Performance of the Wheeler North Reef

Annual Review Workshop for SONGS Reef Mitigation

CALIFORNIA COASTAL COMMISSION

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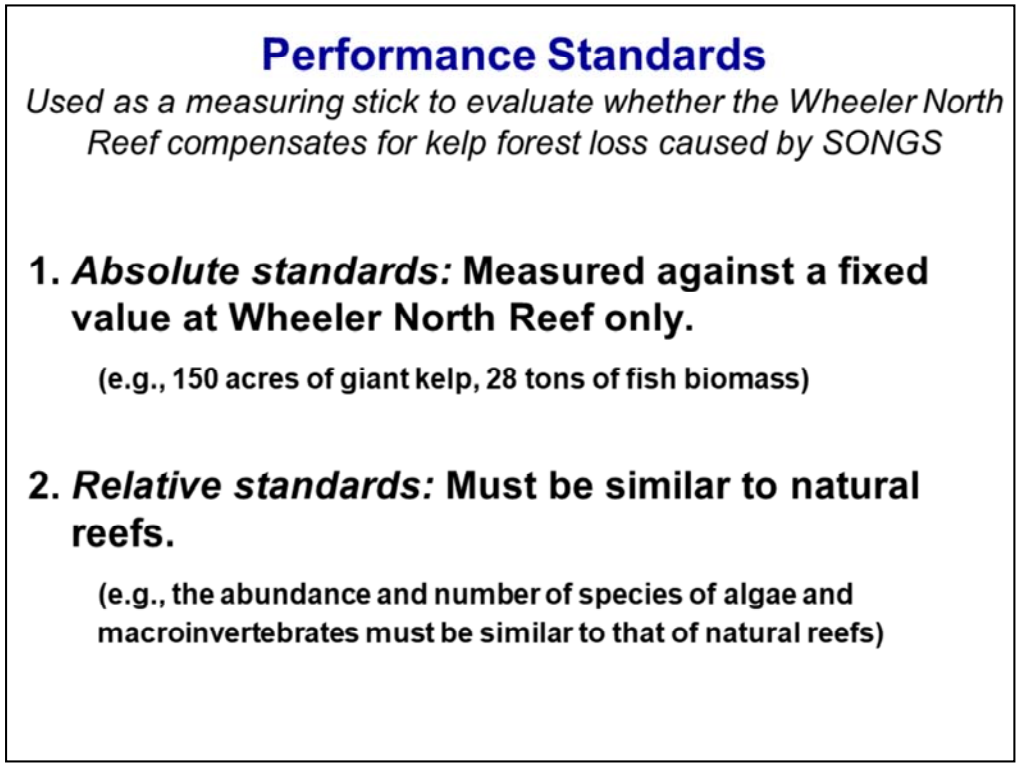
msi Marine Science Institute

SONGS Mitigation Monitoring Project
Marine Science Institute, University of California Santa Barbara



Two types of physical and biological standards are used to judge the performance of the Wheeler North Reef

1) Absolute standards are measured against fixed value at Wheeler North Reef only
2) Relative standards are measured at Wheeler North Reef and the two reference reefs and are used to judge whether the Wheeler North Reef is performing similar to natural reefs

Absolute Performance Standards

Requirement

Wheeler North Reef must meet each absolute performance standard in a given year for that year to count towards mitigation credit.

Method of Evaluation

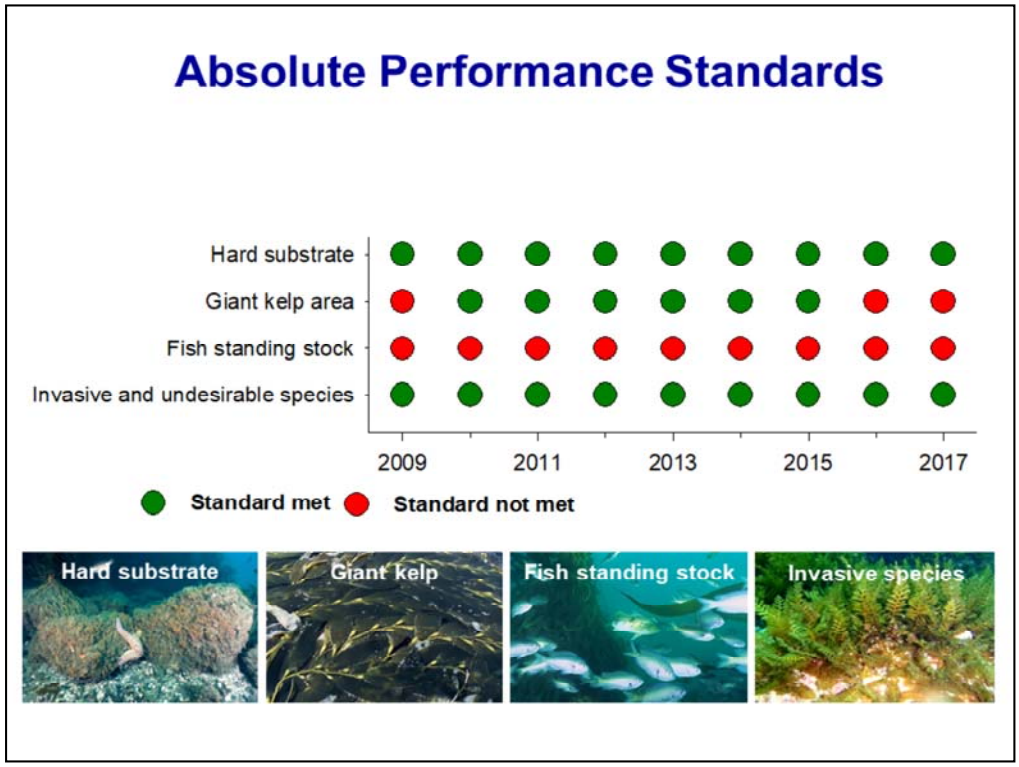
The evaluation of each absolute performance standard is based on the value for the current year, or the 4-yr average value calculated from the current year and the previous three years, *which ever is higher*.

