INDEPENDENT PEER REVIEW

DIABLO CANYON POWER PLANT CLEAN WATER ACT SECTION 316(B)

ECONOMIC BENEFITS VALUATION STUDIES

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1 BACKGROUND

This "Background" section discusses the protocols and research results developed by EPA in connection with its rule-making for Section 316(b) of the Clean Water Act. EPA's research into the measurement of benefits from reduced I&E mortality and the format developed for valid a benefits valuation studies are both thorough and rigorous. In my view, EPA's recommended approach is designed to yield estimates that are as reliable as the current state of the art will permit.

1.1 Regulatory requirements and economic methodology

My understanding of the relevant regulation, Sec. 316(b) of the Clean Water Act, is based on:

> Environmental Protection Agency, *National Pollution Discharge Elimination System—Final Regulations to Establish Requirements for Cooling Water Intake Structures at Phase II Existing Facilities: Final Rule*, as published in Federal Register, Friday, July 9, 2004, pp. 41576-41692.

In my report I reference this document as follows; Fed. Reg., and appropriate page numbers.

A facility that demonstrates that the costs of compliance with performance standards and/or restoration requirements would be significantly greater than the benefits will be given a site-specific determination of best technology available for minimizing adverse environmental impacts (Fed. Reg., p. 41597). EPA carried out extensive analysis on the measurement of benefits of reduced impingement and entrainment (I&E) mortality and developed detailed protocols for such analysis. A description of EPA's general research approach, comments received and EPA responses and reactions are found in Fed. Reg. pp. 41623-41625. At various points, these same passages provide EPA conclusions regarding appropriate procedures for carrying out benefit studies, research methods considered reliable or unreliable and sources of additional information on EPA's more detailed research into these questions.

In Section IX, Implementation, H(2) Alternative Site Specific Requirements, (Fed. Reg., pp.41647-41648) EPA lays out requirements for a valid benefits valuation study. Such studies must use a comprehensive methodology to fully value impacts of I&E mortality and must include a description of the methods used to value commercial, recreational and ecological benefits including any non-use benefits, if applicable. Other requirements are that the effects of significant uncertainty be analyzed and that a narrative description of any non-monetized benefits be included. The same section delineates certain requirements: (i) that 'use benefits' to recreational and commercial fishermen be determined, using well-established revealed preference and market proxy methods; and (ii) that non-use benefits to ecological resources that the public considers to be important be considered and that these impacts be monetized if the I&E study identified substantial harm to threatened or endangered species or to the maintenance of (marine) community structure and functioning. In the course of examining the national costs and benefits of this rule, EPA carried out 'benefits analyses' for 46 facilities in various regions of the country. This research produced both an extensive set of

procedures for implementing benefit estimation and a detailed body of empirical results that can be used to enable benefits analysis at specific facilities.

1.2 EPA procedures for determining 'use' benefits of reduced I&E mortality

The procedures developed by EPA for its regional analysis of the benefits from reducing I&E losses are described in Section 316(b) Phase II Final Rule—Regional Studies, Part A: Evaluation Methods. Figure A5-1 in this document illustrates the procedure and Chapter 5 (Methods used to Evaluate I&E) explains it in more detail.

Briefly, the procedure EPA developed proceeds as follows:

1. Data on I&E losses and species life history are compiled and analyzed. I&E losses are expressed in Age-1 equivalent losses for each species, both forage and fishery species.[1] Reductions in I&E losses resulting from compliance with section 316(b) are then computed.
2. Natural mortality rates are applied for subsequent ages to estimate the number of additional organisms surviving to each age considered, by species, as a result of reduced I&E mortality.
3. Age-specific fishing mortality rates are applied for each commercial or recreational fishery species. This gives potential 'direct' fishing yields gained from reduced I&E mortality, by species.
4. To determine benefits from reduced mortality of forage organisms (species or individual organisms not caught by commercial or recreational gear,) steps 1 and 2 above are followed and weight-by-age information is incorporated to determine the total gain (weight) of forage species due to reduced I&E mortality. Trophic transfer coefficients are used to translate this into additional biomass production commercial and recreational species. Step 3 is then applied to give increased fishing yields due to reduced I&E mortality of forage fish.
5. Total harvest gains due to reduced I&E mortality are split into commercial and recreational fractions based on the split of total harvests in the state, by species.
6. Prices are applied to commercial catches for each commercial species to determine the total revenue gain due to reduced I&E mortality. EPA guidelines estimate that 0%-40% of this total revenue would be captured by commercial fishing enterprises as producer surplus.
7. Unit values are applied to estimated increases in recreational harvests, to determine the associated recreational fishing benefit. These unit values were estimated in EPA's analysis of recreational fishing behavior.

