Status of the Wheeler North Reef

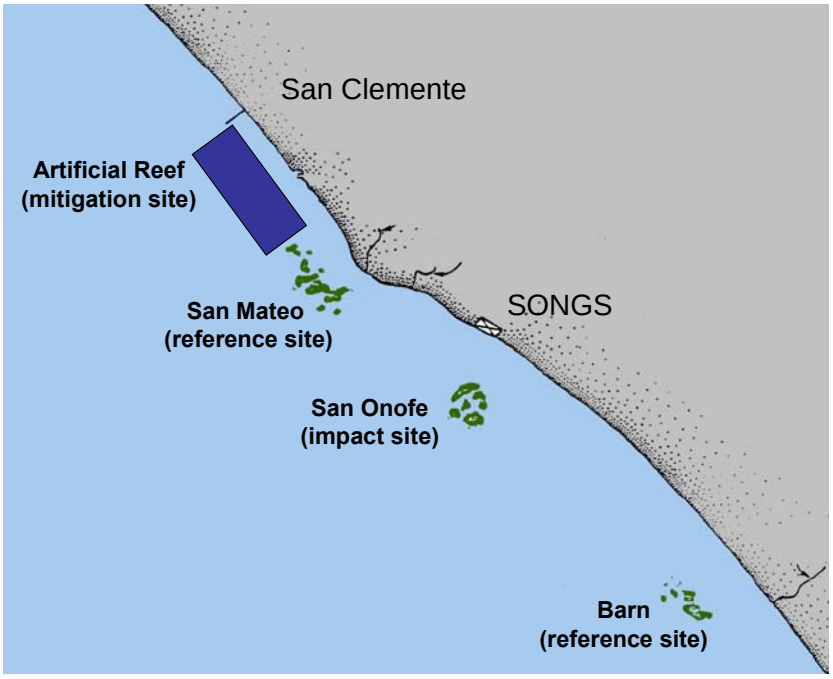
Year 1 (2009) Monitoring Results

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

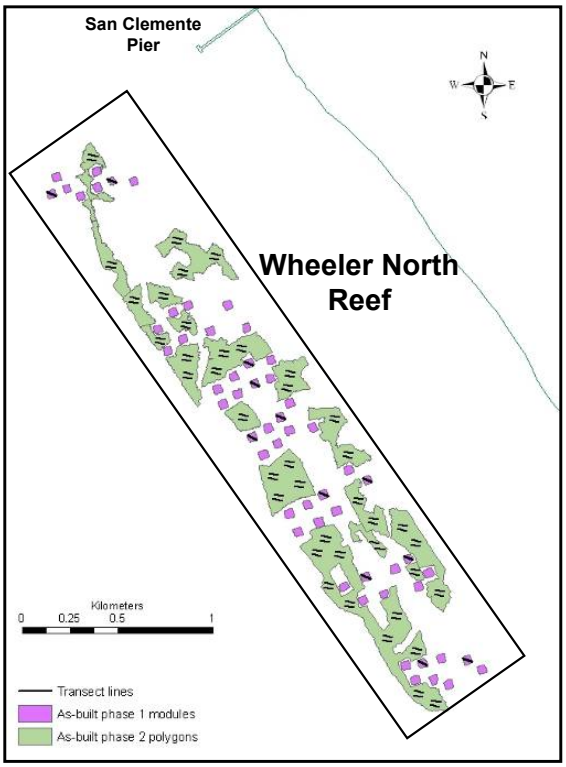
This presentation focuses on:

1. the results of the first year of compliance monitoring of the Wheeler North Reef done last summer and fall, and
2. our evaluation of whether the WNR met the performance standards established for mitigation

Project site and reference reefs



•This slide shows the location of the mitigation site where the WNR is located, the San Mateo and Barn kelp beds that serve as natural reference sites, and the San Onofre kelp bed where the impacts of SONGS have been occurring



Sampling Design

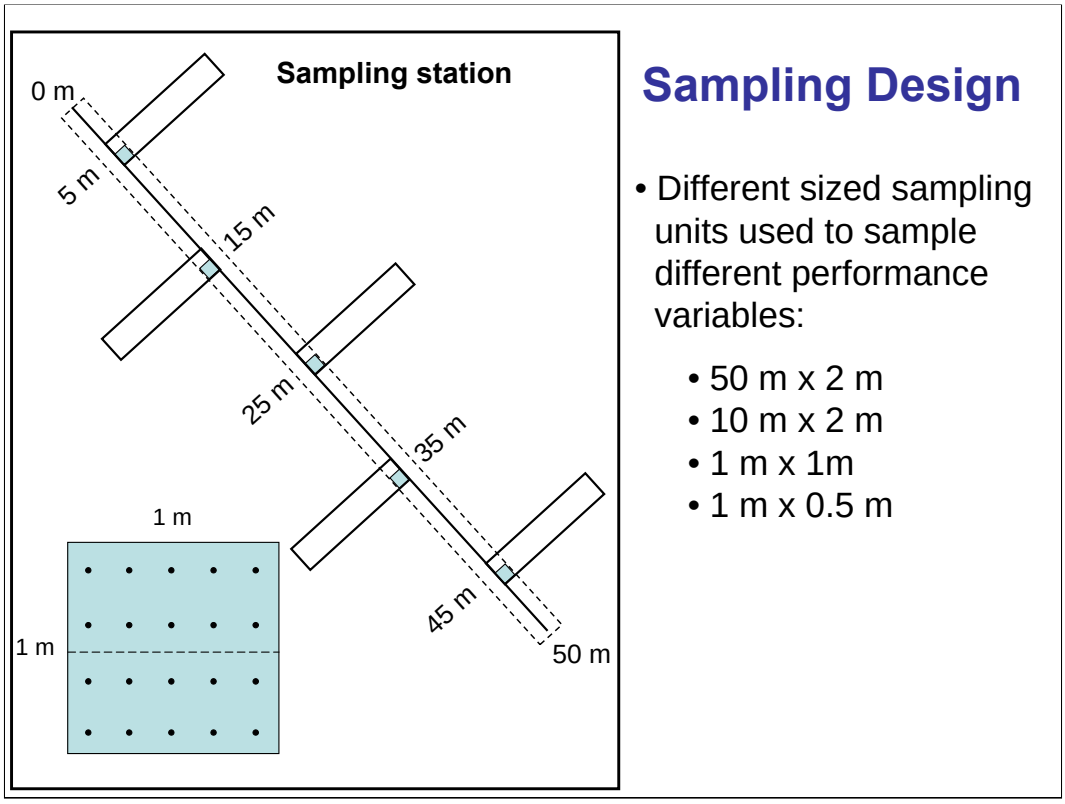
- 92 sampling stations (50m x 10m) arranged in 46 pairs
- Sampling stations distributed uniformly across 176 acre reef
- Each station defined by a differential GPS coordinate and a compass heading
- Sampling design and effort on reference reefs same as on Wheeler North Reef