Rationale

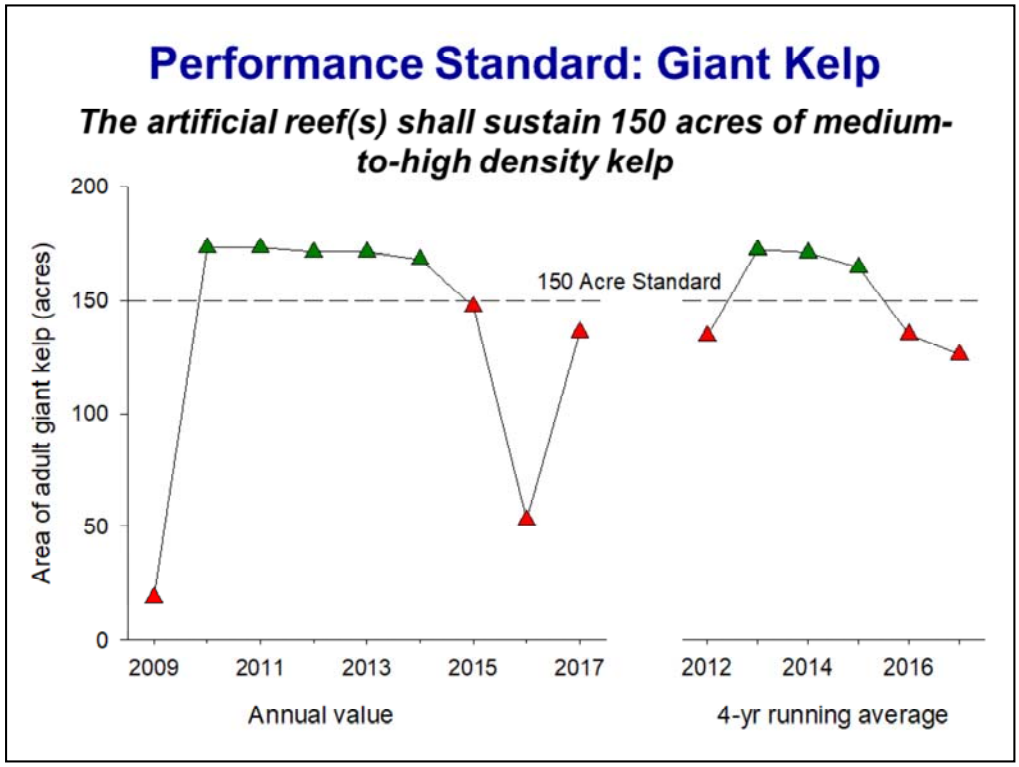
Absolute performance standards are based on average annual losses caused by SONGS and all of them need to be met to insure that the lost resources are replaced.

There are four absolute performance standards that the Wheeler North Reef must meet each year in order to receive mitigation credit:

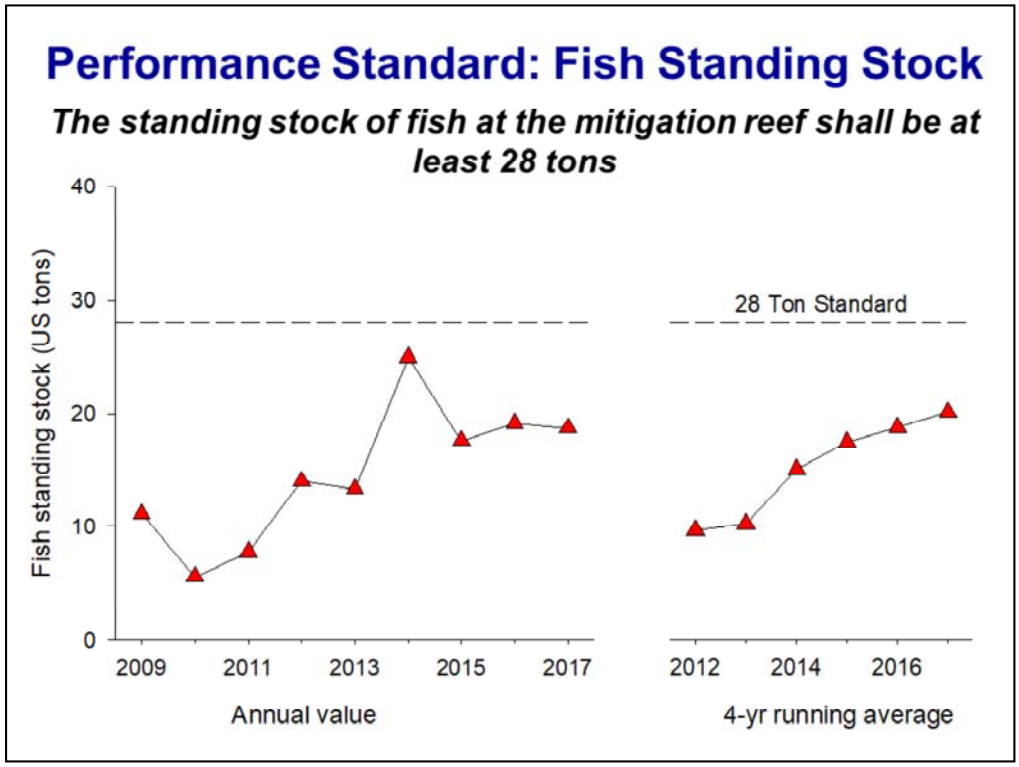
1. The availability of hard substrate The performance standard for hard substrate requires at least 90% of the exposed rock initially present at Wheeler North Reef to remain available for the attachment by reef biota
2. The artificial reef(s) shall sustain 150 acres of medium-to-high density giant kelp
3. The standing stock of fish at the mitigation reef shall be at least 28 tons
4. The important functions of the reef shall not be impaired by undesirable or invasive benthic species



