Exhibit DFG-T-A

DFG-T-A

TESTIMONY OF ROBERT TITUS REGARDING El SUR RANCH WATER RIGHT APPLICATION

I. INTRODUCTION

I am currently employed by the California Department of Fish and Game (Department or DFG) as a Senior Environmental Scientist in the Fisheries Branch. In this position I supervise and contribute technical expertise to fishery projects involving assessments of stream flow, temperature, and other manageable habitat attributes with an emphasis on anadromous salmonids: stock assessment, age and growth, population monitoring and life histories. Prior to my current position, I worked in the DFG Fisheries Branch Stream Evaluation Program. The primary focus of the program was assessment of salmonid-habitat relationships, including stream flow, water temperature, and other manageable stream habitat attributes and their influences on production and life histories of salmon and steelhead.

I hold Bachelor of Arts and Master of Science degrees in Biological Sciences from California State University, Sacramento (CSUS), and a PhD in limnology[1] from Uppsala University in Sweden. Both my Master's and PhD work focused on the study of trout. I have worked on anadromous salmonid research and management issues for over twenty years, in both academic and government settings, in both California and in Scandinavia. My academic experience includes work as both a lecturer and adjunct professor in the Department of Biological Sciences at CSUS. I have lectured on and taught coursework in fishery biology, conservation policy and administration, and natural resource conservation. In my work with DFG, I have published numerous research articles, manuscripts, and technical reports related to both anadromous and freshwater fish. My curriculum vitae is attached as **Exhibit DFG-T-B**.

I have prior experience with studies and data collection efforts relating to steelhead in the Big Sur River. I conducted an investigation of juvenile steelhead habitat use and life history on the Big Sur River from 1992 through 1995. **Exhibit DFG-T-1** provides an overview of the study along with a progress report and summary of preliminary findings as of August 1994. I also led an effort during 1997 to collect scales from adult steelhead spawners on the Big Sur River for an age and growth study. This was a collaborative effort between a graduate student at California Polytechnic University, San Luis Obispo, DFG biologist Jennifer Nelson, local Big Sur and Monterey Peninsula anglers, and me. My last direct involvement in data collection efforts on the Big Sur River itself was during August 1997 when two co-workers and I conducted a brief electrofishing survey of Juan Higuera Creek to follow-up on a tagging study initiated in September 1994. **Exhibit DFG-T-2** is a copy of field notes I compiled during the course of these investigations.

[1] Limnology is the study of inland waters -- lakes, ponds, rivers and streams -- examining physical, chemical and biological variables that influence living organisms in such ecosystems.

II. PURPOSE OF TESTIMONY

The Department is providing testimony to respond to some of the key questions posed by the State Water Resources Control Board (SWRCB) in the Notice of Public Hearing for Water Right Application 30166 of El Sur Ranch (El Sur) and to support the terms and conditions it has proposed for inclusion in El Sur's water right permit. The Department believes that the terms and conditions are necessary to protect public trust resources and other lawful water right holders on the Big Sur River.

III. IMPACTS TO PUBLIC TRUST RESOURCES

a) Will approval of the application result in any significant adverse impacts to water quality, the environment, or public trust resources?

Yes. The El Sur Ranch diversions as specified in water right application #A030166 will likely result in significant impacts to steelhead habitat and other public trust resources. Approval of the diversions at the requested rates creates the physical setting where periods of low flow will likely result in significant impacts to fisheries both in the zone of pumping influence (ZOI) and lagoon because the reduction in flow can restrict fish passage and mobility, degrade habitat, possibly dry up the river, and may result in an increase in water temperature and a reduction in dissolved oxygen depending on the channel location and geomorphology (see **Exhibit DFG-C-A**).

(1) Steelhead is an important public trust resource.

The Big Sur watershed provides habitat for many valued public trust resources, including the steelhead rainbow trout (*Oncorhynchus mykiss*). The steelhead trout is the most widespread anadromous fishery resource in California. In its first biennial report to the California Legislature in 1872, the California Fish Commission reported that "(t)his fish is found in nearly all of the streams that discharge into the Pacific Ocean from the Coast Range of mountains and in the greater number of the mountain streams of the Sierra Nevada." Coastal streams from the Oregon border to northern Baja California in Mexico have historically supported steelhead populations, providing an important source of food to early Californians and an equally important source of recreation to later Californians.

Development of the State's resources by European settlers has over time led to the decline of many California steelhead populations. Most of the steelhead populations in California's southernmost coastal counties have been extirpated or greatly reduced within the last 60 years, and the trend in decline of steelhead appears to be "creeping" northward along the coast. **Exhibit DFG-T-3** (page 257 et seq.) describes the trend in extirpations of steelhead populations from San Diego through San Mateo counties. As of the mid-1990s, an estimated 92% of steelhead populations were extirpated in San Diego and Orange counties combined, 56% in Los Angeles and Ventura counties combined, 38% in Santa Barbara County, 8% in San Luis Obispo County, 6% in

Monterey County, and 0% in each of Santa Cruz and San Mateo counties. Diversion of water from rivers and streams supporting steelhead was found to be the most common factor affecting steelhead distribution and abundance, ranging from 100% of populations in San Diego and Orange counties to 21% of populations in Santa Cruz County and affecting 35% of populations overall. As a result of these losses, a great deal of steelhead fishing opportunity has been lost in California's south and central coastal regions, along with the economic benefits that steelhead fishing provides to local coastal communities.

