Southwest Regional Approach to Data Collection on California Coastal Salmonids[1]

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NMFS Southwest Regional Office
and
NMFS Southwest Fisheries Science Center
Santa Cruz/Tiburon Laboratory
Co-Conveners

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Executive Summary

Need for Data Collection

Numerous California salmonids are listed or proposed for listing under the Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS)[2] has management responsibility for those listings and consequently requires quantitative data on abundance and biological characteristics of the fish populations, both for assessing current status and for projecting the future viability of the populations.

At present, there is need for coordinated, comprehensive data collection on California coastal salmonids. With this in mind, a workshop was convened in Tiburon, California, by scientists and managers of the NMFS Southwest Regional Office (SWRO) and Southwest Fisheries Science Center (SWFSC). Participants discussed what data collection must be done, by whom, and the resources that will be needed. The emphasis of the meeting was on coho salmon and steelhead; participants acknowledged the need for a future meeting to discuss coastal chinook.

Extent of Present Sampling

Presently, California lacks comprehensive sampling for coastal salmonids. A review of ongoing data collection in two evolutionarily significant units of coho salmon and five of steelhead (Appendix C) reveals very few data series originating before the early 1990s, and fewer still before the late 1980s. Most data collection has been abundance sampling of juveniles, and there are very few time series of adult abundances. In other areas of the Pacific northwest, the emphasis has been on estimating adult abundances, and this disparity has increased the difficulty of analyses needed for ESA listing, monitoring, and recovery in California. Because of the lack of comprehensive monitoring and coordination, we lack precise estimates of the status of these salmonids, and we know little about their abundance patterns in the past.

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[2]References to NMFS in this document are generally to the NMFS in the Southwest Region; i.e., to the NMFS Southwest Regional Office and Southwest Fisheries Science Center.

A further concern is lack of coordination among existing sampling programs. Sampling protocols in California vary widely, and there is no central data repository. Existing data are not always available to NMFS for risk assessments or tracking regional population trends, and when available, can be difficult to obtain and interpret. This dispersal of data thus has negative consequences that are ongoing and complex.

Data Collection Priorities

Workshop participants developed a set of priorities for data collection. Given the need for abundance time series for population modeling, a very high priority was given to collecting continuing time series of abundance estimates. Difficulties[3] in estimating adult abundances favor collection of data on juveniles; research is therefore needed on the relationship between juvenile and adult abundances.

Understanding population structure, including straying rates and the degree of multiple-age spawning, is key to understanding whether genetic effects at low population sizes are important factors for viability of California salmonids. Thus, obtaining such information should also be given a very high priority.

The third item assigned very high priority was estimating stage-specific survival rates; these are used in population viability analyses, and are needed to assess where critical bottlenecks in survival occur. Mean values (over time and space) of such rates, along with estimates of variability, will suffice for some uses. Understanding temporal and spatial variation would be quite valuable, and give great insight into life history processes; but, given the high cost of obtaining the necessary data, estimating yearly rates was assigned higher priority. Many conservation measures assume that survival relates to habitat quality; increasing our understanding of the relationships between habitat conditions and stage-specific survival rates would be of great value in the development of conservation planning measures for salmonid recovery.

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[3]Such difficulties include dangerous conditions in streams and lack of accessibility for sampling, due to heavy flows during the spawning period.

NMFS Role in Data Collection and Coordination

Participants at the workshop stressed the need for development of a coordinated California data collection plan, including several levels of involvement by NMFS. It is strongly recommended that NMFS (1) develop a comprehensive sampling plan, a document that would describe required monitoring, including geographic and temporal coverage and details of standard methods; (2) ensure coordination in data collection; and (3) sponsor and maintain a central data repository, to ensure that all data collected are available for regulatory decisions and biological studies. It is envisioned that most data collection would be done by others, with NMFS providing guidance and coordination. Additional direct NMFS involvement (possibly through contracts) should also occur in several areas, including NMFS sampling of selected streams to provide quality control and continuing knowledge of conditions in the field; estimation of adult abundances in selected streams; statistical exploration of the relationship between adult and juvenile abundances; development of methods for reconstructing historical abundances; and focused studies addressing such questions as effects of land management practices (including habitat restoration) and determination of life history characteristics (e.g., survival rates). Thus, the workshop concluded that NMFS must take an active leadership role in assuring that the necessary research is performed and the necessary data are collected on ESA-listed salmon in California.

Workshop participants discussed several ways in which non-NMFS sampling could be supported and coordinated. One was the possible use of a blanket §10(a)(1)(A) permit, issued to NMFS, under which regional or local organizations could conduct abundance sampling. A second was that, before issuing habitat conservation plans, NMFS ensure that the plans include biological sampling that meets our data needs. This provision is especially important because habitat conservation plans are usually issued with durations of decades.

Action Items

The following actions are recommended for coho salmon and steelhead:

- Acknowledgment of NMFS's primary responsibility to ensure collection of data needed for our ESA obligations*
- Definition and prioritization of data needs*

- Decision on the level of NMFS participation in sampling*
- Identification of work best performed directly by NMFS*
- Internal communication of data needs and formulation of budget proposals
- Communication of our data needs to those who can supply the data, or initiation of our own programs to collect the data
- Exploration of opportunities for partnerships with other agencies

Those items marked with an asterisk (*) were discussed at the workshop, and information or recommendations for appropriate action on those topics are found in this report.

The following two areas require further discussion, in order for NMFS to formulate plans of actions:

- Data collection on hatchery releases and practices, and possible formulation of NMFS guidelines to ensure that hatchery operations are in accordance with best scientific practices
- Data collection and modeling approaches for California coastal chinook

It is recommended that additional workshops be held on those two topics as soon as practical.

Conclusions

Although NMFS's stewardship responsibility for salmonids in California is shared with the state and with managers of salmon habitat, NMFS is responsible under the ESA for threatened and endangered salmonids. That responsibility requires that NMFS assume leadership in ensuring that needed data on salmonids are collected, so as to support the protection and recovery of listed species. Without large increases in funding, NMFS cannot collect all necessary data; however, NMFS can and must guide potential cooperators in a coordinated effort to develop sampling plans and collect and store the needed data, while pursuing additional funding as needed. This situation opens significant opportunities for developing partnerships that meet NMFS's responsibilities under the ESA. The chance to bring those partnerships to fruition rests on NMFS' assuming leadership and clearly specifying its needs and objectives.

1   Introduction

Numerous California salmonids are listed or proposed for listing under the Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) has management responsibility for those listings and consequently requires quantitative information on abundance and other characteristics of the fish populations. Such information is critical for assessing the current status and projecting the future viability of the populations.

There is now need for coordinated, comprehensive data collection on California coastal salmonids, such as coho salmon, steelhead, and coastal chinook salmon. With this in mind, a workshop was convened in Tiburon, California, by scientists and managers of the NMFS Southwest Regional Office (SWRO) and Southwest Fisheries Science Center (SWFSC). The objectives of the workshop were to reach a common understanding among SWRO/SWFSC personnel as to what data are needed and to outline a plan for collecting those data. Workshop participants discussed thoroughly what data collection should be done, who should do it, and what resources would be necessary to accomplish the work. Although the emphasis was on coho salmon and steelhead, the conclusions of this report should be relevant to other California salmonids, particularly coastal species.