- Shown here is a chart summarizing whether or not the Wheeler North Reef met each of the four absolute performance standards during each of the past eight years
- Green circles indicate that a standard was met in a given year and red circles indicate that a standard was not met
- The standard for area of adult giant kelp was not met in the first (2009) or in 2016 and 2017.
- Although giant kelp was very abundant at Wheeler North Reef within 1 year after construction, it largely consisted on juvenile plants that had not yet grown to adulthood causing the kelp standard not to be met in 2009
- Because of a large regional decline in kelp in 2016, neither the single year nor 4-year running average met the 150-acre standard for adult giant kelp in 2016 and 2017
- The most notable and consistent deficiency at Wheeler North Reef has been its consistent failure to meet the performance standard for fish standing stock, which is due to an insufficient size for Wheeler North Reef
- SCE has agreed with our assessment of the problem and is preparing to remediate by increasing the size of Wheeler North Reef
- Dr. Kate Huckelbrige will present more details of the remediation plan and implementation



- This graph shows a time series of adult giant kelp acreage at Wheeler North Reef for each year on the left and for the 4-y running average on the right
- Adult giant kelp exceeded 150 acres at the Wheeler North Reef from 2010 through 2014, declined to about 148 acres in 2015, followed by a significant decline to 53 acres in 2016 before increasing to 136 acres in 2016.
- Although the annual value for acreage in 2015 was less 150, the 4-year running average was 165 acres. Therefore the Wheeler North Reef met the kelp standard in 2015
- Neither the annual value nor the 4-yr running average reached 150 acres in 2016 and 2017.
- Thus the giant kelp standard has been met 6 out of the 9 years of monitoring from 2009 through 2017



- This graph shows a time series of fish standing stock at Wheeler North Reef for each year on the left and for the 4-y running average on the right
- The annual value for each year and for the 4-year running average have been below 28 tons each year since 2009
- Fish standing stock reached ~ 25 tons in 2014 due in part to the occurrence of a few very large giant sea bass that were sighted in the transects
- It has declined to ~18-19 tons in the three years since then, when no giant sea bass were counted in the transects
- The high biomass observed in 2014 has contributed to a steady increase in the 4-year running average since 2014 then, despite little change in annual value the last three years.

Relative Performance Standards

(require comparison to natural reference reefs)

RATIONALE: To be successful the Wheeler North Reef must sustain a kelp forest community that is *similar* to those of natural reefs in the region.

Criteria for reference reef selection:

1) **history of sustaining giant kelp**
2) **occur at a depth similar to that of the artificial reef**
3) **primarily low relief, preferably consisting of cobbles and boulders**
4) **located within the local region**

The kelp forests at San Mateo and Barn best met these criteria

- Choosing the natural reefs that are used as reference was a critical element of the mitigation project because the reference reefs are used to evaluate the success of the Wheeler North Reef
- The nearby kelp forests at San Mateo and Barn were selected because they had:
    1. history of sustaining giant kelp
    2. occur at a depth similar to that of the artificial reef
    3. primarily low relief, preferably consisting of cobbles and boulders
    4. located within the local region

This map shows the locations of San Mateo and Barn relative to the Wheeler North Reef and SONGS

What counts as similar when assessing the relative performance standards?

Definition of similar: **The 4-year running average for a relative performance standard at Wheeler North Reef must *not be significantly less than* that at the reference reef having the lowest value for that performance standard.**

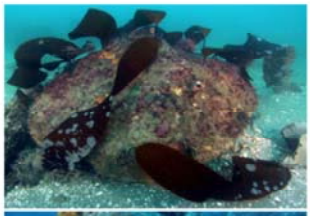
Rationale:

- **For a given relative performance standard, the Wheeler North Reef should perform at least as well as the lowest performing natural reef used as a reference**

