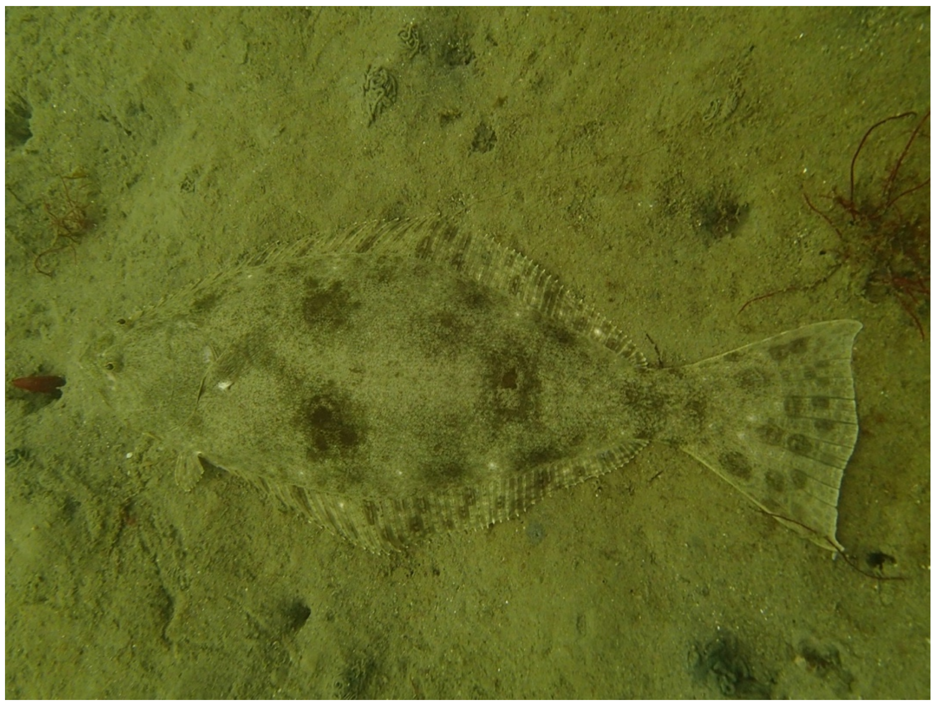
CARLSBAD DESALINATION PLANT

REVISED ENTRAINMENT ANALYSIS FOR BRINE DISCHARGE OPTIONS



Prepared For	POSEIDON WATER CARLSBAD DESALINATION PLANT
Prepared By	ERIC MILLER MILLER MARINE SCIENCE & CONSULTING, INC ALISO VIEJO, CA
Date	DECEMBER 2018
Application Appendix Number	GGG-R1

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PURPOSE

Appendix K to the Report of Waste Discharge (ROWD) the Carlsbad Desalination Plant (CDP) provides an estimate of the intake and discharge entrainment impacts associated with stand-alone operations of the CDP. This Appendix was submitted to the San Diego Regional Water Quality Control Board (RWB) in 2015 and includes a comparison of the estimated entrainment impacts of alternative brine discharge technologies (flow augmentation and a multiport diffuser). Poseidon's entrainment calculations were subsequently reviewed by a third-party science advisory panel (SAP) that revised the methodology used calculate the Area of Production Foregone (APF) used to estimate the entrainment impacts presented in Appendix K. The purpose of this Appendix GGG is to update the Area of Production Foregone (APF) for the brine dilution options under consideration for the CDP to reflect the SAP's guidance. A copy of the SAP's report is included in Attachment 1 to this Appendix GGG.

METHODS

Data Source

The EPS impingement mortality and entrainment characterization study (Tenera 2008) was used as the primary larval-entrainment data source, similar to prior CDP assessments. Entrainment estimates in the EPS study were calculated for both the actual cooling-water flow and the maximum permitted cooling-water flow. This was possible because entrainment estimates were the result of multiplying the sampled larval density by the water volume in question, such as the monthly maximum permitted cooling water withdrawn through the intake. Entrainment estimates were directly proportional to the quantity of water flowing through the intake.

The flow augmentation calculations were derived by applying a scaling factor to the average daily entrainment estimates calculated using maximum permitted flow in Appendix F1 of Tenera (2008). Maximum flow was used because the constant flow excluded seasonal variation in power demand that impacts the EPS's cooling-water needs. Use of the maximum flow simplified the calculations as the CDP flow was also assumed to be constant. All eight species (described below) used for both seawater intake analyses were subjected to this technique and multiplied by a scaling factor of 0.1995 (171 MGD/857 MGD) to 0.2287 (196 MGD/857 MGD) to proportionally represent flow augmentation withdrawals of 171 MGD and 196 MGD, respectively. These entrainment estimates were used in calculations described below for the Empirical Transport Model (ETM) to calculate the APF.

Potential diffuser-induced entrainment estimates were calculated using data from stations near the potential diffuser site located at Station N4 (Tenera 2008), which was 1.2 km offshore of the Agua Hedionda Lagoon mouth and 1.7 km offshore of the CDP (Figure 1). Under the multi-port diffuser option, the CDP is expected to discharge 67 MGD at 63.5 ppt, and this will entrain surrounding waters as it is discharged. This entrainment will result in mixing to reduce the brine salinities to ambient levels. A total of 943 MGD of entrained seawater is needed to dilute the brine to within 2 ppt of the ambient salinity.

The Staff Report and Substitute Environmental Documentation for the Desalination Amendment (SED) noted that there are few studies that estimate shearing-related mortality at brine multiport diffusers and, to date, there is no empirical data showing the level of mortality caused by multiport diffusers.

