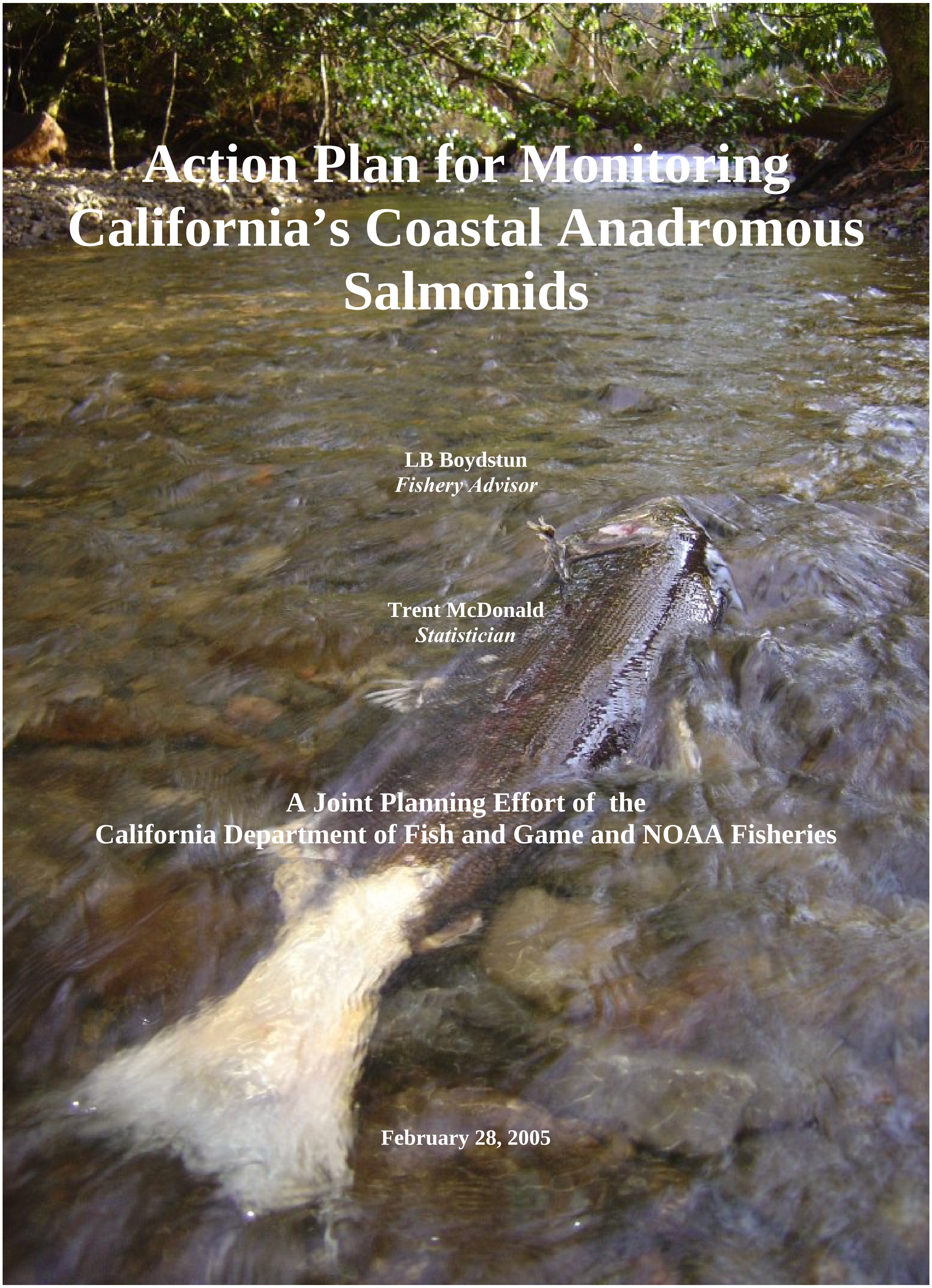

Action Plan for Monitoring California's Coastal Anadromous Salmonids

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A Joint Planning Effort of the California Department of Fish and Game and NOAA Fisheries

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EXECUTIVE SUMMARY

Background

Most of California's coastal Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), and steelhead (*O. mykiss*) populations have experienced marked declines in recent decades. Several Evolutionarily Significant Units of all three species are listed under the Federal Endangered Species Act (ESA) and coho salmon is listed under the California Endangered Species Act (CESA). There is widespread agreement that recovery of these species and eventual delisting will require the efforts and coordination of many agencies and organizations. In addition, there is recognition that better information must be gathered and distributed to all involved parties as recovery efforts proceed.

Monitoring of adult coastal anadromous salmonid populations in California is currently limited to a few adult counting stations, carcass surveys of fall Chinook salmon in various index reaches, snorkel surveys of the major spring/summer Chinook salmon and steelhead populations, and production and harvest monitoring of Klamath-Trinity Basin fall Chinook salmon. There is limited monitoring of adult coho salmon and winter steelhead populations in California.

Fish population data along with habitat condition monitoring, protection and restoration data are critical to any effort to recover the species and populations and to eventually delist them. The Coastal Anadromous Salmonid Monitoring Plan (Plan), described here, was developed for the purpose of obtaining authorization and funding to expand California's coastal anadromous salmonid monitoring program to document the status of the populations and their habitats and to meet ESA and CESA stock assessment needs. Implementation of the proposed Plan is also expected to contribute to the management of California coastal hatcheries and ocean and inriver fisheries and to the advancement of the California Department of Fish and Game's (DFG's) Coho Salmon Recovery Strategy (DFG 2004).

The emphasis of the Plan is on salmonid and salmonid habitat condition monitoring. Plans to evaluate the effectiveness of habitat restoration activities and the biological responses to those activities are under development as separate initiatives.

Plan Development Approach

The Plan was prepared using two workshops to solicit scientific and professional input on scope and content, data needed for stock assessment purposes, and how the data should be collected. The workshop participants included DFG and NOAA Fisheries (NOAA) scientists, biologists and habitat experts; members of the State's three Federally appointed Technical Recovery Teams (TRTs); and invited academic and other governmental scientists and technical experts.

The workshops took place March 9-11, 2004 (Santa Cruz) and May 25-26, 2004 (Folsom Lake). The Viable Salmonid Population (VSP) concept (McElhany, et al. 2000) and associated attributes (abundance, distribution, diversity and productivity) were central to the discussions at both workshops. Specifically, the discussions included data needs by species, life history form (juvenile, smolt, adult) and geographic area. A summary of the workshops follows:

Workshop 1

This meeting focused on providing species listing background information, reviewing current monitoring activities, reviewing adult and juvenile sampling techniques, statistical methods (particularly the rotating panel design for selecting stream sample reaches), sampling and program implementation challenges and data collection priorities by species and life history form. There were 62 attendees at the meeting.

Workshop 2

This meeting focused on reaching agreement on data priorities for individual species and life history forms and recommending sampling and analytical techniques. There were 42 attendees at the meeting.

The group was divided into four panels: Northern (Aptos Cr. to Smith R.), Southern (Pajaro R. to Tijuana R.), Spring/Summer Chinook salmon and steelhead and Habitat. Various recommendations were developed at the meeting. Probably the most important set of recommendations from the workshop process were the VSP monitoring priorities for individual species and life history types organized by population type (provisional at this time) as follows: (1) Functionally Independent Populations (FIPs) and (2) Potentially Independent Populations (PIPs) plus Dependent Populations (DPs). (The Ephemeral Population type was discussed but species monitoring was not prioritized.) The FIP, PIP and DP population types were derived from the VSP concept, which guides recovery planning under the ESA.

Adult monitoring was given the highest priority for both salmon species and steelhead. Juvenile monitoring was determined to be important for measuring spatial distribution of coho salmon, southern steelhead and abundance of cutthroat. The workshop recommendations were used in developing the Plan elements and associated budget and staffing recommendations.

The workshop proceedings, including the Workshop 1 presentations, can be accessed at: www.calmonitor.com.

Plan Summary

1. The Plan covers all four California coastal anadromous salmonid species [Chinook salmon, coho salmon, steelhead, and cutthroat (*Oncorhynchus clarki clarki*)] and all coastal watersheds including San Francisco and San Pablo Bay tributaries downstream from Carquinez Bridge. The wide scope of the Plan is necessary because most coastal salmonid populations have been listed and also because non-listed populations (all in the far north) are vulnerable to decline and future listing.

2. The coast is divided into two monitoring areas: Northern (Oregon Border to Aptos Creek near Santa Cruz, including tributaries to San Francisco and San Pablo Bays) and Southern (Pajaro River to Mexico border). Species composition and abundance level differences and disparate sampling challenges between the two areas are the primary reasons for dividing the coast into two monitoring areas.

3. Annual spawning ground surveys are proposed to monitor adult salmon and steelhead in the Northern Monitoring Area. Sample areas are proposed to be drawn in a spatially balanced manner and following a rotating panel design. This is the same sample design (also known as

EMAP) used for monitoring coastal coho salmon and steelhead in Oregon. Adult population sizes within sample areas are proposed to be estimated based on one or a combination of commonly used techniques including live fish or redd counts and/or salmon carcass counting. Second stage sampling using weirs or other intercept techniques is proposed to be used to mark or count live fish for the purpose of correcting (calibrating) the spawning ground estimates. The annual sample size is proposed to be 10% of all potential adult spawning areas, which is the sample level achieved in Oregon for coho salmon in recent years.

4. Southern steelhead adults are proposed to be counted at existing and future fishways. Studies are proposed to evaluate the use of portable weirs and conventional or new sonar technology, to count the southern steelhead runs. Two studies are proposed: (1) evaluation of a counting weir in combination with conventional sonar counting devise and (2) evaluation of the *Didson* camera, which may not need to be used in conjunction with a weir. The *Didson* camera is in widespread use in Alaska and appears to be effective under high, turbid flow conditions.

5. Life Cycle Monitoring Stations (LCSs) are needed at key coastal locations to monitor annual adult and juvenile salmonid migrations for entire stream basins. The data are critical to gaining a better understanding of the importance of freshwater and marine survival conditions on brood year production estimates. LCSs may also be useful for evaluating sampling techniques for estimating adult spawning run sizes. Six new LCSs are proposed to be established in the coastal zone, two in each of the three coastal TRT Recovery Domains. Site selection criteria are specified in the Plan

6. Juvenile coho salmon and southern steelhead spatial distribution sampling is proposed during summer or early fall months in the northern and southern areas, respectively. Electrofishing and snorkel survey are proposed to be used to detect species presence within sample areas, which are proposed to be selected in a spatially balanced manner using a rotating panel design. Sample size is proposed to be 10% of all suitable stream rearing areas. The proposed juvenile monitoring plan is intended to meet the monitoring criteria specified in the DFG's Coho Salmon Recovery Strategy.

7. Juvenile cutthroat abundance sampling is proposed to take place between the Eel and Smith rivers and 30 miles inland during summer or early fall months. A habitat typing, snorkel counting, electrofishing protocol is proposed for estimating cutthroat population sizes. Sample size is proposed to be 10% of all possible stream rearing areas.

8. Additional Chinook salmon marking (fin-clipping) is proposed for Iron Gate and Rowdy Creek (RCH) hatcheries to increase the marking rates at these facilities to 25% or greater of released fish. Elsewhere in the coastal zone, hatchery fish are being adequately marked to estimate hatchery fish contribution rates to natural spawning populations.

9. Creel surveys are proposed for 200 miles of coastal stream fisheries to estimate annual fishery harvest rates. The specific stream fisheries are identified in the Plan and extend from the Smith River to San Luis Obispo Creek. Two streams are proposed to be surveyed every year for trend analysis purposes. Fishery harvest rate is proposed to be computed as catch/ catch+escapement (from the spawner surveys).

10. Core habitat condition monitoring is proposed to concentrate on pool, riparian, water quality, sediment and large wood presence parameters. Watershed-scale habitat monitoring should focus on water temperature regime, riparian community and geology.

11. Additional monitoring program needs include: evaluation of Klamath River fall steelhead seining, (to minimize pinniped depredation), calibration study of spring Chinook salmon/steelhead snorkel counts, rainbow/steelhead trout interactions, methods to differentiate cutthroat and rainbow trout hybrids and creation of 1:24,000 scale hydrographic maps in digital format for all coastal watersheds.

12. The sample site selection procedure proposed for measuring metrics of spawning adults and juvenile salmon spatial distribution is similar to the one used for coho salmon in Oregon (also known as EMAP). Here, most streams (blue lines) appearing on USGS routed hydrographic maps are broken into 1-2 mile reaches. These reaches are aligned linearly, starting at each stream mouth, sorted together following a specific protocol and stored electronically, along with a stream reach identifier, from a Geographic Information System (GIS). Stream reaches excluded from the sample frame include areas above barrier dams, areas above steep gradients (based on map elevation contours), and areas that are known to be unavailable to anadromous fish spawning or rearing. The sample reaches are proposed to be drawn using a technique (GRTS) that ensures spatial balance.

13. The sample areas are proposed to be arranged in panels as follows: one panel is sampled every year, 3 panels are visited once every 3 years, 12 panels are visited once every 12 years and 30 panels are visited once every 30 years. The rotating panel design is used in monitoring programs that seek high precision in both annual abundance estimates and status and trend estimates over time. Geographic balance in sample areas is important for producing sub-area estimates (ESUs, population types, HCPs, NCCPs, etc.) with sample sizes proportional to their hydrographic representation in the sample frame.

14. A 25% sample size draw is proposed initially to accommodate resource managers that seek greater resolution in sub-area estimates. The 10% sample level proposed for juvenile and adult monitoring as part of this Plan is taken from within the 25% draw.

15. Four administrative positions should be established to ensure that (1) programs are effectively coordinated, (2) plan goals and objectives are met, (3) close contact is maintained with other monitoring entities, (4) staff annual work plans are developed, (5) annual progress reports are prepared and (6) data flow smoothly and efficiently from field operations to a centralized data base. Public access to the data is proposed to be facilitated via the cooperative *Calfish* Web site.

16. Responsibility for anadromous salmonid policy and regulation in the DFG is currently divided between various programs and needs to be consolidated into a single unit. NOAA has a similar situation but is national in scale.

17. A Science and Advisory Committee (SAC) composed of five to seven individuals is needed to provide scientific (peer) review of monitoring plan sampling plans, data and technical reports and locations of LCSs. The members should be compensated for their time and reimbursed for their actual travel expenses. They should be allowed to serve 2-year terms and be eligible for reappointment. The Monitoring Program also needs a Technical Team to produce annual population estimates, analyze program data, coordinate coastal monitoring activities, establish coastal monitoring protocols and assist in the analysis of data relative to the DFG's Coho Salmon Recovery Strategy.

18. The DFG is in the process of consolidating its fish and wildlife data into a centralized data base (BIOS). Coastal monitoring data must flow efficiently, effectively and in a timely

manner from coastal monitoring program offices to a central GIS data base within BIOS for editing and scientific analysis.

19. Funding levels to support seven tasks are identified in the Plan. The estimated annual cost to support all seven tasks is $7 million broken down as follows: (1) Northern Spawner Survey, $2.5 million; (2) Southern Steelhead Monitoring, $541,000; (3) Life Cycle Monitoring, $1.4 million; (4) Juvenile Surveys, $1.3 million; (5) Hatchery Fish Marking, $69,000; (6) Creel Survey, $369,000 and (7) Administrative Support, $789,000. The proposed budget will support 20 permanent positions and 66 person-years of temporary help. The estimated start-up cost for all seven tasks is $1.9 million, mostly for vehicles, weir construction materials and juvenile fish traps. Funds are provided in the Southern Steelhead Monitoring and Administrative Support tasks to support Monitoring Program study needs.

20. If the Plan is not implemented, the risk is high that additional species listings or downlistings will occur under the ESA or CESA. If the Plan is partially implemented, certain tasks must be given higher priority over others (e.g., adult monitoring should have the highest priority). The best scenario, in terms of achieving species recovery and delisting or downlisting, would be that the Plan is fully implemented.

21. The Monitoring Program should be regarded as a long term investment. It may take several decades to detect change in status with high confidence for some species or populations.

22. The Monitoring Program funding options include (1) the DFG redirecting staff and current funding resources, (2) NOAA consider reassigning staff and funds, (3) using current Salmon Grant funds and (4) finding new or augmented State or Federal funding sources. California fishing and environmental organizations can help at the State and Federal levels in finding new or augmented funding sources. The Plan needs to be widely circulated and discussed in regional meetings to garner support in Sacramento and Washington D.C. Ultimately, the decision on how to proceed rests with DFG and NOAA top administrators.

INTRODUCTION

Background and Need

Evidence of population decline, uncertainty in population status and habitat degradation have resulted in the listing of most of California's coastal Chinook salmon (*Oncorhynchus tshawytscha),* Coho salmon (*O. kisutch)* and steelhead (*O. mykiss)* populations under the Federal Endangered Species Act (ESA)[1]. These listing decisions have been for populations or groups of populations that represent distinct Evolutionarily Significant Units (ESUs) (Waples 1991). In addition, one coastal species, coho salmon, has been listed under the California Endangered Species Act (CESA) **(Table 1 and Figure 1).** Because of the unique life-cycle of salmon and steelhead trout, and because they are sensitive to ocean and watershed conditions, there are numerous challenges to restoration and recovery. A broad spectrum of interest groups would like to see species recovery and delisting under both endangered species acts. Commercial, recreational and Native American harvesters are interested in these fish as they represent an important fishery and cultural resource. The general public wants to preserve them for educational and scientific purposes and because they represent an integral part of California's natural heritage. Governmental agencies and private landowners are interested in and concerned with them because of the special regulatory and permitting requirements that are associated with species protection and recovery objectives.

Table 1. Listing status of California coastal anadromous salmonids as of August 6, 2004

Species: ESU or DPS (ESA) or Population segment (CESA)	**Status**	**Effective Date of Listing or Action**
Coho Salmon		
ESA - Southern Oregon/Northern Calif. Coasts	threatened	June 5, 1997
ESA - Central California Coast	threatened	Dec. 2, 1996
CESA - South of Punta Gorda, California	endangered	In process
CESA - from Punta Gorda to Oregon Border	threatened	In process
Chinook Salmon		
ESA - Southern Oregon and Northern California Coastal	not warranted	Sep. 16, 1999
ESA - California Coastal	threatened	Nov. 15, 1999
ESA - Upper Klamath - Trinity Rivers	not warranted	March 9, 1998
Steelhead		
ESA - Southern California	endangered	October 17, 1997
ESA - South-Central California Coast	threatened	October 17, 1997
ESA - Central California Coast	threatened	October 17, 1997
ESA - Northern California	threatened	August 7, 2000
ESA - Klamath Mountains Province	not warranted	March 28, 2001
Coastal Cutthroat Trout		
ESA - Southern Oregon/California Coasts	not warranted	April 5, 1999

[1] Some Central Valley salmon and steelhead populations have been listed under the ESA and CESA. Monitoring of those populations is outside the scope of this document.

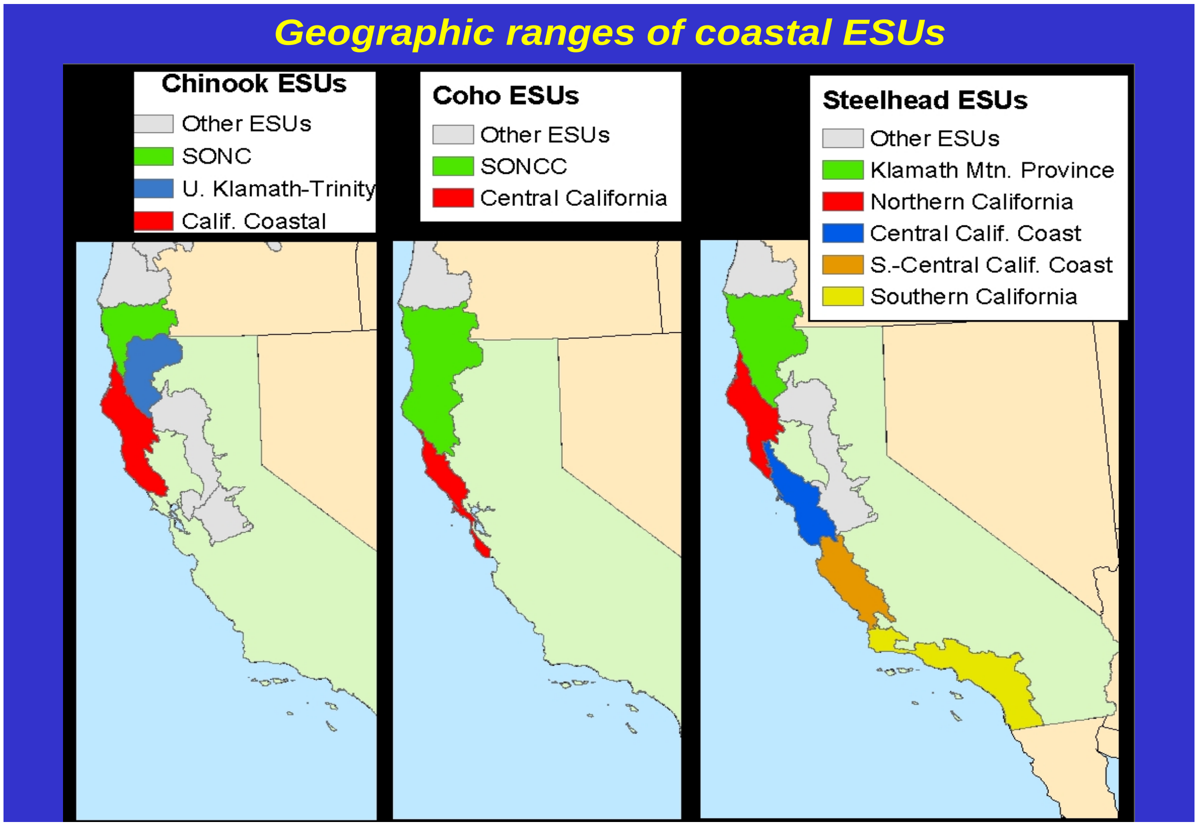

Figure 1. Geographic ranges of California and southern Oregon ESUs

The general way to delist or uplist (from Endangered to Threatened) a species is to demonstrate that it is not at risk of extinction. In the history of the ESA, sometimes the acquisition of additional data has been sufficient to show that a species is not at risk, even though thought previously to be at risk (see FWS 2004). In other cases, a substantial recovery effort must accompany the acquisition of data. At present, there are numerous data-gathering activities for salmonids in the coastal region. Most of these are at a local scale and do not meet the needs of ESA or CESA. This was shown at the recent round of "Status Review Updates" by NOAA Fisheries (NOAA) which cited lack of data on the status of coastal salmonid populations as an extensive problem that poses a risk to the fish in and of itself. Of the many risks faced by salmon and steelhead trout, only habitat degradation was as extensive.

Considerable amounts of time and money are spent by the DFG on habitat restoration activities, Federal Energy Regulatory Commission relicensing issues, water rights hearings, timber harvest plan reviews, streambed alteration proposals, Federal Habitat Conservation and State Natural Communities Conservation plans and regulatory actions to minimize fishery impacts or to list additional salmonid species under ESA or CESA. There is considerable optimism that these efforts will recover salmon and steelhead runs and preclude further listings. However, the actual recovery process (or insurance against the need for additional listings) will, in the end, require data to document improvements in status and trend which eventually signify recovery. Moreover, data will be critical to explain the *cause* of the improved runs, which, hopefully, will point to past habitat restoration efforts and other efforts aimed at maintaining or improving fish populations and their habitats. Increased fish returns will be good news in itself, but the condition and effect of freshwater, estuarine and ocean environments are other important variables that require careful monitoring and analysis.

A substantial flow of State and Federal money devoted to recovery of the State's coastal salmonid resources makes delisting more possible than with most other endangered species. In addition, the data gathered is expected to be useful for other aspects of fisheries management, such as Federally required Fishery Management and Evaluation Plans (FMEPs) and Hatchery Genetics and Management Plans (HGMPs) **(see Appendix A).**

Stock assessment scientists look to specific data sets when making their listing/delisting recommendations. These data sets typically relate to: (1) population abundance, (2) spatial distribution, (3) diversity characteristics (genetic, morphometric, behavioral, etc.) and (4) measures of intrinsic productivity (ability to sustain the population). Available data on these four parameters are used in the stock assessment process to determine whether a population is at risk of extinction and should be listed or not listed under the ESA. This suite of parameters (abundance, distribution, diversity and productivity) serves as the basis for and foundation of the Viable Salmonid Population (VSP) concept (McElhany 2000), an approach that is in widespread use by Federal and State stock assessment scientists. The VSP concept is discussed in detail in **Appendix B.**

The Coastal Anadromous Salmonid Monitoring Plan (Plan) described in this document is necessary because existing efforts to collect data are incomplete for some species in some areas of the State, thus do not meet the needs for conducting scientifically defensible risk assessment of ESUs. The Plan, if implemented, is expected to meet those needs. It has been vetted among numerous scientists as described below, and contains proposals that, if implement, will produce the VSP data sets necessary for credible delisting/listing decisions under the ESA and the CESA.

The DFG has reported to the California Fish and Game Commission that the collection of status and trend data for coho salmon on the ESU scale is important for recommending any future change in coho listing status under CESA. They have recommended the rapid implementation of a strategic, long-term population assessment and monitoring program for coho salmon and emphasized that the data are critical to documenting and achieving coho salmon recovery (DFG 2004).

Plan Development Approach

The approach used in writing the Plan was to: (1) hire knowledgeable individuals to write the Plan and develop the proposed statistical methods, (2) form a Plan steering and report writing committee (Steering Committee) and (3) conduct two workshops to gain scientific consensus on what the Plan should contain along with monitoring priorities for individual species and life history form. The recommendations were developed with the help of experts on salmon ecology, statistics and fishery and habitat management at NOAA, the DFG and various academic institutions. The experts provided input on (1) technical feasibility of implementing the recommendations in the field and (2) technical suitability of the resulting data sets for assessing extinction risk under the ESA and the CESA. Scientists involved in developing Federal extinction risk criteria and policy standards and in conducting State and Federal status assessments were centrally involved in the workshop and Plan writing processes.

Implementation and Scope

Once the Plan is implemented, it becomes the Coastal Anadromous Salmonid Monitoring Program (Monitoring Program), a program within the DFG. Generally, the DFG has the authority to conduct monitoring pursuant to the general State police power and its status as the trustee owner of fish and wildlife for the people of California, thus it is the appropriate lead agency.[2] The Monitoring Program will need: (1) continuing scientific oversight and (2) periodic evaluation to determine if it is meeting its intended goals and objectives. As will be shown, the Monitoring Program will require new administrative and considerable budgetary support for its implementation and sustained operations. The proposed Monitoring Program should be regarded as a long term investment that will produce meaningful data for some populations only after certain statistical issues have been resolved and several brood years of fish have been successfully monitored. The program must be given a high priority within the DFG. Once it is implemented, the loss of even one year of data can result in the loss of several years of data because of the protracted and variable age at spawning of individual cohorts of fish. The program may require several decades of continuous data collection before status and trend and habitat utilization analyses can be projected with a high degree of confidence for some populations.

Habitat condition monitoring, protection and restoration are essential elements of the salmonid recovery process for listed stocks. Habitat condition monitoring is an important and integral part of this Plan. Final listing or delisting decisions under the ESA and the CESA must consider the status of the spawning and rearing environment and efforts that are underway to protect or enhance those conditions. The DFG's coho salmon recovery strategy lists over 750 recovery actions needed to recover the species. These actions range from water rights acquisition to changing timberland management practices to various types of habitat restoration activities (DFG 2004). The current Plan does not extend to providing all of the information needed to show the viability of current habitat conditions or the effectiveness of current habitat protection and restoration activities. The protocols for conducting such evaluations are under development (B. Collins, DFG, pers.comm.) and when implemented will provide a more complete information base for ESA and CESA purposes.

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[2] *"The fish within our waters constitute the most important constituent of that species of property commonly designated as wild game, the general right and ownership of which is in the people of the state…, as in England it was in the king; and the right and power to protect and preserve such property for the common use and benefit is one of the recognized prerogatives of the sovereign, coming to us from the common law, and preserved and expressly provided for by the statutes of this and every other state of the Union."* People v. Truckee Lumber Co., 116 Cal. 397, 399-400 (1897).

PLAN GOALS AND OBJECTIVES

The Steering Committee, with review and assistance from workshop participants, developed the following Plan goals and objectives statement.

Plan Goal 1: Develop a monitoring plan for coastal anadromous salmonid populations and their habitats that meet California and Federal mandates for these species and that is scientifically sound and practical.

> *Objective 1*: Conduct workshops during 2004 involving knowledgeable scientists and individuals to agree upon program goals and objectives, sampling methods and procedures, and species management units. The policy and technical outputs from these workshops, which will contribute to, and eventually become elements of the Monitoring Program, must:
>
> > *Sub-objective 1a*: Address the monitoring needs for designated species throughout their ranges in the coastal zone with regard to population (1) abundance, (2) productivity, (3) spatial structure and (4) diversity ("VSP" attributes).
> >
> > *Sub-objective 1b*: Recommend regional area stratifications (species management units) for population and habitat status and trend monitoring and for monitoring the effectiveness of habitat restoration efforts.
> >
> > *Sub-objective 1c*: Meet quantifiable scientific standards and have the support of workshop participants.
> >
> > *Sub-objective 1d:* Develop estimates of operational and human resources needed to implement the plan.
>
> *Objective 2*: Produce written reports from each workshop that provide for adequate review by Workshop Participants and the Public and that document the basis for the final monitoring program recommendations.
>
> *Objective 3*: Forward the recommended plan to the State's Salmon Restoration Grant Coordinator by February 28, 2005.

Program Goal 2: Recommend an approach for coordinating California salmonid monitoring efforts both within the State and the Northwest involving interested monitoring and restoration entities.

> *Objective 1*: Develop a listing or source of listings, including contact information, of California entities currently or potentially involved in the monitoring of (1) California coastal anadromous salmonids, (2) Central Valley anadromous salmonids and (3) Northwest anadromous salmonids.
>
> *Objective 2*: Develop an operational strategy for coordinating coastal management activities with the entities identified under Goal 2, Objective 1.

WORKSHOP CONCLUSIONS AND RECOMMENDATIONS

NOAA and the DFG sponsored two workshops for the purposes of gaining scientific consensus on the content of and recommendations contained in the Plan. The invitation list included California Technical Recovery Team (TRT) members, invited speakers, and selected NOAA and DFG administrative and technical staffs. Workshop summaries are provided in **Appendix C**. Details of the workshop presentations, questionnaire results and draft monitoring plan documents, are provided at www.calmonitor.org. The conclusions and recommendations from the workshops are summarized below:

Workshop 1

1. A comprehensive coastal salmonid monitoring program is needed if listed populations are ever to be delisted and to show the effectiveness of recovery actions.
2. The Plan must cover all four coastal species [Chinook salmon, coho salmon, steelhead and cutthroat (*Oncorhynchus clarki clarki)*] and all coastal ESUs whether they are currently listed or not**.**
3. The Plan is needed for program implementation.
4. It may be strategic to implement the Plan in stages, but it will take the DFG 18-24 months to make any programmatic changes that require additional staff and/or budgetary resources.
5. Private land access issues and high stream flow conditions during the adult spawning periods will hinder the adult monitoring in most years when based on physical handling or counting of fish under natural conditions.
6. The land access challenge should be approached with an active public outreach program. [Oversampling may be used to find replacement sites due to land access denial but will lead to low (unmeasurable) confidence in the estimates].
7. Close coordination with other Pacific Coast monitoring and data management entities will be important for standardizing monitoring techniques and facilitating data sharing.

Workshop 2

8. For the more robust populations of fish (Functionally Independent Populations (FIPs)), the Plan should give highest priority to monitoring runs of adult fish of all species, not including cutthroat, each year for abundance and productivity data. Secondary attributes for monitoring include spatial distribution of juvenile fish, excluding Chinook salmon, and life history and genetic diversity of adult and juvenile fish.
9. For other populations types (Potentially Independent Populations (PIPs) and Dependent Populations (DPs)), the runs of adult fish of all species except cutthroat should be monitored annually for abundance data following a rotating panel approach built upon sampling watersheds (i.e., populations) from within individual ESUs and treated as a group. Secondary and tertiary attributes for monitoring include adult productivity, spatial distribution of juvenile fish and life history and genetic diversity of adult and juvenile fish.
10. For cutthroat, the monitoring should focus on abundance, diversity and spatial distribution of juvenile fish until more is known about them, particularly when and where smoltification occurs.
11. Live fish marking should be used downstream from adult spawning areas to monitor the adult salmon and steelhead runs wherever feasible. Intercept techniques (weirs, gill nets, seines) should be used to capture live fish for marking. Mark recapture sampling should occur in upstream

stream reaches following a rotating panel approach as part of the general spawning grounds surveys (conclusions 8 and 9) and at hatcheries or other facilities where mark recapture is already conducted. Experimentation with intercept techniques, particularly weirs and seines, should be high priority pilot study issues**.**

12. Spawning ground surveys should be conducted from Aptos Creek northward to develop ESU and individual population estimates. These surveys should include counts of live fish and redds and carcass mark-recapture sampling and should follow a rotating panel approach both within individual FIPs and among PIPs and DPs treated as a group in all years.
13. The sample frames for ESUs need development in terms of defining waters that support adult and juvenile anadromous fish (salmon and trout) and resident trout. The two trout forms are likely important to the overall productivity of individual stream systems, particularly from the Pajaro River southward. The relationships between steelhead and resident rainbow trout in the south and anadromous and resident cutthroat in the north are poorly understood**.**
14. It may be possible to fill data gaps caused by high stream flow events after several years of monitoring in the same or similar areas. Sonar testing should be a high priority pilot study issue**.**
15. Instream habitat condition sampling should be conducted concurrent to adult spawning grounds and juvenile rearing area surveys.
16. Life Cycle Stations need to be established to estimate ocean and river survival rates of individual species and broods of fish. These facilities need to be strategically located and designed to get total counts (or good estimates) of upstream migrating adults and downstream migrating smolts.

MONITORING PLAN

The Plan is presented in the following. It covers proposed monitoring areas; monitoring strategy by species, life history type and area; hatchery fish marking and creel census needs; habitat condition monitoring strategy; sample size recommendations and proposed sample site selection procedure. Where appropriate, workshop conclusions are presented as questions which are answered as Plan recommendations. The recommendations are used in the Administration and Budget section to support the Plan task and budget recommendations. The Plan statistical methods appear in **Appendix H**. The Plan proposes to stratify the coastal zone into Northern and Southern monitoring areas.

Northern and Southern Monitoring Areas

The monitoring program is proposed to follow different strategies from Aptos Creek northward and from Pajaro River and southward (**Figures 2A and 2B**). The northern area includes five listed ESUs and the State-listings for coho salmon**.** The southern area includes two ESUs, both listed **(Table 1 and Figure 1)**. The most important differences between the two areas are: (1) all four Plan species occur in the northern area with steelhead only occurring in the south, (2) the northern steelhead populations tend to be much larger in size with smaller inter-annual variability compared to the south, (3) the northern area has a much larger sample area than the south and (4) winter flows in the south tend to peak more sharply than they do in the north.

In the northern area, steelhead run sizes may reach a thousand or more fish in some years in the more productive waters such as the Klamath, Smith and Eel rivers. Even the smaller coastal streams probably support substantial runs in most years. Juvenile steelhead occur throughout many stream and lagoon systems. Coho salmon are probably not as abundant anywhere as they used to be, and their spawning densities within these areas are probably highly skewed with the largest concentrations representing very few fish in comparison to historic concentrations. Juvenile coho salmon abundance is known to be spotty with most of the rearing taking place in the less disturbed, cooler water areas. Chinook salmon primarily occur in the medium and larger river systems north of and including the

Mattole River. This species is known to spawn in relatively confined stream reaches. Juvenile Chinook salmon begin downstream migration immediately following emergence and enter the ocean in late summer or fall. Thus they depend on stream rearing conditions less so than the other species.

Cutthroat distribution is limited to the lower portions of tributary streams between the Eel and Smith rivers. Their distribution is slightly higher up in the Smith River compared to the other streams to the south. Generally, they occur in streams within 30 miles of the coast (**see Appendix E**.) Throughout the cutthroat area there is considerable hybridization of cutthroat and rainbow trout, particularly among resident forms of the two species. Anadromous adult cutthroat numbers are probably very small in most river systems, except the Smith River where the runs are more substantial in most years. Stream rearing cutthroat are the offspring of a mix of anadromous and resident adults. The cutthroat monitoring area is a sub-area within the Northern Monitoring Area.

At present nearly all southern steelhead populations are believed to be quite small, with run sizes well below 100 adults per year. Additionally, many systems probably do not exhibit regular annual runs, but only periodic runs during exceptionally wet years. One exception is the Carmel River where runs at the trapping station have been 600-1600 fish in recent years. Most steelhead populations in the southern area have probably always been small, particularly those inhabiting the many small coastal basins of southern Santa Barbara County and the Santa Monica Mountains and those that inhabited the watersheds south of Los Angeles. Various historic accounts suggest that there were once runs in the thousands for a few larger river systems, namely the Pajaro, Salinas, and Carmel River basins near Monterey and the Santa Maria, Santa Ynez, Ventura, and Santa Clara River basins clustered around Point Conception. Moderately large runs also probably occurred in the Big Sur River, Little Sur River, Arroyo Grande and possibly San Luis Obispo Creek and the Los Angeles and San Gabriel rivers. With the exception of the Carmel River, each of these basins is currently believed to support annual runs of fewer than 100 adults and in some cases, fewer than 10 or none at all. It is clear that the Plan must be designed to handle very small populations and highly variable run sizes as the rule rather than as the exception in the south.

The natural hydrologic cycles of the southern region pose a challenge to monitoring adult run size. Compared to the northern California coast and the Pacific Northwest, the southern region has fewer rainy days during the winter **(Figure 3A),** although the rainy days that do occur tend to have precipitation comparable to areas further north **(Figure 3B).** The consequence is that the discharge of southern California streams is more episodic than northern streams **(Figure 3C).** Note that winter discharge for Sespe Creek, depicted for the years 1991 and 1995 in **Figure 3C,** may increase by two to four *orders of magnitude* over the few days following a major storm event, while the more northerly streams increase by about one order of magnitude**.** High flow events in this region carry significant loads of silty and rocky debris that pose a variety of challenges for monitoring adult runs: flows would (1) tend to destroy portable weirs used for counting, (2) pose hazards to field crew conducting spawner surveys and (3) reduce the water clarity necessary for spawner surveys. Although all these problems occur in northern California, they are more pronounced in southern California. In addition, because flows tend to decline rapidly after a storm, there is reason to believe that steelhead tend to disproportionately migrate when the flow is high, precisely the time when monitoring is most difficult.

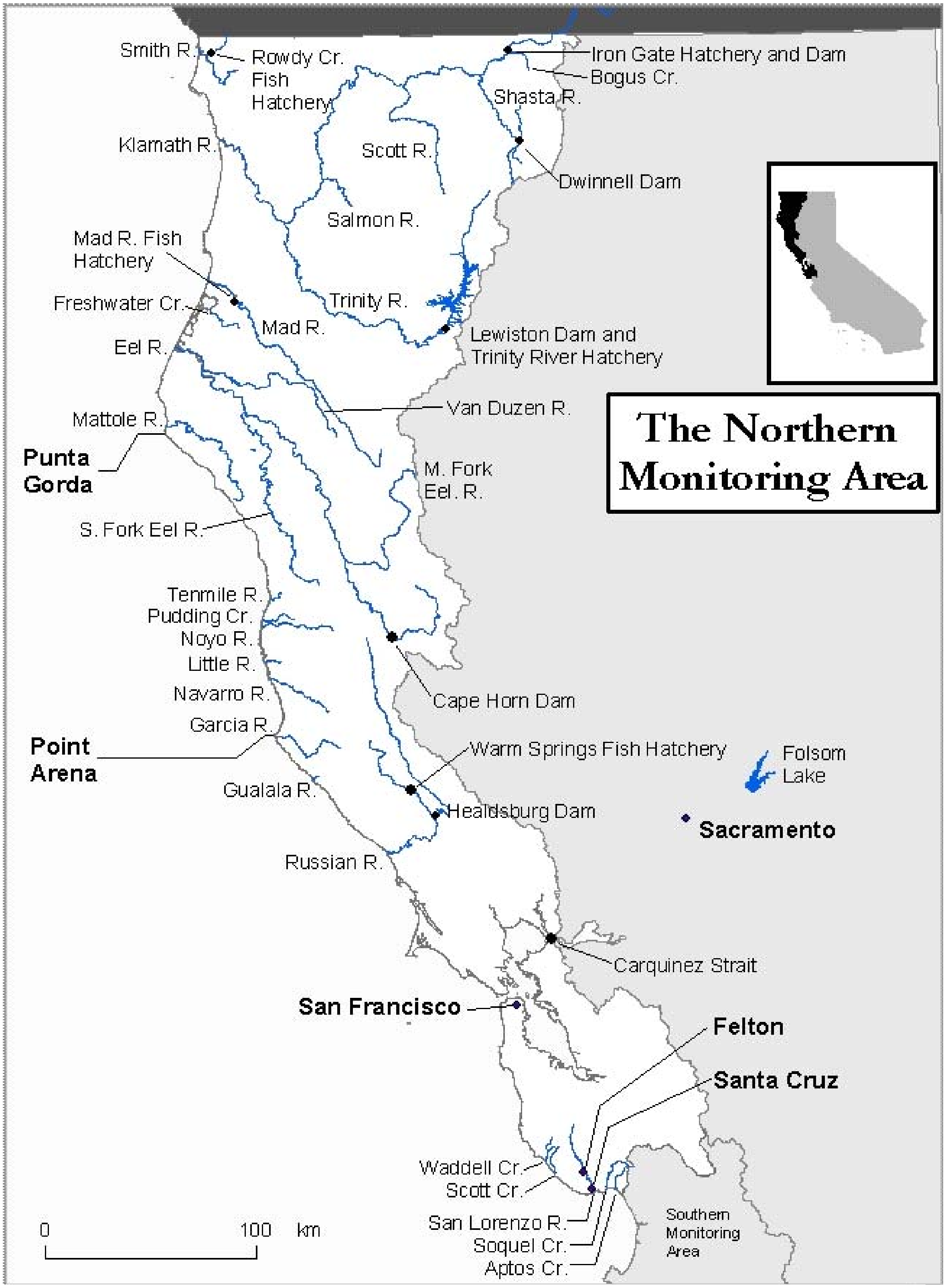

Figure 2A. Northern Monitoring Area location map

Figure 2B. Southern Monitoring Area location map

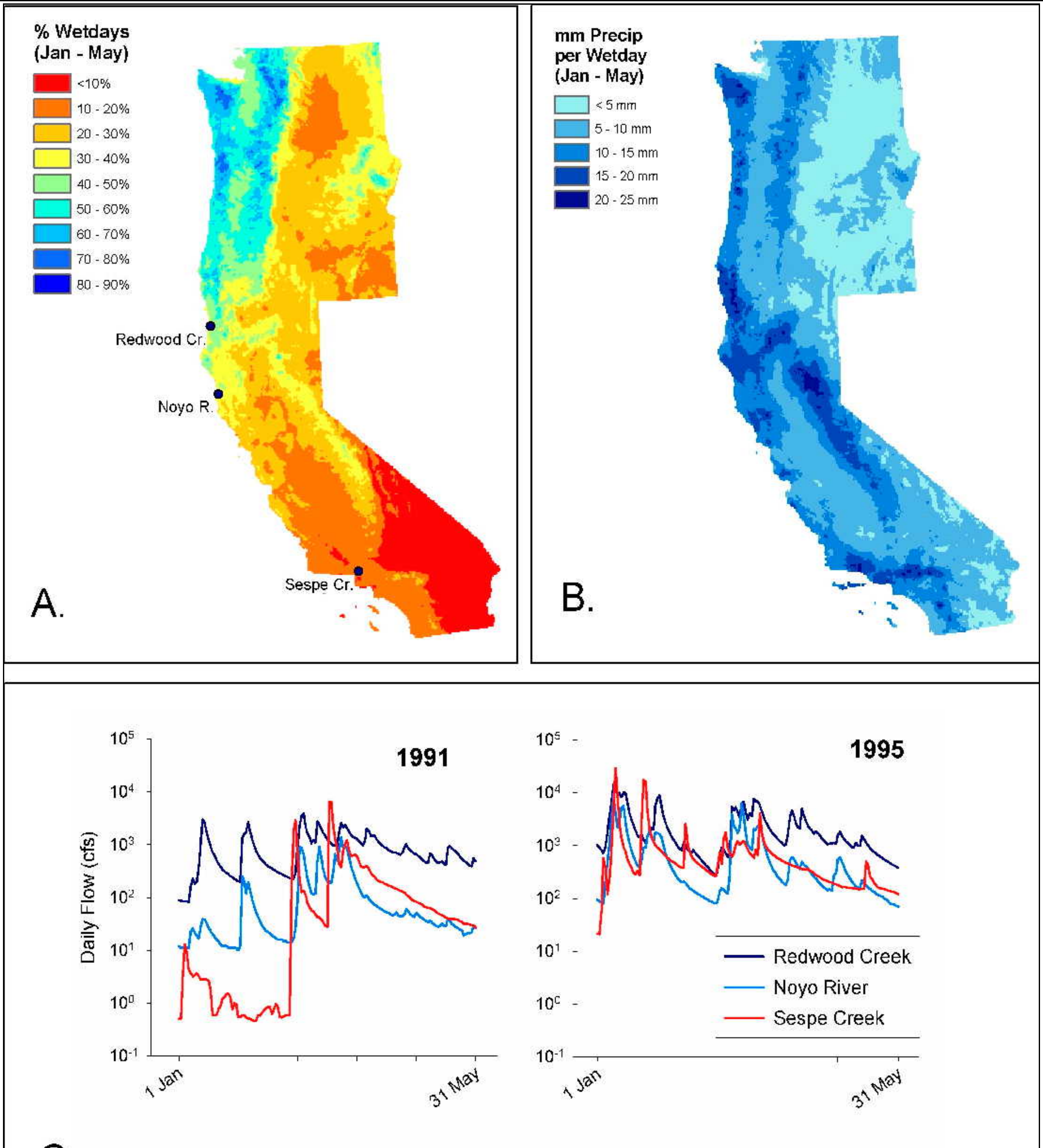

Figure 3. A) Average proportion of wet-days (days of precipitation) during the rainy season on the west coast, for the years 1961 – 1990. B) Average rainfall per wet-day during the rainy season, for the period 1961 – 1990. C) Example hydrographs for California coastal streams during a dry year (1991) and a wet year (1995). Data for A and B from Daly, et al. (1994); data for C from USGS.

Adult Monitoring

<u>Workshop question 1</u>: What is the status and trend in adult salmon and steelhead population numbers within ESUs and individual populations?

Spawning adult Chinoook salmon. DFG file photo.

There was general agreement that the best metric for assessing the status and trend of coastal salmon and steelhead populations is the number of adult fish spawning annually within populations and ESUs **(conclusions 6 and 7**). The adult metric represents the actual number of fish that are available to spawn and sustain the species. The states of Oregon and Washington also emphasize monitoring of spawning fish for assessing status of their Chinook salmon and coho salmon and steelhead populations (see **Appendix G** for a review of the monitoring programs in those states). The other options under consideration for assessing population status and trend were juvenile abundance and smolt abundance.

The juvenile abundance metric was assessed to be easier to measure compared to the adult or smolt metrics. Juvenile monitoring can be done during summer and fall months when stream flows are at their lowest and weather conditions are optimal for field surveys. The relationship between over-summering juvenile abundance and adult numbers has not been established but is known to be highly variable. Without a significant established relationship between summer juvenile abundance and adult abundance, it will not be useful for long term trend monitoring to rely upon juvenile abundance estimates for stock assessment purposes and could be very misleading. Juvenile monitoring is proposed as part of the Plan for the purpose of assessing spatial distribution of and habitat utilization by coho salmon and southern steelhead, but not for assessing the status of populations or ESUs.

Smolt abundance is the best metric for assessing freshwater rearing success of individual cohorts of fish, which is consistent with the view of the Washington Department of Fish and Wildlife (Crawford and Volkhardt (2004)). Use of smolt data to assess population status is problematic because of known wide variations in smolt ocean survival rates. Smolt monitoring is proposed as part of the Plan for the purpose of estimating freshwater and marine survival rates.

The one exception to the above was for cutthroat. For this species there was agreement that the juvenile abundance metric is important for the purpose of assessing population status (**Workshop conclusion 7**). Cutthroat display a variety of life history types and in California appear to depend more on resident adults than on anadromous adults for sustaining individual populations (see **Appendix E** for cutthroat life history description). There was agreement in the workshops that more information is needed on the distribution of cutthroat in freshwater and estuarine habitats, its relationship to resident and anadromous steelhead and the factors that trigger anadromy in the species.

The approaches considered for measuring adult salmon and steelhead abundance included: (1) counting fish at existing fishways, (2) counting fish using electronic technology and (3) conducting spawning ground surveys to estimate spawning adult abundance across populations and ESUs.

We conclude at the outset that fish counts collected at permanent fishways over dams or other such obstacles represent the most reliable means for monitoring adult run size data. These data should be collected in situations where the counts represent a major or relatively constant proportion of the run. Incomplete run size counts are difficult to interpret unless sampling is conducted to determine the proportion of the run that is actually being measured, which can be challenging and expensive.

Northern Monitoring Area

Existing Fishway Counts

There are four major fishways in the area where salmon and steelhead counts currently are made: (1) Cape Horn Dam on the upper Eel River, (2) Pudding Creek Dam on Pudding Creek in Mendocino County, (3) Noyo River Egg Collection Facility (NRECF), South Fork Noyo River, (4) Wohler Inflatable Dam on the lower Russian River and (5) San Lorenzo River Inflatable Dam (SRID) near Felton **(Table 2 and Figure 2A**). The Pudding Creek and Noyo River counts are probably fairly complete for their respective watersheds. The Cape Horn Dam counts are difficult to interpret because there is poor spawning habitat above the dam and variable stream flow conditions are know to affect the counts. The Wohler Dam count is usually incomplete for the coho salmon and steelhead runs. The City of Santa Cruz Water Department working with Monterey Bay Salmon and Trout Project counts the fish at the SRID. However, the Dam is deflated each year after enough steelhead have been collected to meet egg take needs of the local cooperative rearing program, thus it is an incomplete count in some or most years. There is a fishway in the middle of Healdsburg Dam on the upper Russian River, but the run is not counted. To do so would not have consistent meaning because a large and variable proportion of the Russian River salmon and steelhead runs spawn downstream from the Dam (B. Coey, DFG, pers. comm.). All five coastal hatcheries maintain annual salmon and steelhead counts, but those counts are not useful for assessing the status of naturally spawning fish.

Other Adult Monitoring Activities

The DFG has conducted basin-wide annual fall Chinook salmon monitoring in the Klamath-Trinity Basin since 1978. The program uses a variety of techniques to estimate the total basin run size. The data have been used to regulate ocean and river fisheries to meet court-ordered sharing of Klamath River fall Chinook by tribal and non-tribal fishing groups (see **Appendix A**). The DFG also monitors the spring Chinook salmon and steelhead runs in the Klamath-Trinity Basin using a marking weir in the upper Trinity River and snorkel surveys in the tributaries.

Carcass and live Chinook salmon counts are made annually by the DFG in Canon Creek, a tributary to the Mad River, and Sprowl Creek a tributary to the South Fork Eel River. The total Chinook salmon run size is estimated annually in Tomki Creek a tributary to the upper Eel River below Cape Horn Dam. The Middle Fork Eel River spring steelhead run is annually monitored by snorkel survey. Snorkel survey of spring run steelhead also occurs in the Smith River. There are small, usually incomplete Chinook salmon egg-collection projects on Hollow Tree and Redwood creeks, tributaries to the South Fork Eel River. Adult salmon and steelhead counting takes place annually in life cycle monitoring projects on Freshwater Creek, a tributary to Humboldt Bay, and is proposed in Scott Creek, a small coastal stream in Santa Cruz County (**Table 2**).

Table 2. Locations and descriptions of northern area adult salmonid monitoring activities				
System	**Stream**	**Dam**	**Notes**	**Status**
Smith	Various	none	Snorkel survey	Spring steelhead counts
Klamath	Bogus Creek	Low head dam	Fish counting and trapping facility	Annual Chinook salmon counts by DFG
	Shasta River	Fish counting weir	Fall Chinook salmon counts	Annually since 1930
	Scott River	none	Chinook salmon mark-recapture	Annually since 1978
	Salmon River	none	Chinook salmon mark-recapture	Annually since 1978
	Misc tribs	none	Redd counts	Annually since 1978
	Trinity River (Willow Creek)	none	Portable fish weir	Annual fall Chinook salmon estimates by DFG
	Trinity River (Junction City)	none	Portable fish weir	Annual spring Chinook salmon estimates by DFG
	Various	none	Snorkel survey	Spring Chinook salmon and steelhead counts
	Misc. tribs	none	Carcass surveys	Fall Chinook salmon estimates by DFG
Mad River	Canon Creek	none	Chinook live fish and carcass counts	Annually since 1981
Humboldt Bay	Freshwater Cr	none	Fish counting and trapping facility	Annual salmon and trout counts by DFG and HSU
Eel River	Middle Eel R.	none	Snorkel Survey	Annual summer steelhead counts by DFG
	Hollow Tree and Redwood creeks, SF Eel River	Flashboard dam with inserted fish traps	Fall Chinook salmon egg take	Inactive for several years.
	Sprowl Cr, SF Eel	none	Chinook live fish and carcass counts	Most years since 1975
	Tomki Creek, Upper Eel R.	none	Chinook salmon run size estimates	Annually since 1979
	Upper Eel R.	Cape Horn Dam	Pool-weir ladder	Annual salmon and trout counts by DFG
Pudding Creek	Pudding Cr.	Flashboard dam with inserted fish trap	Fish counting and trapping facility	Annual salmon and trout counts by DFG
Noyo River	South Fork Noyo River	SF Noyo Egg Collecting Station – Concrete weir and ladder	Fish counting, trapping, and spawning facility	Annual salmon and trout counts by DFG
Russian River	Lower Russian	Wohler Inflatable dam	Video	Annual salmon and trout counts by SCWA (Dam deflated at end of summer, incomplete count)
Scott Creek	Scott Creek	none	Portable fish weir	Annual salmon and trout counts by NOAA
San Lorenzo River	San Lorenzo R.	Water District Inflatable Diversion Dam	Fishway when dam is inflated	Annual salmon and trout counts by MBSTP (for egg take, incomplete)
DFG=Department of Fish and Game; HSU=Humboldt State University; NOAA=NOAA Fisheries; SCWA=Sonoma County Water Agency: MBSTP=Monterey Bay Salmon and Trout Project				

Carcass surveys are commonly used to monitor Chinook salmon

The adult salmonid monitoring program in the northern area has met the fishery and stock assessment needs for Klamath River fall Chinook salmon and some spring Chinook salmon and steelhead populations. The data have been geographically limited or non-existent for the other coastal Chinook salmon populations. Adult monitoring has essentially been non-existent for all coastal coho salmon and steelhead populations.

