Appendix D

Response to Peer Review Comments on the Staff Report for the Revision of Dissolved Oxygen Water Quality Objectives Peer Review Draft

Response to Peer Review Comments On the Staff Report for the Revision of Dissolved Oxygen Water Quality Objectives, Peer Review Draft, dated March 2009

A peer review draft of the Staff Report for the Revision of Dissolved Oxygen Water Quality Objectives, dated March 2009, was submitted in April 2009 to two peer reviewers selected by the State Water Resources Control Board from the University of Washington. The two peer reviewers are Dr. Daniel E. Schindler, Professor of Aquatic and Fisheries Science and Michael T. Brett, Professor of Civil and Environmental Engineering. Below are the comments submitted by each reviewer with an associated response provided by Regional Water Quality Control Board staff.

Daniel E. Schindler, Ph.D
Professor, School of Aquatic and Fishery Sciences
University of Washington

Schindler Comment #1: Overall, I was extremely impressed with the quality and thoroughness of the Staff Report. Establishing oxygen standards to protect fish and other wildlife is far from a simple task and the Staff Report dealt with nearly every possible complication that I could see.
Response #1: Thank you.

Schindler Comment #2: I believe that the proposed revisions are based on the best scientific information in hand. In particular, prioritizing life cycle objectives over background objectives will provide stronger and more justifiable protection for many fish species.
Response #2: The State of California requires a peer review of any proposed rule or regulation that is based on science. Regional Water Board staff appreciates your focus on the specific questions related to the scientific validity of the proposed Basin Plan Amendment and are gratified that you find them satisfactory. Regional Water Board staff agrees that prioritizing life cycle objectives over background objectives will provide stronger and more justifiable protection for many fish species.

Schindler Comment #3: Improved monitoring technologies also enable expansion of oxygen objectives to include weekly average limits. This will provide better protection to organisms from chronic low oxygen concentrations that may only become problematic over longer time periods.
Response #3: Regional Water Board staff agrees.

Schindler Comment #4: The Staff Report represents a very strong synthesis of the state of knowledge concerning stream oxygen dynamics and the requirements of stream

dwelling fishes.

Response #4: Thank you.

Schindler Comment #5: I feel compelled to say that developing an intricate set of objectives is only a worthwhile enterprise if the appropriate research and implementation funding are provided to put them into action. One important aspect of this will be in more intensive data management demands. Moving to a more spatially and temporally explicit monitoring scheme will produce orders of magnitude more data than the old monitoring methods based on grab samples and titrations. To ensure that these new data streams are useful for management, adequate additional funding must likely be directed towards updating the data management systems as well.

Response #5: Regional Board staff share your concern and orientation with respect to monitoring and data management. The State of California implements the State Wide Ambient Monitoring Program, or SWAMP. The program is designed and coordinated at the state office in Sacramento but implemented within each region by Regional Water Board staff. SWAMP is designed to accept, process, and manage continuous DO data, as well as grab samples and titrations.

The most dramatic change to monitoring and data management to result from adoption of the proposed DO objectives will be for individual waste discharge permit holders. Waste Discharge Requirements (WDRs) currently require only grab sampling of ambient water quality for DO. But, the adoption of the proposed DO Basin Plan Amendment (BPA) will necessitate that when WDRs come up for renewal, the associated monitoring requirements be updated to include continuous monitoring of DO instead. As you mention, this will result in additional monitoring and data management costs. But, the costs will be spread out among individual dischargers rather than borne by a single entity.

Alternatively, Regional Water Board staff is exploring the possibility that dischargers could conduct a study of the diel fluctuation in DO at their particular sampling locations to determine the shape and seasonal duration of the diel curve. With this information, grab samples and titrations could continue to be appropriate, then knowing what part of the diel cycle the grab sample represents.

Schindler Comment #6: The summary of oxygen requirements of all the major fish species in this region of California was strong and thoroughly justified the focus of developing oxygen criteria that protect salmonids. All other species in this region can reasonably be considered less sensitive to low oxygen conditions compared to salmonids. So, although the focus on salmonids is clearly a bias, it is a scientifically justified bias.

Response #6: Thank you.

Schindler Comment #7: The depression of intragravel oxygen concentrations relative to overlying water is expected to vary widely among streams and reaches depending on factors such as gravel porosity, sediment-based oxygen consumption, stream gradient, sediment organic matter content, and temperature. Thus applying a constant correction factor to account for reduced intragravel oxygen concentrations compared to the

overlying stream is certainly a simplifying assumption that is not well substantiated...Although applying a correction factor of 3 mg/L to overlying water concentrations to ensure that eggs and alevins receive adequate oxygen concentrations for development will provide strong protection, this constant correction factor does not seem to be exceptionally well-supported from the scientific literature. I would not say that this correction factor is "over-protective" but it might be unnecessary and in some cases unattainable given the hydrologic, biological, and thermal conditions of streams...It might be worth investing in the science to determine how much intragravel oxygen concentrations deviate from overlying water sources as a function of a variety of physical, chemical, and biological features of streams...I do believe that an 11 mg/L objective will be difficult to achieve under natural conditions in many streams.

Response #7: Staff believes that the water column spawning requirements for salmonids is one of the weak elements of the USEPA's guidance on the development of water quality criteria for DO. As such, we specifically asked for peer review of this element of our proposed objectives.

Staff shares your concern that an 11 mg/L objective is unattainable under natural conditions in many streams. In fact, the water quality model developed for the Klamath River (see Appendix H of the staff report), demonstrates that under natural conditions water quality in the Klamath River mainstem maintains an 11 mg/L 7-day average; but, only from November through February. This is a subset of the period during which actual spawning and incubation occurs for the variety of salmonid species migrating up the Klamath River. One possible explanation is that under natural conditions 11 mg/L is too high an objective for the entire spawning/incubation period.

In combination with the other peer reviewer's comments on this subject, staff has decided to conduct additional research in this area to ensure a more scientifically robust alternate proposal in the future.

Schindler Comment #8: In a cold stream 85% may provide exceptional protection for fish. In a warm stream, 85% may not be adequate because of the compounded effects of a decline in overall oxygen concentration in the warmer water and the increased metabolic rates of fishes in warm waters. I think it is safe to say that at temperatures below 20C that the 85% saturation is a reasonable criterion for establishing baseline conditions that are not stressful to fish. (Although this may not achieve the intragravel requirements). The key point is to embrace the fact that there will be wide variation in what constituted "natural" oxygen conditions among streams. An 85% criterion will capture more of the natural variation than will the 90% criterion.

Response #8: For the reasons you state, the proposed 85% saturation DO objective is intended to apply to COLD designated waters, only. This is a point of clarification staff will include in the revised staff report. Nonetheless, it is important to note that some COLD-designated waters periodically reach temperatures in excess of 20C during the summer months.

Elevated temperatures due to anthropogenic activities
Where elevated stream temperatures are the result of anthropogenic activities, the

Regional Board has the ability to pursue temperature controls through permitting and/or enforcement actions, or through the development of a Total Maximum Daily Load (TMDL) for temperature. The temperature water quality objective contained in the Basin Plan provides a strong basis for protecting natural stream temperatures. It reads: "The natural receiving water temperature of intrastate waters shall not be altered unless it can be demonstrated to the satisfaction of the Regional Water Board that such alteration in temperature does not adversely affect beneficial uses. At no time or place shall the temperature of any COLD water be increased by more than 5F above natural receiving water temperature." Thus, if the summer time temperatures of COLD-designated streams exceed 20C due to anthropogenic activities, the Regional Board can take action to reduce temperature impairments and restore natural temperature conditions for the protection of beneficial uses, including salmonid habitat.

