CALIFORNIA COASTAL COMMISSION
45 FREMONT, SUITE 2000
SAN FRANCISCO, CA 94105- 2219
VOICE (415) 904- 5200
FAX (415) 904- 5400

Th9b

9-19-0025 (SOUTHERN CALIFORNIA EDISON)

MARCH 7, 2019

APPENDICES

Table of Contents

APPENDIX B

Report on the causes of low fish standing stock at Wheeler North Reef and possible solutions for remediation

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) MITIGATION PROGRAM

Submitted to the California Coastal Commission
February 25, 2015

By

Daniel Reed, Stephen Schroeter and Mark Page
Marine Science Institute, University of California Santa Barbara

In consultation with

Richard Ambrose, University of California Los Angeles

Peter Raimondi, University of California Santa Cruz

Russell Schmitt, University of California Santa Barbara

SUMMARY

The Wheeler North Reef was constructed by Southern California Edison (SCE) and its partners as partial mitigation for the adverse effects of the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3 on living marine resources. Results from the first six years of independent monitoring show that the Wheeler North Reef has consistently failed to meet the performance standard for fish standing stock. Results of analyses of time series data of fish biomass indicate that the current size (173.8 acres) and configuration (low relief reef with an average of 47.6 % coverage of rock) is insufficient to consistently meet the requirement for a minimum fish standing stock of 28 US tons. If the performance standards are not met, then the SONGS permit enables the Executive Director to require SCE to perform remediation, which may require constructing additional reef. Monitoring data collected at the Wheeler North Reef since 2000 were used determine the area of different configurations of new reef needed for remediation. Results from these analyses indicate that the area of additional reef needed for the Wheeler North Reef to meet the performance standard for fish standing stock with a 90% degree of certainty ranged from 30 - 175 acres depending on the rock coverage and vertical relief of the new reef added for remediation.

BACKGROUND

A condition of the SONGS Coastal Development Permit issued by the CCC required studies of the effects of the operation of Units 2 and 3 on the marine environment offshore from the San Onofre Nuclear Generating Station and mitigation of any of its adverse impacts. Impact assessment studies conducted by the Marine Review Committee found that the discharge of cooling water from SONGS Units 2 and 3 resulted in the loss of 200 acres of a medium to high density kelp bed and its associated community. As a result of these impact studies, the CCC added conditions to the SONGS permit to mitigate these adverse impacts that required SCE and its partners to construct a 300-acre kelp reef as in-kind mitigation for the loss of giant kelp forest habitat (Condition C). The 1991 conditions also required SCE and its partners to provide the funds necessary for CCC to contract marine scientists to perform technical oversight and independent monitoring of the mitigation projects (Condition D).

After extensive review of new analyses of SONGS' impacts to the San Onofre Kelp Forest, the CCC approved amended conditions in April 1997 that revised the kelp mitigation requirement in Condition C to require SCE to construct an artificial reef large enough to sustain 150 acres of medium to high density kelp, 28 tons of reef fish, and a kelp forest community that is similar to natural reefs in the region. The CCC noted that to accomplish this goal, a reef larger than 150 acres might be required. In addition, SCE was required to fund a marine fish hatchery. The CCC also confirmed in April 1997 its previous finding that independent monitoring and technical oversight were required in Condition D to ensure full mitigation under the permit.

Performance standards for reef substrate, giant kelp, fish, and the benthic community of algae and invertebrates specified in Condition C are used to evaluate the success of the artificial reef in meeting the intended goal of replacing the kelp forest resources

damaged or lost as a result of SONGS operations. Monitoring that is independent of the permittee is done in accordance with Condition D of the SONGS permit to: (1) determine whether the performance standards established for Condition C are met, (2) determine, if necessary, the reasons why any performance standard has not been met, and (3) develop recommendations for appropriate remedial measures. The performance standards fall into two categories: absolute standards, which are measured only at the artificial reef and require that the variable of interest attain or exceed a predetermined value, and relative standards, which require that the value of the variable of interest on the artificial reef be similar to that measured on natural reference reefs.

The values of the absolute performance standards pertaining to giant kelp and reef fish standing stock are linked to the magnitude of SONGS impacts on these resources as determined by the impact assessment studies conducted by the Marine Review Committee. Annual evaluation of these performance standards is based on the greater value obtained from either: (1) data collected at the artificial reef that year, or (2) a four-year running average calculated from data collected at the artificial reef for that year and the previous three years. A running average recognizes that short-term fluctuations in giant kelp and fish are the norm, and it is used to allow excess kelp or fish in good years to be used as mitigation to compensate for occasional years when values for the kelp or fish are below those required by the performance standards.

The relative performance standards are intended to ensure that the ecological structure and functions of the artificial reef are similar to those of natural reefs in the region. Their evaluation is based solely on a four-year running average calculated from data collected at the artificial reef for that year and the previous three years. To receive mitigation credit for a given year the artificial reef must meet all four absolute performance standards, and at least as many of the 11 relative performance standards as the lowest performing reference reef.

Under Condition C, an artificial reef would be constructed in two phases, an initial small experimental reef (~22 acres) and a subsequent mitigation reef that is large enough to meet the 150-acre kelp and 28-ton fish standing stock requirements. The purpose of the Phase 1 Experimental Reef was to determine which combinations of substrate type and substrate coverage would most likely achieve the performance standards specified in Condition C. The design of the Phase 2 Mitigation Reef was to be based on the results of the Phase 1 Experimental Reef.

Construction of the Phase 1 Experimental Reef was competed in August 1999 and five years of post-construction monitoring were completed in December 2004. All reef designs tested showed considerable promise in meeting many of the performance standards established for the mitigation reef, with reefs having a higher coverage of hard substrate tending to outperform those with lower coverage for several aspects of the kelp forest community. These findings formed the basis of the Executive Director’s determination that: (1) the mitigation reef should be built of quarry rock or rubble concrete having dimensions and specific gravities that are within the range of the rock and concrete boulders used to construct the Phase 1 Experimental Reef, and (2) the percent of the bottom covered by quarry rock or rubble concrete on the mitigation reef should average at least 42%, but no more than 86% (the range of low to high coverage

tested in Phase 1). The Commission concurred with the Executive Director's determination for the type and percent cover of hard substrate on October 12, 2005.

Construction of the Phase 2 Mitigation Reef was completed in September 2008. It was designed as 18 low relief rock polygons ranging in area from 1.35 to 38.88 acres for a total reef area of 152 acres, of which only 130 acres met the minimum requirement of 42% rock coverage. The combined area of the Phase 1 and Phase 2 reefs (officially known as the Wheeler North Reef) totaled ~177 acres, however only 155 of these acres met the Permit requirement for a 150 acre artificial reef that averaged at least 42% cover of rock. Consequently, only the 155 acres that met that averaged 42% cover of rock are used to judge the relative performance standards established for the Wheeler North Reef. In contrast, the total area of the Wheeler North Reef is used to judge the absolute performance standards for giant kelp and fish standing stock.

CURRENT STATUS OF THE PERFORMANCE OF THE WHEELER NORTH REEF

In 2013 the Wheeler North Reef met three of the four absolute standards and as many relative standards as the lowest performing reference reef[1]. It failed to meet the performance standard that requires the standing stock of reef fish at the artificial reef to be at least 28 US tons (Figure 1). Preliminary analysis of data collected during the 2014 surveys show a marked increase in the standing stock of reef fish at Wheeler North Reef and elsewhere in the region. Despite this large regional increase, the Wheeler North Reef still fell short of the 28 ton standard.