In recognition of the limited understanding of the level of mortality caused by multiport diffusers, the SED approved by the State Water Board at the adoption of the Desalination Amendment included the following guidance for assessing the mortality caused by multiport diffusers:

> However, until additional data is available, we assume that larvae in 23 percent of the total entrained volume of diffuser dilution water are killed by exposure to lethal turbulence. The actual percentage of killed organisms will likely change as more desalination facilities are built and more studies emerge. Future revisions or updates to the Ocean Plan may reflect additional data that becomes available.

Based on the guidance in the SED, this Appendix GGG analyzed marine life mortality due to a discharge from the theoretical multiport diffuser described above by calculating the required volume of water to dilute the discharge to meet the salinity receiving water limit. This volume was then multiplied by 0.23 (23%) to estimate the volume of water where shearing-related mortality occurs, as was reported by Foster et al. in the SED. Therefore, for the theoretical multiport diffuser described above, the entrained volume of water exposed to 100% larval mortality is 217 MGD. A second theoretical multitport diffuser design and its estimated shearing-related mortality (Roberts 2018) was also modeled resulting in 170 MGD of water where shearing forces would induce 100% larval mortality.

Taxa Selection

Taxa selected for this analysis were consistent with those used in similar analysis during the EPS study (Tenera 2008). The eight taxa used (Table 2) differed in relative abundance between the lagoon and coastal sampling sites. While none of the taxa common to the lagoon support a fishery (commercial and/or recreational), all five of the coastal taxa are fished to varying degrees. Northern Anchovy supports the largest fishery of the group with 378,210 lbs. commercially landed in San Diego County in 2013 (the most recent year with data available; DFW 2014). California Halibut supported the next largest commercial fishery of the group with 15,527 lbs. landed in San Diego County, while the remaining taxa had either less than 510 lbs. landed or are not open to commercial harvest. Spotfin Croaker is not open to commercial harvest but is taken by recreational anglers fishing in the surf zone (Miller et al. 2011). Garibaldi is the California State Marine Fish and is thus protected from fishing harvest. California Halibut supports a prized recreational fishery, while Queenfish and White Croaker are commonly taken by recreational anglers fishing from public piers (Love 2006; Miller et al. 2011).

Figure 1. Map of the source water station representative of the proposed multi-port diffuser location conditions.

Table 1. Taxa selected for inclusion in the Area of Production Foregone Calculations. Parameters used in the decision to choose these taxa as representative include percent of the samples collected in the Agua Hedionda Lagoon and the coastal waters offshore the lagoon entrance, existence and relative size of the fishery (commercial and/or recreational), the pounds commercially landed in San Diego County in 2013, and whether or not the taxa is protected from any harvest.

Taxa	Percent of Lagoon Sample	Percent of Coastal Sample	Fishery	Pounds Landed	Protected
CIQ goby	62%	5%	No	0	No
combtooth blennies	28%	12%	No	0	No
Garibaldi	1%	1%	No	NA	Yes
Northern Anchovy*	4%	46%	Large	378,210	No
White Croaker	<1%	5%	Small	183	No
California Halibut	<1%	4%	Medium	15,257	No
Queenfish	<1%	2%	Small	504	No
Spotfin Croaker	<1%	2%	Small	NA	No
Total Abundance All Taxa	20,601	16,763			
***Unidentified anchovies assumed to be Northern Anchovy**					
NA = Not Allowed					

Modeling

Taxa-specific calculations were completed for each month of sampling in accordance with the OPA and SAP guidance using the ETM to derive the APF. Two modeling processes were used. The SAP recommended the ETM calculation method originally used by Tenera (2008) for the flow augmentation analysis where open coastal taxa are entrained through the intake in Agua Hedionda Lagoon. This calculation method better accounts for the movement of water through the lagoon mouth and this movement of water transports only a fraction of the available source population into the lagoon where it can be entrained. A second ETM calculation method is applicable to analyzing impacts by the potential offshore diffuser on larvae sourced from area estuaries. The ETM calculation method developed for the Huntington Beach Desalination Plant in conjunction with SAP member Dr. Peter Raimondi (MMSC 2018b) was used for this analysis.

Intake Entrainment Analysis

To represent the larval movement through the mouth of the lagoon, the traditional ETM was modified using the results of EPS design flow parameters published in Tenera (2008). For simplicity, the following is presented and coincides with the SAP Equation 4:

$$P_m = 1 - \sum_{i=1}^{n} f_i \, (1 - \frac{CDPV}{857} P_e)^d$$

Where

P_m = Proportional mortality

fi = Estimated fraction of total source water larval population present during the i[th] survey (values presented in the EPS entrainment calculation (Tenera 2008) were used in these new calculations)

CDPV= The volume of water withdrawn from the lagoon by the CDP through the intake structure

857 = The maximum intake water volume reported for the EPS in Tenera (2008)

P_e = Estimated proportional entrainment (maximum intake flow volume derived in the EPS entrainment calculation in Tenera (2008))

d = Larval duration in days (values presented in the EPS entrainment calculation (Tenera 2008) were used in these new calculations)

The APF is the product of multiplying the average P_m for each taxon by the taxon's estimated total source-water area. The eight fish taxa selected for analysis represent a wide range of habitat preferences and life history strategies. The estuarine taxa's total source-water area was restricted to the wetted habitat in the lagoon (302 acres). Coastal ocean taxa, however, had larger source water habitats derived by multiplying the ambient alongshore current by the taxon's ETM parameter d. Therefore, after splitting the taxa into two groups (estuarine and coastal ocean) based on their predominant habitat affinity, consistent with the SAP's approach, the average APF and standard error was calculated by habitat. The average plus 95% confidence interval APF was calculated using the NORM.INV function in MS-Excel substituting standard error for standard deviation as suggested by the SAP (Attachment 1).

