14. Southern California Steelhead Research, Monitoring and Adaptive Management

"The analytic tools to evaluate species health have been greatly developed in recent years. The emergence of extinction theory from population genetics and ecology, the combination of demography and genetics in population viability analysis and the extension of risk analyses into the realm of biological conservation promises to lead us to wiser allocations of effort in the future."

Science and the Endangered Species Act, National Research Council, 1995

14.1 INTRODUCTION

Recovery of southern California steelhead will require a more thorough understanding of the distinctive biology of steelhead within the SCS Recovery Planning Area. Additionally, it is crucially important to identify a program for monitoring the status of individual populations and the DPS as a whole, and a plan for tracking and adjusting the recovery actions and recovery strategy over an extended period to optimize the effectiveness of the recovery effort. The following sections outline the basic elements of a research, monitoring, and adaptive management program, and identify high priority research and monitoring actions.

14.1.1 Southern California Steelhead Research

In 2002 NMFS convened a team of scientific specialists, the Technical Review Team (TRT), whose mission was to survey existing scientific information on steelhead ecology, and formulate a biological framework for a recovery plan for Southern California steelhead (Boughton *et al.* 2007b, 2006, Boughton and Goslin 2006, Boughton *et al.* 2005, Boughton and Fish 2003).

The current state of knowledge of steelhead ecology is largely descriptive and qualitative. This has led to uncertainties in the viability framework, including developing quantitative goals for distribution and abundance of steelhead trout and general strategies for how to achieve these goals. In general, the TRT approached uncertainty about recovery goals with a risk-averse, or precautionary, stance, consistent with accepted practice in conservation biology (McElhany *et al.* 2000). The TRT also recognized that key uncertainties involved in recovery planning arose from the qualitative nature of the current understanding, and could be improved by a carefully conceived and planned program of scientific research and monitoring. The benefits of pursuing such a program would be a more effective, and more-cost efficient, recovery effort for steelhead.

Recovery of southern California steelhead will depend upon a quantitative framework that addresses their annual run size, along with year-to-year variability over the long term; and the quantitative response of steelhead runs to specific recovery actions. These are related to the two overarching questions of steelhead recovery in this region:

- ☐ How do we improve the distribution, abundance, and resilience of steelhead trout populations; and
- ☐ How much do we need to improve these biological characteristics for steelhead to be considered viable and eligible for down-listing and/or delisting?

The following sub-sections focus on the viability criteria developed by the TRT, and a series of related research questions grouped into three areas: enhancing anadromy, clarifying the population structure of *O. mykiss*, and planning for climate change.

14.2 VIABILITY CRITERIA

The viability criteria address two levels of biological organization, populations within the Distinct Population Segment (*i.e.,* only the anadromous form), and the more encompassing Evolutionarily Significant Unit (ESU), which includes all life history forms. The *O. mykiss* ESUs in this Recovery Planning Area are composed of both anadromous and non-anadromous fish, but only the non-anadromous form is on the endangered species list, under the DPS provision of the Federal Endangered Species Act. One of the principal uncertainties is the complicated relationship between the anadromous and non-anadromous (or freshwater-resident) forms of the species. Following convention, the term "steelhead trout" is used for the anadromous fish, "rainbow trout" for non-anadromous fish, and "*O. mykiss*" when referring to both or either. The goal of the Recovery Plan is to ensure the continued persistence of steelhead trout in the region over the long term (Boughton *et al.* 2007b), but it is likely that rainbow trout have some role in securing this future, and thus the viability criteria have provisions for both forms of the species.

14.2.1 Population-Level Criteria

The TRT considered *O. mykiss* in the region to be grouped into demographically - independent populations. Generally, each discrete coastal watershed in the region was assumed to have historically supported one demographically independent population of *O. mykiss.* If migratory steelhead frequently move from one watershed to another, the one-watershed-one-population assumption may have some important exceptions with implications for recovery planning.

The TRT proposed population-level viability criteria for determining whether a demographically- independent population of *O. mykiss* should be considered viable for the purpose of steelhead recovery. The TRT identified two choices for meeting the viability criteria. The first was to meet a set of criteria: a population must exhibit a mean annual run size of at least 4,150 steelhead trout, including during periods of poor ocean conditions (such as occurred from the late 1970s through early 1990s). Additionally, the spawner densities in the river systems needed to meet a minimum density threshold (fish per kilometer of stream channel at some scale), a quantitative criterion yet to be determined. The second choice was to meet a performance-based criterion, demonstrating that the extinction risk for steelhead trout is less than 5% over 100 years, using commonly accepted quantitative methods from conservation biology, demographic data from the population in question, and passing an independent scientific review.

Extinction risk is very sensitive to both annual run size and year-to-year variability. As a result, the performance-based criteria cannot be applied in a meaningful way until run sizes have been monitored for a decade or more, allowing this key quantity to be estimated with reasonable accuracy. In the interim, the prescriptive criteria ensures that the year-to-year variability in run size, whatever its probable magnitude, is unlikely to pose a significant risk to the species. If year-to-year variability turns out to be relatively modest, a mean run size smaller than 4,150 steelhead would perhaps be sufficient to ensure a low extinction risk. Including the option for performance-based viability criteria, provides a mechanism for refining the viability criteria as more is learned over time.

Extinction risk for individual steelhead runs may also be sensitive to the influence of rainbow trout, if the trout tend to stabilize or augment those runs as a result of rainbow trout regularly producing anadromous progeny. This phenomenon is referred to as "life history crossovers," but it is not yet known whether such crossovers occur frequently enough to stabilize steelhead runs. This is another key uncertainty that, if resolved, might allow the run-size criterion of 4,150 spawners per year to be adjusted. In this case, the adjustment would be that some fraction of the 4,150 spawners within a watershed or metapopulation would need to exhibit the anadromous life history, rather than 100%. Additionally, data on the magnitude of natural fluctuations in anadromous run sizes in individual watersheds may identify a smaller mean run size is sufficient for viability in some basins (Williams *et al.* 2011). Until such research is undertaken and revisions made to the viability criteria, the population-level viability criteria for determining whether a demographically-independent population of *O. mykiss* should be considered viable for the purpose of steelhead recovery would remain 4,150. This criteria will be reviewed during NMFSs 5-year review of the Recovery Plan, and potentially during the Southwest Fisheries Science Center's 5-year status review update for Pacific salmon and steelhead listed under the ESA..

In the absence of specific information about the role of life history crossovers, the TRT took a precautionary approach (*i.e.,* it was assumed there was not any beneficial effect of crossovers). This meant that the 4,150 spawners per year required for viability must be composed entirely of steelhead trout, rather than a mixture of rainbow and steelhead to ensure viability. However, the TRT also believed that the criteria should cover the possibility that the beneficial effect of crossovers not only exists, but is necessary for viability of the listed species. This led to additional criteria that the anadromous and freshwater resident life history types should both be expressed in populations for them to be considered viable.

It would be useful to learn whether rainbow trout significantly enhance or stabilize steelhead runs. If rainbow trout progeny crossover does in fact have a beneficial effect on steelhead runs - and its magnitude can be quantified - such knowledge could be used to revise the criteria for anadromous fraction criteria, or it could be incorporated into a performance-based assessment of risk, possibly resulting in different run size and anadromous fraction criteria. Research into these topics is essential to resolve these issues in a way which maintains acceptably low extinction risk to the species.

14.2.2 ESU/DPS-Level Criteria

The TRT outlined a set of ESU/DPS-level criteria, which, if met, would indicate that a steelhead Distinct Population Segment has been successfully recovered. Satisfying the ESU/DPS-level criteria requires a set of *O. mykiss* populations in which:

- ☐ Each population satisfies the population-level criteria described above, and

- ☐ The set of populations as a whole satisfies requirements for ecological representation and redundancy, and
- ☐ The set of populations as a whole exhibit all three life history types (fluvial-anadromous, lagoon-anadromous, freshwater resident)

The criteria for representation and redundancy have two purposes. First, to protect the genetic and ecological diversity that ensures the long-term viability of the species under changing conditions, the set of populations should represent the entire range of ecological and genetic conditions originally present in the ESU/DPS. Second, to protect against catastrophic loss of entire populations due to disease, forest fires, drought, *etc.*, the set of populations should exhibit redundancy with respect to the range of ecological and genetic conditions originally present in the ESU. This ensures that if, for example, entire populations are lost from a particular ecotype, there will be at least one other population in that ecotype that survives, and can serve as a reservoir of individuals retaining the genetic and phenotypic adaptations necessary for inhabiting that ecotype. Ultimately, such individuals would be necessary for recolonizing the watersheds.

The TRT developed criteria for representation and redundancy by grouping the region's populations of *O. mykiss* into biogeographic groups, and specifying a minimum level of redundancy (number of viable populations) within each group. In addition, the TRT recommended that the core populations should inhabit watersheds with drought refugia, should be separated from one another by at least 42 miles if possible, and should exhibit three life history types—the rainbow trout form described previously, and two forms of steelhead trout, the lagoon-anadromous form and the fluvial-anadromous form.

The biogeographic groups were delineated on the basis of geographic proximity, broadly similar climate, and aspects of physiography that are relevant to the fish (see Table 5 and Figure 5 in Boughton *et al.* 2007b). Summer air temperatures, which strongly influence whether summer stream temperatures are cool enough for the fish, were a key consideration. The most important split was between coastal groups of populations, in which cool mesoclimates are maintained by proximity to the ocean, and interior groups of populations, where cool mesoclimates are primarily confined to mountain ranges, and are maintained by the temperature lapse rate (i.e. the reduction in temperature with increased elevation).

The criteria for redundancy within each biogeographic group were based on an assessment of catastrophic risks posed by wildfires and debris flows. However, the assessment was based on historical pattern and did not include considerations of climate change, which could have a large impact on the region. See Chapter 5, Southern California Steelhead and Climate Change.

The TRT also considered the catastrophic risk posed by drought, but could not incorporate it into the criteria due to insufficient information. The broad spatial extent of the typical drought in the region indicated that simple redundancy was not a suitable strategy for protecting the species from its effects. Watersheds having potential as drought refugia—stream systems that maintain suitable summer baseflows and water temperatures during severe multi-year droughts – should be identified and protected.