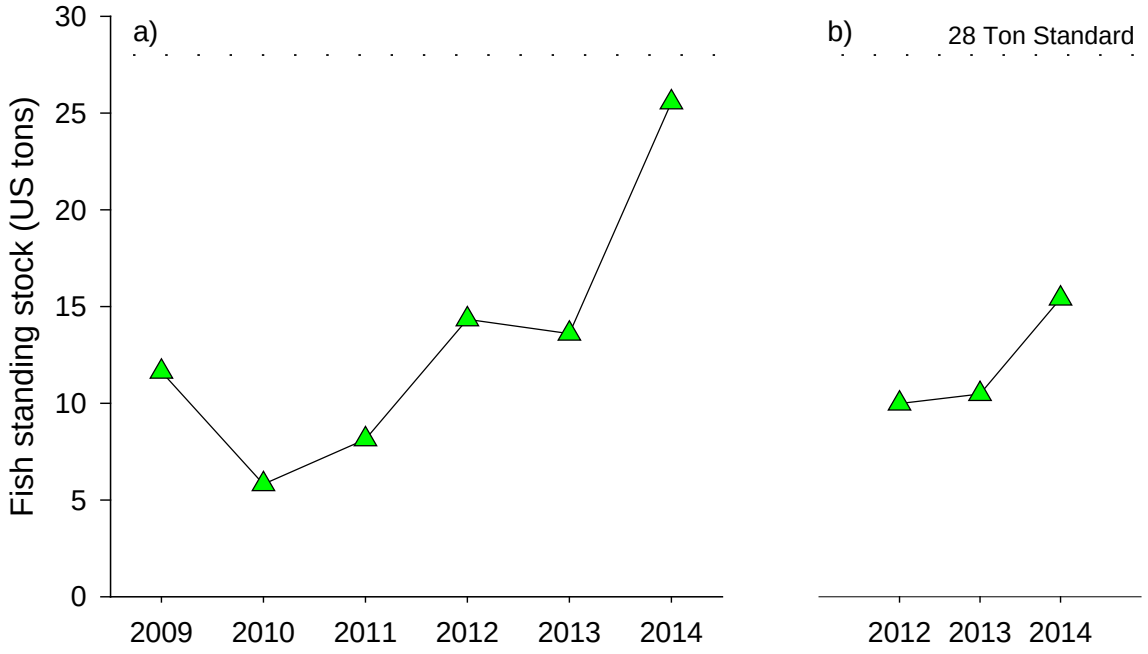

Figure 1. Estimated standing stock of fish at Wheeler North Reef (a) annual values for 2009 - 2014 and (b) 4-year running average.

[1] Reed, D. C., S.C. Schroeter, M. H. Page. 2013 Annual report of the Status of Condition C: Kelp Reef Mitigation. San Onofre Nuclear Generating Station (SONGS) mitigation program. Report to the California Coastal Commission. June 2014. 68 pp. http://marinemitigation.msi.ucsb.edu/documents/artificial_reef/annual_monitoring_reports/2013_annualreport-SONGS_kelp_reef_mitigation.pdf

Fulfillment of the SONGS reef mitigation requirement will occur when the number of years of mitigation credit accrued by the Wheeler North Reef equals the total years of operation of SONGS Units 2 & 3, including the decommissioning period to the extent that there is continuing discharge of cooling water. Operation of Units 2 and 3 began in 1983 and 1984, respectively. Both reactors were shut down in January 2012 due to excessive wear in the cooling tubes of the steam generators, and in June 2013 both units were permanently retired. Full retirement of the units prior to decommissioning is expected to take several years in accordance with customary practices; actual decommissioning will take many years until completion. Although Units 2 and 3 have been permanently shut down, SONGS still circulates ocean water within the plant to cool the spent fuel, and thus continues to discharge cooling water. Thus the number of years of mitigation credit that the Wheeler North Reef must obtain to fulfill the requirements of Condition C of the SONGS coastal development permit is 30 years and counting. As of 2014 the Wheeler North Reef had not earned any years of mitigation credit (Table 1). The reason for this has been its failure to meet the absolute performance standards for giant kelp in the first year (2009) and for fish standing stock in all six years.

Year	Mitigation credit	Reason for no mitigation credit
2009	No	Kelp & fish standing stock too low
2010	No	Fish standing stock too low
2011	No	Fish standing stock too low
2012	No	Fish standing stock too low
2013	No	Fish standing stock too low
2014	No	Fish standing stock too low
TOTAL	**0 years**	
Mitigation Target	**30 years (minimum)**	

Table 1. Summary of the mitigation credit earned by the Wheeler North Reef

Despite the above noted deficiency in the performance with respect to fish standing stock the Wheeler North Reef has shown promise in meeting many of its objectives. For example, it consistently met the absolute performance standards pertaining to hard substrate and lack of invasive species in each of the first five years of monitoring (2009 – 2013) and the absolute standard for giant kelp in in all but the first year of monitoring. Moreover, the overall performance of Wheeler North Reef with respect to the relative performance standards has been similar to that of the natural reference reefs.

REASONS FOR FAILURE TO MEET THE PERFORMANCE STANDARD FOR FISH STANDING STOCK

The standing stock of fish on a reef is influenced by a wide variety of factors including ocean climate, fishing pressure, and the physical attributes of the reef, such as its footprint area, rock coverage and topography. The most recent surveys show that the Wheeler North Reef has experienced a slight decrease in its footprint area and a slight increase in its percent cover of hard substrate relative to its as-built condition. Thus the best estimate of the present configuration of the Wheeler North Reef is ~174 acres of low relief rock that covers on average 48% of the bottom. The Wheeler North Reef was designed to be low relief to mimic natural reefs in the region, including the reef at San Onofre that was damaged by SONGS' operations. Low relief reefs in many areas are also more likely to support giant kelp, which was a major objective of the mitigation project. A critical issue in assessing the long-term performance of the Wheeler North Reef is whether its present configuration is sufficient to sustain at least 28 tons of fish over the long term. Information obtained from monitoring initiated in 2000 for Phase 1 of the reef mitigation project provides a reasonably long-term perspective for evaluating this issue.

Time series data from the Phase 1 rock modules collected from 2000 to 2014 are the most useful for evaluating the effects of rock coverage on the standing stock of reef fish because they include estimates of fish biomass for different coverages of rock over a relatively long time period. We used these data to calculate the annual mean biomass of reef fish per unit area of reef for modules with low (41%), medium (63%), and high (81%) rock coverage. Mean fish biomass per unit area for each of the three rock coverages were scaled up to 174 acres to obtain a time series of the estimated fish standing stock for 174-acre reefs with low, medium or high rock coverage. Results from this analysis show that the ability of a 174 acre reef to support a fish standing stock of at least 28 tons increased with increasing rock coverage (Figure 2). The fish standing

