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**Executive Director's Determination
SONGS Mitigation Reef Reduced Monitoring
March 13, 2024**

EXHIBITS

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EXHIBIT 12

Performance of the Wheeler North Reef

2023 Monitoring Results



April 8, 2024

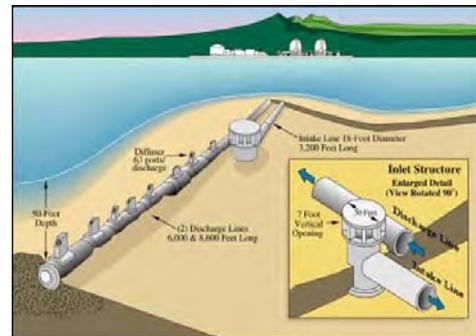
SONGS Mitigation Monitoring Project
Marine Science Institute, University of California Santa Barbara

SONGS generators cooled by a single pass seawater system

(San Onofre Nuclear Generating Station = SONGS)



The nuclear reactors of SONGS units 2 and 3 are cooled by seawater that is taken in by large intake pipes and discharged back to the ocean via two diffuser lines



- The operations of SONGS Units 2 and 3 relied on a single-pass seawater cooling system to cool their nuclear reactors
- Each unit has its own cooling system that includes an intake located in about 30 feet of water about 0.6 miles offshore of the power plant and an 18' diameter intake line that delivers seawater to the unit
- The volume of water taken in each day by these two intake lines when Units 2 and 3 were fully operational was about 2.4 billion gallons, which is equivalent to the volume of water in a cube that covers one square mile and 12 feet deep
- The seawater was elevated 19° F above ambient as it circulated through the plant, and then it was delivered back to the ocean through separate discharge lines that extended 6,000 and 8,000 feet offshore
- The last 2,500 feet of each discharge line is equipped with 63 diffuser ports that are designed to rapidly mix the cooling water with the surrounding seawater

Reef mitigation linked to the adverse effects of the SONGS cooling water discharge

Results from studies conducted from 1976-1987 by the Marine Review Committee determined that a turbidity plume associated with SONGS diffusers was the cause of a substantial reduction in size of the San Onofre kelp forest



- The SONGS artificial reef mitigation project is linked to the adverse effects of the SONGS seawater cooling system on the San Onofre kelp forest, which is located directly offshore of the power plant
- The Marine Review Committee was commissioned by the California Coastal Commission to conduct extensive studies from the mid 1970s –1980s to determine the extent of the impacts associated with the SONGS seawater cooling system
- One of the impacts identified by these studies was that the mixing of the discharged cooling water with the surrounding seawater resulted in the formation of a turbid plume that caused a substantial reduction in area of the San Onofre kelp forest located offshore of the power plant

The California Coastal Act Requires Mitigation of Marine Impacts

The California Coastal Commission (CCC) is responsible for implementing the Coastal Act



To mitigate for the impacts to the San Onofre kelp forest caused by SONGS the CCC required SCE to:

1. Construct an artificial reef large enough to support at least 28 tons of fish and 150 acres of kelp forest habitat to compensate for losses of kelp and kelp bed fish, invertebrates, and algae.
2. Provide funding for scientific oversight and monitoring of the mitigation project that is *independent* of SCE.

- The California Coastal Act requires mitigation for impacts to the marine environment such as those caused by SONGS
- Implementation of the Coastal Act resides with the California Coastal Commission (CCC)
- The CCC is responsible for ensuring that the adverse impacts to the marine environment caused by SONGS are adequately mitigated
- As mitigation for the impacts to the San Onofre kelp forest caused by SONGS the CCC required SCE to:
 - (1) Construct an artificial reef that is large enough to support 28 tons of reef fish and 150 acres of kelp forest habitat to compensate for losses of kelp and kelp bed fish, invertebrates and algae
 - (2) Provide funding for scientific oversight and monitoring of mitigation projects that is *independent* of SCE
- Independent monitoring is done by a team of marine scientists at UCSB who report directly to the CCC

Project Objective

Replace the marine resources that were damaged or lost in the San Onofre kelp forest due to the operations of SONGS Units 2 & 3

Approach

- 1. Design an artificial reef in sandy habitat that is:**
 - **Low-relief with topography & depth similar to the San Onofre kelp forest**
 - **Located near SONGS, but outside the influence of its discharge**
- 2. Construct the artificial reef in two phases :**
 - **A small (25 acre) short-term (5 y) experimental phase to test different reef materials and designs**
 - **A large (> 150 acres) long-term (> 30 y) mitigation phase to replace the kelp forest resources lost at San Onofre**
- 3. Monitor the artificial reef to measure its success based on performance standards developed to ensure that project objective is met**
- 4. Impose corrective measures to remediate the artificial reef if it fails to meet the performance standards**
- 5. End project monitoring and oversight after mitigation requirement is met**

The objective of the project is to replace the marine resources that were damaged or lost in the San Onofre kelp forest due to the operations of SONGS Units 2 & 3.

- While Units 2 and 3 are no longer producing energy, damages to the San Onofre kelp forest occurred throughout the 32 years that they were operating
- Consequently, the SONGS artificial reef project is designed to mitigate for damages to kelp forest habitat that accrued over 32 years

The project involves a 5-step approach that includes:

1. Designing a reef that is similar to the natural reef at San Onofre that was impacted by SONGS
2. Construct the reef in two phases in which the first phase consists of a short-term experiment that tests different reef designs to inform the design of larger second phase that is intended to replace the kelp forest resources lost at San Onofre
3. Monitor the artificial reef to measure its success based on performance standards developed to ensure that project objective is met.
 - These standards include absolute standards measured at Wheeler North Reef only that are based on the size of the impact at the San Onofre kelp forest, and relative standards that require Wheeler North Reef to be similar to natural reference reefs.
4. Imposing corrective measures to remediate the artificial reef if it fails to meet performance requirements
5. End the monitoring and oversight after the mitigation requirement is met

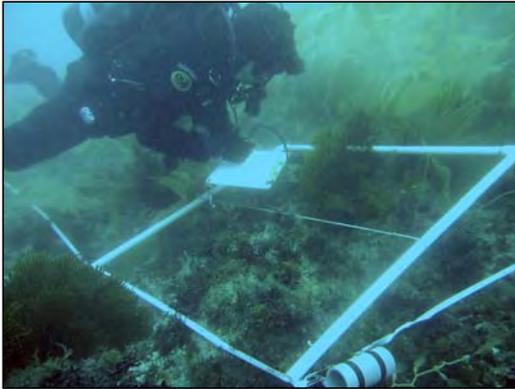
Artificial Reef Construction and Design



- This map provides a general overview of the project site and shows the locations of the two phases of the artificial reef
- Construction of Phase 1 was completed in October 1999 and consisted of 56 modules (shown as dark pink squares) that tested different bottom coverages of quarry rock and rubble concrete in a random block design that totaled 25 acres
- Information obtained from the 5-years of monitoring the Phase 1 reef was used to guide the design of the Phase 2 reef
- Phase 2 was completed in September 2008 and consisted of 18 irregularly shaped polygons (shown in green) of low relief quarry rock which totaled 150 acres
- The Phase 1 and Phase 2 reefs combined to form a 175-acre artificial reef complex, which SCE named after Wheeler North, a famous kelp forest ecologist
- The overarching goal of the 175-acre Wheeler North Reef was to mitigate for the kelp forest losses caused by SONGS

Need for remediation

Seven years of monitoring showed that the 175-acre Wheeler North Reef was too small to consistently meet the performance standards for fish standing stock and giant kelp area



In 2016 the CCC required SCE to **remediate** the Wheeler North Reef by adding up to 210 new acres of low-relief reef
(referred to as Phase 3)

- Performance monitoring of the Wheeler North Reef began in 2009
- Although results from monitoring showed that the Wheeler North Reef was performing similar to natural reefs in the region, they also showed that its 175-acre footprint was too small to consistently meet the performance standards requiring it to sustain a fish standing stock of 28 tons and 150 acres of medium-to-high density giant kelp
- As a result, in 2016 the CCC required SCE to remediate the Wheeler North Reef by adding up to 210 new acres of low-relief reef (referred to as the Phase 3 expansion reef)



- Phase 3 expansion in this map is shown as the 20 white irregular shaped polygons
- A portion of it was built inshore of the southern end of the Phase 1 & 2 reefs and the remainder built along a 4 km (2.5 mile) stretch of coast north of the Phase 1 & 2 reef
- Construction of Phase 3 was completed in July 2020
- The 20 polygons comprised 198 acres of low relief boulder reef similar in design to the Phase 2 reef
- The phase 3 expansion increased the area of Wheeler North Reef to 373 acres of low relief reef with ~ 45% cover of rock

Method for assigning mitigation credit for the performance of Wheeler North Reef was revised with reef expansion