The broad-scale climatic factors that control the distribution of *O. mykiss* in the region appear to be summer air temperatures, annual precipitation, and the severity of winter storms, the last having its effect by determining the power of high flow events that organize the distribution and extent of in-stream steelhead habitat. All of these factors are likely to undergo a long-term shift as part of CO_2-induced climate change. In addition, the region's frequent wildfires strongly influence the sediment budgets of streams, and thus the distribution of steelhead habitat. The overall wildfire regime is also likely to undergo a permanent shift in response to climate change. The magnitudes of these shifts, and the magnitude of their direct and interaction effects on stream habitat, are not yet clear. Thus a key uncertainty is how to plan for climate change both at the level of the ESU and individual stream watersheds.

14.3 RESEARCH FOCUS: ANADROMY, POPULATION STRUCTURE, AND MONITORING STEELHEAD RECOVERY

The natural dynamics of watersheds and stream systems maintain steelhead habitat in the recovery planning area in a stochastic, dynamic equilibrium. This equilibrium can involve dramatic processes such as floods and forest fires that disrupt habitat in the short term but ensure its continued existence over the long term. Other processes that circumscribe the productivity of freshwater steelhead habitat, such as the severity of the dry season or the pattern of high-flow events during the wet season, may affect reproductive success. These ecological constraints are generally understood at a qualitative level, but this level of knowledge is, in some cases, too vague to provide specific guidance for setting goals and choosing specific recovery actions. The research program supporting steelhead recovery in this region should focus on quantitative studies that: 1) identify ecological factors that promote anadromy; 2) clarify key aspects of population structure; and 3) monitor progress toward recovery. Many of these research activities could be carried out within the context of the California Coastal Salmonid Population Monitoring Program (Adams *et al.* 2011).

14.3.1 Identify Ecological Factors that Promote Anadromy

The primary focus of this Recovery Plan - to recover and secure the anadromous form of *O. mykiss* - involves restoring ecological conditions that specifically promote the population growth and abundance of the anadromous form.

While it is necessary to have migration corridors for steelhead to reach a spawning area, this does not necessarily imply that anadromous forms will out-compete the freshwater residents that spawn in the same area. At present it is not clear what ecological conditions specifically promote the sea-going form over the resident form though there are some important clues. These clues present a prime opportunity for research that would lead to more effective recovery actions.

Anadromous females exhibit a large fecundity advantage over their resident counterparts. As shown in Figure 14-1, an adult female's egg production increases exponentially with body length, and adult *O. mykiss* are generally able to attain much larger sizes in the ocean than in freshwater.

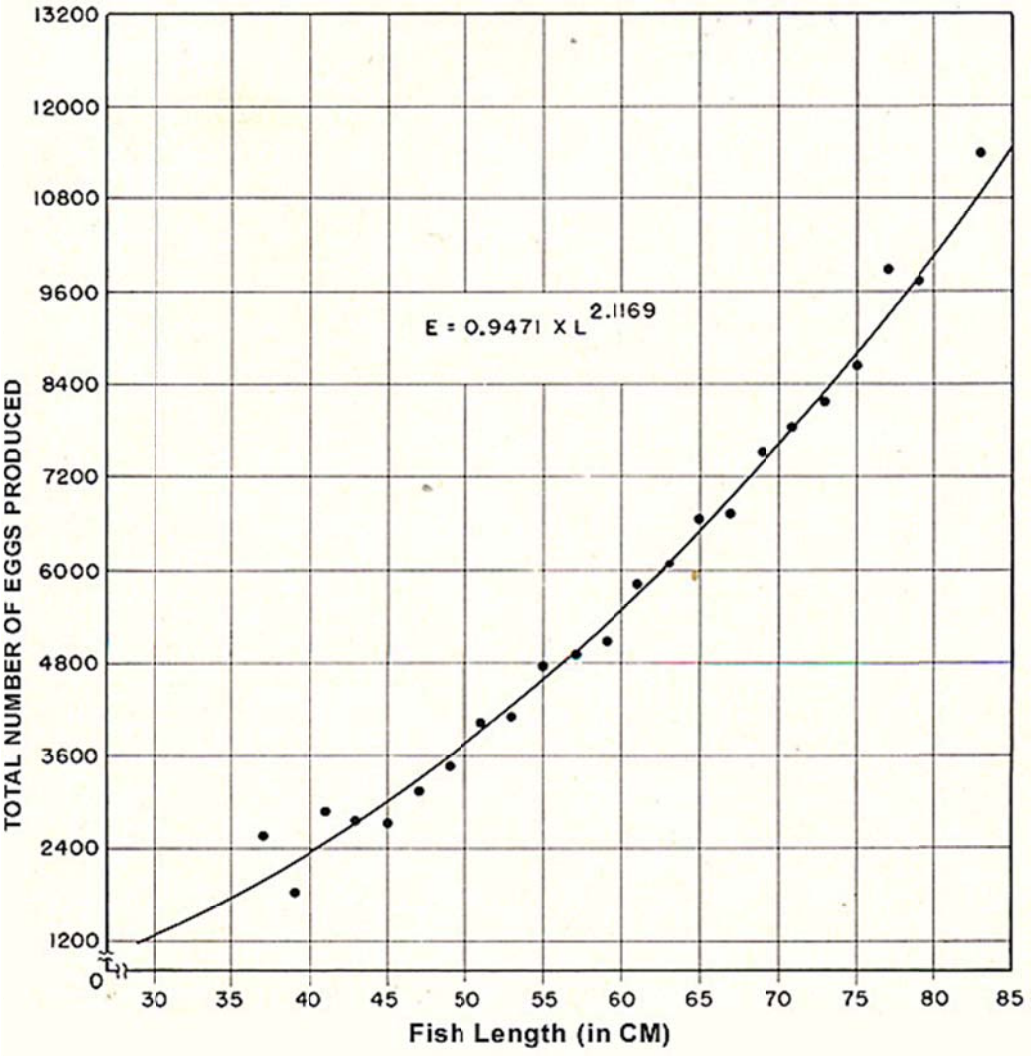

Figure 14-1. Fecundity as a function of body size for female steelhead sampled from Scott Creek in Santa Cruz County. Reproduced from Shapovalov and Taft (1954).

Thus, a typical female rainbow trout might attain a length of 35 cm, enabling her to produce 1800 eggs annually, whereas a medium sized steelhead female at 60 cm could produce over 3.5 times that number. This factor alone gives the sea-going form a distinct advantage and, all else being equal (and assuming the two forms breed true), over time the sea-going form should come to dominate any stream system with migration connectivity to the ocean. The resident forms would become confined to streams that lack migration connectivity. This pattern has been observed, for example, in the Deschutes River in Oregon (Zimmerman and Reeves, 2000).

In southern California, three ecological factors could potentially counteract this size advantage so that the resident form is sometimes favored in anadromous waters. First, the migration corridor between the ocean and freshwater habitat could be unreliable. Second, mortality may sometimes be much higher in the ocean than in freshwater, counteracting the potential size advantage of sea-going fish. Third, juveniles of the freshwater form may survive better or compete better in freshwater than juveniles of the sea-going form, which could also counteract the natural size/fecundity advantage of the sea-going form. Of these three possibilities, the first two are supported by various lines of evidence, and the third has some suggestive evidence. The need is to move beyond existing evidence to a quantitative understanding of ecological mechanism, so that specific recovery strategies can be linked to desired outcomes.

14.3.2 Reliability of Migration Corridors

Question: What is the relationship between reliability of migration corridors, and anadromous fraction?

Discussion: Migration corridors in this arid region are clearly unreliable, but it is not clear precisely how reliable they must be for the anadromous form to persist over the long term, nor how to best characterize reliability.

Recommendation: The relationship between flow patterns in managed rivers, the reliability of migration opportunities, and the long term persistence of steelhead runs is likely to be watershed specific, but could be characterized through the establishment of a long-term monitoring effort that tracks abundance and timing of steelhead runs, and the timing of smolt runs, in specific watersheds of interest. This would provide a framework by which management actions, in the form of managed flow regimes, could be related to outcomes, in the form of migrant abundance and timing. However, answers would probably emerge only over the long term, and numerous confounding factors would also need to be taken into account by the monitoring framework.

14.3.3 Steelhead-Promoting Nursery Habitats

Question: What nursery habitats promote rapid growth rates of juveniles (and therefore larger size) at the time smolts emigrate to the ocean?

Discussion: Marine survival varies among salmonids, ranging from 25% to below 1% (Welch *et al.* 2009, Logerwell *et al*. 2003, Peterson and Schwing, 2003, Ward 2000, Ward *et al*. 1989). Improving the marine survival rate of steelhead would be beyond the scope of most management strategies, since steelhead are rarely fished and other sources of ocean mortality are largely uncontrollable. However, mortality rates of many marine fishes are strongly size-dependent. Consistent with this general pattern, young steelhead migrating to the sea tend to survive much better if they have a larger size at ocean entry (Hayes, *et al.* 2008, Bond, 2006, Ward *et al*. 1989). Thus, their growth opportunities in freshwater may influence their subsequent marine survival.

Figure 14-2, indicates that an outgoing smolt that has a fork length of 14 cm has about a 3% chance of surviving to spawn, but a 16.5 cm smolt's chances are at least 3.5 times better (*c.* 10%), and a 22 cm smolt's chances are an order of magnitude better (37%). Thus, the mortality effects of size at ocean entry can be of the same order as the fecundity advantages of migrating to the ocean in the first place.

A similar relationship between survival and size at ocean entry was observed by Bond (2006) and Hayes *et al.* (2008) in Scott Creek in Santa Cruz County, which is much closer geographically to southern California. Size at ocean entry appears to be at least as important as final spawning size in modulating the relative abundances of the freshwater and ocean-going forms of *O. mykiss.* [1]

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[1] Its importance can vary over time, however. Ward (2000) observed that after 1989, marine survival drastically declined in the Keogh River population, and the relationship disappeared between marine survival and size at ocean entry. This was attributed to a change in ocean conditions, and indicates that the survival advantage of being a large smolt varies over time.