•This slide summarizes the sampling design for the monitoring and shows the distribution of sampling stations on the Wheeler North Reef

• The experimental reef modules constructed in 1999 are shown in purple; the new phase 2 polygons constructed in 2008 are shown in green, together these constitute the 176 acre WNR

•The 92 sampling stations are shown as parallel black lines

•A similar sampling design is used for the two reference reefs



Sampling Design

- Different sized sampling units used to sample different performance variables:
  - 50 m x 2 m
  - 10 m x 2 m
  - 1 m x 1m
  - 1 m x 0.5 m

•This slide is a schematic diagram of each of the sampling stations on the WNR and the two reference reefs

•Different sized sampling units are used to sample different performance variables

•Fish are sampled in 50m x 2m band transect outlined with the dotted line, which extends 2m off the bottom

•Adult Giant kelp > 1m, large understory algae, and larger mobile invertebrates are counted in the five 10m x 2m bands positioned perpendicular to the main transect

•The % cover of invertebrates, algae and substrate is estimated using a grid of 20 points in the five 1m x 1m quadrats shown in blue

•Smaller mobile invertebrates are counted either in 1m x 1m or 1m x 0.5m quadrats depending on their size and abundance

Two different types of physical and biological performance standards will be used to judge the success of the Wheeler North Reef:

1. **Fixed standards: Measured against an absolute value**

   (90% of initial rock, 150 acres of giant kelp, 28 tons of fish biomass)

2. **Relative standards: Compared to natural reefs**

   (e.g., the abundance and number of species of algae and macroinvertebrates must be similar to that of natural reefs)

Relative standards require comparison to natural reference reefs

RATIONALE: **To be successful the Wheeler North Reef must provide the types and amounts of resources that occur on natural reefs in the region.**

Criteria for reference reef selection:

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

Choosing the natural reefs that are used as reference is a critical element because they are an important measure by which the success of the WNR will be judged

What counts as similar?

Two criteria used to assess similarity between Wheeler North Reef and reference reefs

1) The mean values of the performance variables at Wheeler North Reef must be within the range of the 80% confidence intervals of San Mateo and Barn for all performance variables.

and

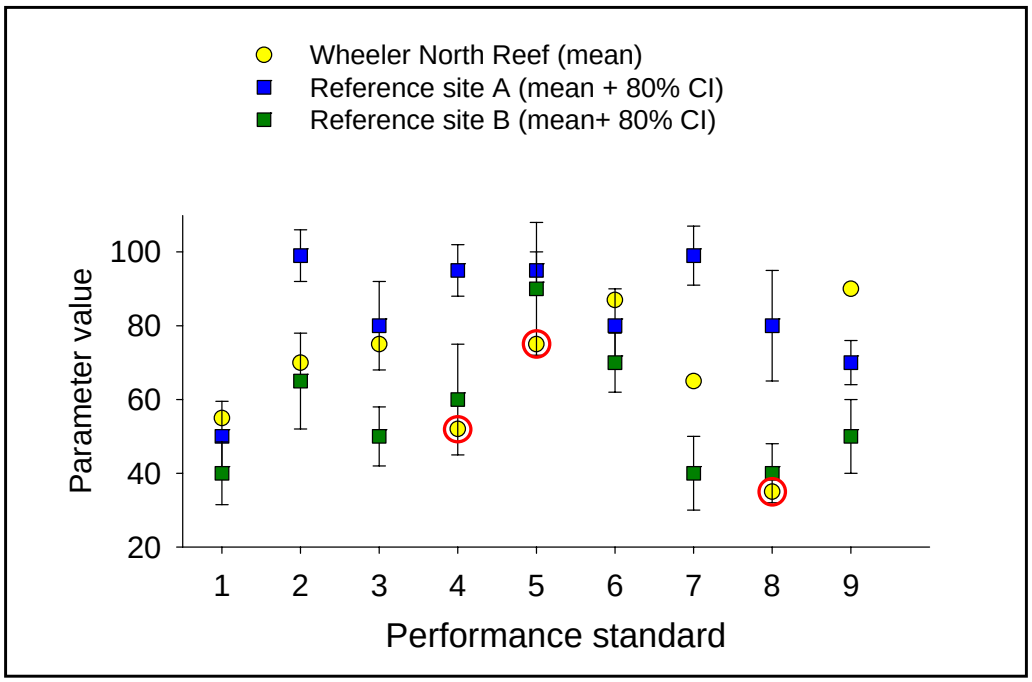
2) Wheeler North Reef must not have the lowest mean value more often than expected by chance alone.

Two criteria are used to assess similarity between WNR and the reference reefs

•Criterion 1 ensures that the values of each performance variable at Wheeler North Reef will be greater than that of the lower confidence limit of the reference site with the lowest value.

