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PACIFIC SHARK RESEARCH CENTER

Pacific coast representative of the National Shark Research Consortium

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To: Maria de la Paz Carpio-Obeso
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Re: Technical Expert Review of Tenera documents (ESLO2013-17.3 and ESLO2013-038.1) and Supplement (ESLO2013-17.4)

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I have now read these two documents, and a report supplement (consisting of a revision of the first one above), for the State Water Resources Control Board (SWRCB).

My sense of the original documents was that they lacked sufficient detail on the methods used to calculate "probabilities" of entrainment and to estimate mortalities. With your approval, both Dr. Pete Raimondi and I discussed this with the authors of the Tenera documents, John Steinbeck and Dr. John Hedgepeth, and they improved upon the description of the methods, and a few other things, resulting in the Supplement mentioned.

So, this review covers both of the documents above and the Supplement, according to the agreement in our contract, which says I will provide "a written evaluation of the documents, and clear explanation of the benefits on using the screens or not using the screens. Included in the evaluation should be a statement on the limitations of these two reports, and an explanation of the potential biological benefits associated with the use of screens in terms of community or population benefits."

1. Review of “Length-Specific Probabilities of Screen Entrainment of larval Fishes based on Head Capsule Measurements (Incorporating NFPP Site Specific Estimates), Revised July 31, 2013” (ESLO2013-17.3) and “Report Supplement: Length-Specific Probabilities of Screen Entrainment of Larval Fishes Based on Head Capsule Measurements,” dated 29 October, 2013. (ESLO2013-17.4)”

This is a modeling exercise using size frequency data from two studies on power plants in California on fish larvae to attempt to estimate what effect the use of different-sized mesh (slot widths) screen might have in reducing larval fish and invertebrate entrainment. It basically assumes that head morphology will influence what sizes of larvae will be impinged (collected) versus entrained (allowed inside) such wire mechanisms.

The report relies heavily on size data for 33 taxa in 15 taxonomic groups (Table 2 of Report; Supplement Table 3) for which notochord length (NL) and head capsule (Head Depth – HD; and Head Width – HW) measurements are available.

In the original document, Table 2 (now Table 3 in the Supplement) provided mean TL, HD, and HW measurements to allow for “probabilities” of entrainment, and subsequent additional tables. This was changed by mutual agreement to calculations of “proportions” of larvae entrained at each mm NL increment for six slot widths tested.

Then, regression analysis was used to predict the sizes of larvae that would be entrained based upon the head capsule dimension calculated from the regressions (Supplement Table 4).

Even though these reports and the Supplement rely heavily on head capsule size, I felt there was a need to discuss the relative role of these dimensions versus the role that other factors, such as larval fish shape, body length, swimming behavior and speed, etc., and physical factors such as screen velocity, surge, etc., might also play in determining the effectiveness of screens. This has now been done in the Supplement.

One way to do empirically evaluate this would be to compare sizes and influence that these variables have by observing and collecting both inside and outside of screens (i.e. unscreened versus screened). Unfortunately, there is no empirical evidence of that, even with the study that was done for the Santa Cruz desalination project (Tenera Environmental 2010). I do not believe that sizes of larval fishes inside and outside of screens have ever been measured or analyzed.

Thus, there ultimately needs to be good quantitative and empirical measurements made, or experiments done, to most effectively evaluate how fish larvae might, or might not, be protected by wedge wire screens with the various mesh sizes available.

In the original report (ESLO2013-17.3), the analytical methods used to get "length-specific probability of entrainment" (pages 6-7), the "length-specific entrainment probabilities" (page 7), "population probabilities" (page 8), and "mortality reductions" (page 9), were not presented in any detail.

However, in the Supplement, (ESLO20131-17.4), the methods were more thoroughly presented (pages 9-12) and the results for “estimated percentage reductions in mortality” (now Table 5) for the six slot opening widths can be more easily interpreted.

Data on abundance of fish larvae from the Diablo Canyon Power Plant (DCPP) entrainment study (Supplement Table 6) and larval fish lengths for seven taxa of larval fishes (Supplement Tables 7 & 8) allowed for estimates of entrainment for these taxa by size (Table 9). Finally, this resulted in estimates of percentage reductions in mortality (Table 10) by slot opening width. This was best done for the DCPP data, but only in a more limited way for data from SONGS (Table 11).