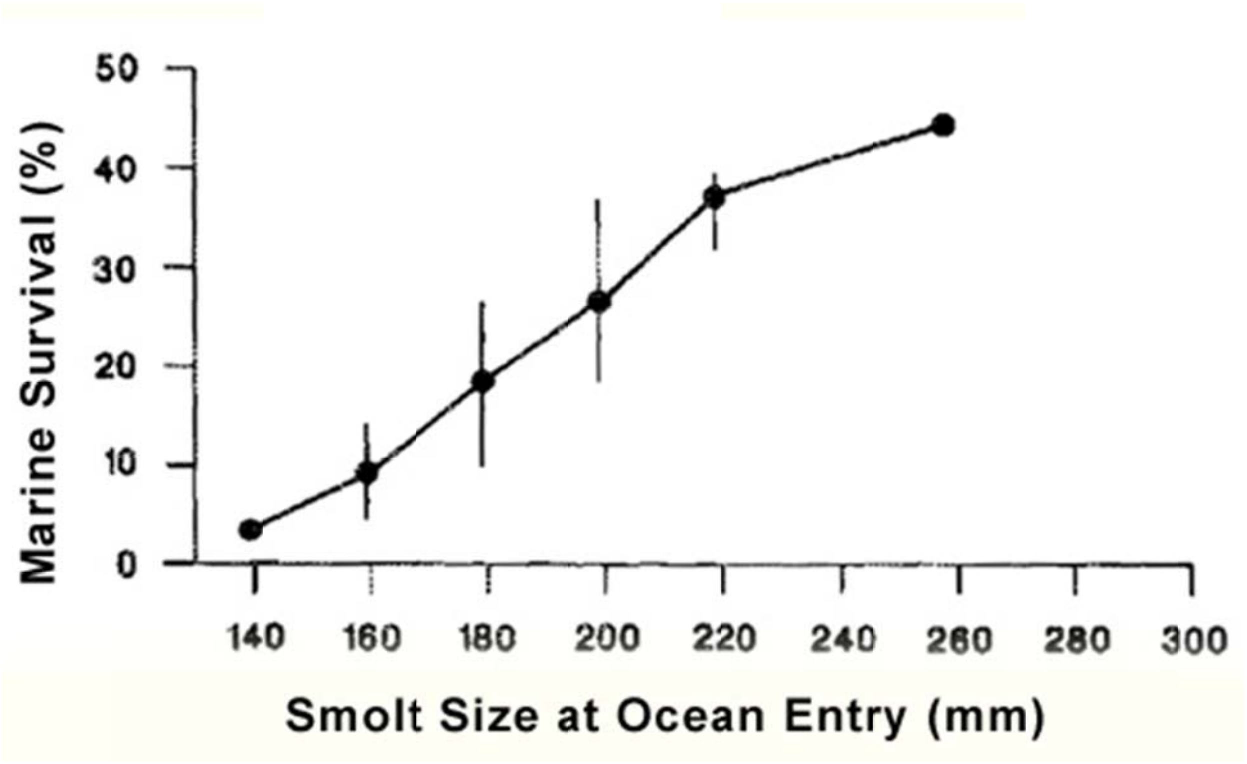

Figure 14-2. Marine survival of steelhead as a function of body size at ocean entry, in the Keogh River steelhead population described by Ward *et al*. (1989). Figure depicts the average survival to spawning of smolts emigrating in years 1977 - 1982.

High quality steelhead nursery habitats might develop where cool-water habitats receive large terrestrial inputs of food items. Terrestrial insects often fall in the water (Harvey *et al.* 2002, Douglas *et al.* 1994), and can provide a significant component of the diet of young steelhead (Rundio 2009, Rundio and Lindley, 2008). The study by Rundio and Lindley (2008) in the Big Sur area found terrestrial insects were sporadic in the diet of *O. mykiss*, but each item had large mass and thus was highly nutritious for the fish. Habitats with more frequent inputs of terrestrial insects would afford larger growth opportunities.

Finally, some habitats might produce rapid growth if there is a mechanism to keep juvenile densities low, so that individuals have expanded feeding opportunities. For example, it might be the case that intermittent streams provide expanded feeding opportunities during their wet season, because their dry season prevents the establishment of a large permanent population of resident rainbow trout. Overall, this suggests that the recovery prospects for steelhead runs would be significantly improved by identifying, restoring, and protecting those freshwater habitats that tend to produce large smolts, as part of the overall recovery strategy. These areas would qualify as steelhead “nursery habitats,” defined as juvenile habitats that produce adult recruits out of proportion to their spatial extent relative to other habitats (Beck *et al.* 2001).

Recommendation: The identification and restoration of steelhead nursery habitats is a prime research opportunity with large potential for enhancing steelhead recovery efforts. Nursery habitats would likely be estuarine or freshwater habitats that support rapid growth of young fish during the first or possibly second year of life, since large body size of migrants at ocean entry substantially improves their subsequent survival in the ocean. The simplest type of study to identify such habitats would be to use mark-recapture techniques to track growth and survival of juveniles as a function of habitat use. A more complete study would also track the consequences for marine survival.

14.3.4 Comparative Evaluation of Seasonal Lagoons

Question: What role do seasonal lagoons play in the life history of steelhead, and in particular, to what extent are seasonal lagoons used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to lagoon suitability steelhead rearing (survival, growth)? What ecological factors contribute to the persistence of those lagoon features?

Discussion: One type of steelhead nursery habitat is the freshwater lagoons that form in the estuaries of many stream systems during the dry season. In some of these seasonal lagoons, juvenile steelhead can grow very quickly and enter the ocean at larger sizes, where they survive relatively well and thus contribute disproportionately to returning runs of spawners (Bond, 2006). Smith (1990), however, has observed that some lagoons can be quite vulnerable to rapid degradation in quality, and others may never be suitable, due to local environmental factors that can produce anoxic conditions or poor feeding opportunities. The existing information on the role of lagoons mostly comes from Santa Cruz County, and is focused only on a few systems. As described above, this work suggests that lagoons can comprise steelhead nursery habitat, but can also be vulnerable to various natural and anthropogenic disturbances (Smith, 1990). There is a need to determine which lagoons have the potential to play a positive role in anadromy-targeted recovery efforts.

Seasonal lagoons are a specific kind of estuary and in general, estuaries are highly dynamic interfaces between two other much larger ecosystems: freshwater stream networks on the terrestrial side, and the ocean ecosystem on the marine side. This accounts for estuaries' dynamism, complexity, and sensitivity to external influences, but also for much of their productivity (Hofmann, 2000; Jay *et al.* 2000). Although there appears to be a general unity in function of many of the small estuaries in our region (due to the general similarity of climate, terrestrial watershed conditions, and the raised coast), there is also much variation and one would expect that small differences in, say, watershed condition or coastal wind and current patterns, would sometimes translate into large differences in the suitability of lagoons as steelhead nursery habitat (Rich and Keller 2011).

Recommendation: Comparative studies on the environmental controls for productivity and reliability of lagoon habitat (including how to restore it if necessary) would aid in identifying those estuaries capable of serving as reliable steelhead nursery habitat. Such studies should focus on factors enabling rapid growth of juvenile steelhead, and factors conferring resiliency against catastrophic failure of habitat quality (anoxia, premature breaching, *etc*.).

14.3.5 Potential Nursery Role of Mainstem Habitats

Question: What role do mainstem habitats play in the life history of steelhead, and in particular, to what extent are they used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to mainstem quality (survival, growth) for steelhead rearing? What ecological factors contribute to mainstem reliability?

Discussion: There may be other freshwater habitats that support high survival and robust growth of juveniles, and so constitute nursery habitat specifically for the anadromous form of the species. Low-gradient mainstem habitats, such as the trunks of the Santa Ynez, Ventura, Santa Clara, Santa Margarita, San Luis Rey, and San Dieguito River may also have once supported rapid growth of juveniles, particularly if reaches received enough sunlight to support primary productivity, but artesian flows or other groundwater inputs kept water cool in the summer (C. Swift, personal communication). Most mainstem habitats have now been highly altered by agricultural clearing and groundwater pumping, so an effort to determine their potential to contribute to steelhead recovery would require a focused effort.

Recommendation: The potential nursery role of mainstem habitat is much more speculative than the nursery role of lagoons. Initial assessment of the potential nursery role could take the form of 1) empirical study of mainstem habitat use by juvenile steelhead, at broad and fine scales; and 2) water-temperature modeling that accounts for effects of climate, insolation, and groundwater interaction on mainstem water temperatures, especially during the summer. The empirical work would be most useful if it applied mark-recapture techniques to assess growth and survival as a function of habitat use, and in managed rivers, as a function of the flow regime.

14.3.6 Potential Positive Roles of Intermittent Creeks

Question: Do intermittent creeks, serving as steelhead nursery habitat, positively influence the anadromous fraction of *O. mykiss* populations, or otherwise enhance viability of the anadromous form of the species?

Discussion: Juvenile *O. mykiss* are common in intermittent creeks (Boughton *et al*. 2009), but it is unclear whether these only function as sink habitat (a net drain on productivity) or play a more positive role in population viability. Boughton *et al*. (2009) observed that during the early summer in a moderately wet year, densities of young-of-the-year *O. mykiss* were nearly identical in the perennial and intermittent creeks of the Arroyo Seco watershed in Monterey County. Much of the intermittent creeks dried up and killed juveniles later in the summer, and indeed such mortality has been observed in the region for many years (Shapovalov, 1944), although it is also common to find scattered residual pools or reaches packed with fish in late summer. For example, Spina *et al.* 2005 observed fish in San Luis Obispo creek moving into sections of the stream network retaining perennial flow as other streams dried out over the summer months. The important issue for recovery purposes is identifying the potential positive, rather than negative, roles of intermittent creeks in sustaining the viability of steelhead populations.

The most obvious positive role is that intermittent creeks provide migration corridors to perennial creeks during the wet season. Perennial reaches often occur in low-order streams upstream of intermittent sections, so the corridor role increases the amount of accessible perennial habitat, and thus the size of the steelhead population that can be supported. In dry years, the corridor function would fail in some areas.