In my opinion this protocol represents a thorough and sophisticated approach to valuing the use benefits associated with reduced I&E mortality.

[1] These estimates are based on a simple yield-per-recruit analysis of I&E losses. That is, one estimates the annual number of organisms lost due to I&E, by species. Then, natural mortality rates are applied to express these in terms of age-1 equivalent animals, by species.

1.3 Comments on the fishery model in EPA guidelines

The population growth model EPA uses assumes recruitment is fixed, survival rates to subsequent life stages are fixed, and fishing mortality rates are fixed as well. The most commonly used fishery economics models incorporate biological models that exhibit density dependent growth.[2] They postulate a finite carrying capacity for the population of a species based on the environmental conditions it inhabits, e.g., food sources, habitat, density of predators, etc. If the population is reduced below its carrying capacity, e.g., due to some new source of mortality, this model predicts that the natural growth rate will increase due to greater availability, per organism, of food, habitat, etc. If EPA had based its analysis on density dependent growth, the resulting benefit estimates might have been substantially different.

EPA's guidelines recommend that commercial fishing benefits should be calculated at 0%-40% of total revenue. A range of outcomes is possible because the fishery rent captured by harvesters will depend on the state of fishery regulation, how well regulations are obeyed, cost conditions and other factors. EPA provides no basis for the percentages it recommends and no guidance as to which percentage from this range should be applied to a particular species. I simply observe at this point that the literature on fishery economics may well allow more precise guidance than the 0-40% span on this question.

EPA's guidelines for commercial fishing benefits assume that reductions in I&E losses are too small to affect prices, hence no consumer surplus would be gained. This is almost certainly true for commercial fish destined for frozen or canned markets, as these markets extend over large areas. It is more questionable for fresh fish markets, which can be more localized.[3]

1.4 EPA's recommendation on non-use benefits

Non-use benefits from protecting a resource are benefits that are not connected with direct use of or interaction with the resource. Of the organisms protected by the section 316(b) Phase II rule, EPA estimates that only about 1.8% will be harvested by commercial or recreational fishing nationwide and only about 4.8% will be harvested in California. Any value society places on the remaining 98.2% nationwide, and 95.2% in California, will not be captured standard methods for measuring use values. The appropriate benefit concept for non-use values is society's willingness to pay for their protection.

One category of non-use benefit results from the fact that uncaught, and hence unused, fish serve as prey for stocks that do have direct use value. These prey resources are indirectly valuable in the provision of use benefits and the resulting benefits can be categorized as non-use (or perhaps indirect use) benefits. As explained in Section 1.2 of this report these 'prey effects' can, given sufficient biological information, be estimated and the associated benefits measured using methods appropriate for measuring use

[2] See Schaefer (1954), Clark (1976), Conrad and Clark (1987).
[3] As explained below TER assumes price reductions do occur.

benefits. This is an entirely appropriate extension of well-accepted economic theory and empirical methods.

Other non-use benefits from protecting a resource are associated with, for example, simply knowing that a resource exists and with the desire to preserve it for use by one's heirs. The only method that has been used to estimate such values in a broad range of applications is the elicitation of 'stated preferences' through surveys. It amounts to asking individual citizens what they would be willing to pay to have the resource in question protected to a specified degree. This approach is controversial and has not gained unanimous acceptance by the profession, but it does encompass the leading set of techniques applied in valuing non-use benefits.

EPA considered various methods for estimating non-use values for the organisms protected from I&E losses by the 316(b) rule and eventually concluded that, aside from valuing 'forage fish' as described above, the current state of the art for estimating such values is too imprecise for use in the present context. (See Federal Register, pp. 41624-41625, 41660-41662; see, also, EPA Regional Studies report, Part B: California, Chapter B5.) EPA noted that the reliability of stated preference approaches cannot generally be validated and that the estimates it produces are potentially subject to a variety of biases. EPA did not attempt to monetize non-use benefits in its California regional study, aside from valuing prey fish, and instead simply listed without discussion potential categories of non-use benefits.[4]

The 316(b) rule EPA requires a qualitative and descriptive discussion of non-use benefits form I&E mortality loss reductions and concludes that monetization is necessary only if an I&E loss assessment demonstrates that such losses impose a substantial harm to threatened or endangered species or to the maintenance of community structure and function. (See Fed. Reg., pp. 41647, 41648.)[5] While precise estimates of non-use impacts surely would be desirable, such precision is not possible given the current state of the art for valuing non-use benefits from protecting environmental resources.