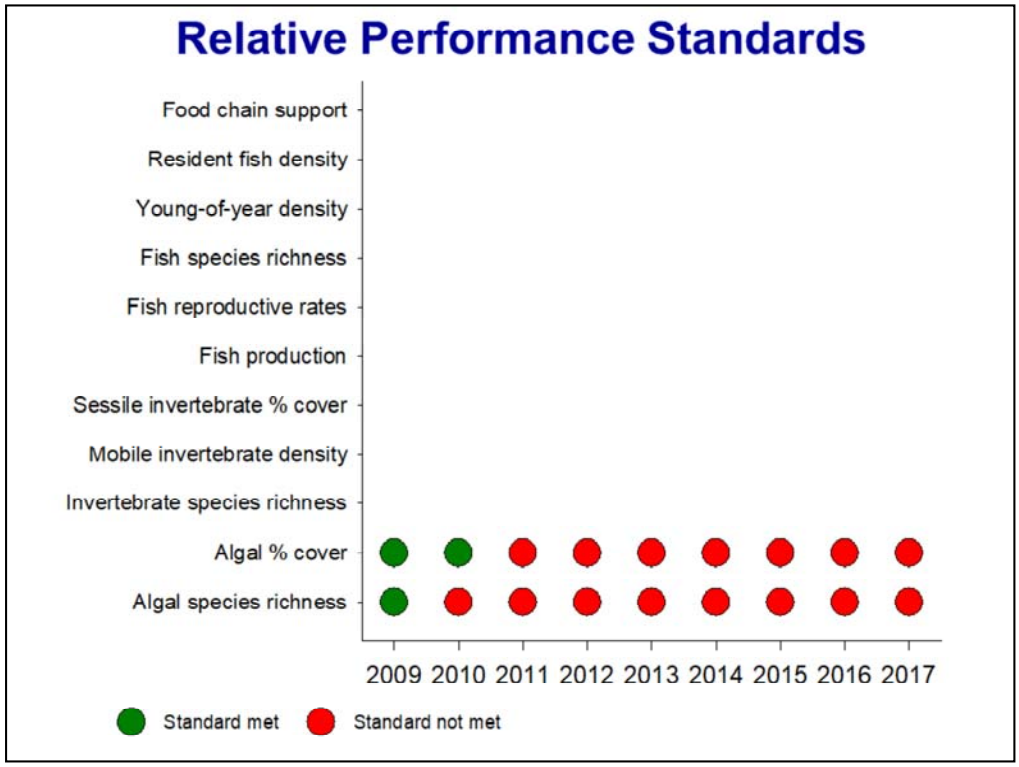
- The SONGS Coastal Development Permit envisioned a quantitative definition of “similar” for evaluating the performance of the reef mitigation projects relative to reference sites, and it specified that the measure of similarity be defined in the monitoring plan for the project
- After considerable discussion the definition for the measure of similarity that was chosen is that the mean value for a performance variable at Wheeler North Reef must not be significantly less than the reference reef having the lowest value for that performance variable
- This definition recognizes that no two natural reefs are identical, but that any reef chosen as a reference site should serve as an acceptable standard. Because there is a certain amount of error associated with any type of sampling (especially when diving in less than favorable conditions) we determined that we needed to be at least 80% confident that the Wheeler North Reef performed as well as the lowest performing reference site

Relative Performance Standards for Wheeler North Reef

1. Algal percent cover
2. Algal species richness
3. Sessile invertebrate percent cover
4. Mobile invertebrate density
5. Invertebrate species richness
6. Resident fish density
7. Young-of-Year fish density
8. Fish species richness
9. Fish reproductive rates
10. Fish production
11. Food chain support

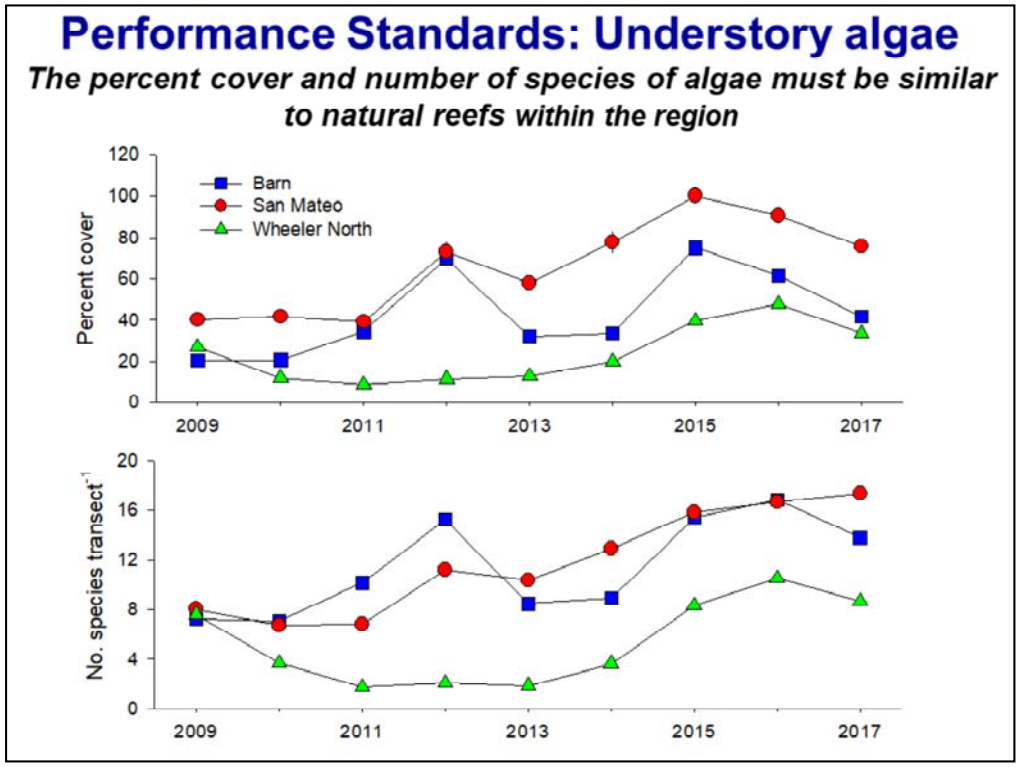


- Shown here are the 11 relative performance standards that are used to judged the Wheeler North Reef
- Standards 1-5 pertain to the benthic community of algae and invertebrates
- Standards 6-10 pertain to reef fishes
- Standard 11 integrates the benthic community of algae and invertebrates with reef fishes by focusing on the extent to which the benthic community supplies food for reef fishes
- What follows is an evaluation of how the Wheeler North Reef has performed with respect to these 11 standards since it was first constructed in 2009