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



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

Original method of evaluation

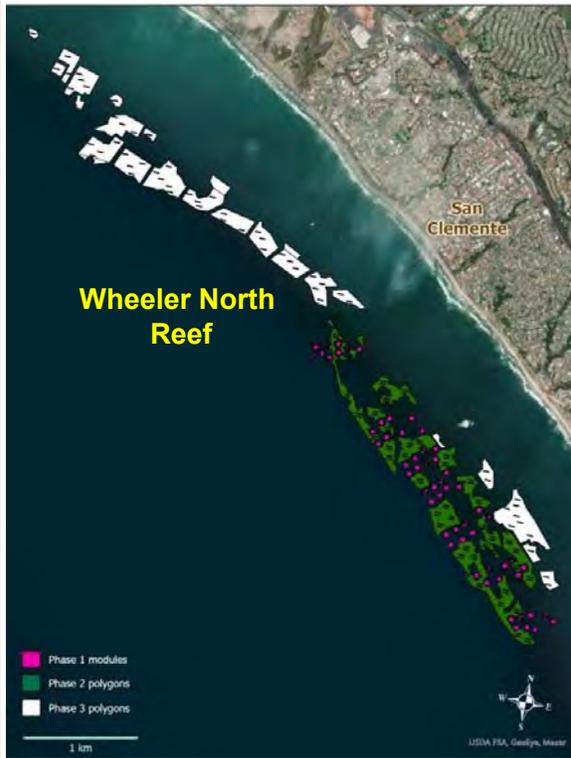
- The absolute performance standards for giant kelp area and fish standing stock must both be met in a given year for Wheeler North Reef to receive mitigation credit for that year

Revised method of evaluation

- Adult giant kelp acreage and fish standing stock at Wheeler North Reef are measured each year and each is summed over time until they reach a cumulative total equivalent to the annual target (150 kelp acres or 28 fish tons) x the number of years of SONGS operations (= 32 years)
- Accumulation of kelp acreage and fish standing stock began in 2019

- The method for assigning mitigation credit for the absolute performance standards for giant kelp area and fish standing stock were revised with the Phase 3 reef expansion
- These standards require Wheeler North Reef to sustain 150 acres of medium-to-high density giant kelp and 28 tons of reef fish standing stock.
- The intent was that the Wheeler North Reef sustain 150 acres of medium-to-high density giant kelp and 28 tons of fish for a period of time equivalent to the operating life of SONGS
- Originally, Wheeler North Reef was required to meet both of these standards in a given year for it to receive mitigation credit for that year.
- This meant that it got no mitigation credit for irrespective of whether it sustained 0 acres of kelp or 149 acres of kelp, or 0 tons of fish or 27 tons of fish.
- With the expansion of Wheeler North Reef to 373 acres the Commission changed this requirement to allow Wheeler North Reef to accumulate credit for kelp acreage and fish standing stock over time
- In this way mitigation credit for these two performance standards is summed over time until the accumulated credit for each performance standard reaches a total value equivalent to the annual target (which is 150 acres for kelp and 28 tons for fish) x the number of years of SONGS operations which the CCC determined to be 32 years
- The CCC determined that the accumulation of kelp acreage and fish standing stock would begin in 2019.

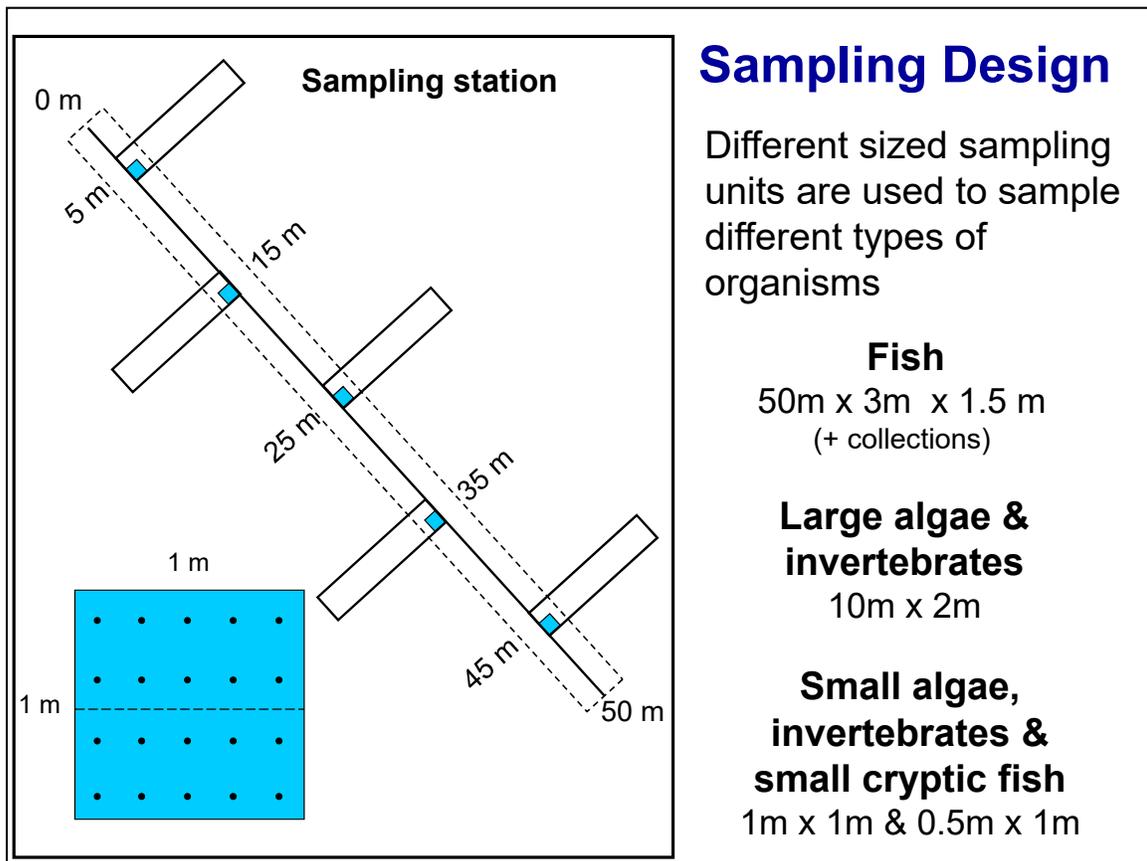
Performance Monitoring



Purpose: to determine whether the Wheeler North Reef is meeting the required project goals

Sampling Design

- 151 sampling stations (50m x 20m) broadly distributed across all three phases of Wheeler North Reef
 - n = 12 Phase 1, n = 80 Phase 2, n = 59 Phase 3
- 82 sampling stations at two reference reefs
- Each station defined by a differential GPS coordinate and a compass heading
- Each station sampled once per year in summer/autumn



- This is a schematic diagram of a sampling station at the Wheeler North Reef and the two natural reefs used as a reference
- Different sized sampling units are used to sample different performance variables
- Fish are counted and sized in 50 m x 3 m band transects outlined with the dotted line, which extends 1.5 m off the bottom.
 - In addition to transect sampling fish are collected broadly across all three reefs for the purpose of evaluating their growth, reproduction and feeding
- Adult giant kelp > 1 m tall, large understory algae, and large mobile invertebrates are counted in the five 10 m x 2 m bands positioned perpendicular to the main transect at 10 m intervals
- The % cover of invertebrates, algae and substrate is estimated using a grid of 20 points in the five 1 m x 1 m quadrats shown in blue
- Smaller mobile invertebrates and small cryptic fish are counted either in 1 m x 1 m or 1 m x 0.5 m quadrats depending on their size and abundance

Performance Standards

The SONGS coastal development permit requires the use of different types of performance standards for evaluating the success of Wheeler North Reef in meeting its mitigation goals

Types of Performance Standards

1. Relative performance standards that require Wheeler North Reef to be similar to reference sites every year
2. Absolute performance standards measured at Wheeler North Reef only that must be met every year
3. Absolute performance standards measured at Wheeler North Reef only that accumulate mitigation credit over time until a required value is met

The goal of the Wheeler North Reef is to compensate for the loss of kelp forest habitat caused by the operations of SONGS.

- A variety of physical and biological performance standards are used to determine whether this goal is met

Three types of performance standards are used to judge the success of the Wheeler North Reef in meeting its goal

- 1) Relative performance standards, that require Wheeler North Reef to be similar to reference sites every year
- 2) Absolute performance standards measured at Wheeler North Reef only that must be met every year
- 3) Absolute performance standards measured at Wheeler North Reef only that accumulate mitigation credit over time until a required value is met.
 - The mitigation requirements for these “cumulative” absolute performance standards are based on estimated losses at the San Onofre kelp bed caused by SONGS operations

Relative Performance Standards (requires 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 & boulders
- 4) Located within the local region, but not affected by SONGS

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



- Evaluating the relative performance standards requires comparing the Wheeler North Reef to natural reference reefs in the region.
- Choosing the natural reefs that are used for reference was a critical element of the mitigation project because they form the basis for determining whether Wheeler North Reef is successful in meeting its goals
- The nearby kelp forests at San Mateo and Barn were selected as reference reefs because they:
 1. have a history of sustaining giant kelp
 2. occur at a depth similar to that of the artificial reef
 3. are primarily low relief, consisting of cobbles and boulders
 4. are located within the local region

Relative Performance Standards *(must be similar to natural reference reefs)*

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 with 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 reference reef
- The biological characteristics of a reef (natural or artificial) fluctuate over time, and a 4-year running average takes this variability into account when evaluating reef performance

- The SONGS Coastal Development Permit envisioned a quantitative definition of “similar” for comparing the performance of the artificial reef to natural reefs, 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 adopted was “the 4-year running average 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 target
- Because the biological characteristics of reefs often vary from year-to-year and there is a certain amount of error associated with any type of sampling, we use the 4-year running average of the performance standard to help account for this variability

Relative Performance Standards for Wheeler North Reef

1. Macroalgal percent cover
2. Macroalgal 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
12. Undesirable and invasive species