Elevated temperatures due to natural conditions

In locations, such as the Klamath River mainstem, where natural conditions result in periodic temperatures in excess of 20C, staff's working hypothesis is that salmonids must have historically had access to cold water refugia so as to withstand the stress associated with elevated mainstem temperatures. In such systems as these, the Regional Board identifies the restoration and protection of cold water refugia, either within the deep mainstem pools or in cold water tributaries, as a high priority for the protection of temperature-sensitive aquatic species. Regional Board staff will clarify the proposed DO objective to provide better attention to the issue of refugia protection.

85% versus 90% saturation

With these temperature-related tools in place, Regional Board staff believe that 85% saturation reasonably represents the natural range of saturation conditions expected within an unimpaired river system and provides the necessary protection of beneficial uses. Staff further agrees with your conclusion that 85% saturation better captures the range of natural variation than does 90%. A 90% saturation criterion could too often result in the false assumption of impairment in watersheds where DO naturally varies more widely, thereby unnecessarily diverting staff time and resources away from other demonstrable water quality issues. Staff will review existing region wide temperature and DO data to determine if an assessment of saturation can be made in which this hypothesis is tested. Please see responses to the other peer reviewer's comments for further discussion on this topic.

Schindler Comment #9: The Staff Report offers several alternatives for estimating the natural temperature regime of streams. The first of these methods is to use reference streams that are known to not have been impacted to any large extent. It is proposed that headwater streams are most appropriate for this type of comparison because their water source is ground water which has a relatively constant seasonal temperature. Although I agree that headwater streams may have the simplest suit of perturbations to them, I do not necessarily agree that ground water can be assumed to be their ultimate water source. If the reference stream method is used to assess natural temperature regimes of another stream, extra care should be taken to ensure that the reference and the study streams have similar hydrologic properties because it can not be assumed that they will both be

dominated by ground water sources and, therefore, have predictable flow and temperature conditions. Although this method may appear the easiest to use, it is critical that appropriate reference streams are chosen to establish "natural" conditions. The other methods suggested are probably more robust.

Response #9: Regional Water Board staff has revised the text to be inclusive of other sources of headwater flows. We agree that care must be taken to ensure the subject and reference streams have comparable hydrologic properties, and have revised the text so that the caveat applies more broadly.

Schindler Comment #10: When using the simple mixing equation to determine reach temperatures, care must be taken to ensure that groundwater is not a large source to the downstream reach. If a reach of interest has a finite set of well-defined inputs, then the simple mixing equation should be adequate for a relatively short (or short residence time) downstream reach. Of course, this method only works for establishing "natural" conditions if all the upstream tributaries are also in a "natural" condition.

Response #10: Regional Water Board staff agrees, and have edited the text to say that this method calculates the resulting temperature immediately downstream of the confluence.

Schindler Comment #11: I believe that the computer models suggested as the more complicated way to establish "natural" temperature regimes are the most appropriate way to establish baselines. Staff should compare model predictions to observed temperature regimes in a set of streams of various sizes and geomorphic and hydrologic features that are deemed "natural." If the models capture the key aspects of the seasonal changes in thermal conditions, then this is probably the easiest justified approach to establish natural thermal regimes.

Response #11: Regional Water Board staff agrees that the use of deterministic computer models to estimate natural temperatures is the most appropriate method in many, if not most, cases. Staff expects that models developed and employed to estimate natural stream temperatures for the purpose of establishing compliant DO levels will be appropriately calibrated and validated. While we hesitate to characterize these exercises as easy, we also recognize that in many cases the use of deterministic computer models may be the only defensible method to estimate natural stream temperatures.

Schindler Comment #12: The Staff Report suggests three steps to use in order to determine whether "natural" conditions prevent the attainment of life cycle objectives. Recognition of this fact demonstrate the thoroughness of the report as it will likely be common that near pristine streams may often not meet life cycle DO requirements because of a suite of factors such as naturally high levels of nutrients and organic matter, or due to low flow regimes.

Response #12: Thank you.

Schindler Comment #13: The first proposed step is to use continuous monitoring to establish that non-compliance is an issue. Clearly this step will require careful Quality Assurance/Quality Control protocols (something that actually was not discussed much at

all in the Staff Report) to ensure that data sondes are not fouled and properly calibrated.

Response #13: The Regional Water Board implements a standard QA/QC program for deployment of the data sondes and retrieval of the data. Any data collected in this manner by WDR permit holders is also required to adhere to the standard, established QA/QC protocols. Data collected by other entities not under the control or guidance of the Regional Water Board will only be used in analysis if the QA/QC protocols are implemented and the data is demonstrated to be sound. The revised staff report will be updated to include this clarification.

Schindler Comment #14: The second step is to produce a conceptual model that specifies all of the anthropogenic and natural conditions that control oxygen conditions in a specific site. This model, as proposed, qualitatively lays out a range of potential drivers of local oxygen conditions. This seems like a logical step in this assessment.

Response #14: Thank you. Regional Board staff also believes this is a logical step in the assessment. As described in the Staff Report, USEPA has produced a generic DO conceptual model which can be used as a template for the development of a site specific model. A link to USEPA's CADDIS web page is included, as well.

The staff report will be updated to clarify the point, however, that the site specific conceptual model requires the development of certain site specific information, including: 1) geology/soils, 2) climate/hydrology, 3) topography, 4) vegetation, 5) DO-related water quality conditions (e.g., DO, temperature, nutrients, sediment), and 6) landuse activities and ownership patterns. This is to ensure that the conceptual model reflects site specific conditions based on a thoughtful assessment of the watershed. This preliminary assessment is also intended to determine what information may already exist which would be helpful to the final step in the analysis.

Schindler Comment #15: The final step is to use a more formal mathematical model (equation) to estimate what the natural oxygen conditions at a site should be given the conceptual model specific in step two. This also seems like a logical step in this process but the specifics of the models to be used are not given so it is difficult to determine whether this final step is achievable. Producing a conceptual model that allows partitioning of the various natural and anthropogenic sources and sinks of oxygen is a relatively straightforward exercise. However, developing a quantitative model that will allow partitioning of anthropogenic from natural sources and sinks is not a trivial task. Although such a model could certainly be developed for any stream in California, these models are generally quite data intensive and will also require considerable technical expertise to develop and use. Without more details on what the model to be will look like, or specifically which data will be used to calibrate and parameterize such models, I really can not comment on whether this procedure will actually achieve what it intends to.

Response #15: There are a limited number of entities that could conceivably seek to demonstrate that the proposed life cycle objectives are unattainable in a given watershed due to the natural conditions of the watershed. Those entities include WDR or National Pollutant Discharge Elimination System (NPDES) permit holders, a watershed group, or

Regional Board/staff. It is important to note, as stated in the staff report, that the quantitative modeling of DO under natural conditions is required only to demonstrate to the satisfaction of the Regional Board's Executive Officer that natural conditions are responsible for excursions of the life cycle objectives. This does not require perfect accuracy. Staff will revise the staff report to clarify the degree of accuracy that is necessary to meet this requirement. Further, staff will identify some of the existing models that could be used to satisfy this requirement.

For WDR or NPDES permit holders, a qualified consultant would be hired to conduct the work. They would identify the available mathematical model(s) appropriate for the watershed in question, given the watershed characteristics, the quality and quantity of existing data, and the ability to collect additional data. The Regional Board, through its Executive Officer, would have final review and approval authority.

A watershed group seeking to redefine the DO objectives for a watershed would similarly have to hire a consultant to assist with the task and face the Regional Board's final review and approval authority. Depending on the nature of the group, it may be eligible to apply for State grant funds to conduct the necessary work. Were State grant funds to be expended to undertake such a project, an additional layer of State oversight would be at play.

Were the Regional Board/staff to undertake the assessment, consultants and/or internal resources, as appropriate, would be employed to conduct the work.