The Big Sur River steelhead population has supported a significant sport fishery on the south-central California coast for several decades, as evidenced in a review of DFG stream survey file information (**Exhibit DFG-T-3**, pages 111 - 117). Fisheries for both rearing juvenile steelhead and adults are documented back to at least the early 1930s. Abundance was so great that several hundred juvenile steelhead were harvested by sport anglers in a single day. Planting of catchable size rainbow trout occurred from 1953 to 1975, primarily to support a summer "trout" fishery in Pfeiffer Big Sur State Park. The summer fishery was productive with an estimated catch rate of 1.1 trout per angler hour in 1962. Like on the Carmel River, adult steelhead on the Big Sur River are the highly sought-after, large California coastal type, ranging in length up to at least 35 inches and in weight to at least 15 lb. Progressively more restrictive regulation of the sport fisheries over time reflects the overall coastwide decline of steelhead abundance that has occurred over the past several decades. Currently, fishing for juvenile steelhead is completely prohibited in streams on the central and south coast, and while angling is still allowed for adult steelhead on the Big Sur River, no harvest is permitted.

While the Big Sur River has long been a focal point for anglers in the Big Sur region, it has also become increasingly important for providing sportfishing opportunity to anglers from other regions. This is perhaps especially the case for anglers from the Monterey Peninsula and northern Monterey Bay as the Carmel River and San Lorenzo River steelhead sport fisheries have declined. While other small streams that drain the west slope of the Santa Lucia Range along the Big Sur Coast also provide steelhead angling opportunity, most of them have only a very short anadromous reach west of Highway 1 available to anglers. In this respect, the Big Sur River is a real standout because the river turns northward after passing under Highway 1, providing several miles of fishable water with good public access. The ecotourism associated with steelhead fishing is a seasonally important source of income to local Big Sur coastal communities.

In summary, from the perspective of the public trust, the Big Sur River steelhead population is an exceptional resource. It, along with nearby steelhead populations such as those in the Little Sur River and San Jose Creek, are the mainstays of wild steelhead along the Big Sur coast. Unlike the populations in the Carmel and San Lorenzo rivers to the north, the Big Sur River steelhead population is not dependent upon intervention from hatchery production or rearing facilities for maintenance of its steelhead population. The river is unimpaired by dams, which means that its continuum of riverine conditions is largely intact from headwaters in the Ventana Wilderness Area to the Pacific Ocean. Not only are these conditions significant from an ecological perspective, but also from a human aesthetic perspective with regard to the quality of the recreational fishing opportunity provided by this roadside water.

(2) The size of the Big Sur River watershed and the steelhead population it contains makes the proper conditioning of the El Sur Ranch water right application a necessity.

While the name, *Big* Sur, perhaps implies a large river system, the Big Sur River watershed is actually rather small, comprising an area of only 58 square miles. The main stem of the river is about 16 miles long, of which only 8 miles are reliably available for steelhead spawning and rearing. This is due to a partial waterfall barrier at the upstream end of Pfeiffer Big Sur State Park where the river exits a high gradient gorge. The management history of this barrier is described in **Exhibit DFG-T-3** (pages 113 – 114). Even though the Big Sur River is the largest unimpaired stream on the Big Sur Coast, its watershed is dwarfed in size among other central California coastal steelhead rivers. The Carmel River watershed is nearly 4.5 times larger at 255 square miles, the San Lorenzo River watershed is over twice as large at 138 square miles, and the Russian River watershed is over 25 times larger at 1,485 square miles. For a size comparison with a stream in the Sacramento region, consider the Dry Creek system (Placer and Sacramento counties) that originates near Newcastle, flows through Roseville, and ultimately joins the Sacramento River via Steelhead Creek and Bannon Slough. This system of foothill creeks supports small populations of Chinook salmon and steelhead but is typically regarded as a relatively minor tributary to the Sacramento River, both in terms of contribution of flow and because of its small addition to Sacramento River anadromous fishery resources. Yet, Dry Creek has a watershed area of 101 square miles, which is 74% larger than that of the Big Sur River.

The Big Sur River watershed produces an annual mean runoff of 73,040 ac-ft. As in most unimpaired, rain-fed streams in California's Mediterranean climate, runoff on the Big Sur River is relatively high during the winter rainy season, declines sharply during spring, and settles into a trough during a summer-to-fall low-flow period. This pattern is illustrated in **Exhibit DFG-T-4** showing monthly mean flow based on streamflow data recorded at United States Geological Survey (USGS) gage 11143000 since 1950. The long-term mean low flow of the year is 15 cfs, on both a daily and monthly basis, and stream flow on the Big Sur River has been as low as 2.6 cfs. As will be discussed later in my testimony, the summer-to-fall low-flow period is of greatest concern with regard to ensuring adequate instream flow for protection of steelhead on the Big Sur River, within the constraints of the watershed's natural water supply.

While the Big Sur River supports one of the most important steelhead populations on the central California coast, the population is nonetheless modest in size, which is consistent with the modest size of both the watershed and the river's anadromous reach. The DFG estimated the population at 300 adults for the State of California's 1965 Fish and Wildlife Plan. In comparison, the steelhead run on Waddell Creek in Santa Cruz County averaged about 480 adults during the 1930-40s, as determined by DFG research done there (summarized in **Exhibit DFG-T-3**, pages 104-105, with citation of the original work by DFG biologists, Leo Shapovalov and Alan Taft). Given that the

Waddell Creek watershed area (24 square miles) is less than half that of the Big Sur River, the relatively higher abundance of adult steelhead at Waddell Creek may have reflected an overall higher level of steelhead abundance along the central coast at that time. The steelhead population on the Carmel River, as indexed at the fishway on San Clemente Dam, averaged 821 adults from 1964 through 1975 as presented in **Exhibit DFG-T-5**, which is consistent with the size of that watershed relative to the Big Sur River. The Big Sur River steelhead population has possibly declined to 100 or fewer adults in more recent decades, as indicated by Nehlsen et al. (1991) in **Exhibit DFG-T-6**.