The workshop consisted of discussions, in some cases including informal presentations, each moderated by a participant. (The agenda is reproduced as Appendix A, and a list of participants as Appendix B.) Rapporteurs and discussion leaders, with the help of other participants, prepared draft sections of this report that closely follow the discussion topics.

This report begins by reviewing existing salmonid population viability models and their data needs, and describing and prioritizing data needs for effective management (Section 2). In Section 3, we describe the current state of information on California coastal salmonids. The identification of strategies for NMFS involvement in data collection is discussed in Section 4, and specific action items for NMFS are recommended in Section 5. Concluding remarks are presented in Section 6. Although the report undoubtedly contains flaws and omissions, workshop participants hope that it will be a valuable resource in better defining the scientific work that must be done to implement the ESA for Pacific salmonids in California. We hope and anticipate that it will be rendered obsolete by future work.

2   Data Needs for Management and Recovery

Workshop participants first undertook to define data essential for monitoring and recovery of coastal California salmonids under the ESA. Data needs are determined partly by the general nature of monitoring and understanding biological populations; partly by general characteristics of anadromous fish (particularly salmonids); and partly by specific geographic and biological characteristics of California's coastal salmonids. In addition, specific issues arise when monitoring depleted populations, and specific modeling techniques are used in such cases.

In studying and managing depleted populations, a frequently used tool is the population viability analysis (PVA). We define a PVA as an analysis in which a study population (species or segment of a species) is defined and its probability of extinction estimated. The estimation is necessarily done as a function of specified risks, which can be classified into four nonexclusive categories: (1) *demographic risks,* variations in, e.g., sex ratio or age structure, which may become critical at low population sizes; (2) *environmental risks,* moderate but possibly cumulative temporal variation in external conditions, expected to affect all members of the population equally; (3) *genetic risks,* such as genetic drift, which occur primarily when the spawning population is quite small; and (4) *catastrophic risks,* rare events such as floods or droughts, which can suddenly and severely affect the population (Shaffer, 1981). Ideally, one would have data on the probability of occurrence of risks in each category and on the likely magnitude of their effects. In practice, for lack of such data, PVAs typically include some, but not all, of the four risk categories.

2.1   Models, Analyses, and Data Requirements

In preparation for identifying the empirical data needed for management under the ESA, it is useful to examine the features and data requirements of some existing salmonid population viability analyses. To accomplish this, five published analyses, using a variety of modeling approaches, are described, followed by a condensed list of their data requirements (Table 1 on page 11).

Table 1. Summary of five recent population viability models applied to Pacific salmon.

Study	Population(s) modeled	Model features	Principal data used	Modeled variation
Emlen (1995)	Snake River chinook salmon	Density-dependent, age-structured, sex-structured.	Time series of redd counts from five index streams.	Environmental, demographic
Botsford and Brittnacher (1997)	Sacramento River winter chinook	Density-independent, Leslie model, delisting criteria that incorporate sampling variation are developed.	Time series of spawner abundance; proportion spawning at age; fecundity.	Environmental
Lee and Hyman (1992)	Representative fall chinook	Density-dependent "life-cycle" model.	Fecundity; egg-smolt survival; hatchery-natural fish interactions; age-specific exploitation rates.	Environmental, demographic
Ratner et al. (1997)	Umpqua River spring chinook	Leslie matrix, density-dependent first year survival.	Time series of spawner abundance; proportion spawning at age; fecundity.	Environmental, demographic
Nickelson and Lawson (in press)	Oregon coastal coho salmon	Density-dependent "life-cycle" model.	Habitat data, capacity of various habitat types to support coho; egg-parr and parr-smolt survival, and their relation to habitat quality and relative coho density, respectively.	Environmental, demographic, genetic

2.1.1 Stock–Recruitment Models

The primary data used in an analysis of Snake River chinook salmon by Emlen (1995) were time series of redd counts (1957–1992) from five index streams. Two stock-recruitment functions were used in the analysis. The progression from number of female spawners to number of redds was modeled with a density-dependent Ricker function; the survival from number of eggs to number of spawners was modeled with a Beverton-Holt function. The projected persistence of the population was strongly influenced by the density-independent parameter α of the Ricker function, while the density-dependent parameter β of this function affected the population size but had little effect on persistence. The projected persistence based upon the estimated level of α was probably too optimistic, because the model omitted genetic and demographic risks.

2.1.2 Leslie Matrix Models

In an effort to develop delisting criteria for endangered Sacramento River winter chinook salmon, a density-independent Leslie matrix model was revised to relate current spawners to previous spawners by Botsford and Brittnacher (1997). The authors identified two potential criteria: the cohort replacement rate should be ≥ 1.0, and the probability of extinction within 50 years should be ≤ 0.1. After a consideration of sampling and measurement error, the investigators concluded that at least 13 years of data are needed for reliable estimation of the cohort replacement rate. The primary data used in this analysis were a time series of spawner abundances and assumptions regarding fecundity and proportions spawning at age.

2.1.3 Life Cycle Models

An alternative to fitting models statistically to time series of abundance data is explicitly defining the transition probabilities between key life history stages. In the "Stochastic Life Cycle Model" of Lee and Hyman (1992), the density-dependent transition from egg abundance to pre-smolt abundance follows a beta-binomial distribution that incorporates both demographic and environmental stochasticity. This model incorporates many other complexities, including separation of natural and hatchery production, a juvenile migration

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submodel, and submodels describing the fates of adults surviving natural mortality (i.e., being harvested, spawning in natural areas, or returning to the hatchery). Such an approach requires an extraordinarily high level of information, including knowledge of stock-recruitment and fecundity relationships and coded-wire-tag data suitable for estimating the allocation of adults among the fates mentioned above. The authors provided example parameters based on Snake River fall chinook salmon coded-wire-tag recovery data.

2.1.4   Habitat Based Models

The presumed relationship between freshwater habitat quality and smolt productive capacity has motivated PVA models that consider habitat. For example, Ratner et al. (1997) modeled chinook salmon in the South Fork of the Umpqua River with a modified Leslie matrix that incorporated density-dependent first-year survival and demographic stochasticity in the spawner sex ratio, instream mortality rate, egg production, and survival of non-spawning adults. First-year survival was multiplied by the factor $\exp(-cN_t)$, where N_t is population size and c is a density-dependent parameter from a Ricker curve fit to a time series of detrended spawner abundances. Habitat degradation was interpreted to have caused the exponential decline in abundance from 1955 through 1983; in the model, it changed the equilibrium population size through changes in the density-dependent parameter c. Projections of future population abundances were made under assumed constant or declining levels of habitat quality. Data requirements for this analysis are similar to those in the work of Botsford and Brittnacher (1997) and include time series of abundance, proportion spawning at age, and fecundity.

Detailed measures of habitat quality may allow modeling of individual stream reaches, as in a life cycle model applied to the Oregon coastal coho (Nickelson and Lawson, in press). Data on overwinter survival of juveniles indicated a positive relationship with potential smolt density predicted by the "Habitat Limiting Factors Model" (Nickelson et al., 1992), suggesting that the survival rate was affected by habitat quality. The data also suggested that egg-to-parr survival was strongly inversely related to egg density; in simulations, this density dependence provides resilience. Data requirements for this approach include knowledge of streambed morphology and its relation to potential fish density, and data on survival and fecundity rates.