•Criterion 2 eliminates the possibility of concluding that Wheeler North Reef is in compliance when it has the lowest value for a disproportionately large number of performance variables

Hypothetical example



- In this hypothetical example, there are 9 performance standards
- All of the performance standards meet the first criterion – above the lower 80% CL of the reference site with the lowest mean
- Assuming that the WNR and the 2 reference reefs come from the same population, we would expect 3 (or 1/3) of the performance standards at WNR to have the lowest average values by chance alone.
- In this example only 3 of the 9 standards have the lowest value on the WNR, which is what you'd expect by chance and so the WNR in this example meets Criterion 2
- Because both criteria are met in this example, the WNR would be considered to be in compliance

Performance Standard: Hard Substrate

At least 90 percent of the exposed hard substrate must remain available for attachment by reef biota

Evaluating the Performance of Hard Substrate

1. **Measure footprint area (A) of Wheeler North Reef using multi-beam sonar**
2. **Measure percent cover of exposed rock (C) in the same 1m^2 quadrats used to verify the as-built specifications of the WNR**
3. **Calculate area of exposed rock as A x C**
4. **Compare area of exposed rock to that measured immediately after reef construction to determine whether 90% or more is still available for reef biota**

9 Substrate categories:

Bedrock
Large boulder (≥ 100 cm)
Medium boulder (≥ 50cm & <100cm)
Small boulder (≥ 26cm and <50cm)
Cobble (≥ 7cm and ≤ 25cm)
Pebble (≥ 2mm and < 7cm)
Sand (< 2mm)
Shell hash
Mudstone

We evaluate performance standard for hard substrate by:

•measuring the footprint area of the reef (A)

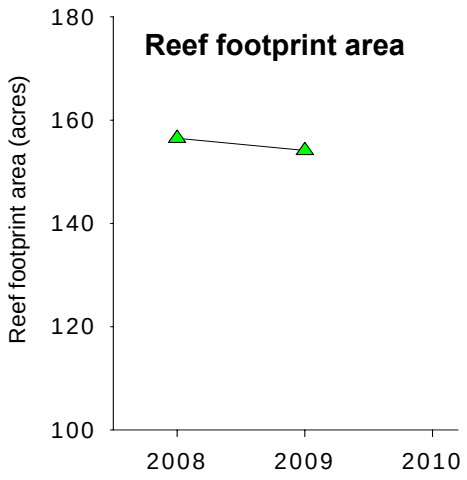
•estimating the percent cover of exposed rock (C)

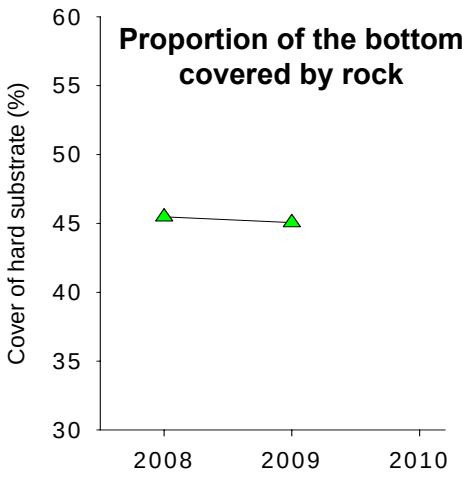
•the product A x C is the estimate of the area of exposed hard subtrate,

•We compare this estimate to that obtained immediately following construction of WNR

•The permit requires that this amount not fall below 90% of what was available immediately after the reef was constructed

Exposed Hard substrate



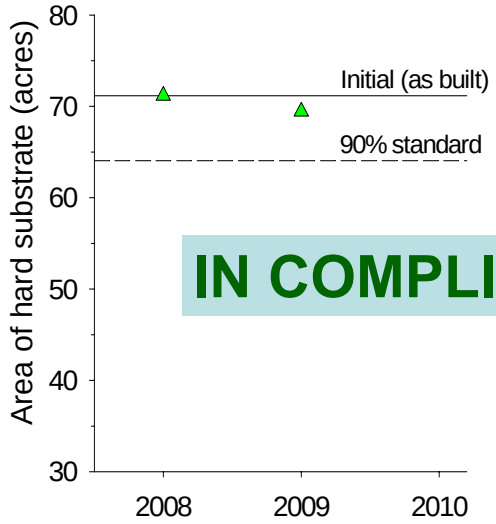


*** This standard applies to the 154 acres of Wheeler North Reef that met the 42% rock cover criteria (i.e., the Experimental Reef modules + the primary polygons of Phase 2 mitigation)**

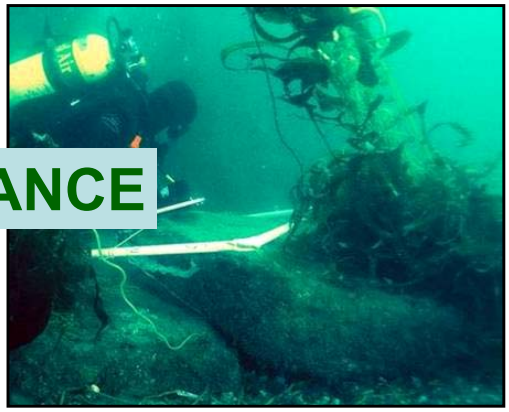
- This slide shows the two variables required to estimate the amount of exposed hard substrate on WNR;
- Both apply only to the 154 acre subset of the WNR, which had a % cover > 42%
- Both the reef footprint area and the % cover of hard substrate declined slightly in 2009 relative to the initial conditions in 2008

Performance Standard: Hard Substrate

At least 90 percent of the exposed hard substrate must remain available for attachment by reef biota



IN COMPLIANCE



•The small declines in footprint and % cover of hard substrate resulted in a small change in the total area of hard substrate (about 1.5%), which was well within the 10% range allowed by the performance standard

• Thus WNR is in compliance with this standard

Performance Standard: Giant Kelp

The artificial reef(s) shall sustain 150 acres of medium-to-high density giant kelp

Medium-to-high density giant kelp is defined as at least 4 adult plants 100 m^{-2}

Evaluating the Performance of Giant Kelp

Measure giant kelp density in fixed transects on Wheeler North Reef (WNR)

Determine whether *P* x 176 ≥ 150

where:

***P* = the proportion of 100 m^2 transects with at least 4 adult plants**

and

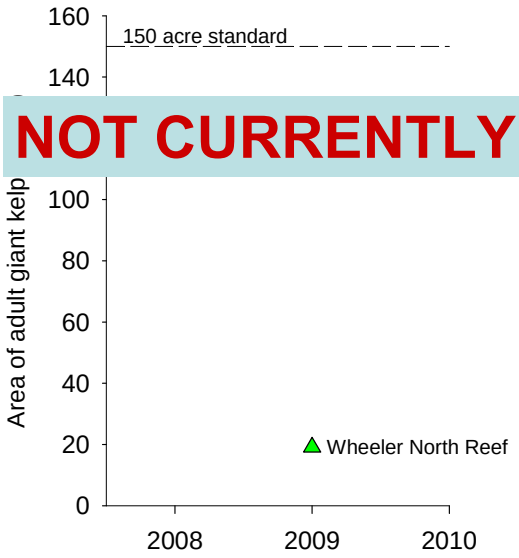
176 = Area of WNR

•The performance standard for giant kelp is evaluated by first calculating the proportion of the 92 transects at WNR that have adult kelp densities >= 4 100m-2