- Shown here are the 11 relative performance standards that are used to judge the performance of Wheeler North Reef
- Standards 1-5 pertain to the benthic community of macroalgae and invertebrates
- Standards 6-10 pertain to reef fishes
- Standard 11 integrates the benthic community of macroalgae and invertebrates with reef fishes by examining the extent to which the benthic community supplies food for reef fishes
- What follows next are the results of the 2022 performance monitoring for these 11 standards

Evaluation of Relative Performance Standards *(must perform as well natural reference reefs)*

Criteria

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

- *The lone exception is the performance standard for undesirable and invasive, which must be met every year*

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

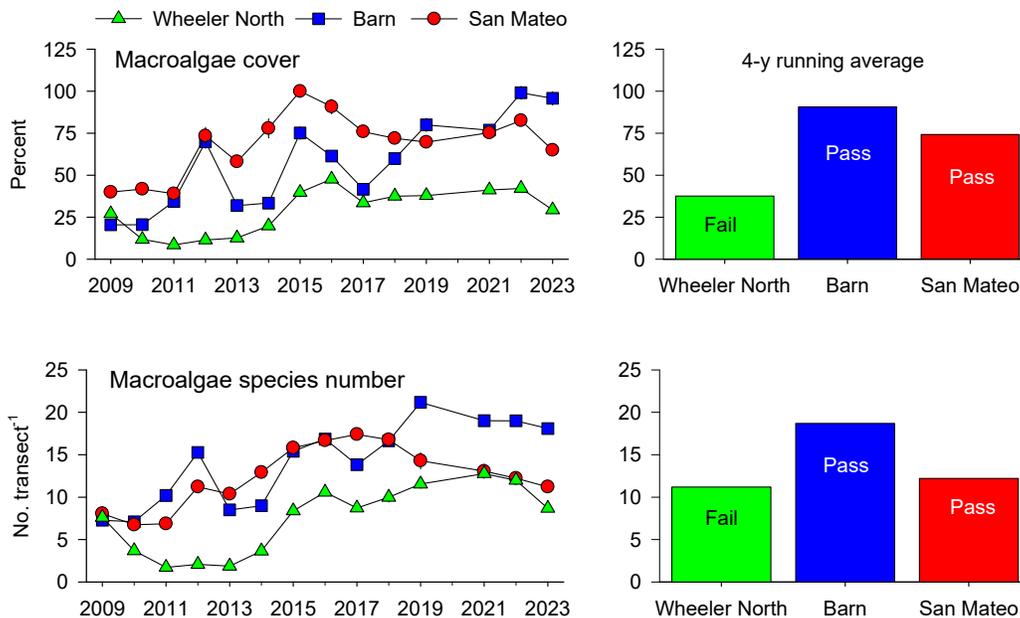
Method of Evaluation

1. Evaluate WNR and the reference reefs with respect to each other to determine whether they meet each relative performance standard
2. Tally the total number of relative standards met by each reef and compare the totals

- Because natural kelp forests vary greatly over time in their species composition and abundance, it is likely that they too would not consistently meet all the relative performance standards in a given year
- Therefore, to avoid requiring Wheeler North Reef to perform better than the reference reefs, 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 count towards mitigation credit
- *The lone exception is the performance standard for undesirable and invasive, which must be met every year*
- This approach achieves the desired goal of Wheeler North Reef being similar to natural reefs without requiring it to consistently outperform them
- The method involves evaluating the performance of the three reefs relative to each other to determine whether they meet each relative standard
- The total number of relative standards met by each reef is then tallied and compared

Performance Standards: Macroalgae

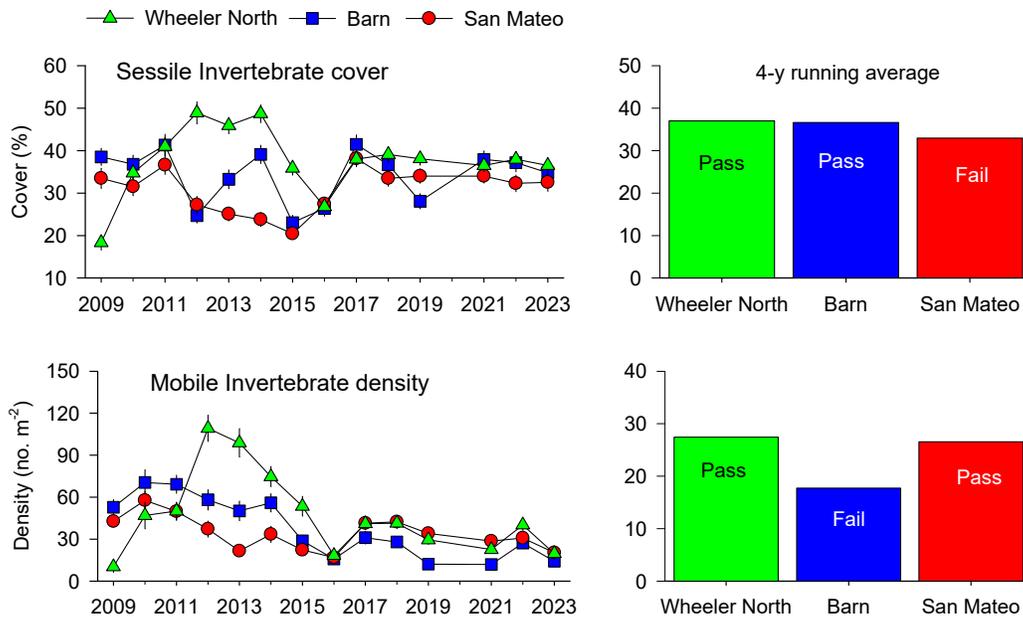
The percent cover and number of species of algae must be similar to natural reefs within the region



- In the slides that follow different colors are used for the different reefs
 - Green represents Wheeler North Reef and blue and red represent the reference reefs at Barn and San Mateo respectively
- In each slide the annual time series since 2009 is plotted on the left and a bar graph showing the average for 2019, 2021 and 2022 is plotted on the right
- The annual time series shows that percent cover and number of species of macroalgae at Wheeler North Reef has been increasing over time, but has nonetheless been consistently lower than that of nearby natural reefs
- The exceptions to this were in 2009 the year after Phase 2 was constructed and in 2021 and 2022 when the number of algal species at Wheeler North Reef was similar to San Mateo
- As such Wheeler North Reef failed both of these performance standards in 2022, while Barn and San Mateo passed them

Performance Standards: Invertebrates

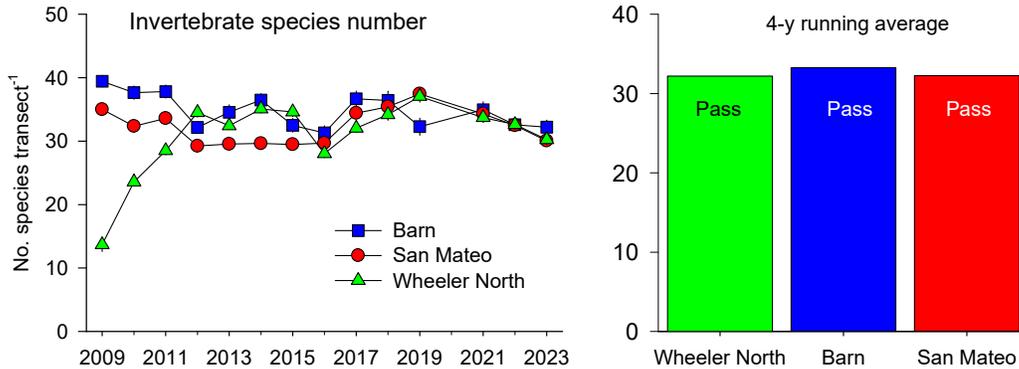
The percent cover of sessile invertebrates and the density of mobile invertebrates must be similar to natural reefs within the region



- Plotted here are data collected at Wheeler North, Barn and San Mateo reefs on the percent of the bottom covered by sessile invertebrates (top two graphs) and the abundance of mobile invertebrates (bottom two graphs)
- Sessile invertebrates compete for space on the reef with macroalgae, but instead of producing their own food via photosynthesis they feed by filtering plankton from the water column
- The percent cover of sessile invertebrates has been relatively constant and similar at all three reefs since 2016
- As a result the 4-y averages of the three reefs in 2022 were similar and all three reefs passed this performance standard
- In contrast to sessile invertebrates, mobile invertebrates consist of a wide range of grazers and predators that feed on reef associated macroalgae, detritus, sessile invertebrates and other mobile invertebrates
- With the exception of the first two years of the time series, their abundance at Wheeler North Reef has consistently been within or above the range of nearby natural reefs
- In 2022 Wheeler North Reef and San Mateo passed this performance standard while Barn failed it