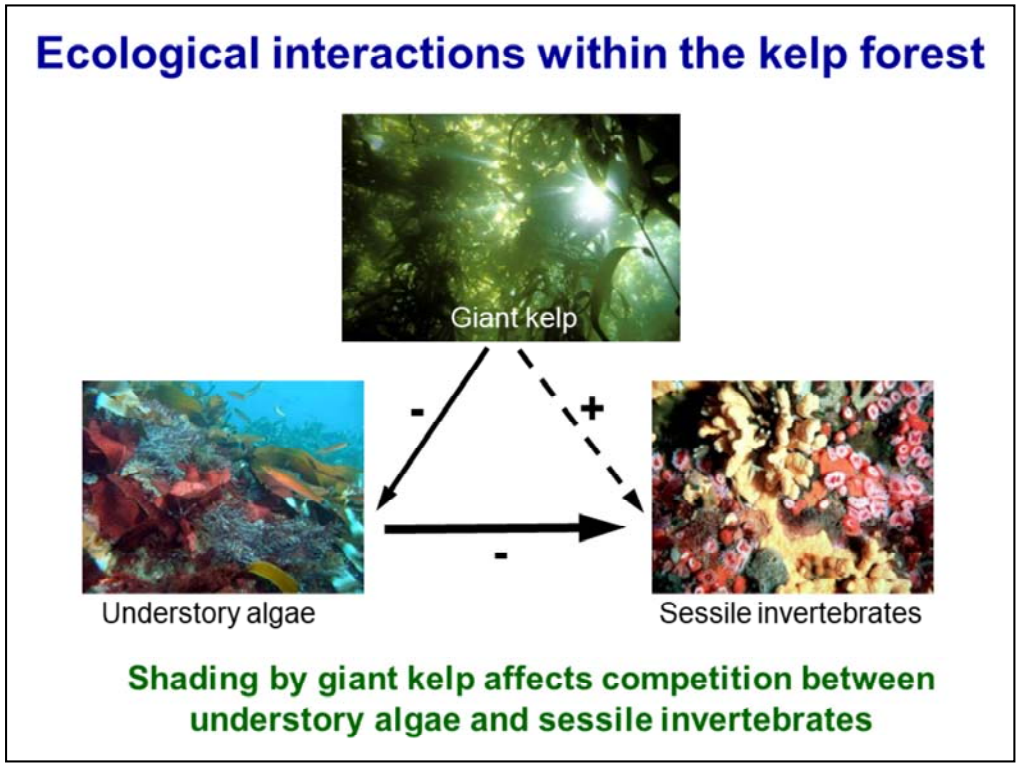


Shown here is an annual summary of the performance of understory algae at Wheeler North Reef

- A green circle means a standard was met in a given year and a red circle means that the standard was not met
- Algae quickly colonized the Wheeler North Reef soon after it was built and the percent cover of algae and number of algal species at Wheeler North Reef was similar to that at the nearby reference reefs by the first year (2009).
- This pattern quickly disappeared and the Wheeler North Reef has been under performing with respect to algae species richness since 2010 and algal percent cover since 2011.



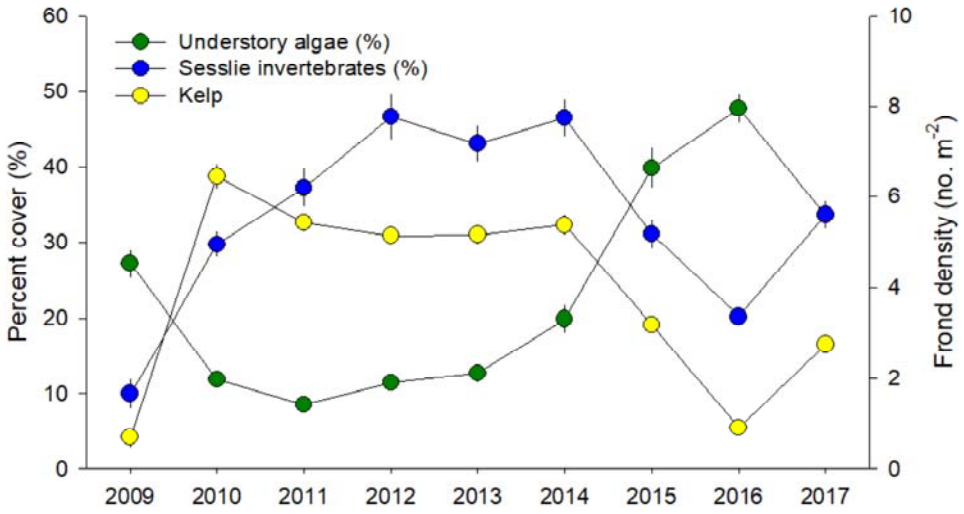
- Plotted here are time series of algal percent cover in the top graph and algal species number or richness in the bottom graph at the Wheeler North Reef, Barn and San Mateo
- The graphs on the left are annual values whereas those on the right are 4-year running averages
- In 2009 the percent cover and species number were similar at all three reefs, but quickly diverged as algae started to decline at Wheeler North Reef.
- Although algal cover and species number have increased at all three sites since 2013 they have remained significantly lower at Wheeler North Reef compared to the two reference reefs