2.1.5 Conclusions on Model Data Requirements

The preceding examples illustrate that data requirements for salmonid PVA models can vary widely. However, in the large majority of cases, time series of abundance estimates are fundamental. It is notable that two risk categories (demographic and environmental) have dominated model development (Table 1). In viability modeling of coastal California salmonids, the ideal would be to have every type of data used by these examples, plus information on genetic and catastrophic risks. In practice, the enormity of such a task makes it necessary to establish priorities for data collection. A more detailed description of data types and costs of collection, along with statements of priority, are found in the next section.

2.2   Data Types and Priorities

In this section, we discuss broadly the types of data desirable for understanding and monitoring salmonid populations. We classify data into three broad categories: (1) time series of abundance, (2) life history characteristics, and (3) genetic information. There is certainly overlap between these categories, as discussed below. A prioritization of data needs (Table 2, page 37) reveals that, in general, the data most desired are typically the most expensive to obtain.

2.2.1 Time Series of Population Abundance

Long term abundance time series over a wide geographic scale are essential for decisions concerning the status and risk of populations of Pacific salmonids. Long term data series provide insight into past stock dynamics and allow population models to be fit to data with more certainty. Unfortunately, long term abundance data are lacking for most California salmonid populations (Nehlsen, 1996). Having only short term data sets or data from only a few locations makes interpretation of trends difficult at best, due to the lack of historical context (Lichatowich, 1996) and the natural variability inherent to most fish species. Having data on the temporal patterns of abundance at many locations, both within and among basins, would be valuable when estimating extinction risks.

In theory, any life stage can be monitored (juveniles, adults, smolts) with equal information content. At small population sizes, however, deleterious genetic effects (e.g.,

genetic drift) may be important if the number of adults is small, which may not be detectable if only juveniles are monitored. In general, the quantitative relationships among abundances of different life stages are poorly understood and are subject to both geographic and temporal variability. Complicating factors include stochasticity in survival rates and possible density dependence, which in theory should be largely absent at small population sizes. The technical and practical aspects of collecting data on adult escapement, juvenile abundance in fresh water, and abundance of outmigrants (smolts) are discussed in more detail below, along with possible ways to obtain abundance data.

Spawning escapement (adult abundance). This is the number of adult fish that escape fishing pressure and other sources of mortality and reach freshwater habitat for spawning. This quantity is generally used in ESA-related population assessments. Walters (1996) states that the current need is for "innovative abundance indexing systems" to measure temporal and spatial distribution and timing of migration. Our interpretation of that statement is that, besides collecting data, we should develop models that can utilize varied types of abundance information, linking them with reasonable assumptions about model structure.

The abundance of spawners is a primary input into stock-recruitment models. In addition, estimates of spawning escapement are particularly useful in detecting possible problems of small population size (reduced effective population size, founder numbers in the case of recolonization, risks due to demographic and catastrophic factors). Spawning escapement data can be collected from direct weir counts, redd surveys, carcass counts, and from harvest data (when combined with other sources of data), among other methods. Unfortunately, collection is often hindered by extreme environmental conditions (e.g., seasonal flooding, poor water visibility) which can prevent field crews from accessing spawning areas. The cost of obtaining direct weir counts is high, while the accuracy of redd surveys, carcass counts, and harvest-derived estimates is often poorly known.

Smolt abundance. Because smolts have survived the freshwater phase of the life cycle, their abundance is sometimes used as an indicator of freshwater habitat quality, especially when the abundance of spawners producing them is known. As with adults, adverse environmental conditions (e.g., flooding) often hinder abundance sampling of smolts; the cost and effort of obtaining smolt abundance data are relatively high. Methods of collection include weir

counts, partial river sampling (e.g., using rotary traps), and estuarine sampling. As with other life stages, the relation of smolt to adult abundance is variable and often poorly understood.

Juvenile abundance. Due to the relative ease of sampling, juvenile abundance is the most common measure of salmonid abundance in California. The two most common methods of data collection are direct observation while snorkeling and census by electrofishing (Hankin and Reeves, 1988). No fish handling is required for direct observation, and therefore sampling mortality is low, whereas electrofishing can cause significant incidental mortality. Electrofishing is sometimes used to calibrate abundance estimates based on counts from direct observation.

Juvenile abundance sampling can also provide insight into life history characteristics, such as distribution in freshwater habitats. Juvenile counts have been compiled for many sites, over various time frames, in coastal California streams; they are thus the most common data type available to NMFS for evaluating abundance trends. In theory, back-calculation of adult abundance from juvenile abundance should be possible, given information on survival and fecundity. However, survival tends to be stochastic, and fecundity may be density dependent. Another approach would be to devise a modeling framework that could accommodate mixtures of juvenile and adult abundance estimates. Whether this is a fruitful line of research and whether juvenile abundance estimates can be used in modeling frameworks designed for adult abundances are topics requiring research.

Summary on Abundance Data. Abundance estimates for the three life stages described would be the ideal when evaluating salmonid populations. Unfortunately, adult and smolt abundance estimates are particularly expensive and difficult to obtain, because field conditions are often difficult and windows of opportunity for sampling can be short. Research is required to better understand relationships among life stage abundances, so that various types of data can be combined to obtain useful time series of abundance. Because most of the information available now and in the future will be summer juvenile counts, it is particularly important that the relationships among summer juvenile abundances, adult escapement, and smolt production are better understood. This will allow using available data sources and expanding juvenile sampling as a primary monitoring tool. As described

in §3.2, the Santa Cruz/Tiburon Laboratory has initiated research to investigate these relationships.

2.2.2 Life History Characteristics

We divide this extensive category into *demographic characteristics* (survival, fecundity, and age structure) and *distributional characteristics* (straying, migration, and relative geographical abundance) associated with habitat. As with abundance estimates, temporal patterns are of interest, as well as spatial patterns over broad areas. Although many life history characteristics are sensitive to environmental conditions, geographic patterns may also reflect local adaptations of evolutionary importance (Waples, 1995). Our understanding of risks and our development of population models would benefit greatly from information obtained from a wide geographic area, with later efforts focused on the spatial patterns of variation within and among basins. The cost of obtaining one-time estimates of many of these parameters would be moderate, although any statistical estimation procedure would involve replication on temporal or geographical scales, or both; obtaining time series of estimates, in order to explore the patterns and causes of temporal variation, would be much more expensive.

2.2.2.1 Demographic Characteristics

This group of characteristics includes those biological features that pertain to populations, or that are best expressed as averages across the individuals in a population. We consider survival, fecundity, and age structure.

Survival. The viability of salmonid populations is strongly dependent upon productivity (smolts produced per spawner) at low population sizes, which in turn can be described by stage-specific survival rates (i.e., egg-to-fry and fry-to-smolt survival). Regional variation in estimated stage-specific survival rates might provide insight into evolutionary processes (i.e., adaptation to habitat), although the relationship between life-stage-specific survival rates and habitat characteristics has not been fully developed. Obtaining such estimates would be expensive.