Performance Standards: Invertebrates

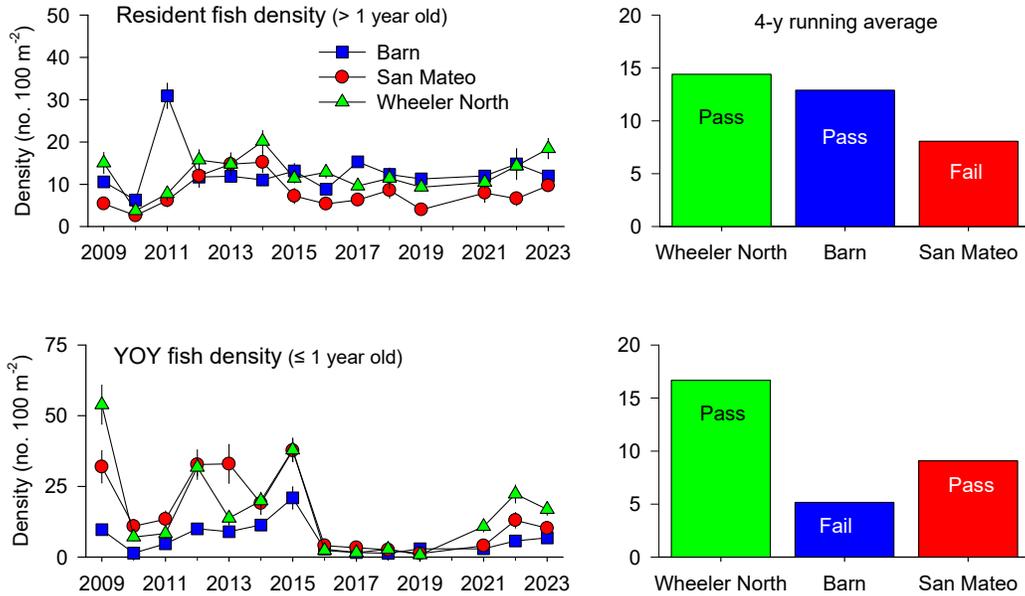
The number of species of invertebrates must be similar to natural reefs within the region



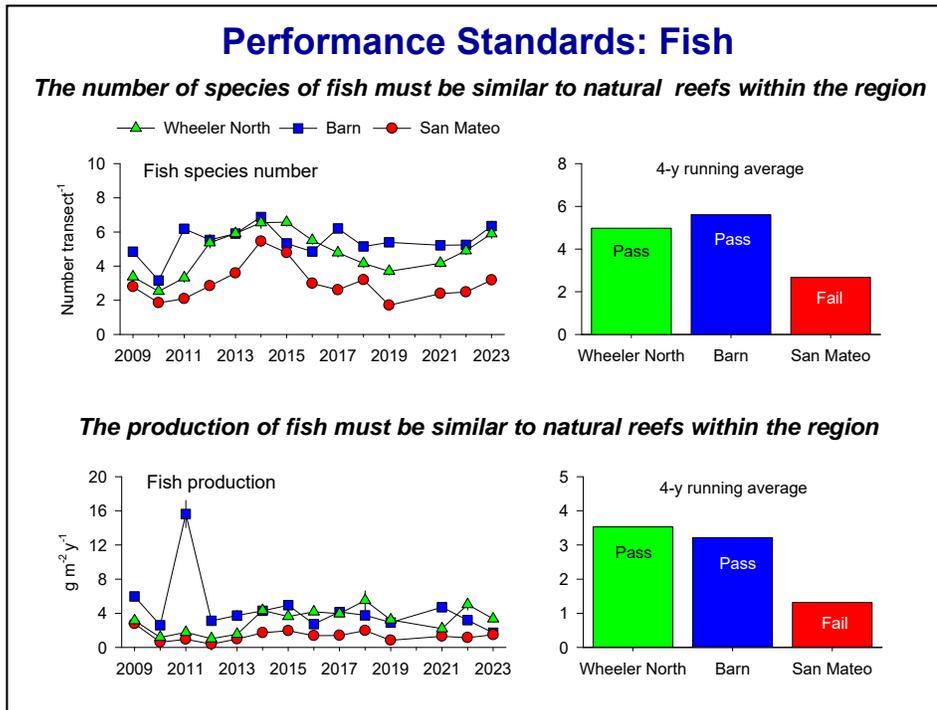
- This graph shows the mean number of species of all invertebrates (sessile + mobile) per transect at Wheeler North, Barn and San Mateo
- Comparatively, few species of invertebrates inhabited Wheeler North Reef during the first couple of years of its existence
- Since 2012 the number of species of reef invertebrates at Wheeler North Reef has been much more similar to that of nearby natural reefs
- In 2022 the 4- year running average of the number of species of invertebrates was similar at Wheeler North Reef and San Mateo, and slightly, but significantly less at Barn (due to a low value in 2019)
- Consequently, Wheeler North Reef and San Mateo passed this standard in 2002 and Barn failed it

Performance Standards: Fish

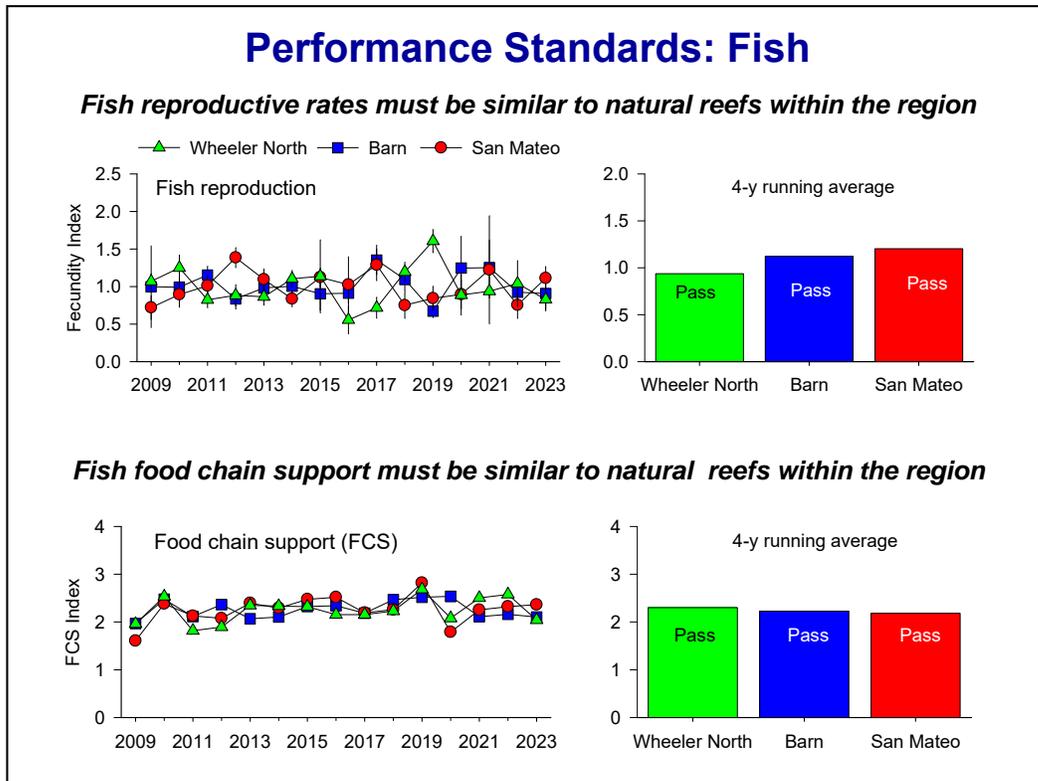
The abundances of resident and young-of-year fish (YOY) must be similar to natural reefs within the region



- Plotted here are data on the mean density of older resident fish (top 2 graphs) and newly recruited Young-of-Year reef fish (bottom 2 graphs)
- Resident fish are defined as fish > 1 year in age as determined by their size, while Young-of-Year fish are smaller fish that were born in the current year
- Densities of resident fish at all three reefs have remained relatively stable throughout the time series, especially since 2015 with the highest densities generally observed at Barn and the lowest at San Mateo
- Thus based on the most recent running average, Wheeler North Reef and Barn passed this standard while San Mateo failed it
- Densities of Young-of-Year fish fluctuated sporadically at all three reefs until 2016 when they declined dramatically at all three reefs
- YOY densities at Wheeler North Reef have consistently been within or above the range of nearby natural reefs throughout the time series
- Beginning in 2021 there has been an increasing trend in YOY abundance, especially at Wheeler North Reef and to a lesser extent San Mateo, which is reflected in the 4-year running averages
- Wheeler North Reef and San Mateo both passed this standard in 2022 while Barn failed it



- The top two graphs show the mean number of species of reef fish per transect at the Wheeler North, Barn and San Mateo reefs.
- The number of species of fish at Wheeler North Reef has consistently been within or above the range of nearby natural reefs as shown by the time series on the left
- This resulted in a 4-year average at Wheeler North Reef in 2022 that was intermediate between the two reference reefs
- In 2022 Wheeler North Reef and Barn met this performance standard and San Mateo failed it
- The bottom two graphs show the mean annual production of reef fish biomass on the left and the 4-year average for 2022 on the right
- Fish production is the amount of fish biomass produced per unit area in a given year and it takes into account both somatic and gonadal growth
- Somatic growth is estimated from the width of annual rings in the ear bones of fish, while gonadal growth is measured as the production of tissue associated with reproduction, which can be quite large
- We measure growth in five indicator species: blacksmith, señorita, black perch, the California sheephead and kelp bass
- These species were chosen because they are among the most common species of fish in the kelp forest and they represent different feeding guilds that use the reef in different ways
- Blacksmith eat plankton during the day and seek shelter on the reef at night, señorita eat plankton and small invertebrates on the reef, black perch feed on small invertebrates that live on or near the bottom, sheephead feed on larger invertebrates on the bottom, and kelp bass primarily feed on other species of fish
- Fish production has been relatively constant over the time series ranging from ~ 1- 5 g per m² of bottom per year
- The exception again being at Barn in 2011 when high production by all five species at this site caused production to spike to ~ 15 g per m² per year
- Throughout the time series fish production at Wheeler North Reef has consistently been within or above the range of the two reference reefs and its 4-y running average in 2022 was in between that of San Mateo and Barn
- In 2022 Wheeler North Reef and Barn met this performance standard and San Mateo failed it