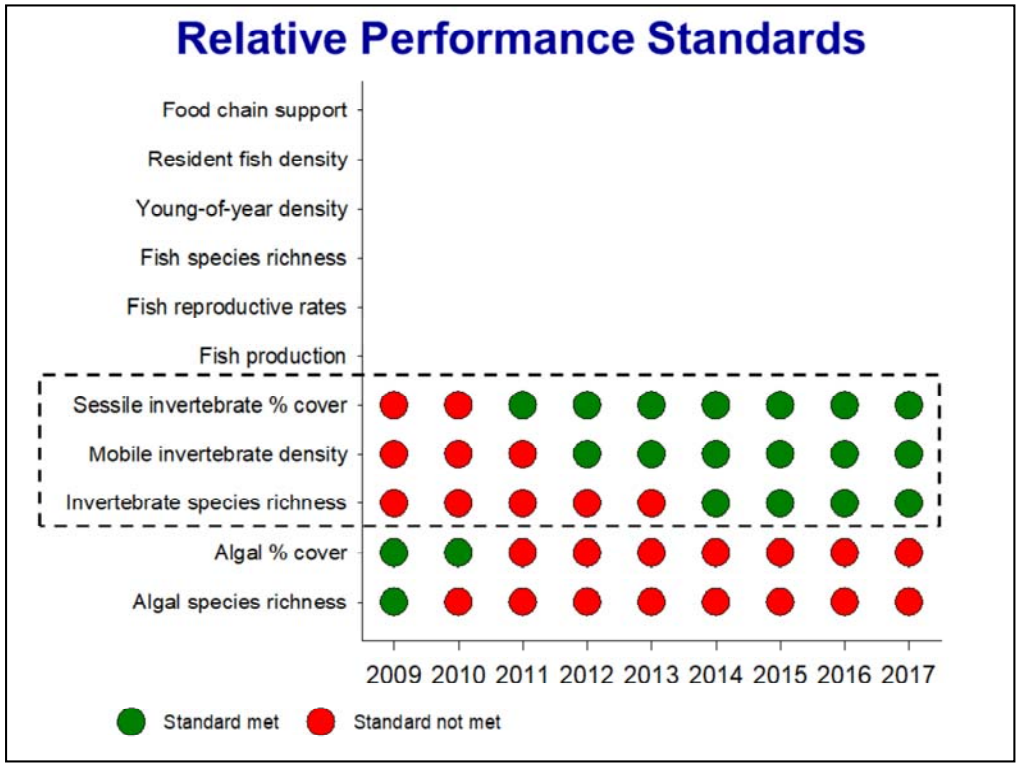
- The patterns of algae abundance and diversity at Wheeler North Reef can be explained by ecological interactions in the kelp forest
- Understory algae and sessile invertebrates compete for hard substrate on the bottom
- When left uncontrolled algae tends to overgrow and out compete sessile invertebrates, which is indicated by the direction of the arrow going from algae to invertebrates and the minus sign
- The surface canopy of giant kelp significantly reduces the amount of light reaching the bottom, and thus has a negative effect on understory algae, which require light to grow
- In doing so giant kelp has a indirect positive effect on sessile invertebrates
- Thus the relative abundance of understory algae and sessile invertebrates on a reef is greatly affected by the presence of giant kelp
- Understory algae are favored in the absence of giant kelp, while invertebrates are favored in the presence or giant kelp

Interactions with understory algae at WNR

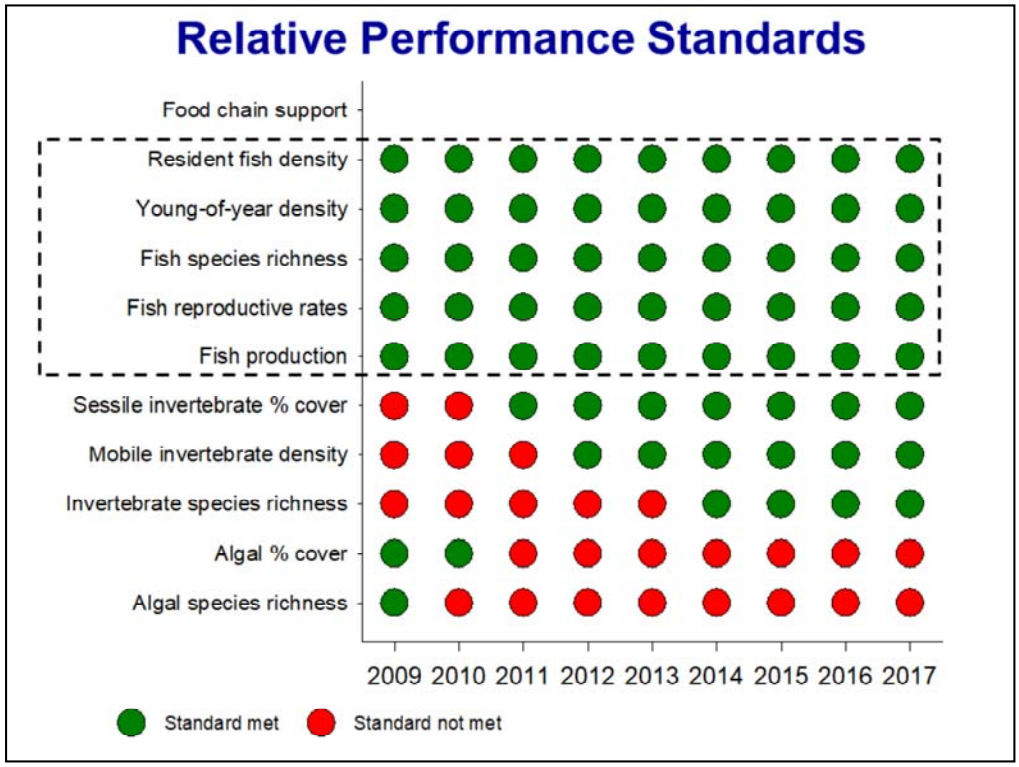
The percent cover of understory algae at Wheeler North Reef has varied inversely with the percent cover of sessile invertebrates and the density of giant kelp



