



Power Analysis of the Intertidal Monitoring Programs at Channel Islands National Park and the Bureau of Ocean Energy Management

Natural Resource Report NPS/MEDN/NRR—2018/1661



ON THE COVER

Researchers sampling the intertidal area at Government Point.
Photo by DAVID LOHSE

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May 2018

U.S. Department of the Interior
National Park Service
Natural Resource Stewardship and Science
Fort Collins, Colorado

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Please cite this publication as:

Raimondi, P. T., K. Ammann, L. Gilbane, S. Whitaker, and S. Ostermann-Kelm. 2018. Power analysis of the intertidal monitoring programs at Channel Islands National Park and the Bureau of Ocean Energy Management. Natural Resource Report NPS/MEDN/NRR—2018/1661. National Park Service, Fort Collins, Colorado.

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Executive Summary

The rocky shores of the west coast of North America are home to dynamic, highly diverse biological communities that are subject to dramatic changes due to natural phenomena and human activity. Channel Islands National Park (CHIS) and the Bureau of Ocean Energy Management (BOEM) have responsibilities to monitor biological resources on rocky shores in adjacent areas of southern California, predominantly within and surrounding the Santa Barbara Channel (Figure 1). For over 20 years, CHIS and BOEM have been committed to a partnership through the Multi-Agency Rocky Intertidal Network (MARINe) to monitor rocky shore biological resources using the same methods and to share data and goals. Periodic assessment of program protocols and sampling designs is required by CHIS and BOEM to ensure that they meet benchmark goals. This report is a statistical assessment of both agencies' rocky intertidal monitoring programs.

MARINe is a partnership of federal, state, and local government agencies in collaboration with many nonprofit groups, universities, and volunteers committed to the long-term study of selected rocky intertidal species primarily in California, Oregon, and Washington. Established in 1997, MARINe conducts long-term monitoring at more than 116 locations along the northeast Pacific coast from Alaska to Baja California, Mexico. Protocols were adopted from the CHIS Rocky Intertidal Monitoring Program, which was initiated in 1982 to assess seasonal and annual changes in populations of intertidal organisms as a result of natural and anthropogenic influences within the five northern Channel Islands offshore of California. Over 20 years later, both BOEM, CHIS, and 15 other groups collecting data all follow identical field protocols and share data publicly as a part of MARINe.

Monitoring along the mainland of Santa Barbara County, California, began in 1991 with a project funded jointly by the BOEM, formerly the Minerals Management Service, and the County of Santa Barbara. The priority for BOEM monitoring has always been to document baseline conditions of rocky intertidal biological resources to assess possible injury from an oil spill or chronic oil and gas activity in state and federal waters.

Results from power analyses indicate that CHIS and BOEM protocols are meeting individual program goals. In other words, both programs have sufficient power to detect relatively small changes in populations of targeted organisms with current levels (biannual sampling) of survey effort. Moreover, given the extensive temporal scales of the two datasets, analyses revealed that it is possible for both programs to reduce survey effort by half (annual sampling) and experience minimal losses in power to detect significant population impacts.

Analyses were performed independently for the two programs and therefore each is presented separately in this report. In the face of budget cuts requiring reduced staffing and impaired ability to access sites, as well as the desire to implement additional protocols designed to supplement current data collection, CHIS and BOEM independently proposed several options to reduce program costs. These proposals and questions regarding consequences and benefits of modifying temporal and spatial sampling designs are addressed in individual Conclusions and Recommendations sections for the two agencies.

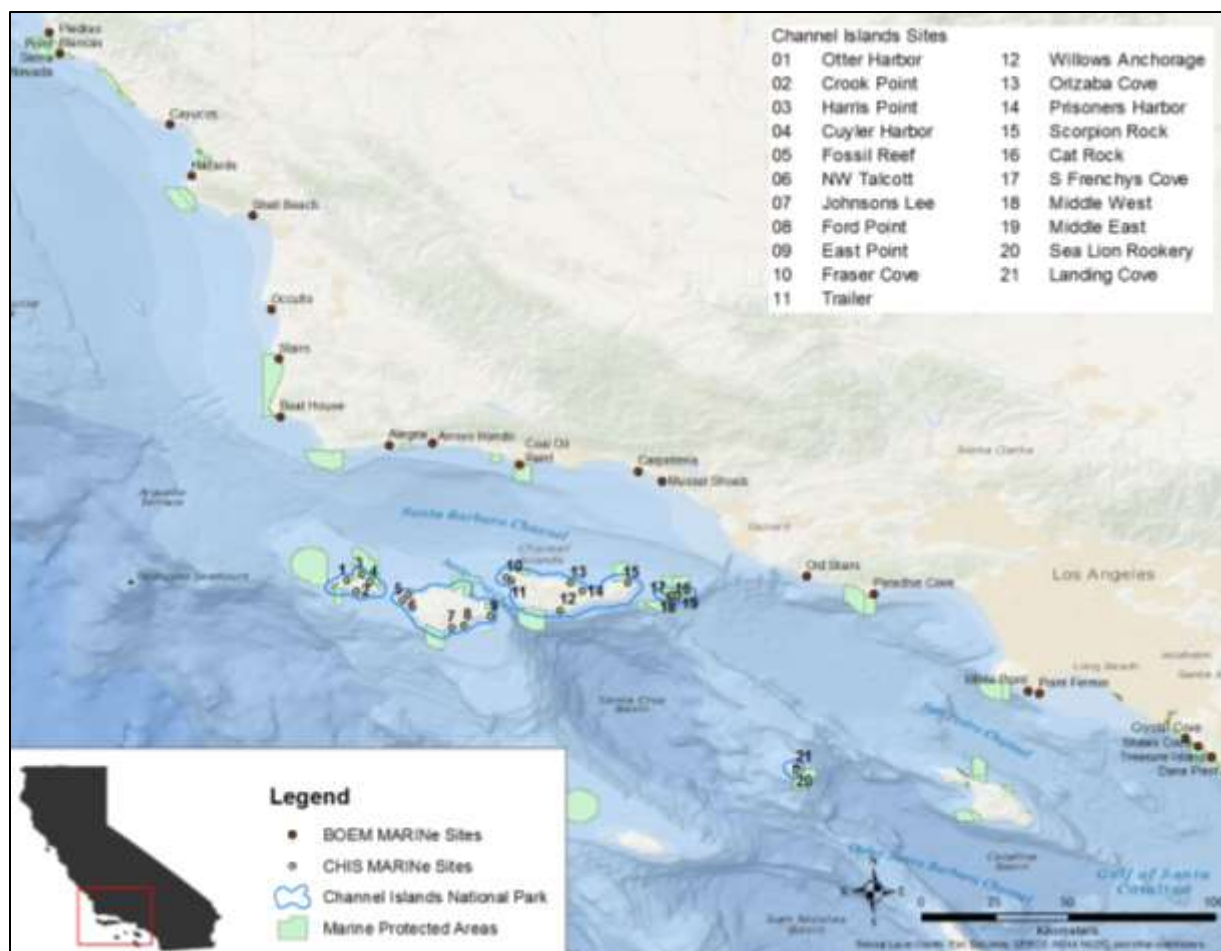


Figure 1. Rocky intertidal monitoring sites along mainland and Channel Islands of California contributing data to this report from either Channel Islands National Park (CHIS) or Bureau of Ocean Energy Management (BOEM) monitoring. All sites and organizations are a part of the Multi-Agency Rocky Intertidal Network (MARINE). Map created by Cassandra Morgan, BOEM.

1. Channel Islands National Park Monitoring Program

1.1. Introduction

Channel Islands National Park (CHIS) is uniquely situated at the transition between the Oregonian and Californian biogeographic provinces and thus has characteristics of both warm and cold water flora and fauna (Daily et al. 1993). Collectively, the park's five islands (Anacapa, San Miguel, Santa Barbara, Santa Cruz, and Santa Rosa; Figure 2) comprise approximately 176 miles (323 km) of coastline, the majority (approximately 80%) of which is rocky shore. Within park boundaries, the rocky intertidal zone harbors a rich community of marine life that varies across islands and is considered to have a distinct community distribution from the adjacent mainland (Schoch et al. 2006). Rocky intertidal communities at the islands also receive considerably less anthropogenic disturbance relative to their mainland counterparts (Blanchette et al. 2015). The relatively undisturbed and diverse nature of the intertidal habitat at the northern Channel Islands is specifically mentioned in the enabling legislation for CHIS (16-U4SC-410).

Rocky intertidal monitoring at CHIS was initiated in 1982 as one of the National Park Service's (NPS) prototype natural resource monitoring programs (Richards and Davis 1988). As the prototype programs demonstrated the value of long-term monitoring, the NPS established a servicewide Inventory and Monitoring (I&M) Program to develop and provide scientifically credible information on the current status and long-term trends of the composition, structure, and function of park ecosystems (National Park Service 1995). This information is necessary to determine the efficacy of current management practices and their ability to sustain park ecosystems.

The Mediterranean Coast Network (MEDN) of the I&M Program includes three park units: CHIS, Santa Monica Mountains National Recreation Area, and Cabrillo National Monument. Rocky intertidal monitoring is one of 15 "Vital Sign" monitoring programs implemented at the MEDN (Cameron et al. 2005).

Periodic, peer-based program review is an important component of all long-term monitoring programs. Ideally, approximately every five years a multidisciplinary group of resource managers, agency scientists, academic researchers, and statisticians would evaluate and refine, as needed, sampling designs and data collection techniques to ensure the program is meeting the stated monitoring goals and objectives. A technical review of the CHIS rocky intertidal program was last held in January 2001 (Lafferty 2001; Minchinton and Raimondi 2001). Key changes to the program as a result of the 2001 review included the following:

- Monitoring objectives were modified to align with the Multi-Agency Rocky Intertidal Network (MARINe) monitoring objectives;
- Sampling plots were added and target species assemblages were renamed in accordance with MARINe (Engle et. al 1997);
- CHIS's target species list was redefined and expanded so it appropriately identified and documented distinct species or species-complexes; and

- Timed surveys for abalone were implemented to provide a better way to sample low numbers of abalone following mass mortalities from Withering Syndrome (Richards and Davis 1993).

The current analysis was prompted by the need to re-evaluate staffing allocations to various components of the program (e.g., field data collection, data entry, data analysis and reporting) and to consider allocating time to a different sampling methodology (e.g., biodiversity surveys) that may provide more robust information on intertidal populations trends over time. Given declining budgets and staffing, in addition to recovering seabird and pinniped populations that hinder access to some sites, the first step in this program review was to answer the following questions:

1. What is the cost (in terms of statistical power) of reducing biannual sampling of target organisms (e.g., selected sessile species in photoplots, black abalone, sea stars, and owl limpets) to annual sampling?
2. If sampling is completed annually, how much does the timing of sampling influence the statistical power to detect changes? What is the best season for sampling? Can sampling be done irrespective of season, thereby taking advantage of multiple low-tide series throughout the year?
3. What level of change in the population dynamics of selected motile invertebrates (owl limpets, black abalone, and sea stars) is the current sampling protocol capable of detecting with 80% statistical power?
4. Due to logistical and financial constraints, CHIS staff recommends discontinuing monitoring at Middle-East Anacapa and Orizaba Cove. Are there reasons related to statistical power to continue monitoring these sites?



Figure 2. Rocky intertidal monitoring site locations in Channel Islands National Park. Note: NPS = National Park Service, TNC = The Nature Conservancy, SMCA = State Marine Conservation Area, SMR = State Marine Reserve. Sites 18 and 19 are on adjacent reefs.

1.2. Field Methods

At CHIS, the rocky intertidal community is monitored at 21 locations (Figure 1, Figure 2) that were established between 1982 and 1998. Data collection primarily consists of quantifying percent cover or counts of target species. Target species (also called focal or indicator species) are species or species groups specifically chosen for long-term monitoring surveys. They dominate particular zones or biotic assemblages in rocky intertidal habitats. Sites generally consist of an array of 15–35 fixed and permanent plots ($0.75 \times 0.5 \text{ m}^2$) established to monitor the cover of multiple sessile target taxa, including barnacles, mussels, and algae (Table 1). Plots were established in areas of high abundance for each target species or species group. Within these plots, species are identified at 100 points to determine the percent cover. Additionally, 3–5 fixed irregular-shaped and circular plots are used to count and size black abalone (*Haliotis cracherodii*) and owl limpet (*Lottia gigantea*) densities, respectively. Following mass mortalities from Withering Syndrome, black abalone have very nearly disappeared from all the fixed plots. Therefore, timed surveys were implemented in the late 1990s to assess the relative abundance and size frequency distribution of black abalone at each site. Ochre sea star (*Pisaster ochraceus*) population dynamics are also sampled through timed surveys within defined areas of the sites, Surfgrass is monitored along three 10 m long fixed-transects within four sites. A series of photographic pans along with field notes are used to describe general conditions at the sites and to document the distribution and abundance of organisms not found within the photoplots. Site selection considered visitation, accessibility, presence of representative organisms, wildlife disturbance, and safety. Sampling has typically been conducted twice each year, once in spring and fall/winter. Additional details regarding sampling procedures are described by Richards and Davis (1988), Richards (2000), and Engle (2008).

Table 1. MARINE taxa or substrate groups scored in photoplots, point intercept transects, circular plots, irregular plots, and timed searches within MARINE sites. Not all groups are found at all sites.

Taxonomic or substrate group	Specific species or substrate group	Photoplots	Surfgrass transects	Circular plots	Irregular plots	Timed searches
Green algae	<i>Cladophora columbiana</i>	X	–	–	–	–
	<i>Ulva/Enteromorpha</i>	X	–	–	–	–
	Other green algae	X	X	–	–	–
Brown algae	<i>Egregia menziesii</i>	X	X	–	–	–
	<i>Eisenia arborea</i>	–	X	–	–	–
	<i>Endarachne/Petalonia</i>	X	–	–	–	–
	<i>Halidrys dioica/Cystoseira</i> spp.	–	X	–	–	–
	<i>Hesperophycus californicus</i> (= <i>H. harveyanus</i>) ^B	X	–	–	–	–
	<i>Sargassum muticum</i>	–	X	–	–	–
	<i>Scytosiphon</i> spp.	X	–	–	–	–
	<i>Silvetia compressa</i> (= <i>Pelvetia fastigiata</i>)(Rockweed) ^B	X		–	–	–
	Other brown algae	X	X	–	–	–
	Ephemeral browns	X	–	–	–	–
Red algae	<i>Endocladia muricata</i> (turfweed) ^B	X	–	–	–	–
	<i>Chondracanthus canaliculatus</i> (= <i>Gigartina canaliculata</i>)	X	–	–	–	–
	<i>Chondracanthus spinosus</i>	X	–	–	–	–
	<i>Gelidium coulteri/ Pterocladia capillacea</i>	X	–	–	–	–
	<i>Mastocarpus papillatus</i> (blade)	X	–	–	–	–
	<i>Mazzaella affinis</i> (= <i>Rhodoglossum affine</i>)	X	–	–	–	–
	<i>Mazzaella</i> spp. (= <i>Iridaea</i> spp.)	X	–	–	–	–

^A Indicates that counts are not conducted at all sites.

^B Species was used in this report for CHIS and BOEM and is a subset of the MARINE target species list. Also shown in bold text.

Table 1 (continued). MARINE taxa or substrate groups scored in photoplots, point intercept transects, circular plots, irregular plots, and timed searches within MARINE sites. Not all groups are found at all sites.

Taxonomic or substrate group	Specific species or substrate group	Photoplots	Surfgrass transects	Circular plots	Irregular plots	Timed searches
Red algae (continued)	<i>Porphyra</i> spp.	X	–	–	–	–
	<i>Prionitis</i> spp.	X	–	–	–	–
	Articulated corallines	X	X	–	–	–
	Crustose corallines	X	X	–	–	–
	Non coralline crusts (reds and browns)	X	X	–	–	–
	Other red algae (any reds not listed above) ^A	X	X	–	–	–
Plant	<i>Phyllospadix scouleri/torreyi</i> (surfgrass) ^B	X	X	–	–	–
Anemones	<i>Anthopleura elegantissima/sola</i> (Green Anemone) ^B	X	X	–	–	–
Polychaete worms	<i>Phragmatopoma californica</i>	X	X	–	–	–
Molluscs	<i>Acanthina</i> spp.	–	–	–	–	–
	Chitons	X	–	–	–	–
	<i>Fissurella volcano</i>	X	–	–	–	–
	<i>Haliotis cracherodii</i> (black abalone) ^B	X	–	–	X ^A	X
	<i>Lottia gigantea</i> (owl limpet) ^B	X	–	X ^A	–	–
	<i>Mopalia</i> spp.	–	–	–	–	–
	<i>Mytilus californianus</i> (California mussel) ^B	X	X	–	–	–
	Limpets	X	–	–	–	–
	<i>Septifer/Brachydontes</i>	X	–	–	–	–
Barnacles	<i>Chthamalus dalli/fissus</i> & <i>Balanus glandula</i> (acorn barnacle) ^B	X	–	–	–	–
	<i>Tetraclita rubescens</i> (thatched barnacle)	X	–	–	–	–
	<i>Pollicipes polymerus</i> (goose barnacle)	X	–	–	–	–

^A Indicates that counts are not conducted at all sites.

^B Species was used in this report for CHIS and BOEM and is a subset of the MARINE target species list. Also shown in bold text.

Table 1 (continued). MARINE taxa or substrate groups scored in photoplots, point intercept transects, circular plots, irregular plots, and timed searches within MARINE sites. Not all groups are found at all sites.

Taxonomic or substrate group	Specific species or substrate group	Photoplots	Surfgrass transects	Circular plots	Irregular plots	Timed searches
<i>Barnacles (continued)</i>	<i>Pisaster ochraceus</i> (ochre star) ^B	X	–	–	X	X
	<i>Pisaster giganteus</i>	–	–	–	–	X
	<i>Patiria miniata</i>	–	–	–	–	X
Invertebrates	Other invertebrates (other animals)	X	X	–	–	–
Substrata	Rock (bare rock) ^B	X	X	–	–	–
	Sand	X	X	–	–	–
	Tar	X	X	–	–	–
	Unidentified	X	X	–	–	–

^A Indicates that counts are not conducted at all sites.

^B Species was used in this report for CHIS and BOEM and is a subset of the MARINE target species list. Also shown in bold text.

1.3. Statistical Analysis Methods

Statistical power analyses require a fundamental understanding of the data analysis that will be used to assess change. Because there was interest in understanding how data from the CHIS monitoring program can be used to detect punctuated events (e.g., oil spills) as well as gradual change (e.g., climate change), statistical power was assessed using two distinct approaches. As explained below, the Before After Control Impact Paired (BACIP) analysis was used to estimate statistical power to detect punctuated events and a regression analysis was used to estimate the power to detect trends caused by gradual change over time.

1.3.1. Statistical Approach: Part 1, Punctuated Effect—Minimum Detectable Effect Size

In the current assessment, there are over 20 years of sampling, enabling the use of the robust and powerful BACIP analysis (BACIP, Stewart-Oaten et al. 1992). For this BACIP approach, temporal samples are considered replicates and the average difference between impact and control sites prior to an impact are compared to the average difference between the same impact and control sites after the impact. Here, spatial replicates within a site (e.g., fixed plots) were averaged to provide a more accurate estimation of the mean for the site at time *t*. The key BACIP assumptions for this report are:

1. Photoplot target species groups *Hesperophycus*, *Silvetia*, *Endocladia*, *Chthamalus*, *Mytilus*, and rock cover were assessed. Mobile invertebrate target species groups *Lottia*, *Haliotis*, and *Pisaster* were assessed separately.
2. The impact will result in a decrease in abundance for target species and an increase in abundance or for bare rock; hence, a one tailed approach was used.
3. Impacts may be limited to a single site, and the location of the site is unpredictable.
4. The set of potential control sites for any impact site includes all other sites having the species groups listed above.
5. Only 22 temporal samples were used (the most recent 10–11 years). This was done for a number of reasons, including: (1) protocols were standardized during this period, (2) this gave the maximum span of years with no missing values for most sites, (3) 10 years seemed like a long enough period to reasonably model differences among sites and sufficiently short enough to exclude any long-term trends (e.g., significant El Niño–Southern Oscillation events) in the region that could compromise the BACIP approach.