Diffuser Impact Analysis

An analysis of the shear-related mortality caused by the multiport diffuser was conducted using the ETM/APF methods, separately, as described below for estuarine and coastal ocean taxa. Coastal ocean taxa were modeled using the standard ETM as described in Appendix E of the SED, but the estuarine taxa were modeled using the derived ETM first proposed in Tenera (2006) where the traditional P_e term is modified and P_s term is removed:

$$P_M = 1 - f_i\left(1 - \left(\frac{E_i}{(SSWDi\ x\ TSWBV) + (Diest\ x\ TEWBV)}\right)\right)^d$$

Where

P_M = Proportional Mortality

f_i = Proportion of the total annual source water population present during the i^{th} survey

E_i = Estimated number of larvae entrained during the i^{th} survey

$SSWD_i$ = Estimated mean larval density in the sampled source water during the i^{th} survey

TSWBV = Total source water body volume derived as the alongshore displacement represented by the larval age (d) x the current speed (km/d) x 3.0 km (for the CDP analysis) x mean depth of sampled source water body.

D_{iest} = Estimated larval density in Agua Hedionda Lagoon during the i^{th} survey

TEWBV = Total estuarine source water body volume from the estuaries used in the analysis

d = Number of days that the larvae are exposed to entrainment per Tenera (2008)

For the coastal ocean taxa occurring at the diffuser site, the ETM/APF was conducted following the specifications detailed in the OPA:

$$P_m = 1 - \sum_{i=1}^{n} f_i\,(1 - PE_i \cdot P_s)^d$$

Where

PE_i = Estimate of proportional entrainment for the i^{th} survey,

P_S = Estimate of the proportion of the total source water population represented by the sampled population,

f_i = Proportion of the total annual source water population present during the i^{th} survey

d = Number of days that the larvae are exposed to entrainment per Tenera (2008)

For all taxa, the d used for the offshore diffuser entrainment impact analysis was the same used for the intake entrainment impact analysis. The age of the larvae used for the intake entrainment impact analysis at Station N4 is derived from the estimated ages reported in Tenera (2008). The sampled source water volume was derived by georeferencing figure 3-2 from Tenera (2008) (Figure 2) in QGIS, measuring the dimensions of each grid cell, and multiplying these dimensions by the mean depth per grid cell reported in Tenera (2008) (Table 2). To account for any differences in these measurements and those used by Tenera (2008) the ETM parameter f_i was calculated based on the new sampled source water estimate. The source water population corresponding to each sampling event used to calculate f_i for the coastal ocean taxa for that sampling event was calculated as follows:

$$SWP_t = V \; x \; M_t \; x \; D$$

Where

SWP_t = Source water population for taxon t

V = Static volume of the source water sampling grid (265,404,000 m^3)

M_t = Mean larval concentration recorded during the survey for taxon t

D = Number of days represented by the survey (listed in Appendix 2)

Figure 2. Source water sampling grid used in the Encina Power Station 316(b) entrainment study reported in Tenera (2008).

RESULTS

The resulting APF estimates are presented in Table 3. The flow augmentation discharge technology would result in a 100% mortality in 171 MGD to 196 MGD with an associated APF of 75.8 to 88.4 acres. Based on the guidance in the SED, a theoretical multiport diffuser that would result in a 23% volume of shearing-related mortality with 100% mortality in 217 MGD with a calculated APF of 584.7 acres. An estimated 458.6 acres of APF result when using the theoretical multiport diffuser design and subsequent volume of water subject to mortal shearing (170 MGD) proposed by Roberts (2018). Use of flow augmentation at the CDP represents the least impactive brine discharge alternative based on the four volumes (two flow augmentation and two diffuser) evaluated.

Table **2**. Measured source water sampling grid cell length (L), width (w), reported depth (D), and resulting volume estimate. Depth as reported in Tenera (2008).

Grid Cell	L (m)	W (m)	D (m)	Volume (m^3)
N1	1900	760	6.0	8,664,000
N2	2400	850	8.8	17,952,000
N3	2900	750	7.2	15,660,000
N4	2400	710	17.6	29,990,400
N5	2400	840	34.1	68,745,600
SW1	1900	710	17.6	23,742,400
SW2	2900	710	17.6	36,238,400
SW3	1900	840	34.1	54,423,600
SW4	2900	840	4.1	9,987,600
Total Water Volume				265,404,000

Table 3. The calculated area of production foregone (in acres) for flow augmentation at 171 MGD and 196 MGD; and multiport diffuser at 170 MGD and 217 MGD.

Taxa Category	FA (171)	FA (196)	Diffuser (170)	Diffuser (217)
Estuarine	36	40.9	17.6	22.2
Coastal Ocean	39.8	47.5	441.0	562.5
Total	**75.8**	**88.4**	**458.6**	**584.7**

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ATTACHMENT 1: APPENDIX FFF – REVIEW OF THE CALCULATION METHODS USED IN THE CARLSBAD DESALINATION PLANT ENTRAINMENT ANALYSIS AND FINAL SCIENCE ADVISORY PANEL REPORT DATED SEPTEMBER 15, 2018.