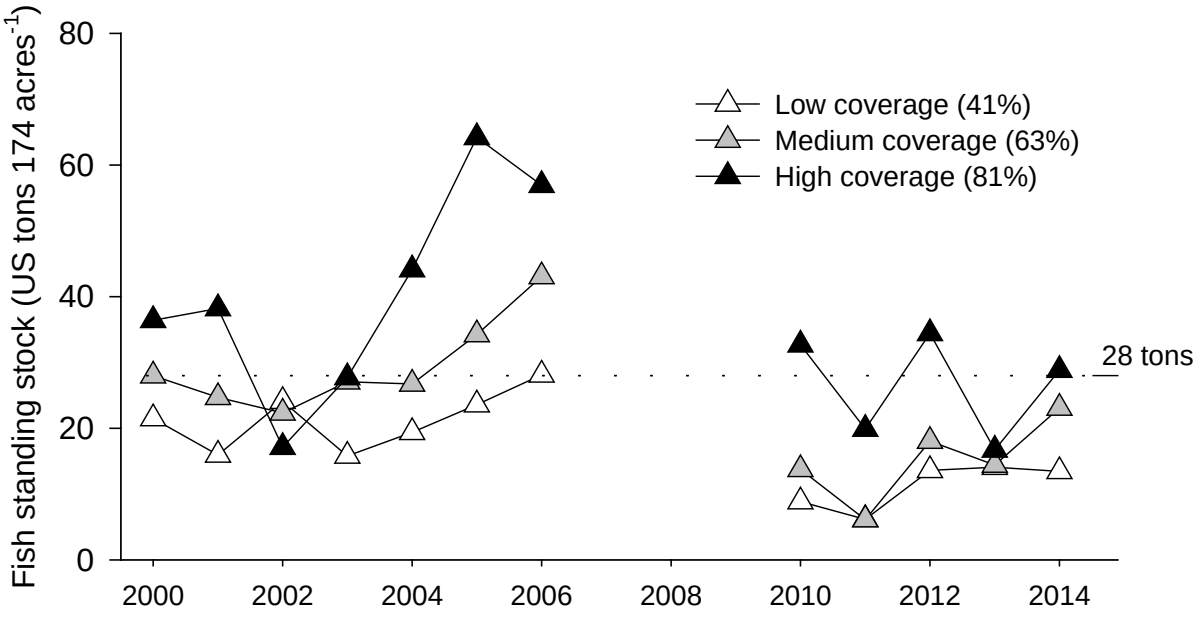

Figure 2. Estimated standing stock of kelp bed fish per 174 acres for the three coverages of rock tested on the Phase 1 modules of Wheeler North Reef.

stock of a 174 acre reef with low rock coverage would have supported 28 tons of fish in only 1 of 12 years. In contrast, a 174 acre reef with high rock coverage would have supported at least 28 tons of fish in 8 of 12 years. A 174 acre reef with medium rock coverage was intermediate in its ability to provide for fish as it would have supported 28 tons or more in 3 of 12 years.

The standing stock of reef fish at the Wheeler North Reef also was compared to that of at the San Mateo and Barn to examine the capacity of natural low-relief (< 1 m tall) reefs to sustain a fish standing stock of at least 28 tons. This also was done using annual monitoring data collected since 2000. The rock coverages at Barn and San Mateo (52% and 47%, respectively) are very similar to that at Wheeler North Reef (48%), however, their footprint areas (328 and 282 acres, respectively) are considerably larger than that of Wheeler North Reef (174 acres). Therefore, we scaled values of fish standing stock at Barn and San Mateo two different ways: (1) to their actual footprint area, and (2) to the footprint area of Wheeler North Reef. Results of this analysis show that when scaled to their actual size Barn and San Mateo frequently supported a fish standing stock of at least 28 tons (i.e., 7 of 13 years for Barn and 5 of 13 years for San Mateo; Figure 3). However, when scaled to the size of Wheeler North Reef Barn and San Mateo rarely supported a fish standing stock of 28 tons (i.e., 2 of 13 years for Barn and 3 of 13 years for San Mateo).

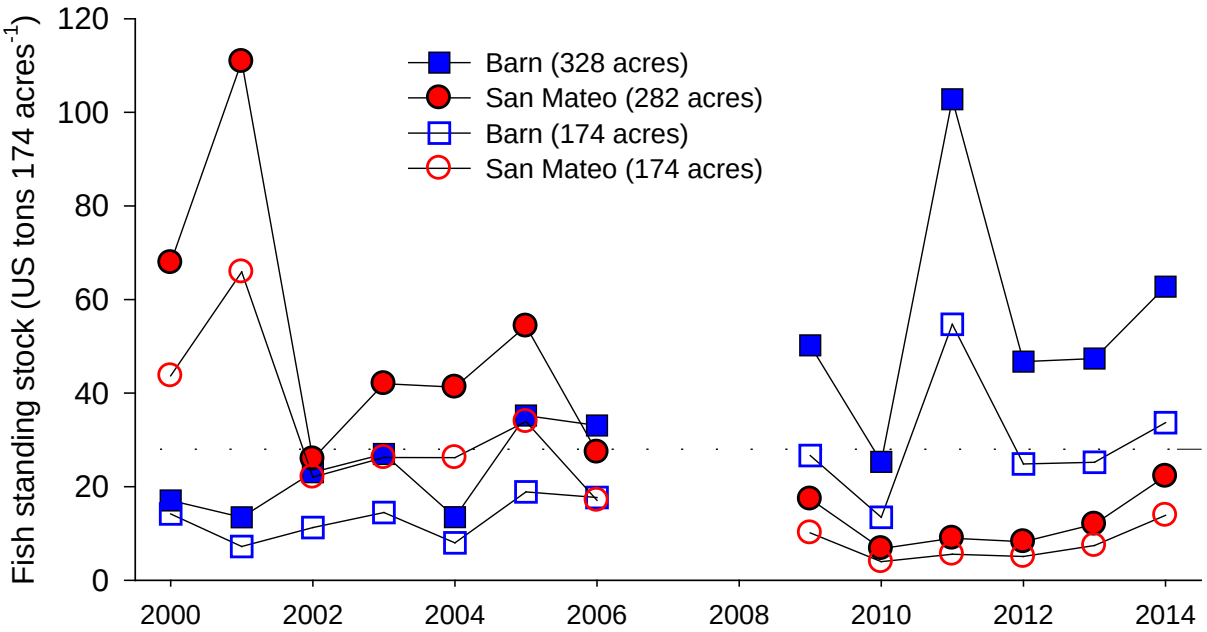

Figure 3. Estimated standing stock of kelp bed fish at Barn and San Mateo. Values are given for the actual size of each reef (328 and 282 acres, respectively) and for each reef scaled to the size of the Wheeler North Reef (i.e., 174 acres).

Collectively, these results suggest that the present size (174 acres) and configuration (48% cover of low relief rock) of the Wheeler North Reef is not sufficient to consistently support 28 tons of reef fish. This finding is notable and indicates that remediation in the

form of additional reef is needed for the Wheeler North Reef to consistently meet its current mitigation requirements over the long term.

ESTIMATES OF ADDITIONAL REEF NEEDED FOR REMEDIATION

Determining the area and bottom coverage of new reef needed for remediation requires realistic estimates of the future performance of the existing 174 acre Wheeler North Reef with respect to fish standing stock, as well as the performance of the additional reef added as remediation. The time series data of fish biomass from the Phase 1 Reef are arguably the most useful data available for predicting the future capacity of an expanded Wheeler North Reef to sustain fish biomass because they: (1) include data for reefs with different rock coverages, (2) contain data collected in 12 years over a 15 year period, which is the longest time series of fish standing stock available, and (3) encompass a broad array of environmental conditions and a wide range of inter-annual variation in the standing stock of fish, which can be expected at Wheeler North Reef in the future.