A possible constraint on salmonid population growth rates in California may be low summer survival due to high water temperatures; this contrasts with the importance of overwinter survival in Oregon streams. Because survival rates are usually measured by

monitoring changes in abundance over time, the practical problems in acquiring adult and smolt abundances apply to survival-rate estimates as well. For species that remain in fresh water for more than one year (e.g., steelhead), summer juvenile estimates may provide some measure of winter survival rates.

Fecundity. The number of eggs produced by a female of given size or age is the individual's fecundity, the primary link between the size of spawning population and so-called "spawning intensity" (Snyder, 1983). Fecundity is often assumed roughly proportional to the weight of an individual, so that a populations's total fecundity depends not only on the number of females, but also on the population's age- and size-structure. Because of that relationship, the long-term decrease in average spawner size in many coho salmon populations suggests a decrease in population fecundity (Weitkamp et al., 1995). When not related to changes in size, change in individual fecundity over time may indicate environmental variability or density dependence. Fecundity data are obtained from gravid females; this requires lethal sampling. Data from hatchery populations, although easier to obtain than data from wild stocks, may not accurately reflect fecundity in the wild.

Age structure. Although most coho salmon follow a 3-year life cycle to maturity, except for 2- year-old precocious males (Weitkamp et al., 1995), a few females returning at age 4 could have important effects for population viability by "rescuing" an otherwise temporally isolated lineage of spawners. Such temporal blending of spawning cohorts represents a pooling of genetic material that could also lessen or prevent deleterious genetic effects associated with small gene pools. The effects of age structure may be especially significant for steelhead, which show substantial variation in freshwater and marine residence times.

Knowledge of age structure is also important in estimating the speed (and likelihood) of a population's recovery from a depressed state. A population with a broader age structure is less likely to succumb to a catastrophic event. It is also believed that variation in age among the spawning population may increase the probability of spawning success, as fish of different ages may have slightly different spawning strategies.

Age structure of an entire salmonid population can be difficult to estimate, especially for species that spend several years in the ocean. In contrast, age structure of the spawning population can be estimated fairly easily from examination of hard parts and the develop-

ment and use of age-length keys. Where coded-wire-tag data are available, age structure can be estimated even more easily, as the ages of marked fish are known. Potential data sources include hard-part samples or length measurements from commercial and sport fisheries and otoliths or scales taken from fish during carcass counts.

2.2.2.2 Distributional Characteristics

This group of characteristics encompasses attributes of location and habitat, especially the varied locations and habitat conditions occupied by members of a population or subpopulation. For our purposes, we consider straying to be distinct from migration and distribution; that is, straying represents inter-population movements, whereas migration and distribution represent intra-population movements.

Straying. Salmonids generally return to natal streams to spawn; this tendency creates local breeding populations. Some fish stray into non-natal streams, the result being a meta-population structure. Estimates of straying rates can provide important insights into the recolonization potential provided by this structure (Schlosser and Angermeier, 1995). Regional patterns of straying rates and straying distances can be used to describe population isolation and delineation. If sufficient natural straying occurs, such potential problems as genetic drift and so-called "mutational meltdown" (accumulation of deleterious alleles) could be minor, rather than major, concerns.

A common way of estimating straying rates is with tagging studies, which tag young fish and recover tags from spawning adults. Because many young fish must be tagged to assure enough returns, tagging studies are expensive and effort-intensive and involve some of the logistical difficulties of sampling the spawning population. To reduce the cost, most large-scale tagging studies have been carried out on hatchery populations, which are assumed to behave the same as wild populations, but whose straying rates may, in fact, differ.

A relatively new technique of estimating straying rates uses stable isotope ratios measured from otolith cores of spawners. Watersheds have unique isotope signatures, which are recorded by young salmon in their otoliths. After laboratory characterization of the signatures of possible streams of origin, the natal stream of a spawner can be determined by analysis of its otolith; this has been done for Atlantic salmon by Kennedy et al. (1997). Advantages of this technique include eliminating the tagging of young fish, which saves

money, effort, and eliminates handing mortality. It seems worthwhile to evaluate this technique in California streams.

As for other information needs, initial efforts in estimating straying rates would benefit from focusing on selected sites spanning a wide geographic range. Later efforts would be focused, to the degree possible, on patterns of variation within and among basins.

Migration and Distribution. By migration, we mean movement within and among various habitat types (marine, estuary, freshwater). Data on the movements of juveniles in freshwater will be most easily collected and will provide some insight into the capacity of various freshwater systems to sustain salmonids. These data can be obtained through direct observation techniques or electrofishing, in conjunction with sampling for juvenile abundance, distribution, and habitat use.

Distribution data include information concerning the use and conditions of habitat types in the freshwater and estuarine environments. With appropriate planning and sampling, these data can be relatively easy to collect, with relatively little additional cost when done in conjunction with juvenile abundance sampling. Although data at a habitat scale are needed for detailed assessment of specific impacts, data at larger spatial scales would incorporate geomorphic properties of the larger-scale terrestrial environment and other environmental factors (such as hydrography, temperature, sediment inputs, land use, and migration barriers); this would provide additional information relevant at the population and metapopulation scales (Reeves et al., 1995).

2.2.3   Genetic Structure

Knowledge of genetic structure within and among populations is important when making management and conservation decisions, particularly to protect local populations (Allendorf and Waples, 1996). Indeed, the concept of evolutionarily significant units (ESUs) used by NMFS (Waples, 1991) to implement the ESA for Pacific salmonids relies on identification of genetic structure, which results from numerous biological processes occurring at spatial scales from single basins to much of western North America. Understanding its spatial and temporal patterns is important to the design and implementation of effective recovery and conservation measures for Pacific salmonids.

Samples used to determine genetic population structure and delineate ESUs represent snapshots of conditions at the time of sampling. It is also important to assess any changes of genetic diversity (e.g., heterozygosity, shifts in allele frequency) and develop an understanding of how to interpret genetic patterns. Such patterns can result, e.g., from gene flow among natural populations (straying), from gene flow into natural populations from hatchery fish, from the effects of small population size (e.g., genetic drift), or from local adaptation.

In general, we need to understand genetic population structure at two principal spatial scales, within and among basins. Much information is already available on the larger spatial structure, and this information has been used to help delineate ESU boundaries. Initial efforts at more intensive sampling should concentrate on smaller geographic areas, and an effort should be made to sample many adjacent streams at a fine scale (e.g., 1–50 km). The importance of this scale is that straying, which provides opportunities for recolonization following local extinction, occurs here. To understand genetic structure at this spatial scale, component tributaries within basins must be sampled. Ideally, such efforts will be made at several locations across a larger geographic area. To detect changes in genetic structure over time will require sampling on year-to-decadal time scales.

Genetic data can be obtained through various molecular tools. These genetic data include allele frequencies, restriction-site patterns, repeat-copy numbers, or nucleotide subsequences (Hillis et al., 1996). From such data, one can estimate genetic distances among populations, the amount of within-population and among-population genetic diversity, and one can attempt phylogenetic reconstruction. In addition, genetic data can be useful for estimating effective population size and dispersal, although assumptions of present models may limit their use (Weir, 1996).