Schindler #16: My final comment pertains to the monitoring plan. Although not stated explicitly, I am assuming that hydrologic flows are monitored simultaneously with temperature and oxygen concentrations. If not, this would be serious oversight. Given the expected changes in hydrologic patterns in response to ongoing climate change, it will be critical to account for changes in hydrology and how these are associated with observed changes in oxygen and temperature. Data describing oxygen and temperature alone will be difficult to interpret as changes could be driven by internal features such as changes in biological productivity, or driven by external features and in particular changes in flow regimes.

Response #16: Thank you for your recommendation. There are several purposes of monitoring associated with the implementation of a given water quality objective. For compliance monitoring, the data necessary include: DO, temperature, salinity, and barometric pressure. From these, we can calculate whether or not DO at a given monitoring station meet the proposed life cycle objectives or the objective of 85% saturation under natural temperatures. We can also assess the degree to which variation in existing temperature from estimates of natural temperatures is responsible for any deviation from the 85% saturation criteria.

As a general principle and when possible, water quality monitoring is conducted in association with USGS gage stations so as to relate flows to water quality data results. The staff report will be revised to clarify this point.

Michael T. Brett
Professor, Department of Civil and Environmental Engineering
University of Washington

Comment #17: It is my general opinion that the current draft guidelines of the North Coast RWQCB dissolved oxygen standard still need some important revisions before they are complete. I would advise basing these guidelines on the strengths of the corresponding Oregon and Washington State guidelines…I don't necessarily advocate directly adopting the standards of either of these states, but the arguments put forth in their guidelines were more thoroughly researched, vetted and explained than those put forth in this document.

Response #17: The guidelines to which you are referring are the 1992-1994 Water Quality Standards Review of Oregon's Dissolved Oxygen standards of the time (Oregon 1995) and Washington State's draft discussion paper and literature summary associated with their evaluation of DO criteria in 2002 (Washington 2002).

1991-1994 Water Quality Standards Review (1995)
The Oregon Department of Environmental Quality convened a Technical Advisory Committee (TAC) and tasked them to review Oregon's Dissolved Oxygen criteria and provide recommendations for improvement. The TAC included Dr. Gary Chapman of USEPA as Chair, Dr. Lawrence Curtis of Oregon State University, Dr. Richard Ewing of the Oregon Department of Fish and Wildlife, Timothy Hall of National Council for Air and Stream Improvement (NCASI), Dr. Robert Hughes a consulting Research Scientist, Kenneth Iceman (P.E.), Dr. Alan Nebeker of USEPA, Ron Rhew of U.S. Fish and Wildlife, and Roger Sherwood of Forest Products Industrial Source.

The TAC drew the following conclusions regarding the DO standards in place at that time:

1. "The "natural" conditions in some streams will cause dissolved oxygen levels to fall below the numerical criteria, especially the conservative 90-95 percent criteria when interpreted as absolute minimums.
2. The currently relaxed criterion of 75 percent of saturation for Eastern Oregon may not be justified based solely on the needs of the aquatic resources.
3. Although scientific data provide the basis for water quality criteria, the data are limited.
4. Saturation criteria may result in inadequate protection at high temperatures and greater than necessary criteria at low temperatures, often inversely related to the needs of the resource. Because of the high level of protection warranted for salmonid spawning, concentration and saturation criteria would be similar for this use.
5. Current criteria do not directly address the intergravel dissolved oxygen concentrations that directly influence the survival of salmonid embryos. Highly sedimented gravels may experience DO losses of more than 6 mg/L.
6. Current criteria recognize that situations will occur where the achievement of dissolved oxygen standards will not be possible due to natural occurring conditions or due to human activities which are beyond regulatory control. In

these cases, the background conditions become the criteria and no further degradation is permitted. Other states, such as Washington, provide an allowance on the order of 0.20 mg/L for further degradation under similar conditions.

7. Application of the minimums alone with inadequate data would allow acute conditions to exist.
8. 10% of the reference sites and 24% of the REMAP sites in the coast range would violate a 90% saturation criterion, even though they meet a no measureable impact to cold-water fish criteria of 8.0 mg/L.

Regional Board staff reviewed Oregon (1995) as part of the research associated with developing its proposal for the North Coast region. Regional Board staff found that Oregon (1995) provided the invaluable insight of numerous talented and respected scientists in the field of water quality protection. For that reason, staff designed the proposed DO objective revisions based, in part, on the recommendations of the Oregon TAC. Below are some of the recommendations of the TAC and the ways in which staff's proposal was designed to address them.

Some of the recommendations of the TAC included:
Recommendation #1: Criteria should be related to the biological resources that are to be protected. Through literature review, staff identified the variety of fish species found within North Coast watersheds and determined their DO tolerances, if known, concluding that DO conditions suitable to protect the life cycle stages of salmonids would also be suitable to protect other fish species. The life cycle requirements of salmonids for DO were then identified through literature review, including review of Oregon (1995), Washington (2002), and USEPA's (1986) guidance on the development of DO criteria. Much of this is summarized in Carter (2005), a staff-prepared and peer reviewed literature survey of the effects of DO on salmonid species by life stage. The resulting proposal includes numeric criteria specifically tailored to the protection of the life stages of salmonid species.

Recommendation #2: There should be greater consistency between the criteria for different river basins. Staff addresses this recommendation by proposing the elimination from Table 3-1 of the Basin Plan the site specific DO objectives assigned to individual waterbodies in the region and establishing life cycle based requirements as the first tier requirements, instead. Second tier requirements are established on a site specific basis only for those waterbodies unable to meet the first tier requirements due to natural conditions.

Recommendation #3: Critical compliance issues related to temperature and dissolved oxygen need to be analyzed. The State needs to manage its aquatic resources much more broadly than by single parameter or by point-source pollution control. Staff addresses this recommendation by fundamentally altering the way in which percent saturation is typically used in the regulatory arena. Percent saturation, as discussed in Oregon (1995) for example, is calculated measuring existing site salinity, site temperature, and site atmospheric pressure. Used in this way, percent saturation "ignores" the effects of anthropogenically elevated temperatures on DO, essentially

sanctioning temperature increases. Staff proposes that percent saturation be used as a water quality criterion but, based on estimates of *naturally* occurring stream temperatures. In this way, any increase from natural temperatures is reflected in the DO compliance record.

In addition to DO, the Basin Plan includes related water quality objectives for biostimulatory substances (including nutrients and organic matter), settleable material, sediment, turbidity, pH, and temperature. These parameters are often evaluated in concert with one another, depending on the waterbody and the issues at play. In a related matter, the Basin Plan prohibits the point source discharge of waste to most of the waterbodies within the North Coast region. As such, the water quality protection strategies employed in the North Coast region focus heavily on nonpoint source discharges, including hillslope and riparian zone alteration through timber harvesting activities and others. This is a unique strength of the North Coast region's water quality protection program and differs widely from the programs in place in many other regions and states where point source control remains the highest priority.

Recommendation #4: Concentration criteria should be used rather than percent of saturation for other life stages of cold-water biological resources, with the exception of supersaturation criteria. The criterion for early life stages of cold-water fish could be equally well presented as a percent saturation. Staff addresses this recommendation by proposing the calculation of percent saturation based on an estimate of *natural* receiving water temperatures, thereby better ensuring that the lower DO of the summer months are in the range to which aquatic species are adapted. Staff does not propose a supersaturation criterion, a fact which will be re-evaluated prior to our final recommendation to the Board.

Recommendation #5: Statistical criteria with associated duration period should be used. Staff has proposed the use of statistical criteria with associated duration periods for the protection of spawning and other life stages of cold water species.

Recommendation #6: Statistical criteria should be applied only when adequate data are available. Staff's proposal includes a discussion of the number and type of data required to measure compliance with the proposed objectives. Staff will ensure that the final proposal makes perfectly clear this requirement.

Recommendation #7: The early life stages criteria for salmonid protection should apply during the latter stages of incubation of embryos and fry, until after fry emerge from the gravels. The protective criteria need only apply to areas of salmonid spawning. Staff's proposed criteria are established as recommended.