1.5 EPA's recommended approach for treating uncertainty

In its regional studies report EPA acknowledges that both the structure of the biological and economic models used to assess I&E losses and the values of the parameters inserted into these models are subject to uncertainty. EPA makes a standard recommendation for addressing parameter value uncertainty, Monte Carlo analysis. The Monte Carlo approach requires one to specify a distribution of possible values for each parameter in the model that is considered uncertain. These distributions are typically based on experience or on intuition. Values of the parameters regarded as uncertain are then drawn from the specified distributions, inserted into the model, and the model's overall

[4] EPA does, in Chapter B6 of the regional studies report, explore a societal preferences approach and a benefits transfer approach for estimating non-use values for protecting threatened or endangered species, but does not put either into practice owing to uncertainties and imprecision that could not be resolved. As explained elsewhere in this report, EPA also considered approaches based on habitat replacement.

[5] In its own regional studies analysis of I&E mortality reductions in California (Regional Studies report Part B: California, Chapter B5: Non-use Benefits), EPA expressed a belief that non-uses values for I&E mortality reductions are likely to be "appreciable," but did not quantify what appreciable means in practice and referred to the entire state rather than to any specific Phase II facility.

prediction or result, e.g., the benefit from reducing I&E mortality, are recomputed.[6] Replicating this process numerous times yields a distribution of possible results that reflects the postulated uncertainty in the model's parameters. (EPA's discussion assumes 10,000 replications.) This general method for quantifying the effects of uncertainty on decision variables is common in economics and other disciplines.

1.6 Peer review criteria

In my opinion the research program EPA carried out in the process of determining the national *use* benefits of reduced I&E mortality is both thorough and sophisticated—it reasonably represents the state of the art for measuring such benefits. While I have questions on certain specifics of their approach to measurement, particularly the model of fishery growth used and the range of uncertainty provided for estimating commercial fishing benefits, these are relatively minor concerns.

While non-use benefits from reduced I&E mortality are potentially significant, EPA has no solution to the problem of providing reliable estimates of the magnitudes involved. This is a reflection of the fact that the state of the art in valuation of non-use benefits has not advanced to a stage where firm estimates of society's willingness to pay for such benefits can be made. In fact, I regard the EPA approach to valuing forage fish as a significant contribution to this problem, while recognizing that the value society attaches to 'uncaught fish' probably extends beyond what this method can represent.

On balance, and in light of the state of the art in this field, I regard EPA's overall approach to valuing the benefits from reduced I&E mortality as a 'best practice' template for assessing the benefits of reduced I&E mortality at DCPP, pursuant to Sec. 316(b) of CWA.

[6] It is common to specify a uniform distribution for the parameter values and to assume that the distributions of different parameters are independent, that is, that the value drawn for one parameter in a particular replication does not depend on the value drawn for other parameters.

2 TRIANGLE ECONOMIC RESEARCH STUDY

2.1 General Question:

Does the TER report provide reliable measures of the economic benefits of reducing I&E at DCPP? What changes, if any, would be needed to provide reliable estimates of these benefits?

See the response to question 9.

2.2 Specific Questions:

1. **Is the organization of the report appropriate and does it present the material in a clear and concise manner? Are there any changes that are recommended?**

Generally, the organization is appropriate and the presentation is clear and concise. Steps in the analysis follow the steps outlined for a benefits valuation study in the EPA regulation (Federal Register pp. 41647-41648). The TER sequence of analysis also generally follows the sequence of steps in EPA's regional study for California (Regional Studies Part B: California Chapters B2-B5.) Because it would be impractical to explain each step taken in the analysis for each species, TER describes its approach in terms of one example, valuation of brown rock crabs, which constitute about 92% of commercially and recreationally valued organisms lost to I&E mortality according the data TER used. Overall, I found TER's explanation of the steps taken to be clear and in accord with the procedures developed by EPA in its regional studies (as reported in EPA Regional Studies Part B: California.) I have no recommendations for changes.[7]

2. **Is the report consistent with economic principles of measuring benefits? Are there any changes that would make it more consistent with accepted economic principles?**

The concepts and methods used by TER are consistent with economic principles for measuring benefits. The TER concept of *use benefits* for recreational and commercial harvests is illustrated in Figures 2 and 3 of the TER report in Section 2 and the links

[7] The TER presentation was unclear at two points, but these instances did not materially impair my ability to understand and evaluate TER's analysis. The passages in question are: (i) p. 18: "However, the number of fish not valued is small. For example, …" I believe TER means to state that its method of valuing forage fish conservation does assign a value to fish that are not directly used by commercial and recreational harvesters. This phrase could be interpreted to mean that their method captures all non-use values. My interpretation here is consistent with a subsequent statement by TER in fn. 35, p. 37. (ii) The explanation on p. 20 regarding the ratio of eggs to larvae entrained was unclear.