Independent review: TOPICS FOR NEUTRAL THIRD PARTY REVIEW IN SUPPORT OF THE REISSUANCE OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR THE CARLSBAD DESALINATION PLANT

Review Panel: **Peter Raimondi, Richard Ambrose, Brett Sanders**

Date: **September 15, 2018**

This document is the result of an independent review based on questions posed in "**TOPICS FOR NEUTRAL THIRD PARTY REVIEW IN SUPPORT OF THE REISSUANCE OF THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) PERMIT FOR THE CARLSBAD DESALINATION PLANT"**. It is important to state that the questions posed to and addressed by the panel were focused on impacts related to intake of seawater. There was no consideration of discharge related impacts. Specifically we did not assess or make comparisons of impacts related to discharger designs or evaluate any assumptions related mitigation ratios associated with habitat affected by discharge water. In addition this panel did not evaluate the 316B study that is discussed in this review.

Reviewers are asked to address the proposed conclusions presented above and are asked to contemplate the following questions:

1. *If the mitigation acreage is increased by 11 acres, are the biological performance standards and associated fish productivity monitoring necessary to verify that the mitigation adequately compensates for impingement from the Facility* ***during co-located operations?***

The basis for the 11 acre estimate comes from Allen 1982. The logic as applied to compensatory mitigation is:

a. Estimates of fish production from a paper by Larry Allen (1982), extrapolated to an estimate of 151.36 kg (wet weight – WW) per acre).
b. The estimation of the impingement losses resulting from water use of 304 MGD of seawater (304 was the value originally estimated). The average impingement loss was estimated at 4.7 kg per day, (Note that this = 10.36 lbs. This is noted because both lbs and kg are used in documents). This led to an estimate an annual loss due to impingement of ~1715 kg per year.
c. Hence, the loss of 1715 kg per year (production) would be potentially compensated by 1715 kg/year / 151.36 kg per acre year = 11.33 acres.
d. Based on the current estimated use of water (299 MGD) the estimate of acres needed to compensate for impingement is (299/304) x 11.33 acres = 11.14 acres.

This estimate is based (in part) on the following assumptions:

a. The estimate of acreage required for compensatory mitigation for impingement, 11.14 acres, relies on the use of averages (~ 50% confidence level). There is nothing wrong with the use of averages as one estimate of effect; however, the use of averages as the only estimate of effect relies on the idea that estimates are made without error, which is unlikely to be true. We note that the concept of "compensatory" mitigation was evolving at the time these calculations were initially presented. In fact, the use of the 80% confidence interval for entrainment impacts was the first time the confidence interval approach was used in a desalinization powerplant determination for either entrainment or impingement, at least in California. A better approach (see later questions) is one based on degree of confidence (or certainty). Here estimates are expressed as the confidence that one has the real average is no higher that some value X. As an example, if the average impingement is 4.7 kg per day, then the equivalent statement using confidence limits is that we are 50% confident that the true average is no greater than 4.7 kg per day. In typical inferential statistics, confidence limits of 95% are often used. If a higher confidence limit was employed, the estimated impingement would be higher.
b. Fish production of the mitigation wetland will be similar to the production estimated in Allen (1982). Allen measured fish production at Upper Newport Bay; since no other comparable work has been conducted at other southern California wetlands, it is not known how representative fish production there (and at the time of Allen's study) is to other wetlands. In addition, the estimate of fish production (151.36 kg per acre per year) was specifically restricted to those areas not including vegetated marsh. Thus, the estimates of fish production are based on the assumption that the mitigation wetland will be made up entirely of intertidal mudflats and subtidal areas.
c. Estimates of acreage required for compensatory mitigation for impingement at 299 MGD, assuming the acreage is subtidal or intertidal mudflats, range from 11.14 (50^{th} percentile) to 17.5 (80^{th} percentile) to 21.11 acres (95^{th} percentile).

The key assumption for monitoring as applied to mitigation for impingement and entrainment is that if the restoration is similar to the overall performance of a natural and functioning set of reference areas, then its specific functions such as adult biomass and larval production are likely to also be comparable to those in the reference areas. Given that the estimates of loss are based on empirical estimates or models of functioning (reference-like) areas, this is a reasonable assumption, but it does depend on monitoring the biological performance standards. Moreover the approaches for estimating fish biomass and larval production may be invasive and counter-productive (see below). Hence, our conclusion is that so long as appropriate reference areas are selected and the mitigation area (here a wetland restoration) is comparable to the performance of reference areas (as determined by monitoring the biological performance standards), no additional specific monitoring of fish productivity is necessary.

2. *Would the methodology for fish productivity monitoring in Allen 1982 undermine the mitigation's restoration efforts? If yes, is there an alternative, less destructive methodology to monitor fish productivity that would still verify that the biological performance standard has been met?*

We conclude that that methodology described in Allen 1982, which was adopted by Poseidon in "Poseidon Resources Draft Productivity Monitoring Plan for the Otay River Estuary Restoration Plan," would likely be counter-productive to the goal for the mitigation for impingement. At best the sampling approach would lead to increased variability in the sample data (making it more difficult to assess compliance with mitigation requirements). At worse, the sampling approach could degrade the wetland over time. In addition it is very likely that underlying spatial and temporal variability would be large and lead to sampling assessment that had low statistical power, which again would lead to difficulty assessing compliance with mitigation requirements.