Allozyme data have been collected and analyzed for many populations in California; with the advent of new techniques and development of new molecular markers, new insights are possible (Avise, 1994; Hillis et al., 1996). These new techniques allow explicating genetic structure at very small geographic scales, such as above and below migration barriers (Hillis et al., 1996; Nielsen et al., 1997). Although presently the cost of some new analyses is high, the amount of information gained is great, and with the advent of the polymerase chain reaction (PCR) technique, tissues can be acquired through minimally invasive methods, such as fin clips obtained during abundance sampling. Many archived samples

have not yet been analyzed with these new techniques, so that opportunities exist for gaining additional knowledge without extensive new sampling. However, comparison of new and archived samples will provide greater insight, including estimates of temporal changes. We therefore recommend that, to provide material for genetic analyses, tissue samples be taken whenever possible during abundance sampling and other field activities.

Hatchery influences. Knowledge of the effects of hatcheries is needed for several reasons:

•   Hatchery fish can carry disease into wild populations.

•   Hatchery-stock introgression into wild populations reduces the variability of the wild gene pool, and probably reduces average fitness.

•   If hatchery fish are not separately identifiable from wild fish, hatchery production will tend to mask declines in wild populations.

•   Hatchery production tends to induce higher rates of mortality on non-hatchery stocks though bycatch or hook-and-release mortality.

•   Hatcheries may be used as tools for recovery of endangered species.

The use of molecular markers should make it possible to obtain more sensitive and precise estimates of hatchery introgression into wild populations (Allendorf and Waples, 1996).

The importance of understanding hatchery effects is increased by the ESA implementation approach used by NMFS, which assumes that wild and hatchery fish can be treated as separate entities. However, the interaction between hatcheries and wild stocks depends on the genetic and disease-control protocols adopted by hatchery fish production, as well as other aspects of their production and release practices. The topic of hatchery influences is a large and complex one, and it was not possible to treat it in sufficient detail at this workshop. As stated in §5, we recommend convening a workshop devoted to this topic alone.

2.3   Summary of Data Needs and Priorities

Data on abundance, stage-specific survival, and population structure (delineation and isolation) are the most important needs (Table 2, p. 37). Given the reliance on abundance time series in conventional population models, such data are of very great importance. Because of the great difficulty of estimating adult abundance in California streams (§2.2.1),

we recommend continued emphasis on estimates of juvenile abundance, coupled with estimation of adult abundance in selected streams and studies of the relationship between juvenile and adult abundances. Such studies will likely require estimation of survival rates, and recovery planning itself will require stage-specific survival estimates to assess where critical bottlenecks in survival occur.

The understanding of population structure, including straying rates and the age structure of spawning populations, is key to understanding whether genetic effects at low population sizes are important factors for California salmonids. Information on straying rates describes how salmon populations from separate streams within an ESU influence one another, and information on the age structure of spawners describes the degree of temporal mixing within a system.

Population structure may well be affected by hatcheries, which operate on many California streams and rivers. This workshop was unable to discuss in detail the data necessary concerning hatcheries nor what role, if any, NMFS should take in setting standards for hatchery operations. We recommend that a workshop be convened on this important topic.

Data on present status are most useful when put into historical perspective. This is especially true when, as in the case of California salmonids, present population levels are depressed. For this reason, a high priority should be given to research, such as that described in §3.2, that could reconstruct historical abundance trends from biomarkers such as tree rings. We note that similar studies have been successful for a variety of species.

Likewise, information on present status of habitat conditions is also most useful when put into historical perspective. Cumulative effects associated with land management have made it difficult at best to define the relationships between long-term trends in fish abundance and land management and how this relationship is linked to the effects of land management on freshwater habitat conditions (Bisson et al., 1992). A high priority should be given to obtaining information that integrates survival studies with land management and effects on habitat conditions within watersheds.

The data categories summarized in Table 2 are not mutually exclusive, and gathering data on other categories is bound to be useful from scientific and management perspectives. Nonetheless, addressing the paucity of information on basic population characteristics such as abundance, survival, and population structure should be our top priority.

3   State of Information on California Coho and Steelhead

A review of ongoing data collection (Appendix C) extends data summaries reported in recent NMFS Status Reviews (Weitkamp et al., 1995; Busby et al., 1996). The review includes two ESUs of coho salmon and five of steelhead. It is notable that very few data series in Appendix C extend back before the early 1990s, and fewer still beyond the late 1980s. Most of the sampling has been fixed-length index-reach sampling of juveniles, usually by electrofishing. There are very few series of adult (spawner) or smolt (outmigrant) abundance data. Sampling protocols vary widely, and index-reach sampling, by definition, is not random, a factor that complicates its expansion to larger scales.

3.1   Concerns

Workshop participants identified several important issues concerning present abundance sampling on California coastal salmonids. It is apparent from Appendix C that California lacks comprehensive data collection for coastal salmonids. A further concern is the lack of coordination among the sampling programs that do exist. Generally, the focus in California has been on estimating summer abundances of juveniles, rather than of adults (spawning escapement); however, elsewhere in the Pacific northwest, the focus has been on estimating adult numbers. These issues have increased the difficulty of making population abundance estimates and risk assessments needed for ESA listing, monitoring, and recovery in California.

Because of the lack of comprehensive monitoring and coordination, we currently lack precise estimates of the status of these salmonids, and we know little about their abundance patterns in the past. There is no central data repository, so it is still not clear what data are currently being collected. Existing data are not always available to NMFS for risk assessments or tracking regional population trends; if available, the data can be difficult to obtain and interpret. Thus, the dispersal of existing data causes ongoing, complex problems.

3.2   Research in Progress

The estimated abundance of spawning adults is the conventional measure used in ESA assessments of salmonid populations. For that reason, the estimates of summer juvenile abundance more commonly available in California can be difficult to use with existing assessment methods. It is hoped that summer-juvenile abundances can be used as proxies for spawning abundances, but the relationship between the two life stages is variable and has not been well studied. It is logical that monitoring a population at any stage of the life history should provide similar information to that obtained from monitoring another stage, but if small-population effects such as genetic drift are of importance, then the monitoring of spawner abundance is necessary, especially at very low population sizes.

The SWFSC Santa Cruz/Tiburon Laboratory is conducting research to improve our understanding of the relationship between juvenile and adult stages. A research project in cooperation with the University of California at Santa Cruz is investigating the relationship between summer juvenile abundances and (adult) spawner abundances. The research includes collection of matched data on both life stages; it also includes a modeling component to characterize the relationship under various sets of assumptions. This research is expected to resolve some of the biological and procedural issues that surround the use of juvenile abundance estimates for ESA analyses in California.

The Santa Cruz/Tiburon Laboratory has also begun a pilot study to determine whether historical population abundance trajectories can be reconstructed through examining stable-isotope ratios in streamside vegetation. This seems feasible, and indeed natural abundance of ^{15}N in lake sediments is currently being used to get qualitative estimates of historical sockeye spawning abundances. With adequate sampling, questions such as these may be answered:

- What is the current spawning population size, and what did it use to be?
- How variable has salmonid abundance been, and how much has the southern distribution limit moved?
- What are the dominant modes of salmonid variability (i.e., how long do good and bad periods last), and what climate and ecosystem proxies are correlated?
- Which watersheds are refuges, and which are sinks during unfavorable conditions?