To address these questions, the Minimum Detectable Effect Size (MDES) was calculated for all target species and site combinations for photoplot species (section 1.4.1.1), rock cover within the photoplots (section 1.4.1.3), and mobile species (section 1.4.1.5). This calculation allows estimation of the smallest effect size (difference) that could be detected with given combinations of Type 1 error (set to 0.10), Type 2 error (set at 0.20), and replication (set at 11 or 22 samples, which is the current average number given once per year sampling [11] or twice a year sampling [22]). Four models were run:

1. All samples: based on twice per year sampling over 5.5 years = 11 samples.

2. All samples (2X): based on twice per year sampling over 11 years = 22 samples.
Comparisons using 22 samples are only shown in the summary figures for photoplot species in *Comparison of sampling periods* section (1.4.1.2) and is used to assess the relative contribution of seasonal sampling versus increased numbers of surveys.
3. Random sampling once per year (11 samples, could be either Spring or Fall in any year).
Note “Spring” and “Fall” refer to the period samples were planned. Actual samples may have been outside the formal dates defining the range of Spring and Fall (see Appendix A).
4. Spring only sampling (11 samples).
5. Fall only sampling (11 samples).

After MDES evaluations were complete, two sites were removed and the BACIP was analyzed with the remaining 19 sites. The difference in MDES was calculated in section 1.4.1.4.

All calculations were based on equations and an automated protocol developed for BACIP assessment. Results were validated relative to power approaches using SAS and SYSTAT statistical engines. Code is supplied in Appendix B.

1.3.2. Statistical Approach: Part 2, Gradual Effect—Temporal Pattern of Power

In addition to understanding the monitoring program’s ability to detect punctuated impacts (e.g., oil spills), the second goal was to assess the ability of the sampling program to detect impacts that led to a trend in measured variables. Below is the assessment of power to detect trends.

The approach taken was very different from that used in part 1. The core approach was:

1. A regression model was used.
2. Historical data were used to determine error structure in the following way:
 - a. To assess the pattern over time, the sum of squares was calculated based on fit to historical trend: SS_H . This approach yielded an estimate of the error structure of data after temporal detrending (should there be a trend).
 - b. Calculate future standard error (SE_F) based on SS_H and number of future samples.
 - c. Calculate power based on alpha, number of samples, and the rate of change per year (slope).

Key sessile species, *Hesperophycus*, *Mytilus*, *Chthamalus*, *Endocladia*, *Silvetia*, and *Lottia* were used in part 2 of this assessment.

1.4. Results and Discussion

1.4.1. Minimum Detectable Effect Size (MDES)

1.4.1.1 Photoplots—target species

Figure 3 shows a summary of median MDES for all target species for $\alpha = 0.1$ $\beta = 0.2$, and with 11 replicates. This means comparing 11 years for the once per year sampling (random, Spring, Fall) and 5.5 years for twice per year sampling (all samples). Note that we compare 11 years for all sampling periods (twice per year sampling) in section 1.4.1.2. Generally, *Chthamalus* (CHT),

Endocladia (END) and *Hesperophycus* (HES) had smaller MDES (that is, smaller effect sizes are more likely to be detected) than *Mytilus* (MYT) and *Silvetia* (SIL), although for most species site combinations, changes of 10–15% (actual not relative percentage) were detectable using the median as the metric of interest. The pattern of MDES among species is interesting because there could be a reasonable expectation that values should be lower for *Mytilus* and *Silvetia*. This is because *Mytilus* and *Silvetia* tend to live longer than *Chthamalus*, *Endocladia*, and *Hesperophycus*, which could result in more stable populations over time. However, *Mytilus* and *Silvetia* abundance tends not to be stabilized by regular recruitment, unlike some of the other species.

Below, Figures 4-8 show MDES values across a range of site and sampling periods, which shows that much smaller effect sizes are possible to detect given specific control sites.

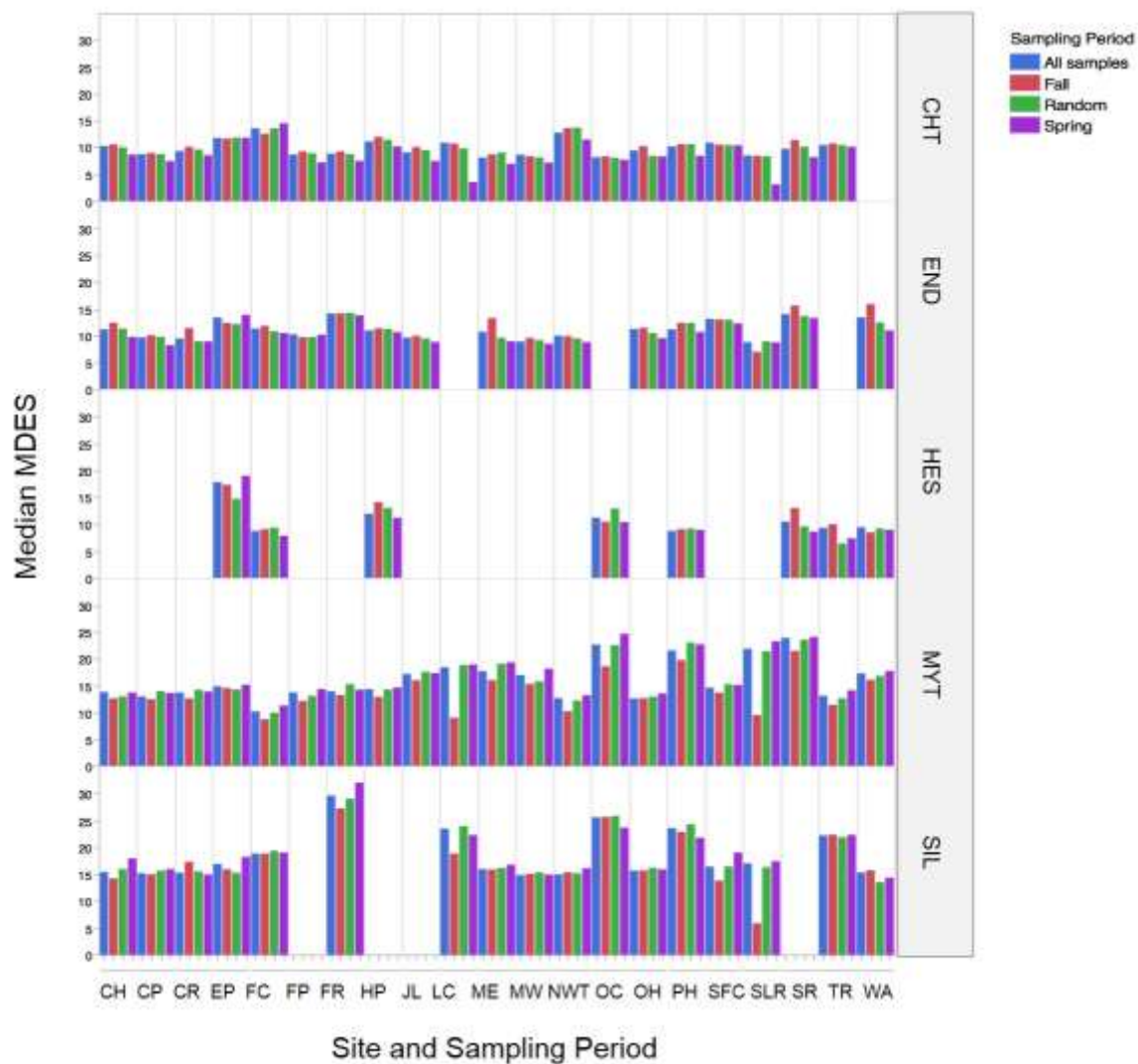


Figure 3. Median Minimum Detectable Effect Size (MDES) for all photoplot species as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Site codes are listed in the glossary (Appendix C). *Chthamalus* = CHT, *Endocladia* = END, *Hesperophycus* = HES, *Mytilus* = MYT, and *Silvetia* = SIL.

Chthamalus

The results for *Chthamalus* are shown in Figure 4. For Figures 4–8, boxplots for MDES values for each site and sampling period are shown. For all figures in this report containing boxplots, the mid-value (line) is the median, the edges of the box are 25% of the observations (pairwise BACIP assessments) below and above the median, and the end lines are the next 25% of the observations. Dots indicate “outlier” observations. For all sites and sample periods for *Chthamalus*, MDES values of <<10% are possible.

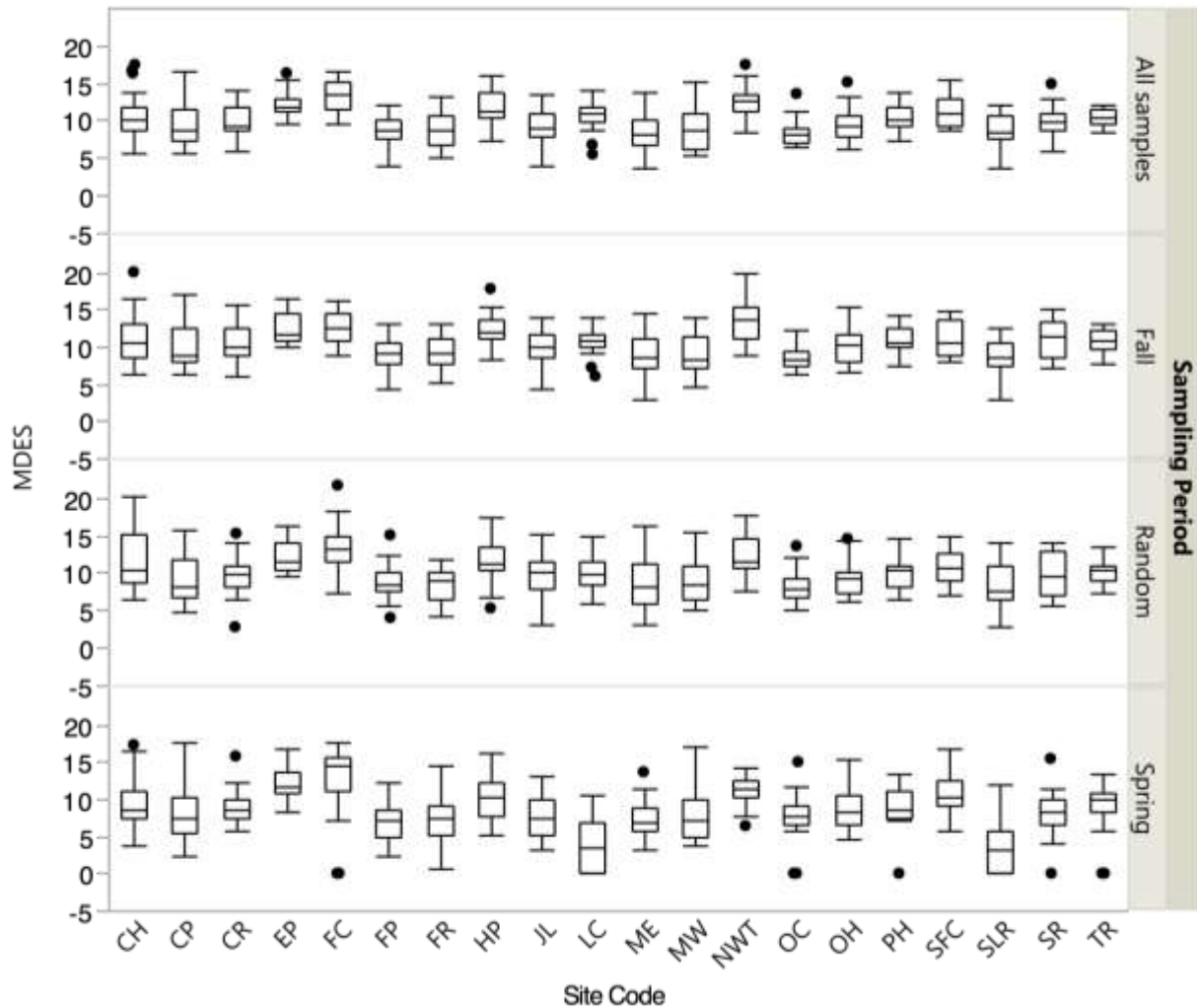


Figure 4. Boxplots of Minimum Detectable Effect Size (MDES) values for *Chthamalus* as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (20) reflects the number of sites with target species. Site codes are listed in the glossary (Appendix C).

Endocladia

The results for *Endocladia* are shown in Figure 5. For all sites and sample periods, MDES values of <<10% are possible.

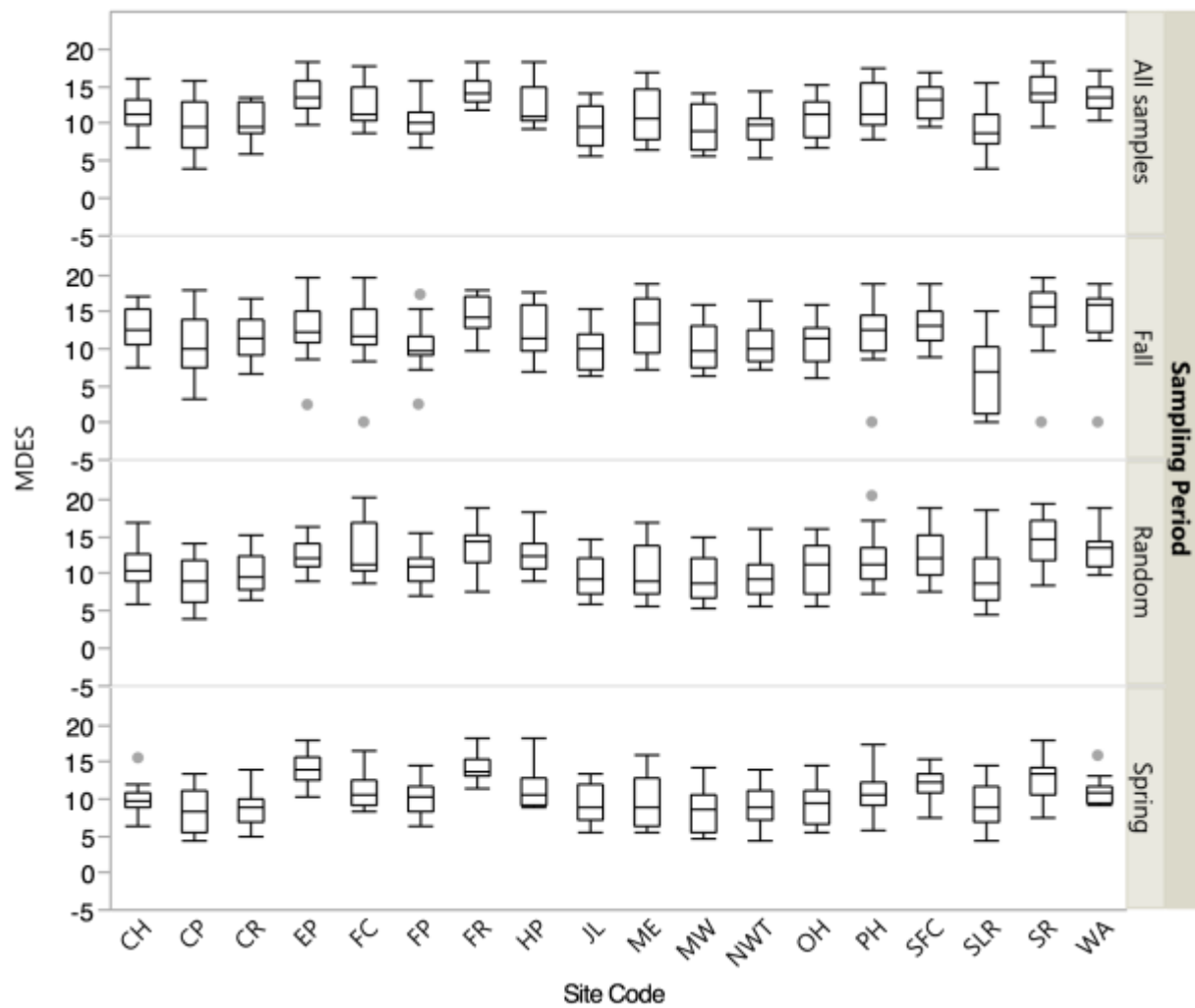


Figure 5. Boxplots of Minimum Detectable Effect Size (MDES) values for *Endocladia* as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (18) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Hesperophycus

The results for *Hesperophycus* are shown in Figure 6. For most sites (other than EP) and sample periods, MDES values of $<10\%$ are possible.

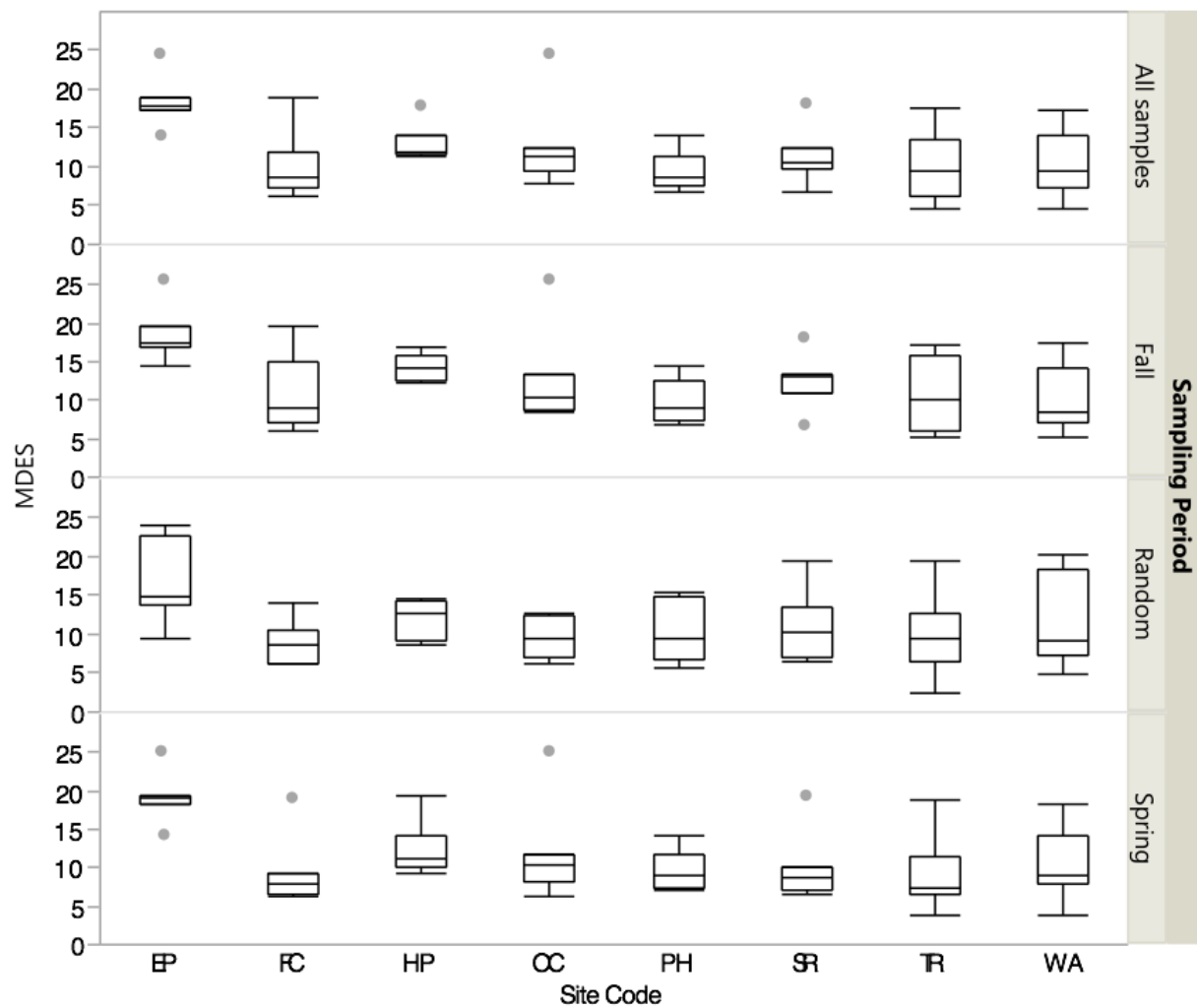


Figure 6. Boxplots of Minimum Detectable Effect Size (MDES) values for *Hesperophycus* as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (8) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Mytilus

The results for *Mytilus* are shown in Figure 7. For most sites and sample periods, MDES values of <10% are possible.