between factors determining fishery value are laid out in Figure 4. The concepts of producer and consumer surplus are standard tools in benefit estimation.[8]

The method TER uses to estimate the economic benefits of enhanced commercial catches departs from the EPA approach spelled out in Chapter A10 of its regional studies report. TER assumes that increased commercial catches resulting from lower I&E mortality will result in lower prices for consumers, yielding a gain to consumers, but total revenue is unchanged, so there is no gain to commercial harvesters. EPA assumes that all gains accrue to producers and, as it turns out, the EPA estimate of producer gains equals 0% to 40% of the gain TER attributes to consumers. The question of which approach (EPA or TER) is more appropriate depends on the price elasticity of demand for fish and neither EPA nor TER provides hard evidence on this.

In any case, the practical effect of this difference in procedures is small, and the direction of the effect is that TER's value of enhanced commercial catches exceeds what an application of the EPA procedure would yield.

3. Is the report consistent with the EPA Phase II 316(b) regulation for measuring benefits? Are there any changes that would make it more consistent?

TER's approach to estimating the benefits of enhanced commercial and recreational fishing due to reduced I&E mortality is consistent with the EPA Phase II 316(b) regulation for measuring benefits. The EPA guidelines for estimating commercial and recreational fishing benefits are outlined in Federal Register Section IX, H (Implementation), part 2, pp. 41647-41648. More specific guidance regarding methods for measuring benefits and an extended discussion of EPA's recommended procedures is found in EPA Regional Studies report, Part A, Chapters A9-A12. With one minor exception noted in the response to question #2 (regarding the valuation of enhanced commercial catches), TER followed the EPA guidelines.

4. Are the potential economic effects of I&E addressed in a manner consistent with standard principles and practices for conducting benefits studies?

In general the *use benefits* associated with reduced I&E mortality are addressed in a manner consistent with applicable economic principles. (Non-use benefits are discussed in a separate question.) The basic economic concepts in play here are simple. The fishery model laid out as a guide by EPA assumes that a set of constant parameters can be applied to egg and larvae losses to obtain implied losses in harvestable populations and, ultimately, to actual harvest levels. The total harvests implied by this mechanistic application of parameters is then divided between recreational and commercial harvesters by applying the recreational and commercial harvest shares for each species examined in statewide landings data. These harvests are then valued by applying appropriate unit values to the enhanced catches.

[8] The TER discussion of economic benefit concepts is similar to the more detailed EPA discussion of relevant economic concepts that appears in the EPA Regional Studies report, Part A, Chapters 9-11.

As noted elsewhere in my report, application of a different fishery model may have resulted in substantially different estimates of the effect of I&E mortality on commercial and recreational catches and on recruitment to adult size for non-fished species. It is beyond the scope of my evaluation to assess whether or not the fishery model used in these analyses (and recommended by EPA) is entirely appropriate. It is also beyond the scope of my evaluation to assess the accuracy of the natural mortality and fishing mortality rates used in any of the studies I examined (TER, IS and EPA.)

As explained in my response to question #2, TER's approach to estimating gains from enhanced commercial harvests differs from the EPA approach in a way that results in larger benefit estimates from reducing I&E mortality. Neither EPA nor TER rigorously defends the particular assumptions they employ regarding the price elasticity of demand. It is plausible that the two estimates serve as sensible end points on the true impact.

Regarding gains due to enhanced recreational harvests, TER follows EPA guidelines by applying species-specific unit values (pseudo prices, or willingness to pay estimates) to projected changes in recreational catches. EPA gives very explicit, sensible guidance on this and TER followed it.

5. **Are all of the relevant benefit categories included in the analysis? Are any significant categories omitted? If there are omitted categories, what methods could be used to reliably address their value?**

All relevant benefit categories are discussed in the TER report. Direct use values by commercial and sport harvesters are estimated. Values resulting from the enhancement of stocks of prey species and organisms, operating through enhanced commercial and recreational catches, are examined. Non-use benefits are discussed qualitatively and descriptively, per EPA guidelines, but are not estimated quantitatively.

It would have been desirable to provide quantitative estimates of non-use benefits. Unfortunately the state of the art does not permit these values to be reliably measured at present. The method most frequently used to estimate non-use benefits uses surveys to elicit stated preferences, or respondent reports of willingness to pay. Although widely applied, this method it remains controversial.