- What is the frequency distribution of local population extinction?
- What were the pre-fishery population dynamics like?

Thus, the proposed research could provide a historical perspective, now absent, for data collected in the present and future. In doing so, it could greatly improve our understanding of salmonid variability over several time scales.

The SWRO has recently begun research to assess habitat characteristics and the relationship between specific habitat features to juvenile salmonid survival. In development of conservation planning efforts on federal and non-federal lands, the goal is to restore the natural functions and processes essential for properly functioning fish habitat. Much of the research assessing fish habitat has been conducted on Douglas fir ecosystems in Washington and Oregon. The SWRO has begun studies to characterize riparian condition and the role of large woody debris in habitat factors and fluvial geomorphology in the coastal redwood ecosystem.

Related research, initiated by the SWFSC Santa Cruz/Tiburon Laboratory in cooperation with Humboldt State University, will examine several streams at several levels of watershed and habitat quality and will relate freshwater survival rates of coho salmon to the perceived quality of the streams.

3.3 Summary of Present Data Collection Efforts

A fair amount of sampling is now being done in California; however, it lacks coordination, a common protocol is not used, and most data series are short. It is not apparent how much of the current sampling effort can be used in ESA recovery deliberations. Much of the sampling has a strong habitat connection, with the goal of developing the means to use some habitat variable (as yet undefined) as a proxy for fish numbers or as an index of the potential for freshwater habitat to support fish production. However, this is quite an indirect approach, and it seems unlikely that any single habitat variable or small suite of variables could encompass all factors that influence fish abundances. The SWFSC's Santa Cruz/Tiburon Laboratory and the SWRO are engaging in research that could improve this situation over time; however, that work in itself does not constitute a plan for overall data collection in California.

4. Strategies for NMFS Involvement in Data Collection

To discharge our obligations under the ESA, NMFS must make informed, science-based decisions on conservation and recovery of listed salmonids in California coastal streams. Monitoring these salmonids to assess status and trends, including risk of extinction, implies the need for estimates of abundance and other characteristics, as described in the preceding sections. There is strong need for coordinated, comprehensive data collection on coastal salmonids statewide, and a corresponding need to clarify the role of NMFS in this data collection effort. The role of NMFS was central to the workshop discussions.

Three possible levels of NMFS involvement were put forward to stimulate discussion (Table 3, p. 38). The three possibilities cover a wide spectrum of possibilities and are not exclusive, nor do they necessarily represent realistic choices. Nonetheless, the level of involvement of NMFS will be somewhere along a continuum from no involvement at all to total responsibility for all aspects of data collection (Table 3).

In considering these options, it was apparent that collection of various types of data requires different levels of involvement by NMFS. Long-term abundance time series are very influential in decisions concerning the status of salmonid populations, and the need to monitor abundance at comprehensive temporal and spatial scales was considered very important by workshop participants. This would require a cooperative effort from various federal, tribal, state, local, academic, and private agencies and organizations. Long-term, comprehensive abundance sampling can most effectively be done by organizations other than NMFS, with NMFS assuming a leadership role that includes coordinating data collection, providing training and technical expertise, and establishing a central data repository. Even these leadership activities need not all reside directly in NMFS, but would require sufficient participation by NMFS to monitor data completeness and quality and to assure that data reviews occur in a timely fashion.

A more direct role by NMFS was envisioned in several areas. For example, NMFS should be prepared to conduct its own sampling in various geographical areas to fill data gaps. Also, NMFS might choose selected streams for long-term sampling, to provide base-line data against which sampling by other agencies can be compared and to maintain

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familiarity with conditions in the field. Focused research on life history characteristics, associations among various types of data, habitat associations, and genetic characteristics may also require direct NMFS research, which can serve as the foundation for the development of new methods and protocols. Finally, research on sampling methods and development of protocols should be vigorously pursued under direct NMFS leadership.

In conclusion, the participants at the workshop acknowledged the need for a coordinated plan including several levels of involvement by NMFS, based on the type of data to be collected. In the language of Table 3, NMFS would assume a leadership role in collection of time series of abundance data, while assuming more direct responsibility in filling other data needs and in development and refinement of methods and protocols. The leadership role would include a range of activities, all of which will require cooperation and coordination with various governmental and nongovernmental organizations. In fulfilling its leadership role, NMFS should develop a comprehensive sampling program that outlines specific types of monitoring, ensure coordination in data collection, and sponsor and maintain a central data repository to ensure that the data collected are available for regulatory decisions and biological studies.

4.1   Possible Use of ESA §10 Permit with NMFS as Permit Holder

Research and Enhancement permits, issued by NMFS under §10(a)(1)(A) of the ESA, are required for all activities involving the direct (intentional) take of listed species. Currently, permit holders statewide represent a wide spectrum of interests; their research programs have varied purposes and protocols. Given that NMFS needs a more standardized approach for data gathering to discharge its obligations under the ESA, a vehicle to accomplish this would be NMFS's holding its own permit, with the intention of specifically defining its data needs, establishing field protocols, providing studies oversight, and managing study data.

The permit application(s) would be prepared as if multispecific and statewide studies were actually being performed by NMFS (with definition of purpose, geographic areas, methods, etc.), but with the intention that other qualified organizations would actually perform the work as agents authorized by the permit. Investigators not willing or not able to subscribe to these limitations could apply for independent permits.

The primary difference between this approach and traditional application procedures concerns the order of project review by NMFS prior to authorization. Traditional procedures evaluate individual studies through the agency- and public-review process (including geographic location[s] and personnel qualifications) and then incorporate them into the overall review/evaluation purpose through an analysis in an internal biological opinion. With NMFS as the permit holder, studies would be comprehensively defined by objectives, methods, and scope. NMFS would qualify individual participants and study locations after issuance, without additional national review of the permit.

A NMFS permit would offer a streamlined approach to field researchers, as compared to traditional application procedures. It would be used where independent investigations are similar in purpose, data coverage is needed by NMFS, and the investigator agrees to follow NMFS's established protocols and reporting formats. Investigators subscribing to this vehicle to conduct their studies would require only minimal formal review within the Southwest Region to be added as an agent on the permit.

The responsibilities of NMFS within the NMFS–agent relationship would be delivery of study design, evaluation of data needs, qualification of participants, provision of technical assistance and training, and definition of the scope and conditions of the permit.

The agent's responsibility to the NMFS–agent relationship would be conducting studies within the scope of the permit, cooperatively developing field applications to meet data needs, and providing data and reports within an agreed format and time frame.

4.2   The Potential Role of Habitat Conservation Plans

The Habitat Conservation Plan (HCP) program, under §10(a)(1)(B) of the ESA, has many applicants in coastal California who are developing HCPs to obtain incidental-take permits for salmonids. Most of these applicants are large, industrial, timberland owners, whose property, located between the coast and higher-elevation National Forests, provides key habitat for coho salmon and other salmonids. Thus HCPs will play a significant role in recovery planning, and as such should provide information necessary to the SWRO in assessing recovery trends.