Boughton *et al*. (2009) found that most spawning habitat in the Arroyo Seco system tended to occur in intermittent streams, and argued that hydrologic and geomorphic processes would tend to produce such a pattern in general. This suggests a second positive function of intermittent streams—significantly expanding the amount of spawning habitat beyond what is available in perennial streams—but it also suggests a need for an additional corridor function. In this case, the corridor function is for young-of-the-year to emigrate to perennial reaches before the summer dry season traps and kills them.

It is possible that intermittent streams enable a high-risk, high-reward strategy on the part of young steelhead. Many individuals may be killed during the summer drying season, but those surviving in the residual pools may benefit from enhanced growth. One mechanism for enhanced growth may be cannibalism of trapped cohorts. Another mechanism for rapid growth may be rapid recolonization of the dried stream channels as flows become re-established with cooler, wet weather in the fall.[2] Such fish would find few competitors, and perhaps even an enhanced opportunity to feed on eggs and fry of the following winter's spawners (Ebersole *et al.* 2006). In this manner, intermittent creeks could serve as steelhead nursery habitat

In wet years, the seasonal drying may be substantially reduced, increasing summer survival and allowing large pulses of juveniles to be recruited to the subpopulation of adult steelhead in the ocean. Under some scenarios, such as a highly plastic life history strategy (see next section), it is possible that such pulses would be the primary mode of production for anadromous individuals, and sustain the anadromous form of the species over the long term.

Recommendation: Intermittent creeks comprise a large proportion of freshwater *O. mykiss* habitat in the region. Despite an obvious negative role in the species ecology, they may have important positive roles as well. These potentially positive roles have the status of hypotheses with general implications for recovery strategies and viability targets, and should be tested.

14.3.7 Spawner Density as an Indicator of Viability

Question: What spawner density (at what spatial and temporal scale) is sufficient to indicate a viable population of steelhead?

Discussion: Answering this question requires that one or more robust anadromous populations be carefully characterized. The answer is more useful in the long-term, as an indicator of progress toward recovery, than it is in the short term for achieving recovery. The most useful data would be a time-series of observations of spawner density over many years.

Recommendation: Monitor a select number of core and non-core populations to determine the numbers of spawners using both mainstem and tributary spawning habitats.

14.3.8 Clarify Population Structure

Population structure concerns the ecological and biological factors that cause fish to naturally group into functional units known as independent populations. Independent populations are defined as "a collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations" (McElhany *et al*. 2000).

If groups of fish regularly exchange individuals, they are members of the same population, whereas if exchange is rare or does not significantly affect population dynamics, they are members of separate populations. This definition of "separateness between, exchange within" means that the proper context of most management strategies is the independent population: a strategy that directly affects only a portion of a population will soon have significant indirect effects on the rest of the

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[2] Fall rains can re-establish flows, but flows may also be re-established by cooler fall weather, which presumably lowers transpiration demands of riparian vegetation, leaving more groundwater to maintain base flows in stream channels.

population, but few immediate effects on other populations. [3]

The independent population is also the fundamental functional unit of species persistence, and hence viability. As a result, many of the viability criteria described by Boughton *et al.* (2007b) were defined in terms of population traits such as anadromous fraction and mean spawner abundance over time. The collections of fish to which these criteria should be applied are a function of what is known about the patterns of exchange of fish among breeding biological units. Open questions about such exchange result in uncertainty about how to apply the criteria.

Thus, an analysis of a simple quantitative model led Boughton *et al*. (2007) to conclude that an annual adult abundance of 4,150 fish were necessary for an independent population to be considered viable. But it was unclear, due to questions of exchange patterns, whether the criteria should be applied to:

- ☐ anadromous fish in a particular watershed, or
- ☐ the sum of anadromous fish across several watersheds, or
- ☐ the sum of anadromous and freshwater-resident fish in a particular watershed, or
- ☐ the sum of anadromous and freshwater-resident fish across several watersheds

The answer has implications for the scope and scale of recovery efforts. The answer depends on the level of exchange of fish across separate coastal watersheds, and on the level of exchange between the anadromous and resident forms of the species within a particular watershed—termed ‘life history crossovers”. A life history crossover is a freshwater parent that has anadromous fish among its progeny, and/or vice versa. Questions about inter-watershed exchanges and life history crossovers, and the implications for viability criteria, are key issues addressed in this section.

14.3.9 Partial Migration and Life History Crossovers

Partial migration is the phenomenon in which a population consists of both migratory and resident individuals (Jonsson and Jonsson, 1993), implying the regular or at least occasional occurrence of life history crossovers. A diversity of crossover patterns have been observed in the small number of studies conducted on *O. mykiss* to date. Zimmerman and Reeves (2000) observed no crossovers in resident and anadromous *O. mykiss* of the Deschutes River in Oregon, suggesting two demographically distinct (independent) populations. For one natural and eight hatchery populations in California, Donohoe *et al.* (2008) found that anadromous females sometimes produced resident progeny, but resident females did not produce anadromous progeny, suggesting a one-way flow of crossovers away from the anadromous form.

The Babine River *O. mykiss* in British Columbia apparently exhibit modest levels of crossover (*c.* 9%) in both directions (Zimmerman and Reeves, 2000), suggesting a single population that is partially subdivided, whereas J. R. Ruzycki (personal communication in Donohoe *et al.* 2008, p. 1072) reports a high level of bidirectional crossover in various tributaries of the Grande Ronde River in Oregon (0% to 33% of anadromous adults were progeny of resident females, and 44% of resident adults were progeny of anadromous females), indicating a fully integrated population in which the two life history forms functionally coexist.

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[3] Over the longer term, a permanent change in population dynamics *would* be expected to trickle out to other independent populations, due to occasional exchanges of individuals. Occasional exchanges are expected to drive important processes such as gene exchange and recolonization of stream systems following a drought.

This continuum has significant implications for viability criteria. Are the populations in southern California fully integrated, or does each form more or less breed true, implying demographically independent populations that share stream systems but play no role in supporting one another, and perhaps even compete? Boughton *et al.* (2007b) made recommendations that embodied these two possibilities (actually two endpoints of a continuum). In one scenario, one should specify criteria that would secure the ocean-going fish if they turn out to comprise a demographically independent population. Under the other scenario, one should specify criteria that secure the ocean-going fish if they turn out to depend on the resident form with which they coexist. However, it is possible that resolution of this uncertainty would eliminate some of the need for hedging and thus lead to a more efficient and effective recovery plan. Resolution would involve two fundamental questions:

Question 1: What is the mechanism for, and frequency of, life history crossovers in southern California?

Question 2: How does crossover affect the persistence of the anadromous form?

Discussion: Answering the first question will take an extended research effort. Currently, Devon Pearse and S. Sogard (NOAA Fisheries) and M. Mangel (UC Santa Cruz) are leading a research effort to better understand life history crossovers in California steelhead; Mangel and Satterthwaite (2008) give an overview of the framework being used. The hypothesis being examined is that the anadromy/residency life history crossover made by individual *O. mykiss* is cued by the environment, using a mechanism similar to what has been observed in Atlantic salmon (*Salmo salar)*, a better-studied species that also exhibits variation in the timing of the smolting process during life history. Specifically, the hypothesis is that the smolting/residency life history crossover is made by individual fish during a sensitive period some months before the actual process of smolting is observed, and that the cues for the crossover are the fish's size and growth rate during the sensitive period. This might be expected because size and growth in the freshwater habitat integrate information about the quality of that habitat, as well as about the expected survival and fecundity in the marine environment versus the freshwater environment. What is hypothesized is a physiological (and perhaps hormonal) process that processes information from the environment to produce an adaptive life history crossover (See Hayes, *et al*. 2011a, 2011b).

Though the research effort of Sogard and Mangel is important progress on the anadromy/residency life history crossover phenomenon in steelhead recovery planning, it has important limitations at this time. First, it has the status of a hypothesis and at this writing no one has actually experimentally induced life history crossovers in *O. mykiss* by manipulating size, growth rates or any other environmental factor. Second, even if the Atlantic salmon model is useful for understanding life history plasticity in *O. mykiss*, there are almost certain to be important differences and indeed surprises in the *O. mykiss* life history story. Finally, the existence of a plastic life history strategy does not preclude the possibility of important genetic constraints. For example, one might expect that even if the model is broadly correct, the specific timing of sensitive periods, and the thresholds for the size and growth cues, would probably vary quite markedly among populations of steelhead due to genetic differences. In short, the responses to environmental cues would likely have a heritable component, and this component would likely exhibit local adaptation to specific conditions. A response that is adaptive in one watershed may be selected against in another watershed, depending on environmental factors such as those discussed in the previous section.

Recommendation: It is essential for rigorous research on the mechanisms of life history plasticity in *O. mykiss* to be pursued vigorously, for it is difficult to envision a successful recovery effort without a better understanding of the functional relationship between resident and anadromous fish. The current effort of Sogard, Mangel, and coworkers should yield useful information over time, but it focuses on two systems outside southern California: Soquel Creek in Santa Cruz County (a coastal redwood forest system), and the American River near Sacramento (a large Central Valley River system). One should expect local adaptation of steelhead populations in southern California.

Because of the likelihood of local adaptation, it would be useful and practical to address some related questions about the frequency of life history crossovers and their implications for recovery planning in the southern California. In particular:

- ☐ Identify environmental factors that specifically promote anadromy (discussed in the previous section). It is clear that the abundance of anadromous fish needs to be increased, and identifying relevant environmental factors would usefully inform this goal. The principal uncertainty is how much the abundance of anadromous fish needs to be increased, a separate question that depends on the frequency of life history crossovers and the mechanisms underlying them. This question can be addressed over the longer term as more is learned about the mechanism, and used to refine the viability criteria described by Boughton *et al.* (2007b).

- ☐ Estimate the frequency of life history crossovers in populations of interest, to determine whether it even occurs with any regularity. The most practical method for doing so is by analyzing otolith microchemistry of juvenile *O. mykiss* (see Donohoe *et al.* 2008), but this requires lethal sampling of juveniles. Modest lethal sampling of juveniles (as opposed to adults) may pose only a negligible increase extinction risk, due to the low reproductive value of juveniles.