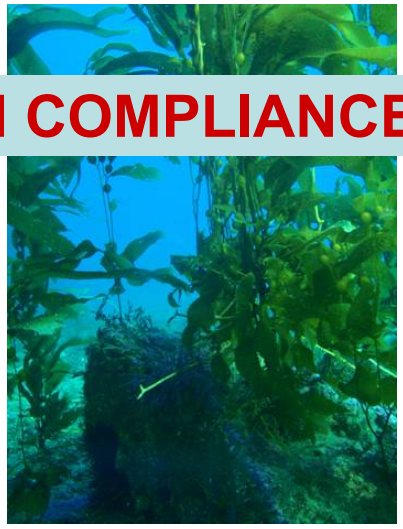
•This proportion is multiplied by 176, which is the total area of WNR measured in the most recent sonar survey to obtain the total acreage of adult kelp

Performance Standard: Giant Kelp

The artificial reef(s) shall sustain 150 acres of medium-to-high density giant kelp



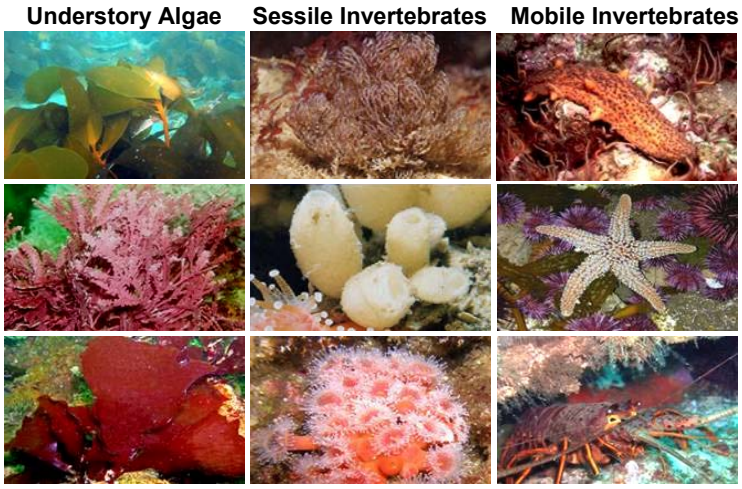
NOT CURRENTLY IN COMPLIANCE



•The area of medium to high density adult kelp at WNR during 2009 was about 20 acres and therefore did not meet the 150 acre performance standard

Performance Standard: Benthic Community

The benthic community (both algae & macroinvertebrates) shall have coverage or density and number of species similar to natural reefs within the region



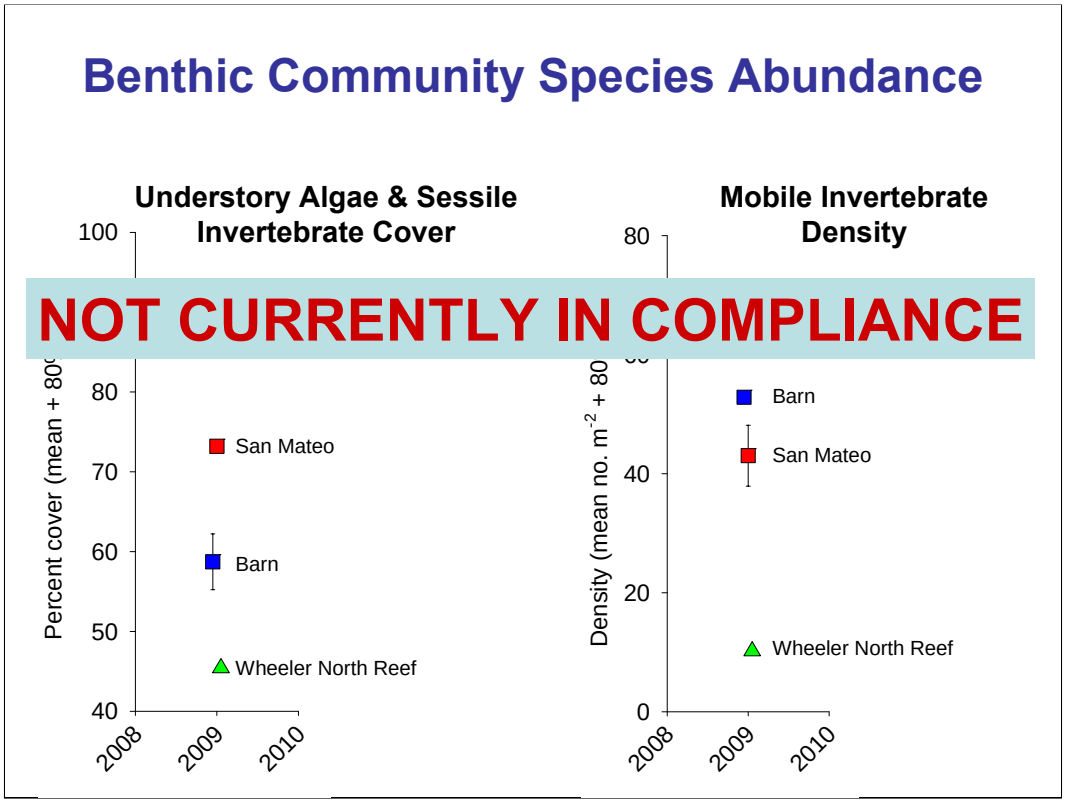
Evaluating the Benthic Community

Three components of the Benthic Community standard to be evaluated separately

1. **Percent cover of understory algae + sessile invertebrates**
2. **Density of mobile invertebrates**
3. **Number of species of all algae and invertebrates combined**

•3 components of the benthic community will be considered when evaluating this standard