The need for a more comprehensive adult salmonid monitoring program in coastal California is the main reason the current State/Federal planning effort. The existing programs were never designed to assess stock status on the ESU scale as required under the ESA and CESA. It is assumed that the current coastal monitoring programs will continue and not need funding as part of this Plan.

Recommendation 1: Use existing facilities to count the runs and implement annual spawning ground surveys to estimate the runs in the Northern Monitoring Area

Complete steelhead counts could be obtained at the San Lorenzo River Inflatable Dam (SRID) with relatively little added cost. Limited spawning occurs in the San Lorenzo River downstream from this facility (K. Urquhart, DFG, pers. comm.). The SRID might require modification to protect it during high flows when floating objects could possibly puncture and deflate the dam. There are numerous other fishways in the northern area that could be retrofitted for use as counting stations, but most are located high up in the watersheds and likely not suitable for population assessment (S. Harris, DFG, pers. comm.).

There is a long history of Chinook salmon, coho salmon and steelhead counts at the Benbow Dam on the South Fork Eel River near Garberville. The dam and ladder were removed in 1976 after 38 years of operation. Since then a removable dam has been installed every summer to create a reservoir that was used primarily for recreation. The dam needs major repairs and has been out since 2000. The Department of Parks and Recreation has been in discussions with NOAA regarding impacts of the dam on listed coho salmon and steelhead.

There are areas where new electronic technologies could potentially be used to count the adult runs in the northern area, but it is proposed that, as a first priority, Monitoring Program funds be used to evaluate such devices in the southern area where options for monitoring adult steelhead runs are more limited. Counting fish using new electronic devices (such as the *Didson* acoustic camera) hold promise but more study is needed before their widespread use can be recommended. For the northern area, the proposal is to continue or expand fish counting at existing fishways and to conduct spatially balanced adult spawning ground surveys as explained below.

Adult abundance monitoring needs to satisfy two conflicting goals: (1) to have widely geographically distributed sampling to be representative of the entire ESU and (2) to have sufficiently dense sampling to provide high precision and accuracy levels. The widely geographically distributed sampling proposed below is essential so that the monitoring reflects the status and trend of these populations over the entire sampling area and not just one area or a group of local areas. The level of precision and accuracy controls the level of effect that the monitoring can detect. A low level means that one can only detect either a large change in the population size or can only detect small changes over a long time period. Neither of these conditions is desirable in a management context. Unfortunately, these goals are in conflict in any sort of resource limited sampling situation. The best solution is a two stage sample design which provides a widely distributed first stage adult survey and a more limited, but more precise, second stage mark-and-recapture or total fish count survey. The widely distributed first stage sampling then can be adjusted by the more precise second stage estimates to produce a more accurate estimate at lower cost.

Spawning Ground Surveys

Estimating adult population size in the northern area should primarily be done by conducting annual spawning ground surveys for both salmon species and steelhead. The proposal is to apply the Environmental Protection Agency's Monitoring and Assessment Program (EMAP) methodology for selecting spawning ground sample units (defined in a later section) in the Northern Monitoring Area. The EMAP methodology forces spatial balance of sampling points and uses a rotating panel design for selection of sample units (Stevens 2002). The EMAP design has been used in Oregon for estimating spawning population sizes of coho salmon since 1998 and steelhead since 2003 (see **Appendix G**). The samples units are proposed to be drawn using the EMAP approach from the entire northern area with no stratification by species or area. The EMAP approach results in spatially balanced samples, which allows for consistent post-season estimates of sub-area populations (e.g., ESUs, individual streams, special management areas). The alternative of estimating population sizes for individual streams or groups of streams has appeal from an operational and, perhaps, fishery management perspective, but may not provide information useful on a coast wide or ESU scale.

First Stage Sampling

Adult spawning numbers should be estimated for each sample unit by sampling throughout the spawning season for each species. Three methods are proposed to be considered for estimating adult spawner numbers within sample units: (1) redd counts, (2) live fish counts and (3) salmon carcass counts. In terms of personnel or equipment needs, there is minimal extra effort to collect data by all three methods. The efficacy of each method will vary with species, sampling conditions and spawner population size. The DFG will need to determine which methods to use by species and area after a few years of field experience and data analysis. A review of the Oregon and Washington adult monitoring methods (**Appendix G**) showed the following:

1. redd counts is the primary method used for all three species in Washington and steelhead in Oregon,
2. live fish counts are used for coho salmon in Oregon and in some Puget Sound streams,
3. carcass counts are used in turbid streams in Washington,
4. live fish and carcass counts are used for Chinook salmon in Oregon, and
5. carcass mark-recapture sampling is not currently used in either State.

The methods used to expand or interpret the data vary between states, streams and species, although there were some similarities.

Redd Surveys

A typical redd survey methodology consists of counting redds and marking them to avoid recounts on successive surveys, then summing them for the season for a total count (Rieman and Meyers 1997). An estimate will need to be made about the combined number of males and females per redd.

Washington assumes each redd represents 2.5 spawners for Chinook salmon, coho salmon and steelhead (Bruce Sanford, WDFW Chinook Salmon Coordinator, pers. comm.). The redd estimation procedure is not as dependent on fixed timing of surveys, which is important considering the size, frequency and duration of California winter storms. Redd counts are the least intrusive method of surveying salmonids (Dunham et al. 2001). However, redd survey have uncertainty due to problems of identification of redds (both as a redd and then by species) and in converting redd counts to spawner escapement (number of females per redd and sex ratio between males and females). Also, redd superimposition introduces bias at higher fish densities (Lestelle and Weller 2002). Approaches using logistic regression have made improvements in redd identification (Gallagher and Gallagher in press.), but converting redd counts to spawners tends to have a great deal of natural variation and have yet to be investigated in California. Gallagher and Gallagher (ibid) investigated converting redd counts to spawners and found the estimates from redd data were not different than those obtained by other methods.

Live Fish Counts

Coho salmon on redd. DFG file photo

Repeated live fish counts or redd counts over time are commonly analyzed using Area Under the Curve (AUC) methodology. (English et al. 1992). It is the method used in Oregon coho salmon surveys. The AUC methodology uses live spawner counts over time and integrates the counts with the total area as the number of total "fish-days." The total number of fish-days is divided by the estimated residence time of fish in the area to give an estimate of total fish. Oregon assumes the average stream life for adult coho salmon is 11.3 days (Jacobs et al 2002). The AUC and redd count methods require some form of sample design to apply the sample over an area to expand individual reach abundances over the larger area. The AUC live fish survey methodology has uncertainty issues associated with it. Visual observations tend to underestimate live coho salmon presence compared to redd counts at low and moderate densities (Lestelle and Weller 2002, Gallagher and Gallagher in press) leading to an inherent negative basis in total escapement that appears to be proportionately larger at lower abundance levels. Also, residence time can change in a directed manner, decreasing as mortality increases later in the season. Failure to account for this can lead to substantial bias in the AUC total escapement estimates (Szerlong and Rundio 2004, in prep.). Studies using weir counts for validation have shown that population estimates from redd and AUC surveys were both below but within 20% of the weir counts (Lestelle and Weller 2002, Gallagher and Gallagher in press). Lestelle and Weller (2002) and Gallagher and Gallagher (in press) show that redd counts are significantly related to adult escapement.

Salmon Carcass Counting

A gaff, hog rings and machete are commonly used tools in Chinook salmon carcass surveys. DFG file photo.

Salmon carcass survey methodology is used in California to estimate spawning populations of fall Chinook salmon in the Central Valley and the Klamath River. It involves tagging of salmon carcasses, sampling for tagged carcasses and recording tagged carcass recoveries. This is done periodically throughout the spawning season. A stratified Petersen estimator (Schwarz and Taylor 1998) sometimes called a Schaefer estimate after its first user (Schaefer 1951) has historically been used in the Central Valley to analyze carcass tagging and recovery data. In these surveys, only "fresh" carcasses are used for tagging, assuming they are reasonable surrogates for live fish. Stratified Petersen estimators provide consistent unbiased estimates of the run totals and run components, but have the drawback of having a great number of parameters to be individually estimated (Schwarz el al. 2002). Often with small populations or low recapture rates, the data are analyzed using a pooled Petersen estimator (Seber 1982). A pooled Petersen estimate uses the data as if they were a single survey and gives a more precise estimate of the total population since it reduces the number of parameters that need to be estimated. However, it can be severely biased if its underlying assumptions are violated; in particular, if there is not complete mixing of tagged and untagged carcasses or if capture or recapture probabilities are not homogeneous. The Jolly-Seber method (Seber 1982) best meets the conditions for estimating salmon carcass numbers (Law 1994). The Jolly-Seber method estimates population (carcass) recruitment and mortality (removal) between tagging and recapture periods throughout the spawning season. The model depends on the initial recovery of tagged carcasses over two or more successive recovery periods in order to estimate the removal rate of tagged carcasses between recovery periods (Boydstun 1994). Lacking a complete data set, an assumption has to be made about the carcass removal rate between recovery periods. Capture-recapture of carcasses appears to work for Chinook salmon, but does not work for steelhead. Gallagher and Gallagher (in press) state it appears not to work in small sections of streams for coho salmon and, when it does, it underestimates escapement relative to other techniques.

Chinook salmon carcass and live fish counts are made annually in coastal Oregon index streams and are used as an index of spawner abundance for between year comparisons (Jacobs et al 2002). Oregon coastal escapement goals and population assessment methodologies are under review and are expected to change upon completion of this process (PFMC 2004). In Washington, Chinook salmon carcass counts for certain turbid streams are compared to historic carcass/redd count data to estimate total redds and total spawners (Bruce Sanford, WDFW Chinook Salmon Coordinator, pers. comm.).

Second Stage (Calibration) Sampling

Additional data are needed to calibrate sample unit abundance estimates. This is done by comparing known counts with estimates using the above methods (redds, live fish, or carcasses). In particular, for the redd surveys, the calibration sampling will give both local and seasonal information about the expansions, number of females per redd and the male to female sex ratio.

The options available to do the second stage monitoring include: (1) use existing counting stations (see **Table 2**), (2) use life cycle monitoring projects (Scott Creek; Freshwater Creek) and/or (3) conduct intercept sampling to mark and release live fish to mix in upstream spawning areas where spawning ground surveys are being conducted. Under Option (3), the marked fish would serve to estimate the efficiency of the spawning ground surveys.

Southern Monitoring Area

Southern steelhead adults are very difficult to sample because of low numbers of fish and difficult sampling conditions. NOAA file photo.

There are major challenges in monitoring adult steelhead in the southern area. The information base for the fish is very limited for most of the runs, including when and where they spawn, although this could be resolved with a set of reconnaissance studies. More problematic is the possibility that the amount or location of spawning areas may vary from year to year as a function of local flow conditions, which are sensitive to inter-annual climate variation as well as up-slope geologic processes. Thus our ability to count or sample adult steelhead in the Southern Monitoring Area is confounded by the unpredictable shifting of steelhead spawning locations coupled with the small number of spawners available for sampling. The one exception in the southern area is the Carmel River, which continues to support a substantial steelhead run in most years.

Portable weirs have been discussed as a possible tool for counting or estimating the southern steelhead runs. It was determined that portable weirs would likely have limited usefulness in the southern area because: (1) the few steelhead that inhabit these streams are know to move upstream and spawn on high flows when portable weirs usually have to be removed and (2) chances were considered remote for tagging and sampling a sufficient number of steelhead for making a meaningful population estimate because of the very small run sizes (**Table 3**). The proposal for the Southern Monitoring Area is to obtain adult counts at existing or proposed fishways where possible and to conduct evaluations of the latest electronic technology for counting the runs.

Recommendation 2: Use existing facilities and experiment with electronic devices to count southern steelhead runs

There are many parts of the seven core basins that historically served as important spawning areas, but that are isolated behind dams lacking fish passage **(Table 3).** Recovery of steelhead in the Southern Monitoring Area will probably require the restoration of fish passage at some subset of these dams. If fishways are constructed at any of these sites, the adult runs must be monitored.

<u>*Existing Fishways*</u>

Data collected at permanent fishways over dams, etc., appear to offer the most reliable means for monitoring run size and should be used whenever possible provided the counts represent a major portion of the run. Of the seven watersheds recommended for adult monitoring, three have permanent dams with fishways useful for monitoring **(Table 4**). The Carmel River has a working fish ladder on San Clemente Dam. Since the early 1990s the Monterey Peninsula Water Management District has monitored the number of adults ascending the ladder each year. These data are currently available on the District web site. The dam and ladder are 16 mi from the ocean. A large portion of the run spawns below the dam (K. Urquhart, DFG, pers. comm.). The Santa Clara River diversion dam and fish ladder are operated by the United Water Conservation District in the vicinity of Saticoy which is downstream of all known major spawning areas in the basin. However, this facility is not currently operated under a Biological Opinion, and the release schedule and fish pass efficiency of this facility have not been demonstrated. A fish ladder is being constructed at the Robles Diversion Dam on the Ventura River in the vicinity of Meiners Oaks. This facility could serve as the core of a monitoring effort on the Ventura River, but might require auxiliary monitoring downstream of the Dam and in San Antonio Creek to get a total estimate. Thus, two of the three Fishways in the Southern Monitoring Area represent an unknown proportion of the respective runs, which makes it even more imperative that ways or means of monitoring the southern steelhead runs be developed.

Table 3. Sample level requirements to reach 95% precision level in mark-recapture studies (from Robson and Regier 1964)

		Run size=100		Run size=30		Run size=10	
		Required capture rates		Required capture rates		Required capture rates	
Desired accuracy	Mark-recapture scenario	At weir	At Spawning	At weir	At Spawning	At weir	At Spawning
Low (± 50%)	Efficient weir*	90%	4%	90%	13%	90%	30%
	Equal capture rates	33%	33%	50%	50%	60%	60%
Medium (±25%)	Efficient weir*	90%	10%	90%	20%	90%	40%
	Equal capture rates	44%	44%	60%	60%	70%	70%
High (± 10%)	Efficient weir*	90%	35%	90%	50%	90%	62%
	Equal capture rates	65%	65%	73%	73%	80%	80%

* Efficient weir is defined as a weir at which 90% capture rate can be achieved.

Table 4. Status of southern steelhead counting facilities			
A. Monitoring recommended at existing fishways			
System	**Stream**	**Dam**	**Notes**
Carmel	Carmel River	San Clemente	Counts done by Water District
Ventura	Ventura River	Robles Diversion	
Santa Clara	Santa Clara	Freeman Diversion	
B. Monitoring recommended should fish passage be restored			
System	**Stream**	**Dam**	**Notes**
Salinas	Nacimiento River	Nacimiento	One of four major spawning areas in basin
Salinas	San Antonio River	San Antonio	One of four major spawning areas in basin
Santa Maria	Cuyama River	Twitchell	
Santa Ynez	Santa Ynez	Cachuma	
Ventura	Coyote Creek	Casitas	
C. No existing counting facility			
System	**Stream**	**Dam**	**Notes**
Pajaro	Pajaro River	none	
Salinas	Arroyo Seco	none	
Salinas	Salinas tributaries upstream of Paso Robles	none	
Santa Maria	Sisquoc River and tributaries	none	
Santa Ynez	Tributaries below Cachuma Dam	none	
Ventura	San Antonio Creek and mainstem below Robles Dam	none	

Electronic Counting Devices

Acoustic cameras are a new technology developed for underwater scouting and mine detection by the US Navy and recently adapted to fisheries monitoring by the Alaska Department of Fish and Game (ADFG). *Didson* acoustic cameras are commercially available and are increasingly being used to count anadromous salmonid runs. The device is a high-frequency sonar system with a lens capable of focusing sound waves onto a high-resolution sensor array. It is self-contained and operates much like a video camera except that it processes reflected sound rather than reflected light. The resulting acoustic image is grainy compared to light-based images, but is a considerable improvement relative to the older-style sonar units. This unit can be operated much like a video camera and requires little training to use (D. Burwen, ADFG, pers. comm.).

The potential utility of the *Didson* camera for monitoring steelhead runs in southern California results from the following: Like a video image, the sonar image is detailed enough to identify and count fish swimming through the beam, but unlike a video camera the unit can detect images in opaque water during high-flow events, and unlike a weir the unit need not straddle the stream thereby making the installation of a weir unnecessary. Thus, it has the potential to provide complete steelhead counts during peak southern California flow events. Additional discussion about the *Didson* camera technology is provided in **Appendix I.**

The *Didson* camera has great promise for solving the problem of obtaining counts during high-flow events, and obtaining unbiased estimates, but it is new enough that we do not know if the promise will bear out in practice. Thus we recommend experiments on its usefulness.

Life Cycle Monitoring

***Workshop question 2*: What is the effect of freshwater and marine survival conditions on adult returns?**

An important component of the Plan is complete life cycle monitoring. Life cycle monitoring is necessary to understand the results of larger scale adult abundance sampling **(Workshop conclusion 16)**. Adult abundance is the result of the survival occurring through all life stages from egg deposition to spawning adults. While adult abundance sampling provides the level of abundance and its trajectory, it does not show at what life stages changes are occurring. That information is essential to understand why a population is changing and how much natural variation in annual adult abundance can be expected.

There are two goals of life-cycle monitoring.

1. *The first goal* is to determine where the majority of variation in overall survival from eggs to spawning adults occurs. This will primarily focus on estimating overall freshwater and marine survival.
2. *The second goal* encompasses the first goal while also investigating habitat-fish productivity relationships and habitat restoration effectiveness. If the association between survival at successive life stages and associated habitat and environmental conditions can be determined, this information can be used to target recovery and restoration actions which can be used to improve survival at specific stages in the fish's life cycle.

The following questions should be asked in life cycle monitoring studies: (1) Are trends in coastal adult salmonid abundance due to changes in freshwater and/or marine survival? (2) Are freshwater and marine survival rates related? (3) Are there geographical patterns in survival rates? and (4) Are survival rates at various life stages related to habitat and environmental conditions?

Recommendation 3: Establish life cycle monitoring stations at strategic locations

Objectives and Procedures

Objective 1: Determine whether trends in coastal salmonid abundance are due to changes in freshwater or marine survival.

The basic sampling will include trapping and counting of upstream migrating adults and trapping and counting of emigrating juvenile fish. Life Cycle Monitoring Stations (LCSs) must be located in watersheds where accurate estimates of numbers of spawning adults and their smolt production will be possible with high confidence in the estimates. Freshwater survival can be calculated as the proportion of eggs of the same brood year that survive to enter the sea. For steelhead, scale samples will be needed from smolts to estimate the proportion of each brood year of steelhead that is represented in the steelhead smolt migration each year. Marine survival encompasses all life stages from the time the fish pass the out-migrant trapping site until the time their spawning escapement is measured. This includes lower river migration downstream of the juvenile trapping site, estuary or lagoon rearing, ocean rearing and upstream migration to the adult trapping site. Marine survival is calculated as the proportion of smolts of the same brood year that survived to return to the river as spawning adults. Scales must be taken from migrating fish to estimate returns by brood year. Comparisons over several years will provide data to determine whether trends in coastal salmonid abundance are due to changes in freshwater and/or marine survival. The locations of these types of studies are somewhat fixed in that not all streams are suitable for adult and juvenile trapping operations. Annual review of the Monitoring Program may lead to inclusion of additional locations or deletion of original locations.

Objective 2: Determine whether freshwater and marine survival rates are related. This objective could be achieved by the data collected to meet Objective 1.

Objective 3: Determine whether there are geographical patterns in survival rates. This objective could be achieved by comparing data collected to meet Objective 1 at two or more LCSs.

Objective 4: Determine whether survival at various life stages correlate with habitat and environmental conditions.

To address **Objective 4**, additional freshwater life stage survival rates and habitat and environmental limiting factor variables must be measured and compared. Survival of eggs to fry is affected by sediment deposition in spawning substrate, water temperature, stream flow and spawning competition. Determination of average survival rate from egg deposition to fry emergence would have to be made. This could be done by making total redd counts, determining the relationship between the number of redds and number of females and estimating the number of eggs deposited based on average female size and size/fecundity relationship (see Lawson et al. 2004).

The Freshwater Creek Weir located near Eureka is used to count adult salmonids and trap their juvenile outmigrants. DFG file photo.

Survival from eggs to fingerlings is affected by all the factors limiting egg to fry emergence plus water temperature, stream flow, food availability, feeding competition and rearing space and quality. Survival from eggs to fingerlings could be determined using the various mid-summer juvenile abundance estimation procedures available (see Duffy et al. 2003). Survival from fingerlings to smolts is affected by all the factors limiting egg to fingerling production, plus factors affecting summer through over-winter survival such as suitable rearing habitat, food supply, the availability of low velocity refugia and low winter water temperatures. Survival from fingerlings to smolts would be estimated by comparing mid-summer juvenile estimates with smolt abundance estimates at the LCS.

Monitoring Station Criteria

The locations for LCSs must take into consideration a variety of factors both physical and ecological. The Oregon Department of Fish and Wildlife has developed criteria for locations of Oregon LCSs **(see Appendix G**). These criteria have been modified for California as follows:

1. There should be a wide geographic spread of LCSs, but their locations should take into consideration the proximity of offices where staff can be headquartered and the work sites. The DFG has coastal offices in Arcata, Yreka, Redding, Eureka, Fortuna, Fort Bragg, Santa Rosa, Yountville, Santa Cruz, Monterey, San Luis Obispo, Santa Barbara, Long Beach, Los Alamitos and San Diego where field crews could be based.
2. Two persons should be used to service adult and juvenile fish traps. Paired sites should not be more than a 30-minute drive apart so that trap watchers can cycle between traps during high streamflows. This is particularly important during smolt trapping. Trapping sites do not necessarily need to be within 30 minutes of the field crew office if travel trailers, or some other means of housing, can be arranged.
3. Fish populations should be stable and good habitat conditions should exist (reference watersheds). Locating LCSs in reference watersheds and focusing on estimating spawning escapement and freshwater and marine survival will enable us to address questions 1-3 above. In order to address question 4, additional freshwater life stage survival rates and habitat and environmental limiting factor variables will need to be measured.
4. Candidate streams must have substantial spawning populations above the trapping sites with species compositions by area as follows:
   - Smith River to Mattole River: coho salmon and steelhead and, where possible, Chinook salmon and cutthroat,
   - Usal Creek to Aptos Creek: coho salmon and steelhead and, where possible, Chinook salmon, and
   - Pajaro River to Tijuana River: steelhead.
5. To maximize the number of fish sampled, streams should be as large as trapping technology allows.
6. Existing fish ladders should be used where possible as adult trap sites. This will reduce construction costs and enable more adult traps to be operated, improving the geographic range of the monitoring effort.
7. Sites must be of sufficient depth and of sufficient velocity at low spring stream flows to allow operation of a smolt trap (or the site must be amenable to modification to meet these criteria). The site should also be neither too constrained nor of such high gradient that the smolt trap will be damaged due to excessive water turbulence, or be so unconstrained that the stream becomes too wide and slow for efficient trap operation during high stream flows.
8. LCSs located high up in the basin will require estimation of downstream freshwater mortalities, thus will be more costly than sites located near the ocean.
9. Land owner willingness to allow access to site must be secured for long term (> 10 years) monitoring.
10. Candidate streams without existing fish ladders need to have sites with the following characteristics to enable the installation of adult trapping facilities:
    - 1-2 percent gradient.
    - Road access needs to be close enough for delivery of materials needed to construct weir.

A listing of existing adult trapping or counting facilities is provided in **Table 5.**

Table 5. Existing or potential adult trapping or counting facilities available for potential use in Life Cycle Monitoring studies						
Area	**Basin**	**Stream**	**Type**	**Miles to Ocean**	**Species**	**Notes**
Northern	Smith	Rowdy Creek	Foundation weir	5	All plus chum	Major hatchery influence
	Klamath	Shasta R	Foundation weir	170	CH some CO & SH	DFG operation would need to be extended for Co, Sh
		Bogus Cr.	Low head dam and fishway	190	CH some SH	Operation would need to be extended for Co, Sh
		Trinity	Portable weir	60	CH some CO & SH	Will blow out
	Humboldt Bay	Freshwater Cr.	Foundation weir	2	All	Existing LCS
	Eel R.	SF Eel @ Benbow	Removable dam	80	CH, CO, SH	Dam out since 2000
	Eel	SF Eel @ Redwood Cr.	Portable weir	70	CH some CO & SH	Restoration project. Will blow out
		SF Eel at Hollow Tree Cr.	Portable weir	100	Ch some CO & SH	Restoration project. Will blow out
	Coastal	Pudding Cr	Flash board dam and fish trap	0.25	Co, SH	DFG study stream
	Noyo R.	SF Noyo Egg Collection Station	Low head dam	10	CO few SH	DFG operation
	Russian Basin	Wholer Dam, Lower Russian R.	Inflatable dam	23	CO & SH	Subject to blow out
		Healdsburg Dam, Middle Russian	Fishway	32	CO & SH	Not designed for counting
	Coastal	Scott Cr.	Portable dam	1	SH	NOAA study stream. Very small stream
	San Lorenzo	Felton Dam	Inflatable dam and fishway	6	SH	Subject to blow out
Southern	Salina R.	New facility.	Inflatable dam and fishway	?	SH	Under construction. Subject to blow out
	Carmel R.	San Clemente Dam	Dam and fishway with trap	16	SH	Existing adult trapping operation
	Ventura R.	Robles Diversion	Dam and fishway	14	SH	Under construction.
	Santa Clara R.	Vern Freeman and Harvey dams	Dam and fishway	9	SH	Fish not being monitored

Permitting

Sponsors of adult trapping operations will need to apply for and obtain permits to comply with various State and Federal laws. Permitting can be a very lengthy process and should be started a year or more before trapping is proposed to be started, depending on the size and potential impact of the proposal. Any operation proposing to affect a large part of a run or that may impact a highly visible area of the coast should probably be started two years before the trapping is proposed to be started.

The potential permitting agencies include: Army Corp of Engineers, Regional Water Quality Control Boards, County Planning Offices, Coastal Commission, DFG Regions and NOAA Fisheries. The California Department of Parks and Recreation and the National Parks Service regulate activities within State and Federal parks, respectively. The DFG may require that trapping operations not substantially alter the stream bed, delay adult upstream migration or impeded downstream migration of spawned out steelhead. NOAA will be concerned with trapping affects on adult and juvenile fish and will require the application of specific conservation measures if ESA species are involved.

Other Uses of Life Cycle Stations

LCSs are intended to investigate the variation in marine and freshwater survival rates and the affect of habitat conditions on juvenile survival. LCSs may also be valuable for evaluating (calibrating) the accuracy of spawner survey methods (AUC, redd counts, salmon carcass counts).

Application of coded wire tags (CWTs) to hatchery fish releases has allowed the DFG and others to reconstruct the life histories of release groups of fall and spring Chinook salmon from Klamath Basin hatcheries since the early 1980's. The proposed LCSs may be useful for collecting and applying CWTs to coastal Chinook salmon for use in estimating ocean fishery impacts and for estimating cohort age-specific survival and maturity rates using cohort reconstruction methods.

Juvenile Fish Monitoring

<u>Workshop question 3</u>: What is the extent of habitat utilization by juvenile coho salmon, cutthroat and southern steelhead trout and the trend in abundance of cutthroat?

Juvenile monitoring for evaluating spatial distribution of fish within ESUs is important for coho salmon, steelhead and cutthroat, but less so for Chinook salmon (**Workshop conclusions 6 and 7**). There was agreement within the Steering Committee that northern steelhead are fairly widely distributed in the northern basins but not in the south where steelhead/rainbow trout distribution is more varied. Chinook salmon are not recommended for spatial distribution sampling because these fish begin ocean migration soon after emergence and leave freshwater by late summer or early fall. Thus their spatial distributions in streams are generally determined by the distribution of spawning adults and their outmigration timing.

The one species that was recommended for juvenile abundance monitoring (plus diversity and spatial distribution sampling) was cutthroat **(Workshop conclusion 7).** For this species, there was agreement that the juvenile abundance metric would be more useful than the anadromous adult run size metric. This is because better information is needed on (1) cutthroat relationship to steelhead trout, (2) factors that trigger anadromy in the species and (3) importance of anadromy in sustaining the species. Some believe that cutthroat have limited dependence upon anadromy and that anadromous run sizes may have little or no relevance to sustaining the species.

Recommendation 4: Conduct juvenile coho salmon and southern steelhead presence-absence and cutthroat abundance monitoring

The proposal for juvenile salmonid monitoring is to apply the Environmental Protection Agency's Monitoring and Assessment Program (EMAP) methodology for selecting sample units. The EMAP methodology forces spatial balance of sampling points and uses a rotating panel design for selection of sample units (Stevens 2002). The EMAP design has been used in Oregon for monitoring juvenile coho salmon since 1998 (see **Appendix G**). As will be explained, samples are proposed to be drawn using the EMAP approach from within each monitoring area. This will allow for post-season estimation of sub-area populations such as ESUs and individual stream populations. The alternative of estimating species presence for individual streams or stream groups has appeal from an operational standpoint, but may not provide information on the coast wide or ESU scale.

Coho Salmon and Southern Steelhead Distribution Monitoring

Electrofishing is used to detect species presence. DFG file photo.

Presence/absence monitoring is a technique wherein species occurrence in a stream or stream reach is determined to provide a regional estimate of occupancy. This approach, targeting juvenile fish in summer or early fall, is operationally simpler and cheaper than sampling adults. Sampling for juvenile coho salmon and southern steelhead may need only occur once or twice in a season, while adult sampling is necessary once a week (or so) over the entire spawning season, which may last 2-3 months, depending on the species. Spatial distribution sampling is a useful recovery monitoring method both because it measures distribution across habitats and often gives the only assessment over the entire geographic range of critical habitat areas. Spatial distribution sampling can also be used to assess the reestablishment of a species at unoccupied streams within its range.

The DFG used juvenile coho salmon presence/absence data to support its recommendation to list coho salmon north of San Francisco under the CESA and has proposed to use spatial distribution data in the future to assess coho salmon population status (DFG 2004). The DFG methodology was based on sampling individual streams (named creeks) starting at the stream mouth (B. Jong, DFG, pers. comm.) and working upstream in a prescribed manner. The sampling was limited to streams determined to be suitable for juvenile coho salmon rearing. The EMAP approach differs from the stream-based approach in that it forces geographic balance in the areas selected for monitoring.

New sampling and statistical techniques, developed by North Carolina State University and Humboldt State University, allow for assessment of presence/absence at a known confidence level (Webster and Pollack 2000). This type of sampling targets juvenile fish and is conducted during the late spring through early fall. Each sample reach is visited once per year starting at the lower end to determine whether the target species is present. Electrofishing and/or snorkeling are/is used to detect species presence. If not detected in the first sample area, additional samples are taken working upstream.

There may be other or new presence/absence approaches to consider. The key issue is that presence/ absence data have an inherent bias. Observed presence means actual presence, unambiguously, whereas observed absence (i.e., you looked for the fish but didn't find it) can mean absence, but it can also mean presence combined with detection failure. Thus, presence/absence data will always tend to make the fish look rarer than it actually is, and the job of the statistical model is to either estimate the size of this bias, or tell how much sampling effort must be expended to make the bias small enough to ignore. One strategy for estimating the bias would be to revisit a proportion of sample units a second time each season. These would be drawn from the set of reaches that were scored as absent in the first visit. The second visit would need to occur soon after the initial survey so the fish do not have time to colonize the area. The fraction of second visits in which the species was detected would give an estimate of detection failure, hence bias.

Cutthroat Abundance Monitoring

Cutthroats occur in streams between the Eel and Smith rivers and primarily in the smaller streams close to the coast (see **Appendix E**). In the Plan we assume that cutthroats extend inland 30 miles, which encompasses Blue Creek in the lower Klamath River and Hurdy Gurdy Creek in the Smith River, two important cutthroat spawning and rearing streams.

Cutthroat occur north of and including the Eel River. Yurok tribal file photo.

The following juvenile abundance protocol is condensed from Duffy, et al. (2003). Estimating the abundance of juvenile salmonids in an area requires information on the habitat and fish. This information is gathered in two steps. First, the habitat available is classified. Second, the fish using those habitats are counted. Individual habitat units are classified as either runs, riffles, pools, deep pools or other habitats. Accurate measurement of habitat units must follow standardized procedures. The primary sampling method recommended for counting fish is visual observation using snorkel gear. This method is less costly and intrusive than other methods. However, visual observation techniques are not possible in all types of habitats, nor are they applicable in some streams. Electro-fishing (see Hankin 1984) is recommended in situations where visual observation is either not possible or would provide inaccurate results. Visual observation may be used to sample run, pool and deep pool habitats. A systematic random sample of each habitat type should be drawn from the total of habitat units measured (Hankin and Reeves 1988). Visual observation methods are not possible in riffle habitats and may not be effective for entire reaches of some shallow streams. Furthermore, cobble and other obstructions in riffle and other shallow habitats also make seine netting inefficient. These habitats must be sampled using electro-fishing techniques. Sampling to estimate population size is essentially devoted to validating assumptions about the efficiency of visual observations (Hankin and Reeves 1988). Additional analyses are required to extrapolate fish counts from a sub-sample of habitats to the entire area represented by that type of habitat.

Hatchery Fish Marking

***Workshop question 4**: What is the contribution of hatchery fish to the adult returns?*

The Steering Committed developed this recommendation based on workshop recommendations to give high priority to measuring stock productivity (**Workshop conclusions 5 and 6**). There are five major salmon and steelhead hatcheries in the coastal zone. Four are run by the DFG: Iron Gate Hatchery, Trinity River Hatchery, Mad River Hatchery (closed at the time this report was prepared) and Warm Springs Hatchery**.** The fifth hatchery is a Del Norte County Hatchery, Rowdy Creek, located on the Smith River. There are also a few relatively small cooperative salmon and steelhead rearing programs on the coast. These small operations are excluded from this proposal because of the small numbers of fish involved **(Appendix Table A-1).** The production from coastal hatcheries, which is about 20 million fish annually, could potentially mask natural production in coastal streams unless a substantial portion of the production is marked so the hatchery component spawning in natural areas can be accurately estimated. Comprehensive marking of hatchery fish releases in combination with natural fish escapement monitoring is important for meeting Federal HGMPs requirements **(Appendix A).**

Recommendation 5: Ensure adequate marking of all hatchery fish releases.

Iron Gate Hatchery is located on the Klamath River near the Oregon border.

Fractional marking is needed of all hatchery releases that are not currently being marked at a statistically valid rate. A minimum of 25% of all releases needs to be marked (fin-clipped), which is the rate being used for Chinook salmon at Trinity River Hatchery (Mark Zuspan, DFG, pers. comm.). Marking 100% of hatchery production has been suggested as means of achieving greater confidence in hatchery fish contribution rate estimates. Marking of all hatchery fish releases would be expensive and not substantially reduce the standard error of contribution estimates compared to a 25% marking rate (see Newman et al 2004 for more information). It would also increase hatchery fish handling mortality.

Extensive marking is already taking place at the coastal hatcheries. The only releases that are not being adequately marked are Chinook salmon at Iron Gate Hatchery (IGH) and Chinook salmon at Rowdy Creek Hatchery (RCH). At IGH the mark rate is only 5% (all with CWTs) of the released fish and none of the Chinook salmon at RCH are marked **(Appendix Table A-3**).

There are several options regarding type of mark to use for hatchery fish contribution rate monitoring. An external mark such as a fin clip would be the least expensive to apply and most readily identifiable in the field. Other options might include freeze branding, otolith marking or genetic techniques such as parental genotyping. These latter options would be more expensive and, except for freeze branding, require laboratory processing of field samples to make the contribution estimates. In California, the adipose fin clip on salmon has been reserved for studies that depend on ocean fishery recoveries of CWTs. Thus the adipose fin clip is not recommended for hatchery salmon marking unless used with CWTs.

Fishery Monitoring

<u>Workshop question 5</u>: What is the effect of fisheries on the adult returns?

The Steering Committed developed this recommendation based on workshop recommendations that gave high priority to measuring stock productivity (**Workshop conclusions 5 and 6).** It is also an important monitoring activity for the development of Fishery Evaluation and Management Plans as required under the ESA.

The DFG has monitored the ocean commercial fishery since the late 1940s and the recreational salmon fisheries since the early 1960s. The ocean fisheries have been managed to harvest abundant populations of Central Valley fall run Chinook salmon while at the same time protecting listed Chinook salmon and coho salmon populations. River fisheries south of the Klamath River have been closed to the harvest of naturally produced salmon, steelhead and cutthroat but continue to have bycatch mortality associated with catch and release fishing.(see **Appendix A**). Chinook salmon take is allowed in the ocean fisheries while coho salmon retention is prohibited in the ocean off California. The two forms of ocean salmon take are: (1) direct take, which affects Chinook salmon only and (2) incidental take (bycatch) which affects coho salmon and sublegal Chinook salmon. Ocean bycatch mortality is estimated and used in the regulation of the ocean fisheries. Steelhead are uncommon in ocean fisheries and the impact is believed negligible.

There continues to be two types of take occurring for salmon and steelhead in inland waters: (1) direct take of Chinook salmon in the Smith and Klamath Rivers, hatchery steelhead in most of the northern waters and all steelhead in the Smith River and (2) incidental take (bycatch) of naturally produced Chinook salmon, coho salmon, steelhead and cutthroat.

Recommendation 6: Conduct freshwater fishery harvest rate monitoring

The proposal here is to conduct harvest rate studies each year of the recreational fisheries on the major streams between San Luis Obispo Creek and the Smith River excluding the Klamath-Trinity Basin fall Chinook and coho salmon fisheries, which are monitored by the DFG (**Table 6)**. All of these waters are open to adult salmonid fishing, but retention is prohibited except for marked hatchery steelhead in some northern streams and one unmarked (natural) steelhead and one Chinook salmon in the Smith River. The aim of the census would be to determine: (1) total catch by species, (2) total catch of hatchery marked fish and (3) total angler effort. The catch estimates when compared to spawning escapement estimates for these same streams would provide fishery harvest rate data that can be used to estimate the proportion of fish removed (i.e., harvest removal rate) from the respective populations.

Table 6. Streams recommended for harvest rate monitoring	
System	**Stream**
Smith River	Smith River
Klamath System (steelhead only)	Main Stem
	Trinity River
	Salmon River
Redwood Creek	Redwood Creek
Mad River	Mad River
Eel River	Main Stem
	South Fork River
	Van Duzen River
Mattole River	Mattole River
Noyo River	Noyo River
Little River	Little River
Ten Mile River	Ten Mile River
Navarro River	Navarro River
Garcia River	Garcia River
Gualala River	Gualala river
Russian River	Main Stem
Pescadero Creek	Pescadero Creek
San Lorenzo River	San Lorenzo River
Carmel River	Carmel River
Big Sur River	Big Sur River
Soquel and Aptos Creeks	Soquel and Aptos Creeks
San Luis Obispo Creek	San Luis Obispo Creek

Creel survey will be important for estimating angler harvest rate.

Two types of creel survey should be considered: (1) access point survey and (2) roving survey. In the first survey, effort and catch are estimated directly. There are pros and cons to this approach. It depends on the veracity of angler responses to questions about effort and released catch but avoids the problems associated with incomplete trip data. The roving census approach is used when angler access points are diffuse or difficult to reach. The census clerk intercepts anglers while they are fishing and asks for time spent fishing and the number of fish caught and harvested. The number of anglers fishing is obtained by a count taken at random times during the work period and the total effort is obtained from the product of count and the number of hours in the work period (Pollock et al 1994).

Additional Monitoring Needs

The following additional monitoring needs are important to include in the field sampling program design. These activities are expected to be accommodated within the budgets developed for the adult and juvenile monitoring and the fishery harvest rate monitoring, except where noted.

Habitat Condition Monitoring

A lengthy and important discussion during the workshop process was how to integrate habitat condition monitoring with fishery monitoring. It was agreed that both activities are important in the species listing/delisting process and to show the status and trend of stream and watershed spawning and rearing conditions. It was agreed that appropriate habitat condition monitoring needs to be conducted along with fishery monitoring. As stated earlier, information on freshwater and marine survival is essential to understand why a population is changing and how much natural variation in annual adult abundance can be expected. It is also essential to understand how habitat conditions are affecting survival. Our ability to recover listed species is to a large extent dependent on conserving and restoring the habitat upon which these species depend. The important question that was left unanswered is what level of habitat sampling would be meaningful in either context?

It was agreed that any habitat sampling should be done with the objective of "measuring the status and trends of habitat suitability through time." Core parameters that should be measured during any fishery monitoring include:

1. pool frequency in sample reaches,
2. pool depths,
3. water flow and temperature,
4. riparian canopy cover percentage,
5. fine sediment levels in both pools and riffles, and
6. large wood presence.

The above sampling is not expected to compromise any fish monitoring objectives and may not need to be collected more often than once or twice per year.

Genetic Monitoring

Genetic monitoring is needed to address the question of whether ESUs are losing genetic diversity characteristics. A review should be conducted at the beginning of the Monitoring Program to determine the status of baseline genetic samples for each ESU. For each ESU, the diversity characteristics identified as important should be monitored using existing methods or their appropriate modification. ESUs found to be lacking adequate baseline genetic data should be sampled to bring them to an adequate level. A select number of sites should be identified for ongoing genetic investigation and tissue samples should be collected at set time intervals to monitor changes in genetic diversity.

Processing of genetic samples requires special expertise. Additional funding would be required to support genetic laboratory work on the coast wide or ESU scale and is not included as part of the Plan.

Other Biological Monitoring

Other biological samples should be collected in the course of the adult, juvenile, creel census LCS and habitat condition monitoring programs. The sampling should include, at a minimum: (1) scale or otolith samples for age composition analysis, (2) adult fish gender determinations to estimate egg deposition potential and (3) length-weight samples for relative weight analysis. These data are important for assessing brood year abundance, stock diversity and stock productivity.

It is important to collect scale samples or otoliths during spawning ground surveys for age composition analysis. Many vital rates including survival and reproduction are age-specific. Thus, the contributions of different aged fish to the spawner return ratios are greater or lesser depending on their age structure and a change in age composition could obscure true changes in these rates. In addition, a consistent shift toward an older age composition would naturally result from recovery and could be used as an early indicator of recovery. Furthermore, some populations have unique age structure features (i.e., steelhead half-pounders) that may need to be tracked in the diversity-monitoring component.

Study or Developmental Needs

Klamath Steelhead Seining

The Klamath River fall steelhead fishery is probably the single largest and most economically important steelhead fishery in the State. It is also an important resource to the Klamath River Indian Tribes. The fish enter freshwater during August-October when weather conditions are optimal for outdoor recreation and migrate to Upper River reaches to spawn during late winter and spring. The run is composed of adult fish (fish over 16 inches in length) and half-pounders (fish 10-16 inches in length), immature steelhead that have spent only a few months at sea (see **Appendix A** for more information).

Intercept sampling of fall steelhead in the Klamath River using beach seining at river mile two was used to monitor the run in the 1970s and 1980s, but pinniped depredation on released fish was substantial and difficult to estimate (Hopelain 1988). Relocating the seining site further upstream might reduce or eliminate the pinniped problem and would be worthy or further study in order to resume monitoring of this highly important steelhead run.

Snorkel Survey Calibration Study

Annual dive counts of holding spring (summer) steelhead and spring Chinook salmon are conducted annually during summer months by the DFG and others. Those counts may need to be calibrated. This could be done by intercept sampling and marking of upstream migrating fish in areas below summer holding areas. Marked fish observations during dive surveys would be used to determine the efficiency of the diver counts. Calibration studies will be needed periodically for each snorkel survey area.

Resident Rainbow Trout/Steelhead Interactions

It is believed that steelhead and rainbow trout commonly interbreed; i.e., steelhead can be the progeny of trout and vice-versa. If true, then trout and steelhead jointly comprise a single population in each basin. If it is rare, then they can effectively be considered two distinct populations. The workshop participants considered it important to learn more about the pattern and process of interchange in steelhead populations, particularly in the south. The participants identified three key needs: (1) data on numbers of adult trout, (2) data on the rate of interchange and (3) a better understanding of the environmental factors that influence the rate of interchange. Of these three needs, only the first does not require extensive research and development. The Hankin and Reeves (1988) habitat/juvenile survey approach, described for cutthroat abundance sampling (above), should be considered for estimating abundance of southern rainbow trout adults.

Microsatellite analysis is being used to compare genetic differences in resident rainbow trout and steelhead above and below barriers within the Russian River watershed. This work may help explain the effect of impassible barriers on the genetic make-up of steelhead populations above and below barrier dams (D. Girman in progress).

Differentiation of Cutthroat, Steelhead, and Hybrids

It is difficult to differentiate between steelhead, cutthroat and hybrids in coastal waters north of and including the Eel River.

Recent work by Humboldt State University (HSU) students has identified problems in distinguishing cutthroat, steelhead and their hybrids. Even when fish are in hand, true steelhead are often classified as cutthroats or hybrids. This work has raised the question, “What is a cutthroat anyway?” There are genetic markers that can be used to differentiate between cutthroat, steelhead and hybrids. It may be possible to use statistical methods to predict species composition based on simple field measurements such as jaw length, head length, etc. There may be less expensive ways of using genetic techniques for differentiating between the various species and hybrid types using different genetic markers. There also appears to be different degrees of cutthroat/steelhead hybridization within tributaries of the same watershed. Some tributaries seem to have pure cutthroat, others pure steelhead and others a mixture with many hybrids. This kind of information could be used in the future to minimize the cost of genetic sampling if temporal stability of species composition could be established (D. Hankin, HSU, pers. comm.).

Routed Hydrographic Maps

U.S. Geological Survey routed hydrographic maps are available in digital format in two scales: 1:24,000 (24K) and 1:100,000 (100k). The higher resolution1:24K maps are needed for constructing the sample frame that is discussed and proposed later in the Plan. Currently, 1:24K maps are only available for some northern California coastal basins and need to be created for the remaining basins.

Sample Size

Sample size plays an important role in generating population estimates that fishery managers and stock assessment scientists can rely upon (i.e., have high confidence in). It is also important for building a program budget that decision makers can use in seeking Monitoring Program funding. In this section we lay the foundation for the next two sections: Sample Selection Procedure, which relates to how the population size estimates and associated variances are developed, and Proposed Budget, which includes estimates of Monitoring Program costs by task and in total.

Northern Spawner Surveys

The adult spawner survey is patterned after the Oregon coho salmon spawner program or EMAP design (Stevens 2002). The area covered extends from Aptos Creek to the Oregon Border. Spawning ground samples are proposed to be 10% of all potential spawning reaches. Sample reaches should be drawn using a rotating panel design and the interval between sample periods should be 7-10 days. The 10% sample level is the same as the level attained for Oregon coho salmon (Jacobs 2003). Oregon coho salmon adult spawning run size estimates and confidence intervals for 2000 and 2001 are shown in Table G-1, **Appendix G**.

Calibration sampling is proposed to be done in conjunction with the spawning ground surveys. This sampling is initially proposed to be limited to four sites per year. Two of the sites should be the same each year to provide information that is important for long term trend analysis. Selection of two streams that are used for Life Cycle Monitoring would serve the dual purpose of: (1) providing data on freshwater and marine survival rates and (2) for measuring bias associated with different population estimation techniques (e.g., redd counting, live fish counting, carcass counting). Calibration data would be used to adjust the adult spawner estimates when warranted. This initial calibration sampling will provide data needed to determine the amount of calibration sampling that will be needed long term.

Southern Steelhead Monitoring

Run size counting is needed at the three existing fishways in the Southern Monitoring Area as well as any future fishways. To do this, personnel are needed to count the runs through the facilities from start to finish of the runs.

Two sites have been proposed as options for an experimental portable weir study: (1) the Salinas River at the site of the proposed Monterey County Water Agency inflatable dam and (2) the main-stem Salinas River just above the lagoon. The latter area has a relatively stable channel shape and sand bottom that would potentially be amenable to a resistance board weir design that could survive high flows and facilitate a 100% watershed count (K. Urquhart, DFG, pers. comm.). Further discussion is needed regarding potential weir sites on other southern area streams.

The *Didson* camera appears to be a promising technology for monitoring adult salmon and steelhead runs. It appears to be accurate enough to estimate very small run sizes; it can be operated continuously even during high-flow events and its acoustic beam is not troubled by turbid water or an uneven rocky streambed. If proved accurate and dependable in a pilot study, five *Didson* stations deployed in the area between Monterey and Los Angeles would effectively cover the southern steelhead populations (**Appendix Table I-1**). A pilot study is proposed to be conducted on one stream to assess the efficacy and cost effectiveness of the unit, which currently sells for about $85,000. A pilot study is needed before widespread use of *Didson* cameras can be recommended.

Life Cycle Stations (LCSs)

Two LCS options were developed for cost analysis purposes.

Option 1: Build Two New Permanent Structures

Substantial one-time funding would be required for station design, engineering, and station construction under this option. These would be permanent facilities consisting of adult and juvenile trapping components. Two facilities are proposed under this option, one each in the Northern and Southern Monitoring Areas.

Option 2: Establish New Permanent or Portable Adult and Juvenile Trapping Operations

Under this option, existing adult fishways or trapping facilities would be preferred for use in capturing upstream migrating adults. Juvenile sampling would be based on using portable trapping equipment such as fence weirs, incline plane screen or rotary screw traps. Site selection would be based on Plan criteria explained above.

There are major differences between the two options in terms of cost and efficiency. The type of facility or operation to invest in depends on many factors such as the level of precision that is sought in the estimates, overall sampling efficiency, and need for wide geographic coverage. Trapping efficiency under Option 1 would be close to 100% for both adults and juveniles, even under moderately high stream flow conditions, but the sampling would be geographically limited. Adult trapping efficiency would be fairly high under Option 2 if existing adult facilities are used, but low for coho salmon and steelhead if portable weirs are used. Juvenile trapping efficiency under Option 2 would be high in low runoff years but low and difficult to estimate during high runoff years. Stream size is an important variable under both options. Smaller streams tend to support a higher proportion of steelhead over salmon. The runs sizes will also be smaller and more difficult to estimate with high confidence. It is much easier and cheaper to trap either adults or juveniles using portable equipment in a small stream ($<20 mi.^2$) compared to a large stream.

Use of portable adult sampling equipment can be effective in the fall for early run Chinook salmon and in the spring for late run steelhead. It is not a dependable sampling method in most coastal streams during late fall, winter and early spring months when most coho salmon and steelhead runs enter freshwater to spawn. It may be possible to use portable weirs to trap adults in very small streams ($< 20 mi^2$) during winter months, but the adult sample sizes will be very small and salmon may not be present in the runs in the Northern Monitoring Area. The mobility of portable equipment allows for experimental uses of the equipment in different streams and under different sampling conditions.

Juvenile Sampling

The area covered in the juvenile sampling extends from the Tijuana River to the Smith River. Presence/absence sampling is conducted in all areas except in the cutthroat sub-area where abundance sampling is conducted. The coho salmon sample area extends from Aptos Creek to the Oregon Border excluding the cutthroat sub-area, and the southern steelhead sample area extends from the Pajaro River to the Mexico border. The cutthroat sub-area extends from the Eel River mouth to the Smith River mouth and inland 30 miles.

Ten percent (10%) of all potential juvenile rearing areas are proposed to be sampled for coho salmon and cutthroat in the north and steelhead in the south. The sample level for juvenile coho salmon in Oregon, inferred from reports by Stevens (2002) and Jacobs (2003), is 3.4% overall. A relatively high juvenile sample level is proposed for California because of know low occurrence levels of coho salmon and cutthroat in the north and steelhead in the south.

Hatchery Fish Marking

An additional one million Chinook salmon need to be marked annually at Iron Gate Hatchery to cover its Chinook salmon production goal of five million fish. At Rowdy Creek Hatchery on the Smith River, 113,000 Chinook salmon will need to be marked annually to cover its Chinook salmon production goal of 450,000 fish. This will ensure 25% or greater marking of all coastal hatchery fish releases from the major production facilities in the area.

Creel Survey

The creel survey proposal is to conduct fishery harvest rate sampling covering 200 stream miles per year on streams between San Luis Obispo Creek and the Smith River that are shown in **Table 6**. Two streams, totaling between 50 and 100 miles, should be sampled every year, and new streams or stream segments totally between 100 to 150 miles would comprise the remainder of the sample. Stream length is proposed as the criterion for selecting creel sample areas because the open fishing area on streams named in **Table 6** varies from less than a mile in length (e.g., Soquel Creek) to nearly 200 miles (e.g., main stem Klamath River steelhead fishery).

Monitoring Approach

<u>Workshop question 6</u>: What is the best approach for monitoring coastal anadromous salmonids to detect species trend and recovery?

The traditional approach of using a specific set of streams or stream reaches for annual monitoring can be useful for long term trend analysis. These "index" streams are often ones where spawning or rearing fish are known to occur in relatively high numbers and also may have specific court-ordered fishery allocations (e.g., some Washington State streams and the Klamath River). However, the "index reach" approach does not yield information on population expansion into low use areas, which is an important indication of species recovery. Appendix B provides more information on the subject of population viability. Spatially balanced population sampling was recommended in the workshops (**conclusions 8, 9, 10, 12, and 13 plus the workshop questionnaires)** and is recommended in the Plan.

Recommendation 7: Use a spatially balanced approach for monitoring coastal populations of adult and juvenile anadromous salmonids.

Sample Selection Procedure

High-precision estimates of abundance require large samples with "good" spatial coverage. Loosely defined, samples with "good" spatial coverage are those that are "spread out" spatially over the entire population of interests, with few large "holes" where no units are sampled, and few large "clusters" of sample units. Powerful tests for trend in population attributes require large numbers of visits to units that have been previously visited (i.e., revisits). Revisiting sample units to improve estimation of trend diverts limited field resources from visiting new units that would otherwise improve estimation of abundance. The sampling approaches that address these competing abundance and trend objectives are generally referred to as "rotating panel" designs.

Rotating panel designs select a probability sample of units from a population and assign units to "panels" (Stevens 2002, McDonald 2003), or sets, that are always all visited during the same sampling occasion. Revisits to sample units are scheduled by organizing visits to entire panels on a rotating basis. Certain panels are visited frequently, while other panels are visited less frequently. This scheduling assures that "good" overall spatial coverage is achieved, and that an adequate number of revisits occur.

In this section, the rotating panel design proposed for salmonid monitoring in coastal areas of California is proposed. This rotating panel design is similar to the one used for Coho salmon monitoring in Oregon (Stevens 2002). First we discuss data management requirements, followed by sample units and sampling universe, sample frame, sample draw and panel construction and rotation of effort among panels.