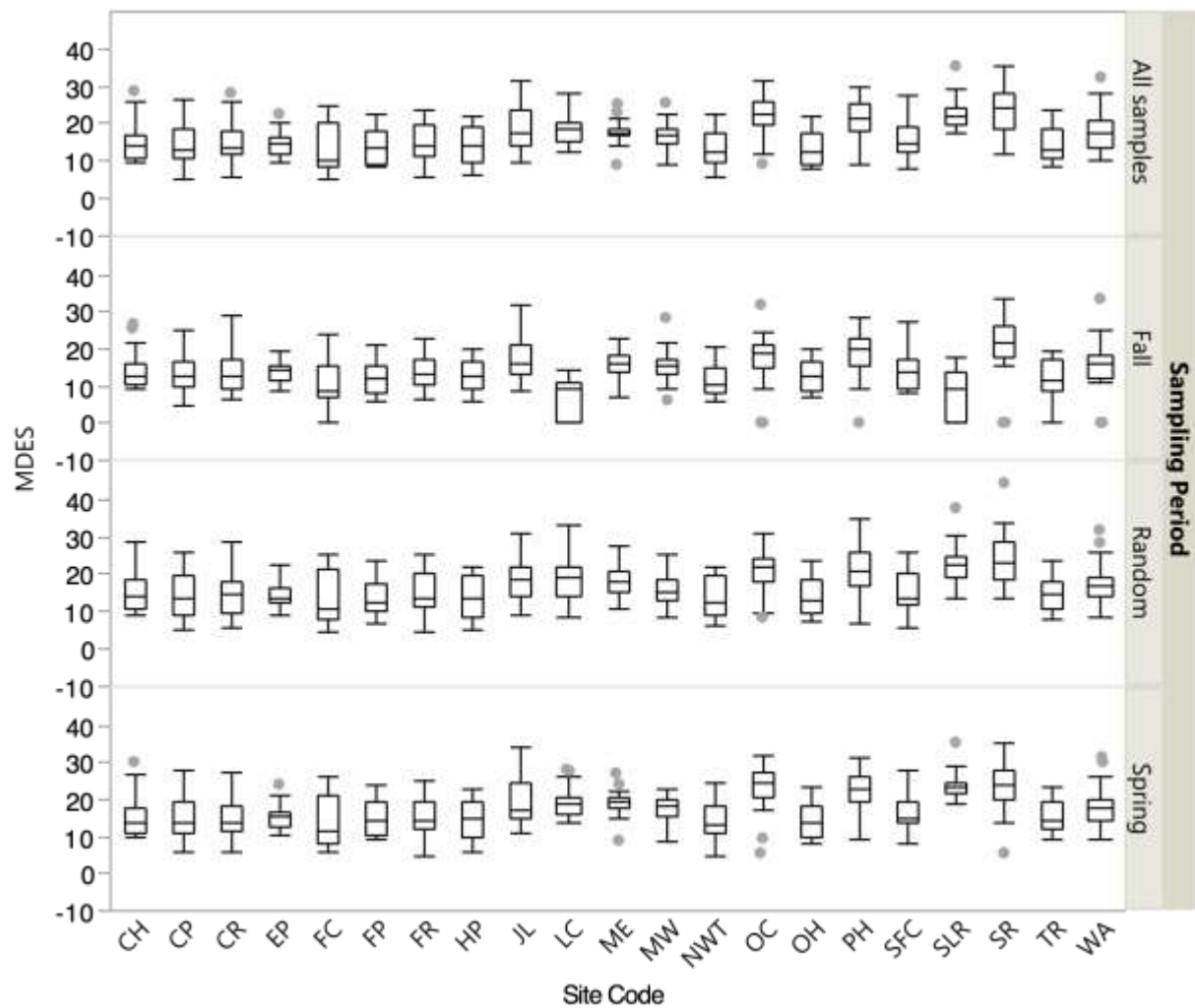


Figure 7. Boxplots of Minimum Detectable Effect Size (MDES) values for *Mytilus* as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (21) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Silvetia

The results for *Silvetia* are shown in Figure 8. For most sites and sample periods, MDES values of <10% are possible.

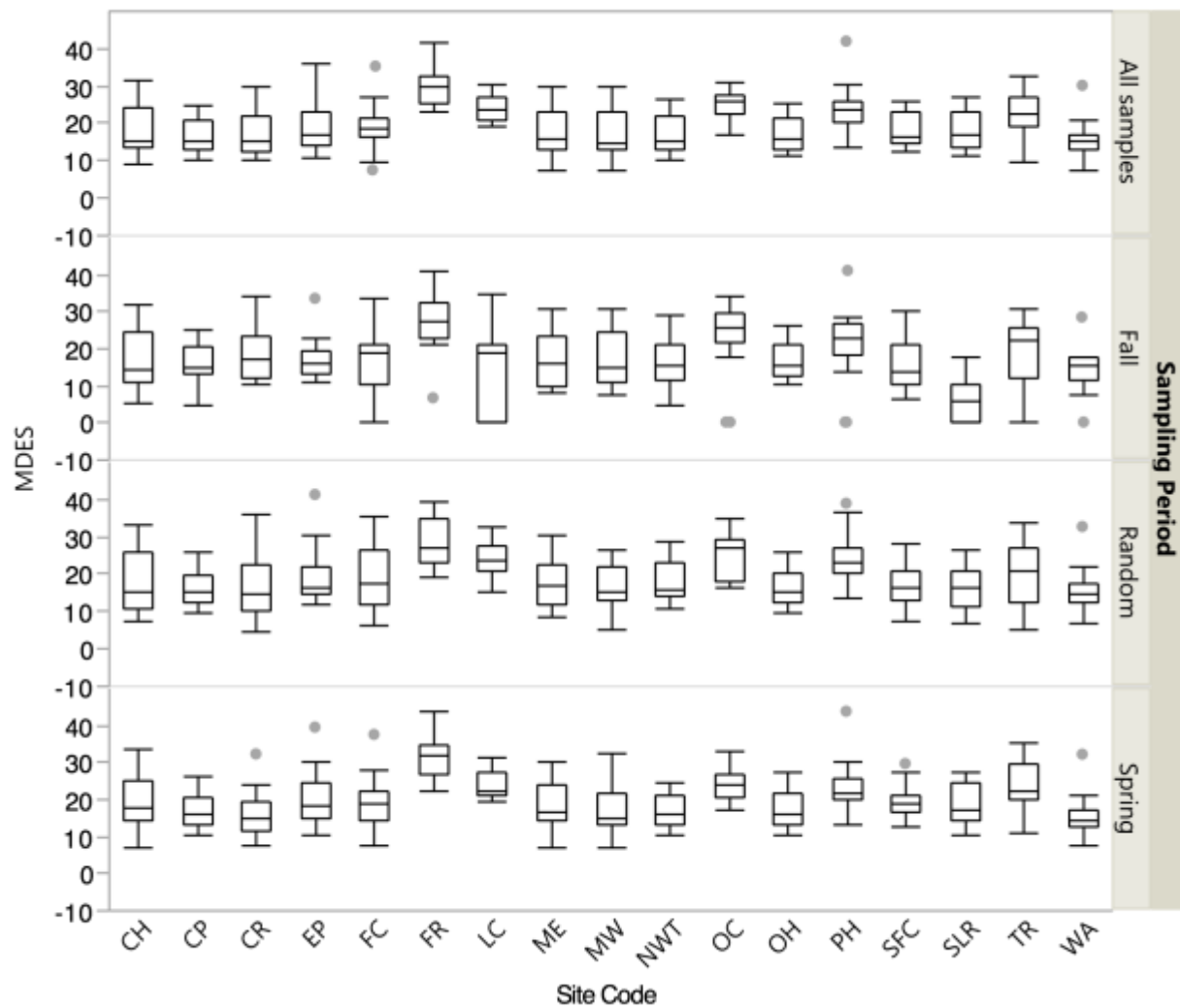


Figure 8. Boxplots of Minimum Detectable Effect Size (MDES) values for *Silvetia* as a function of site and sampling period using $\alpha = 0.10$, $\beta = 0.20$ and 11 replicates. Values are percentages. Number of sites in analysis (17) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

1.4.1.2 Comparison of sampling periods

To assess the performance of the monitoring program based on the timing of sampling period (e.g., Spring, Fall, Random, All), the results of 11 sampling periods (5.5 years for twice per year sampling and 11 years for once per year sampling) were compared to sampling done twice a year for 11 years (22 samples). Here, years were standardized compared to samples (Figures 9 and 10, same data shown in different ways). Doubling sample size had a major effect on the median MDES. Median MDES dropped on average 50% for all species using twice per year sampling and holding years constant at 11. There was little difference in MDES values (medians) as a function of sample period for $n = 11$ samples. On the whole, the best approach was to sample in the Fall, but the advantage was small and species specific. It is possible that the All sample model could be refined to formally

include a season term, and that this could affect the results, but given the BACIP approach, the effect of a season term should be very low.

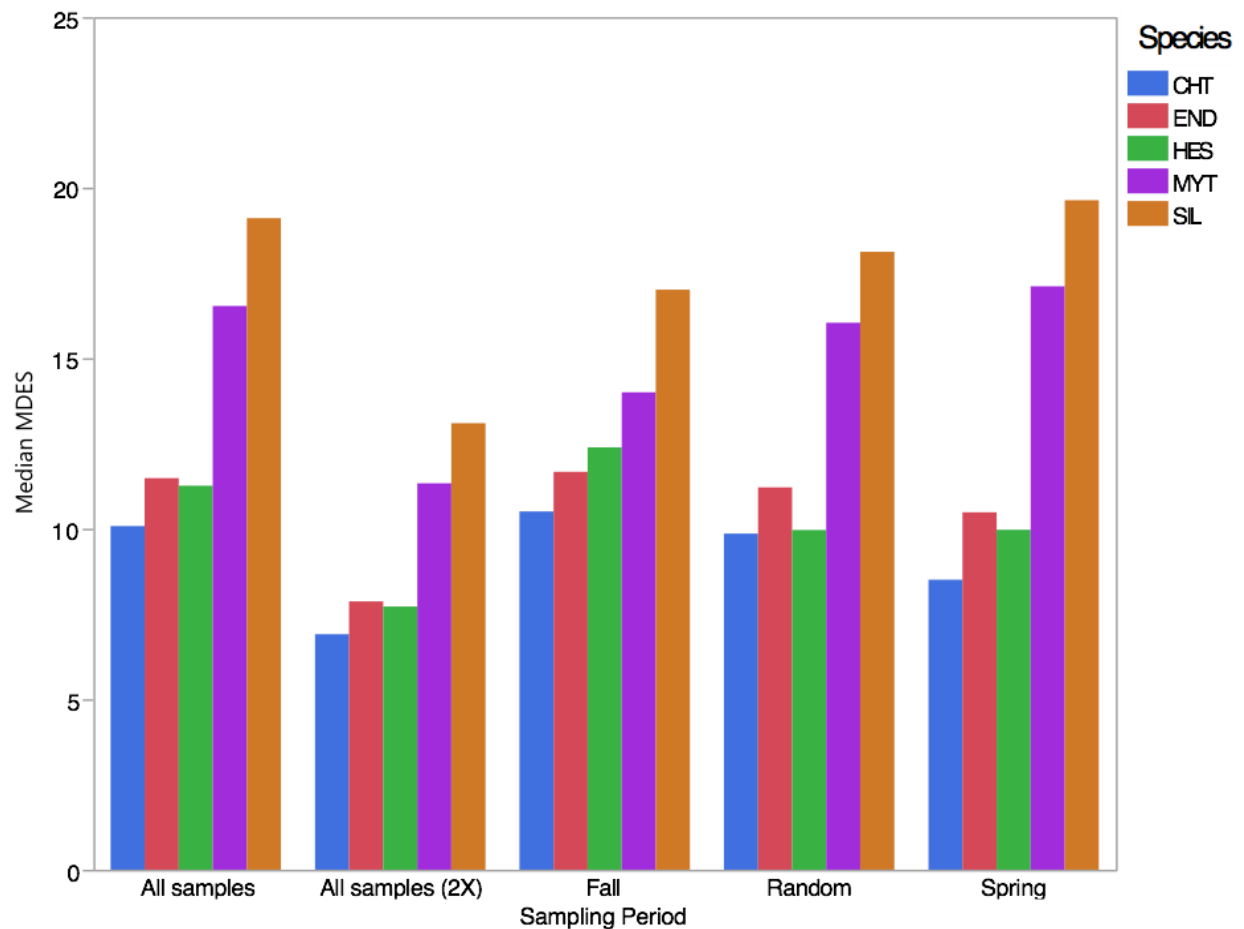


Figure 9. Median Minimum Detectable Effect Size (MDES) as a function of sample period, species, and replication. Alpha = 0.10, beta = 0.20, and 11 replicates for all sampling periods other than 2X (n = 22). *Chthamalus* = CHT, *Endocladia* = END, *Hesperophycus* = HES, *Mytilus* = MYT, and *Silvetia* = SIL.

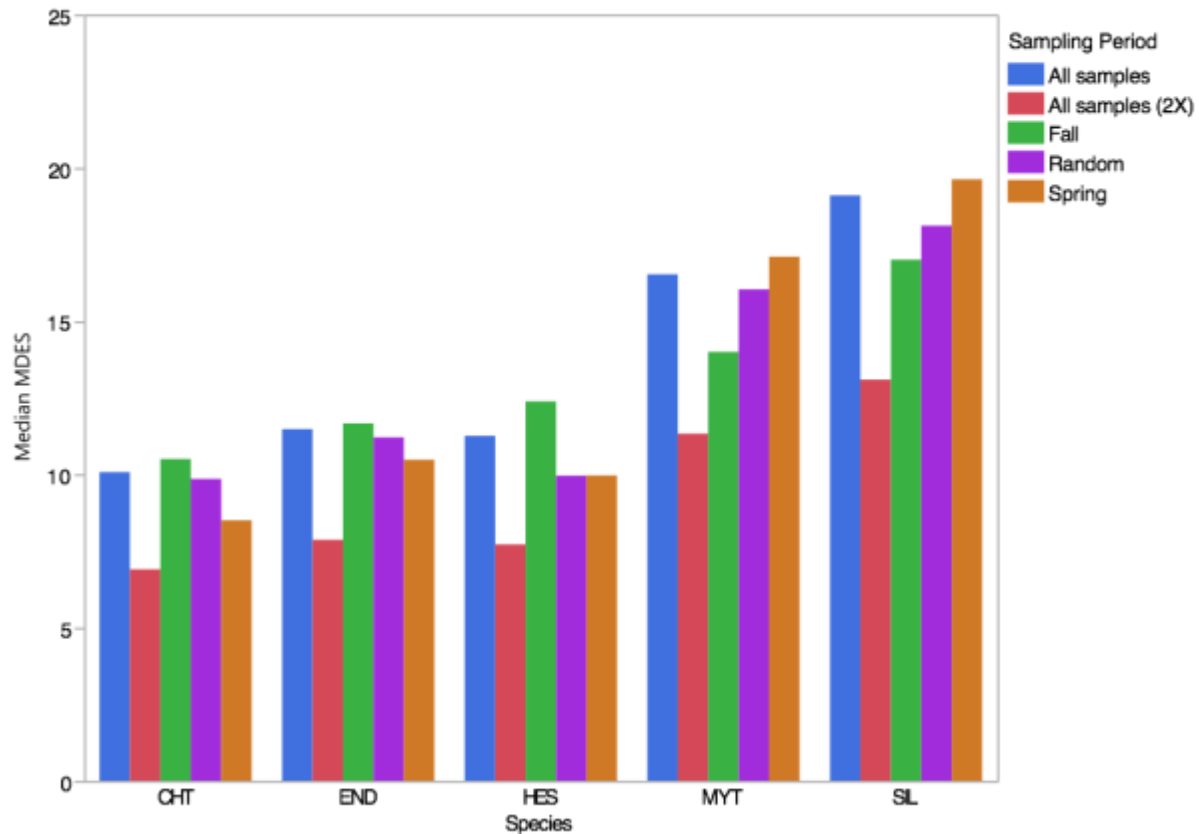


Figure 10. Median Minimum Detectable Effect Size (MDES) as a function of species, sample period, and replication. Alpha = 0.10, beta = 0.20, and 11 replicates for all sampling periods other than 2X (n = 22). *Chthamalus* = CHT, *Endocladia* = END, *Hesperophycus* = HES, *Mytilus* = MYT, and *Silvetia* = SIL.

1.4.1.3 Rock in photoplots by target species

We assessed the MDES for rock cover for all photoplot species. The idea here was to have a single metric (MDES—rock) that could be used for all target plot types. Increase in rock cover is also generally a better indication of disturbance than a decrease in a focal species, which could result from ordinary ecological processes.

Chthamalus

The results for rock in *Chthamalus* plots are shown in Figure 11. For all sites and sample periods, MDES values of <<10% are possible.

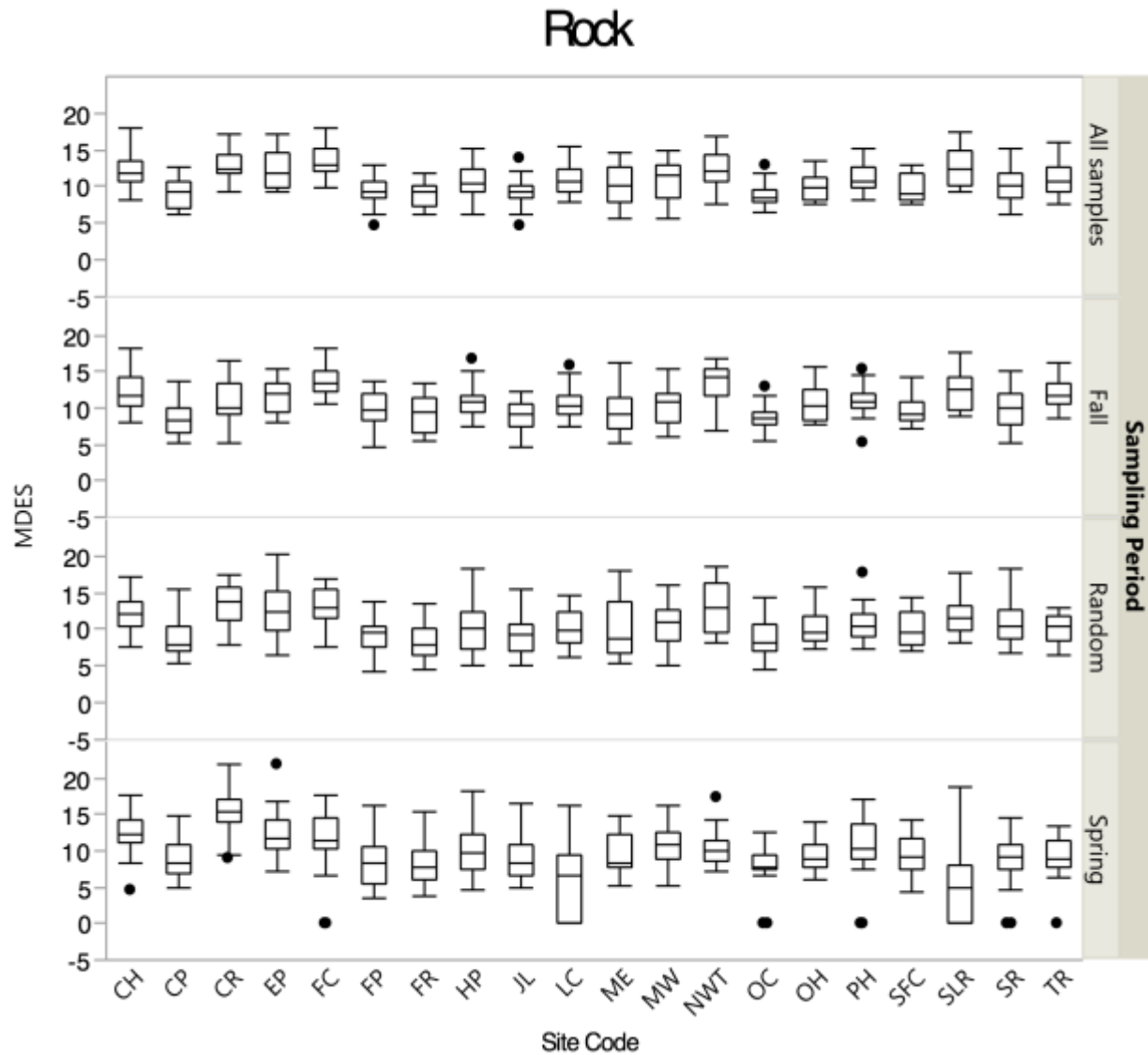


Figure 11. Boxplots of Minimum Detectable Effect Size (MDES) values for rock in *Chthamalus* plots as a function of site and sampling period using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (20) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Endocladia

The results for rock in *Endocladia* plots are shown in Figure 12. For all sites and sample periods, MDES values of $<10\%$ are possible.