Benthic Community Species Abundance



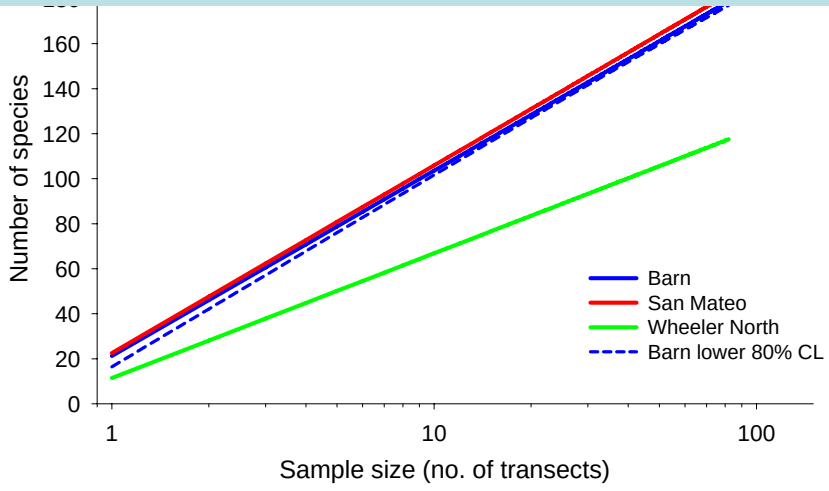
NOT CURRENTLY IN COMPLIANCE

- The percent cover of understory algae and benthic invertebrates and the density of mobile invertebrates on WNR was much lower than on either of the reference reefs
- therefore WNR is out of compliance for these measures of the benthic community

Benthic Community Species Richness

2009 Species richness (algae + invertebrates)

NOT CURRENTLY IN COMPLIANCE



•We evaluated this performance standard as it pertains to the number of species in the benthic community by examining the relationship between the cumulative number of species of algae and invertebrates observed on a reef versus the number of transects sampled

• the green line represents this relationship for WNR, the red and blue lines Barn and San Mateo, respectively

• the dashed blue line is the lower 80% confidence interval for Barn, the reference site with the lower value

• the line for WNR falls well below the blue dashed line indicating that the number of species of algae and invertebrates on WNR is consistently lower than that of the reference reef with the lowest mean value

• Thus the WNR is out of compliance for this standard

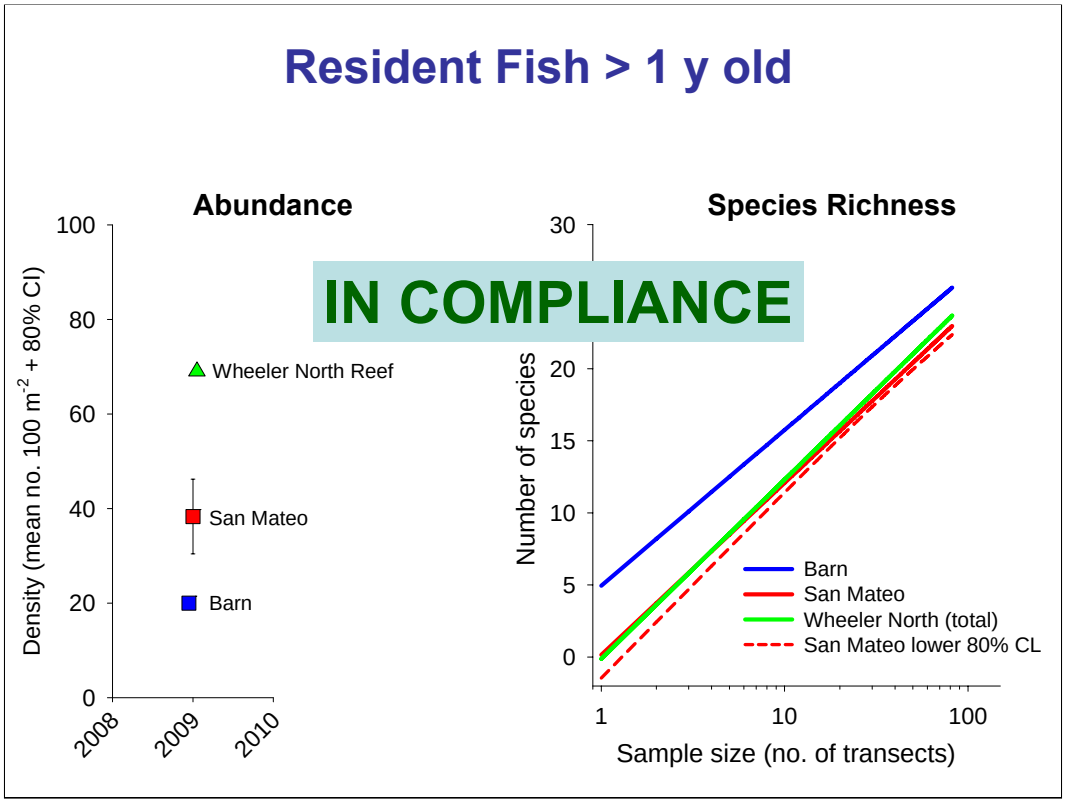
Performance Standard: Resident Fish

The resident fish assemblage shall have a total density and number of species similar to natural reefs within the region.

- The next 2 performance standards pertain to the abundance and number of species of reef fish
- The first of these standard is that “The resident fish assemblage shall have a total density and number of species similar to natural reefs within the region
- Recall that resident fish are defined as reef-associated fish > 1 year old

Measuring Fish Abundance and Diversity

- **Record the size (to nearest cm) and species identity of each fish observed on each transect**
- **The area of bottom sampled on each transect is: 2 m wide x 2 m tall x 50 m long**



•The graph on the left shows the density of resident fish, while the graph on the right shows the relationship between number of species and number of transects sampled, which is how we evaluate species richness

• Resident fish were 2 to 3 times more abundant on WNR than on the reference reefs