- Plotted in the top two graphs are indices of female fecundity, which we use as a measure of fish reproductive rates
- The fecundity index represents a mean of the annual egg production scaled to female size averaged over three indicator species: kelp bass, California sheephead and seniorita
- The mean fecundity index has varied somewhat across all three reefs over the 14 years of monitoring, without any consistent trends among the reefs
- In 2022 the 4-y running average of the fecundity index was very similar at all three reefs and they all passed this performance standard
- There is also a performance standard that requires the benthic community of Wheeler North Reef to provide food for the fishes that feed on the reef at a level 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 food chain support (FCS) index has been somewhat constant over time at all three reefs with the exception of 2020 when it showed a sharp decline at San Mateo and a lesser decline at Wheeler North Reef
- This decline contributed to the 4-year running average of the FCS Index being slightly, but nonetheless significantly, lower at San Mateo than Barn or Wheeler North
- As a result Wheeler North Reef and Barn passed this performance standard in 2002 and San Mateo failed it

Performance Standard: Undesirable and invasive species (must be met every year)

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



Undesirable species that are of potential concern include:

- High density sea fans
- High density sea urchins



Invasive species that are of potential concern include:

- Non-native algae and invertebrates

Primary production by giant kelp and secondary production of reef fishes are the important reef functions used to evaluate this standard

- The relative performance standard that must be met every year for Wheeler North Reef to receive mitigation credit requires that its important ecological functions not be impaired by undesirable or invasive benthic species
- Native species can become “undesirable” if they become so abundant that they impair important functions of the reef
- Two examples of this are dense aggregations of sea fans that can monopolize space and exclude other species including giant kelp, and high densities of sea urchins that can intensively graze the bottom and create large deforested areas commonly called “sea urchin barrens”
- Invasive species are non-native species that become abundant and displace native species or otherwise harm important reef attributes and functions.
- Two non-native species that are known to be invasive in southern CA are the green alga *Caulerpa prolifera* and the brown alga *Sargassum horneri*
- Primary production by macroalgae and secondary production by reef fishes are two important functions of reefs that we use to evaluate this performance standard
- We are using data on the density of giant kelp fronds to estimate the net primary production of giant kelp and data on the growth, reproduction and biomass of 5 indicator species of reef fish to estimate the secondary production of reef fish

Method used to evaluate impairment of reef functions by undesirable and invasive species

1. Measure the abundance of undesirable and invasive species at Wheeler North Reef relative to the reference reefs to determine their potential to impair important reef functions
2. Compare the production of giant kelp and fish at Wheeler North Reef relative to the reference reefs to determine whether these functions at Wheeler North Reef are underperforming relative to the reference reefs
3. If the production of giant kelp and fish at Wheeler North Reef are underperforming, then complete additional analyses/studies to determine whether underperformance is caused by impairment from undesirable and invasive species

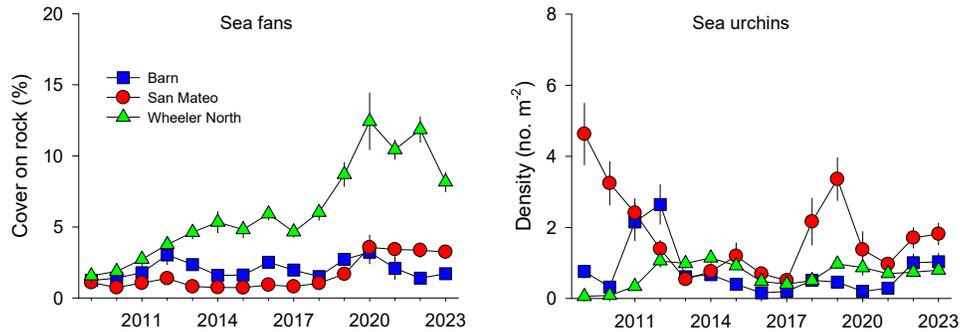


The method used to evaluate impairment of reef functions by undesirable and invasive species is a three-step process

1. Measure the abundance of undesirable and invasive species at Wheeler North Reef relative to the reference reefs to determine their potential to impair important reef functions
2. Compare the production of giant kelp and fish at Wheeler North Reef relative to the reference reefs to determine whether these functions at Wheeler North Reef are underperforming relative to the reference reefs
3. If the production of giant kelp and fish at Wheeler North Reef are underperforming, then complete additional analyses/studies to determine whether underperformance is caused by impairment from undesirable and invasive species

Thus we begin the evaluation of this performance standard by looking at the abundances of undesirable and invasive species at Wheeler North Reef and the reference reefs

Abundances of Undesirable & Invasive Species



- The percent cover of sea fans has been consistently higher at Wheeler North Reef compared to the reference reefs
 - *Potential concern for impairment of important reef functions by sea fans*
- The density of sea urchins at Wheeler North Reef has been consistently low (< 1 m⁻²)
 - *Little concern at this time for the impairment of important reef functions by sea urchins*
- Invasive, non-native species have not been observed at Wheeler North Reef
 - *No concern at this time for the impairment of important reef functions by invasive non-native species*

- When examining this first step in the evaluation process we see that the percent cover of sea fans has been increasing disproportionately more at Wheeler North Reef compared to the reference reefs, raising a potential concern that sea fans could impair important reef functions
- In contrast, the average density of sea urchins at Wheeler North Reef has remained relative low near ~1 per m² since 2012.
- This low density is far below the threshold of 20-30 urchins per m² that is known to convert kelp forested reefs to barren areas
- Consequently, there is little concern that sea urchins are impairing the important functions of Wheeler North Reef at this time
- Lastly, no invasive non-native algae were observed at Wheeler North Reef in 2022 so there is no reason for concern that they are impairing important reef functions at this time

Method used to evaluate impairment of reef functions by undesirable and invasive species

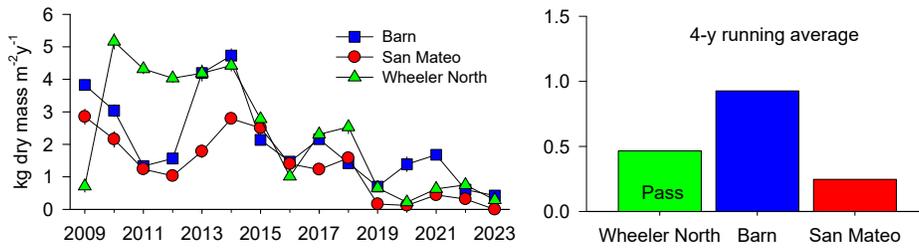
1. Measure the abundance of undesirable and invasive species at Wheeler North Reef relative to the reference reefs to determine whether they have a potential to impair important reef functions
2. Compare the production of giant kelp and fish at Wheeler North Reef relative to the reference reefs to determine whether these functions at Wheeler North Reef are underperforming relative to the reference reefs
3. If the production of giant kelp and fish at Wheeler North Reef are underperforming, then complete additional analyses/studies to determine whether underperformance is caused by impairment from undesirable and invasive species



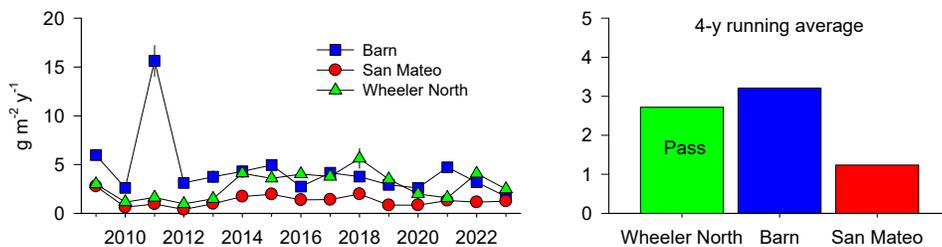
The second step in evaluating whether dense aggregations of sea fans impairs the functions of Wheeler North Reef involves comparing these functions at Wheeler North Reef to those measured at the reference reefs

Performance of important reef functions

Giant kelp primary production



Fish secondary production



The important functions of Wheeler North Reef are within the range of the reference reefs

- In the case of giant kelp primary production we find that the level of this important reef function at Wheeler North Reef has consistently been within the range or higher than that of the reference reefs in all but 2009, which was the first year after the construction of the Phase 2 reef
- Reef fish production at Wheeler North Reef has also consistently been within the range of the two reference reefs throughout the time series
- Recall that this performance standard is evaluated using data from either the current year or the 4-year running average, whichever is higher
- The value for Wheeler North Reef in 2022 whether using the current year or the 4-year running average was within the range of the reference reefs

Performance Standard: Undesirable and invasive species
(*must be met every year*)