Although applicants must still obtain §10(a)(1)(A) research and enhancement permits, HCPs should lay the foundation for monitoring and adaptive management. Key

to the development of HCPs are (1) scientifically based biological goals and objectives, (2) adaptive management to deal with uncertainty and significant data gaps, and (3) monitoring to assess compliance, project impacts, and to verify progress toward the biological goals of the HCP. Given that HCP permits are often of a duration of decades, it would serve both the SWRO and the SWFSC to develop strategies with HCP applicants to address data needs in assessing population status and trends and for recovery planning.

5 Achieving Scientific, Logistic, and Administrative Objectives

Workshop participants assembled a list of recommended action items; some of the recommended actions were completed, or at least solutions were recommended, at the workshop. Those items are marked with an asterisk (*) in the following list:

1) NMFS must acknowledge its primary responsibility to ensure that data needed to discharge our obligations under the ESA are collected, either by NMFS or by other entities. (*)

2) NMFS must define what information must be collected.*
   a) Define sampling requirements and their priority for management.*
   b) Define the level of NMFS participation in collecting those data ranging from primary responsibility for direct monitoring to periodic participation and training.*
   c) Identify work best performed by NMFS.*

3) Internally communicate data needs and formulate budget proposals associated with conducting various levels of NMFS monitoring.
   a) Cost of NMFS conducting all sampling and research.
   b) Cost of NMFS conducting only specific monitoring activities, protocol development, and research projects, and playing a leadership role (coordination, education, planning) for the balance of requirements.

4)   Communicate NMFS's data requirements to those entities who can either supply the data or potentially initiate programs to collect the data.

5)   Explore opportunities for partnerships with other agencies, for example:
     a)   *Federal agencies:* Bureau of Reclamation, Bureau of Land Management. Environmental Protection Agency, Fish and Wildlife Service, Forest Service, U.S. Geological Survey, National Park Service, Natural Resources Conservation Service.
     b)   *Tribal governments:* Yurok, Hoopa, Karuk, Roundvalley.
     c)   *State agencies:* Department of Fish and Game, Department of Forestry and Fire Protection, Water Resources Control Board, Regional Water Quality Control Boards, Department of Mines and Geology.
     d)   Counties, municipalities and local agencies.
     e)   Explore cooperation with watershed councils and other non-governmental organizations, and provide appropriate leadership and training.
     f)   Explore including in HCPs specific monitoring requirements to address NMFS's data needs.
     g)   Consider the issuance of a §10(a)(1)(a) permit to NMFS that would be used to facilitate definition of data needs, standardization of field protocols and coordination of data management.

The following two areas require further work for NMFS to formulate plans of action:

1.   Data gathering on hatchery releases and practices and discussion of a possible NMFS role in guiding hatchery operations.
2.   Data collection and modeling approaches for California coastal chinook.

Although not thoroughly discussed at this workshop for lack of time and because of their specialized nature, these two areas are critically important. We recommend that additional workshops be held on these two topics as soon as practical.

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6   Conclusions

Southwest Center and Region personnel met to develop a strategy for ensuring that NMFS will have access to critical data for management of ESA-listed salmonids. Participants identified data needs for management and scientific objectives. The outcome of the meeting, as discussed in this report, was to outline an agreed course of Center–Region action in the Southwest.

Though the stewardship responsibility for salmon in California is shared with the State of California and managers of salmon habitat, NMFS is responsible under the ESA for threatened and endangered salmonids. That responsibility requires that NMFS assume a leadership role to ensure that necessary data are collected in the quality and scope that will support the protection and recovery of listed populations. Without large increases in resources, NMFS could not possibly implement the full suite of data collection projects desirable for salmonids. NMFS, however, can and must guide potential cooperating agencies and private land owners in a coordinated effort to collect those data. The Tribes, the State of California, local governments, and the private sector are all potential cooperators in conservation and recovery of salmonids.

Presently, NMFS is engaged with the State Watershed Protection and Restoration Council to develop a joint State Salmonid Conservation Strategy. We have also signed a Memorandum of Agreement with the State of California to address the conservation of steelhead. One element of this Memorandum is a review of the California Forest Practice Rules, as land use practices, particularly those associated with timber harvesting, have been important in the decline of coho salmon. Key to addressing the decline of coastal salmonids is the development of baseline data on populations and the quality and use of fish habitats. This information is not now available from the State of California, nor has the state made us aware of any strategy to collect such information. For NMFS to make informed, science-based decisions on conservation and recovery of listed salmonids, therefore, NMFS itself must initiate the collection of these data sets and habitat assessments.

The consensus of meeting participants is that NMFS must develop and publish, or endorse, the necessary sampling protocols and develop the experimental design and budget

plans to provide this information. NMFS clearly has an obligation to carry out the mandates of the ESA, and therefore NMFS must establish a monitoring and research program to follow up the listing decisions it has made. We believe that there is a clear benefit to federal, tribal, state, local, and private sector participation in this effort. We believe that there are significant opportunities to develop partnerships that serve to meet NMFS objectives to comply with the ESA. These opportunities are predicated on NMFS's recognizing its responsibilities and clearly specifying its needs and objectives.

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Table 2. Data types and priorities for monitoring coastal California salmonids

General data type	Specific data type	Desirability[a]	Cost[b]
Time series of abundance			
	Escapement	A	$$$
	Smolt production	B	$$$
	Juvenile abundance	B	$
Life history characteristics			
Demographic	Survival (stage-specific)	A	$$
	Age structure	A	$$
	Fecundity	B	$
Habitat associations	Straying	A	$$
	Migration	C	$$
	Distribution	C	$
Genetic structure			
	Population delineation or isolation	A	$$
	Hatchery influences	C	$$

a - Relative desirability is rated A, most desirable; B, very desirable; or C, desirable.

b - Relative cost is rated $$$, high cost; $$, moderate cost; or $, low cost.

Table 3. Three possible levels of NMFS involvement in data collection.

	No NMFS involvement	NMFS assumes leadership role	NMFS conducts all data collection
Cost	No direct costs	Moderate direct costs	High cost
Quality assurance	No control	Good control	Total control
Data coverage	No control	Good control	Total control
Timeliness	No control	Fairly good	Possibly best

Appendix A. Workshop Agenda

Wednesday, August 12, 1998

(1)   Introductory Remarks: Mike Prager, Rod McInnis.

(2)   Data Needs for Management and Recovery of Coastal Salmonids.
        Discussion leader: Paul Spencer; *Rapporteur:* Pete Adams .

(3)   Current State of Information for Coastal Salmonids.
        Discussion leader: Pete Adams; *Rapporteur:* Paul Spencer.

(4)   The Identification of Strategies for the Collection of Data: What is the need for NMFS
        Involvement?
        Discussion leader: Pete Adams; *Rapporteur:* Paul Spencer.

(5)   How Will the Work Get Done? Identification of Action Items Necessary to Overcome
        Scientific, Logistic, and Bureaucratic Obstacles.
        Discussion leader: Rod McInnis; *Rapporteur:* Dan Viele.

(6)   Relation Between ESA Management Obligations and Quality of Empirical Information.
        Discussion leader: Rod McInnis; *Rapporteur:* Pat Rutten.