Geographic Information System Data

In general, a geographic information system (GIS) is needed to store, analyze and display both pre-field-visit and post-field-visit data. The GIS "system" includes hardware, software and personnel knowledgeable in the workings of the GIS. The basic GIS maps to be used for monitoring are expected to be U.S. Geological survey (USGS) routed hydrographic maps that are available in digital format. Routed hydrography means that all streams in the GIS have been defined as routes. This data structure provides a means for defining events (attributes) along linear features, which is referred to as dynamic segmentation. Dynamic segmentation provides the ability to associate multiple sets of linear (such as lengths of dry streambed) and point (such as deep pool) attributes to any segment of a linear feature. Routed hydrography is available for California coastal streams in two scales: 1:24,000 (24K) and 1:100,000 (100K). The 1:24K maps are preferred for this project because they provide finer resolution for storing, analyzing and displaying data than the 1:100K maps. For coastal California, 1:24K routed hydrography maps are available for all streams from the Russian River north to the Oregon boarder, excepting the Klamath Basin above the Trinity River mouth. All other areas, including the upper Klamath Basin are available only as 1:110K maps (**Figure 4).**

A geographic information system will be important for storing, analyzing and displaying Monitoring Program data.

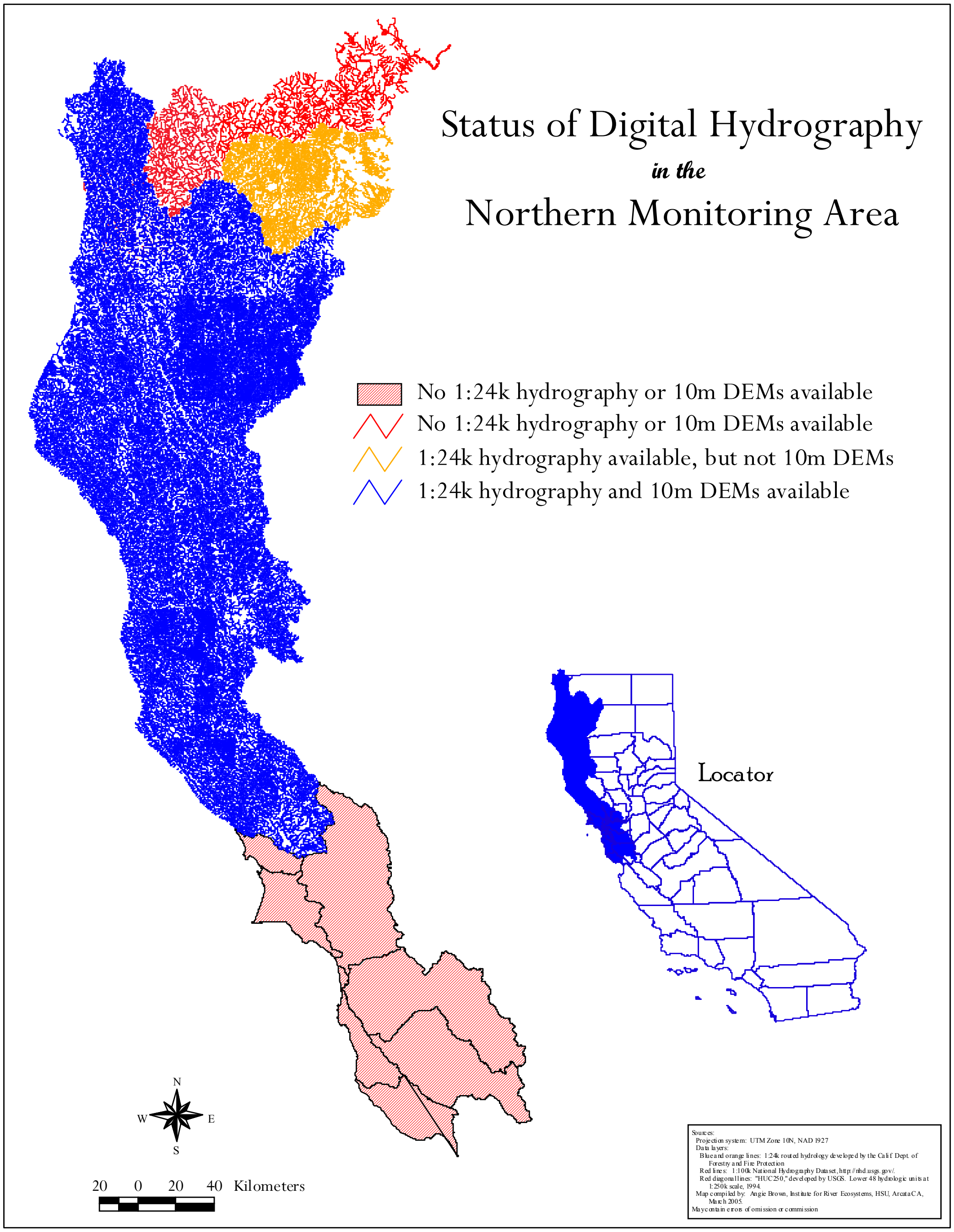

Figure 4. Availability of hydrographic and digital elevation maps for coastal streams north of Aptos Creek

Besides routed hydrography, stream elevation is an important characteristic to include in the GIS. Elevation information is incorporated into the GIS by overlaying 10 or 30 m Digital Elevation Models (DEMs) on the 1:24K routed hydrograph and estimating the elevation for points every 100m along each stream route Stream channel gradients can then be estimated as the difference in elevation divided by 100m (for elevation points taken every 100m) times 100 percent. Ten meter DEMs are available for most of the coastal basins of California (**Figure 4).** Considerable work needs to be done to produce 10 m DEMs for all coastal streams.

Sample Units and the Sampling Universe

In general, a *sample unit* is the smallest entity upon which measurements are taken or reported. The *sampling universe* (or just *universe*) is then composed of all possible sample units for which statistical inferences are sought. For monitoring of coastal California salmonids, sample units will be defined as approximately 1.6 – 3.2 km (1 – 2 mi) steam reaches. The universe of sample units will be defined as all possible 1.6-3.2 km stream reaches in the Plan area shown on U.S. Geological Survey (USGS) hydrographic maps, except for the following areas:

1. Stream reaches above barrier dams (see **Appendix F**). If fish passage is ever provided above any of these structures, the new habitats will be added to the sample universe.
2. Streams above high gradient reaches. High gradient reaches are defined as stream reaches (and associated sample units) located above sections with > 30% channel gradient over a 100m stream segment, or > 20% channel gradient over a 500m stream segment as determined from 10 m or 30 m DEMs. Also, any stream reach that exceeds 10% elevation change from any point within the reach to its downstream boundary is considered high gradient. Field experience has shown that anadromous salmonids normally do not migrate into these areas. High gradient reaches are typically First Order streams that are too steep for spawning or too low or dry during summer for juvenile rearing. In the Mad-Redwood Hydrologic Unit, steep gradient streams account for about 40% of the blue lines shown on USGS 1:24k maps (D. McCanne, Humboldt State Univ., pers comm.).
3. Areas known to be unavailable to or not used by Plan species. Fishery professionals with knowledge of anadromous salmonid distributions will examine the initial distribution of stream reaches laid out in 1. and 2. for availability to salmonids. Areas that are known to be unavailable to anadromous fish will be removed from the sampling universe. Additionally, any reaches that were removed erroneously in step 2. will be added back into the sampling universe. Reconnaissance surveys will be needed to ground truth the sample frame.

For cutthroat abundance monitoring, longer 3.2-4.8 km (2-3 mile) sample units should be considered. Longer reaches may be needed because sampling following the Hankin and Reeves (1988) method counts fish only in a portion of the sample area (D. McCanne, Humboldt State Univ., pers. comm.) and shorter reaches will provide insufficient data for abundance estimation.

Sample Frame

The *sample frame* is a representation of the sampling universe and can be thought of as a list of all possible sample units that will meet Monitoring Program estimation needs. A carefully constructed and properly ordered sample frame is critical to the overall success of the Plan because random subsets of the frame will be constructed to receive field data collection efforts.

Following delineation of sample units in the Plan area, all units above barrier dams, all high gradient units, and all units known to be unavailable to anadromous fish will be eliminated from the frame in order to more accurately represent the intended sample universe. The frame will then be ordered for sampling using a 1-dimensional method that uses the unit's location within its watershed and the watershed's location along the coast. All watersheds in the Plan area will first be ordered from north to south along the coast. Sample units within each watershed will then be ordered starting at the stream system's mouth (where it enters the ocean) and moving upstream. All units in the main stem of the system will appear first in the list, followed by units in tributaries. Tributaries will be ordered based on the stream mile of their confluence with the mainstem. That is, units in lower (farthest downstream) tributaries will appear before units in upper tributaries. In this way, ordering of the frame will continue recursively from main stem to tributaries until all units are placed in the frame. The location of a unit in the ordered frame defines its "spatial" location, and the difference between "spatial" locations of two units defines the "spatial distance" between sample units. This ordering, coupled with the sample drawing mechanism, ensures that sampled units will be spread out and will represent all areas of the Plan in proportion to their geographic sizes.

Sample Draw

A random subset of the frame will be selected and defined to be the *spatial sample* (or just *sample*). This sample will then be allocated to panels that receive different visitation schedules (see below). The key characteristic required of the sample is that the selected units be spatially balanced (i.e., spread out) over the 1-dimensionally ordered sample frame. To achieve the required degree of spatial balance, an equi-probable generalized random tessellation stratified (GRTS) sample will be selected from the 1-dimensional frame (Stevens and Olsen 2004). GRTS sampling, with reverse hierarchical ordering, will allow units to be easily assigned to fixed-size panels that are themselves spatially balanced, while at the same time avoiding adverse alignment problems that can occur with systematic samples. Technical details of the GRTS sampling mechanism can be tedious and will not be presented here. A full account of the method appears in Stevens and Olsen (2004) and McDonald (2003). The most important feature of the GRTS sampling mechanism is that it produces a randomized list of sample units such that any contiguous subset of units in the list constitutes a spatially balanced group of units. This feature, beyond ensuring spatially balanced panels, also allows easy addition and deletion of units in a way that maintains spatial balance.

The initial GRTS sample draw will take a 25% sample of the sample frame. This sized sample will be adequate to provide a collection of primary and secondary units. Primary units will initially be allocated to panels for sampling and will comprise 40% of the 25% sample, or 10% ($= 0.25 \times 0.4$) of the sample universe. Secondary, or "over-sample," units will be made available to projects that seek greater precision in local areas, such as special management areas, and will replace primary units that could not be sampled for one reason or another. Replacement of primary sample units with secondary units will ensure that the 10% sample size objective is met in areas where property owners deny land access or survey conditions in the unit are adverse.

Allocation to Panels and Rotation Schedules

Sample units selected by the GRTS mechanism will be allocated to panels that are in turn assigned four different visitation schedules. Assuming n_i reaches are required in panel *i*, the next contiguous set of unallocated n_i reaches in the GRTS sample will be assigned to membership in panel *i.* For example, if 20 reaches are required in panel 1 and 10 reaches are required in panel 2, the first 20 reaches in the GRTS list will be assigned to panel 1 and the next 10 reaches (numbers 21 – 30) will be assigned to panel 2. The set of all assigned reaches will comprise the primary units in the GRTS list. If certain primary units cannot be sampled for one reason or another, they will be replaced with secondary units, in order, that fall after all primary units in the GRTS list.

The 4 proposed visitation schedules for panels are as follows: (1) 1 panel will be visited every year ([1-0] in the notation of McDonald (2003)), (2) 3 panels will be visited once every 3 years ([1-2]), (3) 12 panels will be visited once every 12 years ([1-11]) and (4) 30 panels will be visited once during the 30-year life of the project ([1-29]) (**Table 7**). This rotation scheme will require a total of 46 panels, each containing multiple sample units. Panel 1 is proposed to contain ~40% of the total number of reaches visited every year. Panels 2 through 46 are each proposed to contain ~20% of the total annual number of sampled reaches. Assuming *n* reaches can be visited every year, the total number of unique reaches visited over the 30-year life of the project will be 9.4*n*. For example, if 20 reaches can be visited annually in a region, the total number of unique reaches visited at least once in the region over 30 years is 188.

The [1-0, 1-2, 1-11, 1-29] rotation scheme proposed here is slightly different than the rotation scheme used by the Oregon coho monitoring plan. The Oregon plan uses a [1-0, 1-2, 1-8,1-26] rotation scheme with equal numbers of reaches in each panel. The Oregon plan's rotation scheme is based on the 3-year life history cycle of coho. Here, we propose a 3, 12, and 30 year visitation cycle based on the life histories of Chinook and steelhead, which mature at ages 3 or 4. The higher percentage of sites that we propose to re-sample every year is appropriate given the importance of detecting trends in our survey.

Example Sample Draw

An example sample draw is illustrated in **Appendix H**.

Sample Frame Refinements

Throughout Plan development, it has been clear that there are certain Plan elements that cannot be finalized until additional data are available. This need for Plan refinements should be formally recognized and a mechanism for insuring that refinements occur needs to be formally incorporated into the Plan implementation process. The sampling plan refinement element will occur after two-four years of sample data are available, but planning for this effort will begin at the end of the first year of data collection. The effort will be summarized in one or more documents and will probably include workshops and documentation of frame refinement issues. Subjects that the refinement effort will include are: (1) sampling frame refinement, (2) species-based estimates and stratification and (3) examination of sampling methodology, variances and statistical power.

Table 7. Proposed rotation schedules for panels in the Plan. An 'x' in table indicates that all reaches in the panel will be sampled that year. This is the [1-0,1-2,1-11,1-29] rotation plan in the notation of McDonald (2003). Panel 1 will contain ~ 40% of the annual number of sampled reaches. Panels 2 – 46 each contain ~20% of the annual number of sampled reaches.

Panel	**Year**																													
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
1	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	X	x	x	x	x	x	x	x	x	x	x	x	x
2	x			x			x			x			x			x			x			x			x			x		
3		x			x			x			x			x			x			x			x			x			x	
4			x			x			x			x			x			X			x			x			x			x
5	x												x												x					
6		x												x												x				
7			x												x												x			
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Panel	Year																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
27											x																			
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The most immediate need will be to update and finalize the sample frame. Initially, the sample frame will be constructed of all fourth order and smaller stream segments. Despite our best efforts, we recognize that the initial frame will includes some stream segments that we will eventually want to drop from the frame because they are dry, inaccessible, unavailable due to private property issues, or cannot be sampled with current sampling methods. In a few limited areas where sampling has been occurring, information necessary to ensure that the frame only includes appropriate segments exists; however, the same is not true for all areas. Experience in the Mad-Redwood hydrographic unit suggests that 30%-40% of initial segments may eventually be dropped from the sampling frame. This frame development and finalization effort is vital to ensuring the accuracy, precision, and appropriateness of collected data.

The second important area of sampling plan refinement is the species-based estimates. Initially in the northern area, the accuracy of information on the distribution and overlap of steelhead, coho salmon, and Chinook salmon may be low. It is hypothesized that as many as half of the stream segments in the Northern area contain steelhead only, while the number of segments containing coho salmon is likely much smaller, and the number of segments containing Chinook salmon is smaller still. If the coho and Chinook salmon species estimates are derived from a sample selected without regard to hypothesized species composition, the coho and Chinook salmon estimates may have unacceptably high variances because they are based on too few segments. If the estimates are judged to be unacceptably imprecise, we will attribute each segment in the frame with its hypothesized species composition (i.e., steelhead only, steelhead and coho only, all three species) and separate samples will be derived for each species to meet minimum sample size requirements. Segments will be attributed as containing a species if it has been confirmed as present or if the species' presence is considered likely. Separate samples for each species will be derived by so-called soft-stratification in which segments in the overall GRTS sample without the attribute of interest will be skipped until the required number of segments with the attribute of interest is attained. Because it is likely that some form of soft-stratification will need to be implemented, the accuracy of segment attributes is critical and that updates of these attributes are included as part of the frame refinement process as soon as initial data become available.

Finally, the sampling plan refinement will address methodologies, variance estimates, and statistical power of the first two-four year estimates. The Plan currently proposes to collect data that can be used to support a number of types of analyses, including mark and recapture, live fish, carcass, and redd methods. In addition, there is a two-stage population estimate to improve the precision of the approaches just mentioned. The quality, utility, and appropriateness of these different methods will be addressed during frame refinement, in addition to issues associated with analysis that impact the sample frame. Review at this stage will include both operational and statistical aspects of the sampling with the overall goal of assuring that Monitoring Program output is meeting the Plan goals and objectives. If outputs are not meeting goals, adjustments will be necessary to bring the Monitoring Program back on track.

Monitoring Area and Sub-Area Estimates

The EMAP approach is designed to produce estimates:

1. for both adult salmon species and steelhead in the Northern Monitoring Area;
2. juvenile coho salmon and steelhead spatial data for the northern and southern areas, respectively; and
3. juvenile cutthroat abundance estimates for the cutthroat sample area.

The estimates for each monitoring area should be produced on an annual basis. Sub-area estimates will be possible for ESUs, populations within ESUs and special management areas (HCPs, NCCPs). The DFG's coho recovery strategy requires annual run size estimates of spawning adult coho salmon for DFG Recovery Units located within the Central California Coastal Coho ESU. Attainment of specific run sizes within these units is recommended as criteria for downlisting under CESA (DFG 2004). Sub-area population estimates will be generated by post-season stratification of the data. The precision of the sub-area estimates will be lower than the overall Monitoring Area estimates due to reduced sample sizes. Precision in smaller area estimates such as DFG Recovery Units can be improved by increasing the sample size in those areas.

For the spawner surveys and the juvenile surveys, 10% sample sizes are recommended based on precision levels estimated in Oregon for adult coho salmon spawners (Jacobs 2003 and **Appendix G**). A larger sample size, 25%, is proposed to be drawn for use by resource managers and scientists that seek narrower confidence limits for small or special interest populations. The proposed sample scheme can also be used to evaluate habitat conditions associated with the adult and juvenile surveys.

Time Frame for Status and Trend Analysis

The proposal here is for a long-term commitment of DFG personnel and budgetary resources in support of the proposed Monitoring Program. Status and trend analysis will be possible for some species or populations only after the statistical frame for selecting sample reaches has been reasonably developed and several brood cycles of fish have been monitored for the various VSP attributes. For other species or populations, the acquisition of data on population size may be sufficient in itself to initiate a stock status review (see FWS 2004 for examples).

The sample frame development phase is expected to take two-four years during which time it is recommended that VSP data collection begin for the four Plan species. It is expected that mixed linear models (**Appendix H)** will be the primary tool for analyzing trend on program data. Chinook salmon is the longest-lived of the four Plan species in terms of maximum age of initial spawning. In California, Chinook salmon can live to be five years of age. Two brood cycles is the minimum number of years needed to construct a brood size trend analysis, but observation of at least three brood cycles is preferable because the accuracy and precision of derived estimates will be much improved. Thus, while initial estimates of brood size and trend can be made beginning in year 5, with variance estimates coming from inter-segment information, more reliable estimates can be made starting in year 10. In all, it will take 14 years to observe 3 cycles of Chinook salmon broods. For coho salmon trend analysis will be possible after 3 years for the initial brood and 2 more year, 5 years total , for the intervening 2 broods. Again, observation of 3 cycles of all 3 coho salmon broods, which will occur after 8 years, will be necessary to realize the full precision potential of program estimates. The steelhead trend analysis time frame will be intermediate to the two salmon species with individuals spawning for the first time at ages 3 or 4, with a few at age 5.

The time frames stated above are the minimum and preferable number of years needed to perform brood size analyses for individual species. In reality, wide variation can be expected around the estimates due to environmental factors such as El Nino events and measurement error. The DFG has commented that the minimum timeline for modeling and evaluating coho salmon recovery will be between 21 and 24 years (DFG 2004). Thus, VSP trends may not be detectable with high statistical confidence for many years into the future.

The DFG needs to plan on supporting the Monitoring Program indefinitely, including budget increases to stay in step with increases in personnel and operating costs. Also, the DFG must at the outset give the Monitoring Program a very high budget priority. Any interruptions in monitoring activities such as staff or funding reductions stemming from budget cuts *in even one* year have the potential of simultaneously disrupting cohort reconstructions of several broods of fish because of the protracted age at initial spawning of Plan species.

ADMINISTRATION AND PROPOSED BUDGET

***Workshop question 7*: How will the DFG and NOAA ensure proper oversight and administrative support?**

The success of the Plan will depend, to a large degree, on proper staffing; an efficient reporting network; outside scientific review; adequate allocation of time for program report writing and data entry; an efficient and effective data management system; close liaison with other monitoring and management entities; funding to support special studies, and stable fiscal and budgetary resources (**Workshop conclusions 1, 4, 7, 11, 13, and 14).**

Recommendation 8: Provide necessary administrative, scientific, data management and funding support to the coastal salmonid monitoring program

Program Coordination

The DFG should establish a Program Coordinator position within its headquarters operations to oversee program coordination within the DFG and liaison with other monitoring entities. The position would ensure that, (1) annual work plans are developed involving monitoring program staff, (2) sampling is conducted following agreed upon protocols and (3) program data flow successfully and smoothly from field operations to designated data repositories. The person must be closely involved in the coastal monitoring program itself and have the authority to affect the work plans of monitoring program staff and their operating funds. The position serves as liaison with monitoring efforts in other areas of the State and the Pacific Northwest. The position should report directly to the DFG principal in charge of salmon and steelhead management for the DFG (DFG Principal, currently the Director). A clerical position is needed to prepare letters and to respond to public requests and to support the Program Coordinator. The duty statement for the Program Coordinator should contain, at a minimum, the following elements.

Annual Work Plans

Annual work planning must be an integral part of the Monitoring Program. This involves reviewing, with each field lead person or supervisor, the monitoring program goals and objectives and assessing how individual work plans are individually and collectively contributing to the program's progress overall. It is also an opportunity to revise work plan activities if they are not meeting Monitoring Program goals. The Program Coordinator should initiate this process, in coordination with DFG regions and NOAA teams, and be a participant throughout the process.

Annual Progress Reports

Annual progress reports should be an important program output. These documents should be prepared in a timely manner, cover all the activities for the year and summarize all program findings. This will eliminate the problem of program staff moving without leaving the benefit of their work recorded. Time to write reports should be one of the tasks included in each biologist's annual work plan.

Sufficient time should be allocated to write annual reports to ensure the data are summarized and that field methods are carefully documented. The Program Coordinator should receive these reports, edit and compile them, add background and summary information needed and post them on an appropriate Web page.

Liaison

It is important for the DFG to continue to participate in fish and habitat condition monitoring forums with other West Coast fishery agencies and interested parties. These forums take place both within and without the State and have thus required an allocation of staff time and travel expenses to participate.

Related Monitoring Program Information Sources

The DFG's Native Anadromous Fish and Watershed Branch maintains close contact with the various entities working on salmon and steelhead projects in the coastal area and within the Central Valley. Their Web page address is: www.dfg.ca.gov/nafwb

An excellent reference for fishery and habitat condition monitoring entities on the West Coast is: www.stateofthesalmon.org/connect/scodsearch.asp. This particular Web site is sponsored by the State of the Salmon Consortium (SOSC) located in Portland, Oregon. They are attempting to coordinate salmonid monitoring activities across the entire range of the species and provide the following comments in that regard:

> "Unfortunately, there is no organization with a clear mandate to coordinate [salmonid] population monitoring and data sharing, nor to serve a role in analyzing the data to draw firm conclusions on the status and trends of salmon across their entire natural range. State of the Salmon is positioned to fill this niche. We are working to develop a novel design for a coordinated, international monitoring effort to keep pace with changes in status and trends of salmon. Our effort is unique in that it is designed to accommodate a broad range of scales, from dynamics of individual populations as they progress through their complex life history, to broad changes in salmon communities at the scale of the Pacific Rim."

The SOSC is currently working on a concept strategy for coordinating international monitoring of salmon populations. Their paper can be found at: www.stateofthesalmon.org/tracking/ConceptStrategy-V4.pdf.

Another good source of fishery and habitat condition monitoring data and addresses for pertinent contact organizations is: www.streamnet.org. This site is sponsored and maintained by the Pacific States Marine Fisheries Commission, also located in Portland, Oregon.

The Environmental Protection Agency maintains a list of restoration groups that are active in individual Hydrologic Units at: www.cfpub.epa.gov/surf/huc.cfm.

Reporting Relationships

Currently, the only entity within the DFG that has total oversight for salmon and steelhead planning and policy is the DFG Director. This makes it very difficult for the public and other salmon and steelhead managers to communicate their concerns and recommendations to the DFG[3].

It is proposed that the DFG modify its current organizational structure to consolidate its salmon and steelhead policy, planning, regulatory and monitoring oversight responsibilities into a single unit. Currently, salmon and steelhead policy issues are distributed between Marine Region (ocean fishing regulations), Habitat Conservation Division (habitat and inland species policy) and Wildlife and Inland Fisheries Division (inland fishing regulations and hatcheries). This new policy unit would be responsible for overseeing all phases of salmon and steelhead management in the State including fishing regulations (ocean and river), fishery management planning, hatchery practices and habitat restoration projects.

There are many organizational options that could be implemented to achieve this goal, but it needs to be done in order to efficiently and effectively implement and carry out the Plan. It is also important for the effective and efficient future planning and management of these valuable natural resources. The tasks identified in this document should not wait on DFG reorganization, however. This is because of the importance of implementing a cohesive coastal Monitoring Program as soon as possible and commencing collection of much needed abundance and trend data for California's listed and non-listed coastal salmonid populations. The Program Coordinator should be a member of the new policy unit.

Need for Scientific Peer Review and Technical Team

Science Advisory Committee

It is important that the scientific and practical merits of the proposed coastal monitoring program receive peer review. This is needed to give the program credibility with the public and the scientific community and to provide the opportunity for external input.

It is recommended that a Science Advisory Committee (SAC) be formed to provide the program with scientific peer review. The SAC would assist in recommending LCS locations, review monitoring program study proposals, review and recommend annual monitoring activities, review and comment on program outputs and provide overall program guidance. (See Data Management-Data Flow section, below, for more SAC data review responsibility.) Formation of the SAC would depend on the degree of success of Plan implementation efforts. The SAC should report to the DFG Principal who should have the authority to determine when and if the SAC should be formed. The Program Coordinator should be in charge of arranging SAC meetings, note taking and responding to other SAC meeting and deliberation needs.

It is recommended that the SAC be limited to 5-7 individuals, appointed by the DFG Principal with the concurrence of NOAA. The appointees should come from different areas of the coast, include members with expertise in salmon and steelhead biology, ecosystem health and statistical methods and

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[3] NOAA Fisheries is also divided with regard to its fishery management and research programs. This is a nationwide situation that is beyond the scope of what can be done in California.

be willing to devote the necessary time and energy to the task. Members should be appointed for two-year terms and be allowed to serve until replaced. The members should be reimbursed for their actual travel and per diem expenses and compensated for time spent on SAC activities at a level determined to be appropriate by the DFG Principal after consultation with NOAA. The SAC should meet at least once every six months, but could meet more often as determined by the Chair who would be appointed by the SAC.

Technical Team

DFG field biologists need to meet regularly to discuss their monitoring programs, deployment of monitoring program staff and to compile monitoring program data in a form that can be used by the public and other interested groups. They will need to compile their program results and make those data available to the Program Coordinator and the SAC at least once annually. It will also be important to include NOAA Fisheries and other non-DFG monitoring program team leaders in these meetings. The proposal here is to form a Coastal Anadromous Salmonid Monitoring Program Technical Team (Technical Team) to facilitate data collection, analysis and reporting.

An important Technical Team function will be the analysis of data relative to assessing stock status and trend, stock productivity, species and population spatial distributions and adequacy of population diversity data. The Technical Team may also be assigned the responsibility for preparing coastal FMEPs, reviewing HGMPs and assessing progress in meeting monitoring needs for and CESA listing change criteria specified in the DFG's coho salmon recovery strategy (DFG 2004).

Annual population estimates and ESA- and CESA-related analyses would be made each year by the Technical Team before an annual post-season meeting of the SAC. The SAC would review the season's sampling program, identify problems and possible solutions, make or review annual population estimates and review the next season's sampling plan. In the first several years, sampling activities will encounter problems and issues that may have significant impact on the estimates. Identifying those problems and their solutions will be assigned to the SAC. The problems and solutions need to be documented by the Technical Team in an ongoing permanent record of Monitoring Program activities. The SAC will review and provide input on Monitoring Program outputs. Finally, the SAC will review the next season's sampling plan and make recommendations for improvement.

Data Management

Data management is a critical and often neglected element of biological sampling programs. It is essential that this particular need be addressed as part of the Monitoring Program now, rather than later.

Centralized Data Base

The DFG recently embarked on an effort to centralize its fish and wildlife data by providing tools for storing, accessing and analyzing these data. Program data, including fisheries data, are often dispersed and lack standardization, and therefore are largely unavailable for fishery or watershed-level assessment and analysis needs. There is a growing need for consolidated and standardized data for use in salmonid restoration, management and recovery programs. In addition, many potentially valuable data sets were collected prior to the advent of tools to express them in spatial form and in relationship to other data. An effort should be made to provide such a spatial component where possible.

The objective of the DFG centralized Bio-geographic Information and Observation System (BIOS; www.bios.dfg.ca.gov) is to facilitate communication between often disparate data sets and provide a centralized system for storing, managing and retrieving them. The current system infrastructure supports two basic database stewardship options: managed and unmanaged. Unmanaged data sets are those received by the Wildlife and Habitat Data Analysis Branch (WHDAB; primary Department-wide data stewardship responsibility) typically as one-time surveys or data collection efforts that will likely not require updates and that reflect single observations in space and time. These database structures are often highly varied with respect to other BIOS data sets and usually require some modification before they can be integrated into BIOS. Managed data sets are those which are subject to regular updates and are frequently part of a business process within the DFG. Managed data sets integrate standard database structures developed by the WHDAB and often require custom data entry or access interfaces. The DFG anticipates that the Monitoring Program will be a managed database system because it is intended for monitoring and it is a high priority program.

The DFG is in the process of finalizing a series of design guidelines containing specific recommendations to assist DFG and BIOS partners in designing databases consistent with the BIOS system. The design guidelines will incorporate the following concepts:

1. utilization of a common set of spatial and user identification data fields to allow queries and relationships between data sets,
2. software specifications for both the database and interface. (Currently the system utilizes Microsoft SQL Server database software.),
3. metadata standards to facilitate use of a metadata catalog for keyword and thematic searches across data sets,
4. suggestions and guidelines for standardizing data structures for monitoring, management, and other parameters and
5. identification of lookup tables and data definition standards.

Data Flow

Plan data base management needs to be structured to improve efficiency and data quality of the Plan's operations. The Plan's data base management goals include: (1) the capture of data collected by field operations, (2) data editing and range checking, (3) transfer of raw data to a Geographic Information System, (4) production of population estimates, (5) an annual meeting of the SAC to review the data and project direction and finally (6) making the data available to agencies and the public. Each of these steps needs to contribute to improved data collection, organization, management, estimation, interpretation and display to the user audiences.

Actual data collection activities will occur over a wide range of locations and conditions, including wet winter sampling. Data recording in the field can be accomplished by using Personnel Digital Assistants (PDAs). The PDAs would need to be programmed using some software like *Pendragon* to create custom data entry systems. These data entry systems have the advantage that some data checking can occur at the time of data collection. Most important, this will do away with the time required for data entry and also eliminate additional errors introduced into the data during the data entry process. The PDAs can then be downloaded into laptops each evening and backed-up onto external media. PDAs are not expected to be a major program expense and are preferred to the traditional method of having support personnel enter field data, usually at a remote location, without field personnel oversight. The disadvantage of PDAs is the loss of paper back up and the potential loss of the raw data collected on any given day's field survey. Timely archiving of daily field data in both electronic and hard-copy formats will mitigate or eliminate this disadvantage of the PDA approach.

Data can be uploaded over the Web to regional data management centers upon the field crew's return to the field offices. This will offer an additional chance for data editing and range checking and also allows a rapid transfer to the regional data management center. The close to real time data transfer allows almost immediate data summary and examination and much better operational control over the Monitoring Program's sampling activities.

The raw data from field activities should be managed by a data management system operating at each regional data management center. These regional data management centers will be part of the operational control of the sampling along with basic data management of the raw field collection data. Each center will have a person in charge of regional data management, including development of data expansion factors and variance calculations. Those individuals will be responsible for the final data editing and storage of the field data after which the data will be integrated into the BIOS. This regional data management will be responsible for the type of in-season data reports and summaries that will be necessary to insure that the year's sampling plan is being fully completed in a timely fashion. This type of in-season sampling information is invaluable for operational control of the Monitoring Program's sampling activities. The regional data management should be housed in one or more of the field data collection offices. The physical co-location of the data collection and the data management will improve cooperation between the two groups and lead to an improvement in data quality.

Data Uploading and Reporting

The annual population estimates and other appropriate parameter estimates will be uploaded to BIOS. BIOS will allow storage and retrieval of the data by both user identification fields and by spatial displays. This will allow designated users to query and investigate the data through web-based access to provide the widest possible use of the data. Reports and query tools will be available through BIOS. By having all the data types available through BIOS, interactive cooperative investigation of different data types (for example, salmonid abundance data and habitat data) will be promoted. Reasonable queries of the raw data will be provided on special request by the regional data management centers. The BIOS Data will then be made available to both agency personnel and the public through *Calfish,* the mulit-agency cooperative program that is designed to gather, maintain and disseminate fish and aquatic habitat data and data standards for California (see: http://www.calfish.org/DesktopDefault.aspx). **Figure 5** shows direction of data flow from field offices to the BIOS, thence *Calfish* for use by the public.

Proposed Budget

Task Cost Estimates

The proposed budget is built upon the assumption that the Monitoring Program will be a DFG program. The funding sources are not identified, nor is it specified that all positions need to be DFG employees. Some staff members could be contract employees. We also do not attempt to factor in the budget savings that might accrue from the use of volunteer labor or collection of program data by non-DFG or NOAA governmental or private organizations.

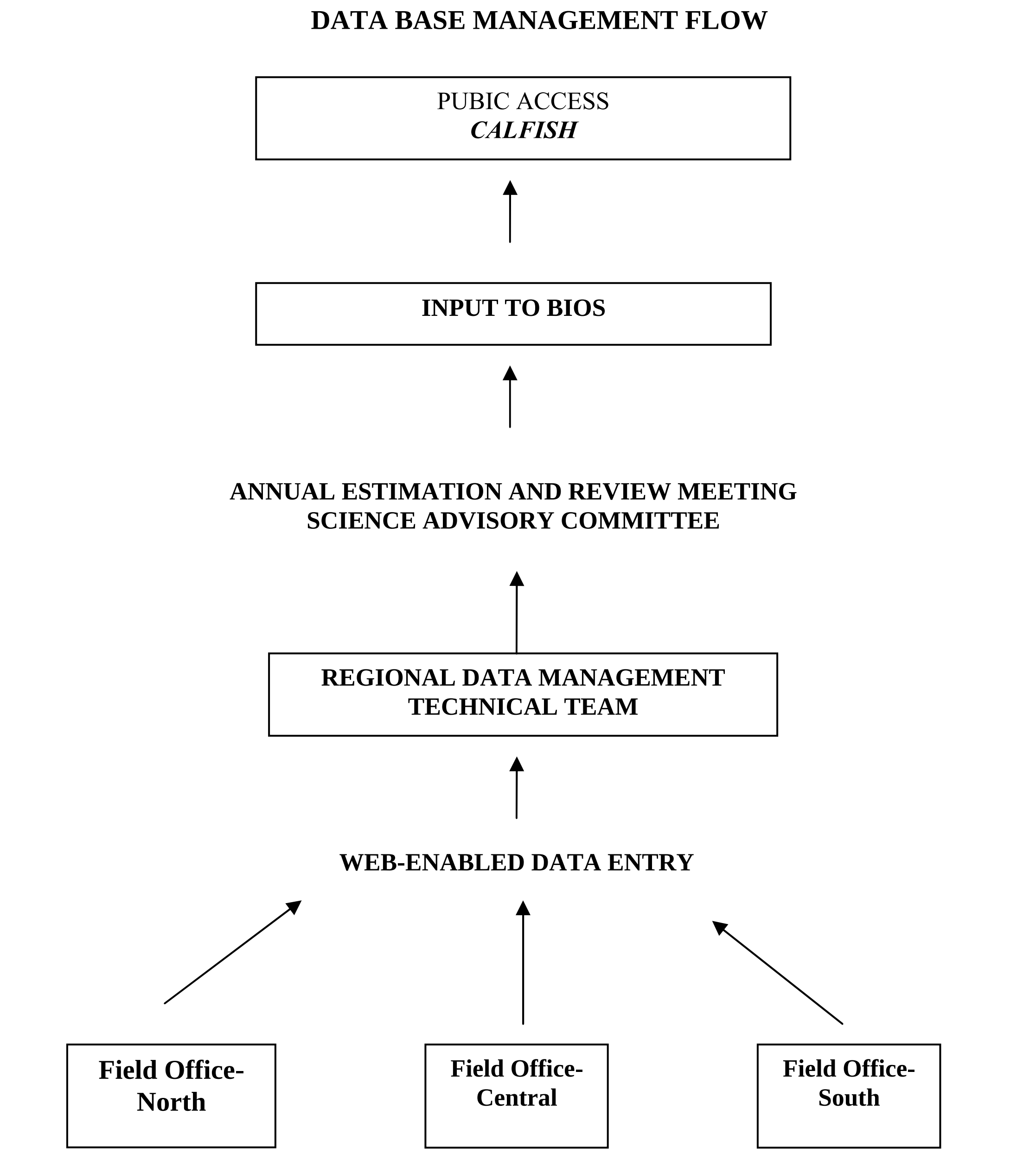

Figure 5. Data flow diagram

Seven tasks are developed to cover the Plan recommendations. The task estimates are based on Plan sample size recommendations, published reports, salary and duty statement information taken from the State Personnel Board web page and information provided by DFG administrative staff. The budget estimates include annual salaries, including personal benefit rate (25.3%), data management needs, operating (15% of salaries and benefits), equipment, rental, contractual services and DFG overhead

(21.3%). The one-time start-up cost includes equipment such as vehicles and computers and construction costs. The proposed task costs in the following are rounded to the nearest $1,000.

The task calculations appear in **Appendix J**. They are numbered to correspond to the Plan recommendation numbers. It is important to note that the estimates for tasks 1 and 4 are sensitive to the stream mileage estimates used for calculating the extent of survey area. This directly affects the amount of personnel resources, operating expenses and equipment that are needed to implement them. The steam mileage estimates are based on assumptions about relationships between miles of coho salmon habitat in Oregon, which have been intensively studied for over 40 years, and miles of coho salmon habitat in California, which have not been studied to nearly the same degree. This was done for preliminary budgetary forecasting purposes and no other reason. We initially proposed to use habitat mileage information from the DFG's 1965 Fish and Wildlife Plan (DFG 1965) but rejected those estimates after DFG staff compared those estimates with more recent survey work in the Klamath Basin and determined the Wildlife Plan estimates were too low.

The cost analysis of Options 1 and 2 for Task 3 shows that building and operating two permanent structures would cost about $772,000 in annual operating cost and about $8.4 million in start up cost, mostly for facility construction **(Worksheet 3a**). The annual operating cost under Option 2 is higher at $1.4 million, but the start up cost is much less at $1.0 million (**Worksheet 3b)**. Option 2 is more costly than Option 1 in the long term, but more useful data are likely to accrue from Option 2 due to greater overall sampling effort and the wider geographic scope of the monitoring.

The recommendation for Task 3 is to establish six new LCSs in the coastal zone, two in each of the coastal TRT Domains as follows: Northern Domain, Oregon/California Border to Punta Gorda; Central Domain, Punta Gorda to Aptos Creek; and South Domain, Pajaro River to Tijuana River. The preferred approach in terms of cost and efficiency is to use streams that have existing or planned fishways or permanent fish trapping facilities that can be used to trap adult fish (see **Table 5)**. Juvenile trapping would depend on using portable trapping equipment such as fence weirs, rotary screw traps or incline plane screen traps.

Monitoring Program Costs

The proposed annual Monitoring Program budget is $7 million. This compares with the annual monitoring cost estimated to monitor coho salmon as part of the DFG's coho salmon recovery strategy of about $1.4 million (DFG 2004). There is a start up cost of $1.9 million, which is mostly for vehicles, adult weirs and juvenile fish traps. Tasks 1, 2 and 4 are integrated; that is, they use the same permanent personnel, facilities and equipment. Tasks 3, 5, 6 and 7 can operate independent of one another (**Figure 6)**.

Annual

Task 1) Northern Spawner Survey	$2,545,000
Task 2) Southern Steelhead Monitoring	541,000
Task 3) Life Cycle Monitoring Stations	1,370,000
Task 4) Juvenile Survey	1,307,000
Task 5) Hatchery Marking	69,000
Task 6) Creel Survey	369,000
Task 7) Administrative Support and Special Studies	789,000
Total	**$6,990,000**

One-time Start-up Costs

Task 1) Northern Spawner Survey.. $566,000
Task 2) Southern Steelhead Monitoring.. 65,000
Task 3) Life Cycle Monitoring Stations.. 1,036,000
Task 4) Juvenile Survey.. 177,000
Task 5) Hatchery Fish Marking.. 0
Task 6) Creel Survey.. 14,000
Task 7) Administrative and Special Studies.. 36,000
Total.. 1,894,000

A summary of personnel needs follows:

Task	Permanent (Personnel Years)	Temporary Help (Personnel Months)
Task 1) Spawner Survey	1.6 Assoc Biol 4.8- Biologist (B)	396
Task 2) Southern Steelhead Monitoring	.5- Biologist (B)	20
Task 3) Life Cycle Stations	1.0 Assoc. Biol 3.0 Biologist (B) 2.0 Habitat Asst.	162
Task 4) Juvenile Survey	0.4 Assoc. Biol 1.2- Biologist (B)	288
Task 5) Hatchery Fish Marking	.16 – Habitat Asst	19
Task 6) Creel Survey	1 – Biologist (B)	56
Task 7) Administrative Support	1 – Environ. Manager I. 2 - Research Analyst 1 (GIS) 1 - Secretary	12
Totals	**19.66 – Personnel Years**	**791 PMs (66 Personnel Years)**

An organization chart showing the reporting relationships or the various Monitoring Program entities is shown in **Figure 6**. In this chart, a DFG Deputy Director is shown as the position in charge of Anadromous Policy.

DO TASKS MEET PLAN OBJECTIVES AND OTHER ESA AND CESA ISSUES?

Plan Objectives

Tasks 1-6 are aimed at measuring VSP attributes. Tasks 1, 2, and 4 are the most robust in this regard. They include the northern spawner survey, which involves all species except cutthroat, southern steelhead adult monitoring, and juvenile salmonid survey, which is presence-absence sampling for juvenile coho salmon and southern steelhead and abundance monitoring of cutthroat. Task 3, Life Cycle Monitoring Stations, is important for determining smolt survival rates and the influence of ocean and inland environmental conditions on adult returns. The hatchery and creel survey tasks are aimed at differentiating hatchery fish in the runs and estimating inland fishery removals, respectively.

These are important parameters in the context of determining brood year productivity and survival rates. Task 7 is aimed at meeting liaison, coordination and data management needs. It also provides funding support for special study needs. An important issue is whether the Plan has scientific merit, hence scientific support. The next step in the Plan development process is to distribute the Plan for scientific peer review. A current assessment of how individual tasks meet key Plan development objectives (see Plan Goals and Objectives section) is provided in **Table 8**.

Fishery Management and Evaluation Plans (FMEPs)

The intent of FMEPs is to devise biologically based fishery management strategies that ensure conservation and recovery of ESUs (see **Appendix A**). The Monitoring Program is expected to provide the data needed to prepare these documents for coastal salmon and steelhead fisheries by providing estimates of annual run sizes (Tasks 1 and 2), fishery harvest rates (Task 6), and hatchery fish contribution rates (Task 5). These are data sets that currently are not available and that are needed for the DFG to estimate fishery impacts and assess whether those impacts will provide for species conservation and recovery.

Hatchery and Genetic Management Plans (HGMPs)

HGMPs are intended to address the take of listed species that may occur as a result of artificial propagation activities (see **Appendix A**). The Monitoring Program is expected to provide essential data on the sizes of natural spawning populations (Tasks 1 and 2), the proportion of hatchery fish spawning in natural spawning areas (Tasks 1, 2 and 5), and the proportion of naturally produced fish that are spawned in the hatcheries (Task 5). These are data that currently are not available to prepare HGMPs.

Coho Salmon Recovery Strategy

The DFG's coho salmon recovery strategy (Strategy) contains over 750 recommendations for protection and restoration of coho salmon habitat, scientific study and resource monitoring for assessing status of coho salmon and their habitats (DFG 2004). The Strategy sets quantitative targets for delisting or uplisting as required under CESA of coho salmon in specified Recovery Units within the Southern Oregon/Northern California Coastal and Central California Coastal ESUs. These targets include: (1) numbers of streams that have or potentially have coho salmon populations, (2) percentage of historical coho salmon streams that currently support coho salmon runs and (3) number of coho salmon adults spawning in individual Recovery Units. Plan Task 4, Juvenile Monitoring, is important for evaluating progress toward meeting quantitative targets (1) and (2). Task 1, Northern Spawner Survey, is needed to evaluate progress toward meeting quantitative targets (1) and (2) and is the primary task for addressing target 3).

COASTAL ANADROMOUS SALMONID MONITORING PROGRAM PROPOSED ORGANIZATIONAL STRUCTURE

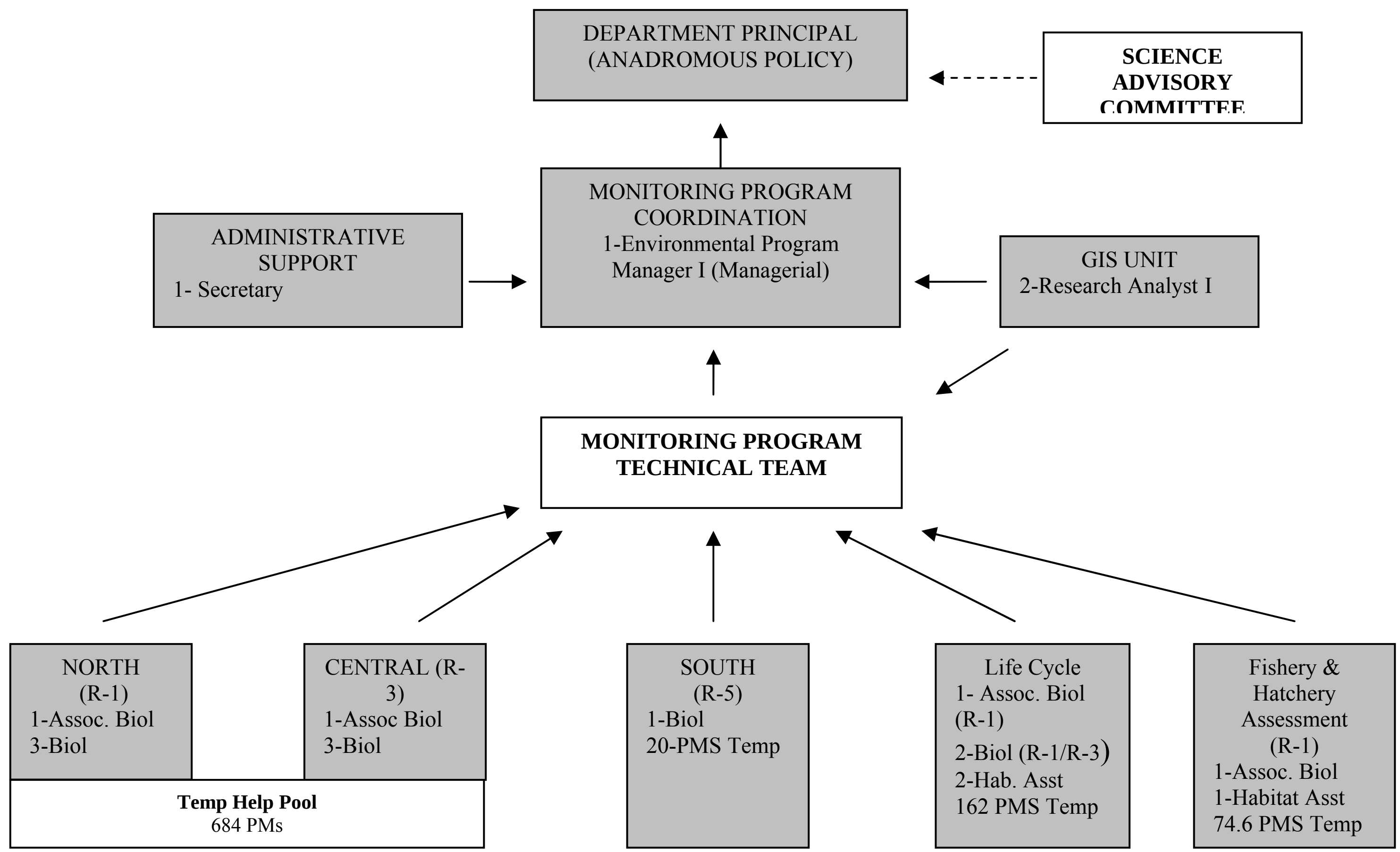

Figure 6. Organization chart for coastal anadromous salmonid monitoring program

Table 8. How tasks meet key Plan monitoring and administrative objectives

	VSP Attribute				Other Issues				
Task	**Abundance**	**Distribution**	**Diversity**	**Productivity**	**Management Units Identified**	**Scientific and Supportable**	**Budget**	**Monitoring Groups Identified**	**Operational Strategy**
Task 1: Northern Spawner Survey	X	X	w/ additional sampling	X	X	More review needed	X		
Task 2: Southern Steelhead Monitoring	X			X	X	More review needed	X		
Task 3): Life Cycle Monitoring Stations				X		More review needed	X		
Task 4): Juvenile Salmonid Surveys	X (cutthroat only)	X	w/ additional sampling	X (cutthroat only)	X	More review needed	X		
Task 5): Hatchery Fish Marking				X		More review needed	X		
Task 6): Angler Creel Survey				X		More review needed	X		
Task 7) Administration and Special Studies						More review needed	X	X	X

RISK ANALYSIS

The risk associated with taking action, taking partial action or not taking action is an important discussion for groups and individuals that are interested in listing/delisting of ESA and CESA salmonids and especially those who are asked to fund the Plan. These 3 scenarios are discussed in the following.

What if the Plan is Not Implemented?

This is status quo. There would likely be no change in the listing status of populations on the Federal level, and regulatory and permitting requirements would be unchanged, at least until the next round of species assessment reviews. The limited data available for coastal populations **(see Table 2**) could be used to uplist (i.e., from Endangered to Threatened) the stocks if they appeared to be rebounding, but more than likely the status quo would continue until better data are produced showing how the ESUs are fairing as a whole. However, if the limited data show an abundance decline, listing or downlisting of species or populations is a likely outcome, which is the more risk adverse approach. The populations that are not now listed have fairly robust monitoring programs (e.g., Klamath Chinook salmon and Klamath steelhead) or have anecdotal information that listing is not warranted (Smith River Chinook salmon and steelhead). If the Klamath management and monitoring program continues, the risk of listing these stocks is considerably reduced. However, if the Smith River runs and their counterpart runs in Oregon take a downward turn based on anecdotal information (which was largely used to keep them out of listing status in California to begin with) and/or Oregon data shows a downward turn, a listing recommendation is very possible based on lack of status data over the entire ESU. But probably the most important threat is the possibility of petition to add species under CESA. If the petitioned action has merit, State regulatory action would be required to protect the species. Those regulations would be in addition to the existing Federal protection requirements.

What if the Plan is Implemented in Part?

This is a likely scenario if the proposed budget is too high for current funding sources. Some tasks have higher priority than others. The adult monitoring tasks have the highest priority, followed by the juvenile monitoring tasks. Without these tasks, it would be difficult to justify implementation of the remaining tasks. **Table 8** shows that all seven tasks need to be implemented if the VSP data, administrative and data management, and other ESA and CESA data needs are to be met. The partial implementation scenario is a very difficult to evaluate because of the uncertainty on what the budget limitations might be and what options are available for fund redirection.

Staged implementation of the various Plan elements is a very likely and perhaps desirable approach to overall Plan implementation. The highest priority would be the implementation of Tasks 1 and 2 (Northern Spawning Grounds Surveys, Southern Adult Steelhead Monitoring) and Task 4 (Juvenile Monitoring). Task 5 (Hatchery Fish Marking) should also have a high priority because of low cost and high value of the data when combined with Task 1.

What if the Plan is Implemented in its Entirety?

This is the best case scenario in terms of meeting ESA and CESA stock listing/delisting criteria and to address potential CESA listing petitions. However, it is the most costly option at $7 million annually with no guarantee that: (1) future Federal stock assessment reviews will not lead to additional ESA listings or downlistings or (2) that additional CESA listing petitions will not be submitted and adopted with associated regulatory requirements. The goal of the Plan is to assemble a data set that provides credible scientific information needed to make ESA and CESA stock assessments. DFG recovery efforts are not limited to counting fish and seeing if the counts go up or down. The DFG is engaged in many efforts to manage and restore the fish and their habitats. The Plan is intended to provide a data base with which to measure the success of Statewide recovery efforts.

PROGRAM FUNDING OPTIONS

The Monitoring Program funding question is a natural response to proposals of this nature. That is, where will the money and spending authority come from to support the proposal? From the start of this Plan development effort, this has been an area of continued questioning by individuals both within and without the DFG and NOAA. All of the principals involved have agreed that the proposal and its implementation should be given high priority within their respective agencies, but way(s) for addressing the issue were not apparent. The Steering Committee does not have an answer either, but did speculate on a variety of paths to explore.

An obvious first approach is for the DFG to re-examine its funding and staffing priorities and to determine whether there is room (and willingness) to re-allocate from within. This is a difficult approach for addressing the situation. It requires careful thought and thorough analysis about what the DFG is currently doing and how those priorities match up against the program needs recommended here. Also, they would need to consider the impact change would have on the "losing" programs and their respective public/fishing interest groups. Re-allocation of funds and staff from one activity to another can result in internal and external conflict over how and where the DFG's limited resources should be spent. The DFG has many high priority fish and wildlife management and protection responsibilities. Salmonids and their management represent one of many competing resource priorities.

Not all DFG funds are discretionary. Many are dedicated to particular habitat or species activities. These may not be on the table for consideration. Even after completing the difficult process of considering use of discretionary funds, the available resources still may not satisfy the need, which is likely to be the case when asked to fund a proposal costing $7 million per year. For perspective, we have compiled budget information for several existing DFG salmonid monitoring programs.

1. Central Valley Chinook salmon monitoring program budget, $2.2 million (Alice Low, DFG, pers. comm.),
2. Klamath-Trinity Chinook salmon monitoring program, $1.2 million (Neil Manji, DFG, pers. comm.),
3. Ocean Salmon Project, $720,00 (Melodie Palmer-Zwahlen, DFG, pers. comm.) and
4. Anadromous Fisheries Research and Management Program (AFRAMP), $920,000.