The general approach used to determine the area of different configurations of new reef needed for remediation consisted of combining the expected future standing stock of the existing 174 acre Wheeler North Reef with the expected future standing stock of fish supported by new acreage of reef added as remediation. The data collected from the seven modules of the Phase 1 Reef with low rock coverage from 2000 -2014 were used to produce a time series of annual estimates of the tons of fish that will be supported by the existing174 acre Wheeler North Reef in the future. Because the rock coverage of the existing low coverage rock modules differed slightly from that of the existing Wheeler North Reef (41% vs. 48%) fish biomass data from the Phase 1 rock modules were adjusted to 48% rock coverage prior to analysis using the relationship between rock coverage and fish biomass density observed during Phase 1.

The adjusted mean and standard deviation of fish biomass density for the existing Wheeler North Reef were used in a Monte Carlo simulation to estimate the standing stock of reef fish that would be supported by the existing 174 acre Wheeler North Reef over the long term with 90% probability (based on the upper 90% confidence limit) using either an annual or 4-year running average, which ever was highest. This estimated standing stock was 15.5 tons. Annual and 4-year running averages of fish standing stock from each of the three rock coverages of the Phase 1 rock modules (low, medium and high) were bootstrapped 1000 times to produce a distribution of the acreage required to produce the additional 12.5 tons needed for a combined standing stock of 28 tons. These distributions were used to determine the 90% probability (based on the upper 90% confidence limit) that the annual or 4-year running average of additional reef acreage (which ever was lowest) for a given reef configuration, when combined with the expected future standing stock of the existing Wheeler North reef, would meet the 28-ton performance standard for fish standing.

Increased certainty that remediation would be successful in meeting the 28 ton standard for fish standing stock could be obtained by increasing this probability above 90%. Doing so would result in increasing the area of additional reef needed for remediation, while decreasing the certainty below 90% would reduce the area of additional reef needed for remediation. These probabilities are based on the assumption that the

standing stock of fish supported by different coverages of rock on the artificial reef in the past is a good predictor of what different coverages of rock on the Wheeler North Reef will support in the future.

The estimated number of acres of various configurations of new reef that are needed for the Wheeler North Reef to meet the performance standard for fish standing stock with a 90% annual probability are provided in Table 2. These results show that remediation involving the addition of low relief, low rock cover reef will require nearly twice as many acres as remediation using low relief, high cover rock (175 acres vs. 90 acres).

Configuration of new reef to be added for remediation	Additional acres needed to support 28 tons of fish
Low relief (< 1 m), high rock cover (81%)	90
Low relief (< 1 m), medium rock cover (63%)	110
Low relief (< 1 m), low rock cover (41%)	175

Table 2. The number of acres of new reef needed for the Wheeler North Reef to have a 90% probability of meeting the 28 ton performance standard for fish standing stock in a given year for different configurations of new reef using Phase 1 as the data source. Phase 1 data were collected from 2000-2014 on 40 m x 40 m low relief rock modules that consisted of low, medium or high rock cover.

Although high relief reefs are known to support more fish biomass than low relief reefs with comparable rock coverage, high relief was intentionally not considered in the design of either phase of SONGS reef mitigation because the intent of the mitigation was to construct a reef that mimicked the type of low relief boulder habitat that was damaged in the San Onofre kelp forest by SONGS' operations. However, because the existing Wheeler North Reef is currently meeting all the performance standards except the one pertaining to fish standing stock, remediation for low fish biomass that involves the addition of high relief reef would be acceptable, and could have advantages in terms of reducing the footprint area, and potential costs and impacts of reef construction.

Because high relief was not considered in the initial design of Wheeler North Reef there are no time series data of fish biomass for high relief reefs available for estimating their efficacy in remediation. To address this deficiency we collected fish biomass data on seven occasions during the summer and early fall of 2014 in areas of high relief (2-3 m tall) with high rock cover (100%) and in adjacent areas of low relief (< 1 m tall) with low to medium rock cover (55%) at two natural reefs in the San Clemente region near the Wheeler North Reef (Two Man Reef and Monument Point). These data were used to calculate a ratio in fish biomass between low relief, 55% rock cover reefs and high relief, 100% rock cover reefs. This ratio was applied to the Phase 1data and analyzed using the methods described above to estimate the additional area of high cover, high relief reef needed for the Wheeler North Reef to have a 90% probability of meeting the 28 tons standard for fish standing stock. This analysis indicated that 30 additional acres of high relief reef would be needed for remediation (Table 3).

Configuration of new reef to be added for remediation	Additional acres needed to support 28 tons of fish
High relief (2.5 m), high rock cover (100%)	30

Table 3. The number of new acres of high relief high rock coverage reef needed for the Wheeler North Reef to have a 90% probability of meeting the 28 ton performance standard for fish standing stock in a given year as estimated using data from Phase 1 (2000-2014). Estimates are based on a fish biomass ratio of low relief, 55% rock cover / high relief, 100% rock cover obtained from repeated sampling of two natural reefs near Wheeler North Reef in summer 2014 (n= 7 sample dates).

Annual time series data of fish biomass in areas of low and high relief from 2002-2014 are available for Naples Reef off Santa Barbara via the Santa Barbara Coastal Long Term Ecological Research Project. We used these data as a measure of comparison for the data that we collected at Two Man Reef and Monument Point in 2014 (see Appendix 1 for details).

Data on fish biomass collected from low and high relief areas of natural reefs in the San Clemente region revealed that the fish biomass in areas of low relief with 55% cover of rock averaged 16.5 % of that at adjacent areas of high relief with 100% cover of rock (Figure 4a). The ratio of fish biomass between areas of low and high relief at these reefs varied slightly over time ranging from of 0.1 to 0.26. By comparison the mean ratio of

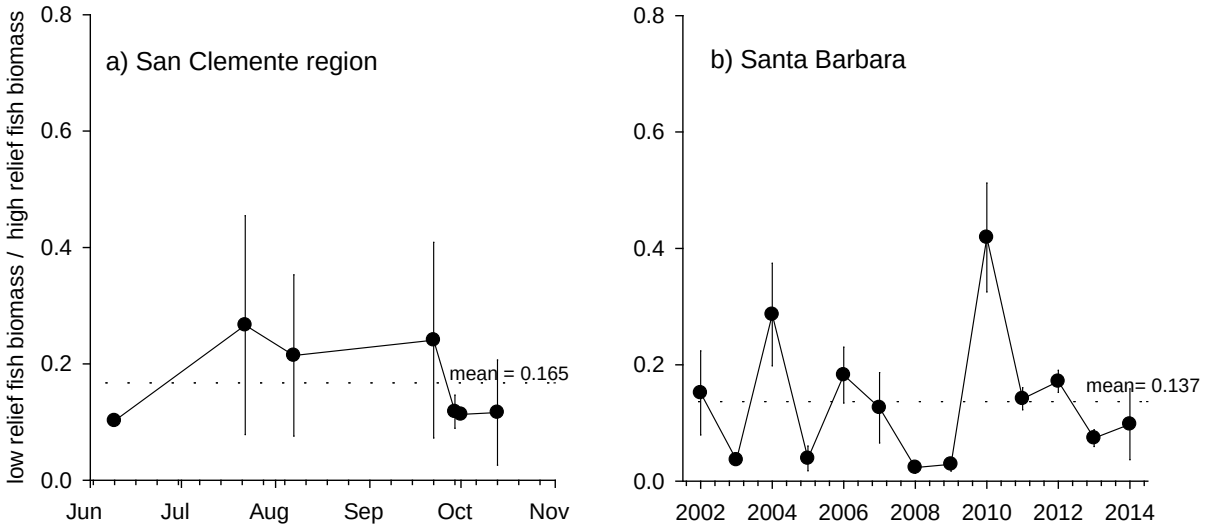

Figure 4. Mean (+/- SE) ratios of fish biomass between low relief and high relief reefs near: (a) San Clemente and (b) Santa Barbara. Data for San Clemente are the mean ratios of two reefs (Two Man Reef and Monument Point) measured on 7 dates during 2014. Data for Santa Barbara are the mean ratios of 7 high relief areas to 1 low relief area at Naples Reef. Values for low relief at Naples Reef were normalized to 55% to match the mean rock cover of low relief areas at Two Man Reef and Monument Point.