- ☐ Determine how life history crossover affects the persistence of the anadromous form. This could be done using existing frameworks in population modeling, such as individually-based models or integral projection models, but would require assumptions about typical mortality and growth rates in freshwater and marine environments, as well as about frequency of life history crossovers. However, it might produce important insights. For example, persistence of anadromous runs could be strongly affected by the difference between complete lack of crossovers and a modest rate, such as 5%. However, effects would be much smaller between a 10% rate versus a 50% rate. It would be useful to more rigorously evaluate the validity and relevance of these levels of life history crossovers.

14.3.10 Rates of Dispersal Between Watersheds

Question: How common is dispersal of anadromous *O. mykiss* between watersheds, and how does it relate to population structure, especially in small coastal watersheds?

Discussion: Just as life history crossovers may knit resident and anadromous *O. mykiss* into integrated populations, frequent movement of anadromous fish through the ocean to neighboring watersheds may knit neighboring *O. mykiss* into integrated "trans-watershed" populations. If inter-watershed exchange is common, the most effective recovery strategies might be those that emphasize integration of recovery efforts across a set of linked watersheds. If inter-watershed exchange is rare, the most effective strategies would be those that identify watersheds having stable conditions that protect small, inherently vulnerable populations.

The places where the implications of the single-watershed versus trans-watershed scenarios are most distinct are those areas along the coast where numerous small coastal watersheds occur in close proximity. In the SCS Recovery Planning Area, these areas include the south coast of Santa Barbara County, and the small watersheds draining the Santa Monica Mountains just north of Los Angeles.

Recommendation: Answering this research question will involve tracking the populations from multiple watersheds, including groupings of small, closely spaced watersheds as well as groupings involving large and small watersheds more spatially dispersed. However, it is not clear at this time what is the most practical and effective way to try to estimate exchange rates in the Recovery Planning Area. Genetic and Radio Frequency Identification (RFID) tags and ecological traps may have potential to effectively address this question, particularly in small basins where it is possible to sample a significant fraction (perhaps all) of a given cohort of adults.

14.3.11 Revision of Population Viability Targets

In the framework described by Boughton *et al.* (2007), the key criteria for establishing population viability was that a population be demonstrated to sustain a long-term mean run size of at least 4,150 anadromous spawners per watershed per year. However, the authors noted that the criteria were chosen to be precautionary due to scientific uncertainty about key issues, and that better information might allow the criteria to be revised without increasing the risk of extinction. There were three types of information that seemed most likely to lead to useful revisions of the viability criteria:

1. The threshold run size might be able to be revised downward from 4,150 spawners per year if it was determined that year-to-year variation in run size was modest enough to be consistent with a lower threshold. The necessary information—annual estimates of run size over several decades—would come from the types of monitoring programs described below.

2. Data on the frequency of life history crossovers might justify that the 4,150 threshold could include some fraction of adult resident fish, rather than the 100% anadromous fraction currently recommended (*i.e.,* because the resident and anadromous forms are shown to comprise functionally integrated populations). The necessary information would come from successfully implementing the recommendations identified above.

3. Data on inter-basin exchanges might justify that the 4,150 threshold include spawners from neighboring watersheds (*i.e.,* because inter-watershed exchanges is sufficiently high that the fish in neighboring watersheds comprise a single, trans-watershed population). The necessary information would come from successfully implementing the recommendations identified above.

It should be noted that data for item 1 would arise over time as a byproduct of a comprehensive monitoring program, which is necessary to assess risk in any case. The priority item, however, is probably item 2, since the integration of the resident and anadromous forms is not well understood, but has profound implications for a very diverse set of management issues beyond just revision of recovery criteria.

14.4 MONITORING PROGRESS TOWARD RECOVERY GOALS

Monitoring should be conducted for each BPG, with monitoring initially focused on Core 1 populations. Monitoring involves two different but related activities: status and effectiveness monitoring. Status monitoring is intended to assess the status of a population (or a DPS) as a whole, and to assess its progress toward recovery or further decline toward extinction. It should also be designed to gather data for assessing the viability criteria described by Boughton *et al*. (2007b). Monitoring the annual run size of populations is the most important objective of status monitoring. Effectiveness monitoring is intended to assess the response of populations to specific recovery actions, and thereby develop a better understand of their effectiveness. Effectiveness monitoring will generally be more powerful if it focuses on the specific life stage affected by the recovery actions in particular habitats, and it if compares it to the same life stage in similar unaffected habitats that serve as controls.

As described by Boughton *et al.* (2007b), the general goal of recovery is to establish a diverse and geographically distributed set of populations, each of which meets viability criteria over the long term. These viability criteria are expressed in terms of mean annual runs size, persistence over time, spawner density, anadromous fraction, as well as the continued expression of life history diversity, and the spatial structure of the population. Strategies for monitoring these properties of steelhead populations over the long term are essential for assessing the attainment of recovery goals.

14.4.1 Strategy for Monitoring Steelhead in Southern California

Southern California steelhead habitats exhibit characteristics that must be considered in formulating a monitoring plan. These characteristics include differences in geology, climate and hydrology, as well as the fact that other species of anadromous salmonids are absent. The differences in the geology, climate, and hydrology are described in Adams *et al.* 2011, Boughton and Goslin (2006), and Boughton *et al*. (2006). The strategy described below considers these factors, as well as the spatial and temporal distribution of southern California steelhead. The basic components of the southern California steelhead monitoring strategy include:

- ☐ Reconnaissance surveys and assessments of steelhead populations
- ☐ Reconnaissance surveys and assessments of riverine and estuarine habitat conditions
- ☐ Counting stations stratified at both the BPG and population levels
- ☐ Life cycle stations (LCS) stratified at both the BPG and population levels

Presently there is no current comprehensive assessment of the condition and distribution of steelhead populations and habitats in southern California that use standard population and habitat assessment protocols. However, NMFS and the DFG have begun to develop a comprehensive coastal salmonid monitoring program and have identified a basic strategy, design, and methods of monitoring California coastal salmonid population (Adams *et al.* 2011).

The monitoring strategy outline here includes an, initial assessment both of the fish populations and habitat conditions. Assessments should initially focus on Core 1 populations in each BPG, and ultimately include all populations that are necessary for full recovery of the species. Stream habitat assessments should be conducted using the protocol in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual (California Department of Fish and Game 2010).

Counting stations comprised of fixed structure utilizing technologies such as DIDSON cameras are the most effective means of establishing abundance and trends of adult anadromous runs of steelhead and juvenile out migration. Counting stations should initially be located in Core 1 populations in each BPG.

Life cycle monitoring can be co-located with counting stations, but may also be conducted in one or more of the non-core populations which support smaller but less impacted populations. LCS monitoring efforts provide the foundation for evaluating the relationship of fish habitat use and habitat condition over time and should focus on:

- ☐ Estimation of marine and freshwater survival
- ☐ Spawning success (spawning ground distribution, redd to adult ratio)
- ☐ Juvenile rearing success (over-summering and winter growth)
- ☐ Major life history traits (anadromy/resident relationships, sex ratio, age and size structure, habitat utilization patterns, emigration age and timing, maturation patterns, run-timing, and physiological tolerances)

These LCSs could also be used in evaluating nutritional needs, predation, disease, and other environmental factors relevant to assessing the status of individual populations. Where permanent LCSs are not established, temporary stations should be deployed to maximize the development of population information in Core population watersheds.

Table 14-1 lists the preliminary sites where counting stations and LCSs should be established. LCS sites should be sited based on two criteria: their relation to the DPS and whether they are necessary to represent the full range of watershed types for each BPG.

Table 14-1. Potential Southern California Steelhead Life Cycle Monitoring Stations (alternative populations are listed in parentheses).*

Life Cycle Monitoring Station	Population	Potential Locations
1	Santa Maria River	Suey Crossing Garey Road Tespesquet Road
2	Santa Ynez River	Highway 1 Alisal Road Refugio Rod Highway 154
3	Ventura River	Robles Diversion Casitas Vista Road Santa Ana Road
4	Santa Clara River	Vern Freeman Diversion Highway 123 Highway 126
5	Mission Creek (Arroyo Hondo Creek)	Highway 101 Tallant Road Mission Canyon Road (Highway 1)
6	Carpinteria Creek	Highway 101 East Valley Road
7	Rincon Creek	Highway 101 Highway 150
8	Malibu Creek (Arroyo Sequit, Topanga Creek)	Highway 1 Cross Creek Road (Highway 1)
9	San Gabriel River	Highway 1 San Gabriel Canyon Road
10	San Juan Creek	Highway 1 Metro-link Crossing
11	San Mateo Creek (Santa Margarita River)	Highway 1 (Highway I-5, De Luz Road)
12	San Luis Rey River (San Dieguito River)	College Boulevard Mission Road (Highway I-5, El Camino Real)

* Note: Additional evaluation of other locations may identify more suitable locations than those provisionally identified here.

To the maximum extent possible, monitoring the status and trends of steelhead populations should be undertaken simultaneously with restoration efforts. Watersheds where restoration has occurred or is occurring should be considered a high priority for monitoring. Monitoring stations, whether counting or life cycle stations, should serve as a magnet for research efforts depending on fish and fish related field data.

14.4.2 Monitoring Protocols

There are various ways that status and effectiveness monitoring can be integrated, but the focus of the following discussion is on status monitoring. Below is a brief summary of potential methods to monitor run-size of steelhead (number of anadromous spawners per year per population). All these methods necessarily involve two components:

1. Observed counts for some life history stage of *O. mykiss* that contains information about run size

2. Some method for estimating the number of unobserved fish

For the first component, the observed count may actually be the run, but if it is some other life stage, there is a need to collect data to estimate a conversion factor. For example, if redds are counted, it is necessary to estimate redds per female and sex ratio to get an estimate of the full run size (Gallagher and Gallagher 2005).

The second component is necessary because simple observations can confound the true number of fish with the detection rate of the observer: A large population with poor observing conditions looks the same as a small population with excellent observing conditions. Thus, one must also estimate the number of unobserved fish, which corresponds to estimating the detection rate of the observer.