Should the DFG redirect from these programs to meet the coastal monitoring program need, leaving major gaps in those other programs? The probable answer is "no way." This is not to say, however, that the DFG could not redirect some of its entire AFRAMP program to coastal salmonid monitoring on a broader scale. This would seem to be a reasonable first approach. We need to be aware, there is a point at which redirection does not have meaning, hence is fruitless, if the remaining gap is too large. This is a matter of bookkeeping and professional judgment. For example, the DFG might be able to fund one or more of the proposed tasks with existing resources, but would such a move be meaningful? Or would it result in a monitoring program that has no chance of success and the loss of an abandoned program that was contributing useful information but on a smaller scale?

Can NOAA Science Center and/or Southwest Region come up with resources from within to help fill the gap? This is an interesting thought. We are aware that NOAA is involved on the ground level in a few fishery studies around the State and on the West Coast. What about redirecting those efforts into a programmatic one, like the proposed Monitoring Program? Redirection of NOAA staff and resources to programmatic field activities may not be a viable option, but should be explored.

It seems likely that a new funding source, even with DFG/NOAA redirection, needs to be pursued if the proposal is to go forward and have any chance of success. Where then are the logical places to look? A couple of options come to mind: (1) allocation of a portion of existing Fisheries Restoration Grant Program funds to the proposal or (2) seek new or augmented State or Federal funding sources. Option (1) may not currently be possible because of State constraints on how those funds can be spent, but does not appear to be in conflict with Federal law that authorizes funding for monitoring from the Pacific Coastal Salmon Recovery Fund. Also, Federal grant money is not a secure funding option for long-term programs that require staffing with permanent personnel. If Congress decided to discontinue or reduce the grant funding amount, it could lead to staff reductions, which the DFG would have to deal with. Option (2) is highly dependent upon the condition of State and Federal coffers, neither of which is healthy at this time. Also, Option (2) would be a very lengthy process with considerable political maneuvering involved and no guarantee of the eventual outcome. One important Federal funding source for anadromous monitoring and research programs is the Anadromous Fish Conservation and Management Act (AFCMA), which provides funding to qualified States on a 50/50 basis. AFCMA funding has been frozen for many years and would require an act of Congress to increase it. There may be other existing Federal funding sources to consider or ways to create a new line item or increase an existing one in the Federal budget to provide Federal funding in support of this proposal. California is an active member of the Pacific States Marine Fisheries Commission (PSMFS) that is charged by its member states to work with Congress to obtain Federal assistance for the member states. They have been very successful in that regard thanks to their Washington D.C. contacts and support by California fishing and environmental groups. Rather than speculate any further on how to increase California funding through Congress, it would be appropriate to engage the PSMFC and its member states (Alaska, Washington, Oregon, Idaho, and California) to work with the very large California congressional delegation, and others, to find funding for this proposal. Please note that even if the PSMFC were successful in getting additional funds for California, a State matching share would likely be required.

Can private and other (non DFG or NOAA) governmental organizations contribute to the statewide monitoring? Yes, to the degree that they are willing and able to volunteer their services or to conform their operations to Monitoring Program sampling plans and protocols. The hatchery fish marking task would be a good volunteer project. Fish marking does not require special expertise and could save the Monitoring Program from having to hire temporary help. Monitoring Program staff would solicit the workers, train them and supervise the marking. However, if there is not a large pool of volunteers in the local area, hired fish markers would still be needed. Ongoing or new adult or juvenile monitoring programs conducted in local areas, whether governmental or private, may be able to contribute, depending on the protocols they are using and their sample area locations. To engage these groups, the DFG and NOAA need to agree upon specific sampling, data collection, and data sharing protocols, some of which are described or proposed in the Plan. The DFG would need to: (1) publish annual sampling plans and direct the public where to find information on sampling protocols, Monitoring Program sampling objectives and sampling protocols and (2) allocate staff to work with and train the local groups. The local groups could contribute data in either of two forms: (1) data required as part of the annual Monitoring Program or (2) data that fall into the "oversample" category (see Sample Draw section). Not all local programs may be collecting data following specific DFG/NOAA protocols, but their data still may be usable. The DFG/NOAA will need to work with individual programs to determine whether their data can be used to meet Monitoring Program objectives. Both data forms would be fed into the Monitoring Program database, along with appropriate identifier information. It is important to note that oversample data will have to be weighted downward when used in large scale analyses (i.e., watershed, population or ESU scale). The use of volunteer labor and local program data is an area that needs further discussion.

Ultimately, the final decision on how to proceed rests with the DFG and NOAA principals in charge of State and Federal funding and management policies. To get high level attention, the public and the parties affected by or interested in ESA and CESA decisions need to get involved. Thus, the current proposal needs to be circulated widely, including discussions in town hall meetings, to let the public know about the program needs and to seek their support and, most importantly, their energies for getting attention at high levels in Sacramento and Washington D.C.

LITERATURE CITED

Boydstun, LB. 1994. Analysis of two mark-recapture methods to estimate the fall Chinook salmon (*Oncorhynchus tshawytscha)* spawning run in Bogus Creek, California. Calif. Fish & Game 80(1):1-13.

Crawford, B.A. and G. C. Volkhardt. 2004. 2004 Washington salmon and steelhead abundance index (trends regarding recovery of populations listed under the Federal Endangered Species Act). Interagency Committee for Outdoor Recreation, Salmon Recovery Funding Board, Olympia WA 95504. 57 p.

Dunham, J., B. Rieman, and K. Davis. 2001. Sources and magnitude of sampling error in redd counts for bull trout. N. Amer. Jour. Fish. Mgmt. 21:343-352.

Duffy, W.G., M. A. Wilzbach, M. Wheeler, and S. Frazey. 2003 (Draft). Validation monitoring of watershed restoration in California. Part III. Calif.Coop. Fish Unit., Humboldt State Univ., Arcata, CA 95521. Interagency Agreement No. P0010565.

DFG (California Department of Fish and Game). 2004. Recovery strategy for California coho salmon (*Ocorhychus kisutch)*—Report to the California Fish and Game Commission. June, 2004. Dept. Fish & Game, Sacramento 95814 (see http://www.dfg.ca.gov/nafwb/CohoRecovery/RecoveryStrategy.html).

Elzinga, C.L., D.W. Salzer, and J.W. Willoughby. 1998. Measuring and monitoring plant populations. US Bur. Land Mgmt. Denver, CO 80225. 492 p.

English, K. K., R.C. Bocking, and J. Irvine. 1992. A robust procedure for estimating salmonid escapement based on the area-under-the-curve method. Canad. Jour. Fish. Aqu. Sci., 49:1982-1989.

Fry, D.H., Jr. 1973. Anadromous fishes of California. Calif. Dep. Fish and Game, Sacramento, CA. 111 p.

FWS (US Fish and Wildlife Service). 2004. Threatened and endangered species system web page: de-listed species. www:ecos.fws.gov/tess_public/TESSWebpageDelisted

Gallagher, S. P. and C. M. Gallagher. In Press. Discrimination of Chinook salmon and coho salmon and steelhead redds and evaluation of the use of redd data for estimating escapement in several unregulated streams in Northern California. North American Journal of Fisheries Management.

Girman, D.J. In progress. Microsatellite analysis of Russian River steelhead. Sonoma State Univ. Rohnert Park CA 94929.

Hankin, D.G. and G.H. Reeves. 1988. Estimating total fish abundance and total habitat area in small streams based on visual estimation methods. Can. J. Fish. Aquat. Sci. 45 (5): 834-844.

Hankin, D.G. 1984. Multistage sampling designs in fisheries research: Applications in

small streams. Can. J. Fish. Aquat. Sci. 41 (11): 1575-1591.

Hilborn, R., B. Bue, and S. Sharr. 1999. Estimating spawning escapement from periodic counts: a comparison of methods. Can. Jour. Fish. and Aqua. Sci. 56:888-896.

Hopelain, J.S. 1988. A four year summary of seining/tagging operations in the lower Klamath River with emphasis on mature fall Chinook salmon, coho salmon, and steelhead trout, 1984 through 1987. Inland Fish. Admin. Rept No. XX-XX (draft). DFG, Sacramento, CA. 40 p +11 tables and 25 figs.

Jacobs, S. 2003. Development and implementation of a program to monitor spawner escapement of anadromous salmonids in Oregon tributaries of the Lower Columbia River. PowerPoint Presentation to Northwest/Central Valley Adult Salmon Escapement Monitoring Workshop. June 17-18, 2003. Available from Alice Low, DFG, Sacramento CA or Steve Jacobs, Oreg. Dept. Fish and Wild., Corvallis OR. 55 p.

Jacobs, S., Firman, J., Susac, G., Stewart, D., and J. Weybright. 2002. Status of Oregon coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002: Monitoring Program Report No. OPSW-ODFW-2002, Oregon Dept. Fish and Wildl., Portland, OR.

Law, P.M.W. 1994. Simulation study of salmon carcass survey by capture-recapture methods. Calif. Fish and Game 80(1):14-28.

Lawson, P. W., E.A. Logerwell, N.J. Mantua, R.C. Francis, and V.N. Agostini. 2004. Environmental factors influencing freshwater survival and smolt production in Pacific Northwest coho salmon (*Oncorhynchus kisutch*). Can. J. Fish. Aqu. Sci. 61: 360-373.

Lestelle, L.C. and C. Weller. 2002. Summary report: Hoko and Skokomish River coho salmon spawning escapement evaluations studies 1986-1990. Point No Point Treaty Council Tech. Rept. TR 02-1. 53 pp.

MSC (Marine Stewardship Council). 2003. MSC evaluation of British Columbia salmon fisheries: units of certification, performance indicators, and scoring guideposts (final version). Chet Chaffee, MSC, Emeryville, CA.

McDonald, T., 2003. GRTS for the average Joe: A GRTS sampler for Windows. WEST Inc., 2003 Central Ave., Cheyenne, WY 82001. 9 pp.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionarily significant units. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC-42, 156.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1997. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

Newman, K. B., Hicks, A.C., and D.G. Hankin. 2004. A marking, tagging and recovery program for Central Valley hatchery Chinook salmon. Report to Central Valley Salmonid Project Work Team. July 7, 2004. Available from CalFed Ecosystem Restoration Program, Resources Agency, State of California, Sacramento, CA 95814.

Pollock, K.H., C.M. Jones, and T.L.Brown. 1994. Angler and survey methods and their applications in fisheries management. Amer. Fish. Soc. Publ. #510.24C. 371 p.

Rieman, B. E., and D.L. Myers. 1997. Use of redd counts to detect trends in bull trout (*Salvelinus confluentus*) populations. Cons. Biol. 11:1015-1018.

Robson, D.W., and H. A. Regier. 1964. Sample size in Petersen mark-recapture experiments. Trans. Am. Fish. Soc. 93: 215-226.

Schaefer, M.B. 1951. Estimation of the size of animal populations by marking experiments. U.S. Fish Wild. Serv. Fish. Bull. 69, 191-203.

Schwarz, C., A.N. Arnason, and C.W. Kirby. 2002. The siren song of the Schaefer estimator – no better than a pooled Petersen. Available from http://www.stat.sfu.ca/~cschwarz/papers/

Schwarz, C.J., and C.G. Taylor. 1998. Use of the stratified Petersen estimator in fisheries management: estimating the number of pink salmon (*Oncorhynchus gorbuscha*) spawners in the Fraser River. Can. J. Fish. Aquat. Sci. 55: 281-296.

Seber, G.A.F. 1982. The estimation of animal abundance and related parameters. MacMillan Pub., New York, NY, 654 p.

Stevens, D.L. 2002. Sampling design and statistical analysis methods for the integrated biological and physical monitoring of Oregon streams. U.S. Envir. Prot. Agen., West. Ecol. Divi., Corvallis, OR.13 p + append.

Szerlong, G., and D. Rundio. 2004 (draft). Estimating mortality and abundance of spawning salmon from a series of counts. Unpub. ms. 22p .

Waples, R.S. 1991. Definition of "species" under the Endangered Species Act: Application to Pacific salmon. Nat. Marine Fish. Serv., NW Fish, Sci. Cntr, Tech Memo-194. Seattle WA 98112.

Webster, R., and K. Pollack. 2004. Presence/absence monitoring of juvenile coho salmon in streams. North Carolina State Univ. (www.calmonitor.com)

GLOSSARY

Abundance: Abundance refers to the number of fish sampled in an area. Abundance is often expressed as the catch given some standardized unit of effort, for example the catch per hour of electrofishing. It is sometimes expressed as the number per unit area, in which case it may be referred to as density (Duffy, et al. 2003). See **Appendix B** for how abundance is used in the stock assessment process.

Adult: A term for maturing salmon and steelhead excluding grilse and half-pounders, respectively.

Area under the curve (AUC): A population estimation technique that uses live fish counts over time to estimate total fish days. This parameter estimate is then divided by the average length of time that fish use the spawning area to derive the population size estimate (Hilborn et al. 1999)

Bycatch: The harvest of non-target species or non-target stocks. All bycatch in stream salmon and steelhead fisheries of California must be returned unharmed to the water. A portion of released bycatch dies as a result of catch-and-release injury or trauma.

Calibration: The act of measuring the accuracy of an estimate or estimator and applying a correction factor to it.

Carcass: The carcass is what is left of a dead animal. Salmon carcasses are commonly used to infer the size of the spawning population because all salmon die soon after spawning and their carcasses usually remain in the close vicinity of the area where they spawned. Various techniques have been developed to estimate salmon runs sizes by carcass counting and/or carcass mark-recapture sampling.

CESA: The California Endangered Species Act.

Chinook salmon: Fish of the species *Oncorhynchus tshawytscha* that depend upon anadromy to sustain the species.

Coho salmon: Fish of the species *Oncorhynchus kisutch* that depend upon anadromy to sustain the species.

Constant fractional marking (CFM): The systematic or random marking, or tagging and marking, of a constant fraction of the entire production of salmonids from individual artificial production facilities, i.e., hatcheries.

Coastal cutthroat trout (cutthroat): Fish of the species *Oncorhynchus clarki clarki*. In California, some coastal cutthroats are anadromous, but the species likely does not depend upon anadromy to sustain the populations.

Creek. A small stream of water that is smaller than a river (and often tributary to a river) and larger than a brook. We generalize that creeks are Third Order and smaller streams

Creel survey: A general sampling approach used to measure catch and effort in a fishery. It usually involves direct fishery sampling to: (1) estimate total effort and catch in a fishery or (2) total effort and catch-per-unit effort to estimate total catch in a fishery. In California, most coastal salmonid fisheries operate as catch-and-release fisheries due to ESA constraints, thus they operate as catch-and-release fisheries with associated bycatch mortality.

Cubic feet per second: A standard U.S. measure of water flow. A common metric expression is cubic meters per second: 1 cfs equals 0.0283 m^3/sec; conversely 1 $m^{3/}$sec equals 35.3 cfs.

DFG or CDFG (California Department of Fish and Game): The administrative department within the California Resources Agency that is the trustee for fish, wildlife and native plant resources of the State.

DFG Principal: The DFG person that is responsible for salmon and steelhead management policy for the State (currently the DFG Director).

Digital Elevation Models (DEMs): Digital representations of topographic surfaces that are available from a variety sources. Here they are used in combination with USGS hydrographic maps to estimate stream channel gradients for use in defining the extent of anadromy in coastal watersheds.

Distribution (also spatial distribution): Generally, distribution refers to the degree to which the available habitats are utilized by a population or species. See **Appendix B** for how spatial distribution is used in the stock assessment process.

Diversity: Diversity is a measure of the distribution of traits expressed within and among populations. These traits are defined broadly, from explicit base pair sequences at single genes to more complex life history traits. See **Appendix B** for how diversity is used in the stock assessment process.

Environmental Protection Agency (EPA): A regulatory and enforcement entity within the Department of the Interior that deals with environmental laws enacted by Congress, particularly those dealing with water, air and land quality issues.

ESA: The U.S. Endangered Species Act.

Escapement: Mature salmon and trout that comprise the spawning component of the stock.

ESU (Evolutionarily Significant Unit): The Endangered Species Act allows the listing of "distinct population segments" of vertebrates as well as named species and subspecies. The policy of the NMFS (NOAA Fisheries) on this issue for anadromous Pacific salmonids is that a population will be considered "distinct" for purposes of the ESA if it represents an evolutionarily significant unit (ESU) of the species as a whole. To be considered an ESU, a population or group of populations must: (1) be substantially reproductively isolated from other populations and (2) contribute substantially to the ecological or genetic diversity of the biological species. Once an ESU is identified, a variety of factors related to population abundance are considered in determining whether a listing is warranted (Meyers, et al, 1997). See Table 1 and Figure 1 for California ESU listings and boundary lines.

Estuary: A water passage area where the tide (saline water) meets the stream current (fresh water) at the lower end of a river. Estuary conditions cease to exist when tidal water flow is impeded during low flow months due to sand build up (bar formation) at the river mouth. The area then becomes a pond or lagoon. Estuaries are important rearing areas for juvenile Chinook salmon and as acclimation zones for upstream migrating salmonids of all species.

Fall salmon and steelhead. Fish that enter freshwater primarily during August-November, thus are ocean maturing fish.

Fingerling fish: Is used here to mean salmonids that have emerged from the gravel and completely absorbed their yolk sacs and are in their first year of life (age 0+) in the stream and excludes yearling and older fish.

Fishery Management and Evaluation Plan (FMEP): A Federal permitting requirement that serves as a mechanism for addressing the take of listed species in fisheries. The primary goal of the FMEP is to devise biologically-based fishery management strategies that ensure the conservation and recovery of listed Evolutionarily Significant Units (ESUs).

Fishway: A single series of artificially constructed pools used by migrating salmonids to swim around and over an instream barrier.

Grilse: A term for age 2 salmon, which are usually males.

Genetic sampling/genetic analysis: This involves tissue sampling of individual fish to determine genetic makeup, which, when combined with multiple fish samples, yields the stock's genetic profile, a frequency distribution. Genetic profiles are important for assessing relative dependence of stocks on one another and for stock contribution estimates in mixed stock ocean and river fisheries. The tissues selected for analysis depends on the proposed analytical technique. These range from simple protein-type to the more complicated DNA-related analyses.

Habitat Conservation Areas (HCPs): An ESA permitting requirement for non-Federal landowners that might incidentally take an endangered species. The plan must be designed to offset any impact land use activities might have on listed species. HCPs are administered by the US Fish and Wildlife Service.

Half-pounder: A life history trait of steelhead exhibited in the Rogue, Klamath, Mad and Eel Rivers of southern Oregon and northern California. Following smoltification, half-pounders spend 2-4 months in the ocean, then return to fresh water during August-September. They return to salt water the following winter or spring. This is often termed a false spawning migration, as few half-pounders are sexually mature.

Harvest: Fish that are caught and kept during a fishery, which is also referred to as landed catch (as opposed to non-landed catch or discarded bycatch).

Hatchery: Salmon and steelhead hatcheries use artificial procedures to spawn adults and raise the resulting progeny in fresh water for release into the natural environment, either directly from the hatchery or by transfer into another area. The fish are released either as fingerling or yearling sizes.

Hatchery and Genetic Management Plans (HGMPs): These serve as a mechanism for addressing the take of certain listed species that may occur as a result of artificial propagation activities. The NOAA will use the information provided by HGMPs in evaluating impacts on anadromous salmon and steelhead listed under the ESA. In certain situations, HGMPs will apply to the evaluation and issuance of section 10 take permits. Completed HGMPs may also be used for regional fish production and management planning by Federal, State, and tribal resource managers.

Hydrologic Unit: These are stream systems or groups of systems that bear individual codes (hence HUCs) for reference by the U.S. Geological Survey. Stream outflow and water chemistry data are stored and made available to the public by HUC from the USGS.

Key stock: A term used by the PFMC for salmon stocks that have specific ocean management objectives.

Key coho salmon populations. These have been identified by the DFG and are believed to be source populations or biological refugia all of which bear creek names on USGS maps. Key coho salmon populations (DFG 2004).

Klamath Fishery Management Council: An 11-member Federal advisory committee that brings together commercial and recreational fishermen, Native American tribes and State and Federal agencies to work by consensus to manage harvests and ensure continued viable populations of anadromous fish in the Klamath Basin. Members include representatives from commercial and recreational ocean fisheries, the in-river sport fishing community, tribal fisheries and agencies (the California Department of Fish and Game, Oregon Department of Fish and Wildlife, National Marine Fisheries Service and U.S. Department of the Interior).

Lagoon: The expanded lower end of stream systems caused by sand bar development at the river mouth during low flow months. Lagoons mostly store fresh water but saline water may found on the bottom in the close vicinity of the bar. Lagoons will breach whenever water accumulation exceeds the capacity of the lagoon to store water. Lagoons are believed to be important rearing areas for juvenile steelhead.

Life Cycle Monitoring Stations (LCSs): Proposed "hard structures" facilities used to count upstream migrating adults and downstream migrating juvenile fish and smolts from within designated watersheds. LCSs are critical for determining instream and ocean survival rates, parameters that are critical for assessing the productivity of coastal salmon and anadromous trout populations.

Magnuson-Stevens Act (P.L. 94-265): The Federal law that provides for regional management councils, each charged with developing management plans and marine fishing regulations in the Exclusive Economic Zone (3-200 miles offshore) for marine fish stocks (including salmon and steelhead trout) that meet the standards for Federal fishery management. The Pacific Fishery Management Council (PFMC) serves in this capacity for Washington, Oregon, Idaho and California marine fish stocks.

Mark and recapture method: An estimation approach that uses changes-in-ratios of marked and unmarked members of a population to estimate or infer the population total. Here its use is proposed to estimate salmon carcass population sizes or to estimate live populations of upstream migrating adults.

Method: Method is used in two senses: (1) as a procedure, plan or process for achieving an end or (2) as a scientific discipline.

Monitor(ing): The collection and evaluation of data and assessment of progress toward meeting management objectives (Elzinga et al. 1998).

Monitoring Areas: There are two monitoring areas in the Plan: Northern, which extends from Aptos Creek to the Smith River, and Southern, which extends from the Tijuana River to the Pajaro River.

Monitoring Plan (Plan): The main report section of the current Coastal Anadromous Salmonid Monitoring Plan. It contains the elements of the proposed Coastal Anadromous Salmonid Monitoring Program (Monitoring Program).

Monitoring Program: Once implemented, the Coastal Anadromous Salmonid Monitoring Plan (Plan) becomes the Coastal Anadromous Salmonid Monitoring Program (Monitoring Program).

Natural Communities Conservation Plans (NCCPs): The DFG's NCCP program is designed to preserve blocks of contiguous habitat large enough to sustain viable populations of listed species and to prevent the need for additional listings, while still allowing for "compatible and appropriate" economic growth and development. The authority for the program stems from the State "Natural Communities Conservation Planning Act of 1991". The NCCP Act, while not intended to supersede the requirements of ESA and CESA, is intended to allow for comprehensive, regional multi-species planning in a manner which satisfies the requirements of these endangered species laws. However, the NCCP Act, unlike the ESA, contains no regulatory standards for plan approval and implementation.

Naturally produced: Salmon or trout that are the offspring of naturally spawning parents, regardless of origin of the parents (i.e., hatchery or natural parents).

NOAA Fisheries (NOAA): The branch of the National Oceanic and Atmospheric Administration, within the Department of Commerce, that deals with marine (including salmon and steelhead trout) fishery management and research issues, formerly known as the National Marine Fisheries Service (NMFS). The two NOAA administrative principals in California are the Southwest Region (SWR) Regional Administrator (Long Beach) and the Science Director, Southwest Region (La Jolla).

Northwest: The states of Washington, Oregon and Idaho.

Pacific Fishery Management Council: See Magnuson Act.

Personal Digital Assistant (PDAs): Small, hand-held computers that can be used in the field to store data files that can be downloaded to a desktop or laptop computer.

Petersen Method: One of several change-in-ratio estimators (a mark-recapture method) proposed to estimate carcass population size. It uses the totals of marked and unmarked organisms observations to infer the population total.

Plan (The Coastal Anadromous Salmonid Monitoring Plan): The current document; i.e., the Coastal Anadromous Salmonid Monitoring Plan. The Plan aim is to meet ESA and CESA salmon, steelhead and cutthroat monitoring needs.

Population: We use population: (1) in a statistical sense to mean the total of sample units in a defined area and (2) in a biological sense to mean a group of salmon or trout that spawns interchangeably within but to a limited extent outside of the group. Here we assume each of the tributaries to the main stems of the larger rivers (e.g., Klamath, Eel, Russian) and each of the other whole stream systems (e.g., Smith, San Lorenzo, Carmel) represent individual populations of salmon or trout. We feel this is a reasonable (and practical) approach to defining populations for monitoring purposes because of the high rate of homing of salmon and anadromous to their natal streams. NOAA currently is classifying stream populations as to their current status, potential status and dependence on straying to sustain the run.

Population size: The absolute number of fish in a defined area. The area is most often an entire stream or stream reach. Estimates of population size are usually obtained by sampling a statistically selected sub-sample of streams and extrapolating to the total area (Duffy et al. 2003).

Population types: NOAA is in the process of designating populations of salmon and steelhead within ESUs as follows: Functionally Independent Populations (FIPs), Potentially Independent Populations (PIPs), Dependent Populations (DPs) and Ephemeral Populations. FIPs are self-sustaining. PIPs are potentially self-sustaining if environmental conditions improve or the fish are able to more fully repopulate and use available habitats. DPs produce offspring but depend on staying of fish from other populations to sustain the runs. EPs occur primarily as a result of strays from other populations.

Portable weir: Portable weirs are distinguished from other weir types in that they use the natural stream bottom to seal the pickets or panels and can be moved or portaged within or between streams in response to monitoring plan needs. Like all other weir types, they funnel upstream migrating adults through a narrow passage where the fish can be counted or trapped.

Presence/absence sampling: A sampling approach that follows a statistically designed sampling protocol to estimate the probability with confidence limits of species absence in a system.

Productivity: The capacity of a population to reproduce and sustain itself. Productivity is commonly quantified using stock and recruitment models. It is important in such studies that accurate measures are made of spawning stock size and recruits resulting from individual spawning events. Recruits are usually measured in terms of harvestable fish or fish that escape to spawn. Various models have been developed to analyze the data and determine the best fit. See **Appendix B** for how productivity is defined and used in the stock assessment process.

River. A large stream of water that empties into the ocean or another river. We generalize that rivers are Fourth Order and larger waterways.

Recovery Unit. The DFG has subdivided each coho salmon ESU into watershed recovery units. These are groups of smaller drainages that are thought to constitute unique and important components of each ESU (DFG 2004).

Reference watersheds: Watersheds that are judged to support healthy and stable habitat conditions for anadromous fish production: ones that can be used as models (controls) in demonstrating and evaluating degraded watersheds.

Redd Survey Method: Here salmon and steelhead redds are counted and marked to prevent recounting throughout the spawning season and summed to produce a redd population size estimate. Information is needed on females per redd and male to female ratio to infer the spawner population size.

Redd: The spawning ground or nest of a female salmon. Redds are recognizable in stream riffle areas as gravel mounds each preceded by a hole or indentation in the stream bottom where the female salmon deposited her last eggs.

Rotating panel design (approach): Our sample units are organized into sets or "panels." These are scheduled to be visited to collect population information over a 30-year time frame following a fixed rotational plan. Sample units are assigned to panels without replacement. Under the proposed rotating panel design, one panel (40% of annual effort) will be visited annually. Three panels (each containing 20% of annual effort) will be visited once every 12 years, and 30 panels (each containing 20% of annual effort) will be visited once every 30 years. Repeat visits to panels are important for population trend analysis while the combination of repeat and single visits is important for population status analysis. Repeat measurement of the same sample units over time removes the component of variation associated with the unit's unique pattern of annual fluctuations.

Sample reach: This is synonymous with sample unit (a statistical term) but is more descriptive of the actual sample area.

Sampling: Is used in a statistical sense to mean the act of taking or measuring a finite part of a population with the aim of extrapolating the findings to the total population.

Sample unit: Our sample unit is defined as a length of stream channel (stream reach). Data elements (e.g., number of fish, lengths of fish) are collected from within sample units; and in some cases population sizes (carcasses, live fish) are estimated for individual sample units. Sample size (n) is, in general, the number of sample units selected for data collection. The total set of all possible sample units is the sampling universe (size N).

Schaefer Method: This is often referred to as a stratified Petersen estimator. It is a change-in-ratio estimator (mark-recapture method) that uses data collected over successive marking and recapture periods throughout the spawning period to estimate the population size.

Science Advisory Committee (SAC): A proposed 5-7 member panel, appointed by the DFG Principal with concurrence of NOAA Fisheries, each appointed for 2-year terms and that serve to review monitoring program scientific documents, data reports, genetic monitoring plans, and proposed sites for Life Cycle Monitoring Stations.

Smolt: A young salmonid that is physiologically ready to enter the marine environment and complete an anadromous life cycle. Smolting salmonids take on silvery coloration and are much slimmer than non-smolting fish (low weight to length ration).

Spawning surveys: Utilize counts of redds, live fish and/or fish carcasses to estimate spawner escapement and identify habitat being used by spawning fish. Annual surveys can be used to compare the relative magnitude of spawning activity between years.

Spring run Chinook salmon/spring run steelhead: These stocks of fish are named spring runs because they enter freshwater primarily during spring or early summer months, thus are stream maturing fish This is a California convention (Fry 1973) and does necessarily reflect differences in biological or genetic diversity. Spring Chinook salmon and spring steelhead "hold over" during summer months in a few suitable holding areas between the Mattole and Smith rivers. The DFG routinely counts these fish by snorkel diving in know holding areas during summer months.

Steelhead: Anadromous fish of the species *Oncorhynchus mykiss.* The resident form is commonly called rainbow trout. In the Southern Monitoring Area the populations may be sustained by a combination of adult life history types (resident/anadromous).

Stock: A group of salmon or trout defined for fishery management purposes by its species, spawning location, spawning region, or run timing. A related term is stock management unit which means one or more stocks of fish for which a specific management objective has been set (MSC 2003).

Stream Order. This is a general way of describing the size of a stream or river. The smallest order streams are called first order streams, which join to form second order streams, which join to form third order streams, etc.

Steering committee: A group of DFG and NOAA scientists and consultants appointed to guide the Plan development process and to write the Plan.

Sustainable Fisheries Act (P.L. 104-297): the 1996 amendment to the Magnuson-Stevens Act that requires, in part, designation of essential fish habitats for managed species.

Technical Recovery Teams (TRTs): NOAA is developing scientifically based criteria for delisting ESUs of anadromous salmonids that are listed under the ESA. Recovery efforts are focused on geographically defined Recovery Domains, of which there are three in California: (1) Southern Oregon/Northern California, (2) North-Central California Coast and (3) South-Central California Coast. TRT have been created for each Recovery Domain, and are charged with developing recovery criteria for all listed ESUs in the Domain. TRTs are composed of scientists from NOAA, other Federal and State agencies and academia, and are chaired by a NOAA scientist.

U.S. Geological Survey (USGS): The unit within the Department of the Interior that collects, analyzes, and provides data on the natural resources of the U.S.A. Its focus is on natural hazards, resources, the environment and information and data management. It has no regulatory authority.

Viable Salmonid Population Concept (VSP): The basic concept or framework used by Federal stock assessment scientists to assess the extinction risk faced by individual ESUs. The stock attributes that are an integral part of this process come under the headings of abundance, distribution, diversity and productivity. See **Appendix B** for more information on the VSP concept and the meaning and importance of the individual stock attributes.

West Coast: The U.S. coastal states of Alaska, Washington, Oregon and California and the Canadian province of British Columbia.

Winter steelhead: The most ubiquitous steelhead run type in California. They return from the ocean during December-March and spawn within a few weeks or a month at most after river entry. Repeat spawners are common among winter steelhead runs.

Yearlings: Used here to mean fish that have lived through the middle of one winter (e.g., February 15) and not completed rearing through the middle of two or more winters in the stream. Older stream fish are referred to as ages 2 and 3 fish, etc.

APPENDIX A: Fisheries and Hatcheries

Here we present information on the management of California salmon and steelhead fisheries and hatchery operations. Federal permitting issues as they relate to these activities are also described along with status reports on DFG efforts to meet those requirements.

Fisheries

California salmon and steelhead fisheries are managed in the ocean consistent with the Pacific Coast Salmon Plan of the Pacific Fishery Management Council. The river sport fisheries are regulated by the California Fish and Game Commission with input from the DFG. The tribal fisheries in the Lower Klamath and Trinity rivers are managed by the Yurok and Hoopa tribes, respectively. Klamath System salmon and steelhead allocations are recommended by the Klamath Fishery Management Council.

Ocean fisheries

Ocean fishery impact rates have been reduced in recent years due to ESA constraints aimed at protecting the California Coastal Chinook ESU (Coastal Chinook). Current information is insufficient to forecast ocean abundance of these fish. The NOAA ESA consultation standard restricts ocean fisheries for age 4 Klamath River fall Chinook to an ocean harvest rate not to exceed 16%. This standard is intended to limit impacts on Coastal Chinook, which are thought to have a similar ocean distribution as Klamath fall Chinook. In the early 1980s, the ocean harvest rates for Klamath age 4 Chinook were between 0.52-0.60 (PFMC 2004a)

There have been insufficient releases of coded wire tagged (CWT) Coastal Chinook to make direct estimates of ocean fishery impacts. This is a high priority with the DFG and NOAA ocean fishery managers. CWT application to coastal Chinook is problematic because there is no successful hatchery operation in the area to spawn and rear them to tagging size. Also, there is no trapping facility in the area to capture natural fish for tagging in sufficient numbers.

Commercial ocean fishery catch averaged 391,400 Chinook during 1994-2003. The ocean recreational fishery averaged 174,300 Chinook in 204,900 angler days (0.85 Chinook/d) during the same period (PFMC 2003).

The Klamath fall Chinook run has been intensively monitored both in the ocean and river since the late 1970s. The heavy management emphasis on this stock has been for allocation purposes involving tribal and non-tribal fisheries (Pierce 1998). It is a key stock in the management of ocean fisheries off the California and Oregon coasts. The spawner goal for the stock is no fewer than 1/3 of the potential spawners of each cohort of fish, but with a minimum escapement in all years of 35,000 naturally spawning adults. Cohort reconstruction data are used to make annual age-specific ocean abundance estimates for the stock. These data are used in the Klamath Ocean Harvest Model to estimate the effect of ocean fishing regulations on Klamath River in-river run sizes of hatchery and naturally produced fish (Mohr, et al. 2001; PFMC 2004a).

The retention of coho salmon is prohibited in California ocean and river fisheries. Coho salmon are caught incidental to Chinook salmon fishing, but at a reduced rate compared to historic levels when retention was allowed. The allowable annual impact rate for Rogue-Klamath coho salmon in ocean fisheries has been set by NOAA at 0.13 (PFMC 2004b). The 2004 pre-season impact prediction for non-retention mortality based on the adopted ocean regulations was 8.6% (Table 5: PFMC 2004b).

Steelhead are uncommon in ocean salmon fisheries. When steelhead were allowed to be caught and retained by anglers, they were a rare occurrence in the landings (Allen Grover, DFG, pers. comm.).

River fisheries

River fishing for salmon and steelhead continues in streams from San Luis Obispo Creek to the Smith River. Retention is not allowed except for: (1) Klamath and Smith River Chinook, (2) hatchery (marked) steelhead and (3) Smith River steelhead. Bag and retention limits, day closures and fishing seasons are used to limit the catch.

The most complete data set for coastal fishing is for the Klamath River fall Chinook fishery. During 1993-2004, the river sport fishery averaged 6,800 adults and 2,000 grilse per year. The tribal fisheries during the same period averaged 22,300 adults and 300 grilse (PFMC 2003). Both fisheries were managed under quotas based on 50/50 sharing of the allowable harvest of fish between tribal and non-tribal fisheries. Ocean fishery take, both commercial and sport, was considered pre-season as part of the non-tribal share.

The following is a summary of the fishing regulation changes that have occurred in response to state and federal endangered species act listings in coastal watersheds. The 1994-96 season regulations are used as the base period for comparison with current (2004) regulations.

Regulation changes

Recreational (Table A-1*)*

Ocean Changes

During 1994-96, ocean fishermen could take 2 salmon of any species in combination per day along with 3 trout. The season length varied along the coast ranging from mid February to mid November in the Fort Bragg area to early May through Labor Day with various in-season closures in the Klamath Management Zone (KMZ: Eureka-Crescent City area) aimed at protecting Klamath River fall Chinook. Since 1996 (1994 in the KMZ), coho retention has been prohibited pursuant to a NOAA jeopardy opinion. Trout retention has been prohibited since about 1998. The salmon season lengths have been about the same statewide except in the KMZ where they have been less restrictive due to better data on fishery impacts on Klamath fall Chinook. (Note: the salmon season length was shortened by about 3 months south of Point Arena to protect Central Valley winter and spring Chinook, both of which are state and federally listed. Also, the fishery minimum size limit was increased from 20 to 24 in some years and time periods to protect winter Chinook).

River Changes

During 1994-96, river fishermen on most coastal streams, were allowed to take 2 salmon, of any species, or anadromous trout per day in designated open fishing areas except that only one fish could be over 22 inches in length. There were no restrictions on sizes or types of hooks or lures that anglers could use. Beginning in 1998 (1996 in Waddell and Scott creeks), retention of salmon and steelhead trout was prohibited from Redwood Creek south except that in some streams either 1 or 2 hatchery steelhead (eroded adipose fin) were permitted per angler. In the Klamath-Trinity system, steelhead retention was restricted to 1 hatchery-origin fish per day and in the Smith River, anglers were allowed to retain 1 hatchery in addition to 1 wild steelhead per day. Chinook retention was allowed in both streams but reduced to 1 Chinook per day in the Smith River. Throughout the state, new terminal gear restrictions were variously applied to reduce hook and release mortality. These restrictions included artificial only lures during summer months and barbless hooks at all times when fishing was allowed for salmon or trout.

Table A-1. Adult salmon and steelhead sportfishing regulations in selected waters: 1994-96 and 2004 seasons (not for enforcement purposes)

SEASON:	1994-96		2004	
Name of Water	**Daily bag Limit**	**Season (approx)**	**Bag Limit**	**Season (approx)**
Ocean-S. of Pt Arena	2 salmon, 3 trout	Mar-Oct	2 Chinook	Apr-Sep or Oct
Ocean-Ft Bragg	2 salmon, 3 trout	Feb 15-Nov 15	2 Chinook	Feb 15-Nov 15
Ocean-KMZ	2 salmon (w/Chinook quota), 3 trout	May 5-Jun 19, Jul 14-Aug 28, Sep 1- Labor D	2 Chinook	May 17-Sep 14
Smith R.	2 (1 > 22”)	All year	1 wild SH, 1 hatch SH, 1 Chinook, 2 CT	Jun-Mar
Klamath-Trinity	3 (1-22” salmon)	All year	3 Chinook or hatch trout with limits: 2 Chinook > 22,” 1 SH	All year
Little R.	2 (1 > 22”)	All year	1 hatch SH, 2 CT	Nov-Mar
Mad R.	2 (1 > 22”)	All year	2 hatch SH	Jun-Mar
Eel R.	2 (1 > 22”)	All year	0	Jun-Mar
Mattole R.	2 SH (1 > 22”), 0 salmon	All year	0	Jan-Mar
Noyo R.	2 (1 > 22”)	All year	1 hatch SH	Nov-Mar
Navarro R.	2 (1 > 22”)	All year	1 hatch SH	Nov-Mar
Garcia R.	2 (1 > 22”)	All year	1 hatch SH	Nov-Mar
Gualala R.	2 (1 > 22”)	All year	1 hatch SH	Nov-Mar
Russian R.	2 (1 > 22”)	All year	2 hatch SH	All year
San Lorenzo R.	2	Nov 16-Feb, S/S/W/H	0	Dec-Mar7, S/S/W/H
Carmel R. (< 101)	2	Nov 16-Feb, S/S/W/H	0	Dec-Mar 7, S/S/W/H
San Luis Obispo Cr. (< 101)	2	Nov 16-Feb, S/S/W/H	0	Dec-Mar 7, S/S/W/H
Santa Ynez R. (< 101)	2	Nov 16-Feb, S/S/W/H	closed	closed
Santa Clara R.	0	Jun-Dec	closed	closed
Malibu Cr.	0	Jun-Nov 15	closed	closed

Commercial (*Table A-2*)

The traditional commercial fishing season prior to the Magnuson Act was April 15-September 30 (except the coho season was from mid May-September 30). Both species were harvested. The major changes in the commercial season started in 1983 stemming from conservation and allocation concerns for Klamath River fall Chinook, a key stock in the management of Oregon and California ocean fisheries by the Pacific Fishery Management Council (PFMC). Since then, the season south of Pt. Arena has generally been May-September, while the season in the Fort Bragg area has been mid-July-September. Commercial fishing in the Eureka-Crescent City area has been prohibited except for a September Chinook fishery managed under trip limits and quotas. The ESA jeopardy opinion (NOAA 2000) regarding California Coastal Chinook (based on Klamath age 4 fish) has resulted in reduced commercial fishing opportunity in the area north of Point Arena in some years. The Chinook minimum size limit in the fishery was originally 26 inches. It was increased to 27 inches in some years since 1996 to protect winter Chinook and to 28 inches in some years during fall fisheries to avoid age 4 Klamath fall Chinook.

Table A-2. Ocean commercial salmon fishing regulations: 1994-96 and 2004 seasons (not for enforcement purposes)

Season:	1994		2004	
Area	**Season**	**Species**	**Season**	**Species**
KMZ	Closed	Closed	Sep 1-30 w/quota	Chinook only
Fort Bragg	Sep 1-30	Chinook only	Jul 10-Aug 29, Sep 1-30	Chinook only
San Francisco	Jun 15- Sep 30	Chinook only	May 1-Aug 29, Sep 1-30 w/special Oct sub area fishery	Chinook only
Monterey	May 1-Jun 11, Jul 1-Sep 30	Chinook only	May 1-Aug 29, Sep 1-30	Chinook only

Key Elements of FMEPs

Fishery Management and Evaluation Plans (FMEPs) are described in the final 4(d) rules issued by NOAA (July 10, 2000; 65 FR 42422) as a mechanism for addressing the take of certain listed species in fisheries. The primary goal of the FMEP is to devise biologically-based fishery management strategies that ensure the conservation and recovery of listed Evolutionarily Significant Units (ESUs).

The following summarizes the NOAA document titled: *Template for Developing a Fisheries Management and Evaluation Plan (FMEP) under "4(d) Rules* (NOAA 2004).

- The primary goal of the FMEP is to devise biologically based fishery management strategies that ensure conservation and recovery of ESUs.
- The amount of detail in the plan will depend on the scope of the proposed fishery and the status of the affected population.
- The ability to monitor run size, harvest rate, and fishery performance is critical to the approval process.
- The proposal must use the best available data.
- VSP thresholds and population escapement objectives or maximum exploitation rates need to be identified and adhered to.
- A description of the public outreach program and enforcement presence needs to be described.
- Interactions with hatchery stocks need to be explained.
- Data must be provided in the plan showing recent run sizes and harvest impacts, in addition to projected future impacts and affects on the population.
- Monitoring programs must be sufficient to evaluate whether the management objectives are being accomplished, evaluate impacts to listed fish, assess compliance with fishery regulations and determine the validity of management assumptions.

- Finally, the plan needs to include what the monitoring is intended to accomplish, the duration and frequency of efforts and whether funding has been secured.

Monitoring could include the following, as appropriate: information on fishing mortality by fishery or catch area (landed catch, non-landed mortality, encounter rates for selective and catch and release fisheries), information on effort by fishery or catch area, escapement of natural and hatchery fish, evaluation of biological characteristics (e.g. sex and age composition, size, fecundity, run timing), fishery parameter validation (including post- and pre-season forecasts) and other information necessary to evaluate population status and management performance.

It is recognized that extensive monitoring programs cannot be conducted within every ESU. This section could include monitoring and/or research in other areas which are not within the management areas of this FMEP. It should explain how the information/results would be applicable to the ESUs included in this FMEP. For example this could include studies conducted elsewhere on fishery effort, catch rates of listed species and/or catch and release mortality estimates.

Status of California FMEPs

The DFG currently has several steelhead FMEP drafts in progress. NOAA Fisheries has not accepted them because they lack population status data or a solid monitoring plan for determining population trends. The proposed Monitoring Program is expected to meet the FMEP data needs, depending on the degree of Plan implementation.

Hatcheries

Production facilities

The State-managed hatcheries are: Iron Gate (Klamath River), Trinity (Trinity River), Mad (Mad River), and Warm Springs (Russian River) (**Figure 2A).** The DFG also manages an egg taking and rearing operation at Van Arsdale Fisheries Station on the upper Eel River. There are no federal hatcheries in the coastal area.

The combined production from these facilities of the 1998-1999 broods was: 8.2 million fall Chinook smolts, 2.6 million Chinook yearlings, 600 thousand coho yearlings, and 1.5 million steelhead yearlings **(Table A-3).** The entire hatchery steelhead production has been adipose-fin (AD) clipped since the 1997 brood year (C. Knutson, DFG Hatchery Coordinator, pers. comm.). All coho releases in the Klamath River System are currently being marked with a maxillary clip (plus an AD clip at Iron Gate). Representative tagging of all Chinook release groups takes place in the Klamath River System. Of the 10.8 million Chinook released of the 1998 brood, 974 thousand (9%) were Ad-CWT marked. Since the 2000 brood, fractional marking (25% rate) of all Chinook releases began at the Trinity River Hatchery (Mark Zuspan, DFG, pers. comm.).

The adult monitoring program will need to be closely integrated with hatchery management and monitoring to be successful. The occurrence of hatchery-produced fish in the adult abundance survey could mask the status or trends occurring in naturally spawned fish, particularly in the Klamath System. The current marking program at all coastal hatcheries involves virtually 100% of all steelhead and coho releases. These fish will be readily identifiable if they show up in coastal spawning surveys. This also means that if any unmarked fish show up at the hatcheries it will indicate the incidence of naturally spawned fish that enter the various facilities. The Chinook marking rate of 6% at Iron Gate Hatchery (IGH) is inadequate for estimating hatchery contribution rates to natural spawning populations within acceptable confidence bounds.

Table A-3. Production, marking and release data for coastal salmon and steelhead hatcheries and cooperative rearing programs (DFG/NOAA 2001 and DFG staff comm.)						
Hatchery	**Species Run**	**Production Goal**	**Brood 1998-1999 Production**	**Tags/Marks**	**Size and Time of Release**	**Location of Release**
Iron Gate	coho	75,000 yearl.	77,147 yearl.	75,460 AD-LM clip	7/lb (Mar 15-May 1)	Hatchery
	Steelhead	200,000 yearl.	37,080 yearl.	35,970 AD-LM clip	12/lb (Mar 15-May 1)	Hatchery
	Fall Chinook	4,000,000 smolts 1,000,000 yearl.	4,965,229smolts 1,122,127 yearl.	200,000 smolts AD-CWT 100,000 yearl. AD-CWT	Smolts 90/lb (Jun 1-15) yearl. 10/lb (Nov 1-15)	Hatchery
Mad River	Steelhead	250,000 yearl.	368,082 yearl.	100% AD clip	4-8/lb (Mar-May)	Hatchery
	Fall Chinook (Mad R)	4,000,000 smolts 1,000,000 yearl.	21,600 yearl.	None	Smolts 60/lb (May-Jun) Yearl. 8-10/lb (Oct)	Estuary
	Fall Chinook (Upper Eel)	12,500 yearl. 12,500 pre-smolts	14,490 yearl.	100% CWT	Yearl. 10-15/lb (Oct-Nov)	Upper Eel
Trinity River	Spring Chinook	1,000,000 smolts 400,000 yearl.	959,000 smolts 399,000 yearl.	200,000 Smolts AD-CWT 100,000Yearl. AD-CWT	Smolts 50/lb (Jun 1-15) Yearl.10-12/lb (Oct 1-15)	Volitional at Hatchery
	Fall Chinook	2,000,000 smolts 900,000 yearl.	1,991,000 smolts 993,000 yearl.	200,000 Smolts AD-CWT 100,000Yearl. AD-CWT	Smolts 90/lb (Jun 1-15) Yearl.10-12/lb (Oct 1-15)	Volitional at Hatchery
	coho	500,000 yearl.	493,700 yearl.	100% RM clip	10-20/lb (Mar 15-May 1)	Volitional
	Steelhead	800,000 yearl.	382,900 yearl.	100% AD clip	7/lb (Mar 15-May 1)	Volitional
Warm Springs	Fall Chinook (Dry Cr)	1,000,000 yearl.	None for 2 yrs	n/a	10/lb (Oct-Nov)	Near hatchery
	Fall Chinook (Upper Eel)	37,500 yearl. 37,500 pre-smolts	45,100 yearl.	100% AD-CWT	Yearl. 10-15/lb (Oct-Nov) Pre-smolts 40-60 days	Upper Eel
	Steelhead	300,000 yearl.	302,005 yearl.	100% AD clip	4/lb (Dec-Apr)	Near Hatchery 40,000 for Coyote VFF

Table A-3. Production, marking and release data for coastal salmon and steelhead hatcheries and cooperative rearing programs (DFG/NOAA 2001 and DFG staff comm.)						
Hatchery	**Species Run**	**Production Goal**	**Brood 1998-1999 Production**	**Tags/Marks**	**Size and Time of Release**	**Location of Release**
Coyote Valley Fish Facility	Steelhead	200,000 yearl.	229,451 yearl.	100% AD clip	4/lb (Jan-Mar)	E Fork Russian
Rowdy Creek (Coop)	Fall Chinook	500,000 eggs	182,600 fing. 49,500 yearl. (02/03 BY)	None	70-100/lb 10-15/lb	At hatchery
	Steelhead	300,000 eggs	90,789 yearl. 02 BY	100% AD clip	6-10/lb	Smith R.
Humboldt Fish Action (Coop)	Fall Chinook	80,000 eggs	28,123 fing. 02 BY	None	90/lb	Freshwater Cr.
Eel R. Restoration (Coop)	Fall Chinook	100,000 eggs	62,797 fing. 02 BY	None	90/lb	Redwood Cr.
Salmon Restoration (Coop)	Fall Chinook	250,000 eggs	14,000 fing. 02 BY	None	90/lb	Hollow Tree Cr.
Monterey Bay Salmon and Trout (Coop)	coho	28,500 eggs	31,429 yearl. 02 BY	None	?	Scott, Pescadero and Waddell Creeks
	Steelhead	40,000 eggs	47,018 yearl. 02 BY	None	?	Scott and San Lorenzo Creeks
TOTALS	**Fall Chinook**	**10,980,000 smolts + eggs 3,950,000 yearl.**	**7,243,749 smolts 2,245,817 yearl.**	**414,490 smolts (AD clip) 259,590 yearl. (AD clip)**		**Mostly Klamath-Trinity**
	Spring Chinook	**1,000,000 smolts 400,000 yearl.**	**959,000 smolts 399,000 yearl.**	**200,000 smolts (AD clip) 100,000 yearl. (AD clip)**		**Trinity R.**
	coho	**603,500 yearl. + eggs**	**602,276 yearl.**	**569,160 (Max clip)**		**Mostly Klamath-Trinity**
	Steelhead	**2,090,000 yearl. + eggs**	**1,457,325 yearl.**	**1,409,197 (AD clip)**		**Various**
	All species	**19,023,500 all forms and sizes**	**12,907,167 all sizes**	**2,952,437 (AD or Max)**		**Various**
Yearling=yearl., fingerling=fing, Adipose fish clip=AD, Coded wire tagged=CWT, Maxillary clip=Max						

None of the Chinook released from Rowdy Creek Hatchery (RCH) on the Smith River are marked, though the numbers released are relatively small (500,000 egg-take goal).

A marking fraction of around 25% would be more appropriate at both facilities, which is the rate used at the Trinity River Hatchery. This would mean an additional 1.0 million (rounded) Chinook should be marked annually at IGH (based on its 5 million Chinook production goal and assuming 300 thousand fish would continue to receive Ad-CWT marks) and 125 thousand (maximum) as RCH.

Cooperative Rearing Programs

The DFG began its Cooperative Fish Rearing Program in 1973 with the goal of increasing salmon and steelhead populations on a broad geographic scale. The program has involved partnerships with nonprofit groups and corporations, service clubs, counties, Indian tribes and many individuals to produce salmon and steelhead for the benefit of fisheries and the enjoyment of California's citizens. There are currently 12 projects from San Luis Obispo to the Smith River. Nine of the projects receive Salmon Stamp Funding, a self-imposed dedicated fee sponsored by commercial fishermen on ocean salmon landings and as a supplemental license stamp. Some programs collect fish for broodstock while others rely on the DFG for fish. All of the projects are required to operate with a current 5-year plan, which must be approved by the DFG district biologist and the Cooperative Rearing Project Coordinator. These programs produce relatively few fish compared to the state hatchery program. The one exception is Rowdy Creek Hatchery on the Smith River **(Table A-3)**.

Authorizing Hatchery Activities under the ESA

Hatchery and Genetic Management Plans (HGMPs) are described in the final salmon and steelhead 4(d) rule (July 10, 2000; 65 FR 42422) as a mechanism for addressing the take of certain listed species that may occur as a result of artificial propagation activities. NOAA will use the information provided by HGMPs in evaluating impacts on anadromous salmon and steelhead listed under the ESA. In certain situations, HGMPs will apply to the evaluation and issuance of section 10 take permits. Completed HGMPs may also be used for regional fish production and management planning by federal, state and tribal resource managers.

NOAA may, through a Section 4(d) rule, apply the take prohibitions for threatened species, but exempt certain programs or activities, such as hatchery operations or recreational fisheries, if they meet requirements specified in the rule. A federal agency is required to enter into Section 7 consultation if it is determined that an action which is authorized, funded or carried out by the agency may affect listed species or critical habitat. Only incidental take of a listed species can be authorized through a Section 7 consultation. The obligation to enter into Section 7 consultation applies to federal agencies that operate hatcheries, such as the U.S. Fish and Wildlife Service, as well as to agencies such as the U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers that fund hatcheries operated by the DFG.