fish biomass between areas of low and high relief at Naples Reef near Santa Barbara varied more substantially among years (0.03 to 0.42; Figure 4b). However, its ratio averaged 0.137 over the 13 year study period, which is remarkably similar to the average ratio of the two reefs in the San Clemente region. This reinforces the assumption that the data on fish biomass collected in 2014 in areas of low and high relief at the two natural reefs near Wheeler North Reef provide a reasonable basis for estimating the standing stock of fish that would be supported by high relief reef used in remediating the low biomass of fish at Wheeler North Reef.

Remediation involving the addition of high relief reef that is 2.5 m tall and covers 100% of the bottom would require about 6 times more rock than a comparable area of low relief reef that is 1 m tall and covers 41% of the bottom ((100%/41%) * (2.5 m /1 m) = 6.1). However, results from the above analyses indicate that a high relief reef would support on average about 6 times more fish biomass than a comparable area of low relief reef (175 additional acres of low relief low rock cover needed to support 28 tons of fish compared to 30 acres of high relief high cover rock = 175/30 = 5.8). Thus the amount of fish biomass supported per unit volume of rock is likely to be roughly similar between a low relief, low rock cover reef and a high relief, high rock cover reef.

There are other elements besides the amount of rock needed when considering remediation that involves the addition of new reef. For example, there are physical limitations to the number of acres of new artificial reef that can be added to the existing lease site. The programmatic environmental impact report (PEIR) developed in 1999 for the construction of the SONGS mitigation reef identified a total of 356 acres within the designated lease site that were suitable for artificial reef construction[2]. Thus the most new reef that can be added to the existing 174 acre Wheeler North Reef as per the PEIR is 182 acres. Moreover, the largest artificial reef evaluated in the PEIR was 277.6 acres. Thus under the existing regulations, remediation designs that involve adding more than 182 acres would require one or more additional lease sites to fulfill the requirement for artificial reef mitigation, while remediation that involves adding more than 103.6 acres (= 277.6 – 174) would require additional environmental impact studies. For these reasons remediation involving the addition of high relief reef may be advantageous in terms of construction planning, impacts, and cost.

[2] Resource Insights. Final Program Environmental Impact Report for the construction and management of an artificial reef in the Pacific Ocean near San Clemente, California. May 1999.
http://marinemitigation.msi.ucsb.edu/documents/artificial_reef/sce_reports/programatic_eir4SONGS_reef_vol1-may1999.pdf

Appendix 1

Data from a 13-year time series of fish biomass density at Naples Reef off Santa Barbara, CA were used as a measure of comparison for differences observed in fish biomass between low and high relief reefs near San Clemente in summer 2014. The number, size and species identity of reef fish at Naples Reef have been recorded annually in summer since 2002 by the Santa Barbara Coastal Long Term Ecological Research project (http://sbc.lternet.edu/cgi-bin/showDataset.cgi?docid=knb-lter-sbc.17). Data at Naples Reef are collected within eight permanent transects using methods very similar to those employed at Wheeler North Reef by the SONGS mitigation monitoring project. Seven of the transects are located in areas of high relief (2-3 m tall) bedrock that covers 100% of the bottom. The remaining transect is located in an area of low relief cobble that covers 85% of the bottom.

Because the percent cover of rock in the low relief area at Naples Reef differed from that at the two natural reefs near San Clemente (85% vs. 55%) we converted the fish biomass data from the low relief area at Naples Reef to that expected for low relief with 55% cover of rock. This was done using the relationship between fish biomass density and rock cover collected at the 92 transects at Wheeler North Reef during 2009-2013 (Fig. A1.1).

We calculated the ratio of fish biomass density of each high relief transect at Naples Reef to that of the low relief transect (adjusted to 55% cover rock) for each year in the time series. We used this annual average to calculate the overall mean low relief (55% rock coverage) to high relief (100 % rock coverage) biomass ratio for Naples Reef for the entire time series (n = 13 years). This value was compared to that estimated for the two natural reefs near San Clemente sampled during the summer of 2014.

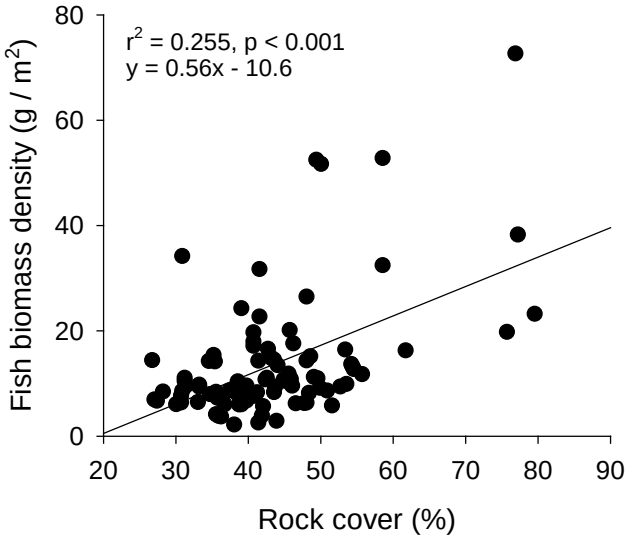

Figure A1.1. The relationship between the percent cover of rock and the biomass density of reef fish on Wheeler North Reef for the period 2009-2013. Data represent the mean value for a transect averaged over all years. N = 92 transects.

APPENDIX C

February 2019

SONGS Reef Remediation: Post-Remediation Compliance and Monitoring

Introduction

The Wheeler North Reef (WNR) was constructed by Southern California Edison (SCE) and its partners as partial mitigation for the adverse effects to the living marine resources in the San Onofre kelp forest caused by the operations of the San Onofre Nuclear Generating Station (SONGS) Units 2 and 3. WNR was constructed in two phases: a Phase I experimental reef (22.4 acres) completed in fall of 1999, and a Phase II mitigation reef (152.02 acres) constructed in fall of 2008. There are two types of performance standards used to evaluate the success of WNR in mitigating losses to giant kelp forests: absolute standards (fish standing stock, area of adult giant kelp, area of hard substrate, and invasive species), and relative standards related to fish, algal, and invertebrate communities. The absolute standards for fish, kelp, and hard substrate are measured only at WNR and are evaluated each year based on either the value for that year or a 4-year running average, whichever is greater. The relative standards are also evaluated each year, based on a 4-year running average measured at WNR that is compared to 4-year running averages measured at nearby reference reefs.