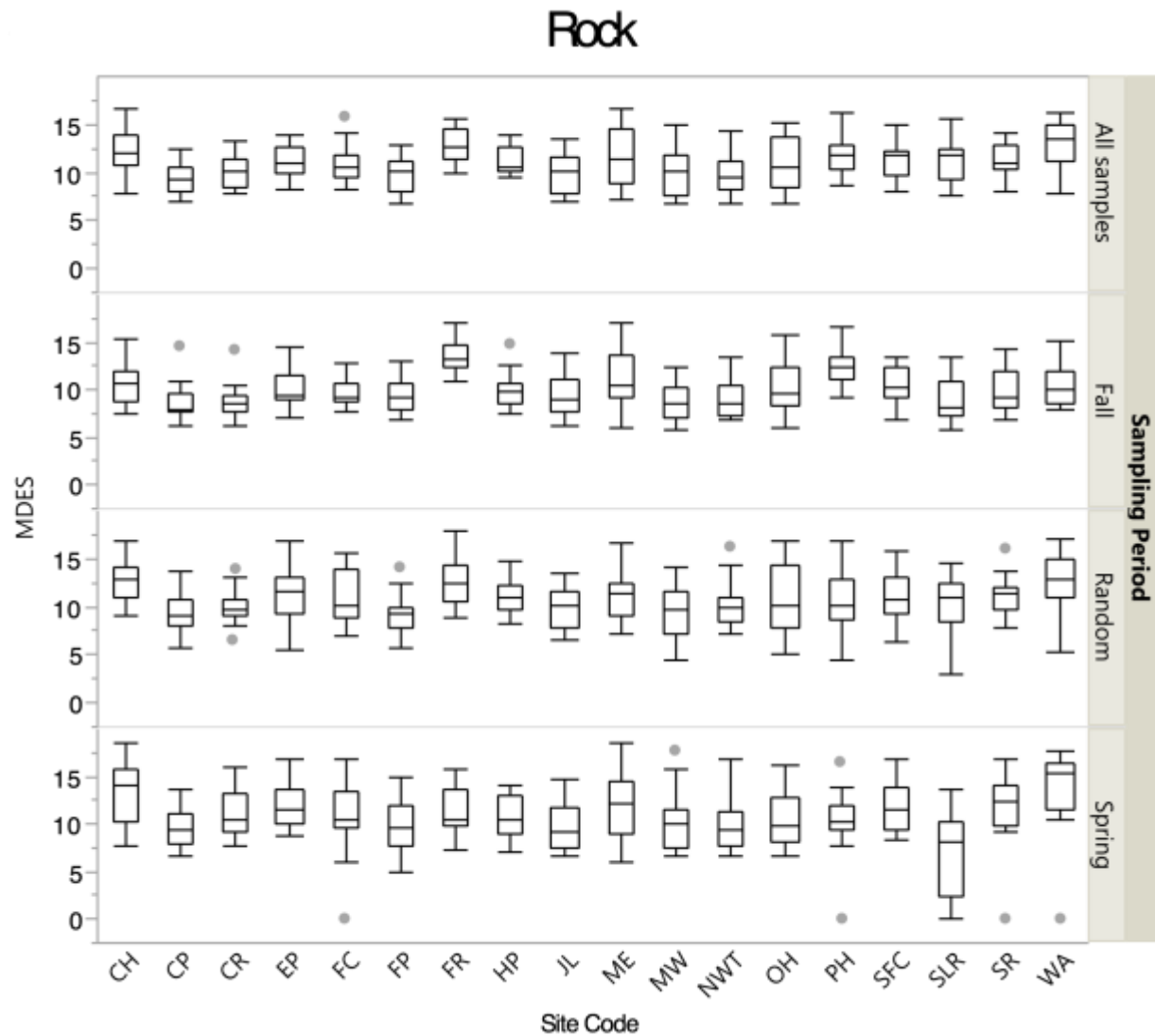


Figure 12. Boxplots of Minimum Detectable Effect Size (MDES) values for rock in *Endocladia* plots as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (18) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Hesperophycus

The results for rock in *Hesperophycus* plots are shown in Figure 13. For most sites and sample periods, MDES values of $<<10\%$ are possible.

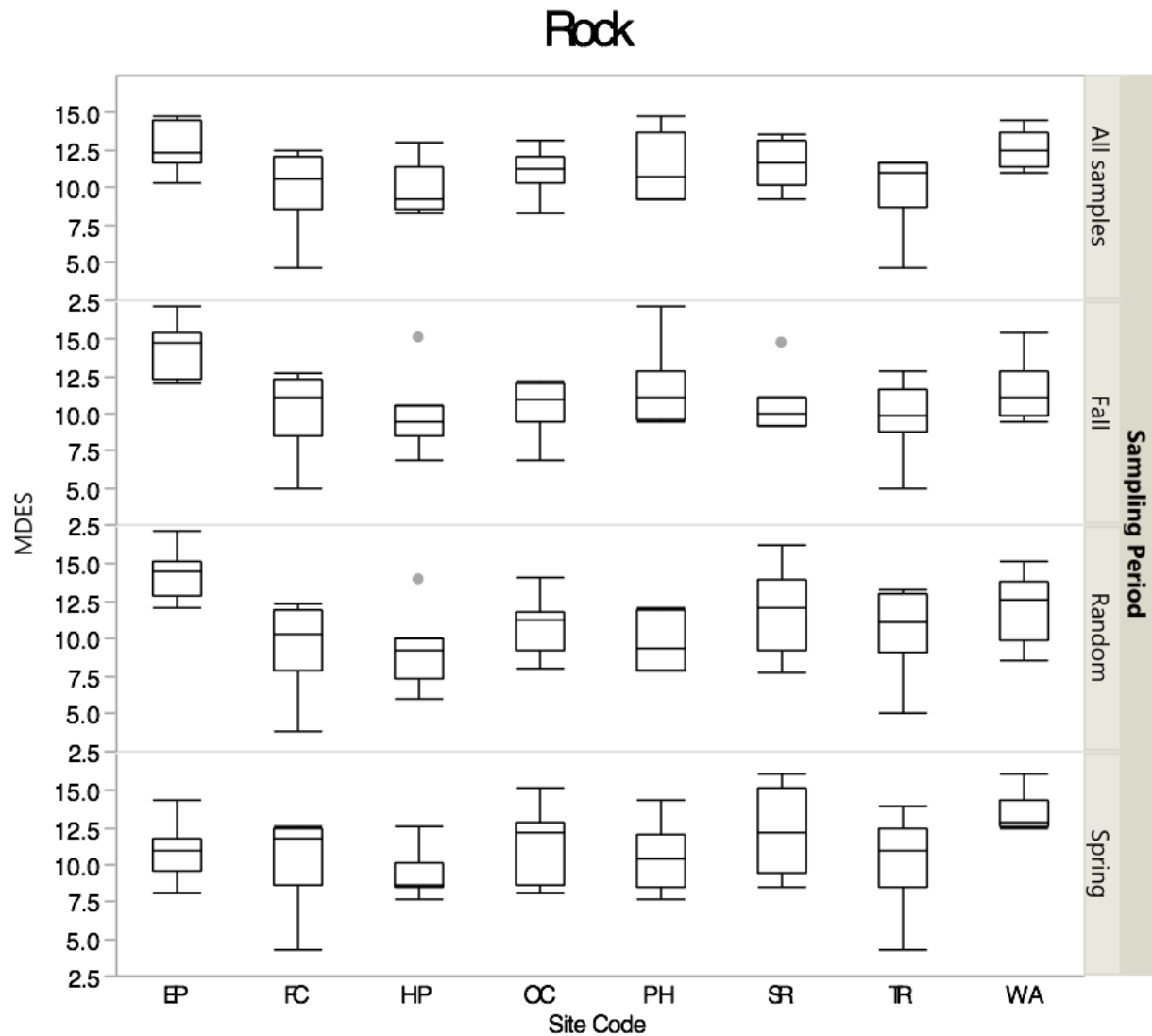


Figure 13. Boxplots of Minimum Detectable Effect Size (MDES) values for rock in *Hesperophycus* plots as a function of site and sampling period using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (8) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Mytilus

The results for rock in *Mytilus* plots are shown in Figure 14. For all sites and sample periods, MDES values of $<<10\%$ are possible.

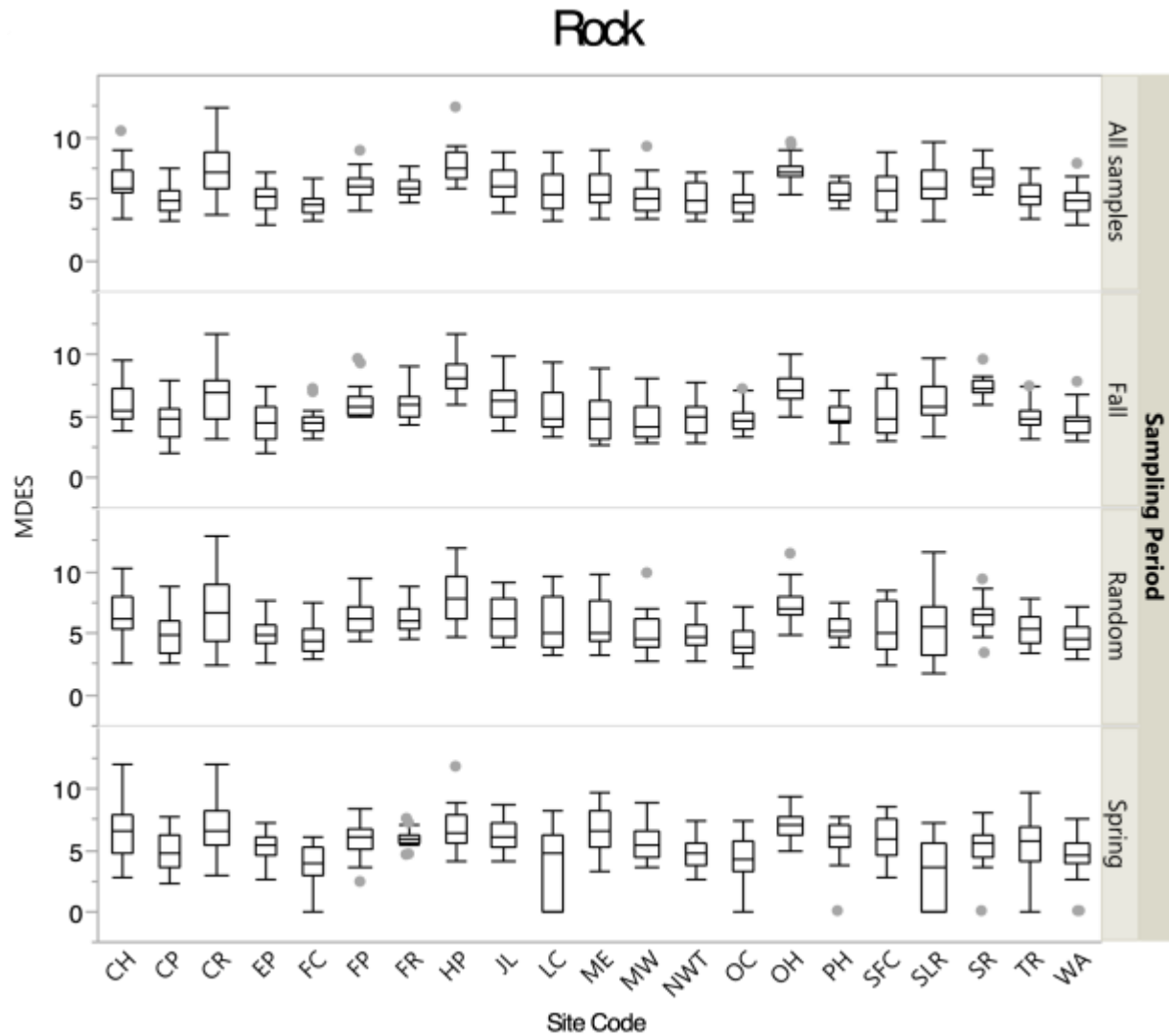


Figure 14. Boxplots of Minimum Detectable Effect Size (MDES) values for rock in *Mytilus* plots as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (21) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Silvetia

The results for rock in *Silvetia* plots are shown in Figure 15. For most sites and sample periods, MDES values of $<10\%$ are possible.

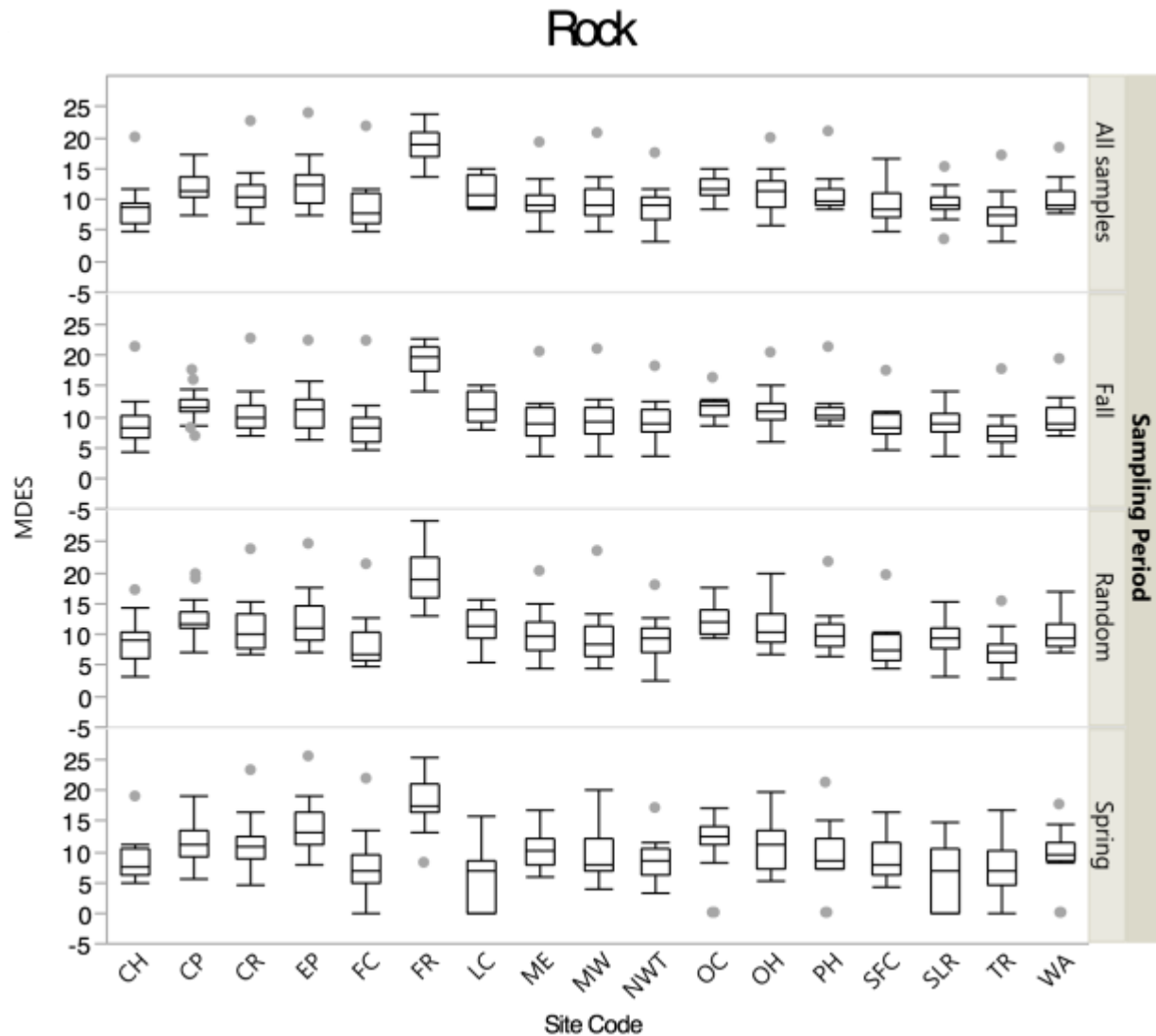


Figure 15. Boxplots of Minimum Detectable Effect Size (MDES) values for rock in *Silvetia* plots as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are percentages. Number of sites in analysis (17) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

1.4.1.4 Consequences if sites OC and ME are not monitored

As noted in the Introduction, CHIS staff recommended removing two sites from long-term monitoring due to logistical and financial constraints. For this analysis both OC (Orizaba Cove, Santa Cruz Island) and ME (Middle East, Anacapa Island) were removed from estimation of MDES and the effect on the median MDES was determined for other sites. It should be noted that this approach only addresses the statistical consequence of site removal. There may be other important reasons to maintain both sites, such as geographical coverage—these were not assessed. In general, there was no important consequence to the removal of OC or ME. The figures below show the net effect of the removal for both the target species (Figure 16) and for rock in the target plots (Figure 17). In no case was the net effect greater than 1%, and in most cases, it was less than 0.5%.

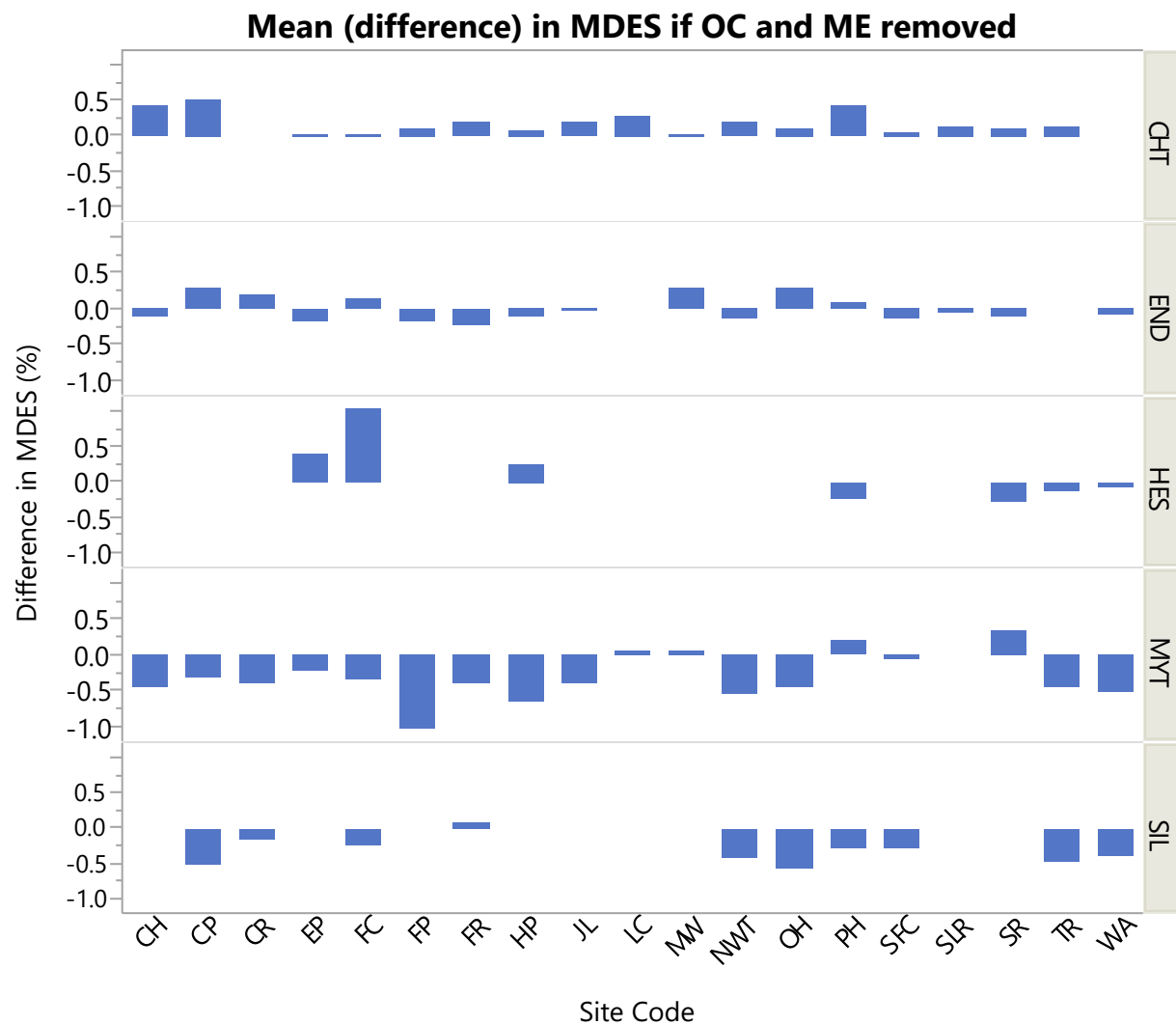


Figure 16. Difference in Minimum Detectable Effect Size (MDES) for target species if sites ME and OC are removed from monitoring program as a function of site and target species. Site codes are listed in the glossary (Appendix C). Species abbreviations on the right Y axis are *Chthamalus* = CHT, *Endocladia* = END, *Hesperophycus* = HES, *Mytilus* = MYT, and *Silvetia* = SIL.