In spite of its modest watershed area and steelhead population size, the Big Sur River is an extremely important production area for steelhead on California's south-central coast, making conservation of the limited water resources its drainage area produces essential for maintenance of the river's steelhead population. In this respect, the magnitude and schedule of diversion as sought by the El Sur Ranch is of particular concern to DFG. Given the small amount of water available from the watershed during the summer-to-fall low-flow period, a diversion of the magnitude in the application will disrupt the ecological function of the river, inducing cascading effects on steelhead production and life histories that, in the long term, would be predicted to result in reduced abundance of an already modestly sized steelhead population. My testimony below presents evidence that addresses specific issues related to juvenile steelhead growth, prospects for survival in the ocean, and ability to migrate freely between the Big Sur River and the Pacific Ocean.

<u>(3) The current conservation status of steelhead on the south-central coast and what it conveys about the importance of protecting the Big Sur River steelhead population in view of the application.</u>

In 1996, the National Marine Fisheries Service (NMFS) published a status review of west-coast steelhead (**Exhibit DFG-T-7**) in response to a petition submitted in 1994 to list steelhead in Washington, Idaho, Oregon, and California under the U.S. Endangered Species Act of 1973 (ESA). The Big Sur River was included in the South-Central California Coast Steelhead Evolutionarily Significant Unit (ESU), which extends from the Pajaro River in the north to, but not including, the Santa Maria River in the south. The status review determined that the ESU was in danger of extinction due to extremely low abundance, which would have been consistent with a listing determination of "endangered" under the ESA. The ESU was listed as "threatened" in 1997, and in 2006 the resident rainbow trout morph of *O. mykiss* was removed from the listing designations by dropping application of the ESU concept and instead adopting the Distinct Population Segment (DPS) concept for steelhead alone. Among activities identified that could potentially "harm" steelhead and result in "take" of the species (and thus a violation of the Section 9 take prohibition of the ESA) was "diverting... surface or ground water flow."

That the Big Sur River steelhead population continues to support a viable catch-and-release sport fishery within the context of a DPS that may have warranted an endangered listing under the ESA underscores the population's overall importance to that conservation unit. Steelhead populations within a DPS must be largely reproductively isolated from steelhead populations in other DPSs, but must interact among themselves to result in the relatedness that distinguishes the DPS. The group of populations within the DPS represents then a "metapopulation," where functionally there are "source" populations inhabiting relatively large, stable habitat "patches" that provide colonizing individuals to "sink" populations in smaller, relatively unstable habitat patches. Stability of a habitat may be related to, for example, hydrological conditions and the relative opportunity that steelhead have to migrate freely between the stream and the ocean, resilience to drought in terms of there being sufficient stream flow to provide low-flow refugia for rearing steelhead, and resilience to flooding where the habitat provides protective cover from scour of spawning gravels and physical displacement of juvenile steelhead. Extinction risk is relatively low in source populations and high in sink populations, placing high importance on colonizing individuals from source populations (i.e., strays) to help maintain the sink populations.

Within the South-Central California Coast Steelhead DPS, the Big Sur River is likely an important source population that helps maintain some of the very small steelhead populations that occur throughout the Big Sur Coast but which have very limited anadromous reaches due to geological barriers at relatively short distances upstream from their mouths. Examples of these likely sink populations inhabit Alder, Anderson Canyon, Bixby, Limekiln, Mill, Partington, Plaskett, Prewitt, Rocky, and Salmon creeks. **Exhibit DFG-T-3**, within pages 108–149, provides descriptions of these streams and what is known about their steelhead populations based primarily on information from DFG and other agency resource assessment activities over several decades.

Among the characteristics of the Big Sur River that indicate its importance as a source population are the relative size of the watershed for water supply, the relative length of the anadromous reach, connectivity of the river to the Pacific Ocean, and the relative size and productivity of the steelhead population. The latter is especially important as colonizing individuals to sink populations are provided by straying. Because central coast steelhead home successfully to their natal stream at a very high rate, straying from larger source populations is important to result in any appreciable numbers of individuals that function as colonizers to sink populations. **Exhibit DFG-T-3** (page18, with citation of the original work conducted by DFG biologists Alan Taft and Leo Shapovalov) summarizes early work by DFG regarding homing rates of central coast steelhead. Homing rates of marked steelhead as estimated at Waddell and Scott creeks in Santa Cruz County were 98% and 97%, respectively. Assuming an average straying rate from these figures of 2.5%, the Big Sur River with a steelhead run size of 300 adults would yield seven to eight strays per year to serve as colonizing individuals to sink populations in the South-Central California Coast DPS. At a run size of 100 adults, the number drops to only two to three strays. **Exhibit DFG-T-8** illustrates the importance of both spatial and temporal scale in detecting metapopulation structure in groups of salmonids populations, and the risk of losing the source-sink function if the metapopulation is not detected or is ignored in conservation efforts. The same would apply to regulatory efforts such as this water right proceeding.

Thus, protecting, maintaining, and even improving conditions on the Big Sur River for steelhead production is of very high importance, not only for the steelhead population on the Big Sur River itself, but also for continued viability of the entire South-Central California Coast Steelhead DPS. The significance of this function gains even more weight considering extreme declines in steelhead abundance in what were other likely source populations in the DPS: the Pajaro, Salinas, and Carmel rivers. **Exhibit DFG-T-7** summarizes the extent of these declines.