6. **Are potential nonuse benefits addressed in a way that is consistent with economic principles and benefits practices? Are they addressed consistent with the EPA Phase II 316(b) regulations? Are any changes necessary?**

Regarding applicable economic principles and practices, TER points out that non-use benefits are typically associated with protecting 'unique' resources whose loss is likely to be irreversible. If, as TER states, the Tenera Environmental I&E study did not find impacts on threatened or endangered species or identify impacts on community maintenance or function, then TER's claim that non-use benefits are likely unimportant (TER report, p. 38) is plausible. It is not decisive, however, as the fundamental question is whether or not society is willing to pay significant sums to reduce mortality among fish that will never be caught by recreational or commercial fishermen. The most well

developed method for answering such questions involves surveying citizens in the relevant population. While this method has been widely applied, it is not based on actual payments (direct or indirect) by individuals in circumstances where preferences are revealed by actual choices. For this reason, the environmental economics profession has not unanimously endorsed this method as a vehicle for measuring non-use benefits; consequently, there is no reliable method for measuring non-use benefits. TER clearly recognizes shortcomings with existing stated preference approaches to estimating non-use benefits. TER also appropriately rejects the use of habitat replacement cost (HRC) or a 'societal revealed preference' approach to estimate non-use benefits, echoing the logic laid out by EPA in Federal Register pp. 41647-41648 and elsewhere.

Regarding the regulatory question, the documents I examined did not present evidence that application 316(b) Phase II technologies would significantly reduce losses of threatened or endangered species or enhance the maintenance of community structure or function. Also, TER states that the I&E mortality study completed for DCPP (by Tenera Environmental) did not uncover evidence that threatened or endangered species would benefit significantly from I&E mortality reductions. I have not attempted to investigate this question further by searching for additional data on I&E losses that would require monetization of non-use benefits. Absent such evidence, monetization is not required under section 316(b) and TER's treatment of non-use benefits is consistent with the regulation.

7. **Is the empirical analysis consistent with standard statistical and econometric procedures? Specifically, are the data appropriate for the task or could better data have been used? Are the benefit calculations performed in a manner that is consistent with standard economic practices? Are there improvements that should have been implemented?**

The protocol for valuing I&E mortality reductions described in Section I of this report (developed by EPA) does not necessarily require statistical or econometric analysis. EPA carried out statistical and econometric analysis in developing benefit valuation procedures and results for use by others, particularly for valuing recreational fishing benefits.[9] Based on a quick inspection, EPA's use of econometric and statistical analysis in developing these results appears to be entirely consistent with accepted practice and the data employed in this research appears to be at least at the standard normally deemed acceptable for such work.

TER describes the method it used to estimate commercial and recreational fishing benefits on pages 15-25. Aside from the uncertainty analysis discussed in the next question, the calculations required to determine benefits simply involve multiplying price (or marginal value) times quantity and summing across species. The prices in these calculations come either from data on dock prices (commercial catches) or from application of EPA's recreational fishing choice models (recreational catches.) The commercial fishery price data TER used in these calculations were taken from reputable sources and, as explained elsewhere in my report, the recreational value data are of high

[9] Presumably such analysis could be carried out if, for example, one had reason not the use the EPA models for valuing recreational catch, but it is not required.

quality. Numerous calculations are required and actually checking these calculations is beyond the scope of my review (and beyond the data and other materials provided). Nevertheless, from the descriptions of how these calculations were carried out I have no reason to doubt their accuracy.

The quantity numbers in these calculations result from combining counts of I&E losses (produced by Tenera Environmental) with information on natural mortality and fishing mortality at each age, by species. Apparently, these data were largely taken from various portions of EPA's analysis, either directly for the species in question or by transferring life history parameters from one species to another similar species. While I did not examine these calculations (and, as an economist, do not claim expertise in applying fishery population models,) it appears from the descriptions that these calculations were performed competently and appropriately.

8. **Is the uncertainty analysis consistent with standard statistical principles and practices? Have the relevant sources of uncertainty been accounted for? Have the appropriate confidence intervals and other statistical principles been calculated and used in the appropriate manner? Are there any improvements that should be implemented?**

In keeping with common practice in the profession and EPA recommendations, TER used Monte Carlo analysis to assess the implications of parameter uncertainty on its benefits estimates. Six sources of uncertainty were considered

(i) Uncertainty regarding I&E mortality: TER used data from the DCPP I&E study to develop ranges of loss rates and used these in Monte Carlo simulations. The ranges are species-specific, and vary from 4% to 65% of the mean loss rate recorded for individual species;

(ii) Life stage parameters for commercial and recreational species: TER specifies ranges for natural and fishing mortality rates for each species, based on the perceived quality or accuracy of the underlying data. In cases where the data used pertain to the exact species studied, no uncertainty is assumed to be present. Where data from one species was 'transferred' for use to another species, an uncertainty range was specified, with the degree of uncertainty increasing for more 'distant' data transfers. The ranges varied from 0% to 10% of the mean value used in generating results.