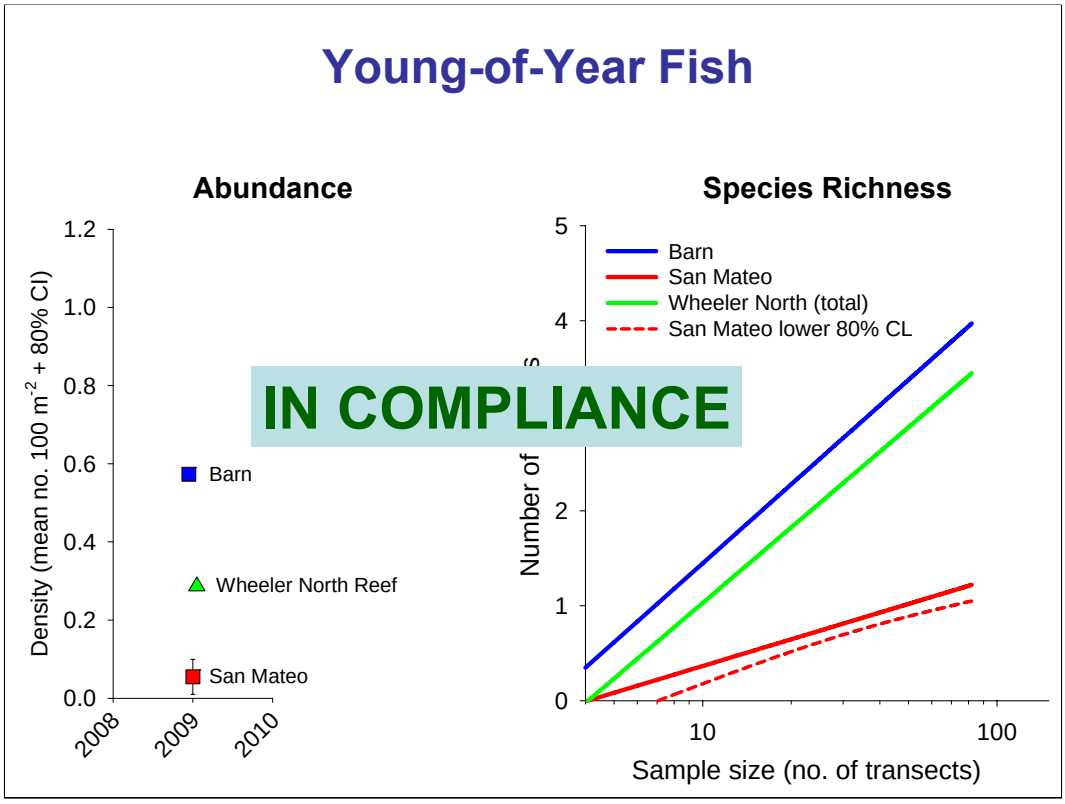
• The number of species of resident fish on the WNR was less than that at Barn, but similar to that observed at San Mateo

• Thus the WNR was in compliance with both of these performance standards

Performance Standard: Young-of-Year Fish

The total density and number of species of young-of-year fish shall be similar to natural reefs within the region

There are similar performance standards for YOY fish (fish born in the year that we sampled)



•The graph on the left shows the density of YOY fish, while the graph on the right shows the relationship between number of species of YOY fish and number of transects sampled, which is how we evaluate species richness

•The abundance and number of species of YOY fish on WNR were well within the range observed at the 2 reference reefs

•Thus the WNR was in compliance with both of these performance standards

Performance Standard: Fish biomass

The standing stock of fish at the mitigation reef shall be at least 28 tons

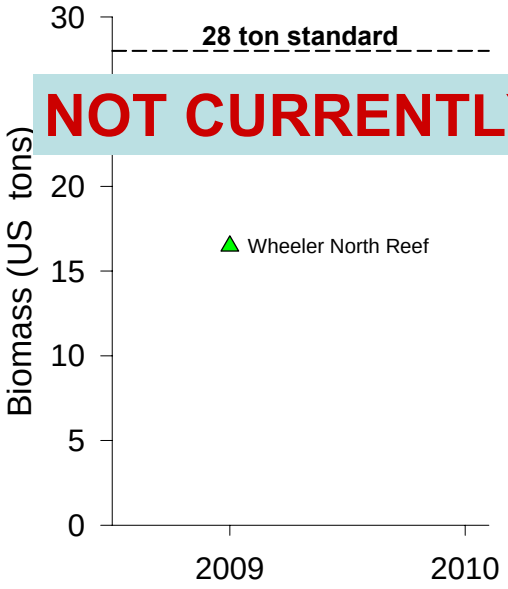
Method of Evaluation:

1. **Apply species-specific length-weight relationships to data on fish density and size to calculate the biomass density (no. m^{-2}) of all fish near the bottom.**
2. **Scale up estimates of 1 m^{-2} to 176 acres to obtain estimate of the standing stock of fish on Wheeler North Reef.**

• The performance standard for fish biomass is a fixed standard that requires the WNR to support at least 28 US tons of fish

Performance Standard: Fish biomass

The standing stock of fish at the mitigation reef shall be at least 28 tons



NOT CURRENTLY IN COMPLIANCE

The WNR supported ~ 16 tons of fish in 2009 and is therefore out of compliance with the performance standard for fish biomass

Performance Standard: Fish Reproductive Rates

Fish reproductive rates shall be similar to natural reefs within the region

Method of Evaluation:

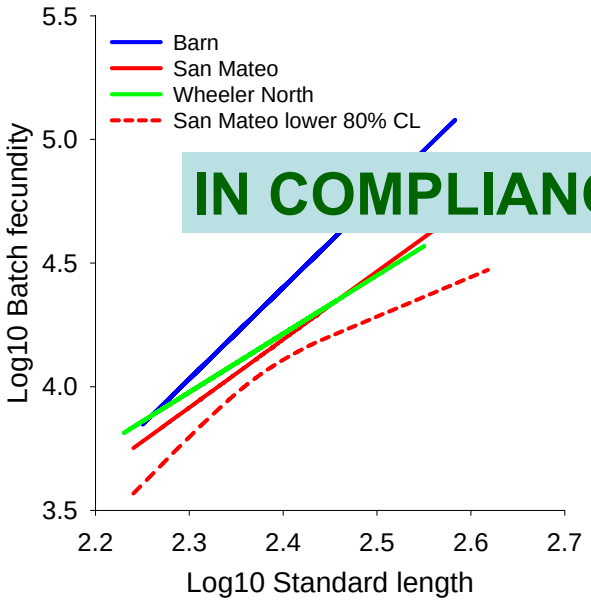
Measure annual egg production relative to body length for common species that represent the major feeding and reproductive guilds of reef fishes in S. California