There are numerous ways to do this (Williams *et al*. 2001 provides a comprehensive technical review), but they all involve making repeated observations (often only two times) of the same group of fish. This redundancy is necessary for estimating unobserved fish. Doing so, and getting an estimate of the full population, is often far more informative than obtaining partial counts in which abundance and detection rate are confounded, because detection rates can be highly variable (Rosenberger and Dunham 2005)

14.4.2.1 Counting at Fish Ladders

Fish ladders can provide important opportunities to count upstream migrants, assuming the fish passage facilities themselves provide effective unimpeded fish passage opportunities. There are a number of technical challenges in operating fish detection and counting devises in extremely flashy systems characteristic of southern California (see discussion below). Additionally, this method is only relevant to watersheds that have fish ladders, and cannot quantify the portion of the run that spawns below the fish ladder. Depending on the location of the ladder and the amount and type of habitat downstream of the ladder, the spawners below the ladder can be an important component of the run.

14.4.2.2 Redd Counts

Gallagher and Gallagher (2005) have shown that salmon and steelhead runs can be estimated using redd counts. A summary of their method and is provided below:

To estimate Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and steelhead *O. mykiss* escapement in several coastal streams in northern California a stratified index redd method was developed, based on the assumption that redd size is related to the number of redds a female builds. Redd area escapement estimates were compared with estimates from more conventional methods and releases of fish above a counting structure. Reduction of counting errors and uncertainty in redd identification, biweekly surveys throughout the spawning period, and the use of redd areas in a stratified index sampling design produced precise, reliable, and cost-effective escapement estimates for Chinook salmon, coho salmon, and steelhead.

This method has considerable promise, but has not been tried in the southern California setting, where stream turbidity and channel geomorphology, or repeated disturbance of redds by winter storms, may make redds difficult to detect.. The method has high personnel requirements, because it requires the survey reaches to be visited biweekly throughout the spawning season. On the other hand, it is simple, requires only modest training in field personnel, and has modest costs other than the hiring of personnel.

14.4.2.3 Monitoring runs using the DIDSON Acoustic Camera

Dual-frequency identification sonar (DIDSON) is an off-the-shelf device that uses high frequency sound waves to produce near video-quality images of underwater objects. It can potentially be used to identify and count all migrating steelhead at some survey point in a stream system, for the entire spawning season. Its advantages are similar to those of using a weir to make counts, but has two additional advantages that are key: 1) There is no need for a weir or other device that impedes flow, and so fouling, destruction by high-flow events, etc., are not a major constraint; and 2) it can see through turbid waters (unlike a regular video camera). These two traits appear well suited to the flashy, turbid conditions typical of southern California streams.

DIDSON has been successfully used to estimate adult salmon escapement in high-abundance rivers in Alaska, Idaho, and British Columbia. In principle it should be suitable for low-abundance creeks, such as those in southern California. NOAA's' Southwest Fisheries Science Center have evaluated field methods for using the device to monitor steelhead runs in southern California streams (Pipal *et al.* 2010).

The principal disadvantages are: (1) the cost of the device; (2) deployment constraints for getting good images; and the risk of "flashy flows" damaging or destroying the installation. These constraints have to do with maintaining a good "insonified region" of the channel being monitored for migrants. Some channel shapes are better than others, and there also need to be a strategies for maintaining a completely insonified cross section during the advance and retreat of high flow events. In addition, there is a need to learn how to interpret poor images when they occur. However, the method has the potential to solve some of the intractable problems of monitoring steelhead in southern California, including counting very small numbers of migrants in very turbid waters during and after very flashy high-flow events.

14.4.2.4 Tagging Juveniles and Monitoring Migrants (T-JAMM design)

Steelhead runs can potentially be estimated by tagging juveniles with Radio Frequency Identification (RFID) tags during their freshwater phase, and subsequently monitoring migrants using in-stream tag readers.

The tagging phase use standard block-netting and electro-fishing techniques during the summer low-flow season. Depletion-sampling can be used to estimate juvenile abundances. However, Rosenberger and Dunham (2005) found that capture-recapture methods gave more robust estimates than depletion sampling, and Temple and Pearsons (2006) showed that the customary 24-hour period in capture-recapture sessions can be shortened to one or two hours, which simplifies logistics so that capture-recapture sampling can have a time-efficiency similar to that of depletion sampling.

The monitoring phase is accomplished using instream tag readers such as those described by Bond, *et al.* (2007), Zydlewski *et al.* (2006, 2001), Ibbotson *et al.* (2004). These must be deployed for the duration of the migration season (both outgoing and incoming) each year.

The design has promise for monitoring runs of steelhead for which many other methods are problematic. In unpublished simulations, Boughton has found that the precision of run size estimates is primarily controlled by the number of tagged spawners that ultimately return and get detected. The number required is modest: around 30 to 90 tagged spawners are necessary to obtain 50% confidence intervals that stay below one-third of the estimated of run size. However, with marine survival typically falling between 0.3% and 3%, the required tagging effort would usually be between 3,400 and 45,000 juvenile fish tagged per generation per population. Other considerations in using implanted tags are the mortality/fitness risks and the permitting requirements to allow some level of take of the species. The tagging effort could perhaps be spread across a set of populations if one were willing to assume uniform marine survival across the populations.

The estimation method is robust to imperfect detection of tagged fish by the instream tag readers, as long as there are at least two readers that independently scan for tags. Reach-sampling allows the entire run to be estimated using fish from a sample of reaches. In the simulations, the number of reaches needed for acceptable precision could be as low as 30-40 under scenarios of high marine survival, with a sampling fraction of around 2% in large watersheds, such as the Arroyo Seco watershed used in the simulations.

Under low marine survival, the necessary sampling fraction was around 10% in the simulations. A side-benefit of this method is that one would obtain very good estimates of ocean survival. This is useful because it allows the overall trajectory of steelhead runs to be decomposed into marine and freshwater components. This, in turn, will deliver greater statistical power for analyzing patterns in the freshwater component. In short, one would have greater statistical power for determining if recovery actions on the freshwater side are actually having the desired effect.

Boughton has written software to estimate run size from data produced by tagging juveniles and monitoring migrants. It is written in the R computer language, a freely-available statistical programming environment that is widely used in the scientific world. Currently the work is in manuscript form. Williams, Rundio, and Lindley of the Science Center are currently tagging juveniles and monitoring migrants in a case study of Big Creek steelhead population, a member of the Big Sur Coast BPG within the South-Central California Steelhead DPS.

14.4.2.5 Sampling Young-of-the-Year Otoliths (YOYO design)

This method is similar to tagging juveniles and monitoring migrants, but instead of tracking the fate of captured juveniles to estimate run size, one would collect some fraction of the juveniles, and examine their otoliths and genetic relatedness. From this, one could estimate the number of anadromous mothers (and as a byproduct, non-anadromous mothers) for each annual cohort of young-of-the year fish. This should be suitable for estimating annual run size, at least of female fish.

This method would dispense with the need to implant RFID tags in fish, and the need to maintain instream tag readers during difficult winter conditions. All field work would consist of electrofishing juveniles at randomly-sampled stream reaches each summer. However, the method would require the time and expense of otolith analysis, and it would require collecting (*i.e.* killing) some fraction of the juveniles that are electrofished during the summer field season.

This method is currently not well-developed, but it has promise as a relatively simple and efficient way to estimate run sizes using established and familiar field methods. A potential drawback is the need to kill juveniles to get their otoliths. The key unknown at this point is how many fish would have to be sampled to get a reasonable estimate of the number of anadromous mothers.

14.5 ADAPTIVE MANAGEMENT: LEARNING FROM RECOVERY EFFORTS

Adaptive management is a systematic process that uses scientific methods for monitoring, testing, and adjusting resource management policies, practices, and decisions, based on specifically defined and measurable objectives and goals (Walters 1997, 1996). Adaptive management is predicated on the recognition that natural resource systems are variable, and that knowledge of natural resource systems is often uncertain. Further, the response of natural resources systems to restoration and management actions is complex, and frequently difficult to predict with precision. The Recovery Plan provides both overall goals in the form of viability criteria, and suite of DPS-wide watershed specific recovery actions. The viability criteria, however, are provisional, and the central recovery actions are couched in broad terms which must be given more specificity on a case-by-case basis, and ultimately assessed for their effectiveness. Hence the need to adapt resource management policies, practices and research decisions to changing circumstances, or a better understanding of natural resource systems and their responses.

The success of an adaptive management program can be enhanced by having stakeholders and scientists engage in developing a shared vision for an indefinitely long future together. The development of a guiding image helps organize an adaptive management program, align interests, and enhance cooperation in a complex process. Focusing on fundamental values, rather than on predetermined means can open up possible alternative solutions; participating in this type of framework, scientists can help construct solutions that may not be self-evident to stakeholders.

Adaptive management can be applied at two basic levels: the overall goals of the recovery effort, or the individual recovery or management actions undertaken in pursuit of overall goals. The research sections above are intended to address the first application. The following discussion is focused on the second application of the concept of adaptive management.

14.5.1 Elements of an Adaptive Management Program

There is no uniformly applicable model for an adaptive management program, and key elements must be identified and tailored to recovery action-specific, site-specific, and impact-specific issues. However, effective adaptive management programs will contain three basic components: 1) adaptive experimentation by which scientists and others with appropriate expertise, learn about ecosystem functions response to recovery or management actions; 2) social learning (through public education and outreach) by which stakeholders share in the knowledge gained about ecosystem functions, and 3) institutional structures and processes of governance by which people respond by making shared decisions regarding how the ecosystem will be managed and the natural services it provides will be allocated.

Six specific elements associated with adaptive management have been identified (Panel on Adaptive Management for Resource Stewardship 2011):

1st Element: Recovery Action Objectives are Regularly Revisited and Revised. Key recovery action objectives (and related questions) should be regularly reviewed in an iterative process to help stakeholders maintain a focus on objectives and appropriate revisions to them. The recovery goals, objectives, and criteria in Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, should provide a basic framework, and the recovery actions identified for each BPG should be a starting point for the adjustment of recovery action objectives. The mandatory five-year review process can serve as a means of conveying any needed modification to the overall recovery goals, as well as individual recovery actions.

2nd Element: Model(s) of the System Being Managed. Four types of models have been have been identified in the use of adaptive management program to test hypotheses regarding the effectiveness of recovery actions (Thomas *et al.*, 2001):

Conceptual Model: Synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological system

Diagrammatic model: Explicitly indicates interrelationships between structural components, environmental attributes and ecological processes

Mathematical model: Quantifies relationships by applying coefficients of change, formulae of correlation/causation

Computational Model: Aids in exploring or solving the mathematical relationships by analyzing the formulae on computers.