The Big Sur River, along with nearby Little Sur River and San Jose Creek to the north, has recently been designated collectively as a steelhead stronghold in the South Coast Ecoregion of California by the North American Salmon Stronghold Partnership (NASSP) (**Exhibit DFG-T-9**). The NASSP designation, based on input from fishery agencies in California including DFG and NMFS, indicates that, "(w)hile not connected hydrologically, this group of small rivers forms an irreplaceable area for strong steelhead populations." The stronghold designation of the Big Sur River is consistent with its role as a source population within the steelhead metapopulation represented by the South-Central California Coast Steelhead DPS.

The bottom-line message here addresses scale with regard to the significance of productivity of the Big Sur River steelhead population. The question of how the El Sur Ranch diversion may affect steelhead on the Big Sur River is not restricted to just individuals within the zone of influence of the pumps on an annual basis, or even to the Big Sur River population as a whole, but also as to how incremental losses in steelhead productivity in the Big Sur River affect the entire South-Central California Coast Steelhead DPS on a time scale of at least decades.

(4) The Department's specific biological concerns with the water right application of El Sur Ranch.

DFG is concerned that the timing and magnitude of the El Sur Ranch's proposed diversion will exacerbate the effects of naturally occurring low flows during summer and fall on steelhead production on the Big Sur River. The El Sur Ranch's diversions do have a measurable effect on the surface flows of the Big Sur River. Refer to the testimony of Kit Custis (**Exhibit DFG C-A**) for a discussion regarding how the El Sur Ranch's diversion from the subterranean stream relates to the surface flow of the Big Sur River. My testimony presented below provides evidence that supports the concerns that diversions from the Big Sur River have the potential to exacerbate the effects of naturally occurring low flows on steelhead production, particularly during the summer and fall.

As with most coldwater anadromous resources in California, DFG views the Big Sur River steelhead population as sensitive to environmental change. This assessment has had broad acceptance for decades. In a review of salmon and steelhead stocks in California, Oregon, Idaho, and Washington, Nehlsen et al. (1991) (**Exhibit DFG-T-6**) identified the Big Sur River steelhead population as a "Stock of Special Concern," a classification including populations that could be threatened by "relatively minor disturbances." The nature of threat category associated with the Big Sur River was habitat damage, which included mainstem passage and instream flow problems. Thus, water diversion has been recognized as a potential threat to the Big Sur River steelhead population for at least 20 years.

Documentation of water diversion and associated effects on steelhead distribution and abundance in other south and central coast streams serve as examples from which to learn. **Exhibit DFG-T-3** (pages 193 – 203) chronicles and assesses the progressive decline in steelhead habitat suitability and use in lower Santa Rosa Creek in San Luis Obispo County resulting from surface and sub-surface diversion of stream flow, and associated effects of adjacent cattle ranching and crop production. Measurement of juvenile steelhead densities in the lower and upper creek areas from 1970 to 1993 revealed a statistically significant shift in habitat use patterns for spawning and early rearing of steelhead. Using average densities of juvenile steelhead in the upper and lower creek areas as an index, the percentage of the population using the upper creek increased from about 73% in 1970, to 87% in 1978, to 97% in 1993, with a corresponding decrease in the lower creek from 27% to 13% to 3%, respectively. Loss of instream flow in the lower creek also rendered the lagoon unsuitable as juvenile steelhead rearing habitat. In addition, steelhead densities overall decreased by an order of magnitude during that 23 year period. State and federal agency biologists, academic researchers, and consultants all agreed that loss of instream flow was the primary factor affecting steelhead abundance and habitat use in lower Santa Rosa Creek.

My testimony addresses several aspects of steelhead life history that may be affected by the El Sur Ranch diversion, especially during the summer-to-fall low-flow period. The testimony is supported with data collected by the Department in years 1992-1997 related to studies of the Big Sur River steelhead population and associated instream habitat, and by other research conducted on central coast steelhead in recent years, including a University of California/NMFS/DFG collaboration (see **Exhibits DFG-T-11 and DFG-T-12**) in which the Department participated. My testimony emphasizes the:

1. low-flow effects on juvenile steelhead growth, consequences for size at ocean entry, and survival to adulthood;
2. depth needs of Big Sur River adult steelhead to ensure upstream passage at critical riffles; and
3. need for protection of life-history diversity within the Big Sur River steelhead population to maintain adaptability to variable environmental conditions.

My testimony concludes with an interim minimum flow recommendation for juvenile steelhead rearing.

4a) Relationship between flow conditions on the Big Sur River and juvenile steelhead growth.

It is my opinion that the diversions of El Sur Ranch have the ability to influence food availability for juvenile steelhead and thus may affect their growth. My testimony below addresses the relationship between food availability and growth, and the importance of maintaining growth in juvenile steelhead populations.

To determine the relationship between food availability and growth, I examined length-frequency distributions and length-weight relationships of juvenile steelhead sampled by electrofishing at intervals from October-November 1992 though August 1995. **Exhibit DFG-T-1** provides the details on the sampling design and methods utilized in the studies. Length-frequency distributions provide an opportunity to estimate average growth rates and to follow changes in population structure through time. Length-weight regressions provide an indication of the gross nutritional status of steelhead in a population by describing how weight varies as a function of length. The actual regression line represents the average condition of this relationship where the slope of the line, *b*, is especially important. When $b = 3$, steelhead in the population have, on average, a "normal" weight and nutritional status relative to a given length. When $b < 3$, weight of steelhead is below normal on average, and thus indicative of a relatively poor nutritional state. The opposite is the case when $b > 3$. A below normal slope in age 1 and older steelhead during the spring may also be an indication of smolting, as steelhead smolts become very streamlined in body shape as they prepare for entry into the ocean.

Exhibit DFG-T-10 contains graphic representations of Big Sur River juvenile steelhead length-frequency distributions and length-weight relationships from October-November 1992 to November-December 1994 and stream flow records from USGS gauge 11143000 on the Big Sur River for the period December 1991 through November 1995. These series of figures are referred to throughout the following discussion on juvenile steelhead growth and nutritional status.