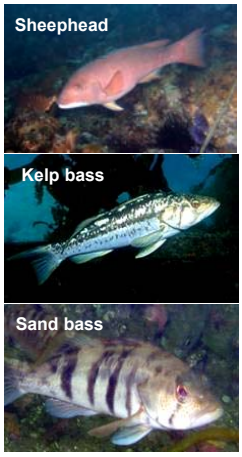
•The rationale for the performance standard pertaining to fish reproductive rates is that for artificial reefs to be considered successful, fish have to adequately reproduce

• We estimate fish reproduction by measuring egg production and size for individuals of 4 species that are abundant and represent the major feeding guilds on the reef

• We then compare the relationship between egg production and size for all species combined across reefs to evaluate the performance standard

Fish Reproductive Rates



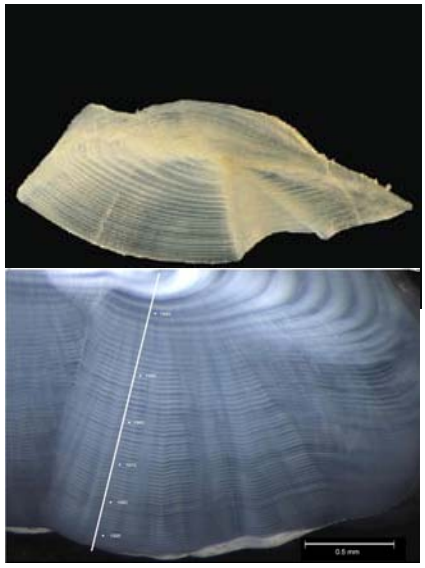


***Results for senorita are in progress**

- The relationship between egg production and fish size at WNR was similar to that of San Mateo and well above its lower 80% CL
- The Wheeler North Reef is in compliance with this standard

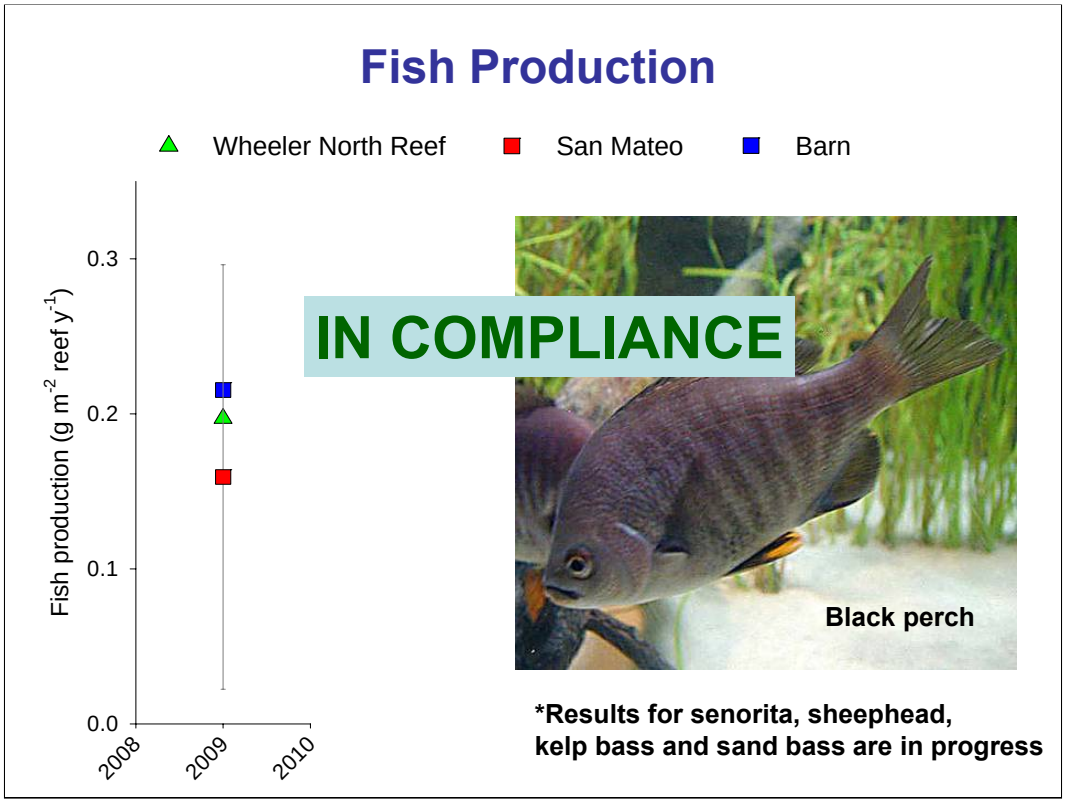
Performance Standard: Fish Production

Fish production shall be similar to natural reefs within the region



Method of Evaluation

Use information collected on fish abundance, size structure, and reproductive rates combined with estimates of somatic growth obtained from ear bones (otoliths) to calculate fish production



•Data on black surf perch show that the production of this species on the WNR was intermediate between the two reference reefs.

•Results for 4 other species that are being used to evaluate this standard will be forthcoming once our analyses on them are complete

