Reeves single-stream method. Firstly, the stream was too wide and/or too deep. The method specifies that no more than two divers should be capable of viewing the entire cross-sectional area of the channel. Secondly, the stream had too many places for fish to hide (complex habitat) or had poor water visibility (high suspended sediment or tannic acid content). Each fish has to have an equal chance of being observed. Thirdly, the segment length
was of insufficient length to provide an adequate number of habitat types and calibration units. Seventeen segments (21.6 miles) could not be effectively surveyed because of these three problems.

Segment Length

The modified Hankin and Reeves stream survey protocol uses somewhat inaccurate single-pass dive counts. A single dive count, alone, may not determine the "true" number of fish present in a particular unit. For this reason, the modified Hankin and Reeves protocol uses a second phase sampling procedure that calibrates a sub-sample of the first phase single dive counts by either 1) method of bounded counts (when < 20 fish observed on first phase dive) or 2) electrofishing (when > 20 fish observed on first phase dive). A sub-sample of the single-pass dives are calibrated with more intensive sampling methods. By using a calibration relationship, the single-pass dive counts can be adjusted to accurately estimate the average number of fish in each dive unit.

The report describing the Overton-McDonald regional design suggests combining the calibration information from different stream segments.

However, there are a number of biologists that are skeptical about how one can combine such information, and even if it is "statistically valid", is it advisable? This area requires further research.

If one does not form a calibration relationship across segments, then it is recommended that there are at least eight calibration units in each reach. The Summer 1999 survey had a maximum of five calibration units per stream sample segment, and this maximum occurred in only one segment. Thus, no reach had an adequate number of calibration units to develop a calibration relationship. If sampling rates were doubled, then most sample segments would have the required amount of calibration points. Even with increased sampling rates, at least three of the 1999 segments would have been too short.

Lack of a "Plan B"

There were a number of coho bearing streams that could not be surveyed by Modified Hankin and Reeves type surveys but could be surveyed by other methods. The Overton-McDonald sampling design report calls for either the use of unbiased stream sampling methods or that the same protocol be used for each segment. There are no known unbiased estimators for fish populations in small streams. By the strictest interpretation, only the Modified Hankin and Reeves surveyed streams can be incorporated into the Overton-McDonald regional abundance estimate at this time. The possibility of combining biased estimates from different protocols into the regional estimate is currently under critical review.

Results for 1999

FSP is not reporting results mainly because biologists should attach much meaning to a single annual estimate of juvenile coho abundance. Three years are required to collect data for the population size of all generation groups of coho (Overton and McDonald, 1998). Additionally, there is no reference with which to compare the current population size. The first three years of surveys will be the first data point in a time-series data set. Several more data points will be needed before any assessment can be made.

However, results for this survey will be reported in an upcoming technical report, including appropriate caveats on analyzing regional stream survey data. Also, data may be made available upon request. (**Contact information is at the end of the report**).

Challenges for 2000

Get an Earlier Start

As with any field research, the sooner field crew personnel can be identified and plans made, the better. Employment commitments to field personnel cannot be made until funds have been secured. While allocation of funds was approved by the funding agencies, funds were not received until well into the field season. A qualified crew was not hired until halfway into the field season. Due to a late start five segments were not surveyed. Getting an earlier start would have ensured a complete survey.

Calibration

Calibration is an unresolved issue. Eight calibration data points per segment are needed to develop a reliable calibration relationship. During the Summer 1999 survey the maximum number of calibration units within a segment was five. No single segment had sufficient calibration data to develop a within-segment calibration relationship. For the Summer 2000 field season a decision will be made to either apply calibration data across segments, increase segment lengths to capture more calibration units, or increase sampling rates. At this time the lead biologist performing juvenile salmonid surveys for NMFS favors increased sampling rates. Since NMFS is the lead agency in administering the ESA for the listed coho salmon, FSP is seriously considering increased sampling rates for Summer 2000 regional juvenile coho salmon abundance surveys.

Across-segment calibration holds great potential reducing the cost of regional abundance surveys. Across-segment calibration uses calibration data from all streams to form one calibration relationship. This results in the need for fewer calibration units in any one segment. Some segments, theoretically, do not need any calibration data; these segments will use the calibration relationship derived from the other segments.

For across-segment calibration to be a viable alternative, some untested assumptions must be validated. Once the validity and the mechanism for across-segment calibration has been established, the cost of these surveys, in terms of time, money, and fish handling, will be greatly reduced.