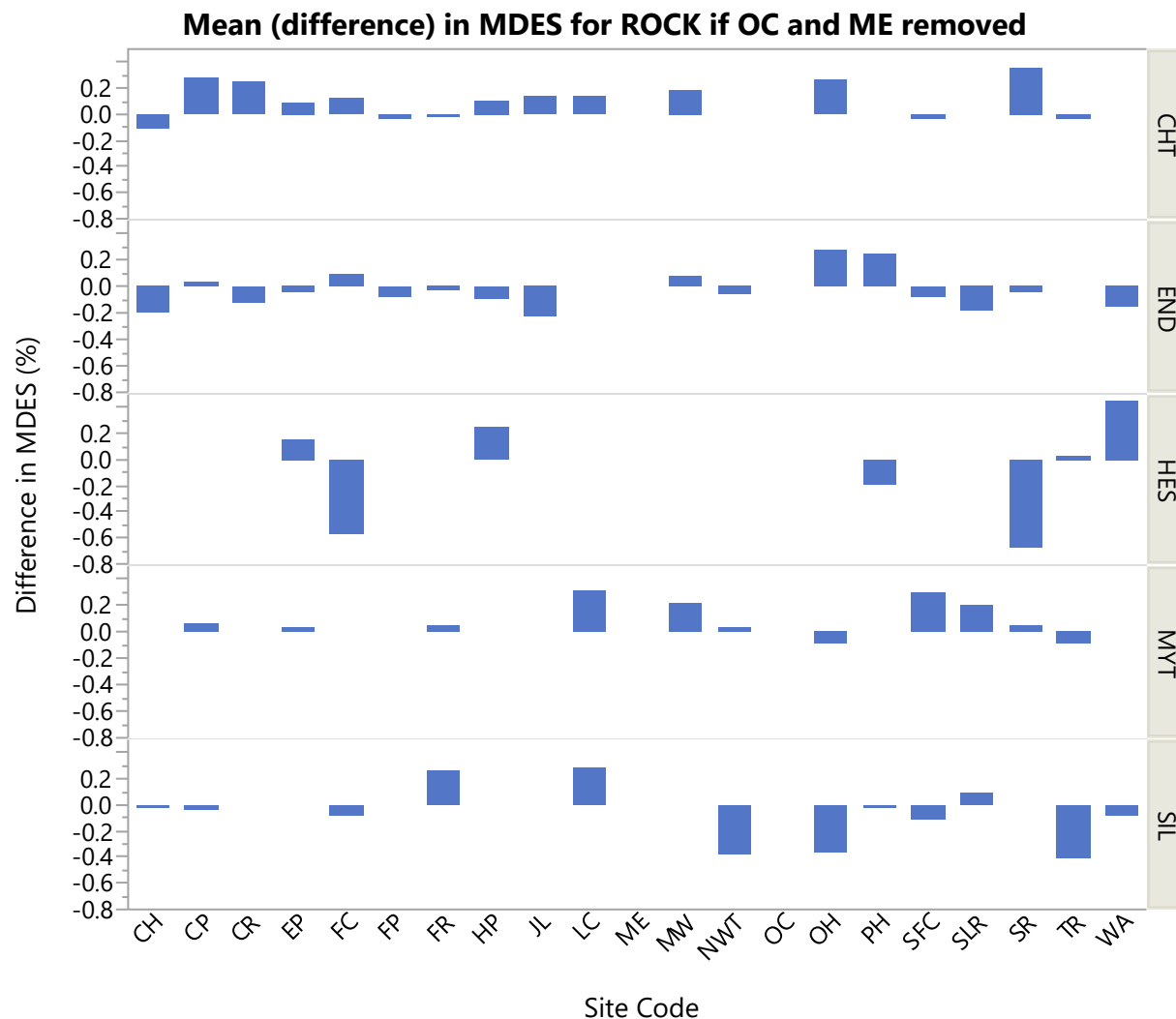


Figure 17. Difference in Minimum Detectable Effect Size (MDES) for rock in target species plots if ME and OC are removed from monitoring program as a function of site and target species. Site codes are listed in the glossary (Appendix C). Species abbreviations on the right Y axis are *Chthamalus* = CHT, *Endocladia* = END, *Hesperophycus* = HES, *Mytilus* = MYT, and *Silvetia* = SIL.

1.4.1.5 Mobile species

The same statistical approach described above was used to estimate the MDES for black abalone, owl limpet, and sea stars. The graphical approach is identical except the unit for mobile species is abundance per plot (or area) as opposed to percentage.

The results shown in Figure 18 are a summary of median MDES for all mobile species for $\alpha = 0.10$, $\beta = 0.2$, and with 11 replicates. This means comparing 11 years for the once per year sampling (random, Spring, Fall) and 5.5 years for twice per year sampling. Generally, owl limpet and black abalone had the smaller MDES (that is, smaller effect sizes are more likely to be detected) than sea stars. Note that this analysis, along with those presented below, does not incorporate size structure, which may improve the MDES results, especially for sea stars.

Current sampling of black abalone is based largely on timed site-wide sampling and is used in this assessment. Originally, CHIS sites conducted plot based sampling, which is still currently done by MARINe in other areas not affected by withering disease. The low MDES for black abalone is largely due to there being very low and relatively steady numbers of black abalone present, coupled with (except at a few sites) low recruitment. Black abalone generally have episodic recruitment (MARINe data), which increases variance in estimating abundance. Increasing variance will inevitably lead to higher MDES values; this is seen in the MDES values for sea stars, which until recently (period not part of the analysis) had high abundances and very episodic recruitment. In such situations a common practice is to divide populations into two groups, recruits and adults, based on size structure. Each group would then be evaluated separately. Usually the majority of mortality occurs in the recruits, which ends up buffering the adult population size and therefore leads to much smaller MDES values for the adult stage than for the recruit stage.

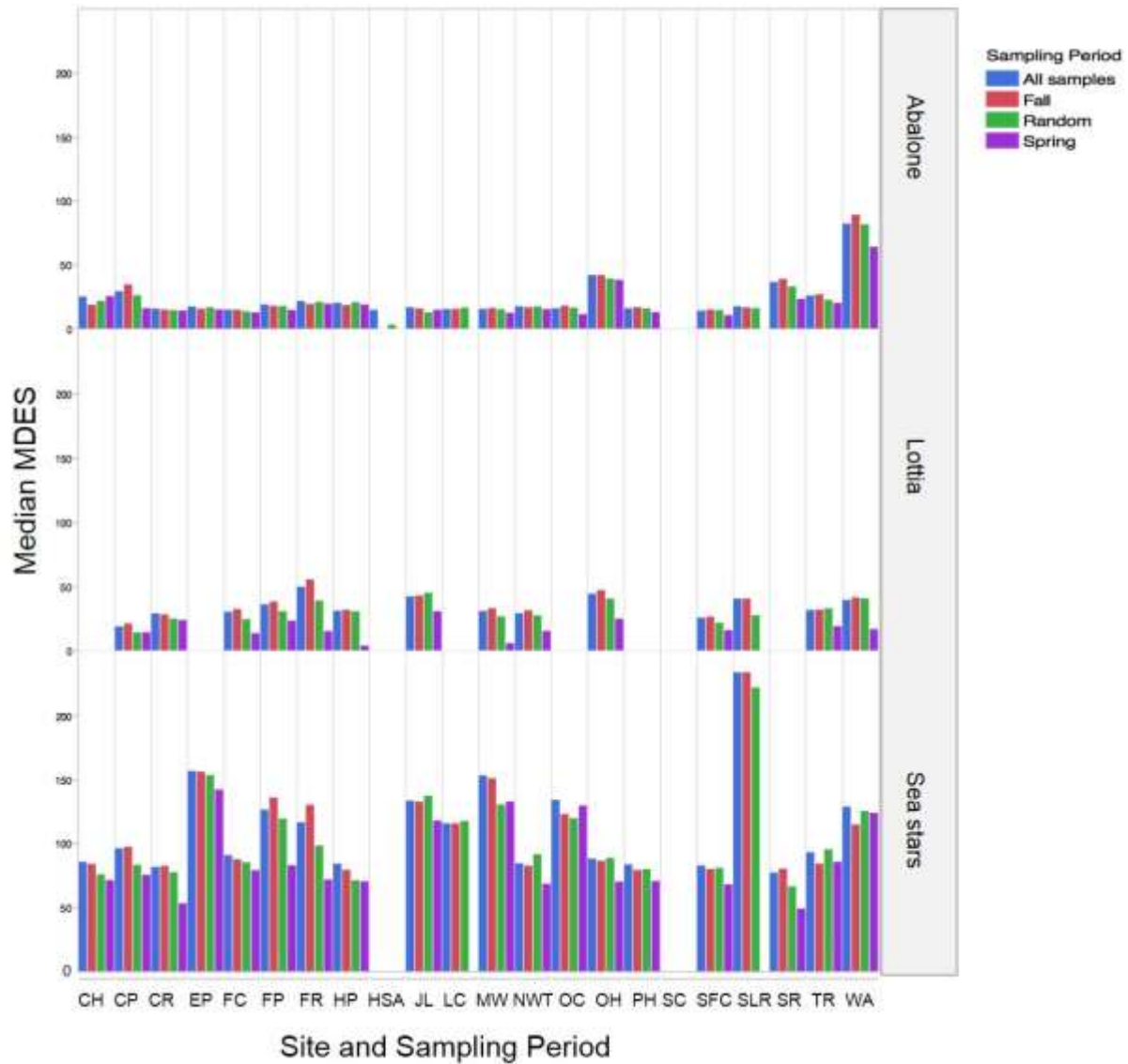


Figure 18. Median Minimum Detectable Effect Size (MDES) for all mobile species as a function of site and sampling period using $\alpha=0.10$, $\beta=0.20$, and 11 replicates. Values are counts. Site codes are listed in the glossary (Appendix C).

Black Abalone (Haliotis)

The results for black abalone are shown in Figure 19. For most sites and sample periods, MDES values of <10 are possible.

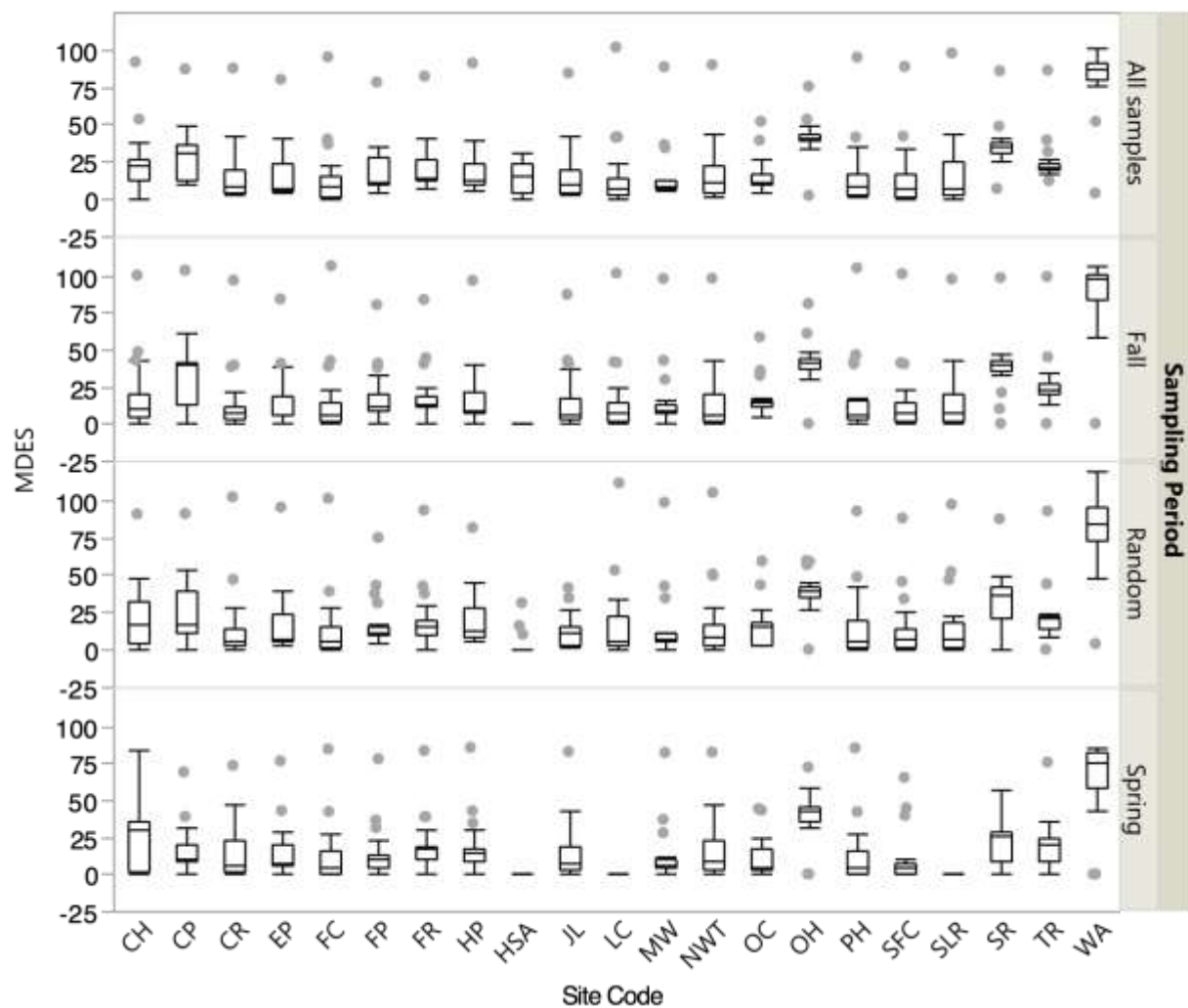


Figure 19. Boxplots of Minimum Detectable Effect Size (MDES) values for black abalone as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are counts. Number of sites in analysis (21) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Owl Limpet (Lottia)

The results for *Lottia* are shown in Figure 20. For most sites and sample periods, MDES values of <15 are possible. Like sea stars, formal incorporation of size structure is likely to dramatically decrease the MDES.

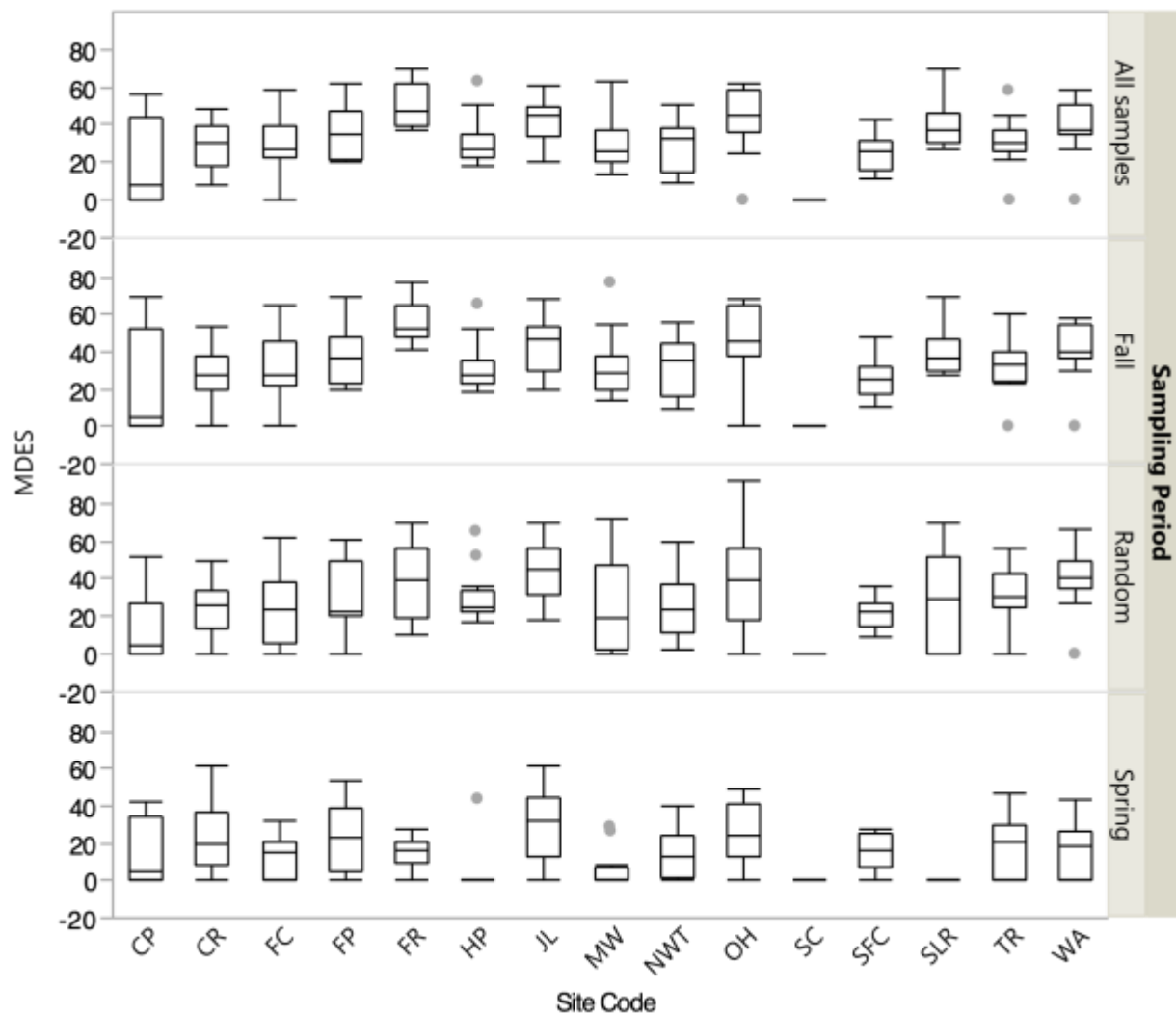


Figure 20. Boxplots of Minimum Detectable Effect Size (MDES) values for *Lottia* as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are counts. Number of sites in analysis (15) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

Sea Star (Pisaster)

The results for sea stars are shown in Figure 21. For most sites and sample periods, MDES values of <50 are possible. Note that this assessment only included data collected prior to the recent sea star wasting event that occurred in 2014. Note also that formal incorporation of size structure is likely to dramatically decrease the MDES.

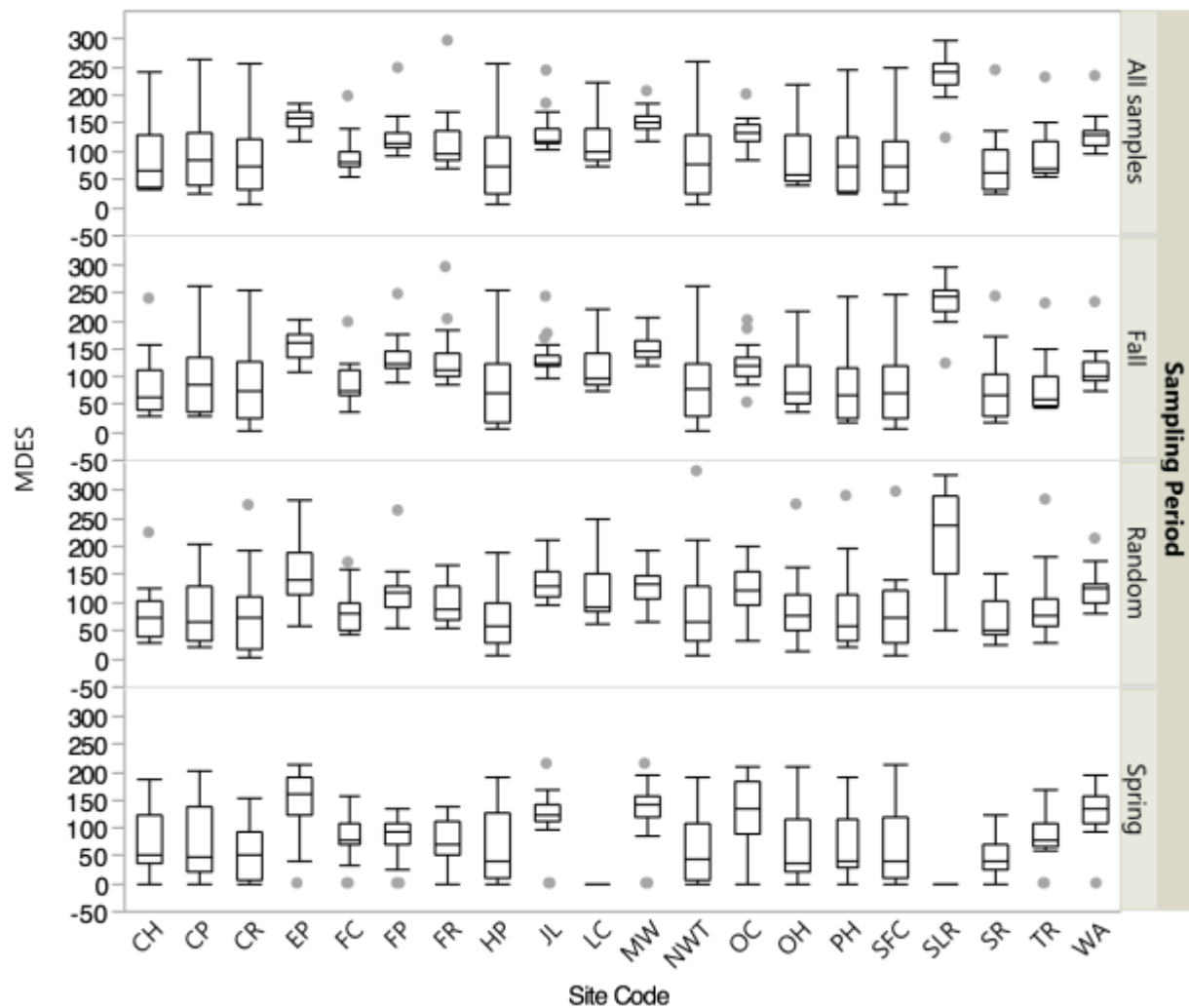


Figure 21. Boxplots of Minimum Detectable Effect Size (MDES) values for sea stars as a function of site and sampling period, using $\alpha = 0.10$, $\beta = 0.20$, and 11 replicates. Values are counts. Number of sites in analysis (20) reflects number of sites with target species. Site codes are listed in the glossary (Appendix C).