The length-frequency distribution of fish sampled during October-November 1992 shows a typical juvenile steelhead population structure. The population was dominated by age 0 steelhead that had a strongly defined mode between 70 and 80 mm fork length (FL) and averaged about 85 mm FL. The distribution of age 1 and older steelhead was apparent but not well-defined because of their very low relative frequency. Flow conditions during 1992 had been well below the long-term mean and were near the low flow of the season (as low as 5.8 cfs) when these fish were sampled. The slope of the length-weight relationship was slightly below normal ($b = 2.92$).

By June-July 1993, the relative frequency of steelhead produced in 1992 was very low, the result of presumed winter mortality and smolt emigration. The abrupt drop in frequency at 160 mm FL was likely due to emigration of age 1 smolts above that size. The population was dominated by the new age 0 group that averaged 52 mm FL. Steelhead between 20 and 30 mm FL were recently emerged from the gravel and indicative of late spring spawning. The slope of the length-weight relationship was slightly above normal ($b = 3.07$).

By August-September 1993, age 0 steelhead had grown an average of 35 mm over a 76 day period, or 0.46 mm per day, to a mean size of 87 mm FL. The slope of the length-weight relationship remained at 3.07. Thus, the young fish grew relatively well and maintained a positive nutritional status through the summer while stream flow declined from about 60 to 20 cfs.

The pattern of growth changed considerably during the fall low-flow period, as evidenced from sampling conducted in November 1993. After an average of 73 days, age 0 steelhead gained an average of only 5 mm in length, or 0.07 mm per day, to a mean size of 92 mm FL. In addition, their average nutritional status dropped below normal where the slope of the length-weight relationship decreased to 2.96. Thus, juvenile steelhead growth in length nearly stopped and the fish lost weight during the fall low-flow period when stream flow varied mostly between 15 and 20 cfs.

Sampling of age 0 steelhead produced in 1994 started in April, capturing the early fry emergence phase and presence of smolts. The length-frequency distribution of age 0 steelhead was distinct from age 1 and older fish. Age 0 steelhead averaged 31 mm FL and included many very recently emerged fry in the 20 – 30 mm FL range. Emigration of age 1 and older smolts was underway at this time and these fish were still evident in the length-frequency distribution as those approaching 150 mm FL or so. The length-weight regression of steelhead sampled during this period also indicated the presence of smolts in the population, as their weight-on-length trajectory fell below that of non-smolting steelhead in the population. The slope of the length-weight regression for fry and parr (non-smolting) steelhead alone was relatively high (b = 3.31), suggesting a relatively high nutritional status, while that for silvery parr and smolts was relatively low (b = 2.90), as is characteristic of these fish. Flow conditions during this survey period were already quite low (25 cfs) and reflected the critically dry water year.

Age 0 steelhead grew an average of 27 mm during 71 days, or 0.38 mm per day, to a mean size of 58 mm FL by the time the population was sampled in June 1994. Recently emerged fry (20 – 30 mm FL) were still present in the population, indicating late spring spawning as was seen in 1993, and the lengths of age 0 steelhead were now blended with those of age 1 steelhead. The loss of smolts from the instream population was evident by the overall reduction in relative frequency of age 1 and older steelhead in the length-frequency distribution, especially those over 150 mm FL. By this time, nearly all the steelhead sampled were following the same length-weight trajectory, although their average nutritional status was beginning to decline relative to non-smolted fish in April as indicated by a slope of 3.15 (c.f., b = 3.31 in April). Flow conditions during this sampling period had dropped to 11 cfs, well below the long-term daily mean flow of 32 cfs.

By September 1994, steelhead fry emergence was complete and the smallest fish were 40 – 50 mm FL. Age 1 and older steelhead were greatly reduced in relative frequency, presumably from seaward migration, whether to the lowermost river/lagoon for continued rearing or to the Pacific Ocean as smolts. Age 0 steelhead averaged 75 mm FL and had grown a very modest 17 mm on average during 93 days since June 1994, at an estimated rate of 0.18 mm per day. This is in sharp contrast to the relatively good growth of age 0 steelhead during summer 1993 when they grew at an average estimated rate of nearly 0.5 mm per day. The slope of the length-weight regression for juvenile steelhead in September 1994 had dropped considerably from 3.15 in April to 2.87, indicating that the nutritional status of these fish was worsening as stream flow dropped to as low as 5.5 cfs.

When sampled in November-December 1994, the arrested growth of age 0 steelhead observed during the fall low-flow period in 1993 was evident once again. Age 0 steelhead averaged 81 mm FL and had only grown 6 mm on average during 71 days since September 1994, or an estimated 0.08 mm per day. The slope of the length-weight regression for steelhead during this sampling period was still below 3 (b = 2.93), but had improved somewhat since September 1994 when b = 2.87. Stream flow preceding this sampling survey was about 10 cfs, so there had been some improvement in flow conditions since September. At least two minor precipitation events during the course of sampling initiated an overall increasing trend in flow.

During the September 1994 sampling survey, 1,000 juvenile steelhead in the Big Sur River were tagged with Passive Integrated Transponders, or so-called PIT tags. Each tag emits a unique alpha-numeric code that allows for tracking of individual fish through time and space in tag-recapture studies. About 200 PIT-tagged steelhead were recaptured in the Big Sur River during the November-December 1994 sampling survey. Growth in length of individually PIT-tagged steelhead during the fall low-flow period corroborated the results of the length-frequency assessment above. The daily mean (± SD) growth rate was 0.05 ± 0.05 mm per day, and variable among individuals given the range of -0.13 to 0.21 mm per day. Growth in weight among individually PIT-tagged steelhead was essentially 0 on average; the daily mean (± SD) growth rate was 0.004 ± 0.022 g per day over the 71 day period. As with growth in length, individual growth rates in weight varied considerably: from -0.10 to 0.08 g per day. Note that negative growth occurred in both length and weight.