(iii) Egg-to-larvae ratio: The ratio for entrained organisms was allowed to vary by plus or minus 5% from the central value of 0.5.

(iv) Recreational values: values for each species were allowed to vary by plus or minus 2.5% from the central value used in generating results.

(v) I&E loss rates for forage species: These rates were allowed to vary by plus or minus 29% from the central values used in generating results.

The ranges specified for parameter values in items (i) and (v) above are based on actual experience to some degree; the others appear to be based on intuition. While it is

best to base such analysis on experience this is often impossible owing to the fact that the true parameters are, after all, unknown.

In summary, TER's treatment of uncertainty is consistent with standard practice. It is also consistent with EPA guidelines. Additional sources of uncertainty in the model were not addressed by TER. Examples are the assumed price elasticity of demand, the assumed trophic transfer coefficients used in valuing forage species, and the ages at which various species become susceptible to commercial and recreational fishing gear. Nevertheless, TER's analysis as explained in Appendix B and reported in Table 3 of Section 3 is adequate for establishing the fact that uncertainty is present and for illustrating the effect of uncertainty on results from the model used.

9. Does the study provide a reliable estimate of the potential benefit of reducing I&E impacts at DCPP? If so, why so? If not, would it be reliable if the proposed changes you have recommended were implemented in an appropriate fashion?

I found TER's analysis to be both rigorous and consistent with the protocols developed by EPA for measuring benefits. The one departure in method (see discussion of question 2) is relatively minor and does not have a substantial impact on the benefit estimates TER produced. Based on my analysis of the protocols TER followed, I believe TER's estimates of use benefits are as reliable as can be produced with the data presently available. The absence of non-use value measures in TER's analysis is a reflection of the current state of the art for measuring non-use benefits.

Confidence in the reliability of TER's estimates could be enhanced by a systematic comparison and reconciliation of the TER benefit estimates with the regional estimates provided by EPA. I believe this would be useful because EPA's benefit estimate for California facilities, on a per facility basis, is higher than TER's estimate. According to TER (p. 31), EPA's Regional Analysis for eight northern California estimates the benefit from reduced I&E losses at $0 to $22,755 for commercial fishing and $790,560 for recreational fishing. This implies a total benefit of over $100,000 (recreational plus commercial) for the average northern California facility. This is roughly four times as great as the TER estimate for DCPP, without accounting for the effect of TER's more generous method for estimating commercial fishing benefits. Of course, Phase 2 facilities no doubt differ substantially in their physical attributes and in their local environmental and economic conditions, so these differences may be entirely reasonable. Reconciling the two sets of estimates would enhance confidence in the reliability of TER's analysis.[10]

[10] I did not have access to the separate benefit study performed for northern California and hence did not investigate this further.

3 INDEPENDENT SCIENTISTS'S STUDY

3.1 General Question:

Do the reports provide reliable measures of the economic benefits of reducing I&E at DCPP? What changes, if any, would be needed to provide reliable estimates of these benefits?

See the response to question 9.

3.2 Specific Questions

1. **Is the organization of the report appropriate and does it present the material in a clear and concise manner? Are there any changes that are recommended?**

The organization is generally clear and follows a logical sequence. Steps in the IS analysis do not follow the steps outlined for a benefits valuation study in the EPA regulation (Federal Register pp. 41647-41648), but rather take an entirely different approach (as explained elsewhere in this report.)[11]

2. **Is the report consistent with economic principles of measuring benefits? Are there any changes that would make it more consistent with accepted economic principles**?

The Independent Scientists' approach, which is based on a habitat replacement cost (HRC) concept, is not consistent with economic principles for measuring either use or non-use benefits. The Independent Scientists first estimate the cost of mitigation measures that might offset I&E losses and then assert that these costs are an appropriate measure of the value of the lost resources.[12] This approach has no basis in economic theory. The only possible relevance HRC can have for benefit estimation derives from the fact that it necessarily places an upper bound on the size of any benefits that may exist. That is, the use and non-use benefits that can be attributed to an action that protects

[11] The IS presentation was unclear at a few points, but none of these instances materially impaired my ability to understand and evaluate the IS analysis. The points in question are: (i) on p. 5 the IS report refers to geographic information on impacts in Table 1, but I found no such information in that table; (ii) I found unclear the explanation, on p. 9, of how ETM calculations are interpreted; (iii) Figures III.19-III.24 are presented in the IS report without discussion or interpretation.