Phase I: Experimental Reef
Phase II: Mitigation Reef
(Phase I + Phase II = WNR)
Phase III: Remediation

Evaluating Compliance

Since 2009, WNR has consistently failed to meet the absolute performance standard for fish standing stock required by permit 6-81-330-A. Although monitoring results indicate that WNR is generally behaving like a natural reef (i.e., it has consistently met the relative standards), results of analyses of time series data of fish biomass indicate that the current size (174.4 acres) and configuration (low relief reef with an average of 47.6 % coverage of rock) is insufficient to consistently meet the requirement for a minimum fish standing stock of 28 US tons. The document *Report on the causes of low fish standing stock at Wheeler North Reef and possible solutions for remediation* written by the UCSB monitoring team in consultation with the Commission's Science Advisory Panel (SAP) in February 2015 and submitted to SCE on March 10, 2015 provides a thorough analysis of the reasons for WNR's failure to meet the fish standing stock requirement as well as estimates of additional reef needed to consistently meet the requirement (Appendix 1).

Reef Remediation Requirement and Estimates

Based on these analyses, the Commission's Executive Director informed SCE, in a letter dated May 24, 2016, that to comply with the requirements of CDP 6-81-330-A,

SCE would be required to remediate Wheeler North Reef by building new reef acreage that meets minimum size, relief and cover requirements. Monitoring data collected at the Phase I reef from 2000-2016 were used to determine the area of different configurations of new reef needed for remediation. Results from these analyses, summarized in Table 1 below and further explained in the February 2015 report (Appendix 1) show that the acreage of additional reef needed for WNR to have a 95% probability of supporting 28 tons of fish in a given year (based on past performance) is inversely related to rock coverage. For example, nearly twice the new acreage is required for a remediation reef with 41% cover of rock compared to one configured with 81% cover of rock.

Configuration of new reef to be added for remediation	Additional acres needed to support 28 tons of fish
Low relief (< 1 m), low rock cover (41%)	200
Low relief (< 1 m), medium rock cover (63%)	125
Low relief (< 1 m), high rock cover (81%)	105

Table 1. The number of additional acres of new reef required for WNR to have a 95% probability of meeting the 28-ton fish standing stock requirement in a given year for different configurations of new reef. Model results are based on data collected from low, medium and high coverage rock modules of Phase I from 2000-2016.

Approach to Compliance Post-Remediation

Although the remediation estimates presented in Table 1 carry a high degree of confidence that the current configuration of WNR (Phase I + II), with the addition of remediation acreage (Phase III) will eventually produce a standing stock of at least 28 tons, a significant source of uncertainty is how long it will take the remediated reef (i.e., Phases I, II and III) to meet this requirement. Data collected at WNR following the addition of 152 acres of Phase II reef indicate that initial colonization was largely through immigration of adult fish from neighboring reefs, which by itself does not increase the aggregate biomass of fish in the region. However, monitoring data also show that WNR is successful in supporting the recruitment of young-of-year-fish and the growth and reproduction of older fish. Thus we expect that fish standing stock on WNR Phases I, II and III will over time reach at least 28 tons, however it is uncertain how long this will take. In the meantime, SCE would receive no mitigation credit for the fish biomass supported by WNR if it was < 28 tons, even if the recruitment of young-of-year fish and the growth and reproduction of older fish at WNR was similar to that at natural reefs.

To address the uncertainty in the timeline for receiving mitigation credit, we propose to modify how the absolute standards are assessed. We can consider this change because our existing data provide a high level of confidence that SCE will over time consistently meet the fish biomass standard if they remediate WNR by adding additional reef as described in Table 1. Currently, the 28-ton fish standing stock requirement and the other absolute standards are evaluated independently each year. To satisfy the mitigation requirement, WNR must meet all absolute standards each year (as well as meeting as many relative standards as the lowest-performing reference reef) for a time period equivalent to the operating life of SONGS Units 2 and 3. An alternative approach would be to evaluate the absolute standards for fish standing stock and kelp area on a cumulative basis. The rationale behind this approach is that full compensation would be based on mitigation for total losses rather than for annualized losses. For example, assuming a total SONGS operating life of 30 years, the loss of fish standing stock would be 28 tons x 30 years or 840 ton-years in which case full compensation would be reached when the remediated reef supported 840 fish ton-years. Each year fish biomass would be measured and the annual total would be added to the cumulative total of previous years. Once a cumulative total of 840 tons is reached, the requirement for mitigation of losses in fish standing stock would be satisfied. Using this same rationale, the cumulative approach would also be applied to the area of giant kelp (150 acres x 30 years or 4500 kelp acre-years). Furthermore, to provide consistency in our evaluation of compliance with the permit, this approach would be retroactively applied to the beginning of the monitoring period for WNR. Thus, the annual fish standing stock and kelp area values from 2000 -present would be applied towards the cumulative total. We believe that this change to the cumulative approach is consistent with the intent of the coastal development permit for SONGS operations and does not require a permit amendment.

However, we can recommend the cumulative approach only if the remediation reef is of a sufficient size to ensure the permit conditions would be met in a reasonable length of time. This is because a reef of any size or configuration would eventually satisfy the cumulative mitigation requirement even if it supported very little fish biomass, but took many decades to centuries to do so. Such a temporal delay in compensation for lost resources would clearly not be consistent with the intent of the SONGS coastal development permit. Thus implementing the cumulative approach without requiring the reef to be of sufficient size would be tantamount to lessening or avoiding the intended effect of the approved permit standard, which is prohibited by the Commission's regulations. Implementing a remediation option that aims to minimize the time required for full compensation such as the use of the cumulative approach coupled with an appropriate sized Phase III remediation reef is consistent with the goals and intent of the SONGS permit and ensures that marine resources that have been impacted for the entire operating life of SONGS without the benefit of mitigation are replaced as quickly as possible.

Additional modeling of the monitoring data was conducted to compare the estimated time needed to satisfy the fish standing stock and kelp area requirements using the

existing approach for accruing mitigation credit and the cumulative approach. The modeling assumed a 30-year operating life for SONGS and a desired 95% level of statistical confidence based on historical data. Results of these analyses show that if SCE constructs a remediation reef with any of the three designs listed in Table 1, then we would expect them to meet the performance standards for both fish standing stock and kelp area in about 19 years following the construction of Phase III using the cumulative approach (Figure 1). This represents a 13-year reduction from the 32 years estimated for the same remediation designs using the existing approach for accruing mitigation credit (these estimates assume that the Phase III reef will initially attract the majority of its fish from natural reefs rather than redistributing fish from the Phase I and II reefs). By contrast, the estimated time needed for WNR to meet the mitigation requirement for fish standing stock and kelp area without remediation using the existing approach for assigning mitigation credit is well over 100 years.