The results of this assessment suggest two primary influences of flow conditions on juvenile steelhead growth in the Big Sur River. First, water year type appears to have an overriding effect on overall growth performance of juvenile steelhead. During relatively "good" water years when flow on the Big Sur River is above the long-term mean, juvenile steelhead grow at relatively high rates, maintain a favorable nutritional status, and attain a relatively large size as they approach the end of their first year. The opposite is the case in "bad" water years when flow on the Big Sur River remains below the long-term mean during most of the year. For example, in 1993, a wet water year type, age 0 steelhead achieved an average growth rate in summer of nearly 0.5 mm per day, maintained an above normal length-weight relationship indicative of a favorable nutritional status, and grew to a relatively large mean size of 92 mm FL by mid-November. In contrast, in 1994, a critically dry water year type, age 0 steelhead grew at a relatively high average rate of 0.38 mm per day during spring but as stream flow receded sharply during summer, their growth rate dropped correspondingly to a very low average rate of 0.18 mm per day. Similarly, the length-weight relationship of juvenile steelhead was above normal until early summer but was below normal by the end of the summer, indicating a worsening of gross nutritional status as stream flow dropped. Age

0 steelhead achieved a mean size of 81 mm FL by early December 1994, which was about 12% smaller than what they were by that time in 1993. Age 0 steelhead in 1992, also a critically dry water year type, grew to a mean size of 85 mm FL by late October, a mean size exceeded by age 0 steelhead by early September in 1993.

The second way in which flow conditions affect juvenile steelhead growth on the Big Sur River is with respect to the late summer-to-fall low-flow period, which is characteristic of California coastal streams. During the low-flow period, juvenile steelhead growth is arrested or nearly so. This near cessation of growth occurs regardless of water year type, suggesting that flow-mediated habitat conditions drop below some threshold in all years to where the energy necessary for growth is not available to the fish. In both 1993 and 1994, average growth rates of age 0 steelhead approached 0, and their length-weight relationships were below normal. Thus, not only did the fish essentially stop growing in length but also were in an energy deficit as indicated by below normal and decreasing slopes for their length-weight relationships.

The underlying mechanism behind the cessation of juvenile steelhead growth during the summer-to-fall low-flow period is the reduction in food availability that occurs under low-flow conditions. Like essentially all stream dwelling salmonids, juvenile steelhead occupy a mosaic of feeding territories in a given habitat area of stream where individual fish compete for access to food organisms that are carried in the current of the stream. Typically, most of these food organisms are invertebrates, primarily aquatic insects that live in the substrate of the stream. When these organisms move into the free flowing water column of the stream, they are transported downstream and become available to juvenile steelhead who consume them as prey. The production and delivery rate of these downstream moving invertebrate organisms, referred to collectively as "drift," is at least in part a function of stream flow.

Exhibit DFG-T-11 is a graphic from a manuscript being prepared for publication by a collaborative team of biologists and ecological modelers from DFG, NMFS, and the University of California, Santa Cruz that illustrates the general relationship between drift density and flow in two small central California coastal streams, Scott and Soquel creeks in Santa Cruz County during 2007. Drift density in both creeks was relatively high during the winter rainy season when stream flow was high but decreased about five-fold during the summer-to-fall low-flow period before increasing again later in fall. **Exhibit DFG-T-12** is a manuscript submitted recently to Transactions of the American Fisheries Society by the same collaborative team, presenting data on juvenile steelhead growth in Scott and Soquel creeks relative to stream flow, and referencing the drift density patterns in **Exhibit DFG-T-11**. Growth rates of age 0 steelhead in these creeks during summer-fall, when both stream flow and drift densities were low, averaged about 0.1 mm per day. This growth rate is very similar to the rates reported above for age 0 steelhead on the Big Sur River from late summer to fall in 1993 and 1994 when stream flow was at the seasonal low. **Exhibit DFG-T-13** is a paper I reviewed for the journal, *Ecology*, several years ago that underscores the importance of food availability on juvenile steelhead growth and survival through experimental laboratory studies. **Exhibits DFG-T-14 and DFG-T-15** involve manipulations of food availability in field experiments, demonstrating an overriding effect of food availability on juvenile steelhead growth rates.

The 1993 growth assessment provides some insight as to a range of flows within which drift densities on the Big Sur River no longer provide enough energy to juvenile steelhead to maintain body condition, much less to continue growing. Referring again back to **Exhibit DFG-T-10**, age 0 steelhead grew at a relatively high rate and attained a relatively large size during summer 1993. Daily mean stream flow was 60 cfs when sampling started on 7 June 1993, decreased to 20 cfs by 20 August 1993, and remained essentially at that level through the end of sampling on 23 September 1993. In contrast, during fall 1993 age 0 steelhead grew very little in length and their average nutritional status decreased. Stream flow through this period varied little and continued to average about 19 cfs.

In summary, the evidence suggests that a threshold flow above which food availability results in appreciable growth of juvenile steelhead over a sustained period of months is above 20 cfs and less than 60 cfs.

4b) The importance of maintaining growth in juvenile steelhead populations.