Recommendation #8: The state should establish intergravel dissolved oxygen criteria for protection of the early life stages of salmonids. For unimpaired watersheds, the expected loss of an average of 3.0 mg/L DO from surface to the gravels provides the method for determining minimum surface-water concentrations. The assumption of a 3.0 mg/L loss between surface and intergravels

may underestimate the loss that occurs in highly impacted spawning areas. Staff has proposed the adoption of water quality objectives designed to protect the intergravel dissolved oxygen requirements of incubating embryos and fry, as described above. The proposed water quality objectives are daily minimum and 7-day moving averages measured in the water column, calculated by adding 3.0 mg/L to the intergravel requirements as described by USEPA (1986) in its guidance. Staff did not distinguish between unimpaired and impaired waterbodies for several reasons.
1, The Basin Plan includes water quality objectives to control settleable matter, sediment, and turbidity, as well as DO.
2. The North Coast Board has a well-developed program designed to identify and control the discharge of excess sediment to waters of the North Coast.
3. A committee of staff and board members has developed as a basin plan amendment, now awaiting Board approval, a region wide prohibition on the discharge of excess sediment to North Coast waterbodies.

It is clear that the DO of the intergravel environment found in heavily sedimented basins could be reduced by more than 3.0 mg/L. Staff's intention is that this issue be addressed through the existing sediment-control program of the Board and the development of the region wide excess sediment discharge prohibition. Of additional concern, however, is the question of whether or not 3.0 mg/L is overly protective under unimpaired conditions. This is of concern because the objectives are designed in two tiers—the first tier based on life cycle requirements and the second tier based on an estimate of background conditions. Staff's proposal is that the second tier requirements only be applied if the first tier requirements can not be met due to natural conditions. If the first tier requirements are set artificially high, then the second tier requirements will apply more broadly than intended. As recommended by the Oregon (1995) TAC, the primary requirements are intended to be designed to specifically address the needs of the biological resources (See Recommendation #1).

Staff's concern about over protectiveness is derived from the fact that modeled estimates of DO under natural conditions in the Klamath River indicate that water column criteria designed to ensure adequate intergravel DO can not be met for more than a couple of months of the spawning and incubation season. It was on this basis that staff asked peer reviewers to consider whether or not 3.0 mg/L might be overly protective and unachievable in some instances.

Staff will reconsider the question of whether or not a distinction should be made in the application of the proposed DO objectives in those watersheds which are sediment impaired versus those that are not.

Recommendation #9: The importance of nutrient and sediment runoff and removal of the riparian canopy as major cause of DO depletion in streams and lakes should be recognized. Please see response to Recommendation # 3 above.

Recommendation #10: The impact of stream flows on temperature changes and therefore on DO should be recognized. The Regional Water Board does not have any

direct authority over the control of river flows in north coast streams. Instead, that authority lies with the State Water Board in Sacramento where water rights permits are reviewed and issued. The State Water Board has an obligation to ensure that any of their actions, including water rights actions, are consistent with the Regional Water Board's basin plan, however. Thus, the North Coast Board has developed flow recommendations in individual Total Maximum Daily Loads (TMDLs), such as in the Shasta and the Scott River watersheds, and has included these recommendations in the Basin Plan to inform the actions of the State Water Board. In these two cases, the flow recommendations are for particular stream reaches which produce an abundance of cold water important to the control of temperature conditions downstream.

Simultaneously, the State Water Board has developed a draft North Coast Instream Flow Policy in which it has attempted to determine the flow requirements necessary to provide healthy, productive salmonid habitat in North Coast streams. This policy will guide the State Board in its decisions regarding water allocations in the future and will certainly improve their ability to make decisions protective of salmonid habitat.

Further, the North Coast Regional Board and the San Francisco Bay Regional Board have collaborated on the development of a narrative flow objective which describes the vertical, lateral, and longitudinal hydrological connectivity necessary to ensure a functioning aquatic system, including the protection of cold groundwater sources and riparian shading as necessary to the maintenance of cold water habitat.

Finally, as described above, staff's proposal to use percent saturation as a criterion by which to establish background DO conditions is based on the recognition of the inter-related nature of temperature and DO. Staff has taken this concept further than is typical in the regulatory arena by tying the calculation of percent saturation not to existing, potentially altered temperature but to estimates of temperatures under natural conditions. This ensures that the definition of background DO conditions as described by percent saturation protects both natural temperature and DO conditions as inter-related phenomena and results in actions specifically designed to improve stream temperatures, when necessary.

The TAC specifically recommended Table 2-2 (Oregon 1995) as the preferred DO criteria for the state of Oregon, including:

For the protection of salmonid spawning-- 11 mg/L as a 7 day mean[1] and 6 mg/L intergravel DO as a daily minimum
For the protection of other life stages of cold water species—8 mg/L as a 30-day mean[2]
For the protection of cool water species—6.5 mg/L as a 30-day mean
For the protection of warm water species—5.5 mg/L as a 30-day mean
To ensure no risk—no change from natural

[1] If conditions of altitude and natural temperature precludes achievement of 11 mg/L, then 95% saturation applies.

[2] If conditions of altitude and natural temperature precludes achievement of 8 mg/L, then 90% saturation applies.

Regional Water Board staff has also proposed 11 mg/L as a 7-day mean for the protection of spawning and incubation. Staff has further proposed a 9 mg/L daily minimum for the protection of spawning and incubation. This is intended to be comparable to the 6.0 mg/L daily minimum proposed by the TAC, as measured in the intergravel environment. Regional Board staff do not believe that the monitoring capabilities of the Regional Board and it's permitees yet allows for the accurate measurement of the intergravel environment without introducing potential risk of disturbance to incubating embryos and developing fry. Thus, a water column criterion was deemed more appropriate. As above, staff will re-consider the need to distinguish in the application of this criterion between waterbodies that are sediment impaired versus those that are not.

As provided by the TAC, staff proposes the application of percent saturation in lieu of concentration-based criteria if natural conditions prevent attainment of concentration-based criteria. Staff's proposal differs from that of the TAC, however, by considering any natural cause of criterion exceedance, not just conditions of altitude and natural temperature. Evidence on the Klamath River, as an example, illustrates that nutrient rich volcanic soils in the low gradient reaches of the upper basin have a profound effect on DO conditions many miles downstream into California, even in the absence of the economic activities (e.g., agricultural, forestry, mining), point source discharges, and dams.

Regional Water Board staff also proposes 8 mg/L mean for the protection of other salmonid life stages. Staff proposes the mean be measured as a 7-day mean, however, to provide greater protection to the threatened and endangered species found in the North Coast region. Staff will re-evaluate this proposal and consider whether the 30-day averaging period may provide adequate protection.

There is no "cool water species" category of beneficial use in the State of California. So, staff did not propose a specific water quality objective for this purpose. Staff did propose, however, a warm water mean criterion—6.0 mg/L as a 7-day average. This is somewhat more protective than the warm water protection suggested by the TAC; but, it adheres to the guidance offered by USEPA (1986). Staff will re-evaluate whether or not a 30-day averaging period is more reasonable than a 7-day averaging period.

<u>Evaluating Criteria for the Protection of Freshwater Aquatic Life in Washington's Surface Water Quality Standards: Dissolved Oxygen</u>
Similar to the approach in Oregon, the State of Washington convened a technical workgroup to evaluate the water quality criteria established to protect freshwater aquatic communities. The workgroup recommended to the Washington State Department of Ecology (WDOE) that it re-evaluate its existing criteria for dissolved oxygen. As with the State of Oregon and the North Coast Regional Board, the existing DO standards were given as single daily minima designed to protect different classes of waters, including a lake class in which "no change from natural levels" applies. Like in California and

Oregon, Washington's waterbody classes are divided by beneficial use; but, they are divided in a manner different from these other two states. Class AA streams are forested upland areas providing salmonid spawning, rearing and migration habitat. Class A streams are salmonid spawning, rearing and migration habitat found more broadly throughout the state. And, Class B streams are protected for salmonid rearing and migration, but not salmonid spawning.