By contrast, an approach designed to assess general performance of the mitigation wetland relative to reference wetlands would be much less intrusive. Such an approach was thoroughly vetted as part of mitigation for intake impacts due to the operation of San Onofre Nuclear Generating Station (SONGS). The key assumption here is that a mitigation wetland could provide compensatory specific performance metrics given:

a. That it is functioning similarly to reference wetlands. This can be assured through a well-designed comprehensive monitoring program focused on comprehensive biological performance standards.
b. The size of the mitigation is sufficient to be compensatory. Here the key is that models relating acreage to impact (i.e. entrainment or impingement) are robust and that there has been a consideration of level of confidence desired (or required under regulatory authority).

Note that this approach assesses overall wetland function but not fish productivity directly. We know of no alternative methods for measuring fish productivity directly that are less destructive than the methods used by Allen (1982).

Reviewers are asked to address the proposed conclusions presented above and are asked to contemplate the following questions:

1. *Were the ETM/APF analyses provided by Poseidon done adequately to account for impacts to all forms of marine life that may be affected by the intake of seawater during stand-alone operations, including but not limited to potential impacts from a fish return system and entrapment in the intake channel? Were the ETM/APF analyses calculated in accordance with the Ocean Plan Requirements, including the one-sided, upper 95 percent confidence bound, and one percent mitigation credit?*

We are dividing this question into parts: entrainment, 1 percent mitigation credit (for entrainment) and impingement (including use of a fish return system [FRS]).

a. Entrainment: The original calculations in the submitted document were not consistent with the ETM algorithms used in the EPS 316B. This was acknowledged by Poseidon and there is now agreement on the approach. Appendix FFF to the Report of Waste Discharge contains the documents used to clarify the approach (submitted by the SAP and Poseidon). Based on the approach advocated by the SAP (and consistent with the EPS 316B) the estimate for APF (at the 95% confidence limit) assuming intake of 299 MGD is 66.63 acres. This is based on:
   i. 59.4 acres related to entrainment of estuarine species
   ii. 72.3 acres related to entrainment of open coast species.
   iii. Applying a 10 / 1 ratio of value restoration of open coast relative to estuarine habitat to the 72.3 acres (b) = 7.23 acres of estuarine habitat
   iv. Summation of 59.4 + 7.23 acres = 66.63 acres of estuarine habitat
b. 1 percent mitigation credit (relative to entrainment impacts): This credit reduces the APF for entrainment from 66.63 to 66.63 x 0.99 = 65.96 acres
c. Impingement: This is more complicated as the APF estimates currently applied by Poseidon were: (1) based on an approach for determining baseline impingement that departs from the approach originally taken by Poseidon and their consultants, (2) reduced based on explicit consideration of ability of fish to leave the intake pipes and forebay and, (3) not assessed at the 95% confidence limit. We will address these topics in the context of stand-alone operations
   i. In the original approach taken by Nordby, the impingement during EPS operations was generally but not completely calibrated to proposed intake flow required by CDP using the ratio MGD:CDP/MGD:EPS, where EPS flow was 657 MGD and the proposed CDP flow was 304 CDP. This seems like a reasonable approach because it assumes that the rate of organismal entrapment in intake flow (here we are talking about non – larval organisms) should be related to the rate and amount of water taken into the plant. It turns out that the empirical relationship is more complicated than this expectation. As noted the calibration was used generally but not completely. Specifically, it was used for 50 of the 52 events where impingement was assessed. Figure 1, below, shows the relationship between impingement and MGD for those 50 events.

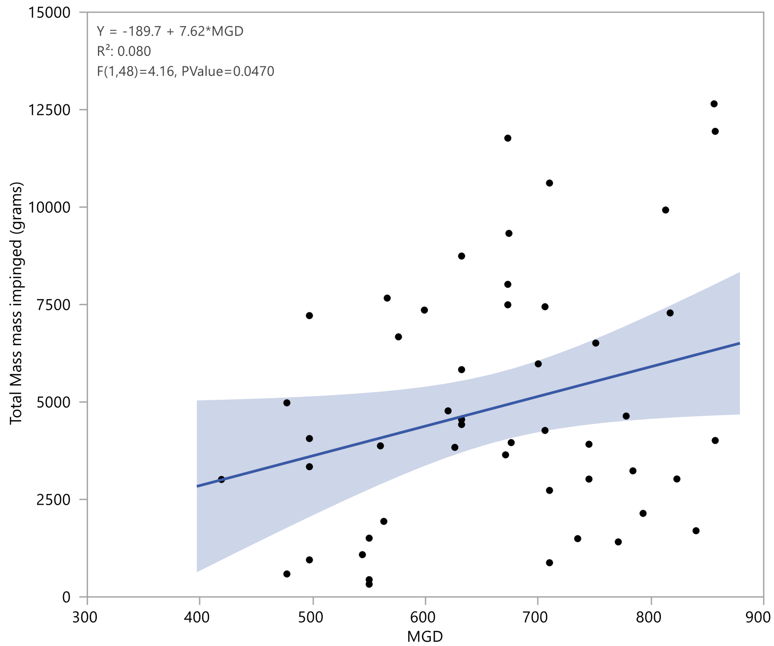

Figure 1: Relationship between Impingement and MGD for 50 "ordinary" events.

The relationship depicted in figure 1, as expected, shows an increase in impingement as MGD increases. However the relationship is much weaker than expected. This is due to the high level of simple temporal variability in impingement unrelated to flow (e.g. pulses of individuals near the intake structure). Adding the two extraordinarily high impingement events corrupts the relationship entirely (see figure 2 below).