Short Segments

There remains the issue of a number of streams being too short, even with increased sampling rates, to provide adequate calibration. A separate sampling universe will be created for these short streams with a different sampling protocol being utilized. The creation of a separate universe consisting of short streams has two advantages. First, the single stream sampling protocol will not require calibration. Second, if the densities of fish are similar in the long and the short streams, the small streams will have fewer fish over the entire length. By stratifying long and short streams into separate universes the overall sampling variance will be reduced.

Fine Tune the Sampling Universe

The first sample drawn from the sampling universe for the 1999 survey revealed a number of segments that were problematic. These problematic segments can be placed into two categories: (1) non-coho bearing and (2) non-surveyable.

Non-coho bearing. There were a number of oversights in the initial coho exclusion. Pieces that were clearly non-coho bearing stream segments were left in. For example, the mainstem of the Mad River has been found to be poor juvenile coho holding habitat. Long reaches were surveyed for summer steelhead and only one juvenile coho was observed (Matt House, pers. comm.; David Anderson, pers. comm.). The mainstem is generally a corridor for migration, thus important to coho. However, the object of the survey is to count juveniles and not describe all aspects of coho habitat. Mainstems of the larger streams, known dry channels, and reaches behind recently identified barriers will be removed from the sampling universe.

Non-surveyable. There are several streams that cannot be surveyed with any available method. The lowest part of Prairie Creek has poor visibility and is not suitable for electrofishing. Even more problematic is the Ryan Creek drainage that has poor visibility when undisturbed, only to be exacerbated by divers stirring up fine silts. Each step into the streams sends thick silt plumes, making electrofishing and visual observations impossible. Landowner knowledge indicates that Ryan Creek has juvenile coho. However, there is no efficient way at this time to quantify the population size. We describe all stream segments not surveyed due to poor visibility, but make no attempt to quantify the number of fish potentially passed over (Table 2).

Plans for the Year 2000 and Beyond

Continue in the Mad-Redwood HUC

The Forest Science Project plans to continue regional juvenile coho surveys in the Mad-Redwood HUC indefinitely. For the year 2000, the universe will be modified to remove non-coho bearing and non-surveyable segments. In addition, sampling rates within segments will be increased to collect data to address unresolved calibration issues. In the near future, data collected in the year 2000 and earlier will be used to fine-tune on-going surveys in terms of sampling rate optimization, determination of the number of segments selected and the sampling intensity within a segment, and segment length. If the optimal segment length is different from the current length, then the sampling frame will have to be reconstructed. The optimal design will either minimize cost given a target confidence interval or minimize the confidence interval given a fixed budget. The synthesis of existing data and optimization procedures are currently being developed.

Collaborate in the Lower Klamath River

The Yurok Indian Tribe has received a grant to conduct a regional juvenile coho abundance survey in the Lower Klamath Basin. The Tribe has expressed a strong desire to undertake a survey that will be compatible with other studies in the state. The FSP has had discussions with Tribal Fishery biologists, and we are assisting them with the design of a similar study plan. The data collected by the Yurok Tribe will be compatible and comparable to FSP data, thereby increasing the geographic area for which juvenile coho salmon population statements can be made.

Expansion into Other Areas

The listing and recovery of threatened coho populations as mandated by the ESA is targeted for entire ESUs. The FSP has recognized that conducting juvenile abundance surveys at an entire ESU level cannot be accomplished by our small staff. We believe that ESUs can be realistically subsampled at the HUC-level, although smaller or

larger sampling universes could be delineated. Whatever the scale, it is best if entire ESUs have similar sampling designs applied and consistent protocols used, to increase the likelihood that population estimates can be aggregated up to an ESU level. FSP would like to form partnerships with other groups, such as our partnership with the Yurok Tribe in the Lower Klamath, to increase the number of watersheds included in regional juvenile coho abundance surveys.

One area of great interest to FSP is the Van Duzen River Basin. The FSP has completed a 1:24,000 channel-routed hydrography for the Van Duzen with support from the U.S. Environmental Protection Agency. The availability of high-quality hydrography datasets for the Van Duzen basin will greatly assist us in developing the sampling frame. Moreover, according to the Van Duzen River TMDL, the basin has very limited coho distribution. Thus, this basin could be surveyed at a relatively small cost, compared to other basins.

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Need More Information?

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