Washington (2002) articulates as the challenge of selecting appropriate DO criteria, the two pronged phenomena of 1) human activities which ubiquitously affect DO conditions and 2) the presence of aquatic species (primarily salmonids) which benefit from DO conditions that are higher than what can often be held naturally in saturation. In consideration of these two opposing phenomena, Washington (2002) proposes DO criteria for individual species and life stages which are given as daily minima and 90-day averages of the daily minima. It further proposes that "when a waterbody's D.O. is lower than the criteria...and that condition is due to natural conditions or human structural changes that cannot be effectively remedied..., then human actions considered cumulatively may not cause the 90-day average of daily minima to decrease more than 0.2 mg/L." (Decision Memo-D.O., dated 12/10/02, page 6).

As assessed by Regional Board staff, this method of water quality protection allows for an unreasonable level of degradation from natural conditions for the following two reasons. First, it allows the degradation of natural conditions if the human-causes of that degradation are structural changes that cannot be effectively remedied. WDOE does not consider the benefits of off-site restoration, as an example, by which structural changes though not *remedied* could perhaps be *mitigated*. Second, it allows degradation of natural conditions by an amount (0.2 mg/L) which represents the limit of instrument accuracy for measurements less than 20 mg/L. But, rather than being applied to individual measurements of DO, as might be reasonable, it is applied to a 90-day average of those measurements. As such, changes to individual daily measurement of DO could be far more than 0.2 mg/L, if within a 90 day period DO recovery is sufficient to meet the average requirement. If the averaging period were on the order of 7- or 30-days, then this approach might be less worrisome. But, an averaging period of 90-days covers an entire season and could result in numerous days of inhospitable conditions during which fish succumb to multiple stressors, increasing, as an example, the risk of disease.

Washington (2002) includes an articulate and thorough literature summary in which studies are evaluated for:

1. Salmonid and non-salmonid incubation requirements,
2. Salmonid and non-salmonid juvenile acute lethality,
3. Salmonid and non-salmonid juvenile growth,
4. Salmonid and non-salmonid avoidance reactions,
5. Predation effects,
6. Salmonid and non-salmonid swimming speeds,
7. Macroinvertebrate species,
8. Synergistic effects,
9. Fluctuation versus constant oxygen regimes, and

10. Duration of exposure.

Staff agrees with the peer reviewer that Washington (2002) provides decision-makers with a detailed picture of the DO requirements of aquatic resources. In fact, Regional Board staff included Washington (2002) as a primary resource in its own literature review of salmonid habitat requirements, as published in Carter (2005).

Washington (2002) draws these conclusions from its literature review. They are similar to the insights provided by Carter (2005):

1. Any depression of oxygen from saturation will produce some reduction in the performance of fish.
2. Statistically significant changes to growth, swimming speed, etc. do not occur until oxygen levels are depressed to levels that are sometimes well below the saturation value.
3. Caution should be exercised when allowing even moderate reductions in oxygen.
4. Full protection implies that impacts to critical life-stages and processes will not reach levels that have a reasonable possibility of impairing the potential health of individuals or populations.

Washington (2002) makes these technical recommendations for the protection of salmonids:

1. ≥9.0-11.5 (30 to 90 day average of daily minima) during spawning through emergence. This assumes 1-3 mg/L will be lost between the water column and the incubating eggs.
2. No measureable change when waters are above 11 °C (weekly average) during incubation.
3. ≥8.0-8.5 (30 day average of the daily minima) and ≥5.0-6.0 daily minimum in areas and at time where incubation is not occurring to protect the growth of juvenile fish.
4. ≥8.0-9.0 (daily minimum) year-round in all salmonid waters to protect swimming performance.
5. ≥5.0-6.0 (daily minimum) year-round in all salmonid waters to protect against avoidance.
6. ≥3.9 (daily minimum) and ≥4.6 (7 to 30 day average of the daily minima) year-round in all salmonid waters to protect against acute lethality.
7. ≥8.5-9.0 (daily minimum or 1 day average) in mountainous headwater streams to protect macroinvertebrates.
8. ≥7.5-8.0 (daily minimum or 1-day average) in mid-elevation spawning streams to protect macroinvertebrates.
9. ≥5.5-6.0 (daily minimum or 1-day average) in low-elevation streams, lakes, and non-salmonid waters to protect macroinvertebrates.
10. ≥8.5 (1-day average) year-round in all salmonid waters to minimum synergistic effects with toxic substances.

Washington (2002) proposes salmon, steelhead and trout spawning and rearing standards of 7.0 mg/L as a daily minimum and 9.5 mg/L as a 90-day average of the daily minima.

These are somewhat less protective than those represented by the technical recommendations, both in terms of the numeric criteria and in the averaging period to which they are applied. It further proposes salmon, steelhead and trout rearing-only standards of 6.0 mg/L as a daily minimum and 8.5 mg/L as a 90-day average of the daily minima. The 8.5 mg/L standard is somewhat less protective than that represented by the technical recommendation because it is applied as a 90-day average rather than a 30-day average as per the technical recommendation. It is worth noting that Washington (2002) assumes 1-3 mg/L DO loss between the water column and intergravel environment and makes no distinction between sediment impaired and unimpaired waterbodies, as recommended by the Oregon TAC.

Comparatively, Regional Board staff proposes a salmonid spawning objective of 9.0 mg/L as daily minimum and 11.0 mg/L as a 7-day average. These are significantly more protective than the WDOE standards and are based on the assumption that an average of 3.0 mg/L DO is lost between the water column and intergravel environment. WDOE assumes a 1-3 mg/L loss and must have relied on the lower end of that range in establishing its water quality standards. Staff further proposes a salmonid rearing objective of 6.0 mg/L as a daily minimum and 8.0 mg/L as a 7-day average which is more comparable to WDOE's standards.

What differs significantly between WDOE's and Regional Board staff's proposals, is the way in which a natural conditions clause is applied. If a waterbody can not meet the life cycle DO requirements due to natural conditions, Regional Board staff proposes that natural background conditions apply. Staff proposes a method of estimating natural background conditions using percent saturation and *natural* temperature for the calculation. Staff proposes 85% saturation as representing the variation from full saturation that naturally occurs within a wide range of free-flowing river systems. For streams in which the variation from full saturation is less wide (e.g., 90% under natural temperature conditions), this approach provides a small allowance for degradation from natural conditions, an allowance which is ecologically acceptable as long as the stream in question is not otherwise an important refuge from temperature/DO impairment elsewhere in the basin. For streams in which the variation from full saturation is more wide (e.g., 80% under natural temperature conditions), this method provides no allowance for degradation from natural conditions so as to ensure protection of salmonids which can show stress when DO saturation is less than 85%. For any waterbody which does not reasonably fit within the model assumed by the proposed objectives, a site specific study can be conducted to develop more appropriate site specific criteria.

WDOE also allows an alternate DO criteria for waterbodies in which DO conditions are less than the ascribed life cycle requirements. However, WDOE allows alternate DO criteria when nonconformance is due to natural causes *and* due to irremediable human-caused structural changes. This approach reasonably recognizes the role of humans in the landscape and attempts to draw a line by which to identify those human activities for which regulatory authority should remain mute. From Regional Board staff's perspective, however, the line drawn unnecessarily ignores the possibility of *mitigation* as a tool for restoring aquatic conditions when legacy problems are irremediable. It also

ignores the compliance schedule as a regulatory tool by which an entity can be given some length of time to study alternatives when current knowledge is inadequate to solve a problem.

Comment #18: Some aspects of the draft guidelines were over-explained and others required more detail. The health of nearly all aquatic animals is related to oxygen availability. The problem of acquiring sufficient oxygen is compounded by the fact that the physiological demands of aquatic fauna for oxygen increase dramatically as temperatures (and metabolic activity) increase. These points are of a "textbook" nature, and should for that reasons be briefly summarized in the North Coast RWCQB dissolved oxygen guidelines.