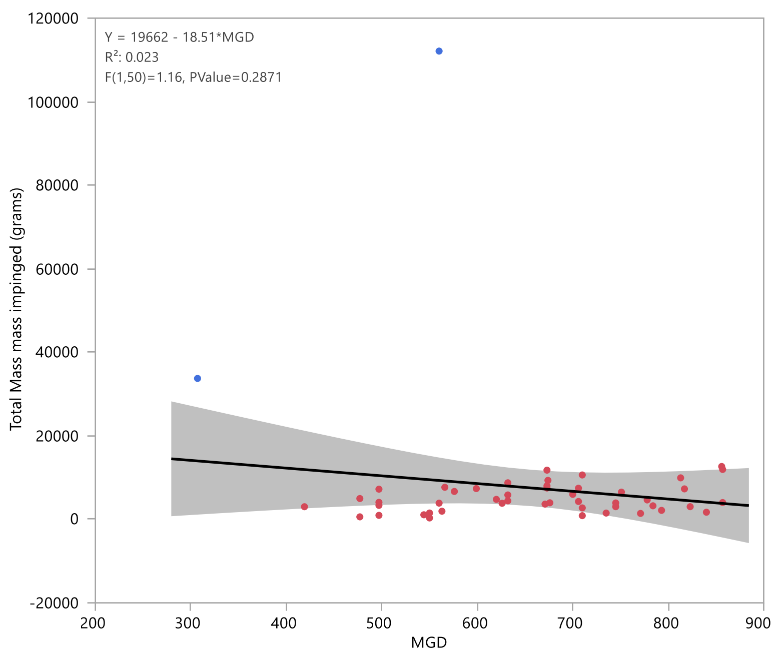

Figure 2: Relationship between Impingement and MGD for 50 "ordinary" (red) and "extraordinary" events (blue).

Including all 52 events causes the relationship to shift from positive (figure 1) to negative (figure 2). Note that the relationship is significant in figure 1 ($p = 0.047$) but not in figure 2 ($p=0.2871$). It is clear that the inclusion of all data corrupts the relationship between MGD and impingement. Nordby recognized this and derived an estimate of impingement related to CDP MGD that was based on a hybrid approach. The 50 ordinary events were calibrated by the MGD ratio noted above and the 2 extraordinary events were not. This lead to an estimated daily impingement rate of 4.7 kg per day (=10.36 lbs per day). For comparison, calibrating all the data and using the relationship shown in figure 2, the estimate for 304 MGD would have been 14.03 kg per day (at the 50% confidence limit).

In the recent submissions by Poseidon (Hogan et al.) a different approach was used. Here all the data were calibrated but differently than shown above. Poseidon assumed that impingement should be affected by flow rate even though the actual empirical relationship was weak. Here, however, events were considered replicates and not part of a regression relationship. Hogan calculated the average impingement for the 52 events (irrespective of MGD for particular event), which led to an estimate of 7.045 kg per day (15.50 lbs per day), This value was then calibrated by the putative CDP flow rate (299 MGD) relative to the average EPS flow rate (657 MGD). This equation (7.045 x (299/657)) yielded a value of 3.206 kg per day (7.06 lbs per day). A different and we think superior way to use the same data is to calibrate the impingement for each event by the event specific MGD. This approach yields an impingement estimate of 3.88 kg per day (8.54 lbs per day). This is equal to 1416 kg per year (see table 2). Note that all of these estimates are based on the 50% confidence interval. At the 95% confidence limit the values are 5.95 kg per day (2172 kg per year, see table 2)

ii. The effects of reduction in flow velocity resulting from stand-alone operations: As noted by Hogan, regardless of the impingement basis (3.206 – 4.7 kg per day), the change in flow velocity associated with stand-alone operations is likely to decrease potential impingement. This is separate from the effect due to reduction in water use. Poseidon assumes that certain individual fish with known swimming speeds (based on size) sufficient to swim against the mean velocity in the intake tunnels all do so and escape. The key, and at this point unanswerable, question is whether this is true. This relates more to fish behavior rather than capability. This is important given that this assumption (those that can escape do escape) has a marked impact on reduction of individuals potentially using the FRS. Given the assumption that all fish capable of escaping the intake tunnel do escape, Poseidon (appendix ZZ page 21) concludes that the biomass subject to impingement after accounting for escape by swimming range from 2.81 kg per day (6.19 lbs per day, alternative 1) to 2.55 kg per day (5.61 lbs per day, alternative 15).

iii. The effects of the FRS: The key metric associated with the FRS system is reduction in fish mortality. Hogan used an approach where species specific estimates (from Love et al. 1989) were used when available and if species specific estimates were not available a value of 15% mortality was used (based on EPRI 2010 for freshwater species). As acknowledged by Hogan, these estimates, while for different FRS and sometimes for freshwater species, are not optimal but are the only estimates available.

iv. Combining ii and iii, above, allows an estimate impingement related mortality due to decrease in flow velocity and the use of the proposed FRS, subject to key untested assumptions. The values are 0.386 kg per day (0.85 lbs per day) for alternative 1 and 0.354 kg per day (0.78 lbs per day) for alternative 15 (Appendix XX page 21). These equate to a reduction of impingement related mortality of 88% (alternative 1: (7.06-0.85)/7.06) and 89% (alternative 15: (7.06-0.78)/7.06). These percentages can then be applied to all impingement scenarios (see Table 1, below)