The intentional take of listed species by a federal or non-federal project is illegal unless it is authorized through a Section 10(a)(1)(A) permit or the take is not prohibited by a 4(d) rule. A Section 10(a)(1)(A) permit authorizes the intentional take of listed species for research or propagation that furthers necessary or desirable scientific purpose or enhances the propagation or survival of the listed species. Incidental take by a non-federal entity may be authorized through a Section 10(a)(1)(B) permit. This would apply if listed species were incidentally captured and released during broodstock collection or if listed species were adversely affected by artificially produced fish through ecological interactions, including disease, competition for food and habitat and reduction of genetic integrity from breeding with artificially-produced fish. ESA compliance for hatcheries is dependent upon the species being propagated, as well as individual hatchery operations. For example, Livingston Stone Hatchery, a federally funded and operated hatchery which propagates Sacramento River winter Chinook, was issued an incidental take permit under Section 7 regarding the effects of winter Chinook propagation on other listed species and a Section 10(a)(1)(A) permit to allow the intentional take of winter Chinook for its own program. NOAA has published a 4(d) rule for Central Valley, Central California Coast and South-Central California Coast steelhead ESUs which provides exceptions to Section 9 take prohibitions for certain activities. NOAA expects to publish a similar 4(d) rule for other threatened salmon ESUs. Under the rule, hatchery operations conducted in accordance with a Hatchery and Genetics Management Plan (HGMP) approved by NOAA are exempted from the application of ESA take prohibitions. An HGMP must: (1) specify the goals and objectives for the hatchery program, (2) specify the donor population's "critical" and "viable" threshold levels, (3) prioritize broodstock collection programs in a manner that benefits listed fish, (4) specify the protocols that will be used for spawning and raising the fish in the hatchery, (5) determine the genetic and ecological effects arising from the hatchery program, (6) describe how the hatchery operation relates to fisheries management, (7) ensure that the hatchery facilities can adequately accommodate listed fish if they are collected for the program, (8) monitor and evaluate the HGMP to ensure that it accomplishes its objectives and (9) be consistent with tribal trust obligations. The 4(d) rules do not remove the responsibility of a federal agency to consult under Section 7 of the ESA.

Hatchery Review Committee Recommendations for Coastal Hatcheries

Many recommendations are contained in the body of the hatchery report recently completed by the DFG and NOAA Fisheries (DFG/NOAA Fisheries 2001). The following are considered of major importance or interest as they relate to coastal hatcheries and this Plan.

1. Hatchery “in-river” releases and water management practices should be coordinated so that emigration survival is maximized.
2. A formal process should be identified for the periodic review and assessment (e.g., every 6-9 years or 2-3 brood cycles) of hatchery production levels. It should include consideration of changing ocean or freshwater regimes, new information on hatchery/natural fish interactions and changes in ESA status of salmonid populations.
3. All agencies should pursue efforts to establish a constant fractional marking program at all hatcheries.
4. All agencies should pursue efforts to develop adequate sampling programs to recover marked fish. The DFG should establish a process to coordinate and oversee the methodologies for estimating salmon escapements.
5. Hatchery and Genetics Management Plans should be developed for each hatchery.

Committee in the following quotation refers to the Hatchery Review Committee: “Changes made in response to the above recommendations (and others included in the report, including those at individual hatcheries) must be accompanied by evaluation and monitoring programs. The Committee is aware that implementation of some of the recommendations contained in this report would require funding that is not yet available. Finally, it is recognized that implementation of the recommendations in this report cannot solve all future concerns about salmon or steelhead populations or hatchery operations. Hatchery production in California was not the root cause of the decline in salmon and steelhead populations to the point that they require protection under the California Endangered Species Act and the ESA. Minimizing and reversing the effects of habitat blockages, logging and agricultural activities, urbanization and water withdrawals in the river drainages that support California salmon and steelhead, will require continuing attention and effort. During its activities and deliberations, the

Committee was cognizant of the biological and societal benefits that California's hatchery system provides. These benefits have to be considered when any changes are proposed to the hatchery system" (DFG/NOAA Fisheries 2001). Please note: The Hatchery Committee recommendations have not been approved by the respective agencies.

Status of HGMPs

The DFG submitted an HGMP for Warm Springs Hatchery that is under review. The Monterey Bay Cooperative Rearing Program has a finalized HGMP for both coho and steelhead releases into Waddell and Scott creeks (K. Urquhart, DFG, pers. comm.). Currently the HGMP process is on hold until certain questions about the management of hatchery stocks within ESUs have been resolved (Craig Heberer, NOAA, pers. comm.).

Literature Cited

DFG/NOAA Fisheries. 2001. California Department of Fish and Game and National Marine Fisheries Service Southwest Region Joint Hatchery Review Committee Final Report on Anadromous Salmonid Fish Hatcheries in California. Available from Dept Fish and Game, Sacramento CA, and NOAA Fisheries, Southwest Region, Long Beach CA. 40p.

Mohr, M.S., A. M. Grover, M. L. Palmer-Zwahlen, and M. Burner. 2001. Klamath ocean harvest model revision documentation outline. Ocean Salmon Proj., DFG, Santa Rosa, CA. 13p plus 7 fig.

NOAA. 2000. Biological opinion and incidental take statement: Effects of the Pacific Coast salmon plan on California Central Valley spring-run Chinook, and California coastal Chinook salmon. NOAA, Southwest Region, Long Beach CA.

______. 2004. Web page address: www.nwr.noaa.gov/1fmep/

PFMC (Pacific Fishery Management Council). 2003. Review of 2002 ocean salmon fisheries. PFMC, Portland, OR. 4 sections plus 4 appendices.

_______. 2004a. Preseason report I: Stock Abundance Analysis for 2004 Ocean Salmon Fisheries. PFMC, Portland OR.

_______.2004b. Preseason Report III: Analysis of Council adopted management measures for 2004 ocean salmon fisheries. Portland OR. 37 p.

Pierce, R.M. 1998. Klamath salmon: understanding allocation. US Fish and Wild. Serv., Yreka. 29 pp plus 3 append.

APPENDIX B: Metrics of Viable Salmonid Populations Attributes

The Viable Salmonid Population (VSP) concept serves as the basis for performing salmonid conservation assessment. As a specific application, VSP approach is intended to help in the establishment of ESA delisting goals. This will aid in the formulation of recovery plans and can serve as interim guidance until such plans are developed (McElhany et al. 2000). The recent DFG recovery strategy for coho salmon lists five recovery goals with associated delisting criteria. The strategy emphasizes that key coho salmon populations need to be closely monitored with respect to abundance and spatial distribution at regular intervals over time. Key populations are those that occur in relatively high quality habitats, have a full compliment of age classes and have high abundance levels relative to other populations in the same recovery unit (DFG 2003).

Here we describe the four VSP attributes, the reasons for their inclusion in the stock assessment process and the metrics that are commonly associated with them.[4] The VSP concept uses two key insights from mathematics: The law of large numbers and the idea of non-independence or correlation. The law of large numbers means that large salmon populations go extinct much less often than small populations. The non-independence idea predicts that this advantage is diminished when the hazards that salmon face are not independent of one another. The four VSP attributes are aimed at keeping populations large and the fates of individual salmon populations as independent as possible (sometimes called risk-spreading), so that the simultaneous failure of all salmon in an ESU becomes very unlikely.

Abundance

Adult abundance is key to any management decision to be made about the fish. The fundamental bases for any management decision about these populations are what their abundances are and whether they are increasing or decreasing. This is true for both CESA and ESA questions because larger populations are at substantially lower risk of extinction, all else being equal. Abundance is also important for other management purposes (i.e. harvest, hatcheries) because the relationship between abundance and productivity (see below) is what determines how many fish can be harvested without depleting the population. Wild abundance, relative to the abundance of hatchery fish, is one of the key pieces of information for determining whether hatchery fish are having a detrimental effect on wild populations.

Abundance is defined as the number or biomass of individuals comprising a defined, scale-dependent population unit at a particular phase of the life-cycle. Abundance during the spawning phase is most useful for assessing risk. In practice this number will differ little from the number of migrants enroute to the spawning ground and we treat the two as equivalent. At organization Levels 1 & 2 (Regional and Metapopulation levels)[5], abundance takes the form of total number or biomass of mature adults enroute to the spawning grounds. For Level 1, individuals are enumerated while staging on the continental shelf, in an estuary or in higher order river reaches. For Level 2, individuals are enumerated at a more terminal position in the watershed in closer proximity to the spawning grounds.

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[4] This discussion is modified from one recently published by State of the Salmon Consortium (2004).
[5] In California, the Regional level appears to equate to the TRT Domain or ESU geo-scale. The Metapopulation level equates to a large river system such as the Klamath-Trinity Basin.

Abundance at Level 3 (ESU or population level)[6] is determined based on counts of individuals bound to, or originating from, well defined spawning events explicitly identified in both space and time.

When abundance is known for two or more stages of the lifecycle, the survival of fish from one stage to the next can be estimated. For the case of the adult-to-egg transition, fecundity can be estimated). Thus, this sort of data collection gives increased insight into the limiting factors on salmon populations and could be conducted at Level 3. In particular, enumerating abundance at Level 3 can be focused over the full spectrum of life stages and could include abundance estimates based on direct observations of eggs, stream or lake juveniles, smolts, marine sub-adults and pre- and post-spawning adults. Some indirect proxies that are calibrated to more direct measures may also be suitable for abundance estimation, including redd counts or marine-isotope markers in lake sediments or tree rings.

Distribution

Spatial structure is the separation of salmonids into geographically distinct populations and sub-populations. It is a natural consequence of the species' ability to home to natal watersheds for spawning and contributes to the species' viability. It does this by spreading the risk: widely-separated populations are less likely to all be extirpated by the same drought, fire, chemical spill and so forth. In general, their independence is increased the further they are from one another. As an extreme case that illustrates the idea, total population abundance could be sufficient for viability, but all the fish are concentrated in one area. Therefore, the population could go extinct due to one of the normal catastrophic events that these species have always been subject to, such as an unfortunately-located forest-fire/siltation event. This in fact is the type of situation faced by Central Valley winter-run and spring-run Chinook due to human activities. The condition is generally considered to be rare in nature except at extreme low abundance levels.

Spatial structure is also sometimes used to refer to the "migration connectivity" between widely-separated populations because it is such connectivity that allows extirpated populations to be recolonized. Much attention has been focused on issues resulting from the interaction of small local populations, minimum population size, inbreeding, and loss of habitat patches (habitat fragmentation) increasing extinction risk (McElhany et al. 2000). Widely distributed spatial structure spreads risk over space by providing refugia from local extinction, so that the same number of individuals would be at much less risk in a large number of widely dispersed sparse populations rather than in a limited number of dense concentrations. Connectivity allows local extinctions to be subsequently reversed by immigration from nearby refugia.

Distribution is a metric of spatial structure and is a composite measure of geo-referenced observations of individuals comprising a population unit. While all data on distribution refer to physical habitat locations, the nature of the distribution data is scale-dependent. For Level 1, distribution is point estimates of presence/absence of adult migrants within a sampling universe composed of all higher-order river reaches in the spatial extent. Similarly for Level 2, distribution is point estimates of presence/absence of adult migrants at interior watershed locations. Level 3 distribution data consists of locations for all life history stages, particularly stream rearing juveniles. Presence/absence sampling is an important tool for measuring distribution of juvenile fish. This is done by selecting sample reaches across entire watersheds and field sampling to detect species presence.

[6] In California, the Population level appears to equate to individual rivers or streams.

Diversity

Diversity is another aspect of salmonid populations that spreads risk. The term refers to both diversity of habitats and diversity of salmonids' strategies for dealing with those habitats. Another benefit of diversity is that it tends to lead to higher overall abundance of the fish, since the fish can exploit more kinds of environmental situations. Diversity monitoring is intended to measure two things: changes in the diversity of life history characteristics displayed by a population and changes in the capacity of the population to respond in diverse ways to future environmental change. In general, the first is monitored directly and the second is monitored using techniques of molecular genetics. This is the least well-defined area of monitoring since the monitoring goal may be different from ESU to ESU. There are several reasons for this: salmonids have unique life history characteristics which vary from area to area; there are recent and ongoing changes in salmonid populations' diversity characteristics (particularly in the interaction between hatchery and native fishes) and the technology to investigate these aspects is rapidly improving.

Diversity itself is a measure of the distribution of traits expressed within and among population units. These traits are defined broadly from explicit base pair sequences at single genes to more complex life history traits. Diversity in salmonid populations spreads risk over time by retaining a range of traits that allow the population to be adapted to a larger range of conditions, and therefore populations with lower diversity are less capable of responding to environmental change over time. More recent research includes efforts to draw explicit links between quantitative descriptors of genes and specific life history traits. Some of the varying traits that almost certainly relate to adaptability of the fish are anadromy, morphology, fecundity, run timing, spawn timing, juvenile behavior, age at smolting, age at maturity, egg size, developmental rate, ocean distribution patterns, male and female spawning behavior, physiology and molecular genetic characteristics. Important factors affecting the maintenance or loss of diversity are natural and artificial selection, straying and homing rate, genetic drift and gene flow and inbreeding. These factors determine effective population size, which in turn is a widely-used metric of the ability of a population to resist loss of genetic diversity.

Genetic data is the central element of diversity monitoring because it is the best overall measure of the capacity of a population to respond to future environmental change, and because it plays a major role in defining species and ESU characteristics. Since smaller and less diverse populations are at greater risk of extinction due to the range of catastrophic events that salmonids have always faced, genetic diversity has important consequences for viability. Several genetic concepts are important in identifying and understanding the effects of quantitative genetic changes in salmonid populations and their relation to recovery. The first issue among these is to establish a genetic baseline to achieve a comprehensive understanding of the nature of salmonid populations covered by the Plan. Other important metrics derived from genetic data are effective spawning population size, effective population size and introgression. These are technical concepts that relate to genetic drift, an important component of diversity analysis. Many different factors affect genetic drift including non-randomness of mating, population fluctuations, non-poisson distributed fecundity, non-random patterns of egg survival, etc. Effective population size and effective number of spawners are standardized measurements of the capacity for genetic drift and allow very different populations to be meaningfully compared. These are concepts that are very difficult to estimate because of the assumptions involved. Introgression results from straying of fishes, and the resulting gene flow from outside the population. It is most often a problem with adjacent hatchery populations. Using genetic approaches to infer changes in these types of characteristics is difficult since similar results can occur from different causes. This is an area of research that is rapidly improving its capabilities as better approaches are being developed.

Other diversity measures need to be identified at the ESU level at the beginning of the Monitoring Program. These other measures could include life history variation, run timing and age composition. The most obvious example of these other diversity measures is the life history diversity of steelhead in the Klamath Mountain Province. It includes winter and summer steelhead and "half-pounders." Loss of any of these life history characters would represent a significant loss of diversity.

Productivity

Productivity is a measure of the growth rate of a population unit, expressed commonly in terms of a per-capita change in total number of fish or per-unit change in biomass, both with respect to time (usually in units of years or of generation times). Productivity is estimated using time series analysis and related techniques to identify temporal patterns in abundance estimates or indices. Population growth rate can be decomposed into its constituent parts—survival of individual life stage from egg to adult and fecundity at the adult stage—using various analyses to identify functional relationships that describe the dynamics of a population. In the context of our monitoring strategy, we use the former to characterize productivity at Level 1 by relying on trends in adult spawner abundance over time. We can rely on a combination of the two approaches at Level 2 and 3. At Level 2, time series methods can be applied to adult spawner counts. If monitoring includes estimates of age composition, then brood years can be discriminated and recruit-per-spawner functional relationships can be inferred. For Level 3, in addition to the approaches that can be applied to Levels 1 and 2, it may also be possible to resolve growth and mortality processes occurring during discrete life stages (e.g. egg to fry, smolt to adult, pre- to post-spawning) that can provide more mechanistic understanding of population processes. Productivity analysis must take into the account the effect of freshwater and marine survival conditions on species abundance and trend patterns. Monitoring of smolt survival rates allows for decomposition of brood year survival rates into their freshwater and marine components. Most importantly, it allows for examination of the effect of the two phases separately, thus reducing the chances that depressed marine survival conditions will mask improvements in freshwater conditions, and vice versa.

Productivity must take into account the contribution of hatchery fish to natural fish runs as well as straying of natural fish into hatchery egg-taking operations. Removals of adults in ocean and inland fisheries can be an important source of mortality of adult fish. Both hatchery and fishery effects can reduce productivity (population growth), but the amount is difficult to estimate and thus can obfuscate the potential population growth if the effects are not measured. This fact has provided the impetus in recent years for the development of Fishery Management and Evaluation and Hatchery Genetic Management Plans. Hatchery monitoring usually takes the form of hatchery marking and sampling for hatchery marks in the wild and hatchery returns. Fishery monitoring usually takes the form of ocean and inland creel or market sampling. Fishing losses should also include pinniped depredation mortality associated with fishing operations. Other man-caused adult fish losses also need to be taken into account including losses at dams and Fishways and adult fish kills stemming from adverse or degraded riverine conditions. A case in point is the major Klamath River fish of 2002 in which 30,000 adult fish, mostly fall Chinook, died due to low, warm stream flow conditions.

Literature Cited

DFG (Department of Fish and Game). 2003. Recovery strategy for California coho salmon. Public Rev. Draft. DFG, Sacramento CA. 13 sections + append. A-I.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionarily significant units U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-42, 156.

State of the Salmon Consortium. 2004. Concept paper for the development of a monitoring strategy for the conservation of Pacific salmon. Objective A: estimate status and trends of Pacific salmon distribution, diversity, abundance and productivity. A joint program of Ecotrust and the Wild Salmon Center, Portland OR 97209. 48 p.

APPENDIX C: Summaries of Workshops 1 and 2

A listing of workshop participants is provided in Table C-1.

Workshop 1 Summary

Workshop 1 was held at the NOAA Fisheries Santa Cruz Lab. Here Larry Week, CDFG, is addressing the group.

Workshop 1 was held March 9-11, 2004 at the NOAA Fisheries, Santa Cruz Laboratory.

1. A total of 62 scientists, state fishery biologists, administrators, and technical experts attended the meeting.
2. They concluded the Plan should cover the coastal watersheds including San Francisco Bay up to the Carquinez Bridge (**Figure C-1**). The species should include all four coastal species of anadromous salmonids: Chinook salmon (*Oncorhynchus tshawytscha),* coho salmon (*O. kisutch),* steelhead rainbow trout (*O. mykiss)* and cutthroat (*O. clarki clarki)* (Churchill Grimes). (See **Appendix E** for Species Descriptions and **Appendix F** for Critical Habitat Condition

Descriptions). Seven coastal areas that support anadromous salmonids meeting the definition of Evolutionarily Significant Units (ESUs) have federally listed species in them; both coho ESUs support the state-listed coho salmon **(Table 1).**

3. Sparse data, along with habitat alteration, was cited as a major factor by the federal Biological Review Teams for recommending listing of California's coastal salmonid populations **(**David Boughton; **Figure C-2**).
4. The Plan is not intended to evaluate habitat conditions or the efficacy of restoration efforts (Barry Collins).
5. Some participants said the Plan should not be constrained by staffing or money. Others said the Plan must be practical and within reason.
6. The Washington and Oregon coastal programs were started many years ago and have created a relatively data rich situation. This allows them to reasonably assess trends in VSP parameters and to analyze the effect of habitat on production, with historic emphasis in both states on coho salmon (Dave Seiler and Kelly Moore, respectively).
7. Since salmon have been listed, monitoring and assessment activities have grown throughout the coastal range in CA. These efforts are largely local in nature and are not designed for stock assessment purposes on an ESU or even watershed scale (David Boughton). Current adult monitoring activities in the coastal region are limited to fall Chinook in the Klamath-Trinity System and coho and steelhead in a few northern streams. Only one project is monitoring coastal cutthroat. There is no adult monitoring for southern steelhead stocks except at a fishway in the Carmel River **(Table 2).**
8. Five talks were presented on adult salmonid monitoring techniques, including a portable weir type, new sonar technologies, salmon carcass survey and redd counting.
9. There were eight juvenile salmonid talks. These covered: (1) several juvenile capture or monitoring techniques (incline plain screen, fyke net, rotary screen trap, electrofishing, snorkel survey), (2) sample frame design considerations and (3) species identification issues (rainbow v. cutthroat).
10. There was considerable discussion about the rotating frame approach for measuring juvenile and adult fish abundance and distribution and for assessing salmonid habitat conditions. This approach has been used in Oregon for coho for several years (Trent McDonald and Dana McCanne).
11. The Workshop 1 questionnaire results plus the VSP session discussion favored the adult spawning escapement metric over all other metrics such as spatial distribution, juvenile abundance, population diversity, etc (LB Boydstun and Eric Bjorkstedt) .
12. The state budget change process follows specific rules and timelines. Sound information is needed to satisfy a variety of mandates. It takes a minimum of 18 months to 2 years to implement a new program and another 2-3 yrs to produce any information. The potential to speed up program implementation is remote (Gary Stacey).
13. Land owner cooperation has deteriorated due to ESA. The coho listing under CESA may further erode cooperation, which is needed to gain stream access (Bob Coey).
14. The scale of the monitoring favored measurement at the ESU level. The final Plan may emphasize more intensive sampling of "independent populations' over "dependent populations," once these have been delineated by the TRTs.
15. Monitoring Program funding should be a high priority with NOAA and the DFG. The funding also needs to be continuous for many decades in order to assess the effect of major climate cycles (Churchill Grimes).

Workshop 2 Summary

Workshop 2 was held at Folsom Lake. Here are some members of the Northern Panel.

1. Workshop 2 was held at Folsom Lake State Park on May 25-26, 2004. The purpose of this meeting was to reach agreement on the Plan monitoring priorities and sampling techniques.
2. The 42 workshop participants were divided into 4 groups: Northern Panel, for ESUs, north of Santa Cruz (all four species); Southern Panel, for ESUs south of Santa Cruz (winter steelhead); Spring Chinook/Summer Steelhead Panel; and Habitat Panel.
3. The Plan development Steering Committee (SC) developed two worksheets that asked each Panel their opinions about Plan monitoring priorities and recommended sampling techniques.
4. NOAA gave an update on TRT progress toward defining historic population types as: Functionally Independent Populations (FIPs), Potentially Independent Populations (PIPs), Dependent Populations (DPs), and Ephemeral Populations (EPs). These designations (which still need work) will be used by the TRTs to define species recovery criteria and were included as part of the worksheet exercises (Eric Bjorkstedt).
5. The Habitat Panel recommended that habitat sampling be emphasized during summer months to assess juvenile survival factors. The sampling should seek to determine the "condition" of each sample site, watershed, sub-basin or ESU. A variety of habitat parameters or attributes were offered as part of the Plan, both physical and biological.

6. The Southern Panel reviewed various adult monitoring approaches and recommended using weirs, as a first priority, to monitor the adult steelhead runs and noted that sonar technology has the potential to count the runs during high flow events (when portable weirs may not work), but needs further evaluation. In the south, the relationship between resident and anadromous rainbow trout needs further investigation (David Boughton).
7. The Spring Chinook/Summer Steelhead Panel recommended the use of weirs periodically to count spring Chinook and spring steelhead moving into summer holding areas in order to calibrate the snorkel counts that have been used for many years to monitor these fish. A pilot study was recommended to resume a Lower Klamath River seining operation that was very successful in capturing fall-run steelhead in the 1970s and 80s. The group recommended a permanent weir for the lower Salmon or South Fork Trinity River to collect life history information on the various salmonid runs that occur in these streams (LB Boydstun).
8. The Northern Panel concentrated their efforts on ranking VSP parameters for individual species and population types. For FIPs of Chinook, coho and steelhead they gave highest priority to monitoring adult fish for abundance, trend and productivity data, followed by spatial structure and genetic/life history diversity data collected from both adult and juvenile fish. For PIPs and DPs, they recommended restricting the sampling to adult salmon and steelhead for abundance and trend data. For cutthroat, the emphasis should be on juvenile fish sampling **(Tables C-1 and C-2).** There was general agreement that, where possible, weirs should be used to mark fish in lower river areas and spawning ground surveys be conducted in the watershed to count fish and recover marks (Eric Bjorkstedt).
9. The Steering Committee should meet to review the Workshop 2 proceedings and make assignments for preparing a Preliminary Draft Plan, which is expected to be completed in early August 2004 for review by Workshop participants.
10. The *First* Draft document is expected to be posted on the Workshop web page for review by the general public in early September 2004.
11. Workshop 3 is proposed to be a series of meetings to receive public input on the *Second* Draft Plan. The meeting sites will be at coastal locations (yet to be determined) and are expected to occur in late October 2004.
12. The Final Plan is due to the DFG by March 2005.

Refinement of Workshop 2 Recommendations

The Steering Committee met and reviewed the input from Workshop 2. They agreed with the Northern Panel approach to prioritizing VSP parameters for individual species and recommended that the Northern Panel recommendations be extended to the entire State, except that genetic sampling should be given a high priority in all areas (**see Tables C-1 and C-2**).

<u>Figure C-1</u>. Geographic area and coastal drainages covered by the Plan.

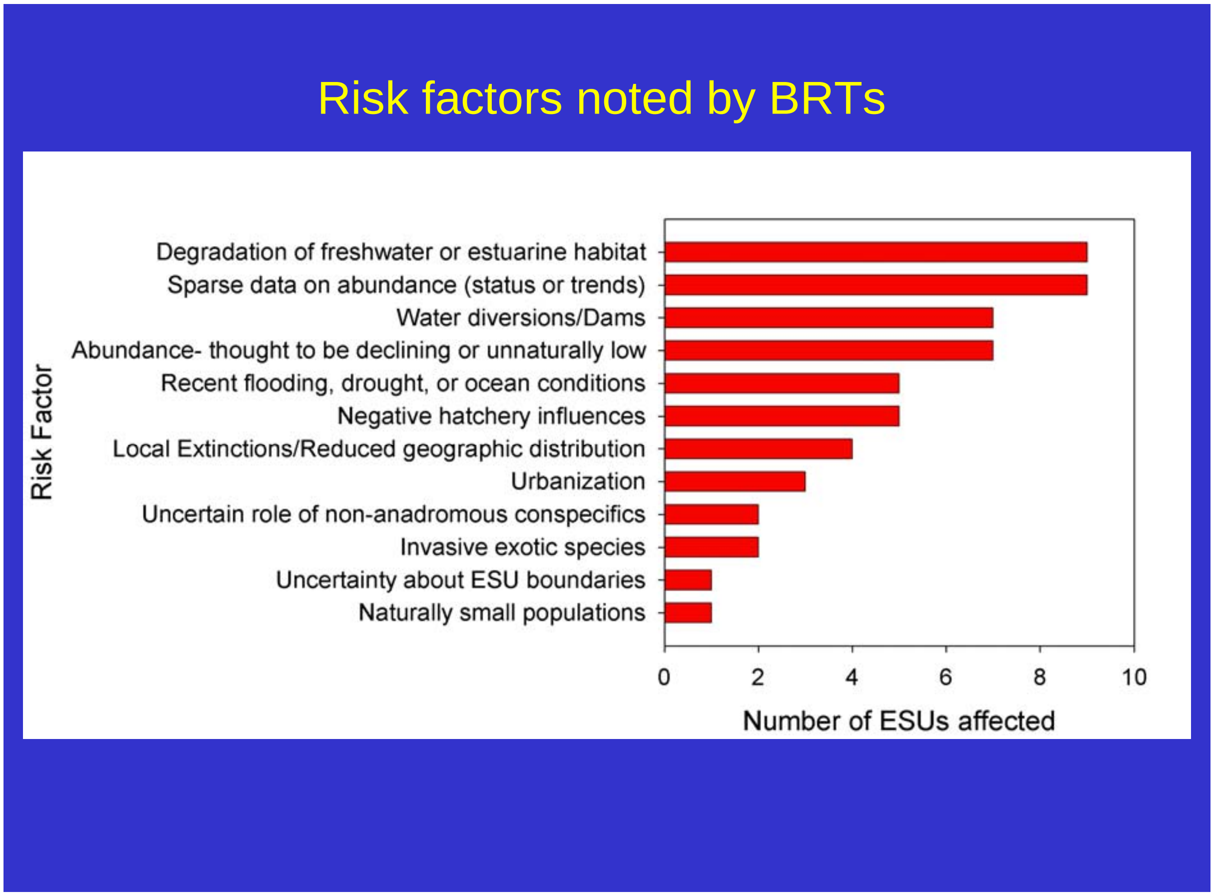


Figure C-2. Risk factors noted by Biological Review Teams for California coastal ESUs

Table C-1. Name and Affiliations of Workshop Participants[7]

Last Name	First Name	Affilication	ONE	TWO
Adams	Dr. Pete	NOAA Fisheries Santa Cruz Lab	X	X
Allen	Mr. Stan	Pacific States Marine Fisheries Commission	X	X
Anderson	Dr. Eric P.	NOAA Fisheries Santa Cruz Lab	X	X
Anderson	Ms. Patricia	CDFG-Region 3	X	X
Bairrington	Mr. Phil	CDFG-Region 1	X	
Birss	Ms. Helen	CDFG-NAFWB	X	X
Bjorkstedt	Dr. Eric P.	NOAA Fisheries Santa Cruz Lab	X	X
Blum	Mr. Joe	NOAA Fisheries-SW Region	X	
Boughton	Dr. David	NOAA Fisheries Santa Cruz Lab	X	X
Boydstun	Mr. LB	Workshop Coordinator (CDFG-Retired)	X	X
Bryant	Mr. Greg	NOAA Fisheries, Arcata		X
Capelli	Mr. Mark	NOAA Fisheries-SW Region		X
Clarke	Mr. Michael	San Luis Obispo, Nat Resources	X	
Coey	Mr. Bob	CDFG-Region 3	X	X
Collins	Mr. Barry	CDFG-NAFWB	X	X
Demko	Mr. Doug	Cramer and Associates	X	
Downie	Mr. Scott	CDFG-Region 1	X	X
Duffy	Dr. Walt	USGS, Coop Fish Research	X	X
Flosi	Mr. Gary	CDFG-Region 1	X	X
Fuller	Mr. David	USDI, Bureau of Land Management	X	X
Gale	Mr. Dan	Yurok Tribe	X	X
Gallagher	Mr. Sean	CDFG-Region 3	X	X
Garza	Dr. John C.	NOAA Fisheries Santa Cruz Lab	X	
Grimes	Dr. Churchill	NOAA Fisheries-Santa Cruz Lab	X	
Hampton	Mr. Mark	CDFG-Region	X	X
Hankin	Dr. David	HSU Fisheries Department	X	X
Harris	Dr. Richard	UC-Berkeley-Forestry	X	X
Harris	Mr. Scott L.	CDFG-Region 3	X	
Jones	Mr. Weldon	CDFG (retired)	X	X
Jong	Mr. Bill	CDFG-Region 1	X	
Jordan	Dr. Chris E.	Northwest Fisheries Science Center	X	
Kautsky	Mr. George	Hoopa Valley Tribe	X	X
Keller	Dr. Edward	UCSB-Environmental Studies	X	
Kelley	Ms. Elise	UCSB-Environmental Studies	X	X
Kocher	Ms. Susie	UC-Berkeley-Forestry	X	X
Larson	Ms. Mary	CDFG-Region 5	X	X
Lentsch	Mr. Leo	Casitas Municipal Water District	X	
Lisle	Dr. Thom E.	US Forest Service, Pacific SW	X	
Low	Ms. Alice	CDFG-NAFWB	X	
Macedo	Mr. Richard	CDFG Region 1		X
Maria	Mr. Dennis	CDFG-Region 1	X	
McCain	Mr. Mike	Six Rivers National Forest	X	X
McCanne	Mr. Dana R.	HSU-Forest and Watershed Institute	X	X
McDonald	Dr. Trent	West-Inc	X	X
McEwan	Mr. Dennis	CDFG-NAFWB	X	X
Moore	Mr. Kelley	ODFW - Corvallis Research Lab	X	
Nelson	Ms. Jennifer	CDFG-Region 3	X	

[7] The individuals named in this table participated in the workshop process and were given the opportunity to comment of the Third Draft Plan, but it is not known if they individually agree or disagree with the Final Plan recommendations.

Table C-1. Name and Affiliations of Workshop Participants[7]

Last Name	First Name	Affilication	ONE	TWO
Newton	Ms. Gale	CDFG-NAFWB	X	X
Nielsen	Dr. Jennifer	USGS, Alaska Science Center	X	
Regan	Dr. Helen	SDSU-Department of Biology	X	X
Ricker	Mr. Seth	CDFG-Region 1	X	X
Roelofs	Dr. Terry	HSU-Fisheries and Wildlife	X	
Seiler	Mr. Dave	Wash. Dept Fish and Wild.	X	
Shaffer	Mr. Kevin	CDFG-NAFWB	X	X
Smith	Dr. Jerry	San Jose State University	X	X
Spence	Dr. Brian C.	NOAA Fisheries Santa Cruz Lab		X
Spina	Mr. Anthony	NOAA Fisheries	X	
Stacey	Mr. Gary	CDFG-Region 1	X	X
Swift	Dr. Camm	Entrix Consultants	X	
Thompson	Dr. Lisa	UC Davis-Wildlife, Fish Biol Dept	X	X
Urquhart	Mr. Kevin	CDFG-Region 3	X	
Voight	Mr. Hans	Yurok Tribe	X	X
Watson	Dr. Fred	CSUMB-Watershed Institute	X	
Webster	Mr. Ray	North Carolina State Univ	X	
Week	Mr. Larry	CDFG-NAFWB	X	X
Williams	Dr. Thom E.	NOAA Fisheries Santa Cruz Lab	X	X

Table C-2. Monitoring priorities for Functionally Independent Populations (see Glossary for definitions)								
Importance:			**Necessary**			**Useful**		
	Coho	Chinook	Steelhead	Cutthroat	Coho	Chinook	Steelhead	Cutthroat
Abundance and Trend	1A	1A	1A	1J				
Productivity (1)	1A	1A	1A	1J				
Spatial Structure	2JA	2A	2J	2J				
Genetic Diversity (2)					3J	3A	3AJ	3AJ
Life History Diversity			1AJS	1AJS	3AS	3AS		

A=adult
J=juvenile
S=smolt
Priority 1 is high, 3 is low.
(1) Productivity is derived from other metrics.
(2) Genetic diversity may only need to be collected once per decade.

- Variability in freshwater residency of coho needs to be considered.
- Steelhead hybridization with cutthroat needs to be addressed.
- Steelhead age structure should be considered in life history diversity if only in a subset of populations.
- Sampling Intensity: FIPs, every year; PIs, are sampled using a rotating panel design; DPs are treated as a group in drawing from a rotating panel.

Comments:

- There was no consensus on the scale of the sampling.
- Precision in the estimates will depend on funding level.

Limited habitat sampling was assumed to occur.

Table C-3. Monitoring priorities for Potentially Independent and Dependent Populations (see Glossary for definitions).								
Importance:			**Necessary**			**Useful**		
	Coho	Chinook	Steelhead	Cutthroat	Coho	Chinook	Steelhead	Cutthroat
Abundance and Trend	1A	1A	1A	1J				
Productivity					3A	3A	3AS	3J
Spatial Structure					3J	3A	3AJ	3J
Genetic Diversity					4J	4A	4J	4AJ
Life History Diversity		2A			4JA		4AJ	4AJ

A=adult
J=juvenile
S=smolt
Priority 1 is high, 3 is low.

- Genetic data will be needed at the outset to verify assigning population status and to assess the population's contribution to the ESU. After that, genetic data would be needed on a 10-year cycle.
- Life cycle monitoring should include both FIPs and PIPs.
- Research is needed on cutthroat: when and where they smolt. Cannot recommend smolt monitoring before that.

Comments:

- There was no consensus on the scale of the sampling
- Precision in the estimates will depend on funding level.
- Limited habitat sampling was assumed to occur.

APPENDIX D: Environmental Setting

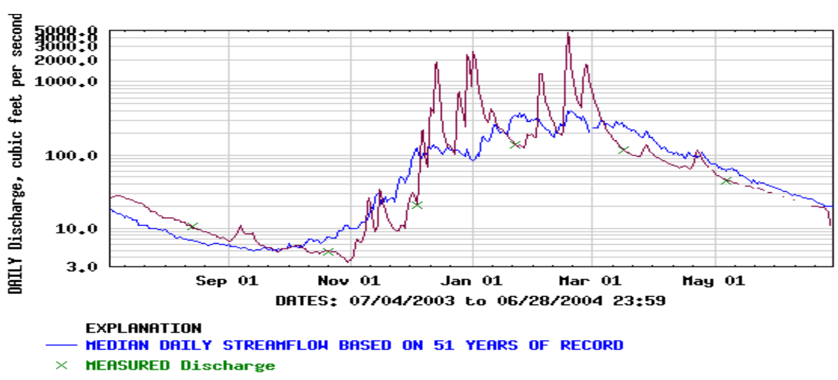
Northern Area

The northern monitoring area extends from north of the Pajaro River to the Oregon border, including the Klamath River System and tributaries to San Francisco Bay, but excluding the Sacramento-San Joaquin River system. The monitoring area is within the Oregonian biotic province (Munz and Keck 1973). The rivers in this area are mostly within the Coast Range Ecoregion as defined by Myers, et al. (1997). The major salmonid production rivers in this area (from north to south) include the Smith, Klamath-Trinity, Eel, Mattole, Navarro, Gualala and the Russian rivers.

Within this province there are four major natural terrestrial communities; North Coast Coniferous, Board Leaf Upland Forest, Lower Montane Coniferous Forest, Riparian habitats, and Bottom Land habitats (Holland 1996). This region is heavily forested, primarily with Sitka spruce (*Picea sitchensis*), western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*) and western red-cedar (*Thuja plicata*). Along the northern coast, redwood (*Sequoia sempervirens*) is common. Forest undergrowth is composed of numerous types of shrubs and herbaceous plants. The primary land use in coastal northern California has been timber harvesting and agricultural development (Busby et al. 1996). Land use for urban development is important in the Russian River basin and south (J. Nelson, DFG, pers. comm.).

Climate in the region is generally Mediterranean, under the influence of the Pacific Ocean, and includes abundant winter rainfall due to the interaction between marine weather systems and the mountainous nature of the region, summer fog and moderate temperatures (Busby et al. 1996). Topographically, the region is generally rugged with steep canyons and a narrow coastal plain. Tributary streams are generally short and have a steep gradient and, as a result, surface runoff is rapid (Weitkamp et al. 1995). These streams are especially prone to low flows during summer and times of drought with average annual rainfall ranging from 60-240 cm.

Rainfall averages are generally lower along the central California coast. River flows peak during winter rain storms common in December through March. Many of the coastal streams in this area are flashy and stream flows can change by an order of magnitude in a few days (**Figure D-1**). The larger rivers (e.g. the Klamath-Trinity and Eel) in this area experience two periods of peak discharge, one in winter associated with rainfall and another in spring due to snow melt.



<u>Figure D-1</u>. Mean daily stream flow in the Noyo River at Fort Bragg, California, from July 4, 2003 to June 28, 2004, and 51-year median daily flow for the same time period. (Data from USGS stream data at http://water.usgs.gov/ca/nwis).

During summer months, stream flows are at their lowest and temperatures at their highest (Weitkamp et al. 1995) in the unregulated streams in this area. There is usually no precipitation during this period of time and the dry period usually lasts four to six months.

Southern Area

The southern monitoring area extends from the Pajaro River south to the Tijuana River at the U.S. Mexican border. The monitoring area encompasses the Californian biotic province (Munz and Keck 1973; California Department of Fish and Game 2003). The rivers within this province fall within two basic groups: short coastal rivers draining the several coast mountain ranges (e.g., Santa Lucia, Santa Ynez, Santa Monica, Santa Ana mountains) and larger river systems (e.g., Salinas, Santa Clara, San Gabriel, and Santa Ana Rivers) that run inland, parallel to the coast mountain ranges, or extend inland through gaps in the coast ranges (Holland 2001).

The major steelhead rivers in this area (from north to south) include the Pajaro, Salinas, Carmel, Santa Maria/Sisquoc, Santa Ynez, Ventura and Santa Clara/Sespe (Busby et al. 1996). South of the Los Angeles Basin, several major drainages and a number of smaller streams once supported runs of steelhead (of unknown size and frequency) but may now be extinct, or only episodic. These include the Los Angeles, San Gabriel, Santa Ana, Santa Margarita, San Luis Rey, San Diego and Sweetwater rivers and San Mateo Creek. (Swift, et al 1993; Titus et al. 2001)

The southern monitoring area is characterized by mountainous topography with a number of inland valleys and coastal plains. The geomorphology is strongly influenced by tectonic activity, with highly folded and faulted rocks of varying types, including sedimentary rocks in the northern Coast and Transverse Ranges and metamorphic and granitic rocks in the southern Peninsular Ranges. Steep slopes and unconsolidated rock formations, combined with an active fire cycle and intense cyclonic storms, create a highly unstable setting for river and stream systems within the area (Bailey 1966; Faber et al. 1999; Norris and Webb 1990; Norris 2003).

Much of the upper watersheds within the area are contained within four national forests (Los Padres, Angeles, Cleveland and San Bernardino National Forest). These forests are managed primarily for water production and recreation (with limited oil and gas and mineral production). Urban development is centered in coastal cities, with the most expansive and densest urban development located within the Los Angeles Basin. Coastal valleys, and some foothills, are extensively developed with agriculture, principally row-crops, citrus and fruit trees and vineyards (Hornbeck 1983; Keeley 1993; Stephenson and Calcarone 1999).

Within the Californian province there are ten major natural terrestrial communities: Coast Coniferous, Closed-Cone Pines and Cypresses, Mixed Evergreen, Oak Woodland, Chaparral, Southern Coastal Scrub, Riparian Deciduous, Valley Grassland, Coastal Salt Marsh and Coastal Dunes. (Barbour and Major 1977; Faber et al. 1999; Ferren et al. 1995; Munz and Keck 1973; Munz 1974; Sawyer and Keeler-Wolf 1995). The upland areas of the northern portion of the area are dominated by a mix of Coast Coniferous, Oak Woodland and Valley Grassland. The upland areas of the southern portion area are dominated by Chaparral, Southern Coastal Scrub, Chaparral, and Oak Woodland and Valley Grassland. Riparian forests range from Coast Coniferous in the northern portion of the monitoring area to Riparian Deciduous in the southern portion of the monitoring area. (California Department of

Fish and Game 2003; Holland 1996; Mayer and Laundenslayer 1988; Stephenson and Calcarone 1999)

The climate is Mediterranean with long dry summers and short, sometimes violent cyclonic winter storms. Rainfall is restricted almost exclusively to the winter months (December through March), though the extreme southern portion of the monitoring area is subject to occasional summer storms originating from the Gulf of California. Precipitation is highly variable between years. Additionally, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas. Annual precipitation from south to north ranges from 25 – 152 cm, with comparable ranges from coastal to inland locations at the same latitude. Fog along the coastal areas is typical in early spring, particularly along coastal reaches with valleys extending into the interior (Karl 1979; Bailey 1966; Hornbeck 1983).

River flows vary widely between seasons and can be highly flashy during the winter season, ranging by several orders of magnitude over a few hours. Snow accumulation is generally small and of short duration and does not contribute significantly to peak run-off. Base flows in some rivers reaches can be influenced significantly by groundwater stored and transported through faults and fractured rock formations. Many rivers and streams exhibit interrupted base flow patterns (alternating sections with surface and no surface flow) controlled by geologic conditions. Water temperatures are generally highest during summer months but can be locally controlled by springs, seeps and rising groundwater, creating micro-aquatic conditions suitable for salmonids (Faber et al. 1999; Jacobs 1993; Mount 1995).

Literature Cited

Bailey, Harry P. 1966. The Climate of Southern California. University of California Press.

Barbour, Michael and Jack Major (eds.) 1977. Terrestrial Vegetation of California. Wiley-Interscience.

Busby, Peggy J., Thomas C. Wainwright, Gregory. Bryant, Lisa J. Lierheimer, Robin S. Waples, F. William Waknitz, and Irma V. Lagomarsino. 1996. Status Review: West Coast Steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27.

California Department of Fish and Game. 2003. Atlas of the Biodiversity of California. Resources Agency. California Department of Fish and Game.

Faber, Phyllis M., Edward Keller, Anne Sands, and Barbara M. Massey. 1999. The Ecology of Riparian Habitats of the Southern California Coastal Region: A Community Profile. U.S. Fish and Wildlife Service. Biological Report 85(7.27)

Ferren, Wayne R. Jr., Peggy L. Fieldler, and Robert A. Leidy. 1995. Wetlands of the Central and Southern California Coast and Coastal Watersheds: A Methodology for their Classification and Description. U.S. Environmental Protection Agency, Region IX.

Holland, Elise. 2001. The State of California Rivers. Western Rivers Program. The Trust for Public Land.

Holland, V. L. 1996. California Vegetation. Kendall Hunt Publishing Company.

Hornbeck, David. 1983. California Patterns: A Geographical and Historical Atlas. Mayfield Publishing Company.

Jacobs, Diana. 1993. California's Rivers: A Public Trust Report. California State Lands Commission.

Karl, William. 1979. The California Water Atlas. California Department of Water Resources.

Kelley, Jon E. (ed.) 1993. Interface Between Ecology and Land Development in California. Symposium Proceedings. Southern California Academy of Sciences.

Mayer, Kenneth E. and William F. Laudenslayer, Jr. 1988. A Guide to Wildlife Habitats of California. California Department of Forestry and Fire Protection.

Mount, Jeffery 1995. California Rivers and Streams: The Conflict Between Fluvial Process and Land Use. University of California Press.

Munz, Philip A. 1974. A Flora of Southern California. University of California Press.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1997. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

Munz, Philip A. and David D. Keck. 1973. A California Flora and Supplement. University of California Press.

Norris, Robert M. 2003. The Geology and Landscape of Santa Barbara County, California and its Offshore Islands. Santa Barbara Museum of Natural History.

Norris, Robert M. and Robert W. Webb. 1990. Geology of California. John Wiley and Sons, Inc.

Sawyer, John O. and Todd-Keeler-Wolf. 1995. A Manual of California Vegetation. California Native Plant Society.

Stephenson, John R. and Gena M. Calcarone. 1999. Southern California Mountains and Foothills Assessment: Habitat and Species Conservation Issues. U.S. Forest Service, Pacific Southwest Research Station. General Technical Report PSW-GTR-172.

Swift, Camm, Thomas R. Hagland, Mario Ruiz, and Robert N. Fisher. 1993. The Status and Distribution of Freshwater Fishes of Southern California. Southern California Academy of Sciences.

Titus, Robert, Don C. Erman, and William M. Snider. 2001. History and Status of Steelhead in California Coastal Drainages South of San Francisco Bay. Prepared for California Department of Fish and Game and University of California Centers for Water and Wildlands Resources.

Weitkamp, L. A., T. C. Wainwright, G. J. Bryant, G. B. Milner, D. J. Teel, R. G. Kope, and R. S. Waples. 1995. Status review of coho Salmon from Washington, Oregon, and California. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-24. 400 pp.

APPENDIX E: Species Descriptions and Abundance Information

The four species of coastal anadromous salmonids covered in the Plan include Chinook salmon (*Oncorhynchus tshawytscha),* coho salmon (*O. kisutch*), Steelhead rainbow trout (*O. mykiss)*, and Coastal cutthroat (*O. clarki clarki)*. This section provides basic life history information and historic and current abundance estimates, where available, for each species. Fishery and hatchery information for these species are provided in **Appendix A.**

Chinook salmon

Chinook salmon primarily occur in streams north of and including the Mattole River. They occur in small numbers as far south as the Russian River (S. Gallagher, DFG, pers. comm.). They are the largest of the seven species of *Oncorhynchus.* Historically, they were believed to occur in significant numbers as far south as the Russian River California. Chinook migrate to sea in their first year of life (ocean-type fish) (Myers et al 1997).

Total Chinook run size in coastal streams in the early 1960s was estimated based on DFG biologists' opinions to be 256,200 fish, mostly fall Chinook. The Klamath was estimated to support 168,000 (66%) fish, followed by the Eel at 55,500 (22%) fish, the Smith at 15,000 (6%) fish, and Mattole at 5000 (2%) (DFG 1965).

There are two recognized races of Chinook in the coastal area; fall and spring run (Fry 1973). The DFG convention for classifying stocks based on run timing is based on physiological and behavioral characteristics and does not necessarily reflect genetic or taxonomic relationships.

Fall Chinook salmon

These fish primarily occur in coastal streams from the Mattole River to the Smith River. The largest run occurs in the Klamath River System and is fall run fish. Klamath fall Chinook fish primarily enter the river from the ocean during August-September and spawn during October-November. The Klamath River run averaged 154,800 fish during 1994-2003 (compared to 168,000 fish in the early 1960s, a difference of 8%). The 1994-2003 average run consisted of 7, 56, 36, and 1% ages 2, 3, 4 and 5 fish, respectively (Table II-3: PFMC 2004a).

Other important fall Chinook runs occur in streams between the Smith and Russian rivers. These runs enter freshwater later than in the Klamath. Drought conditions or river mouth sand bars can delay river entry timing. Generally, flow conditions allow river entry starting in October with spawning occurring November-January. Age composition data are unavailable for these stocks.

Chinook spawning takes place mostly in tributary streams in late fall or early winter and fry emerge occurs in late winter or early spring. Most fish begin to migrate downstream to the ocean soon after emergence. In the Klamath, ocean entry is believed to occur May-July.

Spawner index surveys are conducted annually or periodically on Canon Creek (Mad River), the mainstem Mad River and Sprowl and Tomki creeks (Eel River). Annual fall Chinook counts are available for Van Arsdale Fisheries Station (upper Eel River) and Freshwater Creek (Humboldt Bay) (Bjorkstedt and Spence 2003). The Shasta River run has been monitored since 1930 and shows a noticeable decline beginning in the early 1940s (Table B-6: PFMC 2003).

Spring Chinook salmon

Spring Chinook occur primarily in the Salmon, Trinity and South Fork Trinity rivers. Smaller runs occur in some years in the Smith and Eel rivers.

Spring Chinook enter freshwater primarily during April-June with some fish entering in early August in the Klamath System. Spring Chinook migrate upstream and hold in the deeper pools until September-October when they spawn. The fry emerge in late winter or early spring and begin to migrate to the ocean soon thereafter. Information on timing of ocean entrance of spring Chinook has not been studied but is speculated to be slightly earlier than fall Chinook due to earlier spawn time, probably during May-June.

Dive counts of spring Chinook in the Salmon River since 1980 have ranged from 143 fish in 1983 to 1304 fish in 1993 (DFG files).

Coho salmon

California coho salmon have a uniform life history pattern. The adults spawn in the winter, the fry emerge in late winter or spring and the smolts enter the ocean in the spring of the year following emergence. A few fish, mostly males, return to freshwater to spawn that same year of ocean entry (age 2) but most return the following year as age 3 fish (Shapovalov and Taft 1954).

Total coho run size in California in the early 1960s was estimated to total 99,400 fish with the fish fairly evenly divided between Klamath, Eel and Mendocino-Sonoma county streams (DFG 1965).

Adult run timing depends on distance they have to migrate to reach their spawning areas. In the Klamath, the longest running fish enter in September and October (Hopelain 1988) while in the shorter run streams they enter in November, December or later, depending on stream access and flow conditions (DFG 2003).

The southernmost stream that supports coho salmon is Aptos Creek in Santa Cruz County (NOAA 2001). Probably the largest coho run historically occurred in the South Fork Eel River where the run count at Benbow Dam ranged from 7,400-25,000 fish during the 1940s (Taylor 1978).

Steelhead rainbow trout

Steelhead rainbow trout is the most ubiquitous salmonid in the coastal area. They occur in practically all coastal watersheds from the Smith River to the Tijuana River. Steelhead likely occurred historically in some northern Baja California, Mexico streams (McEwan and Jackson 1966). Rainbow trout, the resident form, occurs in waters used by steelhead. The relationship between rainbow trout and steelhead is not understood but the two life history types are likely related.

Steelhead are highly dependent for their survival upon freshwater environment conditions during their first 1-3 years of life before smolting and entering the ocean. They generally reach smolt size (15-16 cm; Wagner 1974) in the spring of their second year of life with some reaching smolt size in the spring at ages 1 or 3. At this time they are physiologically ready to enter the ocean. Because of their extended freshwater residency, steelhead tend to distribute widely in most river systems.

Repeat spawning in steelhead is common, particularly among females, which generally return to sea soon after spawning. Males frequently spawn with two or more females, which results in a protracted spawning season and reduced survival rate for repeat spawning (Shapovalov and Taft 1954).

Steelhead are distinguished in California based on timing of adult river entry. This convention is based on physiological and behavioral characteristics and does not necessarily reflect genetic or taxonomic relationships (McEwan and Jackson 1996).

Winter steelhead

These are the most widely distributed of three run types of steelhead in the State. They enter freshwater during increased annual flows in late fall or early winter. Sufficient flows are needed to wash out sand bars at many river mouths. During droughts or low runoff years, some fish may not be able to enter their natal streams. At the time of stream entry, winter steelhead are ready to spawn within a few weeks or a month at most.

The largest populations historically occurred in the South Fork Eel River where Benbow Dam counts in the 1940s showed runs of 13,000-24,000 adults annually (Taylor 1978). In the early 1960s, coastal streams were estimated to support 352,300 adult steelhead annually, excluding the Klamath River System, which was mostly fall run fish. The remaining steelhead were distributed as follows: 82,000 (23%) in the Eel River System, 77,000 (22%) in Mendocino-Sonoma county streams, 50,000 (14%) in the Russian River and 30,000 (9%) in the Smith River (DFG 1965).

In the north (north of Pajaro River), winter fish smolt at ages 1-3 and mature at ages 1-3. Age 2/2 (river/ocean years) and 2/1 fish are the most common maiden spawners. Repeat spawners may account for 30% or more of the northern runs (Shapovalov and Taft 1954, Boydstun 1977). Age composition and repeat spawning information is lacking for the southern (Pajaro River and south) runs.

Spring steelhead

These fish are generally limited to the Smith River, Klamath River System (especially Salmon River), Redwood Creek, Mad River and the Middle Fork Eel River. A few fish occur in some years in the Mattole River. After river entry they migrate upstream to summer holding areas where they are annually surveyed by the DFG using summer dive counts. The annual counts in the Middle Fork Eel since 1966 averaged 820 fish and ranged from 198 to 1601 fish. Spring steelhead spawn in late winter or early spring, nearly a full year after river entry. Repeat spawning is low in Middle Eel spring-run steelhead likely due to their protracted adult holding period (Puckett 1975).

Fall steelhead

Fall steelhead are most abundant in the Klamath River System. Much smaller populations occur in the Mad and Eel rivers. Fall steelhead are also abundant in the Rogue River in southern Oregon. Most of these fish make their initial freshwater migration as “half pounders” during August-September after only 2-4 months in the ocean. At this time they are 25-41 cm (10-16 in.) in length (Kesner and Barnhart, 1972, Everest 1973, Hopelain 1998). Half-pounders generally do not spawn. Half-pounders return to sea during winter or early spring following initial river entry and return in late summer or fall of the following year as maturing adults. This is a unique steelhead run on the West Coast. Straying of fall steelhead is common between the Rogue and Klamath rivers (Everest 1973 and DFG tagged fish records). The adult fall steelhead run is more protracted than the half-pounder run and river entry occurs from August-October (Hopelain 1988). The run in the 1970-80s was estimated to range from

87,000-181,400 adult fish (DFG unpublished data in McEwan and Jackson 1996). Adult fall steelhead are presumed to spawn in upper Klamath and Trinity River tributaries.