Response #18: A staff report to the Regional Water Quality Control Board is written to reach a broad audience, including the wider public. As such, staff often expounds on many seemingly "text book" concepts so as to ensure that those without a science education can understand and follow the issues, too. Staff has found that this contributes to a more productive public dialogue about staff's proposals, with less time lost due to poor science understanding.

In addition, a staff report is often designed to include the more technical aspect within the appendix, so as to accommodate the wider audience. In this case, Carter (2005) and USEPA (1986) form a large part of the scientific literature review associated with staff's proposals and are contained in the staff report as appendices.

Comment #19: In general, I am also concerned that most of the literature cited in support of the North Coast RWQCB dissolved oxygen guidelines is quite old. For example, the average paper on the DO requirements of salmonids cited in Carter (2005) was published more than 30 years ago (i.e. 1974 +/- 14 years). The salmonid requirements papers cited in the draft guidelines were just as old. Overall, nearly all of the archival studies cited on this topic were at least 20 years old.

Response #19: Carter (2005) was published by the North Coast Regional Water Quality Control Board in support of numerous actions facing the Board that affect salmonids, particularly work in the Klamath River watershed. Carter (2005) is not meant to be an exhaustive review of the scientific literature as it relates to the DO requirements of salmonid life cycle stages. But, it is meant to broadly capture the DO requirements of individual life cycle stages of functions as represented in the literature, particularly citing seminal field and laboratory studies. Other literature surveys such as Washington (2002) and Oregon (1995) provide additional, invaluable information upon which staff regularly draws.

In the Regional Board's effort to ensure that decisions are based on good science, staff submitted Carter (2005) for scientific peer review prior to its publishing. The peer reviewers were complimentary of the work and found it wholly acceptable. For the purposes of proposing revised DO objectives, staff concluded that USEPA (1986), Oregon (1995), Washington (2002), and Carter (2005) provided a perfectly adequate

survey of the literature regarding salmonid DO requirements. As such, additional literature review was not conducted, except to answer very specific questions.

The peer reviewer should note that the salmonid requirements cited in the Chapter IV (Fisheries of the North Coast Region) are taken directly from Carter (2005) and cited as such. Thus, the issues the peer reviewer has with the age of studies cited by Carter (2005) are necessarily reflected in Chapter IV, as well.

Out of curiosity, staff has repeated the peer reviewer's analysis, including an assessment of Washington (2002) for comparison. Staff discovered that in Carter (2005) the publishing dates range from 1958 to 2002 with 1973 as the median date. The references included in Washington (2002), on the other hand, range from 1938 to 2002 with a median date of 1976. It appears that the age of the studies referenced in Washington (2002) are essentially the same as those referenced in Carter (2005). Staff believes the more important question regarding these literature surveys is whether or not the findings cited represent the current state of knowledge on the subject. As above, the scientific peer reviewers of Carter (2005) found it to represent sound science.

To lay this question to rest, staff will thoroughly review the findings of the literature surveys contained in Oregon (1995) and Washington (2002) to ensure that Carter (2005) has not missed some important aspects of the current science which should otherwise be considered in the development of this proposal.

Comment #20: I spent a short time searching the Web of Science, and in addition to recent review papers..., I found eleven studies published on the importance of intragravel DO for salmonids since the most recent paper cited in the North Coast RWQCB dissolved oxygen guidelines (i.e., Greig et al. 2007, Dumas et al. 2007, Heywood and Walling 2007, Malcolm et al. 2005, Merz and Setka 2004, Youngson et al. 2004, Meyer 2003, Soulsby et al. 2001, Geist 2000, Curry et al. 1995, Deverall et al. 1993). I don't think it is necessary for these guidelines to have an exhaustive review of the salmonid DO requirement literature, but much has been learned about salmonid IGDO (intragravel DO) related issues during the last decade and this new literature should be reflected in the draft guidelines.

Response #20: Thank you for bringing these papers to our attention. We will review them and ensure the findings represented by these papers are represented in the final proposal.

Comment #21: I am concerned that a blanket 3 mg/L correction factor will be overly protective in many cases, and under protective in the more important cases where IGDO availability really is a problem (for example if fine sediment loading is excessive). This 3 mg/L safety factor is apparently based on a 1965 Masters Thesis from Oregon State University via the 1986 USEPA DO guidelines. I find this rationale problematic since a great deal of research has been done on this topic in the intervening 44 years. For example, two excellent comprehensive review papers have been recently written on this topic (Greig et al. 2007, Jensen et al. 2009).

Response #21: Staff also find USEPA's (1986) reliance on a single Masters Thesis for the development of DO criteria to protect embryos and alevin of concern. This is the reason staff specifically highlighted the issue for peer review.

The peer reviewer makes an excellent point, as does the Oregon TAC that a 3 mg/L correction factor will be underprotective in cases where intergravel DO is impacted by excessive fine sediment. Please see Response #17 to TAC Recommendation #8 for further discussion of this matter.

Comment #22: From the literature it is clear that a myriad of factors influence the difference between IGDO and water column DO concentrations, the most important being the presence of fine sediments (and the organic content of these sediments) in the interstitial spaces of the gravel. Based on these reviews I suggest that instead of selecting a fixed safety factor to protect IGDO concentrations, which might be overly protective in some cases and underprotective in others, that a safety factor be determined on the basis of the fine sediment content of the spawning habitat in a particular river. In particular, I think this safety factor should be determined as a function of anthropogenically derived fine sediment.

Response #22: Thank you for this recommendation.

Comment #23: In general, North Coast RWQCB could adopt a 2 mg/L safety factor across the board and much more stringent safety factors when anthropogenic fine sediments are a concern. By basing these guidelines primarily on fine sediment, it will also make it much more likely that the root cause of large differences between water column DO and IGDO concentrations will be addressed. In general, I found the discussion of the IGDO issue had a weak scientific basis in the draft DO guidelines. In contrast, both the Oregon and Washington guidelines had more rigorous discussion of this topic. I think this aspect of the draft guidelines needs to be considerably updated and rethought in lieu of the modern literature (e.g., Greig et al. 2007, Jensen et al. 2009).

Response #23: Thank you for your suggestions on how to make more robust the discussion of intergravel DO requirements of salmonids. Staff will consider your recommendation of adopting a 2 mg/L safety factor. In addition, staff will review Oregon (1995), Washington (2002), Greig et al. (2007), and Jensen et al. (2009) in an effort to better articulate the issues associated with intergravel DO in the final staff report.

Comment #24: Figure 3 is merely the theoretical DO concentration at 85% saturation for a range of temperatures and elevations, so the "evidence" that background DO conditions can be approximated by 85% saturation is tautological. In my opinion, the draft guidelines do not present scientifically based evidence that the background DO levels can be approximated by 85 or 90% saturation. This evidence should be derived from actual data showing the distribution of DO saturation values typically observed during unperturbed natural conditions. I suggest the 5^{th} or 10^{th} percentile of these natural percent DO saturation distributions be used to represent minimum background DO levels. If this is done, it should be acknowledged in the new guidelines that by definition these

minimum background levels will be violated with some regularity even in natural systems. But, the value in these "minimum standards" will manifest itself in cases where it is clear these minimum DO saturation levels are being missed significantly more often than expected based on "natural conditions." For example, if the minimum standard for percent DO saturation is set to the 5th percentile from undisturbed systems, and this minimum standard is violated significantly more often than 5% of the time in a system that is suspected to be impaired there would be unequivocal evidence of actual impaired beneficial use.