1.4.2. Temporal Pattern of Power

Results from the power analysis for detecting trends in populations over time are presented in Figures 22–27. Mean power across sites is plotted as a function of sample years. Each graph contains a bold line depicting power = 0.80 (80%) for an alpha error rate of 0.10. Multiple curves are overlaid in the graph, indicating different temporal sampling schemes (e.g., twice per year, once every two years). Figure 28 shows for one target species, *Chthamalus*, the median power for all sample schemes, along with the range in power across all sites.

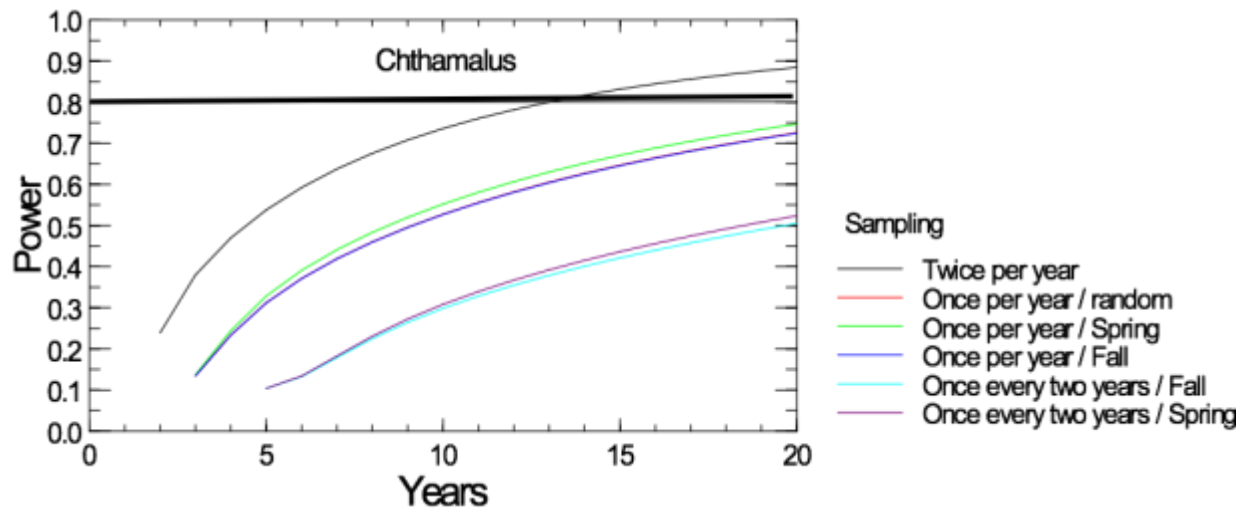


Figure 22. Mean power across sites as a function of number of sample years for *Chthamalus*. Alpha = 0.10 and trend is 2% per year. The red line (once per year/ random) follows the same trajectory as the blue line (once per year/ fall).

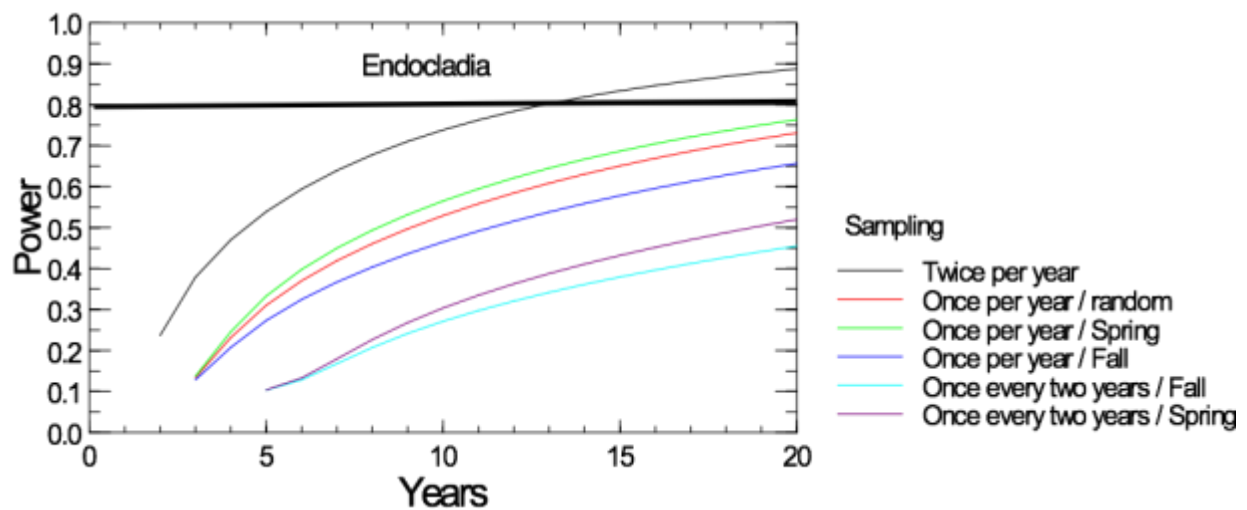


Figure 23. Mean power across sites as a function of number of sample years for *Endocladia*. Alpha = 0.10 and trend is 2% per year.

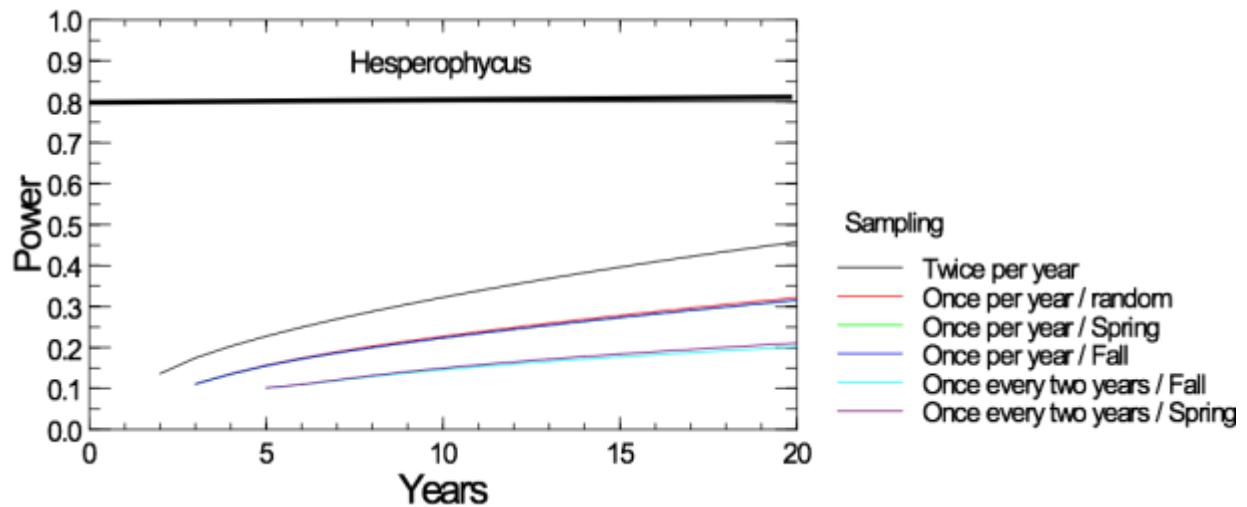


Figure 24. Mean power across sites as a function of number of sample years for *Hesperophycus*. Alpha = 0.10 and trend is 2% per year. The green line (once per year/ spring) follows the same trajectory as the blue line (once per year/ fall).

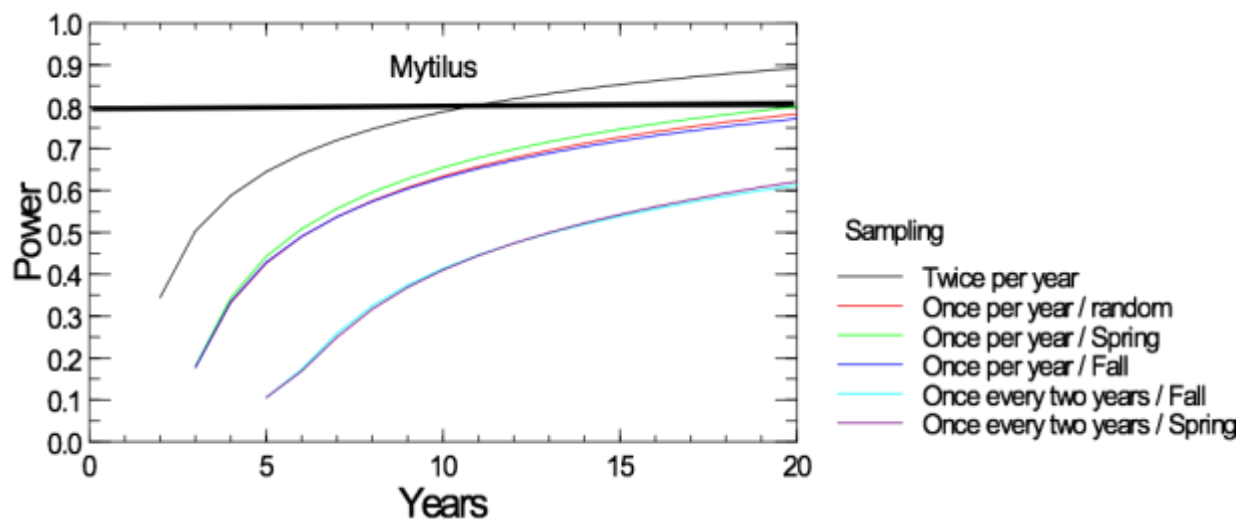


Figure 25. Mean power across sites as a function of number of sample years for *Mytilus*. Alpha = 0.10 and trend is 2% per year.

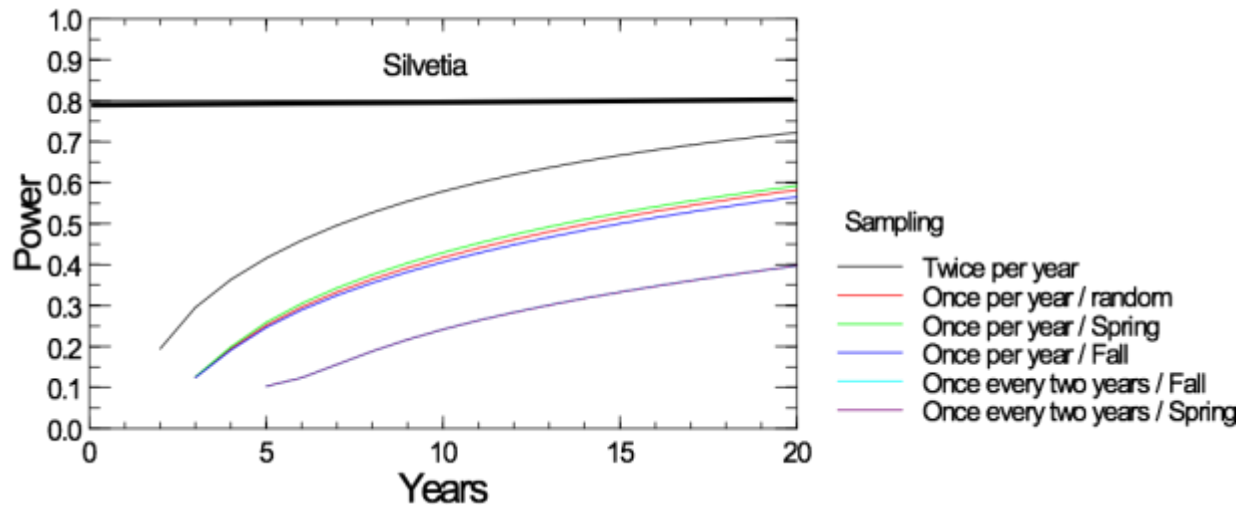


Figure 26. Mean power across sites as a function of number of sample years for *Silvetia*. Alpha = 0.10 and trend is 2% per year. The light blue line (once every two years/ fall) follows the same trajectory as the blue line (once per every two years/ spring).

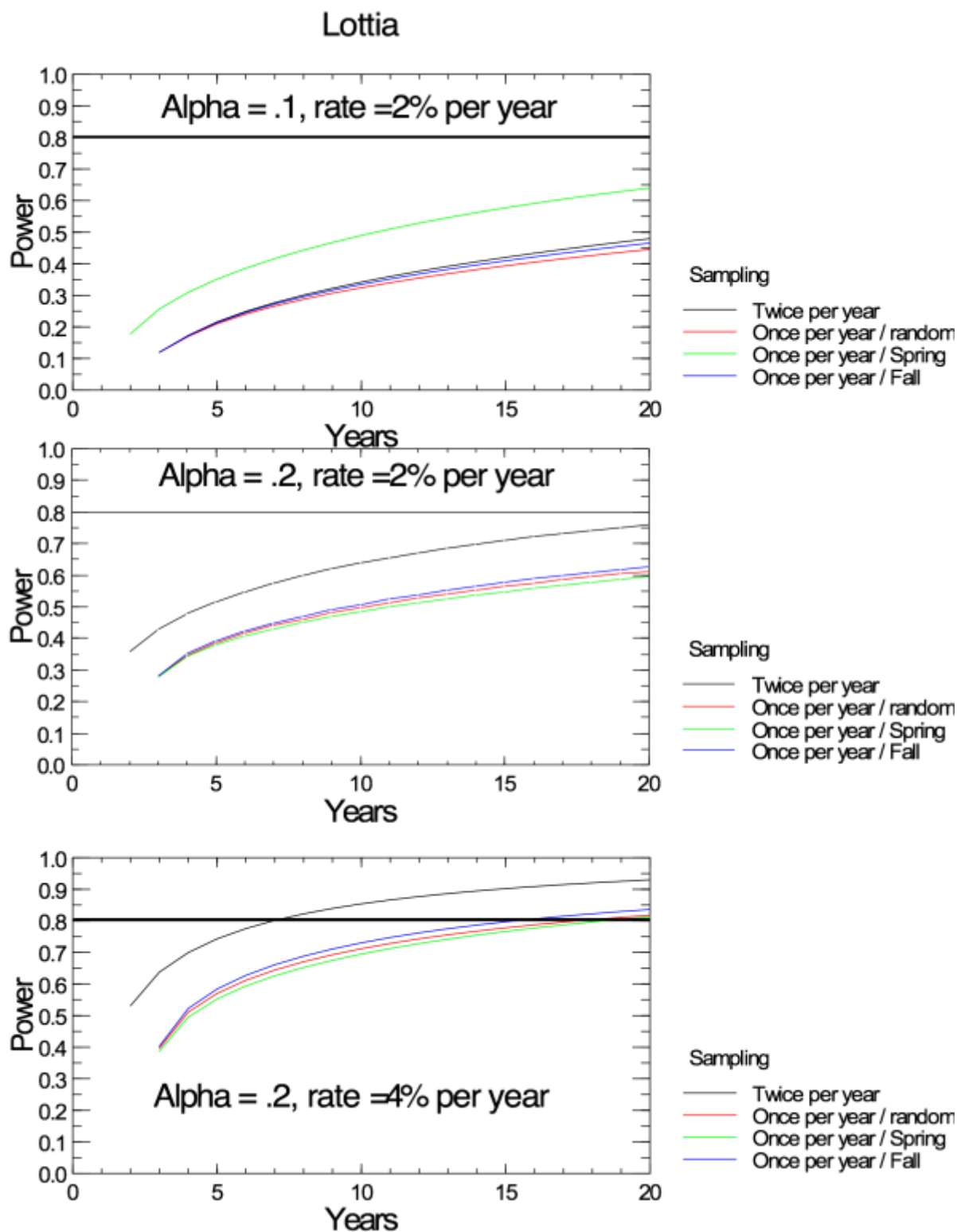


Figure 27. Mean power across sites as a function of number of sample years for *Lottia*. Here alpha and trend are varied to see the effect on power. Top: Alpha = 0.10 and trend is 2% per year; Middle: Alpha = 0.20 and trend is 2% per year; Bottom: Alpha = 0.20 and trend is 4% per year.

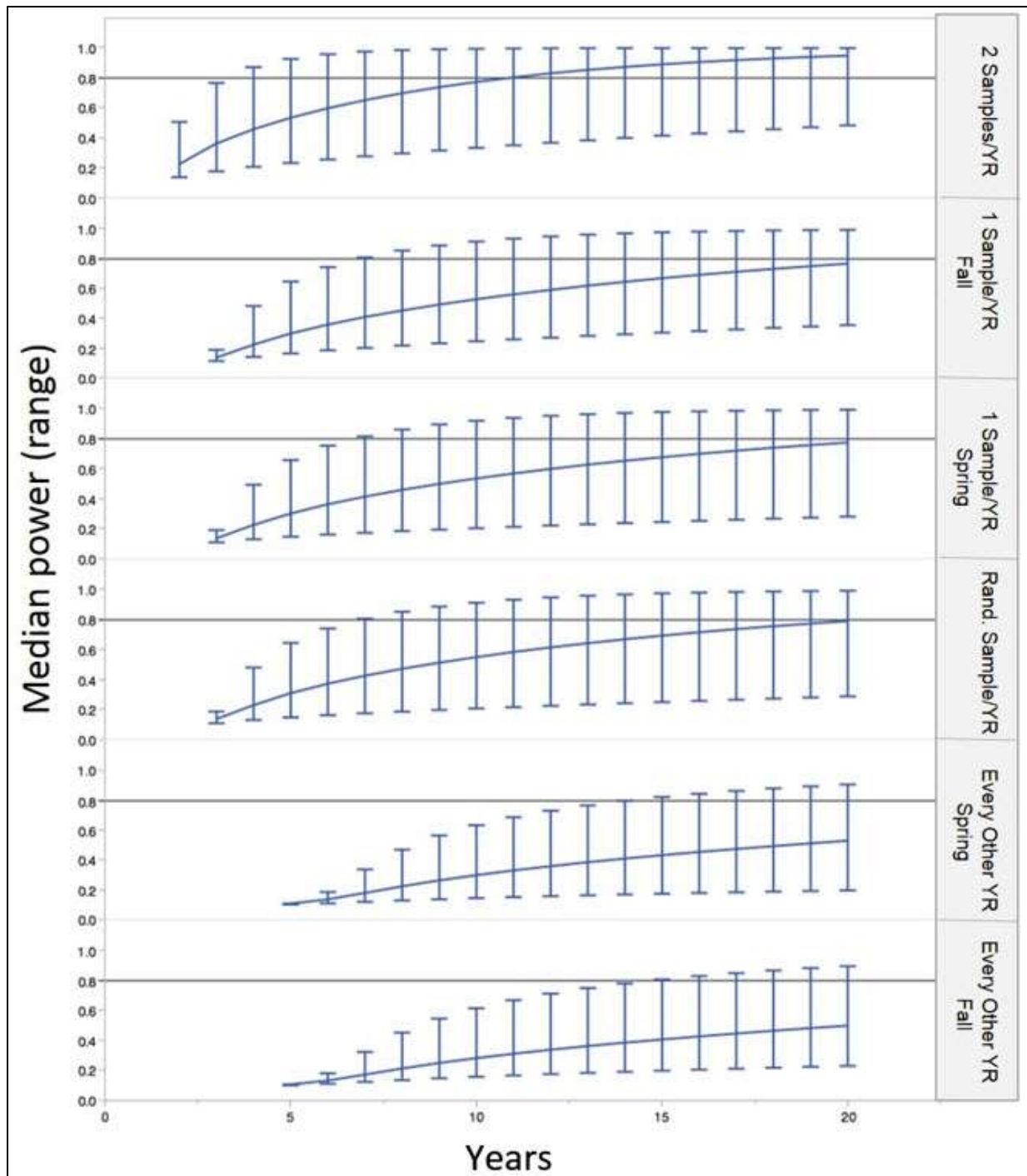


Figure 28. Power as a function of number of sample years for *Chthamalus*. Alpha = 0.10 and trend is 2% per year. Here each sampling scheme is shown in a separate panel. The blue line within error bars depicts the median power as a function of number of sample years. The error bars are the range in power across sites. The black line represents power = 0.80 (80%) for an alpha error rate of 0.10 for each sampling strategy.