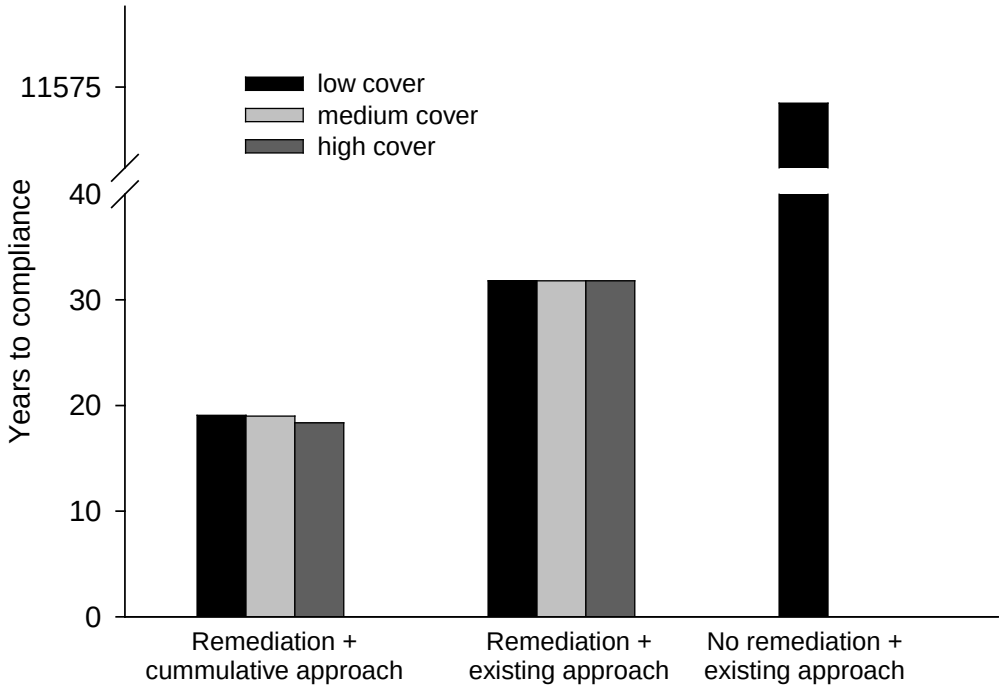

Figure 1. 1. Estimated number of years needed to achieve compliance for the fish standing stock and kelp area performance standards with and without remediation using the current approach for assigning mitigation credit and the cumulative approach. Estimates with remediation are based on the number of years to achieve compliance after Phase III has been constructed. All Estimates are based on 95% statistical confidence.

Post-Remediation Monitoring

When using the cumulative approach to assign mitigation credit for the absolute standards described above, we recommend a revised sampling program that decouples monitoring for fish standing stock and kelp area from monitoring for the relative standards. The monitoring team would continue to conduct annual quantitative

monitoring for the absolute standards for fish biomass and kelp area at WNR Phases I, II and III using existing protocols until the cumulative total requirement for each performance standard is met. Because the existing protocols for assessing the fish biomass and kelp area standards require estimates of reef footprint area, multi-beam sonar surveys of the footprint areas of WNR Phases I, II, and III would be conducted at a minimum of once every five years until the mitigation requirements for fish standing stock and kelp area are met. The sonar surveys would be coupled with diver surveys of rock coverage once every five years to determine whether WNR Phase I, II and III reefs have undergone significant reductions (i.e., >10%) in the amount of available hard substrate, which was the basis for determining the areas for the different Phase III reef configurations (Table 1).

Monitoring needed to assess the absolute standards pertaining to hard substrate and invasive species would also continue using existing protocols. Permit compliance for these two performance standards would continue to be based on data collected from WNR Phase I and II reefs only. This is because these two standards are intimately linked to the relative performance standards, which are aimed at ensuring that at least 150 acres of kelp forest biota on WNR Phase I and II be similar to natural reference reefs in the region. The mitigation requirements for hard substrate and invasive species would be considered fulfilled once the mitigation requirement for the relative performance standards has been fulfilled.

Because the cumulative approach does not apply to the relative performance standards, they will continue to be monitored until they are met for a period of time equivalent to the operating life of SONGS. However, under the cumulative approach, assigning mitigation credit for the relative standards would no longer be dependent on whether the absolute standards for fish standing stock and kelp area are met; mitigation credit for the relative standards would continue to be dependent on the Phase I and II reefs meeting the absolute standards for hard substrate and invasive species. Thus a year of mitigation credit for the relative standards would be given every year they and the absolute standards for hard substrate and invasive species are met. Mitigation credit for the relative performance standards and the absolute standards for hard substrate and invasive species would be evaluated dating back to the first year of mitigation monitoring (2009).

Monitoring for the relative performance standards would continue at the current level of effort, which entails collecting data from 82 transects at WNR (distributed across Phase I and II reefs) and the two reference reefs (San Mateo and Barn). However, the SONGS permit allows for a reduction in monitoring to annual site inspections after WNR has met the performance standards for three successive years following at least 10 years of independent monitoring. Although WNR has yet to meet the fish standing stock requirement of 28 tons, it has consistently met as many of the relative performance standards as the lowest performing reference reef for the past 10 years, the criterion for demonstrating that the mitigation reef functions like a natural reef. Thus, after the Phase III remediation reef is installed and full-scale monitoring indicates that WNR Phases I and II reefs continue to perform similar to natural reefs and have not sustained negative

impacts from construction of the Phase III reef, we think it is appropriate to reduce monitoring to annual site inspections for the evaluation of the relative standards and the absolute standards for hard substrate and invasive species. Therefore we recommend that annual monitoring of the relative standards and the absolute standards for hard substrate and invasive species using existing protocols continue for a minimum of three years after the Phase III reef is constructed to ensure that the new construction does not negatively affect the existing Phase I and II reefs. Monitoring of the relative standards and the absolute standards for hard substrate and invasive species can be reduced to annual site inspections in accordance with the SONGS permit if the Phase I and II reefs meet these performance standards for three consecutive years following the construction of the Phase III reef.

Annual site inspections are intended to represent a significant reduction in effort compared to current sampling protocols. The Commission staff, UCSB monitoring team and the SAP have been working on developing a sampling design for annual site inspections based on the variability observed in the monitoring data collected thus far. The approach under consideration is based on the spatial replication (i.e., number of transects) required to detect a minimum 50% difference between WNR (Phase I and II reefs) and the reference sites with 80% confidence and statistical power. In this way the sampling design for annual site inspections is based on the existing requirements for statistical power and confidence interval, but with a much reduced ability to detect moderate to small effect sizes. The rationale for this approach is to create a sampling design that is only capable of detecting large differences in the performance of WNR relative to the reference reefs. This reduced sampling design, when coupled with cumulative monitoring for fish standing stock and kelp area, involves a sampling effort (measured in terms of diver days) that is approximately 15% of the current sampling effort.

As with the existing full scale monitoring, performance evaluation using annual site inspections will require WNR Phase I and II to meet as many relative standards as the lowest performing reference reef in a given year for that year to count towards mitigation credit. Annual site inspections would continue to be used until either: (1) the mitigation requirement for the relative standards is met (i.e. the number of years of accrued mitigation credit equals the number of years of SONGS operations), or (2) annual site inspections indicate that Phase I and II reefs are performing worse than the reference reefs with respect to the relative performance standards. Full scale monitoring would be restarted in the event that the performance of WNR falls below that of the lowest performing reference reef for two consecutive years and continue until the relative performance standards are met for three successive years at which time monitoring would revert to annual site inspections. Before this approach is implemented the *Monitoring plan for SONGS Reef Mitigation* would be updated to include the specific methods for annual site inspections and the performance triggers that lead to its implementation or initiate a return to full scale monitoring. We believe that once remediation is completed and WNR has demonstrated consistent compliance with the relative performance standards in accordance with the permit, then implementing annual site inspections as described above will provide sufficient information to make an

informed determination of WNR's performance with the relative standards, but at a much reduced effort and cost.