It appears that the main conclusion (Supplement page 20) that ”slot openings larger than about 3 mm (0.12 in) will result in very little reduction in population-level mortality” is true, based on the analyses done in this report and supplement.

It is obviously also true that “the performance of screens will vary by location and also between years due to differences in the composition of entrained larvae and changes to their abundances and proportions over time.” (Supplement page 20).

The analysis of the more detailed larval fish data from the DCPP study do indicate, as stated (Supplement page 20), that the “assumption that the screen would be effective across all length classes up to the maximum lengths…was not valid for some of the most abundant fishes collected during entrainment sampling.”

Thus, I believe that this report effectively provides “information that can be used in evaluating the feasibility and/or physical performance of the screens, including estimates of the potential reductions in entrainment for target organisms.” (Supplement Page 2). However, this report does not evaluate the fouling of the screens by debris and other organisms, something that is covered in Tenera (2010) and another report *In Preparation*.

2. Review of “Evaluation of Fine-mesh Intake Screen System for the Diablo Canyon Power Plant, dated August 5, 2013.” (ESLO2013-038.1)

This document is specifically aimed at evaluating the use of fine-mesh intake screens for the Diablo Canyon Power Plant (DCPP). It relies heavily on the report reviewed above under **#1**. It should be noted that, even though there was a Supplemental Report (revision: ESLO2013-17.4), the conclusions from it that form the basis for this report **(#2**) are the same.

It starts by describing the existing intake screening system, which has relatively coarse mesh screen panels, yet is quite effective at reducing impingement there (documented in Appendix 1).

An alternate screening technology for the DCPP intake is described, including both traveling and passive systems. For the former this included six possible mechanisms, ranging from continuously running the traveling screens to having screen-wash technology and a return system.

The stated goals (page 3) are to evaluate: 1) reducing “entrainment through the use of a smaller screen mesh” and to determine: 2) “the survival or organisms impinged on the screens then returned.”

For the former evaluation, as noted above, this report relied heavily on

Tenera (2013: ESLO2013-17.3 and now 17.4). It correctly noted that the percent of measured larvae in the DCPP study (Tenera Environmental 1988, 1998) greater than 10 mm notochord length (NL) is quite small (Table 1), except perhaps for northern anchovies (*Engraulis mordax*).

Larval entrainment estimates by length, using methods similar to the report covered in **#1** were presented for three taxa (kelpfish: Table 2; monkeyface prickleback: Table 3; and anchovy: Table 4). On page 5, the summary that “effective reductions in entrainment for these three taxa increase only slight for kelpfish and monkeyface pricklebacks, but from 9.0 to 15.8 percent for anchovies” is reasonable.

The next topic considered was “Impingement Survival” (page 9-11) and it was based entirely on a review of the limited literature on this subject. The main conclusion from this review seems to be that there was likely “an increase in survival with increasing length of the fish” that were impinged on the various traveling and passive screens studied (page 9).

And, survival of anchovies, the only species listed above for which fine mesh screens were >10 mm NL (Table 1: 15.8%), was found by EPRI (2006) to have “very low survival” and could not “tolerate the stress resulting from the spray wash and air exposure of the collection system.” Thus, for more than one reason, fine-mesh screens would not likely result in reduced mortality for anchovies.

With only this limited summary of the available literature and a fairly detailed analysis of the DCPP larval fish entrainment data (Tenera Environmental, 1988, 1998), the statement that “expected benefits from the screens would be minimal” is likely true but weakly documented.

There is also only brief mention of the fouling of the screens by debris and other organisms, something that would be problematic should the decision be made to install fine-mesh screens at DCPP (see page 3 in the first paragraph under “Fine-mesh Screen System Efficiency” and the third paragraph on page A1-1 in Appendix 1, along with Tenera (2010) and another report *In Preparation*.

But the statement that the “entrainment studies at DCPP show that the vast majority of the fishes entrained were very small” is true. And, most likely, the statement that “the probability of these larvae surviving impingement, screen-wash systems, and fish return would be very low” is also true.

This final conclusions on page 10 appear to be a good summary of the probably success of fine mesh screens for the DCPP. These are 1) “impingement of the larger life stages at DCPP is not a major concern” and 2) “reducing the mesh size of the traveling screen system installed…” would result in additional larval fish impingement, but “the probability of their survival, even with fish buckets and a return system, is low.”