1.5. Conclusions and Recommendations

1.5.1. Conclusions—Minimum Detectable Effect Size

1. What is the cost (in terms of statistical power) of reducing biannual sampling of target organisms (e.g., sessile species in photoplots, black abalone, sea stars, and owl limpets) to annual sampling? These results will be used to determine if further analysis at additional sites will need to be done in the phase two assessment.

In a general sense, the typical decrease in minimum detectable effect size is on the order of 50%. Having said this, the achievable MDES values are still fairly low—the key next step is to assess what the desired MDES levels are, and to determine the impact from reduction in sampling with respect to desired MDES. One interesting result is that the reduction in MDES resulting from once per year sampling is entirely due to the change in the number of samples and not sampling twice per year. There was essentially no benefit of twice per year sampling versus once per year if the total number of samples was held constant (i.e., 11 annual samples over 11 years versus 11 semiannual samples over 5.5 years). One key extension of this analysis, though not one explicitly part of the original charge, is to assess the tradeoff between temporal and spatial replication of sites. Temporal replication yields increasing power to detect impacts at the sampled sites. Increased spatial replication yields ability to detect impacts that are smaller because of the increased likelihood that at least one survey site will be among those affected by the impact. Another important next step is to define the spatial scale of impact that is important to detect, and even more critically, is measurable.

2. If sampling was completed annually, how much does the timing of sampling influence the statistical power to detect changes? What is the best season for sampling? Can sampling be done irrespective of season, thereby taking advantage of multiple low-tide series throughout the year?

There was unexpectedly very little difference in MDES for the differing sampling periods (random, Spring, Fall); Fall was the best season because it had lower MDES values for some species, but not by much and not for Lottia. This may reflect some inconsistency in the sampling (not all sites were sampled both seasons in every year), but it also appears that seasonal effects are small.

3. What level of change in the population dynamics of motile invertebrates is the current sampling protocol capable of detecting with 80% statistical power?

The MDES is relatively low counts (10–20 for black abalone and Lottia, and moderate for sea star counts (~50). The MDES values detectable should decrease with formal incorporation of size structure.

4. Due to logistical and financial constraints, NPS staff recommend discontinuing monitoring at a few select CHIS sites (Middle-East Anacapa and Orizaba Cove). Are there compelling reasons to continue monitoring at these sites?

There may be compelling reasons but they are not related to loss of power to detect effects at other sites.

1.5.2. Conclusions—Temporal Pattern of Power

1. For a trend of 2% per year with $\alpha = 0.10$, there is moderate power, approaching 80% for most sessile species after a sample period of 20 years.
2. Power goes up substantially if α is set to 0.20 or if the trend is increased (see *Lottia* example, Figure 27). This might seem obvious but power almost always increases asymptotically with increasing α or effect size (here trend percentage). For the range of α and effect size explored here, there was little evidence of asymptotic diminishing of power with increasing values.
3. The error bars in Figure 28 show that there is a range in power across sites for *Chthamalus*. The range represents the differences in historical variance at the sites. A regression-based BACIP approach should be developed. This would enhance power to detect trends.

1.5.3. General Recommendations

Recommendations are based on the following goals:

1. To maintain a robust monitoring program that maintains statistical power to detect relevant punctuated and gradual change to the community.
2. To reduce monitoring effort by identifying temporal sampling, sites, or protocols that can be dropped given goal 1.
3. To maintain a logistically sustainable monitoring program given goals 1 and 2.
4. If possible, to align the monitoring effort with the general MARINE monitoring program so as to link to the MARINE network of sites, database, and logistic support.

Recommendations are to:

1. Sample each site once per year. Fall would be best but little would be lost if the sampling was done in the Spring if logistic constraints and alignment with the MARINE program were better suited to Spring sampling.
2. With respect to the goals noted above, there is no reason to continue sampling at Middle-East Anacapa and Orizaba Cove.
3. Specifically, with alignment to the MARINE program and to increase ability to model community wide change, “biodiversity” sampling should be formally integrated into CHIS monitoring. There are two key options—both would meet an additional goal of feasibility due to time and effort saved by going to once per year sampling of long-term plots:
 - a. Simplified sampling of all sites each year. The set would be based on an analysis of biodiversity data from MARINE sampling of CHIS. The mathematical goal of the analysis would be to develop competing sets of between 20 and 30 species that depict the full community dynamics and spatial association to some extent (e.g., 80%). The logistical goal would be to vet the subset of models meeting the mathematical goal using practitioners (e.g., CHIS staff) to select the model with the easiest set of species to identify in the field. The actual number of lines (transects) would be adaptively managed to fit within a single day’s work.

- b. Sampling a set of sites (4–5) each year using full biodiversity protocols, perhaps in conjunction with MARINE. Full protocols typically require three days of sampling per site depending on field crew. Over a five-year period, all sites would be sampled once. This is the current MARINE model for mainland sites.

2. Bureau of Ocean Energy Management Monitoring Program

2.1. Introduction

The Bureau of Ocean Energy Management's (BOEM) mission is to manage the development of U.S. Outer Continental Shelf energy and mineral resources in an environmentally and economically responsible way. Subsequent to the leasing and developing of ocean areas in federal waters, BOEM is mandated to monitor the coastal environments to provide time-series and data trend information that can be used for comparison for identifying any significant changes in the quality of such environments (Outer Continental Shelf Lands Act 43 U.S.C. Sect. 1346 as amended in the Energy Policy Act of 2005). Rocky intertidal environments are impacted by oil spills and so BOEM's purpose for monitoring is to assess the level of impacts and changes outside normal limits of variation due to oil and gas operations. The current distribution of sites was developed in part from the maximum area of modeled oil spill trajectories from U.S federal oil platforms offshore of California from San Luis Obispo County to southern Orange County. Surveys were done twice a year and began in Spring 1992 in Santa Barbara County, Fall 1994 in Ventura and Los Angeles Counties, Fall 1995 in San Luis Obispo County, and Fall 1996 in Orange County.

The purpose of this report is to assess the long-term sampling protocol's ability to statistically detect changes in abundance of species. Statistically-based program review is an important component of all long-term monitoring programs to evaluate and refine, as needed, sampling designs and data collection techniques to ensure the program is meeting the stated monitoring goals and objectives. A technical review of the rocky intertidal program was last held in January 2001 (Minchinton and Raimondi 2005). Key changes to the program as a result of the 2001 review included the following:

- Monitoring objectives were modified to align with the Multi-Agency Rocky Intertidal Network (MARINe) monitoring objectives;
- Sampling plots were added and target species assemblages were renamed in accordance with MARINe (Engle et. al 1997);
- BOEM's target species list was redefined and expanded so it appropriately identified and documented distinct species or species-complexes; and
- Timed surveys for sea stars were implemented to better sample low numbers of sea stars following mortalities at sites south of Point Conception in the late 1990s. Timed surveys for abalone were implemented to provide a better way to sample low numbers of abalone following mass mortalities from Withering Syndrome (Richards and Davis 1993).

The current analysis was prompted by the need to re-evaluate staffing allocations to various components of the program (e.g., field data collection, data entry, data analysis and reporting) and to consider allocating time to a different sampling methodology (e.g., biodiversity surveys) that may provide more robust information on intertidal populations trends over time. Given declining budgets and staffing, in addition to recovering seabird and pinniped populations that hinder access to some sites, the first step in this program review was to answer the following questions:

1. What is the statistical power of sampling twice a year using the long-term MARINe protocol for target organisms (e.g., selected sessile species in photoplots, sea stars, owl limpets, and surfgrass transects)? What is the cost (in terms of statistical power) of reducing biannual sampling to annual sampling?
2. Are the current sites and species sampled at these sites effectively distributed? Focusing on a punctuated impact (such as an oil spill), are some sites more statistically valuable as control or reference locations?

2.2. Field Methods

The 21 rocky intertidal sites along the mainland of California (Figure 1) in San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and Orange Counties were established between 1992 and 1995. Sampling protocols are the same as described in the *Field Methods* (section 1.2) for Channel Islands National Park (CHIS) and as described for BOEM sites (Miner et al. 2005; Murray et al. 2005; Engle 2008). The MARINe targeted species groups are listed in Table 1. Target species groups sampled in photoplots and transects at the BOEM 21 mainland sites are bolded in Table 1 and listed by site in Table 2.

Table 2. Target species sampled (X) at the 21 Bureau of Ocean Energy Management sites, listed from north to south. Full names of species groups are listed in Table 1.

Site	Site code	<i>Anthopleura</i> (sea anenome)	<i>Chthamalus</i> / <i>Balanus</i> (barnacles)	<i>Endocladia</i> (turfweed)	<i>Mytilus</i> (mussel)	<i>Silvetia</i> (rockweed)	<i>Phyllospadix</i> (surfgrass)	<i>Pisaster</i> (sea star)	<i>Lottia</i> (owl limpet)
Point Sierra Nevada	PSN	–	X	–	X	X	X	X	–
Rancho Marino Reserve	RMR	–	–	–	–	–	–	–	X
Cayucos	CAY	–	X	X	X	X	X	X	X
Hazards	HAZ	–	X	X	X	X	X	X	X
Shell Beach	SHB	–	X	X	X	X	X	X	–
Occulto	OCC	–	X	X	X	–	–	X	–
Stairs	STA	–	X	X	X	X	X	X	X
Boat House	BOA	X	X	X	X	X	–	X	X
Alegria	ALEG	X	X	–	X	–	X	X	X
Arroyo Honda	ARHO	–	X	–	X	–	X	X	–
Coal Oil Point	COPT	X	–	–	X	–	X	X	–
Carpinteria	CARP	X	X	–	X	–	X	X	X
Mussel Shoals	MUSH	X	X	–	X	–	X	X	X
Old Stairs	OLDS	X	X	X	X	–	–	X	X
Paradise Cove	PCOV	–	X	X	X	–	X	X	X
White Point	WHPT	–	X	X	X	–	–	X	X
Point Fermin	PTFM	–	X	–	X	X	X	X	X
Crystal Cove	CRCO	–	X	–	X	X	X	X	X
Shaws Cove	SHCO	–	X	X	X	X	–	X	X
Treasure Island	TRIS	–	X	–	X	X	–	X	–
Dana Point	DAPT	–	X	–	X	X	X	X	X

2.3. Statistical Analysis Methods

Data for all species and sites are available at [rockyintertidal.org](https://www.eeb.ucsc.edu/pacificrockyintertidal/) for visualizing and for download:

<https://www.eeb.ucsc.edu/pacificrockyintertidal/explore-the-data/contact/data-request-form.html>

Statistical power analyses require a fundamental understanding of the data analysis that will be used to assess change. Because the purpose of the BOEM long-term rocky intertidal monitoring program is to detect species abundance changes from punctuated events (e.g., oil spills), the Before After Control Impact Paired (BACIP) analysis was used to estimate statistical power.

In the current assessment, there are over 20 years of sampling, enabling the use of the robust and powerful BACIP analysis (Stewart-Oaten et al. 1992). To compare the statistical power between sampling twice a year and sampling once a year, replicates are the temporal samples. The average difference between impact and control sites prior to an impact (time t_1) is compared to the average difference between the same impact and control site pair after the impact (time t_2). The typical statistical test used for such assessments is either a 1 or 2 sample t-test (1 sample if you are evaluating the impact with only a single post-impact sample). Replicate spatial samples within a site (i.e., the five nonrandom fixed plots or transects at a site) were averaged to provide a more accurate estimation of the mean for the site at time t . The key BACIP assumptions for this report follow:

1. Only five photoplot target species groups, *Anthopleura*, *Chthamalus/Balanus*, *Endocladia*, *Mytilus*, and *Silvetia* were assessed. Three additional mobile invertebrate target species groups, *Phyllospadix*, *Lottia*, and *Pisaster* were assessed separately.
2. The impact to the target species groups will be to decrease in abundance for target species in a predictable way; hence, a one tailed approach should be used.
3. Impacts may be limited to a single site, and the location of the site is unpredictable.
4. The set of potential control sites for any impact site includes all other sites having the species groups listed above.
5. Only the most recent 10 years of sampling were used; the average number of once per year sampling was 11 temporal samples and, for twice a year sampling, 21 temporal samples. The 10 year data cut off was done because: (1) protocols were standardized during this period, (2) this gave the maximum span of years with no missing values for most sites, and (3) 10 years seemed like a long enough period to reasonably model differences among sites and sufficiently short enough to exclude any long-term trends (e.g., significant El Niño–Southern Oscillation events) in the region that could compromise the BACIP approach.

Minimum Detectable Effect Size (MDES) was calculated for selected photoplot sessile and mobile target species and site combinations (section 2.4.1). This calculation allows estimation of the smallest effect size (difference) that could be detected with given combinations of Type 1 error (alpha at 0.20), Type 2 error (beta at 0.20), and replication (set at 11 samples, which is once per year sampling). The predicted effect sizes are absolute and not relative values (that is 10% change, not 10% of what was there). This was done in consideration of oil spill related National Resource

Damage Assessment expectations, which focus on loss, not relative loss. Alpha values bracket the values used in these impact assessments.

The statistical assessments are based on the parameters that are used to calculate MDES and generally in power analyses. Power was estimated for all combinations of parameter values: the predicted effect size (5%, 10% or 20%), the value of Type 1 error (alpha: 0.05 or 0.20), and sample size (11 or 21 samples). Sample size varied explicitly to assess the impact of reducing sampling from two times per year to one time for photoplot species (section 2.4.2.1), surfgrass transects (section 2.4.2.2), and mobile invertebrate surveys (section 2.4.2.3). This report focuses on the specific combination of values that yield 0.80 power: Type 1 error (alpha) = 0.20, effect size = 20%, and Type 2 error (beta) = 0.20. This particular combination is consistent with a 20, 20, 20 rule. This is also known as the alpha = beta = effect size, which is based on the idea that there are no priority parameter values with respect to error type and so alpha and beta should be equal to effect size.

To answer the second question of the utility of sites as controls for a potential impact, results are arranged to display the sites that attain 80% power for each target species. The utility of sites and species are then summarized in section 2.4.3.

All calculations were based on equations and an automated protocol developed for BACIP assessment. Results were validated relative to power approaches using SAS and SYSTAT statistical engines. Code in SAS is supplied in Appendix B.

2.4. Results and Discussion

2.4.1. Minimum Detectable Effect Size (MDES)

MDES values are the minimum effect size (difference) that can be expected to be statistically detectable assuming that the variance structure of data collected to date are representative of data to be collected in the future. Lower MDES values mean that a smaller degree of change can be detectable at 0.8 power and so is considered the best case. The results in Figures 29 and 30 (a and b; two pages of graphs for each figure) show the MDES for all target species and site combinations for alpha = beta = 0.2. Eleven temporal replicates were used, which represents once per year sampling into the future. Each replicate is the averaged value of five plots for each species and site combination.

Figure 29 shows the raw MDES results, which are the actual differences that could be detected for alpha = beta = 0.2, with 11 temporal replicates. Here the units are either number per plot or percent cover, depending on species. Figure 30 shows MDES relative to the mean value for sample period. Here the MDES values are all percentage of that mean. For example, a value of 20% means that a 20% change from the average value of the target species could be detected. Also shown is the actual mean value (blue +), for reference. Note that all of these calculations in the analyses in this report are based on untransformed data. In general the differences (the basis of BACIP) are normally distributed. However, there are some cases where a log transformation may be useful, especially in situations where a focal site has a low mean value, such as with *Pisaster*. *Chthamalus/Balanus* plots in Figures 29a and 30a are labeled as Barnacles.

Most mean MDES values fall under 25% for most species and sites, and many fall under 10%. The exception is *Pisaster*, which has a large range of 70% and mean MDES values between 15 and 55%. A low mean value of percent cover or count of a species contributed to a larger relative MDES value. Changes in abundance or counts when there are low values are more difficult to detect over time and are likely to have a higher MDES value. Note that this analysis, along with those presented below, do not incorporate size structure, which may improve the MDES results, especially for sea stars.

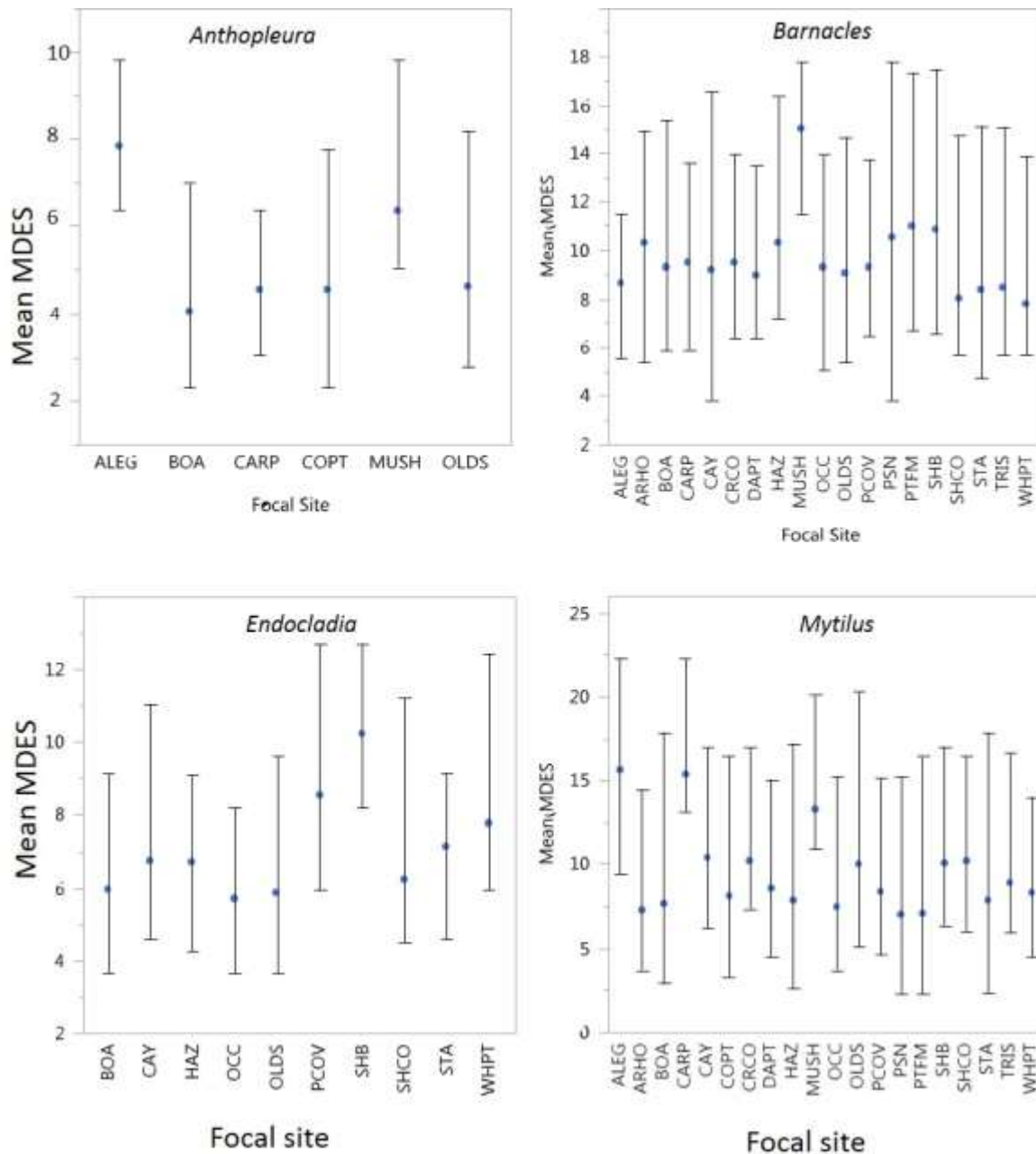


Figure 29a. Minimum Detectable Effect Size (MDES) for *Anthopleura*, Barnacles (*Chthamalus/Balanus*), *Endocladia*, and *Mytilus* for each site. Mean and range in values for all reference sites in the BACIP analyses are shown. Units are percent cover for all species. Site codes are translated in Table 2.