Most fall steelhead smolt at age 2 (range 1-3) and initially return to freshwater as half-pounders. There is a lower rate of half-pounder migration in the Trinity River stock compared to the Klamath River stock. Repeat spawners are common in Klamath-Trinity Basin fall steelhead runs (Hopelain 1998).

Cutthroat

The following is based on Johnson et al. (1999). Coastal cutthroat trout have been observed in 182 of 252 named streams (71%) within their range in California. An additional 45 streams (17%) likely support populations. They occur throughout most of the Humboldt Bay tributaries, the Smith and Little river basins, the lower portions of Redwood Creek and the Klamath, Mad and Eel rivers and numerous small named and unnamed coastal tributaries. They occur in five coastal lagoons and ponds—Big, Stone, and Espa and the Lake Earl-Talawa complex, totaling about 1875 ha. Almost 46% of the population occupies habitats in the Smith and Klamath River drainages. Historically, coastal cutthroat were distributed south through the Russian River.

Cutthroat display a diverse combination of life history types. Some fish live their entire lives in freshwater. Others live part time in fresh and estuarine areas. Some take up an anadromous existence after their initial freshwater spawning run. Still others oscillate between anadromous, estuarine and resident freshwater existence. "The diversity of migratory behaviors in coastal cutthroat makes identification of fish by life-history form particularly challenging." (Johnson et al.1999). In some coastal cutthroat populations, only a small proportion of the individuals may be anadromous. Further complicating the situation is the extensive hybridization of resident forms of cutthroat with rainbow trout (David Hankin, Humboldt State Univ, 2004, draft). In the following we focus on the anadromous form of cutthroat.

In streams with year round access, coastal cutthroat return to northern California streams from July-November with peak migration in September and October. In the Alsea River (Oregon) the first fish in were the "forerunners of larger runs which peaked at later dates" and "smaller numbers of fish were known to enter as late as early October." It was suggested that the early run of fish in the Alsea River may consist of older fish with first time spawners making up the later October-November run. In smaller California rivers and coastal lagoons with seasonal river sand bars, adult immigration begins with the first opening of the sand bar, usually in November or December, and continues through March, with peak migration typically in January and February.

The ocean life history and distribution of the fish is poorly understood. Coastal cutthroat typically mature at an early age (2 - 3 years) whereas sea-run cutthroat rarely spawn before age 4. The incidence of repeat spawning appears to be higher than in steelhead.

Anadromous cutthroat spawning on the West Coast typically starts in December and continues through June, with peak spawning in February. In California, spawning is reported to begin in November, with peak spawning in late December in larger river basins and late January and February in the smaller coastal rivers and streams. Critical stream spawning and rearing conditions and incubation and emergence parameters are described by Johnson, et al (1999).

In California, smolt migration typically begins in March and continues through June and July, with peak migration in April and May. On the California, Oregon and Washington coasts, coastal cutthroat make their initial seawater migration between ages 2 - 3, with a few age-4 migrants of mean sizes ranging from 150 to 255 mm. On the Oregon coast and in the Cowlitz River, Washington, coastal cutthroat migrate to estuaries in the spring and remain there throughout the summer.

Literature Cited

Boydstun, LB. 1977. California's steelhead program. *In* Genetic implications of steelhead management. Calif. Coop. Fish. Unit, Humboldt St. Univ. Rep 77-1. p 26-30.

Bjorkstedt, E. P., and B. Spence. 2003. California coastal Chinook. In: Preliminary conclusions regarding the updated status of listed ESUs of West Coast salmon and steelhead: draft report (Co-manager review draft), p. A93-A102. National Marine Fisheries Service, West Coast Salmon Biological Review Team. (Individual authors not specified in publication.)

DFG (Department of Fish and Game).1965. California fish and wildlife plan, volume III, supporting data, part B, inventory (salmon-steelhead and marine resources). Sacramento, CA. 677 p.

_____. 2003. Recovery strategy for California coho salmon. Public Rev. Draft. DFG, Sacramento, CA. 13 sections + append. A-I.

Everest, F.H. 1973. Ecology and management of summer steelhead in the Rogue River. Oregon State Game Comm., Fish. Res. Rep. No. 7, AFS 31, Final Report. 48p.

Fry, D.H., Jr. 1973. Anadromous fishes of California. Calif. Dept. Fish and Game, Sacramento CA. 111 pp.

Hopelain, J.S. 1988. A four year summary of seining/tagging operations in the lower Klamath River with emphasis on mature fall Chinook salmon, coho salmon, and steelhead trout, 1984 through 1987. Inland Fish. Admin. Rept No. XX-XX (draft). DFG, Sacramento, CA. 40 p +11 tables and 25 figs.

Hopelain, J. S. 1998. Age, growth, and life history of Klamath River basin steelhead trout (*Oncorhynchus mykiss irideus*) as determined from scale analysis. DFG Inland Fish. Admin. Rpt. 98-3. 19 pp.

Johnson, O.W., M.H. Ruckelshaus, W. S Grant, F.W. Waknitz, A.M. Garrett, G.J. Bryant, K.N. Neely, and J.J. Hard. 1999. Status review of coastal cutthroat trout from Washington, Oregon, and California. NOAA Tech. Mem., NMFS-NWFSC-37. Nat. Marine. Fish, Serv., Seattle, WA.

Hankin, D.G. 2004 (Draft). Hybridization of coastal cutthroat trout and steelhead rainbow trout in California north coastal streams. Humboldt State Univ. Arcata, CA. see Workshop 1 presentations.

McEwan, D. and T.A. Jackson. 1996. Steelhead restoration and management plan for California. Res. Agency, DFG. 246 pp.

Kesner, W.D. and R.A. Barnhart. 1972. Characteristics of the fall-run steelhead trout (*Salmo gairderi*) of the Klamath River system with emphasis on the half-pounder. Calif. Fish Game 58:204-220.

NOAA. 2001. Status review update for coho salmon *(Oncorhynchus kisutch)* from the Central California coast and the California portion of the southern Oregon/northern California coasts Evolutionarily
Significant Units. NOAA Fisheries, Southwest Fish. Sci. Cent., Santa Cruz Lab.

Puckett, L. K. 1975. The status of spring-run (*Salmo gairdneri*i) of the Eel River system. Calif. Dep. Water Res. and Calif. Dep. Fish Game, Memo. Rep., 22 p. (Available from California Department of Fish and Game, Inland Fisheries Division, 1416 Ninth Street, Sacramento, CA 95814).

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1997. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

PFMC (Pacific Fishery Management Council). 2003. Review of 2002 ocean salmon fisheries. PFMC, Portland OR. 4 sections plus 4 appendices.

_____.2004a. Preseason report I: Stock abundance analysis for 2004 ocean salmon fisheries. PFMC, Portland OR.

Shapovalov, L. and A.C. Taft. 1954. The life histories of the steelhead rainbow trout *(Salmo gairdneri)* and silver salmon *(Oncorhynchus kisutch)* with special reference to Waddell Creek, California, and recommendations regarding their management. CDFG Bulletin No. 98. 373 pp.

Taylor, S. 1978. The status of salmon populations in California coastal rivers. Dept of Fish and Game, Sacramento CA. 14p.

Wagner H. H. 1974. Photoperiod and temperature regulation of smolting in steelhead trout (*Salmo gairdneri*). Can. J. Zool. 52(2): 219-234.

APPENDIX F: Critical and Essential Habitats

Anadromous salmonids are found in California's small to large coastal streams with gradients < 4-5%. These streams form a continuum from the headwaters to their estuaries (or lagoons) and the ocean, which provides a variety of stream habitats for spawning and rearing salmonids (Vannote et al. 1980). NOAA has defined critical habitat for salmonids as all accessible reaches of all rivers (including estuarine areas and tributaries) within the range of each listed ESU (Federal Register 1999). Essential Chinook and coho salmon habitat, as defined in the Sustainable Fisheries Act (Public Law 104-297), includes all currently viable waters and most of the habitat historically accessible to salmon. It includes aquatic areas above artificial barriers except for impassable dams, of which 12 have been designated in northern California (PFMC 1999). Most of these same barriers have been identified as barriers to adult coho salmon in California's two coho ESUs (Table F-1, Federal Register 1999). These are also barriers to adult steelhead and cutthroat migrations, although not yet designated as such under the ESA. There are also dams on Alameda and Coyote creeks, tributaries to San Francisco Bay, that block salmon and steelhead migration that are not identified in **Table F-1**. In the two southern steelhead ESUs, barriers to adult migration include water impoundment dams, agricultural dams, road and highway crossings, concrete channels, debris basins, concrete aprons and culverts, to name a few. Sand bars can pose a problem to adult fish entry at some stream mouths during low flow periods (NOAA 2004). NOAA (unpublished data) has identified 36 dams in the two southern steelhead ESUs that block adult steelhead migrations (**Table F-2**).

Essential habitat types for salmonids are generally described as juvenile rearing areas, juvenile migration corridors, areas for growth and development to adulthood, adult migration corridors and spawning areas. Essential features of critical habitat for salmonids include adequate substrate, water quality and quantity, water temperature, water velocity, cover and shelter, food, riparian vegetation, space and safe passage conditions (Federal Register 1999). References within the 1999 Federal Register notice provide comprehensive summaries of the environmental factors associated with the critical habitat for these species.

Table F-1. List of man-made barriers (dams) that represent the upstream extent of salmon distribution in north coastal California (PFMC 1999)

Name of Barrier	USGS Hydrologic Unit	Tributary/Basin
Iron Gate Dam*	18010206	Klamath River
Lewiston Dam*	18010211	Trinity River
Dwinnell Dam*	18010207	Shasta River, Klamath Basin
Robert W. Matthews Dam	18010102	Mad River
Coyote Valley Dam*	18010110	E. Fork Russian River
Warm Springs Dam*	18010110	Dry Creek, Russian River
Scott Dam*	18010103	Eel River
Nicasio Dam (Seeger Dam)*	18050005	Nicasio Creek, Lagunitas Creek, Tomales Bay
Kent (formerly Peters) Dam*	18050005	Lagunitas Creek, Tomales Bay
San Pablo Dam	18050002	San Pablo Creek, SF Bay
Anderson Dam	18050003	Coyote Creek, SF Bay
Newell Dam (Lock Lomond R.)*	18060001	Newell Creek, San Lorenzo River

*Designated upstream extent in NOAA critical habitat designation for Central California and Southern Oregon/Northern California Coasts coho Salmon (Federal Register 1999) Phoenix Dam, Novato Creek (HUC 18050002), is in addition to the above listing.

Table F-2. List of man-made barriers (dams) that represent the upstream extent of steelhead trout distribution in Southern Steelhead ESUs (unpublished NOAA data)		
Name of Barrier	**USGS Hydrologic Unit**	**Tributary/Basin**
San Antonio Dam	18060005	San Antonio River, Salinas Basin
Nacimiento Dam	18060005	Nacimiento River Salinas Basin
Salinas Dam	18060005	Salinas River
Whale Rock Dam	18060006	Old Creek (coastal)
Lopez Dam	18060006	Arroyo Grande Creek (coastal)
Twitchell Dam	18060008	Cuyama River, Santa Maria River
Bradbury Dam	18060010	Santa Ynez
Gibraltar Dam	18060010	Santa Ynez
Juncal Dam	18060010	Santa Ynez
Casitas Dam	18070101	Coyote Creek, Ventura River
Robles Diversion Dam	18070101	Matilija Creek, Ventura River
Matilija Dam	18070101	Matilija Creek, Ventura River
Santa Felicia Dam	18070102	Piru Creek, Santa Clara River
Pyramid Dam	18070102	Piru Creek,, Santa Clara River
Castaic Dam	18070102	Castaic Creek, Santa Clara River
Rindge Dam	18070104	Malibu Creek (coastal)
Sepulveda Dam	18070105	Los Angeles River
Hansen Dam	18070105	Tujunga Wash, Los Angeles River
Whittier Narrows Dam	18070106	San Gabriel River
Santa Fe Dam	18070106	San Gabriel River
Morris Dam	18070106	San Gabriel River
San Gabriel No. 1	18070106	San Gabriel River
Cogswell Dam	18070106	San Gabriel River
Prado Dam	18070203	Santa Ana River
Bear Creek Dam	18070203	Santa Ana River
Upper Santa Ana River Dam	18070203	Santa Ana River
San Antonio Dam	18070203	San Antonio Creek, Santa Ana River
Seven Oaks Dam (undrcnst)	18070203	Santa Ana River
Mathews Dam	18070203	Tr Cajalco Creek, Santa Ana River
Vail Dam	18070302	Temecula Creek, Santa Margarita River
Henshaw Dam	18070303	San Luis Rey River (coastal)
Lake Hodges Dam	18070304	San Dieguito River (coastal)
El Capitan Dam	18070304	San Diego River
Sweetwater Main Dam	18070304	Sweetwater River
Barrett Dam	18070305	Cottonwood Creek, Tijuana River
Morena	18070305	Cottonwood Creek, Tijuana River

Salmonids require cold (< 22 C), well-oxygenated water (Moyle 2002). Depth, velocity, substrate and cover habitat criteria for Chinook and coho salmon and steelhead spawning and juvenile rearing were developed by Bovee (1986) and Hampton and Aceituno (1988). Spawning habitat criteria for Central Valley Chinook salmon were developed and evaluated by Gallagher and Gard (1999). Smith (1973) provides spawning depth and velocity criteria for Oregon salmonids. Burner (1951) describes the spawning activity and characteristics of Chinook and coho salmon redds. Orcutt et al. (1968) describes steelhead spawning behavior, redd construction and the general characteristics of redds. Chinook and coho salmon and steelhead redds sizes in coastal California streams are not different from redds in other areas of the Pacific Northwest (Gallagher and Gallagher In Press). For a comprehensive discussion of salmon spawning and spawning habitat requirements see Schuett-Hames and Pleus (1996).

Much has been written on juvenile salmonid habitat and habitat requirements. Juvenile coho salmon prefer pools with velocities < 0.20 cm/s, while steelhead are more common in riffles and deep pools (Bisson et al. 1988). Bell et al. (2001) found that off channel areas are important winter habitat for coho salmon. Bustard and Narver (1975) found that both steelhead and coho move closer to cover as water temperatures decrease and that survival increases for fish using off channel habitats. Shirvell (1990) found that juvenile coho and steelhead are associated with root wads and selected areas with slower water velocities and reduced light intensities irrespective of the physical structure that caused them. In warmer months, steelhead and Chinook salmon are associated with depths and velocities proportional to body size and shift to faster and deeper water as they grow (Chapman and Bjorn 1969). California Chinook are ocean-type fish, meaning that they migrate to sea in their first year of life (see Meyers et al. 1998). Thus, they are less dependent on freshwater conditions than coho, steelhead or cutthroat, which live a year or longer in fresh water before migrating to sea.

McEwan and Jackson (1996) describe the critical habitat conditions for California steelhead spawning and rearing. The recent coho status review by the DFG (2003) provides information for California coho salmon.

Literature Cited

Bell, E., W. G. Duffy, and T. D. Roelofs. 2001. Fidelity and survival of juvenile coho salmon in response to a flood. Trans. Amer. Fish. Soc. (130): 450-45.

Bisson, P. A., K. Sullivan, and J. L. Nielsen. 1988. Channel hydraulics, habitat use, and body form of juvenile salmon, steelhead, and cutthroat trout in streams. Trans. Amer. Fish. Soc. (117): 262-273.

Bovee, K. D. 1986. Development and evaluation of habitat suitability criteria for use in the Instream Flow Incremental Methodology. Instream flow inform. paper 21. U.S. Fish Wildl. Serv. Biol. Rep. 86 (7). 235 pp.

Bustard, D. R. and D. W. Narver. 1975. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). J. Fish. Res. Board. Can. 32:667-679.

Burner, C. J. 1951. Characteristics of spawning nests of Columbia River salmon. U.S. Fish and Wildl. Serv. Fish. Bull. 61:97-110.

Chapman, D. W. and T. C. Bjorn. 1969. Distribution of salmonids in streams, with special reference to food and feeding. Symposia on salmon and trout in streams.

DFG (Department of Fish and Game). 2003. Recovery strategy for California coho salmon. Public rev. draft. DFG, Sacramento, CA. 13 sections + append. A-I.

Federal Register. 1999. Designated critical habitat; central California coast and southern Oregon/northern California coasts coho salmon. Notice 64 FR 24049

Gallagher, S. P. and C. M. Gallagher. In Press. Discrimination of Chinook and coho salmon and steelhead redds and evaluation of the use of redd data for estimating escapement in several unregulated streams in northern California. N. Amer. Jour. Fish. Mgmt.

Gallagher, S. P. and M.F. Gard. 1999. Relationship between Chinook salmon (*Oncorhynchus tshawytscha*) redd densities and PHABSIM-predicted habitat in the Merced and Lower American rivers, California. Can. J. Fish. Aquat. Sci. 56:570-577.

Hampton, M. and Aceituno, M. 1988. Direct observation techniques for habitat use criteria development on the Trinity River, Trinity County, California. *In:* Proceedings of a workshop on the development and evaluation of habitat suitability criteria. Edited by K. Bovee and J. R. Zuboy. U.S. Fish Wildl. Serv. Biol. Rep. 88:159-180.

McEwan, D., and T.A. Jackson. 1996. Steelhead restoration and management plan for California. Res. Agcy., DFG, Sacramento, CA. 246 p.

Moyle, P. B. 2002. Inland fishes of California. Univ. Calif. Press. Berkeley, CA. 502 pp.

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35. 443 p.

NOAA (National Oceanographic and Atmospheric Adminitstration) Fisheries. (2004). Salmon and steelhead, southern California steelhead ESU. NOAA Fish., Southwest Reg. Web Page: www.swr.nmfs.noaa.gov.

Orcutt, D. R., B.R. Pulliam, and A. Arp. 1968. Characteristics of steelhead trout redds in Idaho streams. Trans. Am. Fish. Soc. 97:42-45.

PFMC (Pacific Fishery Management Council). 1999. Pacific Coast salmon plan: Appendix A. Identification and description of essential fish habitat, adverse impacts, and recommended conservation measures for salmon. PFMC, Portand, OR 97201. 46 p.

Schuett-Hames, D. and A. Pleus. 1996. Literature review and monitoring recommendations for salmon spawning habitat availability. Northwest Indian Fish. Comm.. TFW-Am-9-96-002. Available on the Web at http://www.nwifc.wa.gov/TFW/documents/report3.htm.

Shirvell, C. S. 1990. Role of instream rootwads as juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*O. mykiss*) cover habitat under varying streamflows. Can. Jour. of Fish. Aqu. Sci., 47:852-861.

Smith, A. K. 1973. Development and application of spawning velocity and depth criteria for Oregon salmonids. Trans. Amer. Fish. Soc.103:312-316.

Vannote, R. L., G. W. Minshall, K. W. Cummins, J. R. Sedell, and C.E. Cushing. 1980. The river continuum concept. Can. Jour. of Fish. Aqu. Sci , 37:130-137.

APPENDIX G: Review of Oregon and Washington Coastal Anadromous Salmonid Monitoring Programs

OREGON

Oregon coastal streams support five species of anadromous salmonids: Chinook salmon (*Oncorhynchus tshawytscha)*, coho salmon (*O. kisutch)*, chum salmon (*O. keta*), steelhead (*O. mykiss*), and coastal cutthroat trout (*O. clarki clarki)*. The Oregon Department of Fish and Wildlife (ODFW) has monitored the State's spawning salmon and steelhead resources for over 50 years (Jacobs et al 2000). For coho salmon, both spawning adult and juvenile resources have been monitored since 1997 (Jacobs et al 2002).

In their recent assessment (draft) of the status of the Oregon Coastal Coho ESU, the NOAA Fisheries Technical Recovery team drew heavily from conservation principles for salmon and steelhead presented by McElhany et al. (2000) in their publication entitled *Viable Salmonid Populations* (VSP). As such, individual populations were the primary units analyzed in assessing the conservation status of the ESU. Development of population-level biological criteria was necessary to perform population evaluations. The status of the entire ESU was a product of these individual population assessments, rolled up to the ESU level and expressed in terms of the distribution and number of "viable" populations across the ESU. As a result of this review, the ODFW recognizes 77 coastal coho salmon populations in streams between Cape Blanco and the Columbia River mouth. These are classified as Independent Populations (IPs), 19 total, and Dependent Populations (DPs), 48 total. The DPs are ones that are not likely to persist without substantial spawning support provided by strays from the IPs, while the IPs are ones that are likely to persist over the long term (100 yrs) (Nicholas et al 2005).

Oregon salmonid stream surveys have been, and continue to be, used to assess the status of the Chinook and coho salmon populations relative to listing under the ESA (Meyers et al 1997; Nicholas et al 2005). A recent overview of the ODFW anadromous salmonid monitoring program stressed the importance of adult monitoring on the ESU scale and monitoring to estimate freshwater and marine survival rates of individual cohorts of fish (Moore 2004).

Adult Monitoring

Spawning surveys have been the primary tool since 1948 for assessing the status and trends of naturally produced salmon populations in Oregon. This effort has focused on three species: Chinook salmon, coho salmon and chum salmon. Coastal winter steelhead populations have not been monitored through spawner surveys until recent years (Jacobs et al 2002).

Chinook salmon

Since 1950, spawning fish surveys conducted in **standard index areas** have been used to assess status and trends of coastal fall-run Chinook salmon stocks. The surveys were expanded beginning in 1986 in response to obligations under the Pacific Salmon Treaty (PST). The Oregon coastal area has been divided into five Chinook salmon Monitoring Areas (MAs), each of which has its own allocation of sampling resources. The standard spawning index for fall Chinook salmon consists of 53 stream segments from 19 different river basins and totals 52.6 miles. Chinook salmon spawning takes place primarily during November and December with some overlap in some streams into January. Spawning escapement is indexed as **the peak count of live and dead fish** observed in a given survey area. Peak counts are used to index spawning escapement in all survey areas except those conducted for interior populations of Rogue River fall Chinook salmon. Indexes of fall Chinook salmon spawning in the interior Rogue River Basin are based on **the average total count per mile of live and dead fish** for a given set of stream segments. Separate indexes are generated for: (1) adults and jacks and (2) hatchery and non-hatchery influenced streams. The ODFW has used regression analysis to test trends in fall Chinook salmon spawner index data for use in assessing the status and trend of coastal Chinook salmon ESUs (Jacobs et al 2002). The analyses have assumed that standard index data are representative of the un-surveyed populations. The ODFW is developing alternate methodologies for establishing escapement goals for several coastal fall Chinook salmon PST stocks. The escapement goals and population assessment methodologies for these stocks will likely change upon completion of the PST review process (PFMC 2004).

Coho salmon

Beginning in 1950, spawning fish surveys were conducted in standard index areas to assess status and trends of Oregon coastal naturally spawning coho salmon. In 1990, stratified random sampling (SRS), in combination with visual fish counts, was implemented to estimate spawning population size (Jacobs et al 2002). The SRS results indicated that actual escapements were less than estimated by the standard rivers index. Thus the index surveys were replaced by the SRS methodology and the historic data set recalibrated to be comparable to the SRS estimates (PFMC 2004). In 1995 the ODFW established four Genetic Conservation Areas (GSAs) based on genetic variation and life history traits. In response to monitoring needs associated with assessing the progress of the Oregon Plan for Salmon and Watersheds (Oregon Plan), the SRS program was expanded in 1997 to obtain reliable annual spawner abundance estimates for five Monitoring Areas (MAs) along the Oregon coast. The MAs were the same as the GCAs except that one of the GCAs was split to form two MAs. To obtain target precision for these annual estimates, sample sizes were increased to 120 surveys per MA. Implementation of Oregon Plan monitoring in 1998 resulted in the adoption of the Environmental Protection Agency's Monitoring and Assessment Program sampling design methodology (EMAP). The EMAP forces spatial balance of sampling points and uses a rotating panel design for selection of sample units (Stevens 2002). The initial sample draw at the start of the EMAP included over-samples for use in place of sample units that could not be surveyed (e.g., landowner access denial, area too remote, habitat not suitable or downstream barrier present). Also, some sites had to be dropped because of employee work load or inclement stream conditions for viewing live fish. The proportion of sites that were initially selected and successfully sampled was similar within MAs during 2000 and 2001, ranging from about 50% in the Mid Coastal MA to over 75% in the North Coastal MA (Jacobs et al 2002).

Oregon coastal coho salmon generally spawn November-December except in 2000 when most of the spawning was in January. The area under the curve (AUC) methodology is used to estimate spawning population size based on live coho counts. This technique uses fish (or fish indicator) counts over time to compute total fish days during the spawning season. The total fish days is then divided by the average coho salmon spawning life to estimate the total spawning stock size. The average spawning life for coho salmon in Oregon is assumed to be 11.3 days. For each sample unit an estimate is made of the number of spawners per mile of stream. The contributions of hatchery (adipose fin clipped) and natural fish to the runs are estimated separately. Population size estimates are produced for MAs, ESUs and the entire coast using the equations of Stevens (2002). Confidence in the estimates relies on the validity of various assumptions. One of these is that the AUC methodology provides an unbiased estimate of spawning coho salmon density. Previous studies have shown that visual survey of spawning fish tends to underestimate the number of spawners by an average factor of 1.75. Equations have been generated by the ODFW to compensate for underestimation error at different population sizes. More recent work by the ODFW provides further evidence in support of the accuracy of the AUC-based estimates (Jacobs et al 2002).

The data collected using the EMAP continues to show that peak spawner counts do not accurately reflect the abundance of Oregon coastal coho salmon spawners. Spawn timing is an important variable that is not represented in peak count data. Twelve years of trend data using SRS and EMAP shows a significant upward trend in several coastal coho salmon populations. SRS and EMAP surveys allow assessment of the distribution of spawning coho salmon within available spawning habitats. Because these surveys consist of a representative sample of the occurrence of spawners within stream reaches, they provide a means of investigating inter-annual changes in patterns of spawner distribution. In 1997, about 47% of stream reaches had zero spawners and about 80% of stream reaches had spawner densities of four adults per mile or less. Conversely, in 2001, only about 20% of the stream reaches were devoid of spawners and about 80% of reaches had spawner densities as high as about 60 adults per mile. Spawner density curves illustrate that spawner distribution is not uniform but highly skewed with most of the available habitat being occupied by few or no spawners at all in most years. In years with relatively high spawner escapement, there is a somewhat more even distribution of fish throughout their geographic range. Despite this general pattern, there are differences in patterns of spawner distribution among different years. Given these differences, various positions on these curves can be used to track inter-annual variation in distribution patterns and provide benchmarks to gauge changes in spawner distribution. Over the past twelve seasons, an average of about 35% of the spawning habitat was void of spawners. The frequency of available stream reaches supporting a maximum of 10 spawners ranged from about 30% in 2001 to near 90% in 1997. This means that, during the period of 1990-2001, from 10% to 70% of the spawning habitat had spawner densities exceeding 10 adults per mile (Jacobs et al 2002).

Oregon coho salmon spawner estimates and 95% confidence intervals based on EMAP in 2000 and 2001 are shown in Table G-1. Estimates can be generated for the Coastal Oregon Coho ESU by combining the estimates for the four northern MAs. Data are incomplete for the SONCC ESU as spawner escapement data are not available for the California portion of the ESU.

Table G-1. Estimated spawning escapement of Oregon coastal coho salmon using EMAP in 2000 and 2001 (Source: Jacobs et al. 2002).

Year	Monitoring Area	Spawning miles	Number of surveys	Miles	Total adult estimate	Confidence Interval	Wild adult estimate	Confidence Interval
2000	North	932	126	116.0	18,240	4,162	17,898	4,084
	Mid	1,151	104	96.7	14,791	3,637	14,181	3,487
	Mid-South	609	95	90.6	16,241	6,192	16,241	6,192
	Umpqua	1,066	120	11.3	10,926	2,764	10,468	2,627
	South	465	56	57.8	2,883	1,664	2,883	1,664
	Coast-wide	4,223	501	473.0	63,082	8,905	61,670	8,766
2001	North	939	121	114.4	34,590	6,231	33,667	6,080
	Mid	1,160	102	69.5	27,953	5,483	25,528	5,016
	Mid-South	614	83	75.4	73,670	22,116	70,793	21,262
	Umpqua	1,069	97	82.6	37,938	7,803	34,041	6,872
	South	448	51	51.3	8,089	2,695	7,497	2,495
	Coast-wide	4,230	454	420.2	182,164	25,025	171,525	23,8176

Steelhead

Winter steelhead historically occurred in varying abundance in all of Oregon's coastal streams and in the Columbia River upstream to Fifteen-Mile Creek near The Dalles. The ODFW has used a combination of dam passage counts and angler harvest records for tracking trends in adult steelhead abundance. Restriction on angler harvest beginning in 1992 eliminated the utility of using harvest tag data for indexing trends in coastal Oregon natural steelhead populations. Sampling was initiated in 1998 to work towards the goal of implementing a monitoring program for coastal winter steelhead populations.

During 1998-2002, steelhead redd counting was conducted in various Oregon coastal streams for which high confidence run size estimates were generated. Most of the streams had relatively small spawning areas (2.2-18.5 mile) except in 2001-2002 when the survey was expanded to include the Smith River Basin, a lower Umpqua River tributary, upstream from the Smith River falls where there was 225 miles of steelhead spawning habitat. The data for all streams and years combined indicated a very close relationship ($r^2 = 0.982$) between steelhead run size and steelhead redd count for the season using the ODFW steelhead redd counting protocol. The equation showed an average of about 1.54 redds per female at run size of 500 females. The regression is heavily weighted by the Smith River data, which had much larger steelhead run sizes compared to the other streams. The Smith River field data showed that an average of 95% and 86% of steelhead redds were discernible 7 and 14 days, respectively, after initial observation. The recommendation was that future steelhead redd surveys in Oregon coastal streams should be conducted on a 7-10 day recurrence interval (Jacobs et al 2002).

The EMAP sampling design was extended to winter steelhead population estimation statewide, excluding the Rogue River Basin, starting in 2003. The coast was divided into five management areas (MAs) and further stratified within MAs into tributary and large water reaches (ODFW 2004). Ten two-person crews were hired to do the sampling, which consisted of estimating cumulative redd counts for the season in sample reaches. Data were also collected during the surveys on lamprey eel (*Lampetra tridentata)* and cutthroat redds. The steelhead stream wading/boating protocol was the same as the coho wading/boating protocol. Each crew was expected to sample 20 large order and 25-35 small order streams during the season. Surveys were programmed to take place in each survey reach every 10-14 days. Steelhead redds were marked with a colored rock and flag hung in a nearby tree. Flags were removed as redds were no longer discernible. Steelhead redds were described as 3-4 ft wide and 6-8 ft long; lamprey redds were described as round in appearance, usually about 24 inches in diameter. Samplers were instructed to look at live and dead fish for a missing adipose fin, indicating hatchery origin. They also recorded information on spawning gravel size and distribution (ODFW 2004a).

Juvenile Monitoring

The Oregon Plan mandates that summer surveys be conducted to monitor trends in abundance and distribution of juvenile coho salmon in Oregon's five coastal MAs and to provide information on the relationship between freshwater habitat characteristics, adult spawner abundance and juvenile recruitment. The EMAP design described above is followed in selecting annual sample reaches for juvenile coho sampling and uses a subset of the sample reaches used for adult monitoring. A two-person snorkel crew counts the number of juvenile coho salmon in each of the sample reaches. Only pools $\geq 6\ m^2$ in surface area and ≥ 40 cm deep are snorkeled. All fish species present are counted by species excluding trout ≤ 90 mm. The crews are instructed to focus on accurately counting coho salmon and to approximate the number of other species present. Survey conditions are recorded with the data for each dive. Survey sites may be re-surveyed to check on temporal changes in abundance during the sampling season (ODFW 2004b).

Life Cycle Monitoring

Oregon Life Cycle Monitoring Stations (LCSs) are aimed at answering the following questions (ODFW 2004c):

1. Are there trends in abundance of adult or downstream migrant anadromous salmonids in selected index streams?
2. Are trends in abundance of adult coho salmon in selected index streams primarily due to changes in freshwater survival or to changes in marine survival?
3. Are there geographic differences in the patterns of freshwater and marine survival of coho salmon?
4. Are trends in freshwater and marine survival of coho salmon in western Oregon correlated?
5. Are geographic patterns of freshwater survival of coho salmon associated with differences in habitat quality?
6. What are the influences of climate and land-use activities on coho salmon survival rates?
7. How do survival rates of wild and hatchery coho salmon compare?
8. What are the life history characteristics (time, size and age at juvenile and adult migration) of the anadromous salmonids in the index streams?
9. How accurate are methods of estimating spawning abundance of different anadromous salmonid species?

The answers to these questions vary by species. The program is expected to provide information on freshwater and marine survival of coho salmon, but not for Chinook salmon, steelhead or cutthroat. It is not possible to select LCS sites without consideration to stream size and configuration, stream gradient, site access and landowner cooperation. Only a limited number of streams and sample sites are available for consideration. Oregon has developed trapping site criteria based on: geographic spread; employee availability to operate the traps; species present with highest priority for streams that support coho salmon, steelhead and cutthroat and secondarily for Chinook salmon; steam size, width, velocity and gradient; and land owner cooperation to enter into a long term access agreement and presence of fish ladders to count adults. Sites are also considered that allow for the construction of an adult weir and have good road access (ODFW 2004c).

The ODFW operated 14 LCSs during 1998-2002. These operations trapped downstream migrating salmonids using rotary screw traps or rotating incline-plane traps from early March until mid June. Each captured fish was classified as to species and age or size group. Up to 25 fish of each species was marked each day with a small caudal fin clip then released upstream of the traps at night from a time activated device to determine trap efficiencies. Recapture data were used to estimate the total outmigration. Total out-migrants for the season were the sum of weekly estimates. A bootstrap procedure was used to determine the variance and 95% confidence interval for each population estimate, and also to estimate population estimation bias (Solazzi et al. 2003). Adult trapping and estimation took place at 8 LCSs during 1998-2002 as described in Table G-2.

Table G-2. Characterization of ODFW adult trapping facilities used in Life Cycle studies during 1998-2002 (Source: Solazzi et al. 2003)						
Stream	**Adult trap type**	**Estimation method**	**2001-2002 Run Sizes**			
			Coho	**Chinook**	**Steelhead**	**Cutthroat**
NF Scappoose Cr	Fish ladder at falls	Actual count	18	0	10	42
N. Nehalem R.	Fish ladders at falls	Mark-recapture	3948	659	1033	--
Siletz Mill	Fish ladder at falls	Mark-recapture	258	56	92	2
Yaquina Mill	Fish ladder at reservoir	Actual count	833	39	75	8
Cascade R,	Fish ladder at falls	Actual count	41	5	4	78
W.F. Smith R.	Fish ladder at falls	Mark-recapture	1509	38	731	--
Fall Cr. (discontinued)	Fish ladder at falls	N/A	--	--	--	--
Winchester Cr.	Weir and trap (destroyed Jan 6)	Mark-recapture	302	0	--	--

Life cycle estimates have been generated for the 1997-2000 broods of coho salmon in the study streams. They show total egg deposition estimates ranging from 8,344 eggs (Winchester 2000 brood) to 5.8 million eggs (N Nehalem 2001 brood) and smolt production estimates ranging from 13 fish (Cascade 1998 brood) to 42,427 fish (N Nehalem 1996 brood). The freshwater survival estimates range from 0.1% (Cascade 1998 brood) to 12.7% (Winchester 1999 brood). The marine survival estimates range from 0.2% (Winchester 1997 brood) to over 100% (Cascade 1998 brood). The excessive marine survival of the Cascade 1998 brood is the result of more adults returning to spawn in the stream than was estimated leaving the stream as smolts. The estimated population sizes were only 22 adults and 13 smolts (Solazzi et al. 2003).

Cutthroat

Oregon does not appear to have a separate monitoring program for cutthroat. Rather, the species is monitored as part of the salmon and steelhead programs.

WASHINGTON

Washington State (Washington) supports eleven species or subspecies of salmonids including Chinook salmon, coho salmon, steelhead and coastal cutthroat trout. Efforts are underway to prevent further stock declines and to improve the condition of declining stocks. Washington annually monitors its salmonid stocks and uses that information to prioritize recovery efforts and to measure the results of recovery efforts (WDFW 2002). They also use the information to manage harvest.

The Washington Department of Fish and Wildlife (WDFW) defines a stock as “a defined set of individual fishes associated with a specific river or stream and a specific behavior such as time the group of fishes return from the sea. An example would include winter steelhead from the Skagit River (Crawford and Volkhardt 2004).” There does not appear to be a major difference in the use of the term “stock” or “population” by the WDFW, which has been defined for ESA purposes as “a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group (McElhany et al. 2000). A recent overview of the WDFW coastal monitoring program emphasized the importance of life cycle monitoring for assessing salmonid stock productivities and the importance of freshwater and marine conditions on adult returns (Seiler 2004).

Adult Monitoring

Washington uses adult spawner abundance estimates over other possible measures of brood abundance for stock status and trend analysis (Crawford and Volkhardt 2004). The WDFW has identified 435 salmon and steelhead stocks in the State. They have collected spawner data on 247 stocks that have been used for assessing relative stock status. The species break down for monitored stocks is as follows: Chinook salmon, 94 stocks; coho salmon, 72 stocks and steelhead, 81 stocks (Crawford and Volkhardt 2004).

A review of the methods used by the WDFW and the tribes for monitoring Pacific coastal area salmon and steelhead stocks shows that *redd counting is the principal method used* for monitoring all run types of Chinook salmon, coho salmon and steelhead and that carcass counting is the method used for salmon in turbid Puget Sound streams and small streams where were over flight surveys are not possible. Moreover, the monitoring is based on annual estimation of total spawning stock size of individual stocks. Total spawning stock size estimation is possible because many years of spawner survey experience has allowed them to identify the entire range of spawning by species within individual river systems. Thus, population assessment in Washington for individual ESUs is based on assumption of how representative the monitored stocks are of the unmonitored stocks.

A description of the methodologies used to estimate spawning stock size of salmon and steelhead stocks in Washington follows:

Chinook salmon

Coastal stream escapements since the early 1980s are estimated based on the number of new redds counted over the spawning season. Each redd represents 2.5 adult Chinook. Redd surveys are conducted by foot, boat and helicopter. Weekly surveys are made in established indices that account for spawning timing, season total redds and redd life (duration of visibility). One-time surveys are conducted during peak spawning outside established indices. These "supplemental survey redd counts are expanded by data from indices with similar habitat. Redd counts in non-surveyed stream reaches within the mileage base for spawning Chinook are estimated by assigning a redds/mile value from an index with similar potential (Bruce Sanford, WDFW Chinook Salmon Coordinator, pers. comm.).

Redd counting is used throughout Puget Sound streams to estimate Chinook salmon spawning stock sizes. The counting is confined to known spawning times and areas. They use either total (cumulative) redd counts or redd counts versus date and area under the curve methodology to estimate total redds for the season. In all cases, total redd count estimates are expanded by a factor of 2.5 to estimate the total spawning stock size. For streams that are too turbid for redd counting, carcasses are used to estimate total redds using historic redd count and carcass count data. Carcass counting is also used for some streams that are too small for aerial survey (based on information provided by Bruce Sanford, WDFW Chinook Salmon Coordinator, pers. comm.).

Coho salmon

Redd count methods are the dominant approach used on coastal Washington streams and live count based methods are used for Puget Sound region tributaries (Jeffrey Haymes, WDFW Coho Salmon Coordinator, pers. comm.).

Steelhead

The basic protocol used for steelhead is to walk or float index reaches to count total redds, usually once every 10-14 days throughout the spawning season. Each new redd is “flagged” so as not to recount it. Flag colors are changed between survey periods and flags are removed for redds when they are no longer discernible. During peak spawning periods, the survey is expanded to other areas of the survey basin to estimate the proportion of redds represented by the index area redd counts. The cumulative redd count for the index reach is expanded for: (1) other areas of the survey basin and (2) a factor of 2.5 steelhead/redd to estimate the total steelhead spawning stock size (Bob Leland, WDFW Steelhead Coordinator, pers. comm.).

Juvenile Monitoring and Life Cycle Monitoring

The following is paraphrased from Crawford and Volkhardt (2004): Direct measurement of juvenile migrant salmon and steelhead is the most accurate method over time to determine the status and trends in freshwater productivity. No juvenile migrant production goals have been set for Washington streams and rivers. Existing trapping operations are sparse and have not been calibrated to determine whether they are representative of other streams within the same ESU. Baseline trapping data are limited, having been implemented after the ESA listings were made. Marine survival conditions, based on marked juvenile Puget Sound coho salmon, improved between 1997 and 2003 and appear to be related to favorable sea surface temperatures.

Monitoring of juvenile Chinook salmon, coho salmon and steelhead production occurs on several large and small streams of the State. Migrating fish are trapped using a variety of trap types including fan traps, fence traps, scoop traps and rotary screw traps (WDFW 2004). Captured smolts are frequently sampled for biological information and marked with a coded wire tags (CWTs). Some of the adults from these same watersheds are trapped at fishways, fish ladders and weirs either temporary or portable and sampled for CWTs (WDFW 2004). The data collected in these studies have been used to assess stream productivities and to evaluate the effect of freshwater and marine environmental conditions on adult returns. A summary of current juvenile downstream migrant trapping operations is provided in Table G-3.

Cutthroat

The following is from Blakely et al. 2000. Coastal cutthroat occur throughout Washington’s coastal “rainforest belt.” They have two primary life history forms, freshwater and anadromous. Within the freshwater form there are individuals that live in the headwater streams (resident fish), riverine (fluvial) environments, and lakes (adfluvial). Genetic and behavioral relationships among these four life history types are unclear. In any stream, system coastal cutthroat trout are rarely represented by only the anadromous form. Often fish of more than one life history type are commingled in small spawning tributaries, and there may be considerable overlap in spawn time among the different forms. Abundance information for coastal cutthroat is scarce and generally limited to sport catch, fish trap and dam count data from a few river systems.

Table G-3. Summary of Washington State juvenile salmonid downstream migrant and Life Cycle monitoring programs (Source WDFW 2004)							
Stream	**Purpose**	**Location**	**Species**	**Juvenile trap types used and study method**	**Expansion factor**	**Adult sampling**	**Notes**
Skagit River	Estimate wild smolt production and brood survival rate	RM 17	Coho and (recently) Chinook	One each scoop and rotary trap; CWTs are applied	Recapture rate of upstream released marked fish	Ocean and terminal fisheries (presumed)	Coho smolt estimates available since 1986; IMW
Cedar River (Lake Washington)	Evaluate juvenile salmonid production. And track migrations through Lake and Ballard locks	RM 1 above Lake Washington	Sockeye, Chinook, coho, steelhead and cutthroat	Scoop trap for fry and rotary trap for smolts; PITs used to track fish	Index sampling (presumed)	N/A	
Green River (Puget Sound)	Estimate wild juvenile production	RM 34.5	Chinook	Screw trap (Feb-Jul)	Recapture rate of upstream marked fish releases	N/A	
Deschutes River (Puget Sound)	Estimate wild juvenile production and year brood survival rate	Near mouth at Tumwater falls	Coho and Chinook	Screw trap (Feb-Jun); CWTs are applied	CWT fraction from adults	100% of adults are captured at trap; CWTs estimated; ocean fishery as well	
Big Beef Creek (Hood Canal)	Estimate wild coho production using CWTs	Head of estuary	Coho	Fan trap (Mar-Jun); CWTs are applied	CWT fraction from adults	100% of adults are captured and CWTs estimated; ocean fishery as well	In operation since 1977; IMW
Little Anderson Cr (Hood Canal)	Evaluate smolt production	Head of estuary	Coho, steelhead, cutthroat	Fence weir (Apr-Jun)	Index sampling (presumed)	N/A	Since 1992; IMW
Stavis and Seabeck creeks (Hood Canal)	Evaluate smolt production	Head of estuary	Coho, steelhead and cutthroat	Fence weir (Apr-Jun)	Index sampling (presumed)	N/A	Since 1992
Devil's Hole Creek (Hood	Evaluate smolt production and	Below Lake (at stream mouth)	Coho, steelhead and	Trap in Lake outlet	Index sampling	N/A	Since 1998

Table G-3. Summary of Washington State juvenile salmonid downstream migrant and Life Cycle monitoring programs (Source WDFW 2004)							
Stream	**Purpose**	**Location**	**Species**	**Juvenile trap types used and study method**	**Expansion factor**	**Adult sampling**	**Notes**
Canal)	summer use of reservoir		cutthroat (presumed)				
Chehalis River (Grays Harbor)	Estimate coho production, marine survival and fishery harvest rate using CWTs	RM 52	Coho	Various (CWTs applied)	CWT proportion of returning adults	Ocean and terminal fisheries	Since 1980. Largest watershed outside Columbia R.
Bingham Cr (E.Satsop R., Chehalis Basin, Grays Harbor)	Estimate coho, cutthroat and steelhead production, marine survival and fishery harvest rate using CWTs.	About 50 miles from Grays Harbor	Coho, steelhead and cutthroat	Fan traps	CWT proportion of returning adults	Ocean and terminal fisheries and fishway at low head dam	Since 1980 (adult counts) and 1982 for smolt trapping
Elk Cr, Chehalis R.	Estimate adult coho returns to upper Chehalis R.	RM 1.5 thence RM 100.2 on Chehalis River	Coho	none	Total run size at Denil fishway; collect data on CWT proportions from other basin tagging		Since 1972
Mill, Abernathy and Germany creeks, Lower Columbia R	Estimate coho and steelhead smolt emigrations	Columbia RM 53.9-56.2	Coho and steelhead	Screw traps only since 2002 (Mar-Jun)	Marked fish releases upstream from traps; hatchery steelhead checked for PITs	N/A	Since 2001
Wenatchee River	Estimate juvenile salmonid emigrations	Columbia R near Lake Chelan	Chinook, coho, steelhead and sockeye	Rotary screw traps	Marked fish releases upstream from traps	N/A	Since 1994

LITERATURE CITED

Blakely, A., B. Leland, and J. Ames (editors). 2000. 2000 Washington State salmonid stock inventory: Coastal cutthroat trout. Washington. Dept. Fish & Wild., Olympia WA 98501. 267 p.

Crawford, B.A. and G. C. Volkhardt. 2004. 2004 Washington salmon and steelhead abundance index (trends regarding recovery of populations listed under the federal Endangered Species Act). Interagency Committee for Outdoor Recreation, Salmon Recovery Funding Board, Olympia WA 95504. 57 p.

Jacobs, S., 2003. Development and implementation of a program to monitor spawner escapement of anadromous salmonids in Oregon tributaries of the lower Columbia River. Slide show to Northwest/Central Valley adult salmon escapement monitoring workshop, June 17-18, 2003, Sacramento CA. Available from Alice Low, Calif. Dept. Fish and Game, Sacramento CA 95814.

Jacobs, S., J. Firman, B. Riggers, and G. Susac. 2000. Status and trends: coastal salmonid populations. Coast. Salmonid Inventory Project, Oregon Dept Fish Wild., Corvallis OR (see: http://oregonstate.edu/Dept/ODFW/spawn/pdf%20files/Misc/MONITOR2000.pdf).

Jacobs, S., Firman, J., Susac, G., Stewart, D., and J. Weybright. 2002. Status of Oregon coastal stocks of anadromous salmonids, 2000-2001 and 2001-2002: Monitoring Program Report No. OPSW-ODFW-2002, Oregon Dept. Fish and Wildl., Portland, OR.

McElhany, P., M. H. Ruckelshaus, M. J. Ford, T. C. Wainwright, and E. P. Bjorkstedt. 2000. Viable salmon populations and the recovery of evolutionarily significant units. U.S. Dep. Commerce, NOAA Tech. Memo. NMFS-NWFSC-42, 156.

Moore, K. 2004. Monitoring Efforts in the Northwest: The Oregon Plan for Salmon and Watersheds. NOAA Workshop for developing a coastal salmonid monitoring plan. NOAA Fish,. Santa Cruz, CA March 2004. (see http://www.calmonitor.org/resources/presentations/Tuesday_SCL_compressed/Monitoring%20Efforts%20in%20the%20Northwest_Kelly%20Moore.ppt#2).

Myers, J.M., R.G. Kope, G.J. Bryant, D. Teel, L.J. Lierheimer, T.C. Wainwright, W.S. Grand, F.W. Waknitz, K. Neely, S.T. Lindley, and R.S. Waples. 1997. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. U.S. Dept. Commer., NOAA Tech. Memo. NMFS-NWFSC-35, 443 p.

Nicholas, J., McIntosh, B. and E. Bowles. 2005. Oregon coastal coho assessment: Part 1: synthesis of viablity analysis and evaluation of conservation efforts. IMST, Stakeholder Team, NOAA Fisheries, and Public Review Draft. Oregon Watershed Enhancement Board and Oregon Dept. Fish and Wild., Salem OR (see http://nrimp.dfw.state.or.us/OregonPlan/default.aspx?page=152)

ODFW (Oregon Department of Fish and Wildlife). 2004a. Coastal steelhead spawning grounds survey manual. Oregon Dept. Fish and Wildl. Corvallis OR. 61 p. (see http://oregonstate.edu/Dept/ODFW/spawn/pdf%20files/reports/04steelheadmanual.pdf)

_____. 2004b. Oregon Department of Fish and Wildlife western Oregon rearing project description. Oregon Dept. Fish and Wildl. Corvallis OR. (see http://oregonstate.edu/dept/pacrim/Description.htm)

_____. 2004c. Salmonid life cycle monitoring project. Oregon Dept. Fish and Wildl. Corvallis OR. (see http://oregonstate.edu/Dept/ODFW/life-cycle/index.html)

PFMC (Pacific Fishery Management Council). 2004. Review of 2003 ocean salmon fisheries. PFMC, Portland, OR. 4 sections plus 4 appendices.

Seiler, D. 2004. Monitoring wild salmon production and survival in Washington State. NOAA Workshop for developing a coastal salmonid monitoring plan. NOAA Fish,. Santa Cruz, CA March 2004 (see: http://www.calmonitor.org/resources/presentations/Tuesday_SCL_compressed/Monitoring%20Efforts%20in%20the%20Northwest_Washington_Dave%20Seiler.ppt#1).

Solazzi, M., Johnson, S., Miller, B., Dalton, T., and K. Leader. 2003. Salmonid life-cycle monitoring project 2002. Monitoring Program Report No, OPSW-ODFW-2003-2, Oregon Dept. Fish and Wildl., Portland, OR. (see: http://oregonstate.edu/Dept/ODFW/progress-reports/annual2002ver2.pdf)

Stevens, D.L. 2002. Sampling design and statistical analysis methods for the integrated biological and physical monitoring of Oregon streams. U.S. Envir. Prot. Agen., West. Ecol. Divi., Corvallis, OR.13 p + append.

WDFW (Washington Department of Fish and Wildlife). 2002. Salmonid stock inventory 2002. WDFW, Olympia WA. (see: http://www.wdfw.wa.gov/fish/sasi/)

_____. 2004. Wild salmon population monitoring. Wash. Dept. Fish and Wild., Olympia WA 98501. (see: http://wdfw.wa.gov/fish/wild_salmon_monitor/index.htm)

APPENDIX H: Statistical Methods for Coastal California Salmonid Monitoring

This appendix describes some of the statistical estimation methods to be applied to data collected by the Monitoring Program. Specifically, the basic analyses used to estimate abundance, spatial distribution, and to detect trends in abundance are described. For illustration, the techniques are applied to a fictitious set of data ostensibly collected in a portion of the Northern Management Area.

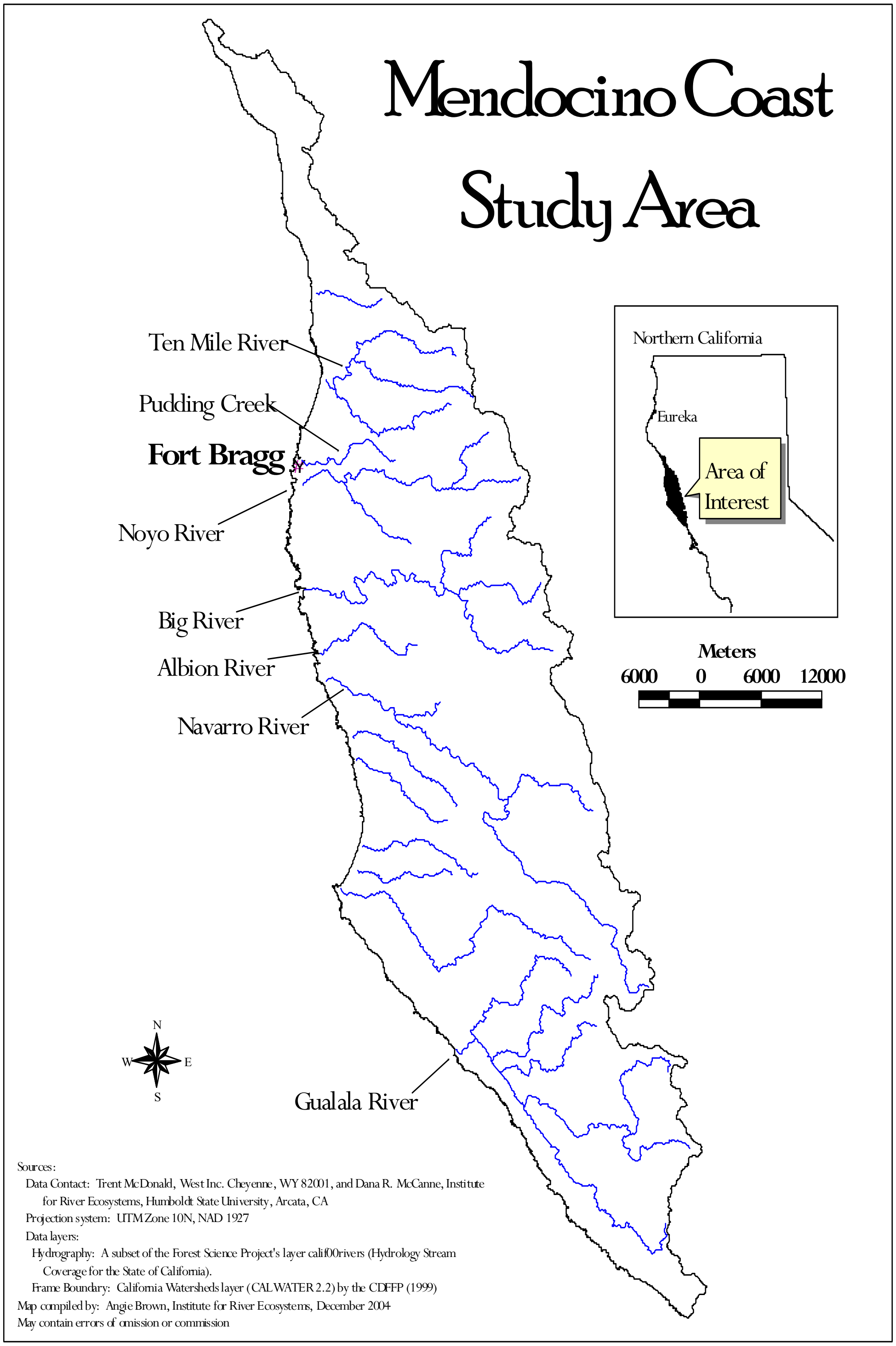
Example Sample Draw

To illustrate the methods, an example sampling frame was constructed, the proposed sampling plan was implemented, and fictitious data were generated. In later sections this data will be analyzed. Here, the example frame and sample selection will be described.