Response #24: Figure 3 is titled "Theoretical 85% D.O. Saturation at Standard Pressure (760 mm Hg) at Various Elevations" with the intention of indicating that the data contained in the graph represent theoretical values. Figure 3 and its companion Figure 2 are offered not as evidence that 85% saturation reasonably represents background DO conditions as interpreted by the peer reviewer, but as evidence that the existing background DO objectives as contained in Table 3-1 of the Basin Plan require updating. The staff report reads: "The third line of evidence that the background DO objectives require updating is based on an assessment of the theoretical DO concentrations possible within North Coast waterbodies at 100% and 85% DO saturation." Staff believes a misunderstanding of the text has led the peer reviewer to erroneously conclude the argument is tautological. Staff will revise the language of this section to reduce the risk of other's misunderstanding.

Section VI.3.2.2 provides a discussion of the use of percent saturation and natural temperatures to estimate background DO conditions and is based on the review of a basic stream ecology text, personal communication with a noted Fisheries Biologist, other water quality control plans within the State of California and the world, scientific studies, and the review of Oregon's DO criteria (Oregon 1995) by their Technical Advisory Committee. Staff agrees with the peer reviewer that a statistical analysis of DO distributions in unperturbed systems would provide far better "evidence" of the appropriate DO saturation value by which background concentrations can be calculated specifically for North Coast streams. Planning staff pursued this avenue with monitoring and assessment staff but were hampered by a dearth of historic DO data, particularly for unperturbed systems. In response to this comment, staff will pursue the following:

1. The identification of North Coast streams unperturbed by temperature alteration, flow alteration, nutrient enrichment, or historic excess sediment delivery.
2. The collection of new DO data in some reasonable subset of these streams.
3. The analysis of these data to determine the 5th percentile.

Comment #25: I will also point out that I suspect the "background DO objectives" presented in Table 2 (page 39) of the material provided to me, are also based on "rough estimates" and should be based on more rigorous data in cases where impairment might be of concern. Ideally, comprehensive datasets documenting "natural conditions" would be obtained prior to any signs of incipient impairment.

Response #25: The DO concentration values included in Table 2 (page 39) are the water quality objectives for DO contained in the North Coast Region's Basin Plan. As described in the text associated with Table 2, these site specific concentration limits were derived from two decades of monthly DO grab samples collected by a myriad of state and

federal partners during the 1950s and 1960s. They represent the background conditions of that era. The point staff is attempting to make with Figure 2 and the associated text is that the existing background DO objectives are based on extensive sampling. But, because the data were collected as grabs during the day, they do not capture the diurnal fluctuation typically expected-- with DO minima observed during the night. In this modern era where datasondes are available to collect 24 hour data, the existing background DO objectives do not provide a reasonable baseline against which to compare.

Comment #26: The write up on pages 55-57 of the draft guidelines describing how "natural temperatures" might be estimated at a disturbed site were well thought out and scientifically based.

Response #26: Thank you.

Comment #27: The problem of non-attainment due to natural conditions needs to be strengthened considerably in the draft DO guidelines. As is extensively discussed in the Oregon and Washington DO guidelines and alluded in the North Coast region draft guidelines, in some cases it may be impossible to meet DO objectives for purely natural reasons. How will anthropogenic loading that negatively affects DO concentrations be managed in systems that are in non-attainment for natural reasons? This needs to be given careful consideration because in cases like this an absolute "no impact" standard will result in unreasonable outcomes. For example, if the standard is no impact, even recreational use (which could theoretically damage riparian vegetation or increase sediment and nutrient loading somewhat) would be excluded. The States of Oregon and Washington have dealt with this problem by setting the lowest allowable impact at 0.2 mg/L below saturation. In my opinion, this seems like a very reasonable approach and should be directly adopted by the North Coast RWQCB.

Response #27: The question raised by the peer reviewer is a matter of policy, not science. As such, it is not specifically relevant to the scientific peer review.

Please see the last few paragraphs of staff's response to Comment #17 for a discussion of the differences between staff's proposed natural condition clause and that of the State of Washington.

Comment #28: The personnel of the North Coast RWQCB should make a more concerted effort to define natural DO levels in the most important aquatic habitats of this region, in particular systems that are anthropogenically degraded or are naturally sensitive to DO stress...Surely considerable DO data has been archived during the last several decades and an effort should be made to extract the distribution of natural saturation levels from these data. In some cases, more DO data will be necessary to establish estimates of natural conditions for specific systems and this additional data should be collected when necessary. As previously noted, I am of the strong opinion that "natural conditions," as measured by typical percent DO saturation distributions for undisturbed waterbodies, should take precedence when establishing DO objectives for systems that are suspected to be impaired. Natural DO conditions should be established

for a representative, but moderately small number of field sites within the region that are known to be minimally impaired at present. From these field studies of undisturbed systems, distributions of naturally occurring percent DO saturation levels could be established. These distributions could then be applied throughout the region.

Response #28: Please see Response #24.

Comment #29: I found the Washington State approach of classifying streams according to their "type of use" and level of protection for aquatic biota to be compelling model. Each waterbody in the North Coast region should be classified into one of the categories specified below and the DO in these systems managed accordingly. The RWQCB should be explicit as regards its intended beneficial uses for every major waterbody within the region, as well as all smaller waterbodies these standards are intended for, and as near as I could tell there was no mention of lakes whatsoever. This is problematic, as the types of DO standards that are most appropriate will depend greatly on the types of fish that are known to naturally occur in these systems. The DO guidelines need to more clearly state which types of waterbodies will be held to what DO standards.

For example, I suggest these categories for the North Coast region: critical habitat, salmon spawning habitat, salmon rearing habitat, cool water fish habitat, warm water fish habitat, lake habitat for salmonids, lake habitat for warm water fish, estuarine habitat. Based on what I have read I suggest the following long-term average DO standards:
General: all salmonid habitat will be considered in compliance if average DO exceeds 10 mg/L and IGDO is not adversely impacted by anthropogenic factors (e.g., fine sediment loading).
Critical habitat: no more than 0.2 mg/L below saturation
Salmon spawning habitat: no more than 0.5 m/L below saturation
Salmon rearing habitat: no more than 1.0 mg/L below saturation
Cool water fish habitat: no more than 2.0 mg/L below saturation
Warm water fish habitat: no more than 4.0 mg/L below saturation
Lake habitat for salmonids: not less than 7 mg/L on average in the hypolimnion
Lake habitat for warm water fish: not less than 4 mg/L on average in the hypolimnion
Estuarine habitat: not more than 1 mg/L below naturally occurring levels.
The seven day minimum standard shall be no less than 8 mg/L in any anadromous salmon bearing streams or rivers.

The standards above have the advantage of being simple so determining compliance is easy to monitor. Most of the standards above are relative to saturation, but in cases where the system is naturally below saturated oxygen levels, the standards should apply to the expected natural DO concentration. For example, along the west coast of the US, many estuaries are naturally below saturation because density stratification (due to freshwater inputs) and nutrient rich conditions along the entire coast naturally lead to moderately (and in some cases severely) hypoxic conditions.

Response #29: The State of California has adopted a system of beneficial uses similar but not identical to those adopted by the State of Washington. Individual waterbodies are designated beneficial uses based on the past or present uses of water. Please see Chapter II and Appendices A and B of the staff report for a review.

The proposed action associated with the staff report under peer review is the revision of the water quality objectives for DO, including objectives for individual beneficial uses. It does not extend to the issue of beneficial use designation; nor, does it contemplate the revision of the State's existing system. Staff believes the peer reviewer has strayed from the assigned task of reviewing the scientific basis for the proposed action.

Staff acknowledges the lack of comment in the staff report to the Region's lakes. A program of regulation for lakes is being developed for the Klamath River system under the Total Maximum Daily Load (TMDL). A section in the staff report will be added which described the approach under consideration in the Klamath and its broader implications for the rest of the region's lakes.

The exercise before staff is the development of numeric criteria protective of beneficial uses and the elaboration of the scientific basis for the recommended approach. The peer reviewer has recommended his own set of numeric criteria for DO. But, he does not provide the scientific basis for those recommendations, not even citations from which staff could substantiate his findings. This is problematic because staff can not propose that the Regional Board adopt any of the recommended criteria without a defensible scientific rationale.