[12] The two mitigation measures that receive greatest attention are construction of artificial reefs and the establishment of a marine reserve. The Independent Scientists provide estimates of the costs of these actions. Artificial reefs of the size they recommend are estimated to cost $10.6-$26 million to construct. Marine reserves are estimated to cost $6-$8 million, although this does not appear to be a firm estimate and ongoing costs for monitoring are not separately estimated.

organisms from I&E mortality cannot exceed the cost of providing the same protection via habitat restoration or some other action. Consequently, HRC can only serve to restrain other benefit estimates and cannot serve as a defensible estimate in itself. There is no principle of economics that allows one to substitute the cost of one action for the benefit or value of another action and there is no way the Independent Scientists' replacement cost estimates could be modified to provide a defensible estimate of the value of I&E mortality reductions.

The well-understood, extensively studied concepts of consumer and producer surplus are standard theoretical tools for measuring use values associated with enhanced fish populations. There are well-established methods for estimating use values associated with both commercial and recreational fishing.[13] The IS analysis makes no mention of these concepts and methods.

3. Is the report consistent with the EPA Phase II 316(b) regulation for measuring benefits? Are there any changes that would make it more consistent?

The method IS used to estimate benefits from reduced I&E mortality is not consistent with the 316(b) regulation. EPA considered, and appropriately rejected, 'habitat replacement cost' (HRC) as a proxy measure for nonuse benefits (Federal Register 41624-41625.) EPA also considered a variant of the habitat replacement approach which bases benefits on the values of services provided by the new habitat rather than replacement costs, but ultimately rejected this as well.[14] This point is discussed further in the answer to question 6, which concerns non-use benefits.

There is no change that would render the basic IS approach consistent with benefits assessment requirement of rule 316(b). This is not surprising as the clear intention of the IS study was not to address policy or legal issues (IS report, p. 3.)

4. Are the potential economic effects of I&E addressed in a manner consistent with standard principles and practices for conducting benefits studies?

The economic effects of I&E losses are not addressed quantitatively. They are discussed at various points, but economic effects are not quantified or valued.

Costs and benefits are referred to at various points in the IS study, but not in a fashion that is consistent with standard practice in benefits studies. For example, the

[13] EPA recognizes the existence of these methods, describes them briefly in Fed. Reg. 41658 and 41659 and in more detail in the regional studies report, and recommends their use in the context of applying rule 316(b).

[14] EPA also considered, and rejected as insufficiently defensible, a 'societal revealed preference' approach to estimating non-use benefits. This method interprets actions taken by governments to protect marine organisms or other resources as evidence that society values these resources by amounts at least as great as the cost of the actions. There is an element of circularity in applying this notion in the present context. In any event, the state of knowledge on how well government decision-making is linked to the preferences of constituent is too imprecise to recommend this approach as a defensible benefit estimation procedure.

benefits associated with establishing marine reserves are describes as "fishery management" and "conservation" benefits. The costs that marine reserves would impose on recreational and commercial fishermen are not mentioned. Any effects such reserves might have on stocks and harvests outside of no take zones are not quantified. Comparisons of costs and benefits are sometimes difficult to interpret and difficult, at best, to reconcile with the conclusions reached.[15]

5. **Are all of the relevant benefit categories included in the analysis? Are any significant categories omitted? If there are omitted categories, what methods could be used to reliably address their value?**

The relevant benefit categories are the use values that would accrue to commercial and recreational fishermen as a consequence of enhanced fish populations and the non-use values that society more broadly attaches to the same stock enhancements. The IS study makes no systematic attempt to address these benefit categories quantitatively or conceptually.

6. **Are potential nonuse benefits addressed in a way that is consistent with economic principles and benefits practices? Are they addressed consistent with the EPA Phase II 316(b) regulations? Are any changes necessary?**

The Independent Scientists' approach to estimating both use and non-use benefits from I&E reductions is based on the cost of actions (artificial reefs and marine reserves) that would replace the eggs and larvae lost to I&E mortality. This method is not consistent with economic principles or practices for estimating non-use benefits. As pointed out elsewhere in the present report, there is no universally accepted method that will give a reliable, comprehensive measure of non-use benefits. There is, however, a well-developed method for valuing one category of non-use benefits, the value of uncaught 'prey' fish that ultimately nourish stocks caught by commercial and recreational fishermen. This method is described elsewhere in the present report and was developed extensively in EPA's background studies for rule 316(b). The Independent Scientists made no attempt to implement this method and, indeed, present no discussion of standard economic principles and practices for estimating non-use (or use) benefits at all.