River systems are generally too complex and unique for controlled, replicated experiments, or to be the subject of traditional scientific models. However, conceptual models based on generally recognized scientific principles can provide a useful framework for refining recovery actions and testing their effectiveness. Diagrammatic models such as the one used to characterize the parallel and serial linkages in the steelhead life cycle, can also be used *in lieu* of formal mathematical models to test hypotheses regarding the effectiveness of recovery actions. Mathematical and computational models, themselves have their limitations in the context of an adaptive management program: they are difficult to explain, and require specific assumptions that may be difficult to justify. As noted in the discussion above regarding recovery goals, viability criteria are based on a combination of a synthesis of current scientific information and a simplified model which uses data not specific to the Southern California Steelhead Recovery Planning Area. Additional quantifiable data is necessary to refine the viability population and DPS models that form the basis of the provisional recovery goals, objectives and criteria. Modification of the model could result in modification of the priorities assigned to the individual recovery actions in individual populations or BPGs.

3rd Element: A Range of Management Choices. Even when a recovery action objective is agreed upon, uncertainties about the ability of possible recovery or management actions to achieve that objective are common. The range of possible recovery or management choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. A range of recovery actions and management measures should be considered, either through a planning process or the environmental review process prior to permitting the individual recovery action.

4th Element: Monitoring and Evaluation of Outcomes. Gathering and evaluation of data allow for the testing of alternative hypotheses, and are central to improving knowledge of ecological and other systems. Monitoring should focus on significant and measurable indicators of progress toward meeting recovery objectives. Monitoring programs and results should be designed to improve understanding of environmental systems and models, to evaluate the outcomes of recovery actions, and to provide a basis for better decision making. It is critical that "thresholds" for interpreting the monitoring results are identified during the planning of a monitoring program. This element of adaptive management will require a design based upon scientific knowledge and principles. Practical questions to be addressed include what indicators to monitor, and when and where to monitor. Guidance on a number of these issues is provided in the sections above regarding research and monitoring.

5th Element: A Mechanism for Incorporating Learning Into Future Decisions. This element recognizes the need for means to disseminate information to a wide variety of stake-holders, and a decision process for adjusting various management measures in view of the monitoring findings. Periodic evaluations of the proposed recovery action, the monitoring data and other related information, and decision-making should be an iterative process in which management objectives are regularly revisited and revised accordingly. Public outreach, including Web-based programs, should be actively pursued. Additionally, the mandatory five-year review process can serve as a means of conveying any needed modification to the Recovery Plan, and well as individual recovery actions.

6th Element: A Collaborative Structure for Stakeholder Participation and Learning. This element includes information dissemination to a variety of stakeholders, as well as a proactive program focused on soliciting decision-related inputs from a variety of stakeholder groups. Inevitably, some of the onus for adaptive management goes beyond managers, decision makers, and scientists, and rests upon interest groups and even the general public. NMFS has provided a general framework by which a shared vision can be further developed and pursued for restoring a set of watersheds supporting a network of viable steelhead populations, and providing sustainable ecological services to the human communities of southern California (Boughton, 2010a, Tallis *et al*. 2010, Levin *et al*., 2009, Ruckelshaus *et al*. 2008). Such a vision also provides opportunities for the protection and restoration of other native freshwater and riparian species which form an integral part of the ecosystems upon which steelhead depend.

15. Implementation by NMFS

"If anthropogenic changes can be shaped to produce disturbance regimes that more closely mimic (in both space and time) those under which the species evolved, Pacific salmon should be well equipped to deal with future challenges, just as they have throughout their evolutionary history."

Dr. Robin R. Waples, NOAA Fisheries, Research Fish Biologist

15.1 INTEGRATION OF RECOVERY INTO NMFS ACTIONS

NMFS must formally incorporate the Recovery Plans within its daily tasks and decision-making, including the actions identified in the DPS-wide Recovery Action narratives and the Recovery Action summaries for each BPG. All of NMMS' missions can be accomplished with due consideration to the needs of listed salmon and steelhead. If NMFS is to promote species and ecosystem conservation (and meet its obligations under section 7(a)(1) of the ESA), then means of incorporating recovery goals and actions must be incorporated into all of the programs and actions we administer and implement. This includes, for example, listing reviews and critical habitat designations under ESA section 4, ESA consultations under section 7, and permit actions under ESA section 10.

Implementation of the Recovery Plan by NMFS will take many forms and is generally and specifically described in the NMFS Protected Resources Division (PRD) Strategic Plan. The Interim Recovery Planning Guidance (National Marine Fisheries Service 2010a) also outlines how NMFS shall cooperate with other agencies regarding plan implementation. These documents, in addition to the ESA, shall be used by NMFS to set the framework and environment for plan implementation. The PRD Strategic Plan asserts that species conservation (in implementing Recovery Plans) by NMFS will be more strategic and proactive, rather than reactive. To maximize existing resources with workload issues and limited budgets, the PRD Strategic Plan champions organizational changes and shifts in workload priorities to focus efforts towards "those activities or areas that have biologically-significant beneficial or adverse impacts on species and ecosystem recovery" (National Marine Fisheries Service 2006a). The resultant shift will reduce NMFS engagement on those activities or projects not significant to species and ecosystem recovery.

NMFS actions to promote and implement recovery planning shall include:

- ☐ Formalizing recovery planning goals on a program-wide basis to prioritize work load allocation and decision-making (including developing mechanisms to assure the effective and timely implementation of the Recovery Plan);
- ☐ Conducting an aggressive outreach and education program aimed at all stakeholders, including federal, tribal, state, local, non–governmental organizations, landowners, and interested individuals;

❑ Facilitating a consistent framework for research, monitoring, and adaptive management that can directly inform recovery objectives and goals;

❑ Participating in the land use and water planning process at the federal, state, and local level to ensure that the provisions of the steelhead Recovery Plan are reflected in the full range of decision making processes;

❑ Establishing an implementation tracking system that is adaptive and pertinent to annual reporting for the Government Performance and Results Act, Bi-Annual Recovery Reports to Congress and 5-Year Reviews of each species listing status.

15.1.1 Work with Constituents and Partners

Successful implementation of Recovery Plans will require the efforts and resources of many entities, from federal agencies to the individual contributions of members of the public. NMFS commits to working cooperatively with other individuals and agencies on implementation of recovery actions and to encourage other federal agencies to implement the actions for which they have responsibility or authority. The benefits of a successful plan to the species and the currently regulated communities are immense, but the costs can be counted in time, money, and changed behaviors. NMFS is committed to using Recovery Plans as the guiding mechanism for its daily endeavors and can directly implement some of the actions called for in the plans. However, our primary role in plan implementation will be to promote the recovery strategy and provide the needed technical information and expertise to other entities implementing the part of the plan or contemplating actions that may impact the species' chances of recovery.

NMFS is engaged in outreach to various constituencies where we provide technical assistance regarding listed salmonids, their habitat needs, and various life history requirements. Developing partnerships through providing technical assistance will be critical for recovery. Our outreach efforts will need to increase both towards those constituencies with which we already engage and to expanded sets of constituencies including communities, Non-Governmental Organizations (NGOs), and Federal and State legislative representatives.

To focus efforts in areas critical for recovery, NMFS shall:

❑ Develop outreach and educational materials to increase public awareness and understanding of the multiple societal benefits that can be gained from steelhead recovery in southern California watersheds;

❑ Inform federal, state, and local governmental agencies of the provisions of the Southern California Steelhead Recovery Plan, and how these respective agencies' activities or planning and regulatory efforts may assist the implementation of the Recovery Plan;

❑ Advise watershed groups and other non-governmental organizations about the Recovery Plan, and the role of on-going watershed conservation efforts in implementing recovery actions and achieving steelhead recovery within their respective watersheds;

❑ Facilitate and participate in public forums designed to provide interested parties with an opportunity to directly share experiences and ideas, and learn about the methods and means of implementing steelhead recovery actions;

❑ Provide technical support and assistance to partners engaged in implementing steelhead recovery actions identified in the Southern California Steelhead Recovery Plan, including research and monitoring;

❑ Work with Federal and State agencies to coordinate and develop programmatic permits for incidental take authorization for actions that contribute to the recovery of southern California steelhead and their habitats;

- ☐ Work to assure adequate funding and staff support for full compliance with the legal requirements of land use, water, and natural resource protection laws, codes, regulations and ordinances across the Southern California steelhead DPS; and
- ☐ Support the development of information networks that allow collaborators to disseminate information to a broad array of interested and affected parties about steelhead recovery efforts;

15.1.2 Funding Implementation of Recovery Plans

As a means of providing funding to the States, Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Nevada, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes receive PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal, and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NMFS has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho, and Alaska, and with three tribal commissions on behalf of 28 Indian tribes. The MOUs establish criteria and processes for funding priority PCSRF projects.

For as long as these funds are available to the State of California, NMFS intends on working with the State to ensure the southern California steelhead recovery strategy and priorities are included in the considerations of funding for projects. NMFS also intends on using PCSRF reports as a mechanism to highlight those areas and actions where PCSRF funds have been used to implement needed recovery actions that might not otherwise occur in the absence of PCSRF funds.

NMFS has also identified other potential funding sources to support the implementation of recovery actions identified in the Southern California Steelhead Recovery Plan (for a list of additional funding sources, see Appendix E, Habitat Restoration Cost References for Steelhead Recovery Planning).

15.2 ONGOING REGULATORY PRACTICES

The ESA provides NMFS with various tools for first protecting and then recovering listed species. The ESA focuses on first identifying species and ecosystems in danger of immediate or foreseeable extinction or destruction and protecting them as their condition warrants. Then, the ESA focuses on the prevention of further declines in their condition through the consultation provisions of section 7(a)(2), habitat protection and enhancement provisions of sections 4 and 5, take prohibitions through sections 4(d) and 9, cooperation with the State(s) in which these species are found (section 6) and needed research and enhancement as well as conservation of species taken by non-federal actions through section 10. Ultimately, the ESA focuses on the conservation (commonly equated with the term recovery) of these species and ecosystems through the recovery planning provisions of section 4, cooperation with States in section 6, and direction to all federal agencies to conserve species in section 7(a)(1). Clean Water Action Section 404 is an important tool for regulating the discharge of material or the additional of fill material to the rivers, streams, and estuaries of California, and is one of the principle means by which consultations under section 7(a)(2) can be initiated.