Scenario	Impingement kg/year	reduction (alt 1 at 88%), kg/year	reduction (alt 15 at 89%), kg./year	Estimated impingement alt 1 (kg/year)	Estimated impingement alt 15 (kg/year)
Nordby original estimate	1715	1509	1526	206	189
Based on slope calibrated MGD	5037 (14.03 x (299/304) x 365	4433	4483	604	554
Hogan revised estimate	1171	1030	1042	141	129
SAP revised estimate	1416	1246	1260	170	156

Table 1: estimated impingement for the models assessed

v. As noted above, all of these estimates are based on the 50% confidence limit. In order to estimate the 95% confidence limit there needs to be data where a variance term can be calculated. Currently this is not possible for either the reduction in impingement mortality due to a reduction in in flow velocity or the reduction due to the FRS. Our suggestion is that there be a post-implementation monitoring program to assess these assumed values in order to determine the realized APF related to impingement mortality. There is a variance term associated with data used to estimate base impingement. This can be used to calculate a preliminary 95% confidence limit. We calculated the upper 95% confidence level in two ways: (1) using the same approach as taken for entrainment by Poseidon using the NORM.INV function implemented in EXCEL, and (2) using a resampling approach with 2500 iterations of the 52 samples. These two approaches led to differing values. Using NORM.INV (using the standard error in place of the standard deviation, as per APF practice) the upper 95% limit is 5.95 kg per day. Using the resampling approach resulted in an estimate of 6.2 kg per day. As expected the difference between the two estimates is very small and for consistency with the approach used for entrainment we used the value associated with the NORM.INV estimate.

vi. Based on Allen's (1982) estimate of 151.36 kg per acre year of production for mudflats and subtidal habitat, we calculated the APF for the 95% confidence limit using the SAP revised estimates, which we consider the appropriate values (Table 2). These values were 1.8 acres for alternative 1 and 1.65 acres for alternative 2. We want to note again that: (1) these estimates assume 100%

escape from the intake tunnel for species of a given size and that FRS mortality estimates are accurate and, (2) that the assumptions should be assessed after implementation.

Scenario	Impingement kg/year	reduction (alt 1 at 88%), kg/year	reduction (alt 15 at 89%), kg./year	Estimated impingement alt 1 (kg/year)	Estimated impingement alt 15 (kg/year)	Estimated APF alt.1 (acres)	Estimated APF alt.15 (acres)
SAP revised estimate	1416	1246	1260	170	156	1.12	1.04
SAP revised estimate at the 95% confidence limit	2172	1911	1933	261	239	1.72	1.58

Table 2: estimated impingement and APF for SAP revised estimate and 95% confidence limit

vii. Based on the discussion above the total APF for intake effects should be: for alternative 1 = 65.96 + 1.72 = 67.68 acres and for alternative 15 = 65.96 +1.58 = 67.54 acres. Recall that the APF for entrainment, including the 1% mitigation credit, was 65.96 acres.

viii. If the assumption is that no fish escape from the intake tunnel then the estimated APF is 2172 kg /151.36 kg per acre = 14.34 acres

2. *Does Poseidon's proposed mitigation of 67.83 acres compensate for the intake and mortality to all forms of marine life resulting from the stand-alone operation of the Facility, including but not limited to potential impacts from a fish return system and entrapment in the intake channel?*

Based on the discussion above and the assumptions noted, the proposed restoration of 67.83 acres of estuarine habitat, should be adequate compensation with respect to intake related impacts under stand-alone operation if it is successful (assessment as described above).

3. *Do the ETM/APF analyses in Appendix K include species that are representative of a full range of life histories, habitats, and future productivity that may be subject to intake and mortality by construction and operation of the Facility? If not, please identify which additional species should be included in the ETM/APF analyses and explain the basis for including those species.*

We are going to address a slightly modified question. That question is "*Given the data and the ETM/APF modelling approach*, do the analyses in Appendix K include species that are representative of a full range of life histories, habitats, and future productivity that may be subject to intake and mortality by construction and operation of the Facility?". For this question the answer is yes. One of the key requirements for reliable use of the ETM/APF approach is adequate representation in the samples. This means that there has to be sufficient data to reliably estimate the Pm and when appropriate Ps for determination of the species-specific proportional mortality and source water bodies. Given this modification of the question, we think that the species evaluated are reasonable. One other set of candidate species for which there are likely to be sufficient data for analyses are the kelpfishes. Their omission may be explained by the second selection guideline used by Tenera for the 316B analysis: "The following eight taxa were selected for detailed evaluation of entrainment effects based on their abundance in entrainment samples and/or **importance as fishery species**:" (page 3-19)

4. *Did Poseidon and their consultants appropriately use and apply the information and data from Tenera Environmental's 2008 report, Encina Power Station Clean Water Act Section 316(b) Impingement Mortality and Entrainment Characterization Study, for calculating the mitigation acreage required for stand-alone operation and to adequately account for all impacts to all forms of marine life from the Facility during stand-alone operation, including but not limited to impacts from entrapment and a fish return system? If not, please cite the reasons for such.*

The original approach provided by Poseidon for the calculation of entrainment impacts was inconsistent with approach used in the 2008 316B approach. Following discussions with the SAP the approach has been reconciled with that in the 316B (see description above). With respect to impingement, there was no analytical approach to the calculation of acreage in the 316B, but the current approach proposed by Poseidon is inconsistent with both the original approach proposed by Nordby and the SAP proposed approach (see above). Having said this, the total acreage proposed by Poseidon slightly exceeds the SAP calculated value for compensatory mitigation.