First year growth performance of juvenile steelhead in the Big Sur River is of cascading importance to the fitness of individual fish. Most steelhead on the Big Sur River smolt and enter the Pacific Ocean at age 1, and most, if not all, of the rest at age 2. This is evidenced in the demographic changes that occur in the juvenile population from one year to the next, as illustrated in **Exhibit DFG-T-10** and discussed above. The instream growth of steelhead during their first year determines their size at ocean entry. **Exhibits DFG-T-16, DFG-T-17 AND DFG-T-18** provide evidence from British Columbia and central coastal California of the importance of steelhead size at ocean entry on ocean survival and ultimately survival to spawning. Ocean survival of steelhead smolts is strongly size dependent, where relatively large smolts have a higher survival than small smolts. Research from Scott Creek in Santa Cruz County (**Exhibit DFG-T-17**) and San Gregorio Creek in San Mateo County (**Exhibit DFG-T-18**) demonstrates the importance of growth benefits provided to juvenile steelhead rearing in lower system habitats, such as lagoons and estuaries, and the relatively high proportionate representation of those individuals among adults returning from the ocean to spawn. While these examples from central California underscore the importance of maintaining estuarine and lagoon habitats for superior growth in juvenile steelhead, the same principle applies to upstream riverine habitats, as well. Thus achieving as much growth prior to smolting as the natal stream can support under natural conditions has far reaching implications for the individual.

This growth imperative during the early life history of steelhead also has implications for the population. For a steelhead population to grow, its productivity must increase to where the spawning adults being produced exceed simple replacement. Evidence in this testimony and from other sources clearly indicate that the arrested growth of juvenile steelhead that occurs under low-flow conditions in the Big Sur River, and in other California coastal streams, may represent the greatest bottleneck to population productivity. While juvenile steelhead rearing in habitats where water is diverted during low-flow periods may survive and even appear to be healthy and in good condition, the nuances of how diversion of flow affects delivery of food to steelhead, their growth rates, size at ocean entry, ocean survival, and ultimately survival to spawning may go completely undetected.

In summary, achieving as much growth prior to smolting as the natal stream can support under natural conditions has far reaching implications for the individual. Further, protecting the essential role the Big Sur River steelhead population likely plays in the South-Central California Coast Steelhead DPS requires conservative regulatory action to protect instream function that supports juvenile steelhead growth and ultimately population productivity.

b) What terms and conditions, if any, should the State Water Board adopt to avoid or mitigate any such potential adverse impacts?

In order to avoid potential adverse impacts to the biological resources of the Big Sur River, I recommend that the SWRCB include, as a condition of El Sur's water right permit, interim minimum bypass flow requirements. Further, due to the fact that a Physical Habitat Simulation Model (PHABSIM) study is being conducted on the Big Sur River, I believe the SWRCB should include a re-opener clause in the permit requiring the conditions to be revisited when the Department completes its PHABSIM study on the Big Sur River.

(1) Interim Minimum Flow Recommendation

In his testimony (**Exhibit DFG-C-A**), Mr. Custis described the process the Department used to develop its interim bypass flow conditions. As noted in his testimony, the calculation to establish bypass flows at the El Sur Ranch Point of Diversion (POD) requires three separate parts: (1) minimum flows to mitigate biological impacts; (2) flows to account for the maximum flow loss downstream from the monitoring gauge; and (3) flows to account for maximum instantaneous rate of El Sur Ranch's diversion. My testimony addresses the rationale for the first component of the bypass flow calculation, the flows needed to mitigate biological impacts.

(1a) Interim Minimum Bypass Recommendation for Adult Steelhead for Upstream Passage

The Department's recommended interim minimum bypass flow for the period of December 1 through May 31 is 132 cfs. This flow is recommended to accommodate upstream and downstream passage of spawning adult steelhead on the Big Sur River.

Given the large size of adult steelhead on the Big Sur River, there may be some question as to what an appropriate depth criterion may be for adult passage at critical points on the lower Big Sur River. The so-called "Thompson Method" for developing upstream passage flow recommendations for adult salmonids applies a 0.6 foot depth criterion for adult steelhead as a standard. **Exhibit DFG-T-19** presents information developed by DFG regarding growth curves of California steelhead and adult steelhead body depths. Adult steelhead range up to at least 90 cm (35 inches) on the Big Sur River (**Exhibit DFG-T-3**), which corresponds to an average body depth of about 186 mm, or 7.3 inches based on a body depth-fish length model developed from data collected at Warm Springs Hatchery. Thus, development of passage criteria for steelhead on the Big Sur River may require a greater depth criterion of 0.7 or 0.8 foot, should this approach be used.

(1b) Interim Minimum Bypass Flow Calculation for Juvenile Steelhead Rearing

The Department recommends an interim minimum bypass flow of 29 cfs for juvenile steelhead rearing. DFG is currently conducting a Physical Habitat Simulation Model (PHABSIM) study on the Big Sur River from which to develop instream flow recommendations for adult steelhead upstream passage and juvenile steelhead rearing. This study will not be completed until 2012. **Exhibit DFG-T-22** is a wetted perimeter analysis I conducted to develop an interim minimum flow recommendation for maintenance of juvenile steelhead rearing habitat on the Big Sur River pending the completion of the PHABSIM where it is anticipated that the additional information obtained may justify different flow recommendations. The 17 cfs flow recommendation resulting from this analysis represents the first of the three-part minimum bypass flow described by Mr. Custis in his testimony: "the minimum flows needed to protect fisheries and other public trust resources." The complete minimum bypass flow recommendation of 29 cfs also accounts for parts 2 and 3 of Mr. Custis' construct: "maximum historic flow losses downstream from the gauge used to monitor compliance," and "the maximum permitted instantaneous diversion rate." Full details of sampling design, data collection, application of the wetted perimeter method, and interpretation of results are contained in **Exhibit DFG-T-22**.