(7)   Development of outline for report and assignment of writing responsibilities.

Thursday, August 13, 1998

(8)   Draft and review report.
(9)   Adjourn.

Appendix B. Workshop Participants

Name	Affiliation	Position[a]
Peter Adams	SWFSC, Tiburon (CCB)	Salmon field program chief
Greg Bryant	SWRO, Eureka (PRD)	Status review coordinator
Tom Hablett	SWRO, Santa Rosa (PRD)	Program coordinator, §10 permits
Rod McInnis	SWRO, Long Beach	Deputy Regional Administrator
Sharon Kramer	SWRO, Arcata (PRD)	Regional science coordinator
Jan Mason	SWFSC, Monterey	(Attending as observer)
Michael Prager	SWFSC, Tiburon (SAB)	Chief, Salmon Analysis Branch
Pat Rutten	SWRO, Santa Rosa (PRD)	Supervisor, N. California
Paul Spencer	SWFSC, Tiburon (SAB)	Coho population dynamicist
Dan Viele	SWRO, Long Beach (FMD)	Ocean-harvest §7 permits
Thomas Williams	SWFSC, Tiburon (CCB)	Salmon field program: leader of development, training and coordination

[a] In most cases, these are short descriptions of major job activities relevant to this workshop, rather than formal job titles.

Key: CCB: Coastal Communities Branch; FMD: Fishery Management Division; PRD: Protected Resources Division; SAB: Salmon Analysis Branch; SWFSC: Southwest Fisheries Science Center; SWRO: Southwest Regional Office

Appendix C. Ongoing Data Collection Efforts

Note: This review of data collection efforts in several ESUs is intended to be illustrative, not definitive. This information should not be used as the basis for regulatory actions. Please see text ($3) for further information. Editor of this Appendix: Peter Adams.

Coho—Central California ESU

ESU-wide data

> Status Review: Brown and Moyle 20-fish rule
> Review Meeting: Presence–absence data

Location Specific Data (South to North)

> Santa Cruz/San Mateo Counties
>> **Scott, Waddell, and Gazos Creeks:** Juvenile index reach sampling, 1992–present. Future Plans: California DFG plans continuation of juvenile index reach sampling on Scott, Waddell, and Gazos Creeks, adult surveys on Scott, Waddell, and Gazos Creeks, undefined sampling on other historical coho streams.
>> **Soquel Creek:** Juvenile index reach sampling, 1994–present.

> Marin County
>> **Redwood Creek:** Juvenile index reach sampling, 1992–present.
>> **Lagunitas Creek:** Juvenile index reach sampling, 1993–present; some adult sampling since 1994.
>> Future Plans: Consortium plans Hankin-Reeves abundance estimates and adult surveys.

> Sonoma County

Russian River - Green Valley, Santa Rosa, and Maacama Creeks: Consultant seines juvenile index reaches, 1993–present.

Future Plans: Sonoma County Water Agency plans future monitoring involving juvenile index reaches and outmigrant trapping; DFG intends to do juvenile index reach sampling, beginning this year.

Mendocino County

Gualala River: No sampling.

Garcia River: Miscellaneous adult surveys from 1990–91 to 1996–97.

Navarro River, LNF: Miscellaneous juvenile sampling, 1994–97.

Big Salmon Creek, Big River, NF of the Noyo River, Pudding Creek, Ten Mile River, Usal Creek: Juvenile index reach sampling, 1993–present.

Ten Mile River and Big Salmon Creek: Basinwide juvenile abundance estimates, 1997–present.

Albion River and Noyo River: Sampling data unavailable.

SF of Noyo Adult Counts: Partial-season adult counts, 1970s–present.

Little River, Caspar and Pudding Creek: Juvenile index reach sampling, 1988-present.

Little River, Caspar and Pudding Creek: Outmigrant trapping, 1992–present.

Humboldt County

None

California Portion of the Southern Oregon - Northern California Coho ESU

ESU-wide data

Status Review - Brown and Moyle 20-fish rule

Review Meeting - Presence-absence data

Location Specific Data (South to North)

Humboldt County

Mattole River: Outmigrant trapping on main stem and Bear Creek, 1993–present. Miscellaneous juvenile surveys.

Thompson Creek: Juvenile index reach, 1988–present (?).

Rattlesnake, Oil, and Green Ridge Creeks: Juvenile index reach, 1991–present (?).

Eel River
South Fork
South Fork: Adult snorkeling, 1968–present.
Hollowtree Creek: Juvenile index reach, 1988–present.
Sproul and Redwood Creek (SF of the Eel): Juvenile index reach sampling, 1988–?present.
Canoe, Bull, Squaw, and Cow Creeks: Juvenile index reach sampling, 1996–present.
Middle Fork
Ryan Creek (off Outlet): Juvenile index reach sampling, 1988–present
Bear and Monument Creek: Juvenile index reach sampling, 1997–present.
Van Duzen River
Lawrence and Shaw Creek: Juvenile index reach sampling, 1991–present.

Redwood-Prairie Creek
Upper Prairie Creek, Boyes, and Steelow Creek: Outmigrant trapping, 1994?–present.

Trinity River (Willow Creek): Outmigrant juvenile trapping, 1992–present.
Canon Creek: Juvenile index reach sampling, 1988–?present.
New River: summer juvenile surveys, 19??–present.

Del Norte County

Klamath River, McGarvey, Tarup, and Ah Pah Creeks: Juvenile index reach sampling, 1988–present(?).

Smith River
Mill Creek: Adult surveys, 1980 –present; outmigrant trapping, 1994 –present.

Siskiyou County

Iron Gate Dam: Adult Counts, 7-98 –present.

Klamath River (Big Bar): outmigrant trapping, 1992–present.

Klamath River, Bogus Creek: summer juvenile surveys, ?–present.

Steelhead Trout (In addition to the coho sampling)

Southern California ESU

ESU-wide presence-absence sampling.
> **Santa Ynez River:** Outmigrant trapping, summer surveys, 1993–present.

South-Central California Coast

ESU-wide presence-absence sampling
> **San Simeon and Santa Rosa Creeks:** Juvenile sampling, 1993–present.
> **Carmel River:** Adult escapement, 1991–present, miscellaneous juvenile sampling.

Central California ESU

ESU-wide presence-absence sampling
> **San Lorenzo River:** Juvenile sampling, 1993–present.

Northern California ESU

ESU-wide presence-absence sampling
> **Benbow and Mad River Dam counts:** Status review ending in mid-1970s
> **Van Arsdale sampling:** Dam counts, juvenile sampling, 1991–95.

Klamath Mountain Province ESU
(Includes sampling for coastal cutthroat trout)

ESU-wide presence-absence sampling
> **Klamath River**
> **Lower Klamath:** Seining at several locations, 1990–present

EF Indian, O'Neill, Grieder, and Walker Creeks: Juvenile index reach sampling, 1997–present.

Blue Creek, McGarvey and Hunter Creek: Outmigrant trapping, 1996(?)–present.

Blue Creek: Adult snorkel survey, 1995–present.

Shasta River: Outmigrant trapping, 1996–present.

Scott River

Canyon, Kelsey, and Thompson Creeks: Juvenile index reach sampling, 1997–present.