5. *Were species that were included in the ETM/APF analyses in Appendix K appropriately classified by habitat? If not, please identify and explain what type of classification(s) would be appropriate to use. Where available, please provide references to peer-reviewed literature supporting any specific conclusion(s).*

Yes the designations are appropriate with respect to both species life history and sampling results. . Moreover the designations are consistent with those used in the 2008 316B. It is important to note that the key reasons for the designations are to allow identification of the source water bodies and the equations that should be used in the ETM models to calculate Pm and source water bodies (which are a function of Ps). These were originally proposed by Tenera and have been treated consistently in the Poseidon submissions.

Reviewers are asked to address the proposed conclusions presented above and are asked to contemplate the following questions:

1. *Were operational impacts to marine life that could result in the intake and mortality of all forms of marine life (e.g., entrainment, impingement, entrapment) from the onshore screen location adequately evaluated in Appendices HH and YY? If not, identify specific reasons for such conclusion and, where available, provide references to peer-reviewed literature supporting any specific conclusion(s). Is entrapment an additional source of impacts to marine life for the onshore screen location?*

Poseidon's submissions relative to intake related mortality are comprehensive and we think evaluated sufficiently in the context of a particular interpretation of the guidance afforded under NEPA and State law (e.g. SED: Final Staff Report Including the Final Substitute Environmental Documentation Adopted May 6, 2015). The key language is (from final 316B rules, USEPA 2014):

"Entrapment means the condition where impingeable fish and shellfish lack the means to escape the cooling water intake. Entrapment includes but is not limited to: Organisms caught in the bucket of a traveling screen and unable to reach a fish return; organisms caught in the forebay of a cooling water intake system without any means of being returned to the source waterbody without experiencing mortality; or cooling water intake systems where the velocities in the intake pipes or in any channels leading to the forebay prevent organisms from being able to return to the source waterbody through the intake pipe or channel."

This language is used in the Poseidon submission along with language from SED in the interpretation of "organisms caught in the forebay of a cooling water intake system without any means of being returned to the source waterbody without experiencing mortality" and "systems where the velocities in the intake pipes or in any channels leading to the forebay prevent organisms from being able to return to the source waterbody through the intake pipe or channel". While this language was provided under the context of power plant operations, it was applied as guidance for CDP. Given this language Poseidon argues that lowering the velocity in the intake pipes to ~2.6 feet per second (actual value driven by intake design) provides opportunity for certain sized individuals with known swimming speed capabilities to return to source water body without experiencing mortality. Poseidon assumed that this was 100 percent effective (meaning that all individuals that could return, based on documented swimming ability) would return. This is an untested assumption, which we recommend should be evaluated once flow reduction is implemented. Also as noted above the mortality rates for species being returned using the proposed FRS are also based on either a different FRS system or (model) test species that do not occur in the source water for CDP. Again we recommended that the assumed rate of mortality be assessed following implementation of the FRS

Hence, our opinion is that given available information, Poseidon did adequately evaluate operational impacts to marine life but that the current information is not adequate to make a strong and supportable prediction concerning operational impacts.

2. *Is it scientifically sound and reasonable to use the marine life survival data from a different fish return system design at SONGS to evaluate operational impacts of the fish return system for the onshore screen intake option for the Facility? If not, please identify specific reasons for such conclusion and, where available, provide references to peer-reviewed literature supporting any specific conclusion(s), and identify whether there are other readily available data that can be used for this purpose?*

Poseidon's use of survival data gathered from a different form of FRS used at SONGS was based on the unfortunate reality of the limited use of FRS systems and the paucity of monitoring efforts designed to assess their effectiveness. As such the inclusion of such information is reasonable to provide some context for the possible effectiveness of FRS systems in a general sense. Although this was a reasonable approach for Poseidon to use, there is a lot of uncertainty associated with it. Not only were the Love et al. (1989) survival data from a different type of FRS, those data have their own uncertainties and limitations.

Because the FRS estimates used by Poseidon have so much uncertainty but there are no alternatives available we know of in the peer- reviewed literature, a key recommendation concerning the effectiveness of the proposed FRS is to assess it after implementation, along with testing of the assumption of fish swimming out of intake tunnels and the forebay back to the source water body. These assessments should also be linked, if possible, to the possibility of modifying the mitigation requirements to ensure compensatory acreage (assuming APF use for establishing compensatory mitigation).

3. *Is it scientifically sound and reasonable to use total marine life mortality as measured in kg of fish/day for purposes of quantifying operational impacts of the onshore intake screen option that could result in additional intake and mortality of all forms of marine life? If not, please identify specific reasons for such conclusion and, where available, provide references to peer-reviewed literature supporting any specific conclusion(s). Please also describe the limitations to this approach of quantifying operational impacts and suggest more appropriate metric(s) for quantifying these impacts, if they exist.*

It is important to note that we are specifically limiting this discussion to impingement of larger organisms, Entrainment of smaller planktonic forms are treated using a different approach (the ETM/APF model). Kg of fish per day is an appropriate metric to use so long as "fish" is meant to include all species that are impinged. This primarily would include fin fish and invertebrates. This is especially true so long as mitigation is in the form of habitat creation or restoration under APF modeling. This is because, under APF mitigation models, both direct and indirect effects of impact are assumed to be covered. For example, assume that the loss of fish of certain mass leads, under APF modeling, to an acre of wetland creation. This would mean that quantitatively this acre would provide the same increase in fish mass and also that those species that would been affected by the direct loss mass of fish (e.g. predators) will be made whole.