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

Conclusion: PASS

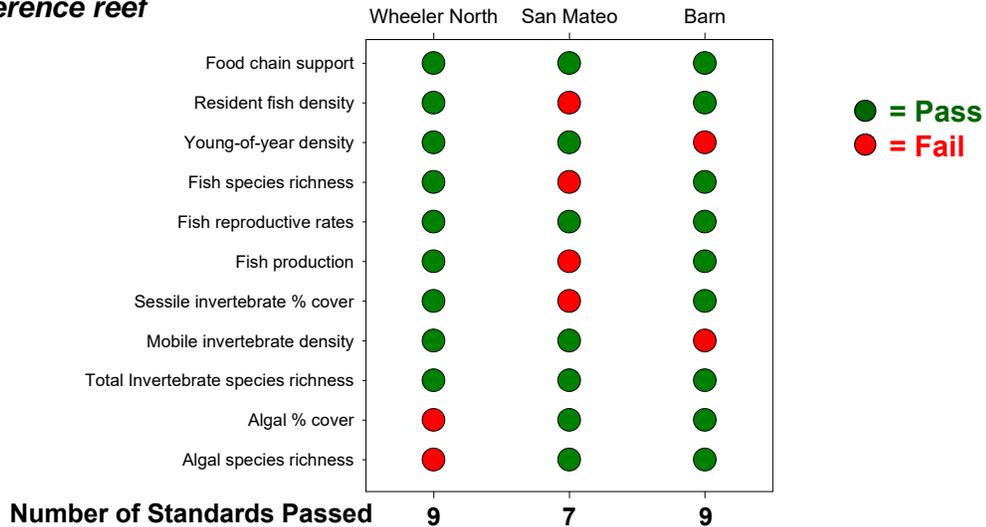
- No compelling evidence that *undesirable* native species or *invasive* non-native species impaired important functions of Wheeler North Reef in 2023
- We will continue to closely monitor the abundance of sea fans and their potential impact on the primary production of giant kelp and the secondary production of reef fish



- We conclude from these analyses that there is no compelling evidence that undesirable native species or invasive non-native species impaired important functions of Wheeler North Reef in 2022
- Therefore Wheeler North Reef met the performance standard for undesirable and invasive species
- Nonetheless, due to their increasing abundance we will continue to closely monitor sea fans and their potential impact on the primary production of giant kelp and the secondary production of reef fish

2023 Summary of relative performance standards

✓ **Wheeler North Reef met more standards than the lowest performing reference reef**



✓ **Wheeler North Reef met the standard for undesirable and invasive species**

Wheeler North Reef met the mitigation requirement for the relative performance standards in 2023

- This slide summarizes the number of relative standards met by Wheeler North Reef and the two reference reefs (San Mateo and Barn) in 2022
- The monitoring results show that Wheeler North Reef met 9 of the 11 relative standards in 2022, which was one more than the number of standards met by Barn and 2 more than that met by San Mateo, the lower performing of the two reference reefs in 2022
- Based on these results we conclude that the ecological resources and functions provided by Wheeler North Reef in 2022 were *similar* to those provided by nearby natural reefs
- Therefore, Wheeler North Reef met the collective mitigation requirement for the relative performance standards in 2022

Absolute performance standard that must be met every year

(measured at Wheeler North Reef only)



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

Method of evaluation

The evaluation of each standard is based on the value measured for the current year, or the 4-year running average (calculated from the current year and the previous three years), *whichever is higher*.

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

1. The performance standard for hard substrate requires at least 90% of the exposed rock initially present on the Phase 1 and 2 Wheeler North Reef remain available for the attachment by reef biota
2. The performance standard for invasive species requires that Wheeler North Reef shall not be impaired by undesirable or invasive benthic species

The evaluation of each of these standards is based on the value measured at the Phase 1 and 2 Wheeler North Reef for the current year, or the 4-year running average (calculated from the current year and the previous three years), which ever is higher

Method used to measure the Area of Hard Substrate

1. Measure footprint area (A) of Wheeler North Reef (Phases I + 2) in sonar surveys
2. Measure percent cover of exposed rock (P)
3. Calculate area of exposed rock as $A \times P$
4. Compare area of exposed rock to that measured shortly after reef construction in 2009 to determine whether 90% or more is still available for reef biota



9 Substrate categories:

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

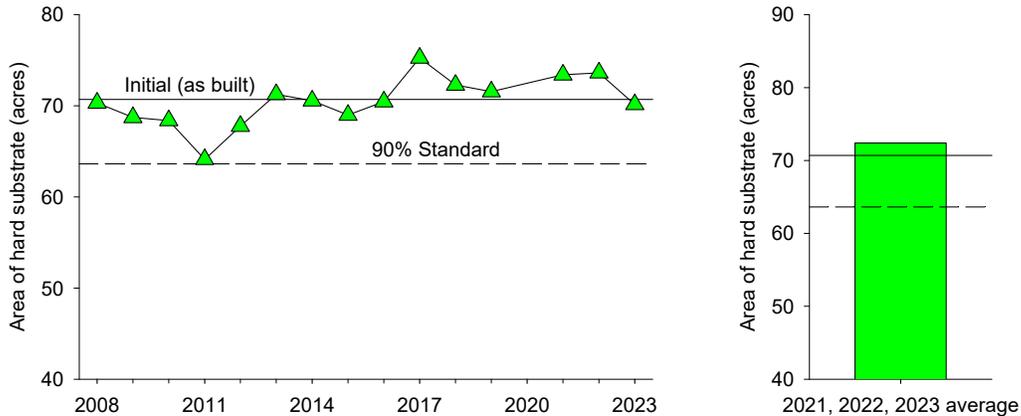
The performance standard for hard substrate is evaluated in the following way:

- Multi-beam sonar is used to measure the combined footprint area (A) of Phase 1 and 2 of Wheeler North Reef once every 5 years
- Divers estimate the percent cover of exposed rock (P) in five 1 m^2 quadrats on the 82 transects distributed across Phase 1 and 2 of Wheeler North Reef.
- The product $A \times P$ is the estimate of the area of exposed hard substrate
- We compare this estimate to that obtained immediately following construction of Phase 2 of Wheeler North Reef
- The SONGS coastal development permit requires that this amount not fall below 90% of what was available immediately after the reef was constructed
- Divers collect percent cover data for nine different types of bottom substrate
- The five categories of bottom substrates outlined in the green box are those that constitute hard substrate in our analyses

Performance Standard: Hard Substrate

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

PASS



- Plotted here is an annual time series of the total area of exposed hard substrate at Wheeler North Reef (left) and the 4 year average for 2022 (right)
- The annual time series shows that at least 90% of the initial area of exposed hard substrate on the Phase 1 and 2 Wheeler North Reef has remained available every year since the Phase 2 reef was constructed
- Annual values greater than the initial as-built in some years likely reflect scouring and/or redistribution of reef material that resulted in an increase in the total area of exposed hard substrate
- Wheeler North Reef met this performance standard in 2022 as both the annual value and the 4-year average were greater than the as-built condition and thus exceeded the 90% threshold

Absolute performance standards that accumulate mitigation credit on an annual basis



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



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

Method of evaluation

- The annual standing stock of fish and acreage of giant kelp at Wheeler North Reef are measured each year and summed over time until they reach a cumulative total equivalent to the annual target x the number of years of SONGS operations (= 32 years)
- Accumulation of kelp acreage and fish standing stock began in 2019

Unlike the absolute performance standards for hard substrate and invasive species that must be met each year, the absolute standards pertaining to giant kelp area and fish standing stock are evaluated on a cumulative basis and Wheeler North Reef receives partial credit for these standards each year

1. The performance standard for giant kelp is based on the intent that Wheeler North Reef sustain 150 acres of medium-to-high density giant kelp for a period of time equivalent to the operating life of SONGS
 2. Similarly, the performance standard for fish standing stock is based on the intent that Wheeler North Reef sustain a fish standing stock of at least 28 tons for a period of time equivalent to the operating life of SONGS
- Mitigation credit for these two performance standards is summed over time until the accumulated credit for each performance standard reaches a total value equivalent to the annual target (which is 150 acres for kelp and 28 tons for fish) x the number of years of SONGS operations which was defined by the CCC to be 32 years
 - The CCC determined that the accumulation of kelp acreage and fish standing stock would begin in 2019

Methods used to estimate the area of medium-to-high density of adult giant kelp

Divers record the density of adult giant kelp in a fixed 100 m² area of each transect at Wheeler North Reef (n = 151 transects)

- medium-to-high density is defined as > 4 adults per 100 m²
- adults are defined as individuals with > 7 fronds



Acres of medium-to-high density adult kelp = $P \times 373$ acres

where:

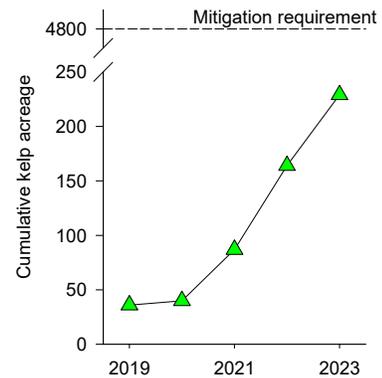
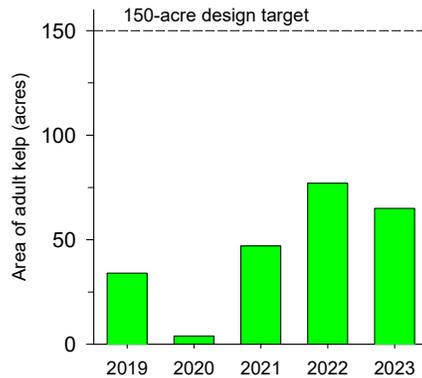
P = proportion of transects with > 4 adult plants, and

373 = footprint area of Wheeler North Reef in acres based on the most recent sonar survey

- The performance standard for giant kelp is evaluated by measuring the density of giant kelp in 151 fixed transects across all three phases of Wheeler North Reef
 - medium-to-high density is defined as > 4 adults per 100 m²
 - adults are defined as individuals with > 7 fronds
- Using these data we calculate the proportion of transects at Wheeler North Reef that have a density of adult kelp > 4 plants per 100 m²
- This proportion is multiplied by 373 acres (= the combined footprint area of Phases 1, 2 and 3 of Wheeler North Reef measured in the most recent sonar survey) to obtain the total acreage of adult kelp at Wheeler North Reef.