The specific recommendations are further complicated by the fact that staff has seen very few studies (e.g., Davis 1975) that link DO saturation directly to salmonid health. This leads staff to wonder how the proposed criteria were developed. For example, what evidence is there that 0.5 mg/L DO less than saturation is adequately protective of salmonid spawning habitat? Does this water column limit adequately protect the DO conditions of the intergravel environment so critical to developing embryos and alevin?

Finally, the peer reviewer recommends the adoption of saturation-based DO criteria despite some compelling arguments against it. For example, the TAC responsible for reviewing Oregon's DO criteria argues that saturation criteria are comparable to concentration-based criteria in terms of protectiveness, only for spawning and embryo/alevin development. This is because the temperatures of the late fall through early spring are generally low enough to ensure relatively high DO during this period. The Oregon TAC, however, recommends against year round saturation criteria because the metabolic needs of the fish can easily outstrip the availability of DO as temperatures increase in the late spring through early fall. As discussed in the staff report, staff proposes the adoption of a saturation-based criterion that is calculated using an estimate of *natural* stream temperatures. This ensures that the DO concentrations associated with percent saturation are not unduly influenced by anthropogenically-elevated stream temperatures, particularly during the summer months.

Comment #30: Dissolved oxygen standards within a system should vary seasonally depending on the predominant use during that period of the year, e.g., a salmonid rearing standard during the summer months and a salmonid spawning standard during the fall and winter. The State of Washington compared data documenting the timing of

salmon/steelhead spawning to water DO data to derive their salmonid spawning standards for specific systems. This is an important consideration because many systems will always be within compliance during the colder months of the year, but might be out of compliance as spawning habitat during warm periods in the fall. These out of compliance periods need to be considered within the context of the proclivity of anadromous salmon to delay their spawning until water temperatures are favorable. For example, some salmon runs migrate into rivers before temperatures are favorable for spawning and wait until suitable conditions arise. If the DO standard is based on a particular DO concentration during for example late September this could be difficult to achieve certain years solely for climatic reasons. However, if the standard is relative to saturation as recommended above this would be much less of a regulatory problem. The literature which assesses the capacity of salmonids to delay spawning until favorable temperature conditions prevail should be reviewed and considered within the context of this particular issue. Failing the salmonid spawning DO objectives early in the spawning season when only a small proportion of the population has spawned is far less problematic than failing these objectives latter in the season after most fish have spawned.

Response #30: The peer reviewer raises an excellent point regarding the ability of salmon to delay the timing of migration and spawning to wait for favorable water quality conditions. Staff is familiar with the literature regarding this phenomenon.

Staff's proposal is consistent with the idea that the onset of favorable water quality conditions for spawning varies over the years. This is because the life cycle based requirements to protect spawning are intended to be applied in those locations and during those times when spawning is or has historically occurred. This means that if fish do not enter a river until October 1st because prior to that date the water is too warm, the spawning criteria will be applied beginning on October 1st. Conversely, if fall rains are early and fish begin entering a river to spawn on September 15th, the DO criteria will apply at that time.

At the behest of staff from USEPA, the staff report includes an estimated calendar period in which spawning and early development typically occur in North Coast streams. This all inclusive period is estimated to last from September 15 through June 6. Only for those waterbodies in which staff has little understanding of the actual timing of spawning and early development would this specific time frame apply; and, only until an assessment of site-specific timing could be conducted.

With respect to his recommendation of a saturation-based criterion for spawning, the peer reviewer may not fully appreciate that reduced DO in the fall can be the result of anthropogenic activities, including loss of stream side riparian cover, summer water withdrawals for irrigation, nutrient-laden agricultural return flows, dams, channel braiding and widening due to sedimentation emanating from hillslope disturbance, etc. If one were to establish a DO criterion based on saturation as a way of protecting the onset of spawning, one would likely find widespread compliance with the criterion but site-specific locations of DO-related spawning impact. The primary goal in establishing water quality criteria is to prevent impact to beneficial uses.

Comment #31: When considering potential anthropogenic impacts on DO, equal consideration should be given to factors that might affect water temperatures (as this affects the concentration at which oxygen will be saturated), direct or indirect (via eutrophication) biochemical oxygen demand (as this affects whether DO saturation will be met), and fine sediment loading (as this affect IGDO exchange with the overlying water). For example, agricultural practices could impair riparian vegetation, as well as load warmer water, nutrients and sediments with return flows. If the temperature in a stream or river is increased due to damaged riparian habitat such that the concentration at which DO would be saturated declined by 1.5 mg/L, this system would be out of compliance even if it was saturated with DO. Similarly, if excessive erosion caused fine sediment to reduce IGDO 1.5 mg/L more than it would otherwise be, the system would also be out of compliance even if the overlaying water was in compliance. It is essential that the DO guidelines are designed to focus management attention of those factors that have the most direct impact on the DO limitations that will have the greatest impact in any particular system.

Response #31: Staff agrees completely. It is for this reason that staff propose life cycle-based criteria as the first tier of the program. If the ambient water quality conditions of a given waterbody do not provide DO conditions suitable to support salmonid life cycle requirements, then an assessment of the causes needs to be made. This might be done as part of compliance order issued to a specific discharger, including a schedule for studying the issue and achieving compliance. Or, it might be done as part of a watershed study conducted by the Regional Board in the form of a TMDL, as an example.

If the cause of noncompliance is determined to be associated with natural conditions, then the second tier requirements are applied. The second tier requirements are based on an estimate of natural background calculated by estimating natural temperatures and applying 85% DO saturation. As described in Response #17, for streams in which the variation from full saturation is less wide (e.g., 90% under natural temperature conditions), this approach provides a small allowance for degradation from natural conditions, an allowance which is ecologically acceptable as long as the stream in question is not otherwise an important refuge from temperature/DO impairment. For streams in which the variation from full saturation is more wide (e.g., 80% under natural temperature conditions), this method provides no allowance for degradation from natural conditions so as to ensure protection of salmonids which can show stress when DO saturation is less than 85%. For any waterbody which does not reasonably fit within the model assumed by the proposed objectives, a site specific study can be conducted to develop more appropriate site specific criteria.

Comment #32: One important detail that is never mentioned in the draft DO guidelines is the issue of climate change and how that might affect DO concentrations in some systems. Northern California is towards the southern end of the natural range for anadromous salmonids, especially inland of the fog-belt where summer air temperature can be quite high (>30 °C). This is particularly the case for inland areas of the Klamath/Trinity River system. It is well documented that the mean average temperature

in the Pacific Northwest region has increased by 1.0-1.5 °C during the last 50 years, and there is every reason to expect this rate of temperature increase will continue through the remainder of this century (Service 2004). How will warming of stream/river water solely due to this mechanism be treated vis-à-vis the DO standard? It is conceivable that a further warming of 1.5 °C could tip a number of systems in the North Coast region past the point of no return as it regards being viable salmonid habitat.
Response #32: Staff believes that the proposed water quality objective for DO is uniquely well-suited to deal with the effects of stream temperature increases resulting from global climate change. The first tier requirements are life cycle-based requirements taken from the scientific literature and designed to provide salmonid life cycle needs. If the ambient DO in a waterbody does not meet these life cycle requirements, then an assessment of the causes must be conducted. If natural conditions are found to be the cause of noncompliance, then an alternate DO criterion can be calculated. For the purpose of this objective, one could argue that the effects on ambient stream temperature from global climate change constitute a "natural condition." For such a waterbody, an alternate DO criterion is calculated using 85% saturation and an estimate of natural receiving water temperatures. In this example, the effect of global climate change could be included in the estimate of natural receiving water temperatures thereby resulting in a DO criterion that represents natural background conditions under the influence of global climate change.