The example frame used to illustrate analysis methods encompasses streams in coastal Mendocino County and the Gualala River in Sonoma County. We refer to this collection of streams as the Mendocino Coast study area (**Figure H-1).** The example frame was constructed from 1:24,000 (1:24k) routed hydrography and digital elevation data maintained in a geographic information system at the Institute for River Ecosystems at Humboldt State University (D. McCanne, HSU, pers. comm.). Reaches above barrier dams and high gradient reaches as defined in **Sample Units and the Sampling Universe** were excluded from the frame. When the real monitoring frame is constructed, fishery biologists familiar with the area will be consulted on the status and appropriateness of individual streams for fish sampling. For expediency, this step was not taken for our example frame.

Stream segments with target lengths of 1.6-3.2 km were constructed from the non-excluded blue lines on the 1:24k maps. Due to the presence of short tributaries, realized stream segments varied from 0.1-3.18 km. Data associated with each segment consisted of segment ID (UNIT.ID), stream system ID (LLID), starting stream km of the segment (FROM), ending km of the segment (TO), length in km (UNITDIST), midpoint river km of the segment (MID.PT), UTM easting of the segment midpoint (X.COORD) and UTM northing of the segment midpoint (Y.COORD). In all, 2033 stream segments were identified in the example study area. A portion of the sample frame appears in **Table H-1**.

Prior to sampling, the example frame was ordered based on watershed, stream and segment location. Watersheds in the example study area were ordered from north to south along the Mendocino coast. Sample units within watersheds were ordered from the stream system's mouth (where it enters the ocean) upstream according to the segment's midpoint location. All units in the main stem of the stream system were ordered in the frame prior to units in tributaries. Segments in tributaries with lower (farther downstream) main-stem confluences appear in the frame prior to units in tributaries with higher confluences (**Figure H-2**). In this way, the frame was recursively sorted, from watershed to main stem to tributaries, and produced a unique ordering of the frame. The location of a unit in the ordered frame (i.e., UNIT.ID) was taken as its "spatial" location, and the "spatial" difference between two sample units was the difference in frame locations (i.e., $UNIT.ID_1 - UNIT.ID_2$). It was possible under this scheme for a segment in a tributary near a confluence with a main stem to be "spatially" far away from a segment on the main stem that contains the confluence. However, this ordering was chosen to increase the possibilities of obtaining a main stem segment, along with a nearby tributary segment, in the observed sample. In addition, when coupled with the sample draw mechanism (see below) this ordering ensured that selected sampled units were spread out, and that all streams in the study area were represented in proportion to their respective lengths.



<u>Figure H-1</u>: Map showing the location and major river systems in the Mendocino Coast example study area

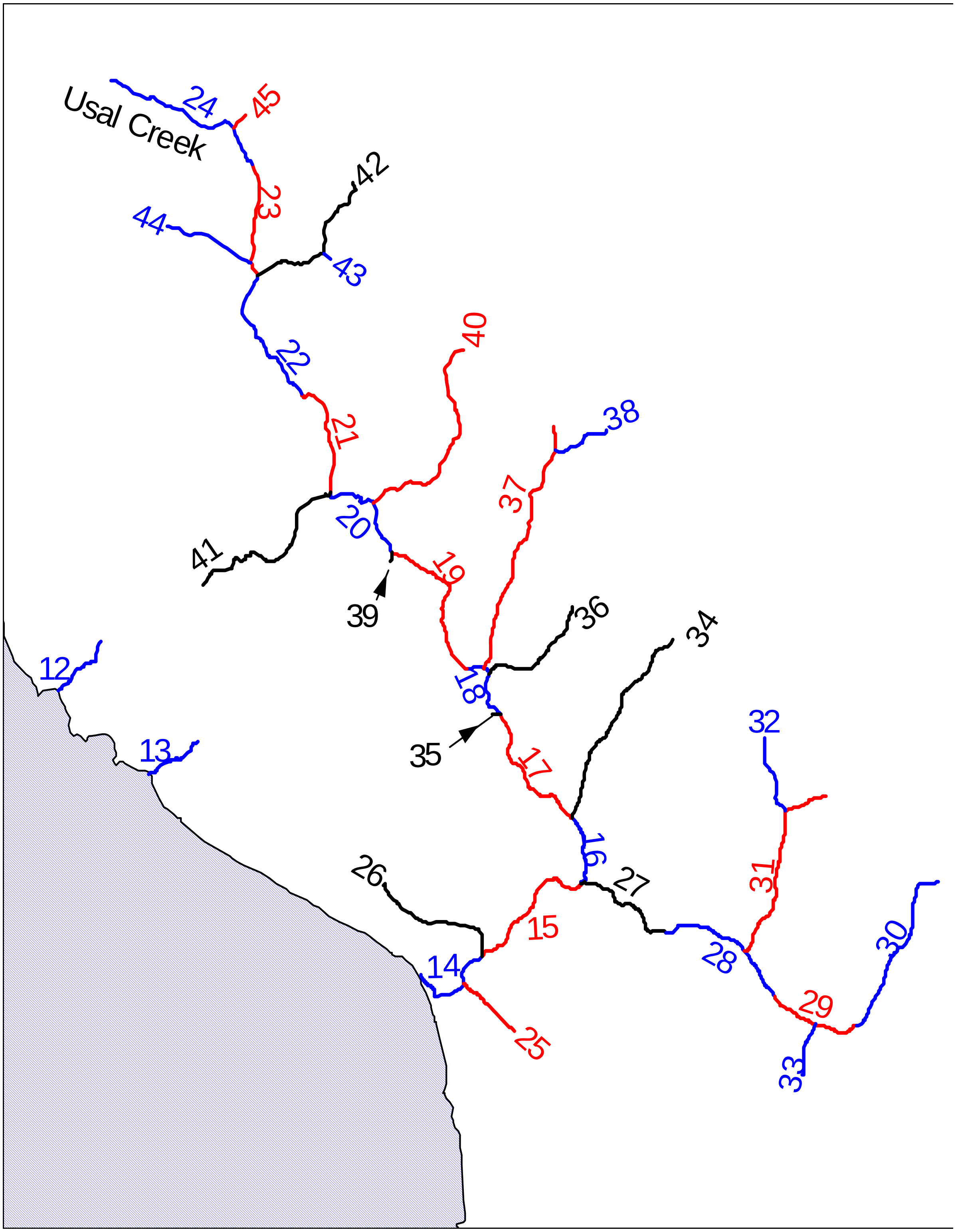


Figure H-2. Illustration of the proposed sample frame ordering. Segments in the frame are numbered from north to south based on watershed membership. Within watersheds, main stem segments are numbered prior to tributaries. Lower segments are ordered prior to higher segments. There were no exclusions for non-anadromous waters in this example.

<u>Table H-1</u>. The first 30 and last 10 units in the Mendocino Coast example sampling frame. Units on columns "FROM", "TO", "UNITDIST", and "MIDPOINT" are kilometers. Columns "X.COORD" and "Y.COORD" are UTM coordinates in meters.

UNIT.ID	LLID	FROM	TO	UNITDIST	MID.PT	X.COORD	Y.COORD
1	1239737399536	0.000	0.100	0.100	0.050	416867.8	4422858.3
2	1239730399537	0.000	0.300	0.300	0.150	416915.2	4423007.0
3	1239706399498	0.000	0.720	0.720	0.360	417351.2	4422607.4
4	1239375399132	0.000	1.310	1.310	0.655	419808.5	4418890.2
5	1239395399172	0.000	0.310	0.310	0.155	419581.3	4418882.1
6	1239146398808	0.000	2.730	2.730	1.365	422807.3	4415176.6
7	1239114398849	0.000	1.745	1.745	0.873	422069.1	4415979.3
8	1239114398849	1.745	3.490	1.745	2.618	421985.5	4417431.8
9	1239124398956	0.000	0.400	0.400	0.200	422142.7	4416492.6
10	1239091398848	0.000	0.100	0.100	0.050	422302.1	4415128.9
11	1238942398897	0.000	0.200	0.200	0.100	423566.6	4415783.0
12	1239004398603	0.000	0.800	0.800	0.400	423256.5	4412697.7
13	1238879398522	0.000	0.720	0.720	0.360	424346.9	4411687.5
14	1238506398326	0.000	1.133	1.133	0.567	427625.1	4409142.3
15	1238506398326	1.133	2.795	1.662	1.964	428510.8	4410054.5
16	1238506398326	2.795	3.601	0.806	3.198	429110.8	4410681.8
17	1238506398326	3.601	5.199	1.598	4.400	428433.2	4411511.1
18	1238506398326	5.199	6.056	0.857	5.628	427980.5	4412514.2
19	1238506398326	6.056	7.863	1.807	6.960	427508.1	4413466.4
20	1238506398326	7.863	9.147	1.284	8.505	426652.0	4414501.3
21	1238506398326	9.147	10.492	1.345	9.820	426141.9	4415243.8
22	1238506398326	10.492	12.151	1.659	11.322	425323.8	4416285.5
23	1238506398326	12.151	13.437	1.286	12.794	425264.1	4417577.4
24	1238506398326	13.437	15.550	2.113	14.494	424510.5	4418699.8
25	1238446398318	0.000	0.800	0.800	0.400	428025.4	4408976.8
26	1238422398345	0.000	1.600	1.600	0.800	427407.9	4409900.3
27	1238288398418	0.000	1.287	1.287	0.644	429621.1	4410101.4
28	1238288398418	1.287	2.959	1.672	2.123	430844.9	4409712.7
29	1238288398418	2.959	4.065	1.106	3.512	431814.3	4408788.0
30	1238288398418	4.065	6.070	2.005	5.068	432814.2	4409611.2
.							
.							
.							
2024	1231505384785	0.000	0.806	0.806	0.403	487253.8	4258743.2
2025	1231505384785	0.806	2.060	1.254	1.433	488131.8	4259088.3
2026	1231505384785	2.060	3.860	1.800	2.960	489535.6	4259270.9
2027	1231292384813	0.000	1.300	1.300	0.650	488566.4	4259628.5
2028	1231505384786	0.000	1.199	1.199	0.600	486811.4	4259258.5
2029	1231505384786	1.199	2.110	0.911	1.655	486800.0	4260142.1
2030	1231506384789	0.000	1.549	1.549	0.775	486264.9	4259235.0
2031	1231506384789	1.549	3.712	2.163	2.631	485897.9	4260742.7
2032	1231506384789	3.712	5.230	1.518	4.471	484787.9	4261780.5
2033	1231358384552	0.000	0.700	0.700	0.350	488131.3	4256425.9

This means that if a stream is twice as long as another, approximately twice as many segments from it will be selected than from the other.

To select a sample, total sample size over the life of the project and projected size of the over-sample was required. As outlined in **Allocation to Panels and Rotation Schedules,** the example study assumed 4 sets of panels were defined, each containing multiple segments and each with their own rotation schedule. The first panel in this example will receive sampling effort every year ([1-0] rotation). The 2nd through 4th panels receive sampling effort once every 3 years ([1-2] rotation). The 5th through 16th panels receive sampling effort once every 12 years ([1-11]), and the 17th through 46th panels receive sampling effort once every 30 years. Together these rotation plans comprise the [1-0, 1-2, 1-11, 1-29] rotation design in the notation of McDonald (2003) and imply that stream segments from 4 separate panels will be sampled each year (**Table 7** in main text).

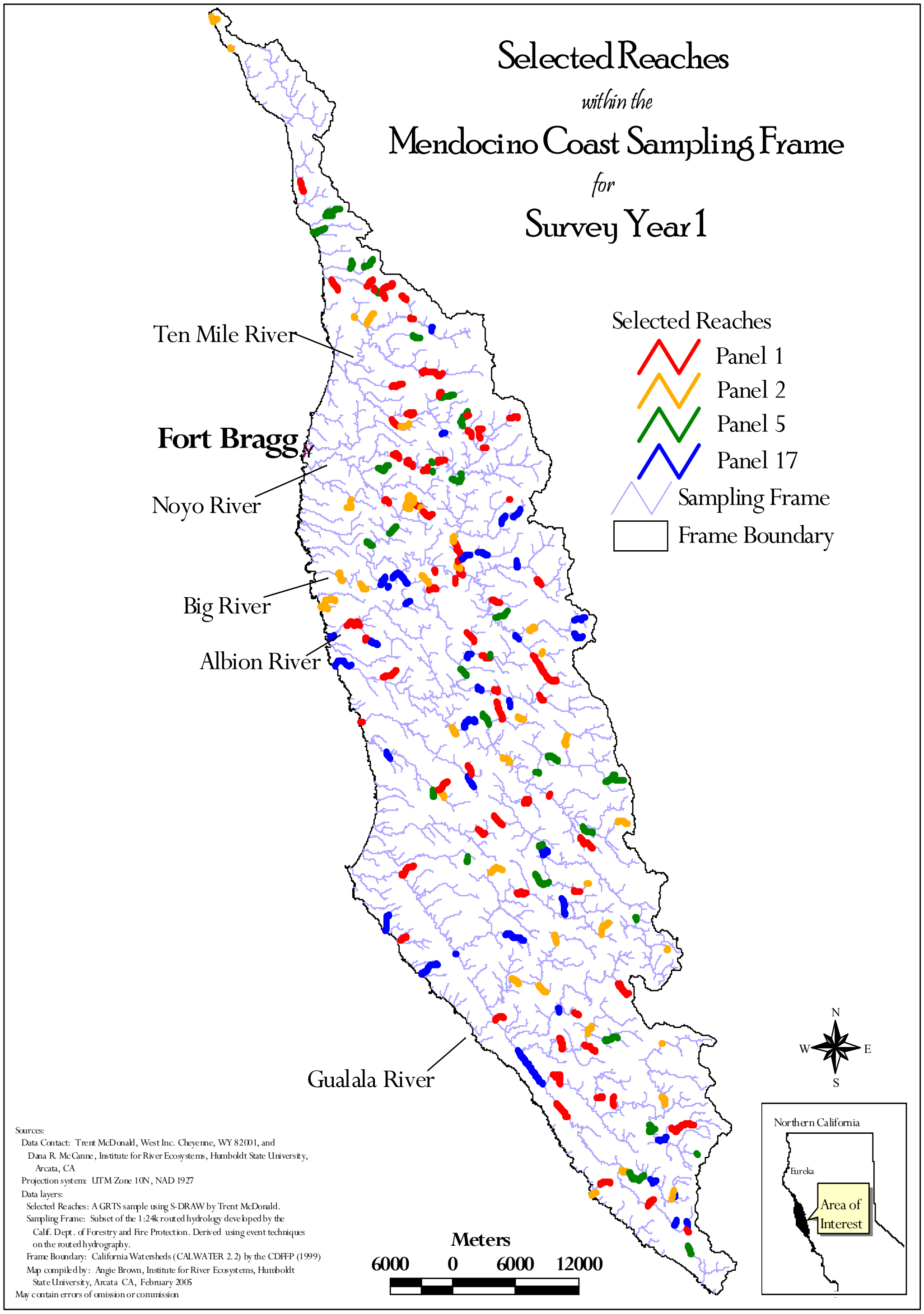
Because members of 4 panels are visited each year, and because revisits increase power to detect trends, it was decided to allocate 40% of the annual field sampling effort to the 1st panel, with 20% of annual effort going to each of the remaining 3 panels. Targeting a 10% annual sample size (i.e., 203 units each year), 80 (=203(0.4) rounded down) units were allocated to panel 1, and 41 (=203(0.2)) units were allocated to each of the 3 remaining panel types. The total sample size required to populate all panels was then 80 + 45(41) = 1925. If annual sample size changes from 203 to *n* segments, the total number of unique units visited over the 30-year life of the project will be approximately 9.4*n* (=0.4*n* + 3(0.2)*n* + 12(0.2)*n* + 30(0.2)*n*), discounting rounding errors. When 10% of the population is sampled annually, approximately 94% of all segments (0.94N=9.4(0.1*N*)) will be sampled over the life of the program.

To populate the panels with units and to facilitate replacement of segments that could not be sampled for one reason or another, an over-sample was desired in addition to the sample of units allocated to panels. However, in our example 94% of the population will be sampled over 30 years, which leaves only 6% of the population for a potential over-sample. It was decided to take the maximal over-sample and consequently a sample consisting of the entire frame (i.e., a census) was taken using the generalized random tessellation stratified (GRTS) (Stevens and Olsen 2004) algorithm. When all units in the frame are selected, only the tessellation randomizations and reverse hierarchical ordering inherent in the GRTS algorithm were applied. If the proposed annual sample size is reduced below 10%, and a non-census is required, an equi-probable GRTS sample with reverse hierarchical ordering will be taken.

Following randomization and reverse hierarchical ordering of the frame, allocation of sample units to panels was made using successive groups of units. The first 80 units in the GRTS census were allocated to panel 1. Successive groups of 41 units were allocated to each of the remaining 45 panels (**Table H-2**). The spatial locations of all 203 segments in the first year's sample appear in **Figure H-3**. Eighty of these segments are members of panel 1, 41 segments are members of panel 2, 41 are members of panel 5 and 41 are members of panel 17. The locations of units in the 2nd year's sample (i.e., those in panels 1, 3, 6, and 18) appear in **Figure H-4**. Allocation of successive groups to panels assured good spatial coverage of every individual panel.

Table H-2. Allocation of the reverse hierarchically ordered GRTS sample (census) of size 2033 drawn from the Mendocino Coast stream segment frame to panels in the proposed design. Table shows position in the sample, the unit's ID, and panel membership. Panel = 'over' are units in the over-sample which will be used to replace units that could not be sampled or to intensify sampling in some areas.

GRTS Position	UNIT.ID	Panel		GRTS Position	UNIT.ID	Panel		GRTS Position	UNIT.ID	Panel
1	48	1		204	1137	5		368	262	9
2	732	1		205	1179	5		369	117	9
3	1712	1		206	471	5		370	155	9
.				.				.		
.				.				.		
.				.				.		
78	103	1		242	1971	5		.		
79	1769	1		243	70	5		.		
80	1803	1		244	1147	5		.		
81	372	2		245	1917	6		.		
82	807	2		246	858	6		1923	1282	46
83	489	2		247	801	6		1924	37	46
.				.				1925	340	46
.				.				1926	563	over
.				.				1927	799	over
119	1991	2		283	91	6		1928	253	over
120	373	2		284	478	6		.		
121	1627	2		285	1102	6		.		
122	414	3		286	1479	7		.		
123	7	3		287	55	7		2031	623	over
124	2013	3		288	1839	7		2032	47	over
.				.				2033	1	over
.				.						
.				.						
160	1347	3		324	1776	7				
161	1773	3		325	457	7				
162	941	3		326	1707	7				
163	201	4		327	56	8				
164	8	4		328	166	8				
165	1927	4		329	1858	8				
.				.						
.				.						
.				.						
201	278	4		365	1183	8				
202	1755	4		366	1648	8				
203	150	4		367	996	8				



<u>Figure H-3</u>. Map showing the location of 203 stream segments to be sample during year 1 of the example salmonid monitoring study

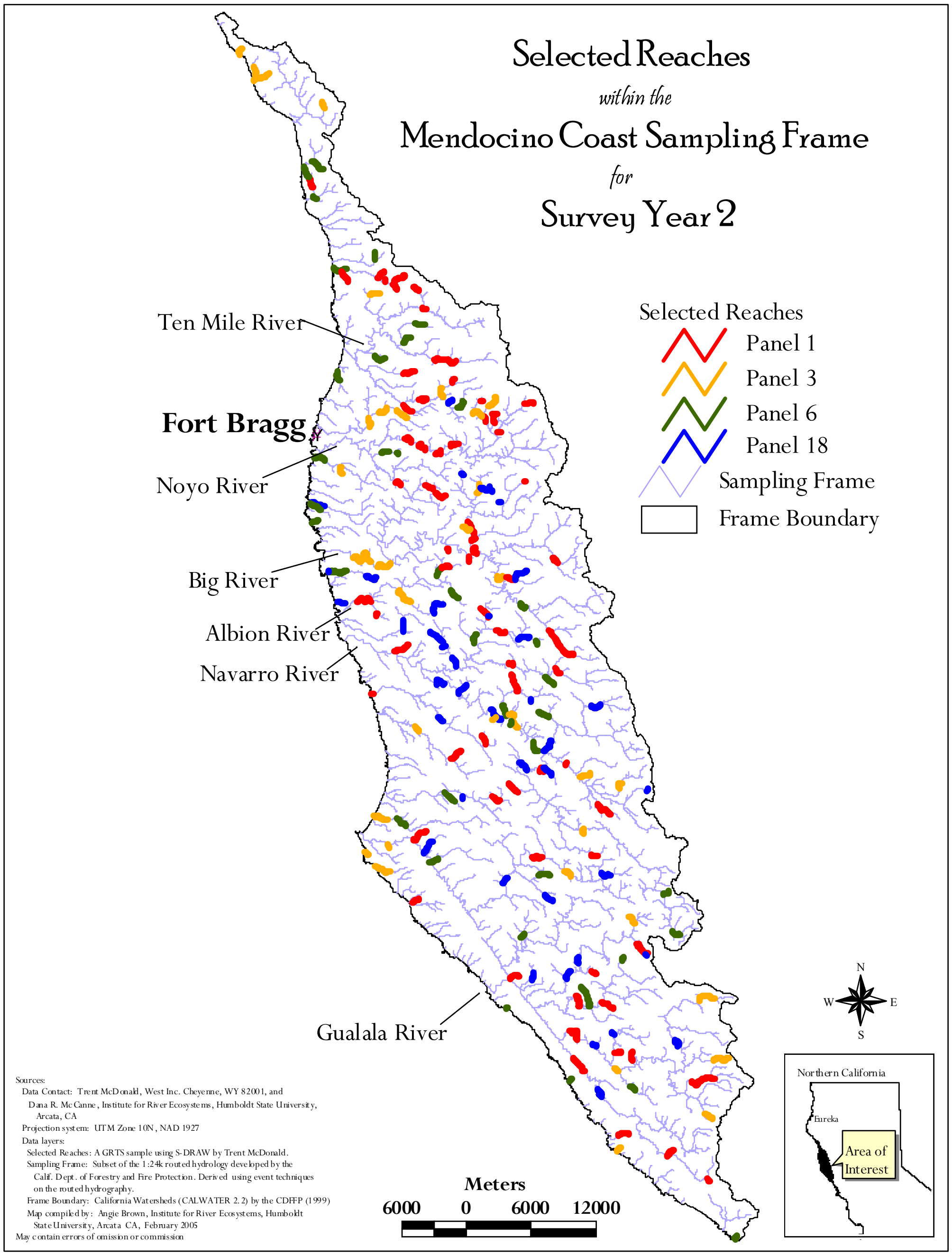
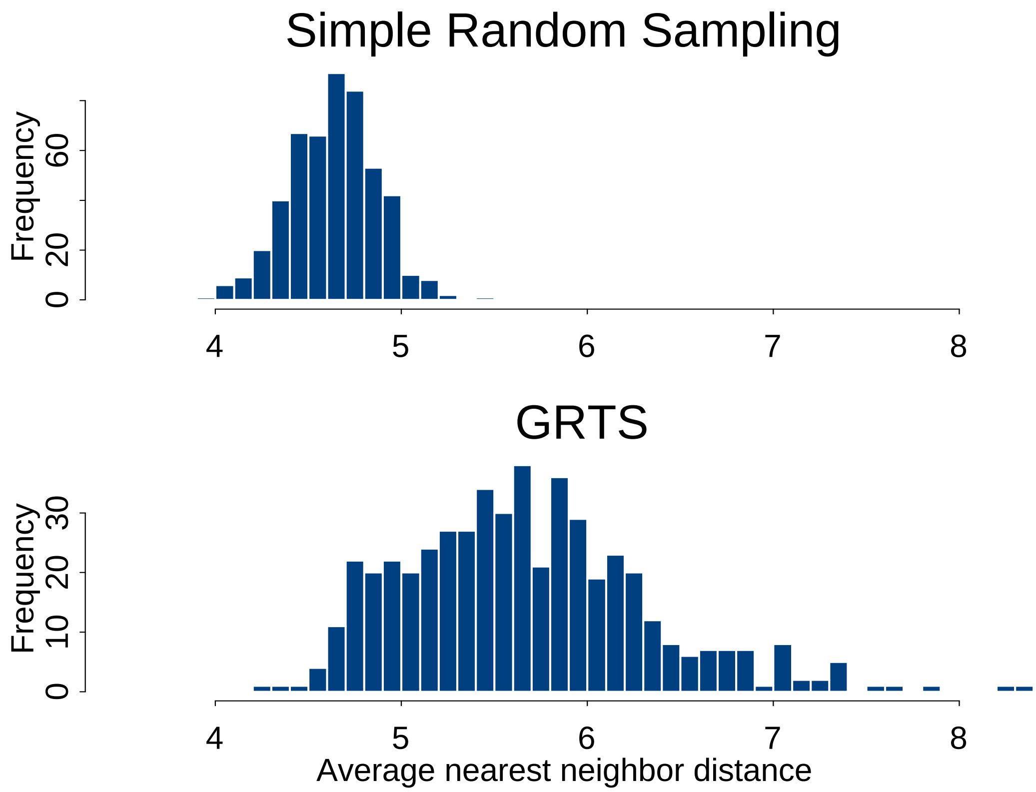


Figure H-4. Map showing the location of 203 stream segments to be sample during year 2 of the example salmonid monitoring study

To demonstrate that GRTS and our allocation scheme produces a more spatially balanced (i.e., "spread out") sample than does simple random sampling, a small simulation experiment was conducted on the example frame. Five-hundred GRTS samples of size 234 and 500 simple random samples of size 234 were taken from the example frame. For each sample, the average nearest neighbor distance was calculated, where "distance" between two units was defined as the difference in positions in the frame. Frame position is our proxy for spatial position in the river system, and units close together in the frame are generally from the same river system. Results from these 500 samples of both types show that the distribution of average nearest neighbor distance under GRTS sampling was substantially larger (more spread out) than that of the simple random sample and was considerably more variable (**Figure H-5**). This is confirmation that GRTS produces more spatially balanced samples than simple random sampling.



<u>Figure H-5</u>. Distribution of average nearest neighbor distance, as measured by difference in frame position, under simple random sampling and GRTS sampling. 500 replicates samples of size 234 from 2033 units were taken using both types of sampling schemes to construct the histograms. Larger nearest-neighbor distances imply larger distances between chosen sample segments.

Example Data

To illustrate the proposed statistical methods, fictitious data were generated for a single response on all stream segments visited during the first 6 years of monitoring. In later sections, this data will be analyzed to estimate average fish per kilometer in the Mendocino Coast study area, total abundance of fish in the study area, and trend. Data were generated assuming that 40% of all segments in the population of 2033 contained 0 fish initially (year 1). Total number of fish in the other 60% of segments was assumed to be a Poisson random variable with mean 500. Realized average abundance during year 1 was 216 fish, while the realized site component of variance was 82,694 (i.e., standard deviation of true initial segment abundance = 288). True abundance of fish was assumed to be increasing rapidly in all segments of the population. Fish abundance was assumed to increase by 100 annually through time on all segments in the population. A change of 100 equates to a realized average annual increase of approximately 27%, or 230% over 6 years. Variance estimates for fish abundance realized on individual segments each visit was assumed to follow a Poisson distribution with mean equal to abundance on the segment. Measured segment lengths were assumed to follow a normal distribution with mean equal to the length reported in the frame and standard deviation equal to 0.1. The absolute value of measured lengths was taken to assure positiveness of short segments. Plots of the raw data for panels visited during the first 6 years appear in **Figure H-6**. R language computer code used to generate example data is given in **Table H-3**. The Mendocino coast example frame and the realized GRTS sample are available by emailing T. McDonald (tmcdonald@west-inc.com).

In generating data for the example analysis, it was assumed that all segments were accessible and measurable. In reality, some segments will be un-measurable for one reason or another. When some units are un-measurable, they can either be replaced with units from the oversample, or simply dropped if the overall sample size is large enough. When segments go un-measured, analysis proceeds by first estimating the proportion of measurable segments in the population. The proportion of measurable segments is the number of measurable segments in the sample divided by total sample size. Analysis then continues using data from segments that were measurable. Results of these latter analyses apply only to the fraction of the population that was measurable. Unfortunately, unless total sample size is very large, the geographic location(s) of the un-measurable portion of the population will generally not be known. An exception occurs when segments that would have been un-measurable, had they been selected, can be identified and mapped.

Regional Estimation of Status

Using generated data, mean fish density and total abundance will be estimated separately for each year of the example study. In this section, it will be assumed that field crews visited stream segments in accordance with the revisit design outlined above and somehow obtained an unbiased estimate of the number of fish per kilometer in the segment. These methods will, in reality, apply to any unbiased estimate of a quantity associated with an individual segment. Examples of other interesting quantities include redds per kilometer, fry to parr ratio, percent cover, temperature, etc. Constructing an unbiased estimate of fish abundance for a particular segment will not in general be trivial and may involve further sub-sampling of the segment in order to apply a technique like mark-recapture, electrofishing, or snorkel counts. Statistical methods necessary to carry out estimation of a parameter on an individual segment are covered elsewhere and will not be repeated here. When finished, our estimates of total abundance and mean fish density will apply to the entire Mendocino Coast study area. Estimation of status in a sub-region of the study area such as a watershed (so-called *domain estimation*) is straightforward but will not be covered here. The interested reader is referred to Lohr (1999).

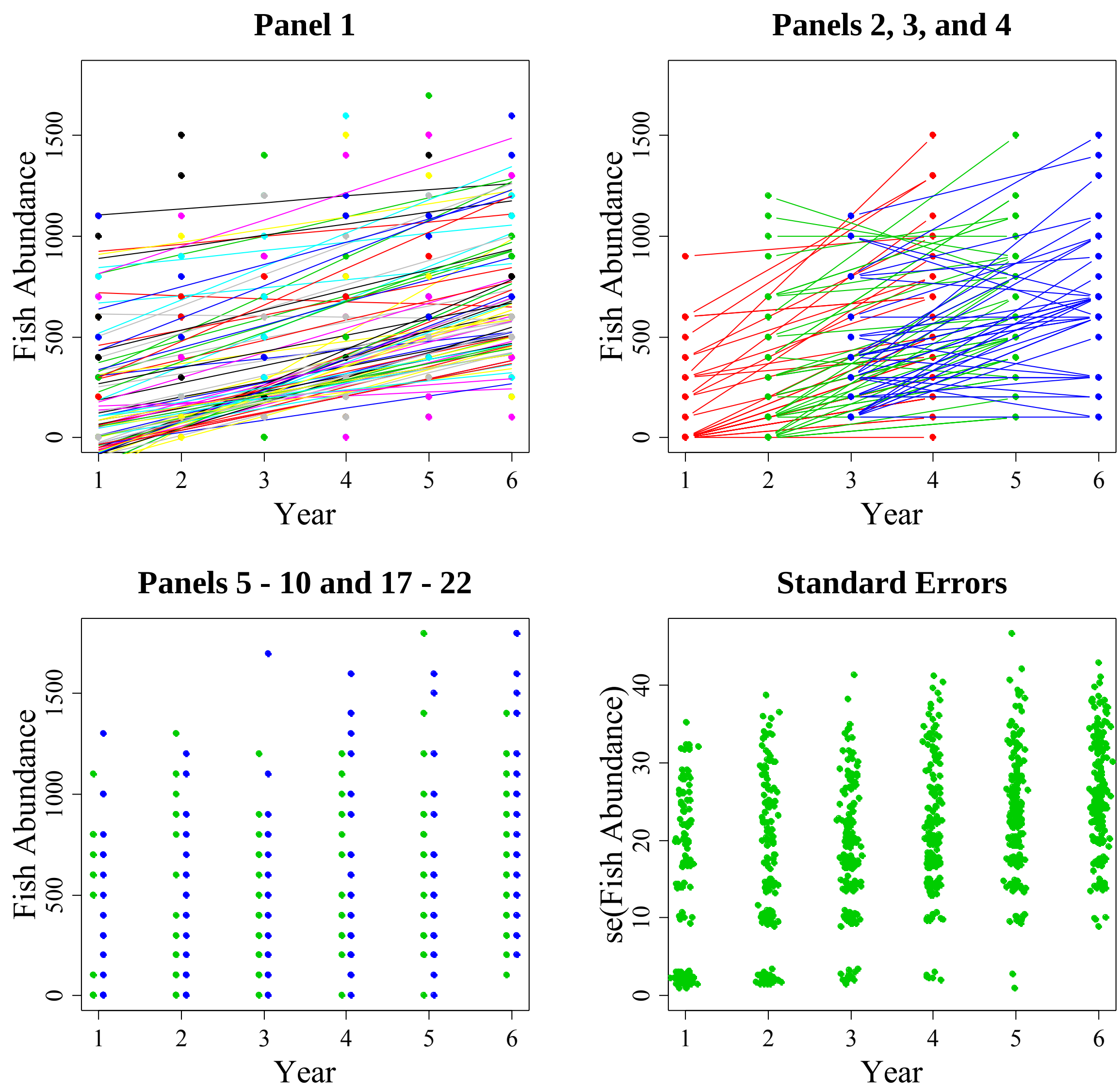


Figure H-6: Plots of fictitious data collected during the first 6 years of the example salmonid monitoring project. The response, *fish abundance*, was estimated for stream segments in Panel 1 every year, and is plotted with least-squares regression lines (upper left). Segments in panel 2 were measured in years 1 and 4 (upper right). Segments in panel 3 were measured in years 2 and 4 (upper right). Segments in panel 4 were measured in years 3 and 6 (upper right). Segments in panels 5 and 17 were measured in year 1 (lower left, red=panel 5, green=panel 17). Similarly, panels 6 and 18 were measured in year 2, panels 7 and 19 were measured in year 3, etc. Standard errors (bottom right) of fish abundance followed a Poisson distribution and were approximately the same size as abundances. All data were generated such that the true trend on all segments was 100 per year, which equates to approximately 27% annually. R code to generate the data appear in Table H-3.

Table H-3. R code used to generate example data analyzed in this Appendix. The Mendicino sample frame (*mendoframe.txt*) and realized GRTS sample (*sample_20050211_130906.txt*) are available by emailing T. McDonald (tmcdonald@west-inc.com). S-Draw, a program for drawing GRTS samples, is available at www.west-inc.com.

```
#	Merge the Mendicino example frame and a sample drawn by S-Draw
mendo.frame <- read.table("mendoframe.txt", head=T, sep=",", as.is=T, row.names=NULL )
s.draw.out <- read.table("sample_20050211_130906.txt", as.is=T, skip=20, row.names=NULL, col.names=c("unit.id","prob","lab1","lab2"))
names(mendo.frame) <- casefold(names(mendo.frame))
grts.samp <- mendo.frame[ s.draw.out$unit.id, ]

#	Assign segments to panels
grts.samp <- data.frame( grts.samp, panel= c( rep(1, 80), rep( 2:46, rep( 41,45 )), rep(46, nrow(grts.samp)-1925)) )

#	Function to generate example data
F.generate.data <- function( df, initial.prop.of.zeros, initial.mean, sigma.site=5, sigma.err=3, slope=1 ){
n <- nrow(df)
set.seed( 393939)
tmp <- rbinom( n, 1, initial.prop.of.zeros)
tmp <- tmp*rpois( n, initial.mean )   # mean is 100(initial.mean) variance is 10000*initial.mean
yr1 <- rpois(n, tmp + 0*slope) * 100
yr2 <- rpois(n, tmp + 1*slope) * 100
yr3 <- rpois(n, tmp + 2*slope) * 100
yr4 <- rpois(n, tmp + 3*slope) * 100
yr5 <- rpois(n, tmp + 4*slope) * 100
yr6 <- rpois(n, tmp + 5*slope) * 100
f.gen.se <- function( mu ){
	tmp <- mu
	tmp[ mu <= 0 ] <- 5
	sqrt( rpois( n, tmp ))}
se1 <- f.gen.se( yr1 )
se2 <- f.gen.se( yr2 )
se3 <- f.gen.se( yr3 )
se4 <- f.gen.se( yr4 )
se5 <- f.gen.se( yr5 )
se6 <- f.gen.se( yr6 )
len1 <- abs( rnorm( n, df$unitdist, .1) )
len2 <- abs( rnorm( n, df$unitdist, .1) )
len3 <- abs( rnorm( n, df$unitdist, .1) )
len4 <- abs( rnorm( n, df$unitdist, .1) )
len5 <- abs( rnorm( n, df$unitdist, .1) )
len6 <- abs( rnorm( n, df$unitdist, .1) )
#	Impose the panel rotation
panel <- df$panel
yr1[ !(panel==1 | panel==2 | panel==5 | panel==17) ] <- NA; se1[ !(panel==1 | panel==2 | panel==5 | panel==17) ] <- NA
yr2[ !(panel==1 | panel==3 | panel==6 | panel==18) ] <- NA; se2[ !(panel==1 | panel==3 | panel==6 | panel==18) ] <- NA
yr3[ !(panel==1 | panel==4 | panel==7 | panel==19) ] <- NA; se3[ !(panel==1 | panel==4 | panel==7 | panel==19) ] <- NA
yr4[ !(panel==1 | panel==2 | panel==8 | panel==20) ] <- NA; se4[ !(panel==1 | panel==2 | panel==8 | panel==20) ] <- NA
yr5[ !(panel==1 | panel==3 | panel==9 | panel==21) ] <- NA; se5[ !(panel==1 | panel==3 | panel==9 | panel==21) ] <- NA
yr6[ !(panel==1 | panel==4 | panel==10| panel==22)] <- NA; se6[!(panel==1 | panel==4 | panel==10| panel==22) ] <- NA
len1[ !(panel==1 | panel==2 | panel==5 | panel==17) ] <- NA
len2[ !(panel==1 | panel==3 | panel==6 | panel==18) ] <- NA
len3[ !(panel==1 | panel==4 | panel==7 | panel==19) ] <- NA
len4[ !(panel==1 | panel==2 | panel==8 | panel==20) ] <- NA
len5[ !(panel==1 | panel==3 | panel==9 | panel==21) ] <- NA
len6[ !(panel==1 | panel==4 | panel==10| panel==22) ] <- NA

df <- data.frame( df, yr1, yr2, yr3, yr4, yr5, yr6, se1, se2, se3, se4, se5, se6, len1, len2, len3, len4, len5, len6 )
df}

#	Call the function
grts.samp <- F.generate.data( grts.samp, initial.prop.of.zeros=0.4, initial.mean=5, slope=1 )
```

Because the GRTS sample was selected with equal probabilities, estimation of current status is reasonably straight forward. Assume that $\tau_{p(i),t}$ is an unbiased estimated of the total number of fish present (abundance) on segment *i* of panel *p* when it was sampled during occasion *t*, and that $s_{p(i),t}$ is an estimate of the standard error of $\tau_{p(i),t}$. An estimate of total fish abundance in the entire study area during year *t* is,

$$T_t = N \sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \tau_{p(i),t} \bigg/ \sum_{p=1}^{P} I_{p,t} n_p$$

where *P* is the total number of panels (46 in the example), n_p is the number of segments in panel *p* (80 for panel 1; 41 for all others), $N = \sum_{p=1}^{P} n_p$ is total number of segments in the sample frame (2033 in the example), and $I_{p,t}$ is an *indicator* function that takes on the value of 1 if panel *p* was sampled during occasion *t* and 0 otherwise. Despite the complicated looking formula, this equation is simply the arithmetic average of fish abundance measured on all segments visited during occasion *t* [i.e., $\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \tau_{p(i),t} \bigg/ \sum_{p=1}^{P} I_{p,t} n_p$ = (sum of abundance on all segments sampled year *t*) / (number of segments)] multiplied by frame size *N*.

Note that T_t does not account for varying segment lengths. This fact produces several desirable features in the proposed Plan. All these desirable features stem from the fact that T_t remains unbiased for true total abundance regardless of true or measured variation in segment length. For example, segment lengths estimated from GIS data are notoriously inaccurate and errors in the GIS lengths compound if fish abundance is estimated as fish density times total stream length from the GIS. Another desirable feature is that field implementation of the Plan is unperturbed by stream channel mapping errors. For example, if a previously unmapped small stream, channel, or slough is discovered while field crews are collecting measurements on a particular segment, the additional habitat can be measured immediately and its data can included in $\tau_{p(i),t}$ for that segment. This causes T_t to be "self-correcting" in the sense that it accurately estimates total abundance regardless of map inaccuracies in the GIS. Another desirable characteristic of this approach is that real length of a segment does not absolutely need to be measured in the field, thus potentially simplifying some field protocols. That said, most protocols will probably want to measure stream length for other purposes.

The quantity $n_{t\bullet} = \sum_{p=1}^{P} I_{p,t} n_p$ is the number of segments actually sampled in year *t*. The estimated standard error of T_t is,

$$se(T_t) = N \sqrt{\left(1 - \frac{n_{t\bullet}}{N}\right) \frac{sd^2\left(\tau_{p(i),t}\right)}{n_{t\bullet}} + \frac{1}{N n_{t\bullet}} \left(\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} s^2_{p(i),t} \right)},$$

where

$$sd\left(\tau_{p(i),t}\right) = \sqrt{\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \left(\tau_{p(i),t} - \overline{\tau}_t\right)^2 \bigg/ \left(n_{t\bullet} - 1\right)}$$

$$= \sqrt{\left(n_{t\bullet} - 1\right)^{-1} \left[\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \tau^2_{p(i),t} - n_{t\bullet}^{-1} \left(\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \tau_{p(i),t} \right)^2 \right]}$$

(Thompson 1992 p. 129). This formula is the variance estimator of a total under two-stage sampling, assuming equi-probable sampling at stage one (whole segments), and unbiased sampling at stage two (sampling within segments). The finite population correction factor, $1 - n_{t\bullet}/N$, for stage-one segments has been included, but a similar correction for sample size at the second stage is not due to the varied nature of field measurements called for under the Plan. Certain protocols may wish to include a finite population correction factor in the last term of $se(T_t)$ if, for example, a large fraction of all pools in the segment were measured to obtain $\tau_{p(i),t}$ for the segment. The segment (first stage) correction factor will usually be negligible in the real monitoring study, and it can generally be dropped.

The above standard error estimators, and all other standard error estimators in this section, ignore the fact that the original sample of segments was selected using the GRTS algorithm. Ignoring the fact that the original sample was a GRTS, effectively treats the sample as if it were a simple random sample and results in an over estimate of variance. That is, standard errors calculated using these formulas are larger than the true standard errors of the associated estimator. This is unfortunate because a spatially balanced sample should result in estimates with lower standard error than simple random samples, but the lower standard error may not be realized because estimators assume simple random sampling. In other words, improved accuracy is realized under GRTS sampling, but improved precision may not. We present the simple random sampling estimators because they are easy to calculate, and because the improvement in precision estimates afforded by more complicated estimators is slight for parameters with high residual variation. Nonetheless, analyses of data collected under this plan should consider the local neighborhood variance estimator for $se(T_t)$ proposed by Stevens and Olsen (2003). The local neighborhood variance estimator averages variances estimated on local neighborhoods surroundings each segment (on nearby segments). The local neighborhood variance estimator is technically complicated, and its utility for estimating the variance of a regression estimator (see below) is unknown at present.

Provided $n_{t\bullet}$ is large enough (generally > 30) a 95% confidence interval for the true average fish density is,

$$T_t \pm 1.96 se\left(T_t\right)$$

regardless of the distribution of fish density on an individual segment. If sample size at occasion t is small, a confidence interval for mean fish density should be constructed using a nonparametric bootstrap method (Manly, 1997, Ch. 3).

Contrary to intuition, empirical evidence suggests that the relationship between fish abundance on a segment and segment length is weak (Trent McDonald, pers. communication; unpublished data from North Cascade National Park). However, there may exist combinations of stream systems and fish species where density is relative constant throughout the system, and correlation between fish abundance and segment length is strong. In addition, there may exist exogenous covariates such as average gradient or latitude that could potentially explain a significant fraction of the variation in T_t. Because of these potential advantages, regression estimators for T_t should be considered. Besides total abundance, regression estimation should yield excellent estimates of the true total miles of stream in a system, which will in turn be used to estimate average fish density.

Assume that an auxiliary variable, say $x_{p(i),t}$, is known for all segments in the population, both sampled and unsampled. In most cases, $x_{p(i),t}$ will be derived from the GIS system. Examples of potentially useful $x_{p(i),t}$ include segment length as measured in the GIS, gradient of the segment as derived from DEM's, latitude (or longitude) of the segment's midpoint, average flow as predicted by a flow model, etc. Provided the true correlation between $x_{p(i),t}$ and $\tau_{p(i),t}$ is strong, we can use variation in $x_{p(i),t}$ to explain variation in $\tau_{p(i),t}$ and thereby improve the precision of T_t. We assume only one auxiliary variable is involved in estimation, even though it is possible to use more than one in a multiple regression estimator. Extension of the simple linear regression estimator to a multiple regression estimation is straightforward and is given in Thompson (1992, p. 86). Non-linear or scatter-plot smoother regression estimators are also possible.

The simple linear regression estimate of total abundance at a particular occasion is,

$$T_{R,t} = T_t + \hat{\beta}_1 \left(T_{x,t} - N\bar{x}_t \right)$$

where

$$T_{x,t} = \sum_{p=1}^{P} \sum_{i=1}^{n_p} x_{p(i),t},$$

$$\bar{x}_t = \sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} x_{p(i),t} \Big/ \sum_{p=1}^{P} I_{p,t} n_p$$

are the known total of x in the population and the mean of x in the sample at time t, respectively. $\hat{\beta}_1$ is the slope of a least-squares-estimated line through the scatter plot of $\tau_{p(i),t}$ on $x_{p(i),t}$ (Thompson, 1992, p. 80). The estimated slope, $\hat{\beta}_1$, should be as accurate as possible and can be based on multiple years of data. An estimate of the standard error of $T_{R,t}$ is,

$$se\left(T_{R,t}\right) = N\sqrt{\left(1 - \frac{n_{t\bullet}}{N}\right) \frac{\sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \left(\tau_{p(i),t} - \left[\hat{\beta}_0 + \hat{\beta}_1 x_{p(i),t} \right] \right)^2}{n_{t\bullet}\left(n_{t\bullet} - 2\right)} + \left(\frac{1}{Nn_{t\bullet}}\right) \sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} s^2_{p(i),t}}, \qquad (1)$$

where $\hat{\beta}_0$ is the estimated intercept of the least squares regression fit (Thompson, 1992, p. 80 and 131). Note the first term under the square root is a function of the mean squared residual from the regression of $\tau_{(i),t}$ on $x_{p(i),t}$, thus affording a reduction in variance if $x_{p(i),t}$ indeed explains a large proportion of the variation in $\tau_{p(i),t}$.

To estimate total stream length in the population, we rely on correlation between segment length in the GIS and actual segment length measured in the field. If maps in the GIS are useful for locating stream segments, the correlation between map and actual length should be high. Assuming $l_{p(i),t}$ is the actual measured length of segment i in panel p at time t, and that $\lambda_{p(i),t}$ is length of the same segment reported by the GIS, we can apply the regression estimator above to estimate total length as,

$$L_{R,t} = N\,\bar{l}_t + \hat{\beta}_1 \left(T_{\lambda,t} - N\bar{\lambda}_t \right)$$

where,

$$\bar{l}_t = \sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} l_{p(i),t} \Big/ \sum_{p=1}^{P} I_{p,t} n_p,$$

$$T_{\lambda,t} = \sum_{p=1}^{P} \sum_{i=1}^{n_p} \lambda_{p(i),t},$$

$$\bar{\lambda}_t = \sum_{p=1}^{P} \sum_{i=1}^{n_p} I_{p,t} \lambda_{p(i),t} \Big/ \sum_{p=1}^{P} I_{p,t} n_p.$$

The standard error of $L_{R,t}$ can be estimated using Equation (1), substituting l for τ and λ for x.

Average fish density in the population of stream segments can now be estimated by dividing estimated total stream length into estimated fish abundance. This is an instance of a ratio-of-totals estimator, and should yield highly accurate estimates. Prior to estimation, the best estimate of abundance, either T_t or $T_{R,t}$, should be determined. If estimates of fish per kilometer (or mile) are desired, the regression estimator $L_{R,t}$ should be used. If estimates of fish per hectare (or square meter or acre) are desired, measured values of segment area should be substituted for l in the regression estimator equations to obtain a regression estimator for total hectares in the system. Unless area of a segment can be estimated from GIS data, segment length should remain as the explanatory variable for estimating total area.

The ratio of totals estimate of average fish density at time t is either,

$$\bar{d}_t = \frac{T_t}{L_{R,t}} \text{ or } \bar{d}_t = \frac{T_{R,t}}{L_{R,t}}.$$

Assuming T_t is used, the estimated standard error of $\bar{d}_t$ is,

$$se(\bar{d}_t) = \sqrt{\frac{se^2(T_t) + \bar{d}_t^2 se^2(L_{R,t}) - 2\bar{d}_t \operatorname{cov}(T_t, L_{R,t})}{L_{R,t}^2}}$$

where $\operatorname{cov}(T_t, L_{R,t})$ is the estimated covariance between fish abundance and total length (Särndal et al, 1992, p. 179, eqn. 5.6.10). If $T_{R,t}$ is used to estimate density, $T_{R,t}$ should be substituted for T_t in this equation. Estimation of the covariance can be difficult in some surveys, and it is standard practice to drop this term during estimation. If the covariance term is dropped and if it can be assumed > 0, the resulting standard error is conservative in the sense that it is too large. However, after multiple years of sampling, covariance between fish abundance and total stream length can be estimated directly from data collected by the Plan. Furthermore, we might expect strong positive covariance between total number of fish and total stream miles in a system and the estimated standard error of $\bar{d}_t$ could be substantially reduced in this case. After m years of sampling under the Plan, the covariance between fish abundance and total steam length can be estimated as,

$$\operatorname{cov}(T_t, L_{R,t}) \approx \operatorname{cov}(T, L_R) = \frac{1}{m-1}\sum_{t=1}^{m}(T_t - \bar{T})(L_{R,t} - \bar{L}_R)$$

where

$$\bar{T} = \frac{1}{m}\sum_{t=1}^{m} T_t,$$

$$\bar{L}_R = \frac{1}{m}\sum_{t=1}^{m} L_{R,t}.$$

Again, $T_{R,t}$ should be substituted in place of T_t if $T_{R,t}$ is used to compute density.

Other estimates of average fish abundance and density at a particular point in time are available. The so-called MVLUE estimator reviewed by Binder and Hidiroglou (1988) is an alternate estimator of status that makes use of temporal correlation in fish abundance on individual segments (i.e., between $\tau_{p(i),t}$ and $\tau_{p(i),t-1}$) to improve estimates. The strength of correlation in fish abundances through time determines the magnitude of precision improvement, with higher correlation yielding higher improvement in precision. The MVLUE estimator is complicated and the improvement in precision afforded by it is unknown at present. The MVLUE estimator will therefore not covered in this appendix, but it should not be disregarded.

Estimates of total stream length, fish abundance, and fish density by both the straightforward and regression method for the first 6 years of monitoring appear in **Table H-4**. The regression estimates used GIS-measured segment length as the *x* variable, and the regression was calculated separately each year. Because little relationship was generated between fish density and length reported by the GIS, little difference existed between the straightforward total estimates and the regression estimates. Both sets of estimators indicate approximately 439,000 fish in the population during year 1, increasing to approximately 1,448,000 fish by year 6. An estimate of annual change will be calculated in the next section.

Table H-4. Estimates of total stream length ($L_{R,t}$), fish abundance (T_t and $T_{R,t}$), and density (fish per km; $\bar{d}_t$ and $\bar{d}_{R,t}$) from the example data.

	Length (km)		Total Estimator				Regression Estimator			
Year	$L_{R,t}$	se($L_{R,t}$)	T_t	se(T_t)	$\bar{d}_t$	$se(\bar{d}_t)$	$T_{R,t}$	se($T_{R,t}$)	$\bar{d}_{R,t}$	$se(\bar{d}_{R,t})$
1	2,654	12	439,649	42,599	165.6	16.1	438,104	42,283	165.0	15.9
2	2,629	13	645,953	47,762	245.7	18.2	644,380	47,863	245.1	18.2
3	2,682	13	780,151	41,764	290.9	15.6	780,666	41,841	291.1	15.7
4	2,677	13	998,473	48,227	373.0	18.1	999,149	48,303	373.3	18.1
5	2,660	13	1,192,760	49,702	448.5	18.8	1,188,364	49,802	446.8	18.8
6	2,666	14	1,448,137	49,214	543.2	18.7	1,447,589	49,321	543.0	18.7

Trend Detection

Trend in a parameter can be detected by a number of nonparametric and parametric analyses. Nonparametric trend analyses include the Mann-Kendall test and the CUSUM procedure (Manly 1994; Manly and MacKenzie 2000). Parametric trend analyses usually involve some type of linear model and assumptions regarding the distribution of data and variances. While all trend analyses are useful in some situations, the most utilitarian and powerful trend analysis when assumptions are met involves mixed linear models. In this section, a mixed linear model analysis presented by Piepho and Ogutu (2002), which was a slight modification of the model presented by Van Leeuwen (1996), will be applied to example data. While both fish abundance and fish density can be analyzed for trend, we demonstrate the calculations using abundance because we assume it was directly measured in the field.

The mixed linear model analysis for detecting trend views the estimates of fish abundance on each stream segment as being generated by both fixed and random effects with potentially correlated observations. The mixed linear model used by Piepho and Ogutu (2002) was,

$$y_{p(i),t} = \mu + x_t\beta + b_t + a_{p(i)} + x_t s_{p(i)} + c_{p(i),t}$$

where μ is a fixed overall intercept coefficient, x_t is a fixed year covariate (i.e., 1,2,…), β is a fixed overall slope coefficient, b_t is a random effect of the *t*-th year, $a_{p(i)}$ is a random effect of segment *p(i)* on the intercept, $s_{p(i)}$ is a random effect of segment *p(i)* on slope, and $c_{p(i),t}$ is a random effect of segment *p(i)* in the *t*-th year. This model postulates that abundance on a particular stream segment at a particular time is a function of some true underlying trend line, parameterized by μ and β, and random perturbations associated with the *t*-th year and the *p(i)*-th site. If all $s_{p(i)}$ were 0 (and hence not a random variable), fish density on all segments would be assumed to have the same trend through time but different mean levels. If all $a_{p(i)}$ and $s_{p(i)}$ were 0, fish density would be modeled as random perturbations (parameterized by b_t and $c_{p(i),t}$) around a common line. In this analysis, we are interested in inferences on β, and specifically whether or not $\beta = 0$.