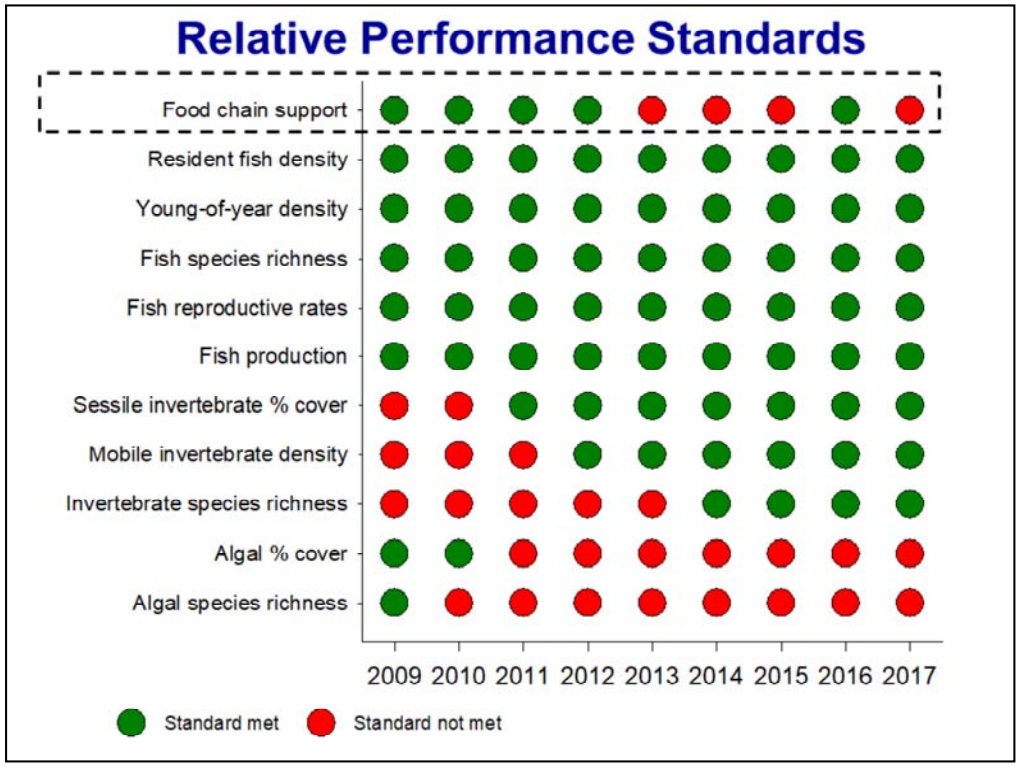
- Results of monitoring of the Wheeler North Reef support the hypothesis that giant kelp has a direct negative effect on the percent cover of understory algae by shading and an indirect positive effect on the percent cover of sessile invertebrates resulting from reduced competition for space with understory algae
- This time series graph plots the percent cover of algae (shown as green) and sessile invertebrates (shown as blue) on the left hand axis and the density of giant kelp (shown as yellow) on the right hand axis for each year since 2009
- Shortly after construction there was a rapid decrease in the percent cover of understory algae at Wheeler North Reef which coincided with a rapid increase in the density of kelp fronds and a corresponding increase in the percent cover of sessile filter feeding invertebrates
- In the last two years the opposite pattern occurred: the decrease in kelp and the percent cover of sessile invertebrate cover corresponded with an increase in the percent cover of understory algae



- Highlighted within the dotted lines is an annual summary of the performance of invertebrates at Wheeler North Reef
- The performance standard for sessile invertebrate cover was not met in the first 2 years but has been met every year since
- This is the exact opposite pattern observed for algal percent cover which is consistent with previous slide showing the ecological interactions between algae, sessile invertebrates and kelp
- The Wheeler North Reef also underperformed with respect to density of mobile invertebrates and the number of species of all invertebrates early in the time series, but this trend has reversed in recent years and the Wheeler North Reef has met all three of these standards the last couple of years



- The Wheeler North Reef has performed quite well with respect to the relative performance standards pertaining to reef fish having met all 5 standards in all 8 years of monitoring



- Finally, there is a performance standard that requires the benthic community of the Wheeler North reef to provide food for the fishes that feed on the reef in an amount that is similar to that provided by natural reefs
- We evaluate this performance standard by measuring the weight of the food in the guts of two common species of fish that feed on the bottom: black perch and the California sheephead
- We use this information to calculate an index of food chain support that is scaled to the weight of the fish
- The relative performance of the Wheeler North Reef with respect to food chain support has varied inconsistently over time, but overall it has met this criterion in 5 of the 9 years.

Relative Performance Standards

Requirement

Wheeler North Reef (WNR) must meet as many relative standards as the lowest performing reference reef in a given year for that year to count towards mitigation credit.