In the case of listed salmon and steelhead in California, NMFS has already used the listing and designation of critical habitat provisions to protect the current populations of these species. For the past two decades, NMFS has also worked closely with federal agencies and private landowners pursuant to sections 7(a)(2) and 10(a)(1) of the ESA to avoid and minimize additional harm to these species during the course of land and water-use activities. Significant benefits have already accrued to these listed species from changes in land and water-use practices. Unfortunately, in many areas, salmon and steelhead populations continue to decline. The development and implementation of Recovery Plans has a greater scope and objective than the project-by-project focus of most section 7 and 10 efforts, however. NMFS intends to use this broader perspective to effect more significant and focused beneficial change for salmon and steelhead. In addition, NMFS intends to implement every action within this Recovery Plan for which it has authority.

The following sections describe the methods NMFS intends to use when implementing various sections of the ESA. These methods are intended to institutionalize the Recovery Plans in the daily efforts and decision-making at NMFS in the Southwest Region. Of necessity, some of these methods address the urgent issues of staffing and workload that NMFS faces. As a result, our commitment to implementing Recovery Plans extends to the ways in which we prioritize the many requests for consultations and permits we receive.

15.2.1 ESA Section 4

Section 4 provides the mechanisms to list new species as threatened or endangered, designate critical habitat, develop protective regulations for threatened species, and to develop Recovery Plans. The currently designated critical habitat includes only a portion of the habitat which may be necessary for recovery of the DPS. NMFS intends on using our recovery strategy, recovery criteria and recommended recovery actions to review the Southern California steelhead DPS critical habitat designation. A review of the current critical habitat designations may result in modifications of the current critical habitat designations, including the addition of unoccupied habitat which exhibit Primary Constituent Elements (PCEs).

15.2.2 ESA Section 5

Section 5 is a program that applies to land acquisition with respect to the National Forest System. Four National Forests (Los Padres, Angeles, Cleveland and San Bernardino) are present within the range of southern California steelhead. As funds become available, NMFS will work with the U.S. Forest Service to acquire important habitat areas for the purpose of protecting habitat features and functions needed to support the expression of diversity and spatial structure in the species.

15.2.3 ESA Section 7

15.2.3.1 Section 7(a) (1)

Section 7(a)(1) provides that all Federal agencies shall "…in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species…". Section 7(a)(1) provides that Federal agencies give the conservation of endangered species a high priority.

To prompt Federal agencies to develop conservation programs to fulfill their Federal obligations, NMFS shall:

- ☐ Prepare, and send, after Recovery Plan approval, a letter to all other appropriate Federal agencies outlining section 7(a)(1) obligations and meet with these agencies to discuss listed steelhead conservation and recovery priorities;
- ☐ Incorporate recovery actions in formal consultations as Conservation Recommendations;
- ☐ Encourage meaningful and focused mitigation, in alignment with recovery goals for restoration and threats abatement, for all

actions that incidentally take steelhead or affect their habitat;

☐ Encourage Federal partners to include recovery actions in project proposals; and

☐ Incorporate conservation actions, as appropriate, into the actions that NMFS authorizes, funds, or carries out.

15.2.3.2 Section 7(a) (2)

The purpose of section 7(a)(2) is to "insure that any action authorized, funded, or carried out by [a Federal agency] is not likely to jeopardize the continued existence of any [listed species] or result in the destruction or adverse modification of [a listed species' critical habitat]." Federal agencies request interagency consultation with NMFS when they determine an action may affect a listed species or its critical habitat. NMFS then conducts an analysis of potential effects of the action. In the process of consultation, NMFS currently expends considerable effort to assist agencies in avoiding and minimizing the potential effects of proposed actions, and to ensure agency actions do not jeopardize a species or destroy or degrade habitat. Whether the action has a negative effect on the likelihood of the species recovering is considered as part of the analysis; the action may not appreciably reduce the likelihood of recovery. As a result, these consultations have helped avoid and minimize direct take and contributed to recovery of Southern California steelhead DPS.

Because section 7(a)(2) applies only to Federal actions, its applications are limited only to those areas and actions with federal ownership, oversight, or funding. In the Southern California Steelhead DPS, land ownership varies across the watersheds from areas with significant levels of public ownership to areas almost entirely privately owned. Most of the land use practices on private ownership do not trigger interagency consultation.

Currently, NMFS expends most of its staff time and resources on conducting section 7 consultations. Implementation of the Recovery Plan will require improvements to the process and application of section 7(a)(2) consultation requirements across the DPS.

In order to devote more resources towards recovery action implementation and to ensure section 7(a)(2) consultations are effective, NMFS will utilize its authorities to:

☐ Use recovery criteria, objectives, and ongoing monitoring efforts as a reference point to determine effects of proposed actions on the likelihood of species' recovery;

☐ Utilize information on threats to species recovery and needed actions to address such threats when evaluating the impacts of proposed Federal actions on southern California steelhead;

☐ Place high priority on consultations for actions that implement the recovery strategy or specific recovery actions;

☐ Develop and maintain databases to track the amount of incidental take authorized and effectiveness of conservation and mitigation measures;

☐ Incorporate recovery actions in formal consultations as Reasonable and Prudent Measures, Reasonable and Prudent Alternatives, and Conservation Recommendations as appropriate;

☐ Focus staff priorities towards section 7 and 9 compliance in watersheds identified as core populations for the purpose of recovery of the Southern California Steelhead DPS;

☐ Streamline consultations for those actions with little or no effect on recovery areas or priorities. Develop streamlined programmatic approaches for those actions that do not pose a threat to the survival and recovery of the species; and

- ☐ Apply the VSP framework and recovery priorities to evaluate population and area importance in jeopardy and adverse modification analyses.

Within this framework NMFS will utilize its authorities to encourage:

- ☐ Federal Emergency Management Agency (FEMA) to fund upgrades for flood-damaged facilities to meet the requirements of the ESA and facilitate recovery;
- ☐ Environmental Protection Agency (EPA) to prioritize actions on pesticides known to be toxic to fish and/or are likely to be found in fish habitat; and to take protective actions, such as restrictions on pesticide use near water;
- ☐ Development of section 7 Conservation Recommendations to help prioritize Federal funding towards recovery actions (NFMS, USFWS, NRCS, EPA, *etc.*) during formal consultations;
- ☐ All Federal agencies that designate a non-Federal representative to conduct informal consultation or prepare a biological assessment to ensure the associated documentation comports to 50 CFR 402.14(c) prior to initiating consultations with NMFS; Compliance with these requirements is expected to increase consultation effectiveness and timeliness;
- ☐ All Federal agencies, or their designated representatives, to field review projects and actions upon project completion to determine whether or not the projects were implemented as planned and approved. Encourage all Federal agencies, or their designated representatives to report the initial findings of field review to NMFS; and
- ☐ Federal agencies to coordinate and develop programmatic incidental take authorization for activities that contribute to the recovery of southern California steelhead to streamline their permitting processes

15.2.4 ESA Section 9

Section 9 prohibits any person from harming members of listed species including direct forms of harm such as killing an individual, or indirect forms such as destruction of habitat where individuals rear or spawn. The Recovery Plan will assist NMFS' Office of Law Enforcement (OLE) personnel by targeting focus watersheds essential for species recovery. NMFS PRD staff will work closely with NMFS' OLE regarding the identification of threats and other activities believed to place steelhead at high risk of take.

Towards this end, NMFS will:

- ☐ Conduct outreach and provide the NMFS' OLE a summary of the recovery priorities and threats;
- ☐ Prioritize those actions and areas deemed of greatest threat or importance for focused efforts to halt illegal take of listed species
- ☐ Periodically review existing protocols establishing responsibilities and priorities between PRD and Enforcement to ensure activities by NMFS staff, when supporting NMFS' OLE are focused on the highest recovery priorities; and
- ☐ When take has occurred in a primary focus area, NMFS PRD will work with NMFS' OLE, to the extent feasible, with the development of a take statement.

15.2.5 ESA Section 10

Section 10(a)(1)(A) provides permits for the authorization of take of listed species for scientific research purposes, or to enhance the propagation or survival of listed species. Typically NMFS has authorized conservation hatcheries and research activities under section

10(a)(1)(A). Section 10(a)(1)(B) provides permits for otherwise lawful activities that incidentally take listed species. Habitat conservation plans minimizing and mitigating the incidental take of listed species from non-federal activities are prepared under section 10(a)(1)(B). Currently, both processes take a long time to implement and Recovery Plans have not been available to guide priorities for permit issuance. To improve the section 10 authorization process, NMFS will utilize its authorities in the following ways:

15.2.5.1 Section 10(a) (1) (A) Research Permits

In order to assure that the best available science is developed and used to recover the Southern California Steelhead DPS NMFS will:

- ☐ Prioritize permit applications that address identified research, monitoring, and/or enhancement activities, including any conservation hatchery operations, in the Southern California Steelhead Recovery Plan;
- ☐ Evaluate all proposed research and/or enhancement activities within the framework of identified threats, recovery strategy, and recovery actions identified in the Recovery Plan;
- ☐ Develop a streamlined process for permitting priority research activities to facilitate the implementation of the research program identified in the Recovery Plan; and
- ☐ Support and maintain the national research and enhancement database to track the amount of take authorized and the effectiveness of conservation and mitigation measures identified in the Recovery Plan.

15.2.5.2 Section 10(a) (1) (B) Habitat Conservation Plans

To ensure that all of the mechanisms available to achieve the goals, objectives and criteria of the Southern California Steelhead Recovery Plan, NMFS will:

- ☐ Place the highest priority on cooperation and assistance to landowners proposing activities or programs designed to achieve recovery objectives; and
- ☐ Prioritize those areas and actions where threats abatement has the potential to provide the most significant contribution to species recovery based on the threats assessment developed and updated as part of the Recovery Plan.