Estimation of the fixed and random effects in the above model is best carried out using restricted maximum likelihood (REML) estimation. Provided the panel rotation scheme yields a "statistically connected" design, the occasions when a stream segment is not measured are treated as missing values in the analysis. In this sense, the linear model analysis is possible with any pattern of revisits, planned or unplanned, provided they yield "statistically connected" data. While the concept of "statistical connectedness" is beyond the scope of this appendix, it is sufficient to note that any rotation schedule in which at least 1 panel is always revisited (i.e., it contains a [1-0] panel) is "statistically connected" and estimation by REML is possible.

Analysis of the example data for trend using the above linear model was carried out using the SAS computer package by submitting the following code:

```
proc mixed data=mendo_coast method=REML nobound;
class year segment;
model nfish = xyear /ddfm=satterth s;
random int/sub=year;
random int xyear/sub=segment type=UN;
```

where xyear was a variable containing the integers 1, 2, …, 6. This code assumed that the random effects *ap(i)* and *sp(i)* in the mixed model were correlated with one another in an unstructured way. Alternatively, it is possible to assume that the correlation in effects declines as the time between measurements increases. Other covariance models, including so-called spatially-explicit models, are possible.

Estimation of the mixed model on example data resulted in an estimated intercept of $\hat{\mu}$ = 106.46 with standard error $se\left(\hat{\mu}\right)$ = 11.01. The estimated common trend was $\hat{\beta}$ = 99.31 with standard error $se\left(\hat{\beta}\right)$ = 1.3016, which is very close to the true value of 100. In fact, the approximate 95% confidence interval for β of 96.8 to 101.9 includes the true value. One of the tests suggested by Piepho and Ogutu (2002) for H_0: $\beta = 0$ is the "Type III" test output by SAS. For example data, the "Type III" test of $\beta = 0$ yielded a p-value of 0.0930, which is significant only at the $\alpha = 0.10$ level. The mixed linear model correctly estimates substantial positive covariance between fish abundance estimated on the same segment at different times. This covariance reduces effective sample size and correctly increases the p-value of the slope test over what it would have been had each measurement been independent. Close inspection of the status estimates and standard error estimates in **Table H-4** would give the impression that trend is occurring, and because 95% confidence intervals on the estimates do not overlap, that the trend is significant at least at the $\alpha = 0.05$ level. However, informal inspection of the status estimates in this way does not account for the correlation of measurements through time taken on the same segment, and should not be done (unless measurements are truly independent).

Presence-Absence Estimation

The Plan calls for snorkel and electrofishing surveys to determine presence or absence of juvenile coho and juvenile steelhead in stream segments in the Northern and Southern monitoring areas, respectively. The objective of these surveys is two-fold. First, they will either document presence or infer absence of juvenile fish for a particular segment. Second, data from these surveys can be used to estimate region-wide occupancy, colonization, extinction, and expansion rates. Estimates of these region-wide parameters will be critical to future recovery assessments.

During presence-absence surveys, segments selected and assigned to panels will be visited once during late spring or summer of the same year that their panel is scheduled for visitation. If juvenile coho or steelhead are detected in at least one pool, riffle, or run of the segment, presence is inferred with 100% probability and the segment will not be revisited later that same season. If, however, coho or steelhead are not detected in any habitat units of the segment, at least one and preferably 2 additional visits to the segment will be conducted. Data from the segments with 2 (or more) visits can be used to estimate probability of detection (or equivalently, probability that coho are present, but field sampling missed them) and both the site-specific occupancy models of MacKenzie et al (2002) and the regional occupancy models of MacKenzie et al (2003) can be applied. In this section, we focus on the region-wide estimation of occupancy and closely follow MacKenzie et al. (2003). When occupancy status remains constant over the course of a summer field season, the methods of MacKenzie et al. (2002) or forthcoming work by Webster and Pollock (2004) can be applied to estimate occupancy for individual segments.

For regional estimation of occupancy, assume that T years of data collection has occurred, and that the occupancy status of segments could have changed between years, but that occupancy can be expected to remain constant within years. Within each year, assume that k_t is the maximum number of visits to any segment to assess presence of the target species (e.g., coho). We denote the history of detections at segment i (in this section, we will drop the panel designation $p(i)$) during year t as a vector $\mathbf{X}_{i,t}$ of length k_t containing 0's and 1's. The j –th element of $\mathbf{X}_{i,t}$ is a 1 if the target species was detected at site i during survey j of year t, and is 0 otherwise (i.e., 0 = "undetected"). For example, if three surveys were conducted on segment i and coho were detected during the second and third survey, $\mathbf{X}_{i,t}$ for that segment would be [011]. If site i was visited less than k_t times during year t, the latter elements of $\mathbf{X}_{i,t}$ are missing. Estimation is still possible in this case.

Let ψ_t be the probability that a segment is occupied by the target species during year t, and $p_{t,j}$ be the probability of detecting the target species, given it is present, in survey j during year t. Also, let γ_t be the probability that a segment unoccupied during year t is occupied by the target species during year t+1, and ε_t be the probability that a site occupied by the species during year t is unoccupied during year t+1. Put another way, ψ_t is the proportion of segments occupied in the region during year t, γ_t is the probability that the target species colonizes a segment between years t and t+1, and ε_t is the probability of (local) extinction from a segment between years t and t+1. An important assumption of this method is that all parameters (i.e., ψ_t, γ_t, and ε_t) are constant across segments during year t. Failure of this assumption introduces heterogeneity, which leads to bias in parameter estimates (MacKenzie et al., 2003). Use of environmental covariates (such as cover, flow, elevation, etc.) measured on the segment can eliminate or remove a majority of this heterogeneity, but heterogeneity caused by unknown or unmeasured sources often remains. Relating environmental covariate values to parameters is straight forward and is accomplished the same way that covariates are included in regular open population capture-recapture modeling. Covariates are included by reparameterizing the likelihood (defined below) to be a function of coefficients in a linear logistic model.

Parameter estimates are obtained by the method of maximum likelihood. To define the likelihood, consider the multi-year detection history $\mathbf{X}_i = [\mathbf{X}_{i,1}, \mathbf{X}_{i,2}] = [001, 000]$, which indicates that the target species was detected on the third survey of year 1 and never detected during year 2. The probability of observing the first 3 surveys during year 1 is,

$$\Pr(X_{i,1} = 001) = \psi_1(1 - p_{1,1})(1 - p_{1,2})p_{1,3}$$

In words, this is the probability that the segment was occupied times the probability that the species went undetected for two surveys, times the probability of detecting the species on the third survey. During the second year, there are two reasons why the species could have gone undetected. First, the target species could have been present but field sampling failed to detect it, or second, the target species could have been genuinely absent from the segment. The probability of not observing the target species during year 2 is,

$$\Pr(X_{i,2} = 000 \mid X_{i,1}) = (1 - \varepsilon_1)(1 - p_{2,1})(1 - p_{2,2})(1 - p_{2,3}) + \varepsilon_1$$

(MacKenzie et al. 2003). This probability is the probability that the target species does not go extinct at segment *i* between years 1 and 2 times the probability of missing it on three surveys, plus the probability that the species went extinct on the segment. $\Pr(\mathbf{X}_{i,2})$ can be reparameterized by noting that the probability of occupancy during year *t* is the probability of occupancy during year *t-1* times the probability that the species does not go extinct, plus the proportion of unoccupied sites times the probability of colonization. In equation form,

$$\psi_t = \psi_{t-1}(1 - \varepsilon_{t-1}) + (1 - \psi_{t-1})\gamma_{t-1} .$$

Solving for ε_{t-1} yeilds

$$\varepsilon_t = 1 - \frac{\psi_{t+1} - (1 - \psi_t)\gamma_t}{\psi_t} = 1 - \lambda_t + \frac{1 - \psi_t}{\psi_t}\gamma_t$$

where $\lambda_t = \psi_{t+1} / \psi_t$ is the rate of change in region-wide occupancy status between years *t* and *t*+1. λ_t is analogous to population rate of change and measures the rate at which the target species is colonizing new segments or is going extinct from previously occupied segments. If $\lambda_t > 1$, the target species was expanding its range between years *t* and *t*+1. Conversely, if $\lambda_t < 1$, the target species' range contracted between years *t* and *t*+1 Substituting for ε_t in the previous equation yields a parameterization involving ψ_t, γ_t, $p_{t,j}$ and λ_t, i.e.,

$$\Pr(X_{i,2} = 000 \mid X_{i,1}) = (\lambda_1 - \frac{1 - \psi_1}{\psi_1}\gamma_1)(1 - p_{2,1})(1 - p_{2,2})(1 - p_{2,3}) + (1 - \lambda_1 + \frac{1 - \psi_1}{\psi_1}\gamma_1) .$$

The probability of observing the full detection history $\mathbf{X}_i$ is $\Pr(\mathbf{X}_{i,1} = 001)\Pr(\mathbf{X}_{i,2} = 000|\mathbf{X}_{i,1})$, and the full likelihood over all segments is

$$L(\boldsymbol{\psi}, \boldsymbol{\lambda}, \boldsymbol{\gamma}, \boldsymbol{p} \mid X_1, \ldots, X_{n_{\bullet t}}) = \prod_{i=1}^{n_{\bullet t}} \Pr(X_i) .$$

Under the assumptions of data collection, the likelihood and histories of detection from all segments can be used to, among other things, obtain direct estimates of the proportion of segments occupied each year (i.e., ψ_t) and the rate at which the species is expanding or contracting (i.e., λ_t). Because parameter estimates are obtained by maximum likelihood, they enjoy all the desirable characteristics of maximum likelihood estimates. In particular, they are asymptotically consistent, certain aspects of their asymptotic distributions are known, and profile likelihood confidence intervals can be estimated.

If surveys cease after the first detection in a given year, the missing surveys do not cause a problem for estimation. When surveys are missing, $\Pr(\mathbf{X}_i)$ for that segment is modified to account for the fact that no information on variability in probability of detection is collected. When an entire year's surveys are missing, such as when the segment's panel is not visited, a set of missing values is introduced. These missing values do not cause a problem for estimation, although additional modifications to Pr($\mathbf{X_i}$) are needed to account for the fact that no occupancy information is collected at that site that year. In this way, all segments in the rotating panel design can be used simultaneously to estimate occupancy and expansion rates.

It should be noted that at least some repeat surveys to the same segment, both within and between years, are necessary for this method to work, and that if surveys cease following the first detection, detection probabilities must be assumed constant within years (MacKenzie et al., 2003). To actually carry out estimation of the occupancy models, either a generalized maximization program must be used, or program PRESENCE (www.proteus.co.nz) written by Darryl MacKenzie can be used.

REFERENCES

Binder, D.A., and M.A. Hidiroglou (1988) "Sampling in time", In P. A. Kishnaiah and C. R. Rao, eds, *Handbook of Statistics,* 6: 187-211.

Lohr, S.L. (1999) *Sampling: Design and Analysis*, Duxbury Press.

MacKenzie, D. I., J. D. Nichols, G. B. Lachman, S. Droege, J.A. Royle, and C. A. Langtimm (2002) "Estimating site occupancy rates when detection probabilities are less than one", *Ecology*, 83:2248-2255.

MacKenzie, D. I., J. D. Nichols, J. E. Hines, M. G. Knutson, and A. B. Franklin (2003) "Estimating site occupancy, colonization, and local extinction when a species is detected imperfectly", *Ecology,* 84:2200-2207.

Manly, B. F. J. (1994) "CUSUM methods for detecting changes in monitored environmental variables", In D. J. Fletcher and B. F. J. Manly (eds.), *Statistics in Ecology and Environmental Monitoring*. P.O. Box 56, Dunedin, NZ, p. 225-238, University of Otago.

Manly, B.F.J. (1997) *Randomization, Bootstrap and Monte Carlo Methods in Biology, 2nd edition,* London: Chapman and Hall.

Manly, B. F. J. and D. MacKenzie (2000) "A cumulative sum type of method for environmental monitoring". *Environmetrics* 11:151-166.

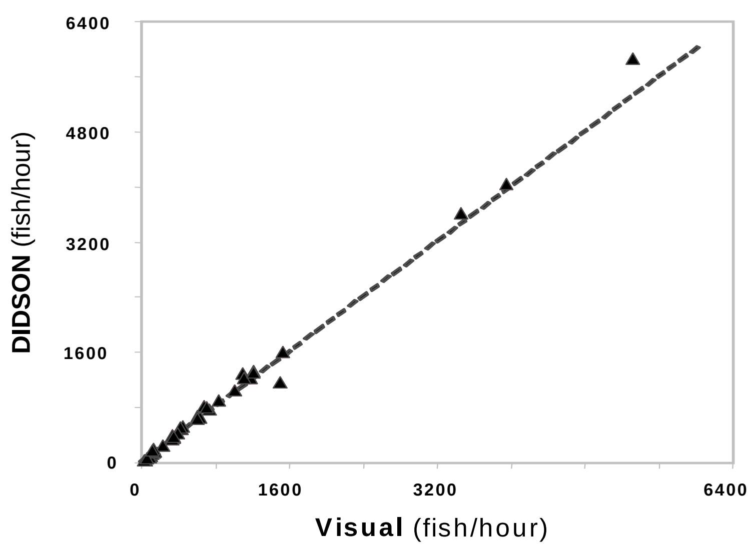
Piepho, H. P. and J. O. Ogutu (2002) "A simple mixed model for trend analysis in wildlife populations", *Journal of Agricultural, Biological, and Environmental Statistics,* 7: 350-360.

Särndal, C. E., S. Swensson, and J. Wretman (1992) *Model Assisted Survey Sampling*, Springer-Verlag.

Van Leeuwen, D. M., L. W. Murray, and N. S. Urquhart (1996) "A mixed model with both fixed and random trend components across time", *Journal of Agricultural, Biological, and Environmental Statistics,* 1: 435-453.

APPENDIX I: Discussion of *Didson* Technology

Figure I-1. Comparison of salmon counts from the *Didson* camera vs. visual tower counts (made by an observer sitting in a streamside tower, currently considered the benchmark data type by Alaska Dept of Fish and Game). Notice that the *Didson* performs well even when more than 5,000 fish per hour pass the monitoring site (older sonar technologies tend to fail to discriminate individual fish at high passage rates).



Due to the newness of the technology, it does not enjoy a set of standard practices for application to fisheries monitoring. Some practical issues that must be solved are the following: First, although the unit need not straddle the stream, it does need to be placed in the stream at one side, and its sonar beam directed across the stream. The effective range of the beam is 20m (a long-range version is soon to be available), so streams wider than this would require multiple units. Immersion in the stream requires that some sort of measures would have to be taken to protect the unit from high-flow events. Second, field deployment would require a power source, a possible data uplink and provisions for security from vandalism or theft (also applicable to weirs, which additionally require daily inspection and cleaning, etc.). Finally, the unit produces a prodigious data stream, most of which would consist of images of fish-less water flowing by. At present, there is no way of processing this data stream other than having a technician play back the video stream and count the fish by inspection (generally takes 5 – 10 minutes to play back and count an hour of data). There are currently two efforts underway to develop software that will automate this software somewhat. Overall, none of the above problems appear to be intractable, but they do appear to require a pilot study.

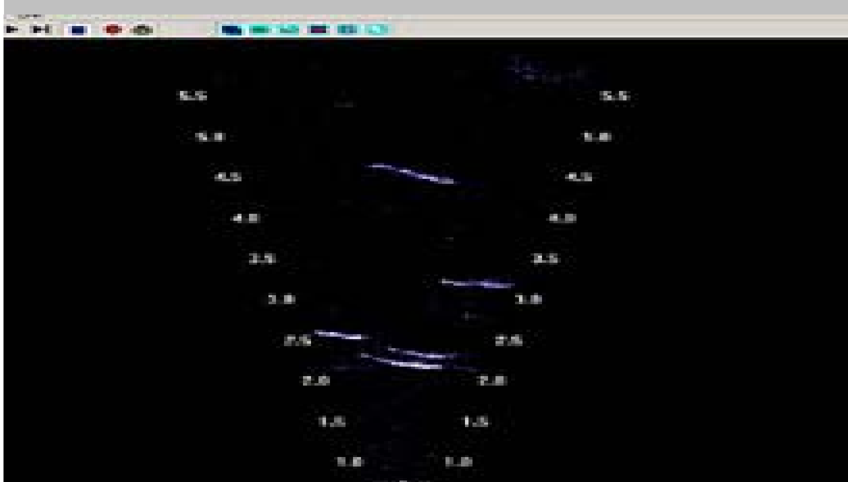
The Alaska Department of Fish and Game has conducted a series of pilot studies using the *Didson* camera to monitor salmon runs. Here are a few of their conclusions (D. Burwen, ADFG, pers. comm.): The camera appears to produce accurate estimates of fish passage, including at high passage rates **(Figure I-1).** It can be used to assess the direction of fish movement, and can detect fish well even on rocky and uneven substrates, making site-selection much more flexible (this is a problem with older sonar due to back-scatter). Estimates of fish size can be obtained from the camera images for fish at closer ranges. Finally, it was noted that the unit was easy to use, particularly when contrasted with the more recent split-beam sonar systems. In particular, operators were adequately trained with a few hours of instruction; the system did not exhibit fatal crashes and the controls are familiar, mimicking those of a video camera.

The Alaska studies also included some experience with high-flow events. The investigators note that older sonar technologies were not useful in this sort of situation because rearrangement of the stream's substrate during a flood rendered the acoustic data un-intelligible. They found this not to be the case with the *Didson* camera because its operating system includes an algorithm capable of filtering out back-scatter from the image. Hence, they could deploy the unit in situations unsuitable for the earlier sonar technologies - streams with rocky substrates that are subject to rapid changes in flow over the course of hours or days.

The *Didson* camera appears to be the one technology (other than expensive permanent fishways at dams) suitable for monitoring adult steelhead runs under the conditions present in southern California. It appears to be accurate enough to estimate very small run sizes; it can be operated continuously, even during high-flow events and its acoustic beam is not troubled by turbid water or an uneven rocky streambed. An initial accounting suggests that this report's recommendations for adult monitoring could be achieved by five *Didson* stations deployed throughout the area between Santa Cruz and Los Angeles **(Table I-1).**

A. DIDSON acoustic camera

B. Acoustic image of sockeye salmon swimming through sonar



<u>Table I-1</u>: Potential monitoring stations for the *Didson* acoustic camera

Monitoring Station	Population	Location
1	Pajaro River system	
2	Salinas River system	Lower Arroyo Seco
3	Salinas River system	Mainstem near Paso Robles
4	Santa Lucia Range	San Simeon Creek and/or San Luis Obispo Creek
5	Santa Maria River system	Sisquoc River near town of Sisquoc
6	Santa Ynez River system	Mainstem below Lompoc
7	Santa Ynez Mountains system	Mission Creek mainstem below Rocky Nook Park and/or Carpentaria Creek
8	Santa Monica Mountains system	Malibu Creek mainstem below Rindge Dam and/or Topanga Creek
9	Peninsular Range	Trabuco Creek mainstem below U.S. 1 and/or San Mateo Creek

APPENDIX J: Details of Task Cost Estimates

The proposed budget for tasks 1 and 4 is based on Oregon survey data. This is because no reliable information currently exists on amount of anadromous salmonid habitat in California coastal streams. The California Fish and Wildlife Plan (1965) provides estimates of salmon and steelhead habitat available in the early 1960, but in comparing those estimates with more recent survey data in the Klamath River Basin, the earlier estimates appeared to be too low for budget development purposes. Considerable work needs to be done to determine the exact miles of stream in the coastal area that currently or potentially support adult salmonid spawning and juvenile salmonid rearing. The proposed Monitoring Program will be able to answer those questions after a few years of field survey. Oregon has been conducting coho and steelhead spawning and juvenile area surveys for over 40 years. That work has shown that Oregon coastal streams have about 4,500 miles of coho spawning habitat (Jacobs 2003). We are not aware of a similar estimate for juvenile coho salmon habitat, but in the Oregon Mid-Coast Management Area, the juvenile habitat has been reported to be 126% of the adult habitat (Stevens 2002). Using that figure in combination with the adult mileage estimate of 4,500 miles indicates Oregon may have about 5,684 miles of juvenile coho salmon habitat.

It is important to note that the Oregon mileages exclude many stream miles that are above impassible barriers, are not accessible to survey crews or not suitable for salmonid spawning or rearing. The actual total stream miles in Oregon coastal streams is probably much larger than the miles used for recent monitoring purposes.

We have used Oregon data to speculate on the amount of coho salmon habitat, measured in terms of stream miles, that may exist in the two California monitoring areas. This is done separately for adult and juvenile fish. We do not attempt to differentiate stream mileages used by individual species. This approach may underestimate habitats used by steelhead but likely overestimate habitats used by Chinook salmon and cutthroat trout. **Please note: this analysis is for planning purposes only and is not intended for any other use. We use this approach to build a budget and for no other reason.** We compare physical data for Oregon and California to arrive at estimates for the two California monitoring areas. The first analysis is based on linear miles of coastline and the second on drainage area, adjusted for areas not accessible to anadromous salmonids. However, only the drainage area approach was used for the Southern Monitoring Area because of the extensive changes that have occurred in that region and the need to adjust for areas that are no longer accessible to steelhead.

Analysis One

The Oregon coastal area spans four degrees longitude or 240 nautical miles (276 statute miles) while the Northern Monitoring Area spans about five degrees longitude which is 300 nautical miles (345 statute miles). Assuming a similar density in stream habitats between the two areas per linear mile of longitude, this would indicate the Northern Monitoring area may have about 5625 miles of adult salmonid spawning area and about 7088 miles of juvenile habitat.

Analysis Two

The Oregon coastal drainage area accessible to coho salmon is about 13,689 $mi^{2.}$ By comparison, the California northern and southern areas estimated accessible to anadromous salmonids are 17,989 and 3,101 mi^2, respectively (Table I-1). Assuming a similar density in stream mileages between the Oregon coastal area and each of the two California areas per square mile of drainage area, after adjustment for areas not accessible to anadromous fish, the estimates are: Northern Management Area, 5,913 miles of adult spawning habitat and 7,469 miles of juvenile rearing habitat; Southern Management area, 1,019 miles of adult spawning habitat and 1,288 miles of juvenile rearing habitat.

For budget planning purposed we use an average (rounded) of the two approaches, when applicable, as follows: Northern Management Area, adults, 5,800 miles; juveniles, 7,300 miles; Southern Management Area, adults, 1,000 miles, juveniles 1,300 miles.

Staff workload estimates for adult survey were based on Oregon survey experience (Kelly Moore, ODFW, pers. comm.) as follows: each 2-person crew can cover 3-4 miles per day and revisit every site every 11-12 days. Here we assume each crew can cover 3 miles per day and survey 75% of the sites every week. Oregon has 1 crew leader (a biologist) for every 10 crews.

Tasks 1, 2 and 4 are integrated; that is they share permanent personnel, equipment, and facilities (see **Figure 6** in text).

Task 1: Northern Spawner Survey

A high priority program need is to implement annual spawning ground surveys to estimate adult spawning population sizes for the area north of and including Aptos Creek. These data are needed to begin to develop a database useful for analyzing population status and trends for individual species, not including cutthroat trout. The first two-four years of survey will provide much needed data on stream access and habitat utilization for use in refining the statistical sampling frame. We do not recommend the inclusion of funds to cover any additional fish counting at fishways in the area. The DFG and NOAA should discuss counting the steelhead run at the San Lorenzo River Inflatable Dam using existing funding sources.

The entire area should be sampled as a unit but with samples spread out (balanced) between stream systems so that sub-area samples (ESUs, population types) can be reasonably estimated. The surveys will estimate adult populations in each survey reach by counting redds or live fish or conducing salmon mark-and-recapture carcass survey. It is proposed that sample reach selections be initially drawn for use over a 30-year time frame. The proposed annual sample level is 10% of potential adult spawning reaches each for fall Chinook salmon, coho salmon and steelhead. This is the same sampling level that Oregon uses for coho salmon (Jacobs 2003).

Calibration (second stage) sampling using weirs, electrofishing or other intercept techniques is included in the budget. It is needed to evaluate the accuracy of the spawner survey estimates and includes funding to support four calibration sites per year.

The estimated annual cost is $2.5 million with a one-time added start up cost of $ 566,000 **(Worksheet 1**). This will cover personnel, operating, equipment and overhead. It includes about $300,000 per year for calibration sampling.

Task 2: Southern Steelhead Monitoring

We propose to use existing fishways to count the runs. One facility is operated by the local water district and does not need funding. The other two need personnel to count the runs. Two experiments are proposed under this task. One is to evaluate the use of weirs to count the runs using conventional video or sonar equipment. The other experiment would test the use of the *Didson* acoustic camera. The latter equipment does not require the run be funneled through a narrow opening to count them thus has high potential for use throughout the state. Annual cost of the task, including 1 part time biologist, 4 temporary help positions, operating and contract funds, is $541,000 plus first year added start up cost of $65,000 **(Worksheet 2).** The two contracts are for $200,000 each per year, based on the cost of a recent Central Valley experimental weir contract (see **Workshop 1** presentation).

Task 3: Life Cycle Monitoring Stations

It was agreed during the workshop process that LCSs are needed to measure salmon and steelhead inriver and ocean survival rates **(Workshop conclusion 14).** In the Northern Monitoring Area, stream size and location are related to species present. If the objective is to monitor all four northern species (Chinook, coho, steelhead and cutthroats) then the LCS focus should be on medium or large size streams (>200 mi ^{2}) from the Eel River northward. However, if coho and steelhead are the priority species then streams as small as 8 mi ^{2} southward to Aptos Creek could be considered. In the Southern Monitoring Area, only steelhead are present, thus the species criterion is not an issue. In the following we compare the cost of building a new permanent adult and juvenile trapping facility in the Northern Monitoring Area (Option 1) versus use of existing trapping or portable trapping equipment (Option 2):

Option 1: Build a New Permanent Facility

The cost of building an LCS is directly related--all other factors being equal--to the amount of flow that must be)1) blocked to count and process adult fish and (2) screened to count and process juvenile fish. Our conceptual facility design encompasses:

1. a concrete-base barrier dam with side entrance Fishway and holding pool/crowding facility to collect upstream migrating adults,
2. a juvenile fish screen, situated on or closely upstream from the dam, with a juvenile fish bypass channel and juvenile fish holding facility and
3. a fish processing room/laboratory where LCS personnel can process, mark and sample both adult and juvenile salmonids.

Bechtel Corporation designed a facility having the above features, minus the fish processing room, for two replacement dams proposed for the Carmel River in the early 1990s (Bechtel Corporation 1991). The Carmel River is a small-to-medium size coastal stream (220 mi.^{2} drainage) that supports a viable steelhead run. It has two major water storage dams, San Clemente and Los Padres. Each dam was proposed to be replaced and equipped with new adult collection and juvenile fish screening facilities. The estimated construction cost for each of the adult collection facilities was $2.8 million. The cost estimates for the juvenile facilities at New San Clemente and New Los Padres dams were $8.3 million and $11.9 million, respectively ($9.3 million average). The New San Clemente adult facility, located downstream from the Dam, would span 100 feet of river, operate at flows up to 1,900 cfs, and pass 4,000 adult steelhead per year. The juvenile screens (rotary drums) would be placed at the head of the new reservoirs. The screens were designed to handle up to 600 cfs, which would screen an estimated 99% of the juvenile steelhead outmigration (presumed to be February-May, although not specified). Over 600 cfs, the screens would have to be shut down missing 1% of the outmigration. The screening portion of the project was by far the most expensive element, costing an average of $17,000 for each cubic foot per second (cfs) of screened flow.

George Heise, DFG senior engineer, reports (pers. comm.) that the DFG has built juvenile anadromous salmonid screens that cost as low as $1,000 per cfs, but that $2,000-$10,000 per cfs is the normal range. He noted that the DFG screen shops can construct screens much cheaper than outside contractors because the labor cost is discounted, but they have their limitations. A large screen would have to be contracted out. Regarding the adult trapping facility (dam, fishway and holding pond) work of this nature would have to be contracted out, although DFG engineering staff could help with the conceptual layout, sizing of the structure and performance of the contract drawings and documents. An interagency agreement with Department of Water Resources, Division of Engineering might also be considered as they can oversee construction administration.

We speculate in the following on the cost of building an adult collection and juvenile screening facility on *a small coastal coho and steelhead stream in the Northern Monitoring Area*. We use Soquel Creek located near Santa Cruz as our "model stream" because it is one of the smallest coastal streams in the area (40.2 mi^2) that has a USGS stream flow gauge located near the stream mouth (USGS Hydrologic Unit 18060001) and that supports viable coho and steelhead populations. Water flows for February-May of water years 1995-2000 (6 years; base years) were used in the analysis.

We initially conclude that it would be economically (and probably structurally) infeasible to screen the entire flow of our model stream in all years because of very high peak discharge levels. Flows exceeding 1,000 cubic feet per second (cfs) were observed in three of the six years examined **(Table J-1)** and the peak discharge recorded was 15,800 cfs on December 23, 1955.

Table J-1. Comparison of Oregon and California coastal drainage areas by U.S. Geologic Survey Hydrologic Subregion, adjusted for non-anadromous areas

State	**Accounting Unit**	**Description**	**Adjustments**	**Area (mi^2)**
Oregon	171002	Northern Oregon Coastal	None	4310
	171003	Southern Oregon Coastal	Exclude: Upper Rogue and Illinois and Chetco in CA	9379
Oregon Total	**Above 2 units**	**Oregon Coast**	**See above 2 units**	**13,689**
California	180101	Northern California Coastal	None	9230
	180102	Klamath	Exclude: Williamson, Sprague, Upper Klamath (both), Lost, and Butte and 25% of Trinity	6268
	180500	San Francisco Bay	Exclude: Coyote and SF Bay and 50% of Suisun Bay	2117
	180600	Central California Coastal	Exclude all except San Lorenzo-Soquel	374
Sub-total	**Above 4 units**	**California Northern Monitoring Area**	**See above 4 units**	**17,989**
	180600	Central California Coastal	Exclude: San Lorenzo-Soquel, Carrizo Plain, Estrella, Cuyama, Santa Barbara Channel Islands and 75% of all others.	2085
	180701	Ventura-San Gabriel	Exclude San Pedro Channel Islands and 90% of all others.	438
	180702	Santa Ana	Exclude San Jacinto and 90% of all others	192
	180703	Laguna-San Diego	Exclude 90%	386
Sub-total	**Above 4 units**	**California Southern Monitoring Area**	**See above 4 units**	**3101**
California total	**Above 8 units**	**Both California Monitoring Areas**	**See above 8 units**	**21,090**

Our approach for designing (sizing) a juvenile fish screen for our model stream was to examine the proportion of days during the base period that screens of various sizes (capacities) would screen the entire flow during the usual juvenile fish outmigration period, which for steelhead and coho salmon is February-May (Shapovalov and Taft 1954). Our model screen capacities ranged, in 100 cfs increments, from 100-500 cfs.

In only two years (1996 and 2000) did a screen in our size range handle the entire flow. The largest screen, 500 cfs, handled >95% of the flow in all years, while the smallest screen, 100 cfs, handled > 83 % of the flow in all years. Thus, selection of screen size depends on what level of flow can be bypassed without seriously affecting juvenile sampling objectives. However, cost and benefit of different screen sizes should also be considered. In this regard, the six year average efficiencies for the five screen sizes increased from 85.5% to 98.3% between the 100 and 500 cfs screens, respectively. The greatest efficiency increase (7.8 points) was between the 100 and 200 cfs screens (**Table J-2**).

Table J-2. Percentage of days with average flow (cfs) under a SPECIFIED SCREENING capacity and Number of Days over 1000 cfs for Soquel Creek during February-May, water years 1995-2000

Screening capacity (cfs)	95	96	97	98	99	00	Average (increment over previous screen capacity)
100	84	97	73	83	84	92	85.5
200	89	100	87	96	91	97	93.3 (7.8)
300	95	100	92	98	96	99	96.7 (3.4)
400	97	100	94	99	97	100	97.8 (1.1)
500	97	100	96	99	98	100	98.3 (0.5)
Days over 1000 cfs	1	0	3	0	2	0	n/a

Juvenile fish marking, in combination with adult fish sampling for marks, would be required under any of the flow screening options. The absence of marks on returning adults, by age class, would indicate the proportion of juveniles that were missed due to high flow events.

We did not analyze screening efficiencies by month, but noted that the heaviest run-off months were February and March. The smaller screens (100 and 200 cfs) appeared to be about as equally effective as the larger screens (400 and 500 cfs) during April and May. (A more thorough analysis would examine the temporal emigration patterns of both coho and steelhead.)

Using the above information for February-May, we use the 200 cfs screen for our model stream cost analysis, assuming > 90% screening efficiency is an acceptable minimum screen efficiency criterion. Our estimate for a screen of this size, and assuming the DFG would build it, is between $400,000 ($2,000/cfs) and $2.0 million ($10,000/cfs) with a mid-point estimate of $1.2 million. However, because of the large screen size, the DFG screen shops may not be able to do the job, thus it would likely have to be contracted out (George Heise, DFG, pers. comm.).

We assume the adult trapping and juvenile screening facility would be constructed by a private contractor and use the Carmel River adult and screening facility estimates [$2.8 million and $9.3 million (average), respectively] to speculate on the cost of similar facilities on our model stream, Soquel Creek. The Soquel Creek drainage (40 mi ^{2}) is 18% the size of the Carmel River drainage (220 mi ^{2}). Also, we estimate the amount of low that would need to be screened to capture juvenile fish in Soquel Creek was 33% (200 cfs) of that proposed for the Carmel River (600 cfs). Thus, we would expect an adult and juvenile facilities built by the same contractor on Soquel Creek would be considerably less than on the Carmel River due to the smaller stream channel, lower flows and lower juvenile screening capacity. Whether it would be proportionately less is difficult to say because some costs are likely fixed regardless of stream or facility size. Here we speculate that the two facilities on our model stream would cost 25% of the Carmel River estimates, or $700,000 for the adult facility and $2.3 million for the juvenile screening facility. Adjusting for increase in the Consumer Price Index between 1991 and 2004 (33%), the adult facility cost estimate is $0.9 million and the juvenile screening portion is $3.1 million in 2004 dollars.

We estimate that $4.0 million (rounded) would be needed to construct an LCS meeting our specifications on our model stream. This includes $0.9 million for a dam and adult collection/processing facility and $3.1 million for a juvenile fish screen that would handle 200 cfs. It is anticipated that actual cost could vary considerably depending on site conditions, how the facilities are designe, and where the facilities are constructed. The estimated annual cost for salaries and operating is $386,000 per year (**Worksheet 3a**).

Finally, LCS placement would require California Environmental Quality Acts/ National Environmental Policy Act analyses. We speculate this will add $100,000 to the start up cost. Other costs **(Worksheet 3a**) bring the LCS start up cost to $4.2 million.

Two other streams of about the same drainage area as Soquel Creek were considered for additional analysis. However, cursory examination of stream discharge levels and temporal flow patterns suggest the results would be about the same as the Soquel Creek analysis. They were Little River near Trinidad and Big Sur River near Big Sur. These latter streams have attributes that should be given additional consideration when/if it comes time to prioritize LCS location, Little River supports all four northern species while Big Sur is in the Southern Monitoring Area.

Another stream that has been under study by various watershed and resource management agencies since 1961 is Caspar Creek, located near Fort Bragg in Jackson State Forest. It is a very small stream with a drainage area of about 8 $mi.^2$. It supports runs of coho salmon and steelhead trout. The stream has two existing fish ladders and stream flow, and other water quality parameters are routinely monitored. There is also a trapping site near the stream mouth that was washed out in the early 1960s. The DFG was a participant in the Caspar Creek Experimental Watershed Experiment until 1964 (Henry 1998).

Option 2: Use Existing Facilities and Portable Equipment

This option entails the use of existing facilities or portable weirs to trap and estimate upstream migrating adults coupled with the use of rotary screw or other juvenile trap types to mark, tag and estimate abundance of downstream migrating juvenile salmonids. The equipment is low in cost compared to permanent facilities and there are a few prototypes in operation around the state. Based on the price of the current LCS operations, we estimate the cost of building and installing a portable resistance board weir at about $70,000 with annual repair costs of about $7,000. This will cover a channel about 30-ft in width. If we use two rotary screw traps to capture and tag downstream migrants at each site, the juvenile trapping start up cost would be about $40,000. The cost of purchasing micro-tagging equipment at each site is about $30,000 per machine. One biologist would be assigned to oversee the operations of each pair of LCSs and one Associate Biologist would oversee the three Fishery Biologists. We estimate the annual cost of establishing six coastal LCSc at $1.4 million per year with a one-time start-up cost of $1.0 million (**Worksheet 3b).**

Task 4: Juvenile Salmonid Surveys

Juvenile sampling is proposed as a high priority sampling need in order to assess the distribution and relative utilization of stream rearing habitats by coho salmon, cutthroat trout and southern steelhead trout. Sample areas should be drawn following a rotating panel design. This work will provide a good opportunity to collect habitat data that can be used in assessing habitat conditions. The surveys will determine presence or absence of each species following established protocols. In the cutthroat sample area (Eel to Smith and inland 30 miles), juvenile abundance estimates will be made for salmonids present in the sample reaches. Chinook is not proposed to be sampled under this proposal as they generally migrate to the ocean in their first few months of life. Northern steelhead are excluded because they are everywhere abundant in the north. We propose to sample 10% of the available rearing habitat for coho salmon and southern steelhead. The estimated annual cost of this task is $1.3 million with a one-time added start up cost of $177,000. This will cover personnel, operating, equipment and overhead **(Worksheet 4).**

Task 5: Hatchery Fish Marking

This project will mark 1 million Chinook annually at Iron Gate Hatchery and 113,000 at Rowdy Creek Hatchery to ensure at least 25% of their fish can be identified in basin fishery and spawning escapement programs. Supplemental marking is not proposed at the other coastal hatcheries as their fish are already being marked at a 25% or greater rate. The cost is $69,000 per year with no start up cost (**Worksheet 5**).

Task 6: Angler Creel Survey

Under this task, annual creel surveys would be conducted in the northern and southern areas from San Luis Obispo Creek to the Smith River. The creel survey cost is $369,000 to survey 200 stream miles per year. There is a one-time added start up cost of $14,000 for equipment (**Worksheet 6**).

Task 7: Administration and Data Management

This project depends on the level of implementation of the other tasks. It provides for four DFG staff positions, Program Coordinator, two Research Analysts and a Secretary. This task would be implemented if and when a substantial flow of data can be expected from the Monitoring Program. Thus, it has a lower priority status than the other tasks yet is also highly important. It is intended to support data flow into a system designed to input and store data in a widely accepted format and in a timely manner. The data will be available for use by fishery management agencies and ultimately the public. The task provides support for the Science Advisory Committee and includes a $200,000 budget item to fund additional study needs, such as Klamath River fall steelhead seining, resident rainbow/steelhead interaction studies and coastal cutthroat genetics work. The Program Coordinator serves as liaison with other monitoring entities and ensures program goals and objectives are met. The program has one year of temporary help for data editing and data management purposes. The budget is $789,000 per year with a start-up cost of $36,000 (**Worksheet 7**).

Summary of Plan Costs

We recommend **Option 2** for the LCS task. The cost is higher long term than **Option 1** but would be expected to provide more data overall, be able to sample much larger stream systems (thus a broader range of species), and provide much broader geographic coverage than building two new permanent facilities, which would need to be constructed on fairly small streams.

The proposed annual budget for all seven tasks is $7.0 million (rounded). The single most expensive task is the Northern Spawner Survey ($2.5 million) followed by the LCS task ($1.4 millions) and Juvenile Survey ($1.3 million). Three of the tasks each cost between $369,000 and $789,000 (Southern Steelhead Monitoring, Creel Survey and Administrative Support). The hatchery marking task totals $69,000. Totals of 19.66 permanent positions and 791 person-months (about 66 person-years) of temporary help are needed to implement these tasks. There is a start up cost of $1.9 million, mostly for vehicles, weir construction materials and juvenile screens. Funds are provided in tasks 2 and 7 to fund sonar counting studies.

LITERATURE CITED

Bechtel Corporation. 1991. Monterey Peninsula water supply project: New Los Padres and New San Clemente projects fish collection facilities. Conceptual designs and cost estimates. Available from George Heise, DFG, Sacramento CA. 21 p plus maps and tables.

DFG (Department of Fish and Game).1965. California Fish and Wildlife Plan, Volume III, supporting data, Part B, Inventory (Salmon-Steelhead and Marine Resources. Sacramento, CA. 677 p.

Henry, N. 1998. Overview of the Caspar Creek watershed study. p 1-9. *In:* Proceedings of the conference on coastal watersheds: the Caspar Creek story. U.S. Dep Agricul., Pac. SW Res. Stat., Tech. Rep.: PSW-GTR-168.

Shapovalov, L., and A.C. Taft. 1954. The life histories of the steelhead rainbow trout *(Salmo gairdneri)* and silver salmon *(Oncorhynchus kisutch)* with special reference to Waddell Creek, California, and recommendations regarding their management. DFG Bulletin No. 98. 373 pp.

Budget Sheets

WORKSHEET NO. 1

Area and Species:	Aptos Creek to Smith River; Chinook, Coho and steelheads		
TASK TITLE	**NORTHERN SPAWNER SURVEY**		
VSP Parameter	Abundance and distribution		
Priority:	1		
Statistical Approach:	Rotating panel		
Frequency:	Annual		
Primary Methodology:	AUC, redds, carcasses		
Current Activity Level	see Table 2	Budget Methods	**Adults:** 5800 miles x .10 x .75=435 mi/wk;87 mi/d
Colateral Sampling Opportunities:	genetics, habitat, age composition		(5-d wk);= 29 crews for 6 mo.=348 pm
Dependence on Other Sampling:	none		**Biologists** work 9.6 mo/yr on project

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Assoc. Biologist	$65,090.00	1.6	py	2	$104,144
Biologist (B)	$58,760.00	4.8	py	6	$282,048
Seasonal Staff Requirements:	$2,748.00	396	pm	66	$1,088,208
Data Management:					
Data entry					$5,000
Operating	0.25				$368,600
Equipment					$0
Vehicles	$36,000.00	4	ea		$144,000
Computer	$2,000.00	2	ea		$4,000
PDAS	$500.00	5	ea		$2,500
Misc	$1,000.00	5	ea		$5,000
Rental: Office	$12,000.00	7	ea		$84,000
Contractual:					$0
Scale reading					$10,000
Misc	$500.00	5	ea		$2,500
Overhead	0.213				$444,638
Total:				74	$2,544,638

Vehicles: .5/crew and bio; 1/calib. Team/
Crew: 2 persons, can cover 3 mi per day.

Calibration:1PY+ 4crews, 6mo.(48py);+10% for weirs

Start Up	**Number**	**Units**	**Cost**	**Total**
Vehicles	15	ea	$36,000	$540,000
Computers	6	ea	$2,000	$12,000
PDAs	28	ea	$500	$14,000
				$0
				$0
				$0
				$0
				$0
				$0
Total				$566,000

WORKSHEET NO. 2

Area and Species:	South--Steelhead		
TASK TITLE	**SOUTHERN STEELHEAD MONITORING**		
VSP Parameter	Abundance		
Priority:	1		
Statistical Approach:	Total counts		
Frequency:	Annual		
Primary Methodology:	Live fish counts at key locations		
Current Activity Level	see Table 2	Budget Methods	Temp help: 2 Fishways, @ 5 mo.(2crews)
Colateral Sampling Opportunities:	age composition, genetics		Crew=2persons
Dependence on Other Sampling:	None		

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Biologist (B)	$58,760	0.5	py	1	$29,380
					$0
					$0
Seasonal Staff Requirements:	$2,748	20	pm	4	$54,960
Data Management:					$0
Data entry					$100
Operating	0.15				$12,651
Equipment:					$0
Vehicle	$36,000	0.25	yr		$9,000
Computer	$2,000	1	yr		$2,000
Misc	$2,000	1	yr		$2,000
Rental: (Office)	$12,000	0.5	yr		$6,000
Contractual:					$0
Weir evaluation	$200,000	1	yr		$200,000
Didson evaluation	$200,000	1	yr		$200,000
Overhead	0.213				$24,727
Total:					$540,818

Start Up	**Number**	**Units**	**Cost**	**Total**
Vehicles	1.75	ea	$36,000	$63,000
Computers	1	ea	$2,000	$2,000
				$0
				$0
				$0
				$0
				$0
				$0
				$0
Total				$65,000

WORKSHEET NO. 3a

Area and Species:	Northern Monitoring Area-Small Stream: One permanent facility		
TASK TITLE	**PERMANENT LIFE CYCLE MONITORING STATION (OPTION 1)**		
VSP Parameter	Productivity		
Priority:	4		
Statistical Approach:	n/a		
Frequency:	continuous		
Primary Methodology:	Live fish counting and marking		
Current Activity Level	Scott Creek, Freshwater Creek	Budget Methods	
Collateral Sampling Opportunities:	Watershed habitat conditions		extras: $24K elect ($1K/mo);$5K gas; $10K repairs;
Dependence on Other Sampling:	Task 1		$5K gas; $5K repairs; $10K nets, lab supply;$5K misc.

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Biologist (B)	$58,760	1	yr	2	$58,760
Habitat Assist.	$42,697	1	yr	2	$42,697
					$0
Seasonal Staff Requirements:	$2,748	36	pm	4	$98,928
Data Management:					$0
Data entry					$5,000
Operating	0.15 + extras	32000	extras		$62,058
Equipment:					$0
Pumps, winches	$2,000	1	ea		$25,000
Vehicles	$36,000	0.5	ea		$18,000
Computers	$2,000	1	ea		$2,000
Misc	$4,000	1	ea		$4,000
Rental:					$0
Contractual:					$0
Misc	$2,000	1	ea		$2,000
					$0
Overhead	0.213				$67,402
Total:					$385,845

Start Up	**Number**	**Units**	**Cost**	**Total**
Design	170	hrs	$50	$8,500
Facility	1	ea	$4,000,000	$4,000,000
Vehicles	1.5	ea	$36,000	$54,000
Computer	1	ea	$2,000	$2,000
Pump	1	ea	$1,000	$1,000
Generator	2	ea	$5,000	$10,000
CEQA	1	ea	100,000	$100,000
				$0
				$0
				$0
Total				$4,175,500

WORKSHEET NO. 3b

Area and Species:	**TRT Domains (3); establish 2 per domain, 6 total**				
TASK TITLE	**LIFE CYCLE MONITORING STATIONS (OPTION 2)**				
VSP Parameter	Productivity				
Priority:	4				
Statistical Approach:	n/a				
Frequency:	continuous				
Primary Methodology:	Live fish counting and marking				
Current Activity Level	Scott Creek, Freshwater Creek			Budget Methods	
Colateral Sampling Opportunities:	Watershed habitat conditions				
Dependence on Other Sampling:	Task 1				

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Assoc. Biol.	$65,090	1	yr	1	$65,090
Biologist (B)	$58,760	3	yr	2	$176,280
Habitat Assist.	$42,697	2	yr	2	$85,394
Seasonal Staff Requirements:	$2,748	162	pm	4	$445,176
Data entry					$5,000
Operating	0.15 + extras	105000	extras		$220,791
Equipment:					$0
Traps	$20,000	2	ea		$40,000
Vehicles	$36,000	1	ea		$36,000
Tag machines	$30,300	1	ea		$30,300
Computers	$2,000	1	ea		$2,000
Tags	$1,750	6	ea		$10,500
Misc	$4,000	1	ea		$4,000
Rental:	$5,000	1	ea		$5,000
Contractual:					$0
Misc	$5,000	1	ea		$5,000
Overhead	0.213				$239,738
Total:					$1,370,269

Methods: Each facility will need:
Adult trapping: weir or trap modification= $70,000
Juvenile trapping: 2 rotatary screw traps: $20,000 each
Vehicle: 1 pickup
Tagging: 1 CWT machine: $30,300 (NW web page)
Detector: $12,000
Handheld injector: $7,000
Tags: $1750/yr (50,000 at $35/1000)
Temp help: 27 pm/uni/yr.
Operations: Oct-Jun annually
Extras: materials: $17,500 (10% of new price)

Start Up	**Number**	**Units**	**Cost**	**Total**
Weirs	5	ea	$70,000	$350,000
Juv. Traps	10	ea	$20,000	$200,000
Vehicles	5	ea	$36,000	$180,000
Detectors	6	ea	$12,000	$72,000
Computer	5	ea	$2,000	$10,000
Tag machines	6	ea	$30,300	$181,800
Hand injectors	6	ea	$7,000	$42,000
				$0
				$0
Total				$1,035,800

WORKSHEET NO. 4

Area and Species:	Coho, cutthroat and southern steelhead		
TASK TITLE	**JUVENILE SURVEY**		1643 cds, 18 crews for 3 mo (60d).
VSP Parameter	Distribution, cutthroat abundance		
Priority:	3		
Statistical Approach:	Rotating panel		
Frequency:	Annual		
Primary Methodology:	Presence-absence, cutthroat estimates		**North**=7300mi x .10=730mi @2 mi/d=365d
Current Activity Level	Highly variable	Budget Methods	(1095cds) x 1.5 (2nd pass), 1643 cds,
Collateral Sampling Opportunities:	Habitat conditions, life history, genetics		27 crews for 3 mo (60d).
Dependence on Other Sampling:	None		**South**=1300mi x .10=130 mi. @ 2mi/d=65d

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Assoc. Biologist	$65,090.00	0.4	py	2	$26,036
Biologist (B)	$58,760	1.2	py	6	$70,512
Seasonal Staff Requirements:	$2,748	288	pm	96	$791,424
Data Management:					$0
Data entry					$5,000
Operating	0.15				$133,196
Equipment (amortized):					$0
E-gear	$5,000	5	ea		$25,000
Boat/Misc	$10,000	0.25	ea		$2,500
Dive gear	$900	5	ea		$4,500
Rental: Office	$12,000	1.6	ea		$19,200
Contractual:					$0
Misc	$500	1	ea		$500
Overhead	0.213				$229,479
Total:				104	$1,307,347

(195cds) x 1.5 (2nd pass), 293cds,
5 crews for 3 mo (60d)
Crew=3 persons
North includes cutthroat habitat

Note: this task integrates with tasks 1 and 2

Start Up	**Number**	**Units**	**Cost**	**Total**
E-gear	27	ea	$5,000	$135,000
Boat	1.75	ea	$10,000	$17,500
(see tasks 1 and 2 for shared equip)				$0
Dive gear	27	ea	$900	$24,300
				$0
				$0
				$0
				$0
Total				$176,800

WORKSHEET NO. 5

Area and Species:	North--Chinook
TASK TITLE	**HATCHERY FISH MARKING**
VSP Parameter	Abundance, productivity
Priority:	1
Statistical Approach:	Mark 25% of production
Frequency:	annually
Primary Methodology:	Fin clipping
Current Activity Level	Being met except IGH and RCH
Collateral Sampling Opportunities:	
Dependence on Other Sampling:	Augments spawning surveys

Budget Methods

3000 fish/d/marker; 1.113M total=371d or 18.6 mo

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					$0
Habitat Asst	$42,697	0.16	py	1	$6,832
					$0
					$0
Seasonal Staff Requirements:	$2,133	18.6	pm	8	$39,674
Data Management:					$0
Data entry					$1,000
					$0
Operating	0.15				$6,976
Equipment:					$0
Misc.					$500
					$0
					$0
Rental: Auto	0.40	3000	mi		$1,200
Contractual:					$0
Misc					$500
					$0
Overhead	0.21				$11,967
Total:				9	$68,648

Start Up	**Number**	**Units**	**Cost**	**Total**
(None)				0
				0
				0
				0
				0
				0
				0
				0
				0
Total				0

WORKSHEET NO. 6

Area and Species:	San Luis Obispo Creek to Smith River-Salmon and Steelhead		
TASK TITLE	**CREEL SURVEY**		
VSP Parameter	Productivity		
Priority:	5		
Statistical Approach:	Rotating panel		
Frequency:	Annual		
Primary Methodology:	Roving or exit survey		
Current Activity Level	Smith, Mad and Klamath R.	Budget Methods	Need 4 2-person crews for 7 mo ea.
Collateral Sampling Opportunities:	Age comp, genetics		
Dependence on Other Sampling:	Spawning ground surveys, hatchery marking		

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**	**Start Up**	**Number**	**Units**	**Cost**	**Total**
Permanent Staff Requirements:					$0					
Biologist (b)	$58,760	1	py	1	$58,760					
					$0					
					$0					
Seasonal Staff Requirements:	$2,748	56	pm	8	$153,888					
Data Management:					$0					
Data entry					$5,000					
Operating	0.15				$31,897					
Equipment:					$0					
Vehicles	$36,000	1	yr		$36,000	Computer	3	ea	$2,000	$6,000
Boat and motor	$10,000	0.2	yr		$2,000	Boat	0.8	ea	$10,000	$8,000
Computer	$2,000				$0					$0
Rental: Office	$12,000	1	yr		$12,000					$0
Contractual:					$0					$0
Scale reading					$5,000					$0
Misc					$500					$0
Overhead	0.213				$63,803					$0
Total:				9	$368,848	**Total**				$14,000

WORKSHEET NO. 7

Area and Species:	All		
TASK TITLE	**ADMINISTRATIVE SUPPORT**		
VSP Parameter	n/a		
Priority:	2		
Statistical Approach:	n/a		
Frequency:	continuous		
Primary Methodology:	n/a		
Current Activity Level	new	Budget Methods	**Data editing:** 12 mo. temp help **SAC support: $6K travel; $1K misc**
Colateral Sampling Opportunities:	n/a		
Dependence on Other Sampling:	Task 1-3 implementation needed		**SAC comp: $450/d=$21K**
			Studies: weirs, seining, trout/steelhead

BUDGET DETAILS	**Rate**	**Number**	**Units**	**Positions**	**Total**
Permanent Staff Requirements:					
Environmental Manager I	$106,425	1	py	1	$106,425
Res. Analyst I (GIS)	$48,115	2	py	2	$96,230
Secretary	$45,875	1	py	1	$45,875
Seasonal Staff Requirements:	$2,748	12	pm	2	$32,976
Data Management:					
Data entry					$5,000
Operating	0.15				$42,226
Equipment (amortized):					
Vehicle	$36,000	0.25	yr		$9,000
Computers	$2,000	2	yr		$4,000
Misc	$2,000	1	yr		$2,000
Rental: Office	$12,000	3	yr		$36,000
Contractual:					
SAC support	$28,000	1	yr		$28,000
Special studies	$200,000	1	yr		$200,000
Misc	$100,000	1	yr		$100,000
Overhead	0.213				$80,883
Total:					$788,615

Start Up	**Number**	**Units**	**Cost**	**Total**
Vehicle	0.75	ea	$36,000	$27,000
Computer	3	ea	$2,000	$6,000
Printer	1	ea	$3,000	$3,000
				$0
				$0
				$0
				$0
				$0
				$0
				$0
Total				$36,000