Summary of Post-Remediation Monitoring and Compliance

Once the remediation reef (Phase III) has been constructed, we recommend the following approach to monitoring and assigning mitigation credit for assessing compliance:

Monitoring:

- Absolute Standards
    - Fish standing stock- Annual quantitative monitoring of Phase I, II and III reefs using existing protocols until the cumulative total requirement is met
    - Area of adult kelp- Annual quantitative monitoring of Phase I, II and III reefs using existing protocols until the cumulative total requirement is met
    - Hard Substrate
        - Phase I and II reefs: Quantitative monitoring of percent cover by divers annually until the requirement for the relative standards is met, and once every five years until the requirements the fish standing stock and kelp area standards are met. Surveys of reef footprint area using multi-beam sonar once every five years until the requirements the fish standing stock and kelp area standards are met
        - Phase III reef: Quantitative monitoring of percent cover by divers and reef footprint area by multi-beam sonar once every five years until the cumulative total requirements for the fish standing stock and kelp area standards are met.
    - Invasive species- Annual quantitative monitoring of Phase I and II reefs using existing protocols until the requirement for the relative standards is met
- Relative Standards
    - Annual monitoring of Phase I and II reefs and the two reference reefs using existing protocols for a minimum of 3 years following construction of the Phase III reef
    - Reduce to annual site inspections after the Phase I and II reefs have met the relative standards for three consecutive years following construction of the Phase III reef
    - Annual site inspections:
        - Purpose is to identify large differences in the performance of WNR relative to the reference reefs at a much reduced effort and cost

- The specific methods for the annual site inspections will be developed and incorporated into the Monitoring Plan for SONGS Reef Mitigation.

Mitigation credit:

- Assign mitigation credit for fish standing stock and kelp area standards on a cumulative basis:
  - Cumulative totals are calculated using data collected from 2000 (after the construction of Phase I reef) to the present.
  - Cumulative requirement for fish standing stock = 28 tons * number of years of SONGS' operations (ton-years)
  - Cumulative requirement for kelp area = 150 acres * number of years of SONGS' operations (acre-years)
- Assign mitigation credit for the relative standards on a year-by-year basis using data collected from Phase I and II reefs since 2009.
  - Requirement for relative standards are met when the number of years of mitigation credit equals the operating life of SONGS
  - Annual credit for relative standards in any given year is not dependent on the absolute standards for fish standing stock and kelp area
  - Annual credit for the relative standards in any given year is dependent on whether Phase I and II reefs meet the absolute standards for hard substrate and invasive species
- Mitigation credit is not assigned to the absolute standards for hard substrate and invasive species. These performance standards are considered to be met when the number of years of mitigation credit for the relative standards equals the number of years of SONGS' operations
- All the above changes are consistent with the intent of the SONGS permit

Appendix 1.

Report on the causes of low fish standing stock at Wheeler North Reef and possible solutions for remediation

SAN ONOFRE NUCLEAR GENERATING STATION (SONGS) MITIGATION PROGRAM

Submitted to the California Coastal Commission
February 25, 2015

By

Daniel Reed, Stephen Schroeter and Mark Page
Marine Science Institute, University of California Santa Barbara

In consultation with

Richard Ambrose, University of California Los Angeles

Peter Raimondi, University of California Santa Cruz

Russell Schmitt, University of California Santa Barbara

SEE APPENDIX B FOR FULL REPORT

APPENDIX D

Changes in sampling effort following the remediation of Wheeler North Reef

The current sampling effort for SONGS Reef mitigation that is used to assess the performance standards using the existing method of assigning mitigation credit involves a team of university divers collecting data annually within 256 transects (50 m x 20 m) distributed among the Phase I and II Wheeler North Reef (92 transects), and the two reference reefs (82 transects at San Mateo and 82 transects at Barn). This level of effort was needed to attain the monitoring goal of being able to detect a 20% difference in the relative performance standards between WNR Phase I and II reefs and the reference reefs with an 80% confidence interval ($p = 0.20$) and 80% statistical power. Approximately 512 diver days per year from June through mid-November are required to complete this monitoring. In addition to sampling these transects, selected species of fish are collected from the three reefs and dissected and analyzed for the purpose of evaluating the relative performance standards pertaining to fish reproduction, production and food chain support, and multi-beam surveys of Wheeler North Reef (WNR) are done once every 5 years to determine the footprint area of WNR, which is required to evaluate the absolute standards for hard substrate, fish standing stock and giant kelp area.

The current level of sampling described above for WNR (Phase I and II), San Mateo and Barn would continue for a minimum of three years after the WNR Phase III remediation reef is constructed to ensure that the new construction does not negatively affect the existing Phase I and II reefs. Monitoring of the relative performance standards would be reduced to annual site inspections in accordance with the SONGS permit if the Phase I and II reefs meet the relative performance standards for three consecutive years following the construction of the Phase III reef. Full scale monitoring would be restarted in the event that annual site inspections indicate the performance of WNR is below that of the lowest performing reference reef for two consecutive years and continue until the relative performance standards are met for three successive years at which time monitoring would revert to annual site inspections.

Annual site inspections are intended to represent a large reduction in monitoring effort. Therefore, the amount of sampling conducted for annual site inspections would be reduced to a level capable of detecting a 50% difference between WNR Phase I and II reefs and the reference sites (as opposed to a 20% difference using full-scale monitoring) with an 80% confidence interval ($p = 0.2$) and 80% statistical power. This reduced level of detection for assessing the relative performance standards and the absolute standards for hard substrate and invasive species (which are intimately linked to the relative standards) could be achieved by sampling 15 transects per year at each reef ($n = 45$ transects for all three reefs) for an estimated total of 30 diver days per year. To further decrease sampling effort, we would suspend the collections, dissections and analyses of selected species of fish that are used to evaluate the relative standards pertaining to fish production, reproduction and food chain support. Instead we would evaluate these three standards using the data collected on fish biomass density, recruitment and the abundance of reef invertebrates as proxies. We feel this is justified

because the proxy data are linked to fish production, reproduction and food chain support, and should be sufficient for detecting large differences in these attributes between WNR and the reference reefs. Multi-beam surveys to determine the footprint area of WNR would continue at a frequency of once every 5 years during the period of annual site inspections.

A total of 46 new transects would be established on the Phase III remediation reef for assessing the absolute performance standards pertaining to fish standing stock and area of adult giant kelp. Using the cumulative approach for assessing these two performance standards would involve collecting data within 92 transects at WNR (46 of the existing 92 transects at the 174-acre Phase I and II reefs and the 46 new transects at the 200-acre Phase III reef) until the cumulative total requirement for each standard is met. We estimate that 77 diver days would be required to sample 92 transects for fish standing stock and giant kelp area. Because 15 of the 46 transects at the Phase I and II reefs would be sampled as part of the monitoring for the relative standards, a total of 77 additional transects (i.e., 92-15) would be required to sample fish standing stock and kelp area as long as annual site inspections for the relative standards are conducted.

The total sampling effort in a reduced monitoring scenario having annual site inspections at WNR Phase I and II, San Mateo and Barn for assessing the relative standards and broad spatial monitoring for assessing the absolute standards for fish standing stock and kelp area would involve a total of 122 transects (45 for site inspections + 77 for fish and kelp at WNR) for an estimated effort of 81 diver days per year, which is ~ 15% of the current sampling effort of 512 diver days per year.

Multi-beam sonar surveys of the footprint areas of WNR Phases I, II, and III and diver surveys of the percent cover of hard substrate would be conducted at a minimum of once every five years until the mitigation requirements for all the performance standards are met.