Regarding the regulatory question, EPA's discussion of the 316(b) rule-making process notes that the problem of estimating non-use values for organisms lost to I&E mortality is particularly troublesome. At various stages in its analysis, EPA considered habitat replacement cost as a vehicle for estimating non-use benefits.[16] EPA also considered a variant of this general idea that involves measuring willingness to pay values for the habitat attributes that would result from restoration or replacement. In its

[15] The discussion on p. 22 is an example. "Conservation benefits result from a return to a more pristine ecosystem, and permanent protection of the ecosystem. In contrast, entrainment losses are temporary. It is therefore reasonable to conclude that the long0term benefits of marine reserves are greater than the temporary impact of entrainment." This argument is repeated on p. 23.

[16] See Fed. Reg. p. 41624, 41625 for a discussion of this process.

Regional Studies, Part A: Chapter A9, EPA expressed a belief that this method could serve as a useful supplement or alternative to other assessment methods, or that it could provide otherwise useful information. In the end, however, EPA elected not to include benefit estimates based on this approach in its own national benefits analysis due to inherent limitations and uncertainties.

More importantly, the actual 316(b) rule states that non-use benefits can generally only be monetized through the use of stated preference methods[17] and states that non-use benefits only need to be monetized only when an I&E mortality study demonstrates substantial harm to a threatened or endangered species, to the sustainability of populations of important species, or to the maintenance of community structure and function. This requirement for monetization has not been demonstrated in the Independent Scientists' report or in the other documents I reviewed. Even if it had been demonstrated, the HRC approach cannot yield a reliable estimate of non-use values.

7. Is the empirical analysis consistent with standard statistical and econometric procedures? Specifically, are the data appropriate for the task or could better data have been used? Are the benefit calculations performed in a manner that is consistent with standard economic practices? Are there improvements that should have been implemented?

There is no statistical or econometric analysis in the Independent Scientists' analysis and the IS benefit estimates do not rely on statistical or econometric analysis done by others.

The IS benefit estimation method does use the Tenera data on I&E losses and, to my knowledge, the Tenera study yielded reliable data. The Independent Scientists also used an empirical transport model (EMT), which incorporates information on ocean currents to estimate the source water body for the larvae entrained. This, in turn, was used to estimate the amount of habitat, reef in this case, that would be needed to replace I&E losses. The resulting estimate of reef required for the replacement is 85-400 hectares. The details of the EMT model were not presented in the IS report and could not be evaluated.

The other key item of data in the IS analysis is the cost of constructing artificial reef and of establishing and maintaining a marine reserve. For artificial reef construction the IS study relies on cost data from the San Clemente Artificial Reef. I have no way to verify the accuracy of these data. They are based on actual experience and for that reason may well be reasonably accurate. In any case, I know of no source of superior information. The IS cost estimates for establishing a marine reserve are more speculative. The source given is a discussion with the Resources Legacy Foundation Fund.

Regardless of data accuracy, the illegitimacy of habitat replacement cost as an approach to measuring benefits renders this question moot.

8. Is the uncertainty analysis consistent with standard statistical principles and practices? Have the relevant sources of uncertainty been accounted for? Have the appropriate confidence intervals and other statistical

[17] The relevant text is in Fed. Reg. p. 41647, 41648 in Section IX, Implementation, part H.

principles been calculated and used in the appropriate manner? Are there any improvements that should be implemented?

There is no statistical analysis in the IS study.

Uncertainty regarding various aspects of their analysis is mentioned at various points, but the likely effects are not quantified in any way.[18]

9. Does the study provide a reliable estimate of the potential benefit of reducing I&E impacts at DCPP? If so, why so? If not, would it be reliable if the proposed changes you have recommended were implemented in an appropriate fashion?

The IS approach, which is based on habitat replacement cost and makes no references to standard economic concepts and methods for measuring benefits, cannot provide a reliable estimate of the benefits of reduced I&E mortality. There is no way that the IS analysis, given this approach, can be revised to yield a reliable estimate.

From text in the IS report it seems clear that the authors did not set out to perform a benefits valuation study for reduced I&E mortality. Rather, the goal was to identify a set of mitigation actions that would replace the organisms lost to I&E mortality and to provide estimates of the costs of these actions. Toward this end, they estimated the size of artificial reef and the area of marine reserve that would suffice to offset I&E losses, and the associated direct costs. (Opportunity costs such as foregone recreational or commercial catches in no take zones are not addressed.) The IS report refers in various places to this replacement cost as the best value measure for I&E losses. As noted repeatedly in this peer review report, replacement cost is unconnected from the value individuals in society place on a resource and cannot serve as a defensible benefit measure.

[18] It is mentioned on pp. 2 and 5 that uncertainty will be considered in the IS analysis. Pages 21 and 25 refer to uncertainty in the entrainment study and the mitigation that would result from marine reserves, but no quantification is presented.

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