I would also like to bring to the Board's attention two other minimum flow recommendations that have been promulgated for the Big Sur River in the past. **Exhibit DFG-T-23** is a Protected Waterway Management Plan that Monterey County developed for the Big Sur River during the mid-1980s. As part of the management plan, DFG developed an interim minimum flow recommendation of 19.6 cfs based on a hydrological analysis. This flow recommendation is also discussed in the wetted perimeter analysis report. **Exhibit DFG-T-24** is a letter from Mr. Lewis Moeller, SWRCB to Mr. James Hill, El Sur Ranch dated December 27, 2000. In this letter, SWRCB recommends a restricted diversion schedule for the El Sur Ranch pumps that would avoid diverting flow during the summer period altogether to protect steelhead and other listed and sensitive species. The specific recommendation was "to limit the season of diversion to a period of December 15 through March 31 and to restrict the maximum rate of diversion to 3 cfs or less." This recommendation clearly embodies DFG's concerns about the schedule and magnitude of the El Sur Ranch's proposed diversion, especially as related to diverting flow during the summer-fall low-flow period.

(1c) Minimum Bypass Flows are Necessary for Protection of Life History Diversity in the Big Sur River Steelhead Population

One of the most striking observations I made when I first began working on the Big Sur River in September 1992 was the perennial connectivity between the lower river and the Pacific Ocean. In field notes dated September 20, 1992 (**Exhibit DFG-T-2**), I indicated that "(t)he river mouth is still open to the ocean." This came as a surprise given what I knew about sandbar closure on California coastal steelhead streams and the fact that the river was at the low point of the annual hydrograph near the end of a 5-year-long drought. I came to learn that most of the streams along the Big Sur coast maintained a continuous connection with the Pacific Ocean, presumably because of the very high gradient conditions in their watersheds. A continuous connection between the river and the ocean allows for greater diversity of life histories on the Big Sur River than on streams where sandbar closure is a regular annual occurrence, if not multi-year occurrence during extended drought conditions, as occurred on the Carmel River during the above-mentioned drought cycle.

Protection of the connectivity between the Big Sur River and the Pacific Ocean is a priority and concern of DFG in light of the El Sur Ranch diversion application. During August-September 1994, one of the Department's collaborators at Big Sur, Mr. Jeff Davis, made a series of observations that suggested the El Sur Ranch pumps were having a direct effect on the river's connection to the ocean. These observations, which include Mr. Davis' impressions from over a 2-year period at Big Sur, are documented in a memorandum he sent me dated October 6, 1994 (**Exhibit DFG-T-20**). Mr. Davis' observations of the connectivity between the river and the ocean during summer 1992 corroborated my own from that time. He also presented information that suggested the El Sur Ranch pumps reduced flow in the lowermost river and lagoon area to the extent that the "effluent water," as Mr. Davis referred to it, stopped thus breaking the connection between the river and ocean.

During the period that we conducted our studies on the Big Sur River, we observed and documented a very wide variety of life history diversity within the steelhead population. **Exhibits DFG-T-1** and **DFG-T-2** refer to and present documentation of many of these observations, otherwise also recorded in actual data sets. The Big Sur River steelhead population includes a strongly anadromous component of fish that rear in the river for 1 or 2 years, smolt and emigrate to the Pacific Ocean, and return to spawn after one or more years at sea, ranging up to at least 5 years old and up to 90 cm (35 inches) in size, as documented earlier in my testimony. Some males mature as stream dwelling "parr," and likely contribute to spawning aggregations with large sea-run adult females, and then have the option of either remaining instream and assuming a "resident" life history, or ultimately migrating to the ocean and assuming the "steelhead" life history. The population does indeed include what appear to be strongly resident fish, or rainbow trout, especially in the Gorge Reach of the mainstem river, and in Juan Higuera Creek. Resident trout in upper Juan Higuera Creek were extremely stationary and persistent in their locations, with one PIT-tagged individual from September 1994 recaptured as late as our last sampling there in August 1997. Another very unusual observation made in this area was the presence of very small (70 – 80 mm) and young (age 0) mature male parr, along with relatively small (<200 mm) resident females with ripe ova in spring. On August 1, 1995, we also intercepted a 346 mm TL "half-pounder" steelhead in the lower Big Sur River adjacent to the walk-in campground in Molera Park that had recently come back into the river from the Pacific Ocean. This fish was immature and was perhaps in the river to prey on juvenile fishes there; that is, it may have been on a feeding migration. **Exhibit DFG-T-21** includes a photograph of the fish along with one of its scales showing evidence of ocean growth. The opportunity for this fish to re-enter the river could only occur because of the connectivity between the river and the ocean that persists largely year-round on the Big Sur River. Flow conditions on the Big Sur River in 1995 were particularly favorable as that year was a wet water year type and flow was 38 cfs on the day this fish was captured. Observations of steelhead with similar characteristics were made by DFG during October 2010 (Jennifer Nelson, DFG, pers. comm.).

Protection of this behavior and the various other life histories assumed by steelhead on the Big Sur River is of high priority to DFG under the general rubric of conserving biodiversity. Maintaining a portfolio of life history flexibility is a major part of what will allow this population to persist under the highly variable environmental conditions in which it exists on an ecological timescale, and for the species to adapt as conditions change over an evolutionary timescale. Concerns about the El Sur Ranch diversion interrupting the continuum of conditions between the river and ocean are warranted within the context of protecting steelhead behaviors that involve movement between the two habitats. To ensure the protection of steelhead behavior and other life histories assumed by steelhead on the Big Sur River, the SWRCB should include in El Sur's water right permit the Department's recommended minimum bypass flow condition of 132 cfs for the time period of December 1 through May 31, and 29 cfs for the time period of June 1 through November 30.