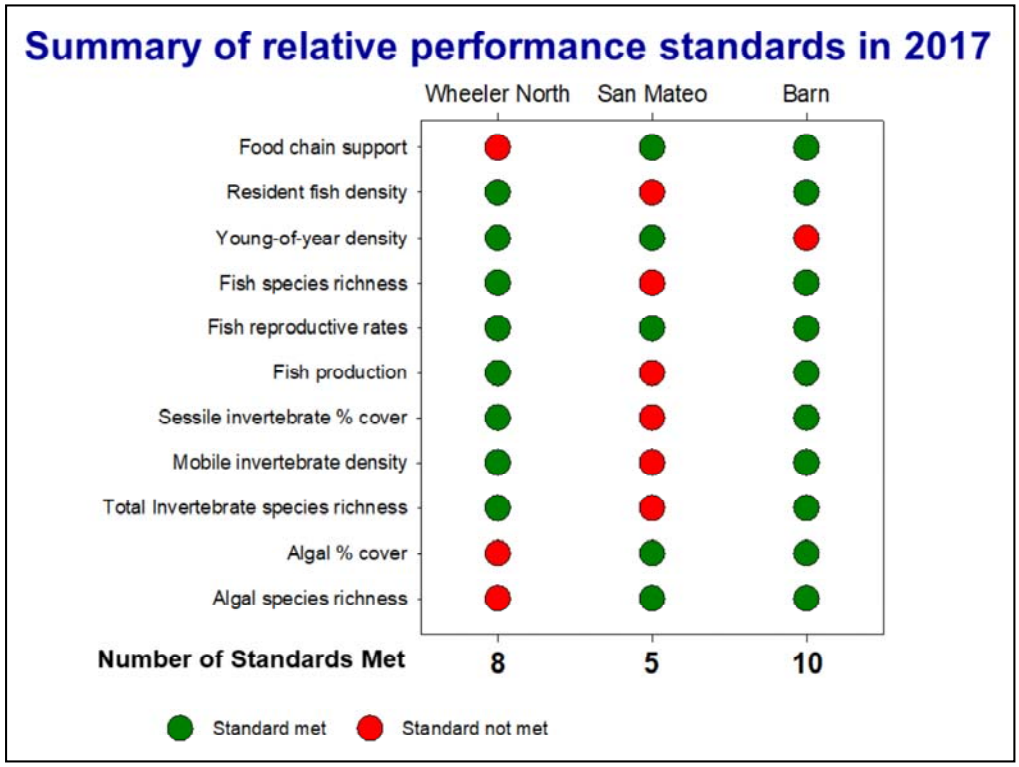
Method of Evaluation

WNR and the reference reefs are evaluated with respect to each other to determine whether they meet each relative standard and the total number of relative standards met by each reef is tallied and compared.

Rationale

Requiring WNR to meet at least as many relative standards as the reference reefs achieves the desired goal of WNR being similar to natural reefs without requiring it to consistently outperform them.

- The interactions among species in the kelp forest such as those shown for algae and sessile invertebrates and kelp at Wheeler North Reef greatly hamper its ability to meet all the relative performance standards in a given year
- Because natural kelp forests also vary greatly in their species composition and abundance over time and it is likely, that they too would not consistently meet all the relative standards in a given year
- Therefore, to avoid requiring the Wheeler North Reef to perform better than the reference reefs, the Wheeler North Reef is required to meet only as many of the relative standards as the lowest performing reference reef in a given year for that year to court towards mitigation credit
- This achieves the desired goal of Wheeler North Reef being similar to natural reefs without requiring it to consistently outperform them



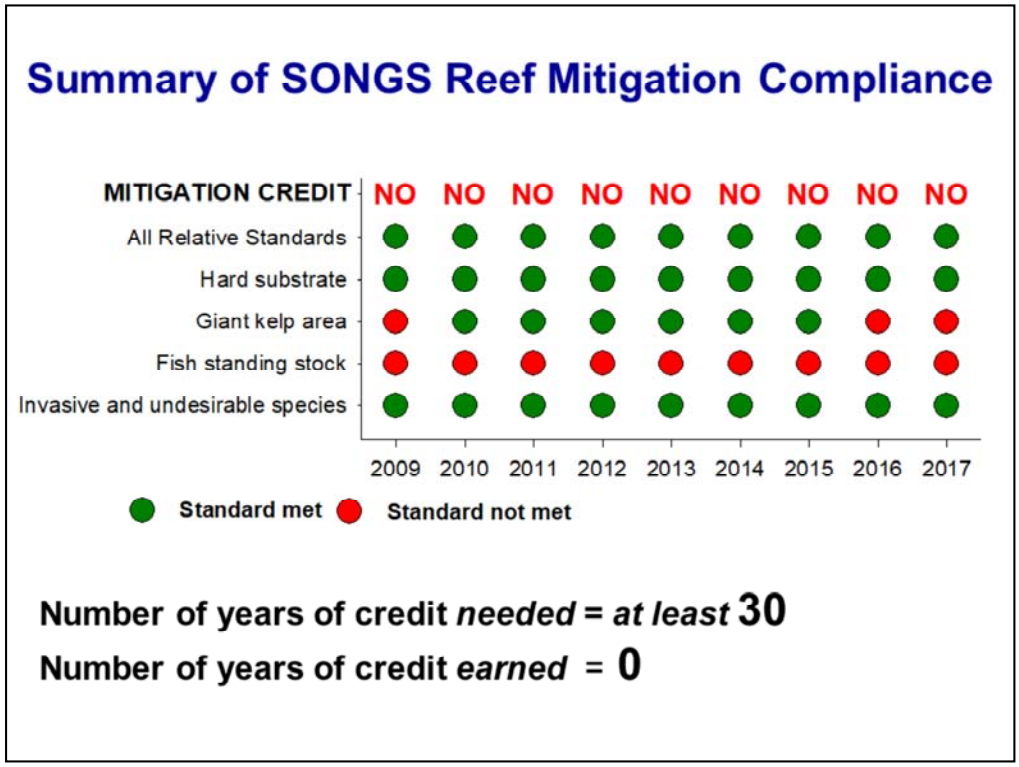
- This slide summarizes the number of relative standards met at Wheeler North Reef and the two reference reefs, San Mateo and Barn in 2017
- Wheeler North Reef met the performance of the relative standards as a whole, meeting 8 of the 11 standards, three more than were met at San Mateo, the lower performing of the two reference reefs

SONGS Reef Mitigation Compliance

Goal: ***Replace kelp forest resources lost by SONGS' operations***

- **One year of mitigation credit is given for each year that Wheeler North Reef meets the performance standards**
- **Fulfillment of the SONGS reef mitigation requirement occurs 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 are continuing discharges**

- The goal of the SONGS reef mitigation project is to replace the kelp forest resources that were lost due to the operations of SONGS Units 2 & 3
- One year of mitigation credit is given for each year that Wheeler North Reef meets the performance standards
- Wheeler North Reef is required to provide compensation for damages to kelp forest resources for a period of time equal to the lifetime operation of SONGS Units 2 & 3
- Thus, fulfillment of the SONGS reef mitigation requirement occurs 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



- Shown here is a summary of project compliance for the SONGS reef mitigation project
- As described in the previous slide project compliance requires that the Wheeler North Reef meet all 4 absolute standards and the collective group of relative standards in a given year for that year to count towards mitigation credit
- Although it has met the relative standards in all years. the Wheeler North Reef has failed to meet the performance standard for fish standing stock in every year and thus has not accrued any mitigation credit to date