Performance Standard: Giant Kelp

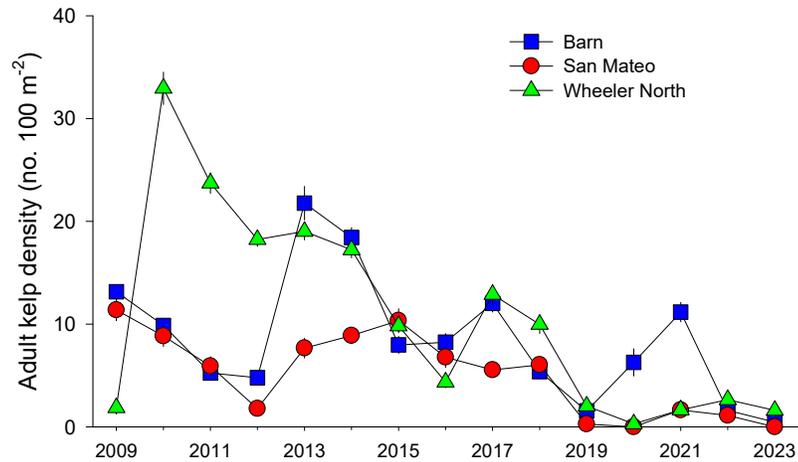
Reef design: Average 150 acres of medium-to-high density adult giant kelp for a minimum of 32 years



Wheeler North Reef earned mitigation credit for 65 acres of medium-to-high density adult giant kelp in 2023 resulting in a cumulative total of 229 acres

- This graph shows the area of medium-to-high density adult giant kelp supported by Wheeler North Reef since 2019, which is the first year that mitigation credit for the cumulative performance standards went into effect
- In 2022 Wheeler North Reef earned 77 acres of credit for sustaining medium-to-high density giant kelp, which is more than it supported in the previous three years
- When added to the previous three years, Wheeler North Reef has accumulated a total of 164 acres of medium-to-high density adult giant kelp
- While the area of kelp recorded in 2022 was greater than that recorded in the previous three years it is substantially below the 150-acre design target, which could be reason for concern

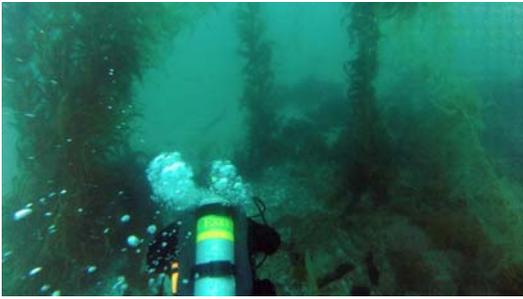
Area of adult giant kelp at Wheeler North Reef compared to natural reference reefs



The density of adult kelp at Wheeler North Reef has typically been *within or above* the range of nearby reference reefs

- Comparison of temporal changes in kelp area at nearby natural reefs provides insight into whether the low kelp acreage is specific to Wheeler North Reef or more characteristic of the region
- The data plotted in this graph show that since 2010 the Wheeler North Reef has typically supported as much or more adult kelp per unit area as nearby natural reference reefs
- The general decline in giant kelp observed at Wheeler North Reef since 2017 was also observed at Barn and San Mateo

Methods used to evaluate the standing stock of reef fish



1. Apply species-specific length-weight relationships to fish density and size data collected by divers to calculate the average biomass density (g m^{-2} reef) of all fish near the bottom from all transects.

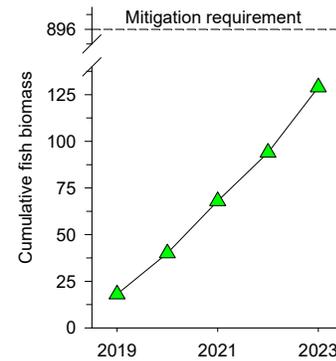
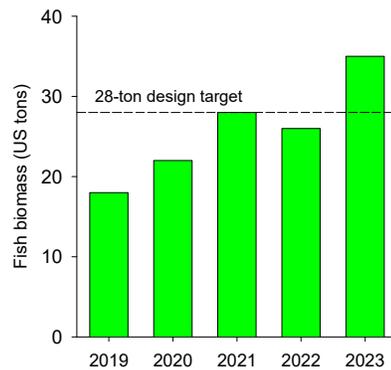


2. Scale up estimates of fish biomass m^{-2} to the footprint area of Wheeler North Reef (= 373 acres) to obtain an estimate of the standing stock of fish near the bottom at Wheeler North Reef.

- Data on fish density and length collected from the 151 transects distributed across the 3 phases of Wheeler North Reef are used to calculate the total standing stock of reef associated fish near the bottom
- The weights of the fish counted are estimated from known relationships between length and weight for each species
- The weights of all fish counted on a transect are summed to obtain an estimate of fish biomass density for each transect in units of grams per m^2 of reef
- The biomass density of fish is averaged over all transects in a polygon and multiplied by the area of the polygon to obtain an estimate of the biomass of fish in each polygon
- The biomass of fish in each polygon is summed to obtain an estimate of the standing stock of fish near the bottom on the 373-acre Wheeler North Reef

Performance Standard: Fish Standing Stock

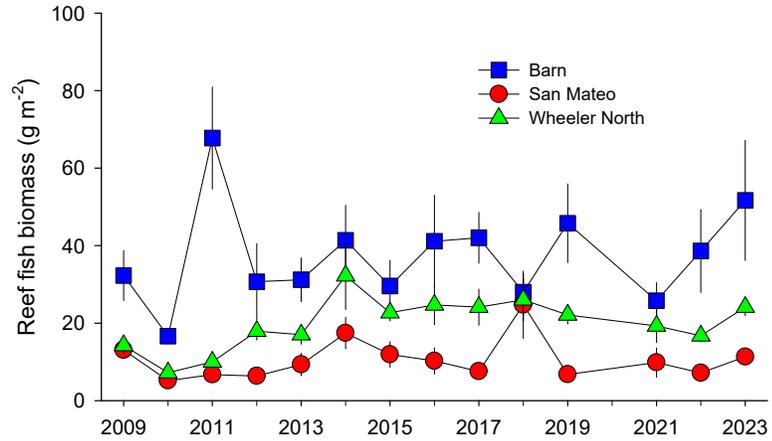
Reef design: support a standing stock of fish that averages at least 28 tons for 32 years



Wheeler North Reef earned mitigation credit for 35 tons of fish standing stock in 2023 resulting in a cumulative total of 129 tons of fish standing stock

- Shown here is annual standing stock of reef fish on Wheeler North Reef since 2019
- Wheeler North Reef earned 26 tons of credit for its fish standing stock in 2022, which is just below the 28-ton design target achieved in 2021
- Wheeler North Reef has accumulated mitigation credit for 94 tons of fish standing stock since 2019, which is still far below the mitigation requirement of 896 tons

Fish biomass at Wheeler North Reef compared to natural reference reefs



Fish biomass density at Wheeler North Reef has been consistently within the range of nearby natural reefs

- Its worth noting that the biomass density of fish at Wheeler North Reef has been consistently *within the range* of nearby natural reefs, lower than Barn but higher than San Mateo
- This suggests that the standing stock of fish at Wheeler North Reef is within the range of a natural reef of comparable size

SONGS Reef Mitigation Requirements

Assignment of mitigation credit

➤ ***Relative performance standards and the absolute performance standard that must be met every year***

- One year of mitigation credit is given for each year that Wheeler North Reef meets both of these types of performance standards
- Fulfillment of this 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 (= 32 years)

➤ ***Absolute performance standards that accumulate mitigation credit over time (i.e., giant kelp area and fish standing stock)***

- Giant kelp and fish standing stock are separately evaluated and assigned mitigation credit
- Fulfillment of these mitigation requirements occurs when the total accrued mitigation credit for each standard equals the targeted annual value (= 150 acres of kelp or 28 tons of fish) x the total years of operation of SONGS Units 2 & 3 (= 32 years)

- 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, which lasted for 32 years
- One year of mitigation credit is given for each year that Wheeler North Reef meets the collective group of relative performance standards and the absolute standards pertaining to hard substrate and undesirable/invasive species
- Fulfillment of the mitigation requirement for these performance standards occurs when the number of years of mitigation credit accrued by Wheeler North Reef equals the total years of operation of SONGS Units 2 & 3 (= 32 years)
- Unlike the other performance standards the absolute performance standards for giant kelp area and fish standing stock accrue mitigation credit over time independently of the other performance standards
- Fulfillment of the mitigation requirements for these performance standards occurs when the total amount of credit accrued equals the targeted annual value (= 150 acres in the case of giant kelp and 28 tons in the case of fish standing stock) x the total years of operation of SONGS Units 2 & 3 (= 32 years)

2023 Summary of earned mitigation credit

(assignment of mitigation credit began in 2019)

Performance Standards that must be met every year

(Relative standards and absolute standard for hard substrate,)

Credit earned in 2023	Yes
Years of credit earned since 2019	5
Years of credit required	32
Years of credit still needed	27

Performance Standards that accumulate credit over time

	2023 credit	Cumulative credit	Credit required	Credit needed
Giant kelp area	65 acres	229 acres	4800 acres	4571 acres
Fish standing stock	35 tons	129 tons	896 tons	767 tons

- Shown here is a summary of project compliance for the SONGS reef mitigation project
- In 2022 Wheeler North Reef earned 1 year of credit for meeting the collective group of relative standards and the absolute standards for hard substrate and invasive species
- It has earned a total of 4 years of mitigation credit for these performance standards and needs another 28 years of credit for this mitigation requirement to be met
- In 2022 Wheeler North Reef earned credit for 77 acres of giant kelp for a cumulative credit of 164 of the 4,800 acres of giant kelp required for the giant kelp performance standard
- An additional 4,636 kelp acres is needed before the mitigation requirement for the giant kelp performance standard is met
- In 2022 Wheeler North Reef earned credit for 26 tons of fish standing stock for a cumulative credit of 94 tons
- It needs to earn an additional 802 fish tons of mitigation credit before the mitigation requirement for the fish standing stock performance standard is met

Provisions in the SONGS' coastal development permit for reduced monitoring of Wheeler North Reef

Condition C. Kelp Reef Mitigation

Upon completion of **ten years of independent monitoring** that demonstrate the mitigation reef is in compliance of the performance standards, the permittee shall be fully responsible for funding independent **annual site inspections**, which will serve to identify any noncompliance with the performance standards.