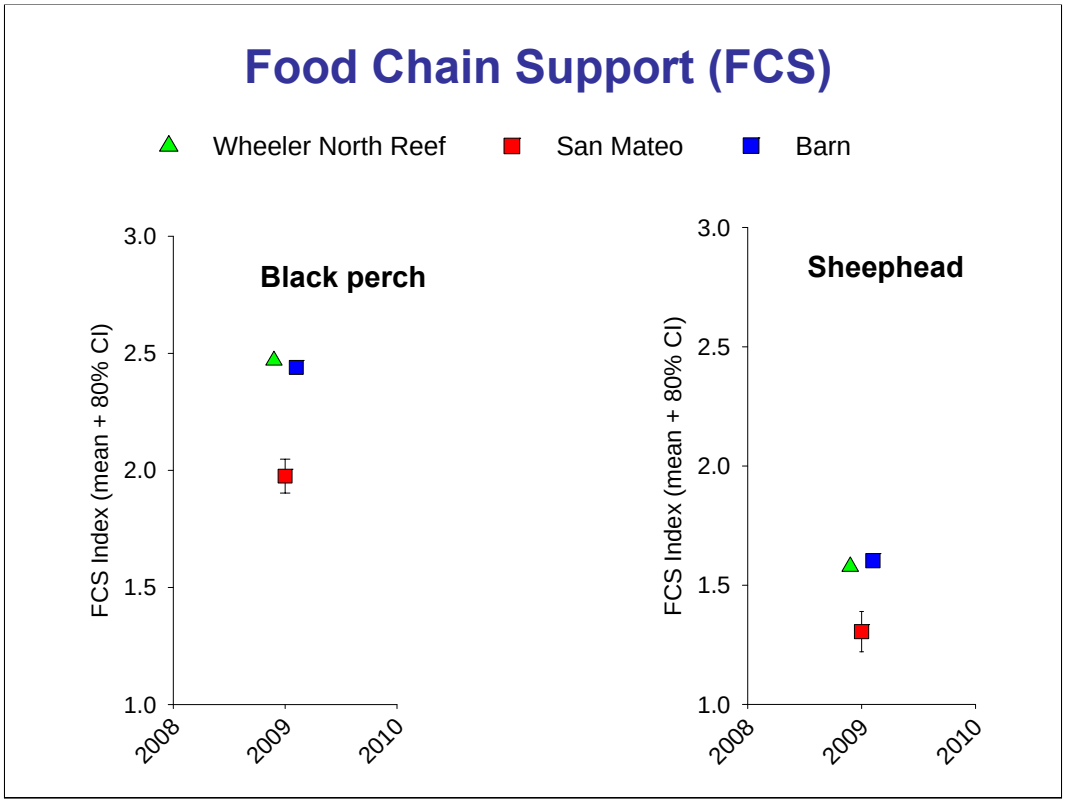
•When considering black perch alone, the WNR was in compliance with this performance standard in 2009

Performance Standard: Food Chain Support

The benthic community shall provide food-chain support for fish similar to natural reefs within the region

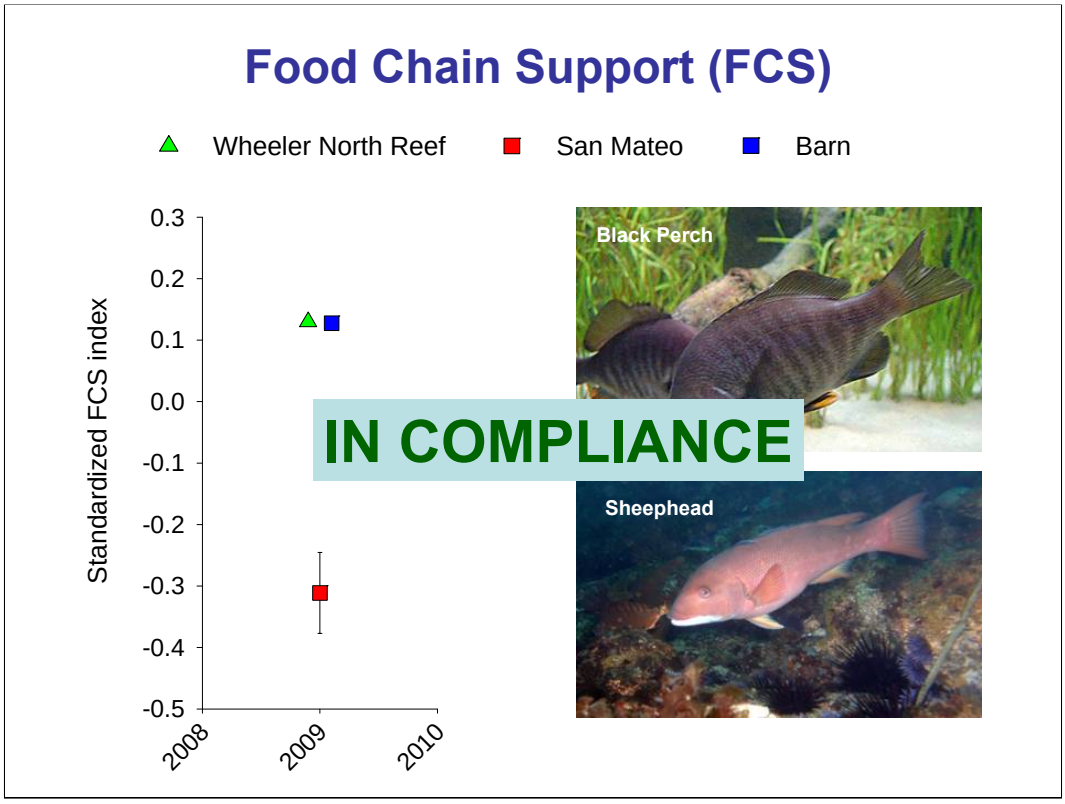
Method of Evaluation:

- **Weigh gut contents in two common species of reef fish that feed on the bottom**
- **Scale mass of gut contents to total mass of fish (FCS index)**



• this slide shows the FCS index for the two species used to evaluate the performance standard

• For both species the FCS at WNR much higher that at SMK, the reference site with the lowest value



•To evaluate the FCS performance standard we transform the FCS values for each of the two species into a standardized FCS index and assess the performance standard using data from both species

•When we do this we see that the standardized FCS index at WNR is similar to that at Barn and approximately 4x greater than at San Mateo, which means that the benthic community of WNR provided food for fish at levels similar to or greater than that provided by the natural reference reefs

•Thus the WNR is in compliance with the performance standard for FCS

Performance Standard : Reef Function

The important functions of the reef shall not be impaired by undesirable or invasive benthic species

Important Reef Functions include:

- **Benthic food-chain support to fish**
- **Primary production by giant kelp**

Performance Standard : Reef Function

The important functions of the reef shall not be impaired by undesirable or invasive benthic species

Undesirable or invasive species that are of potential concern include:

- **Sea urchins**
- **Brittle stars**
- **Sea fans**
- **Non-endemic algae (e.g., *Sargassum, Caulerpa*)**

•The abundance of all species of concern was low in 2009 indicating that undesirable or invasive species did not impair the important functions of Wheeler North Reef

•Thus the WNR was in compliance with this performance standard in 2009