Condition D. Administrative Structure

The mitigation projects will be successful when all performance standards have been **met each year for a three-year period**. If the Commission determines that the performance standards have been met and the project is successful, the monitoring program will be scaled down, as recommended by the Executive Director and approved by the Commission.

Wheeler North Reef has been monitored for > 10 years and has met all the performance standards for > 3 consecutive years

Annual site inspections will begin in 2024

- There are provisions in the SONGS' coastal development permit to reduce the level of monitoring to annual site inspections once the Wheeler North Reef has demonstrated that it has successfully met the performance standards.
- Specifically, Condition C of the permit pertaining to kelp reef mitigation states that after 10 years of monitoring that demonstrate the artificial reef is meeting the performance standards monitoring shall be reduced to annual site inspections that serve to identify whether the performance standards are being met
- Condition D states that monitoring will be scaled down after all the performance standards have been met each year for a three-year period
- Wheeler North Reef has been monitored for more than 10 years and has met all of the performance standards for more than three consecutive years. Therefore, annual site inspections will begin in 2024.

Assessment of similarity using full monitoring vs. annual site inspections

Full monitoring

Uses inferential statistics to compare performance variables to determine whether Wheeler North Reef is similar to the reference reefs

- sampling effort of the relative performance variables was designed to detect a 20% difference between reefs (effect size = 0.2) with 80% statistical power using a Type I error (α) = 0.2

Annual site inspections

Compares mean values of performance variables without inferential statistics to determine whether Wheeler North Reef is similar to the reference reefs

- based on historical performance, sampling effort of the relative performance variables was designed to “identify any noncompliance with the performance standards”, but with substantially reduced monitoring and associated costs

- Given the reduction, we wanted to test whether we would identify or misidentify departure in the past. That data and the outcomes from the reduced monitoring approach show they are comparable to the full monitoring analytical approach
- The full monitoring approach uses inferential statistics to compare performance variables to determine whether Wheeler North Reef is similar to the reference reefs. The sampling effort of the relative performance variables was designed to detect a 20% difference between reefs (effect size = 0.2) with 80% statistical power using a Type I error (α) = 0.2.
- In contrast, the reducing sampling approached for annual site inspections compares mean values of performance variables without inferential statistics to determine whether Wheeler North Reef is similar to the reference reefs. The sampling effort of the relative performance variables was designed to “identify any noncompliance with the performance standards”, but with substantially reduced monitoring and associated cost. This approach involves accepting less assurance of correctly determining whether two values are truly similar.

Annual site inspections for relative performance standards

Comparison of sampling effort between full monitoring vs. reduced monitoring of annual site inspections

Type of Performance Standard	Monitoring effort per reef		Amount Reduced
	<i>Full</i>	<i>Reduced</i>	
Relative: transect data (WNR, SM, B)			
9 standards	82	15	82%
Undesirable & invasive species	151 (WNR), 82 (SM, B)	111 (WNR), 15 (SM, B)	55%
Relative: fish collections (WNR, SM, B)			
Fish production	100 of 5 species	0 (measured by proxy)	100%
Fish reproduction	100 of 4 species	50 of 2 species	75%
Fish food chain support	100 of 2 species	50 of 2 species	50%

WNR = Wheeler North Reef, SM = San Mateo, B = Barn

- This table shows the comparison of sampling effort between full monitoring and the reduced sampling approach developed for annual site inspections for the relative performance standards.
- For nine of the relative standards currently collected on transects, sampling will be reduced from 82 to 15 transects, which is an 82% reduction.
- The undesirable and invasive species standard will be reduced from 151 to 111 transects on WNR and from 82 to 15 transects on the reference reefs, which is a 55% reduction.
- For the relative standards currently collected via fish collections, fish production will no longer incorporate fish collection under reduced sampling and will instead be measured by a proxy (fish biomass density), which represents a 100% reduction.
- For fish reproduction and fish food chain support, we will reduce the number of individuals and species of fish collected, representing a 75% reduction for fish reproduction and a 50% reduction for fish food chain support.

Comparison of “Relative Performance” Full monitoring vs. reduced monitoring

Analyses based on 11 relative performance standards*

Year	Wheeler North		San Mateo		Barn		Red = lowest performing reef
	Full monitoring	Reduced monitoring	Full monitoring	Reduced monitoring	Full monitoring	Reduced monitoring	
2012	8	8	6	5	10	9	
2013	7	8	6	5	10	9	
2014	8	8	5	5	10	10	
2015	9	7	6	5	9	10	
2016	9	8	6	5	9	9	
2017	9	7	5	5	10	10	
2018	8	7	8	6	9	9	
2019	8	6	8	7	10	9	
2020	9	7	7	6	10	9	
2021	9	9	7	4	10	9	
# years not the lowest	10	9	2	1	10	10	

**the relative standard for undesirable and invasive species was not included in this analysis because it must be met each year for Wheeler North Reef to receive mitigation credit for that year*

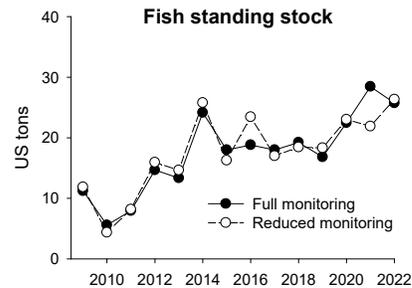
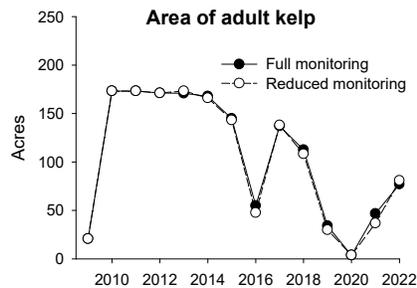
Estimates of similarity based on reduced monitoring are comparable with those based on full monitoring

- This table compares the reef-level outcomes for 11 of the relative performance standards using the full and reduced monitoring approaches for the monitoring data collected on all three reefs from 2009 to 2021.
 - The relative standard for undesirable and invasive species was not included in this analysis because it must be met each year for Wheeler North Reef to receive mitigation credit for that year.
- Numbers in columns are the number of performance standards passed by a reef in that year for full monitoring (left) and reduced monitoring (right).
- Green numbers mean a reef met as many or more standards as the lower performing reef used for reference (i.e., it was “similar”)
- Red numbers mean a reef met fewer standards than the lower performing reef used for reference (i.e., it was “dissimilar”)
- Overall, estimates of similarity based on reduced monitoring are comparable with those based on full monitoring.

Reduced monitoring for absolute performance standards

Eliminate one of the transects in each of the 40 pairs on Phase 2

Type of Performance Standard	Monitoring effort per reef		Amount Reduced
	Full	Reduced	
Absolute: transect data (WNR only)			
Hard substrate	82	42	48%
Kelp area	151	111	26%
Fish standing stock	151	111	26%



Estimates of adult kelp area and fish standing stock based on reduced monitoring are comparable with those based on full monitoring

- This table shows the comparison of sampling effort between full monitoring and the reduced sampling approach developed for annual site inspections for the absolute performance standards, which are all collected on transects.
- For the hard substrate standard, sampling will be reduced from 82 to 42 transects, which is a 48% reduction.
- For the kelp area and fish standing stock standards, sampling will be reduced from 151 to 111 transects, which is a 26% reduction.
- The bottom two figures show that estimates of adult kelp area and fish standing stock based on reduced monitoring (open circles) are comparable with those based on full monitoring (black circles).

Plans for future monitoring of Wheeler North Reef

- Begin reduced monitoring for annual site inspections in **2024**
- Return to full monitoring if:
 1. Wheeler North Reef fails to meet as many relative performance standards as the lowest performing reference reef,
and
 2. the reason for Wheeler North Reef's failure is not associated with reduced monitoring



- Moving forward, reduced monitoring for annual site inspections will begin in **2024**
- The project will return to full monitoring if:
 - Wheeler North Reef fails to meet as many relative performance standards as the lowest performing reference reef and
 - the reason for Wheeler North Reef's failure is not due to lower confidence associated with reduced monitoring and instead, a true difference among the reefs.