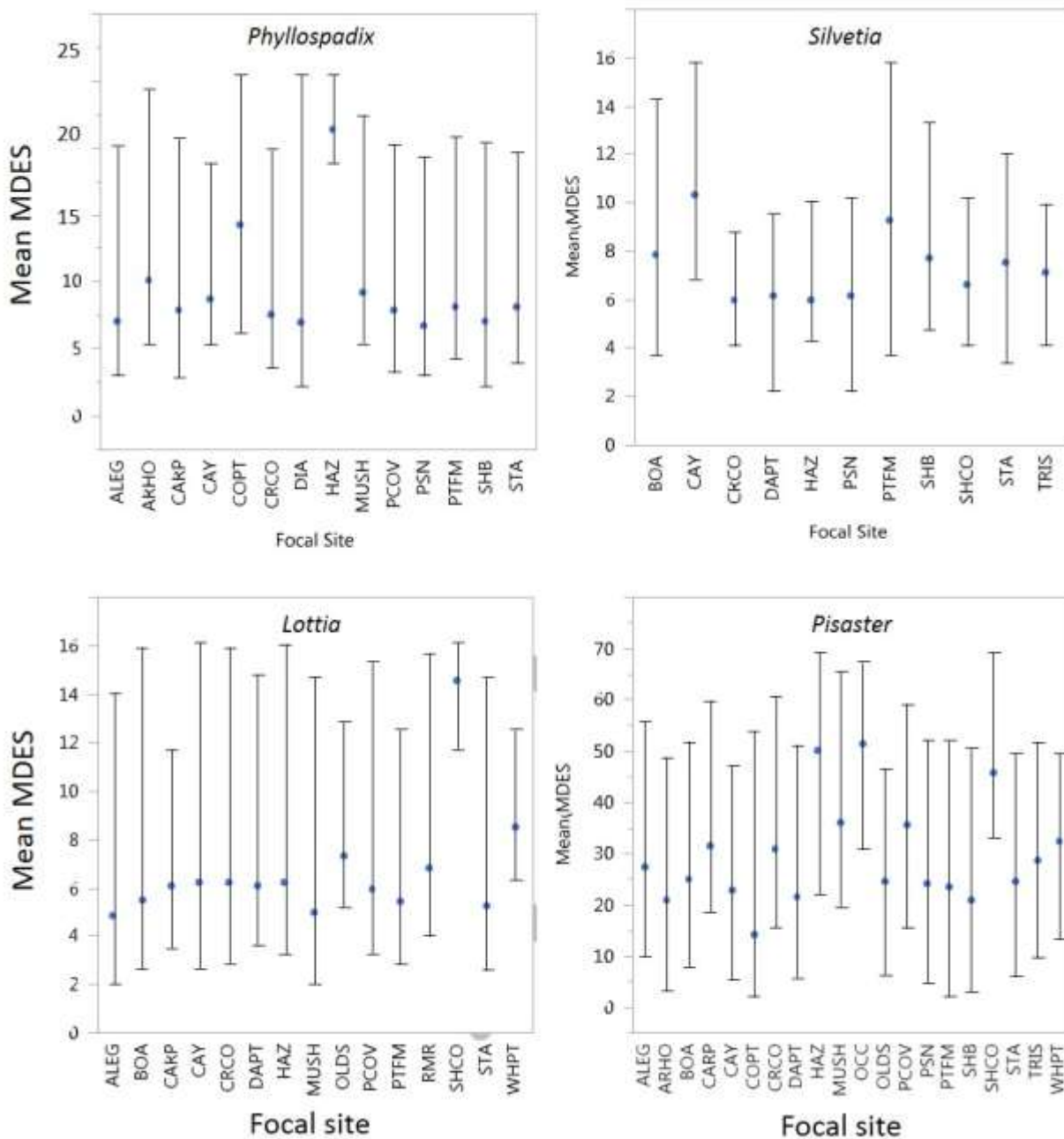


Figure 29b. Minimum Detectable Effect Size (MDES) for *Phyllospadix*, *Silvetia*, *Lottia*, and *Pisaster* for each site. Mean and range in values for all reference sites in the BACIP analyses are shown. Units are percent cover for *Phyllospadix* and *Silvetia* and abundance per plot for *Lottia* and *Pisaster*. Site codes are translated in Table 2.

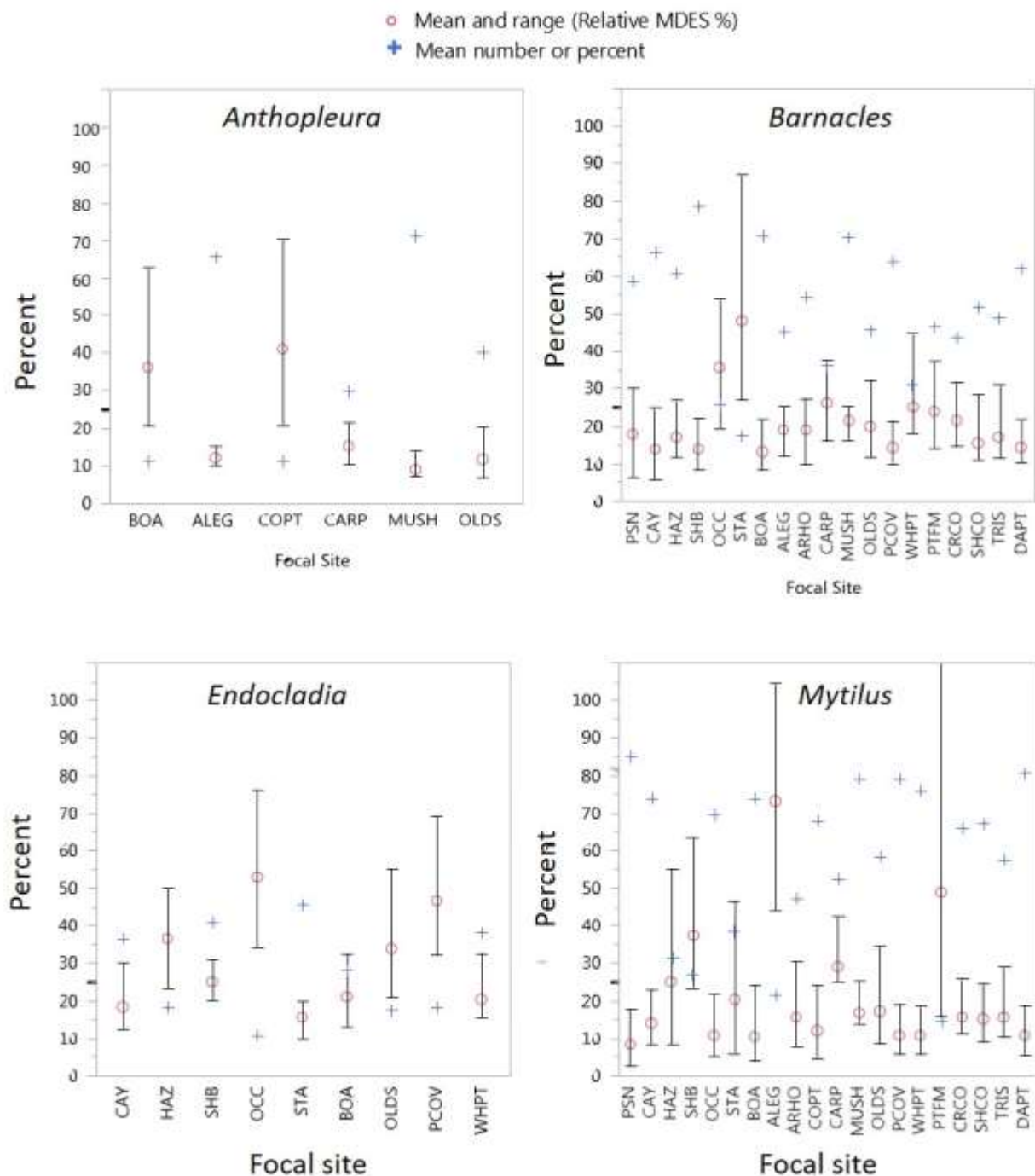


Figure 30a. Relative Minimum Detectable Effect Size (MDES) for *Anthopleura*, Barnacles (*Chthamalus/Balanus*), *Endocladia*, and *Mytilus* for each site. Mean and range in MDES values for all reference sites in the BACIP analyses are shown, along with actual average value for the species. Horizontal tick mark at 25% is for reference. Site codes are translated in Table 2.

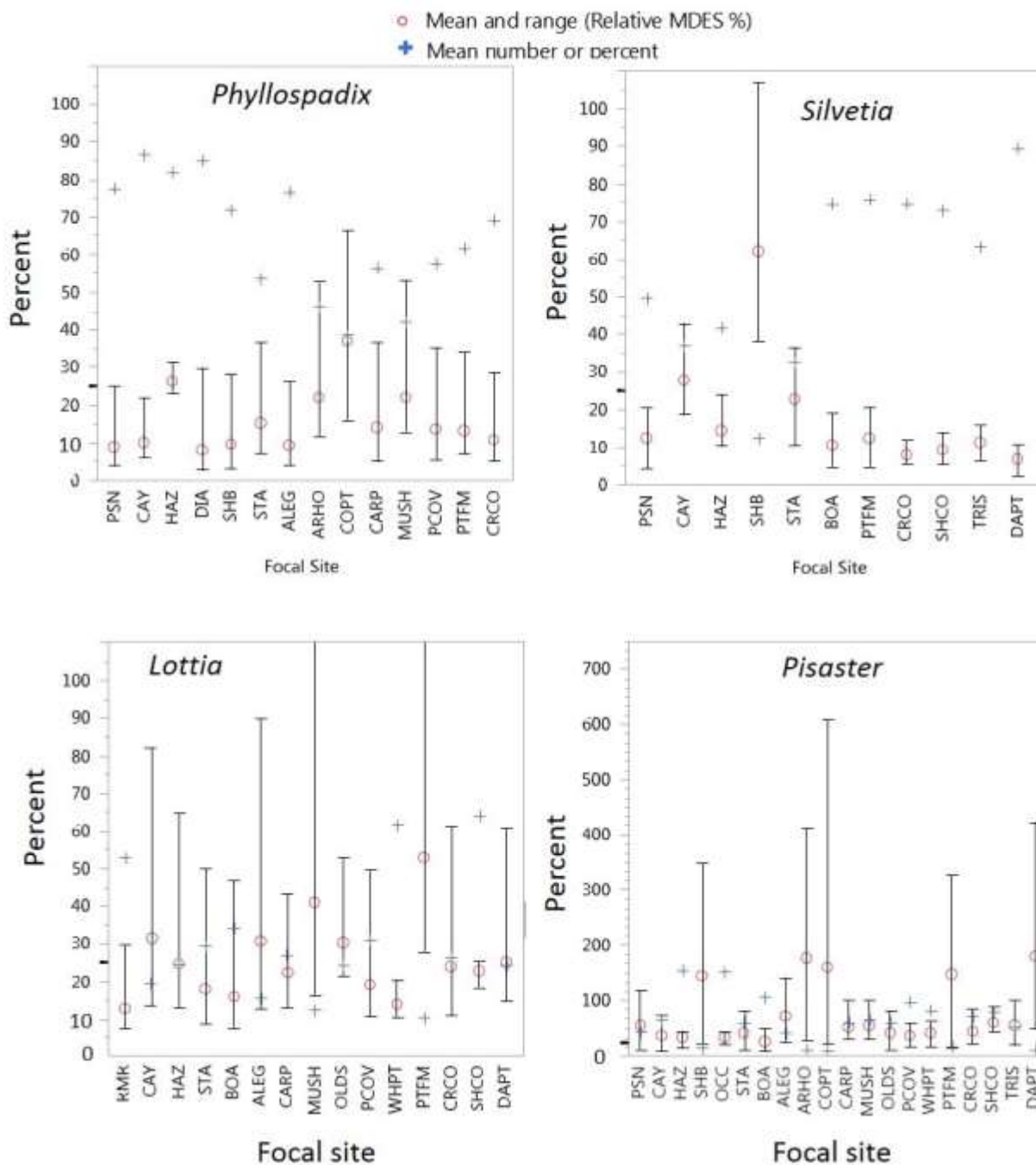


Figure 30b. Minimum Detectable Effect Size (MDES) for *Phyllospadix*, *Silvetia*, *Lottia*, and *Pisaster* for each focal site. Mean and range in MDES values for all reference sites in the BACIP analyses are shown, along with actual average value for the species. Horizontal tick mark at 25% is for reference. Site codes are translated in Table 2.

2.4.2. Power Analysis—Parameter and Species Combinations

2.4.2.1 Photoplots—target species

Figure 31 shows the overall power for all parameter combinations combined for the five photoplot selected target species. As expected, average power increases with increasing effect size, increasing sample size, and increasing alpha. The range in values for power suggest that, for all parameter combinations, there are combinations of control and impact sites with power above 80%.

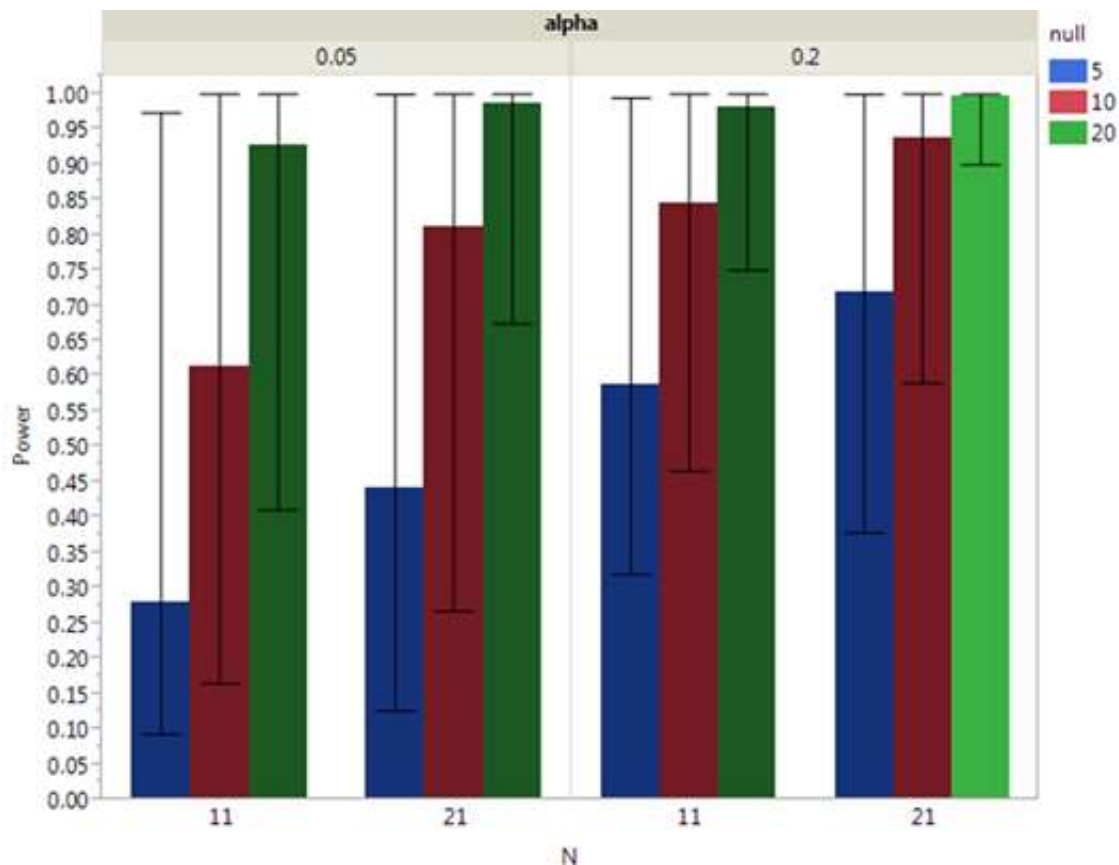


Figure 31. Mean and range of power (y-axis) for all parameter combinations. Replicate temporal samples (N) shown on x-axis for 11 (once a year sampling) and 21 (twice a year sampling) for alpha set to 0.05 and 0.2. The top of each bar is the mean power value. The ends of the brackets depict the range of power values for that parameter combination. The color of the solid bars shows effect sizes (null) of 5, 10 and 20%.

More detail in Figure 32 shows the same information broken out by selected photoplot target species and site. For example, power at White Point (WHPT) to detect impacts to *Endocladia* ranges from about 20% to 100%, with a median of 90%, depending on the control/impact site pair used and the power parameter values of alpha, effect size, and temporal sample replicates (N).

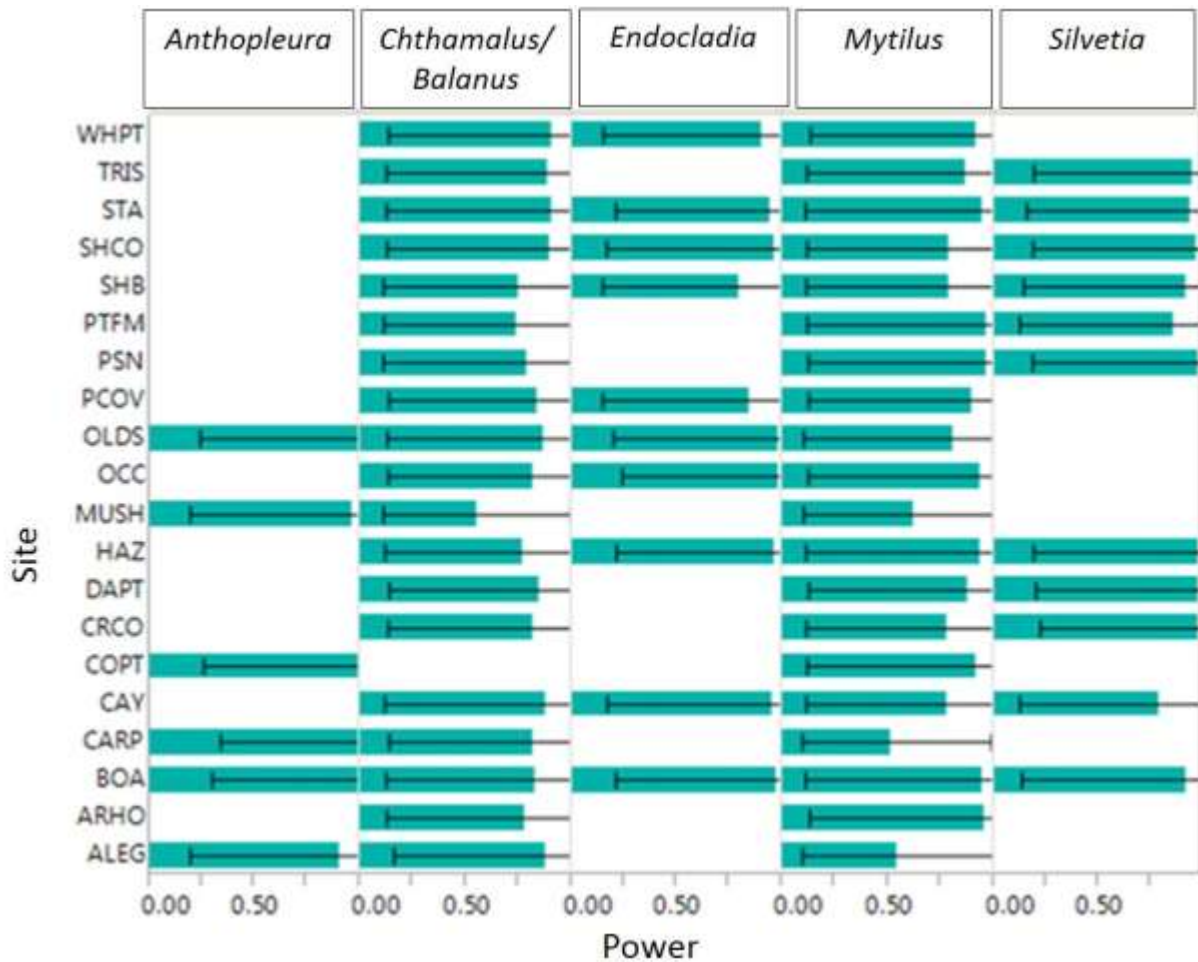


Figure 32. Median and range of power (x-axis) for all sites (y-axis) and five selected species. The top of each blue bar (oriented to the right) is the median power value. The ends of the black brackets depict the range of power values for all parameter combinations (alpha, effect size, and N listed in Figure 31). Site codes are shown in Table 2.

Even more detail is given in Figure 33, which shows the power associated with all combinations of power parameters. Each point on the graph is the power associated with a single pair of sites (one impact, one control). We see a greater ability to detect change in species percent cover (effect size = 10) at higher alpha (0.2) and with more replicates ($N = 21$). *Anthopleura*, *Endocladia*, and *Silvetia* show smaller ranges and over all higher power values than *Mytilus* and *Chthamalus/Balanus*.

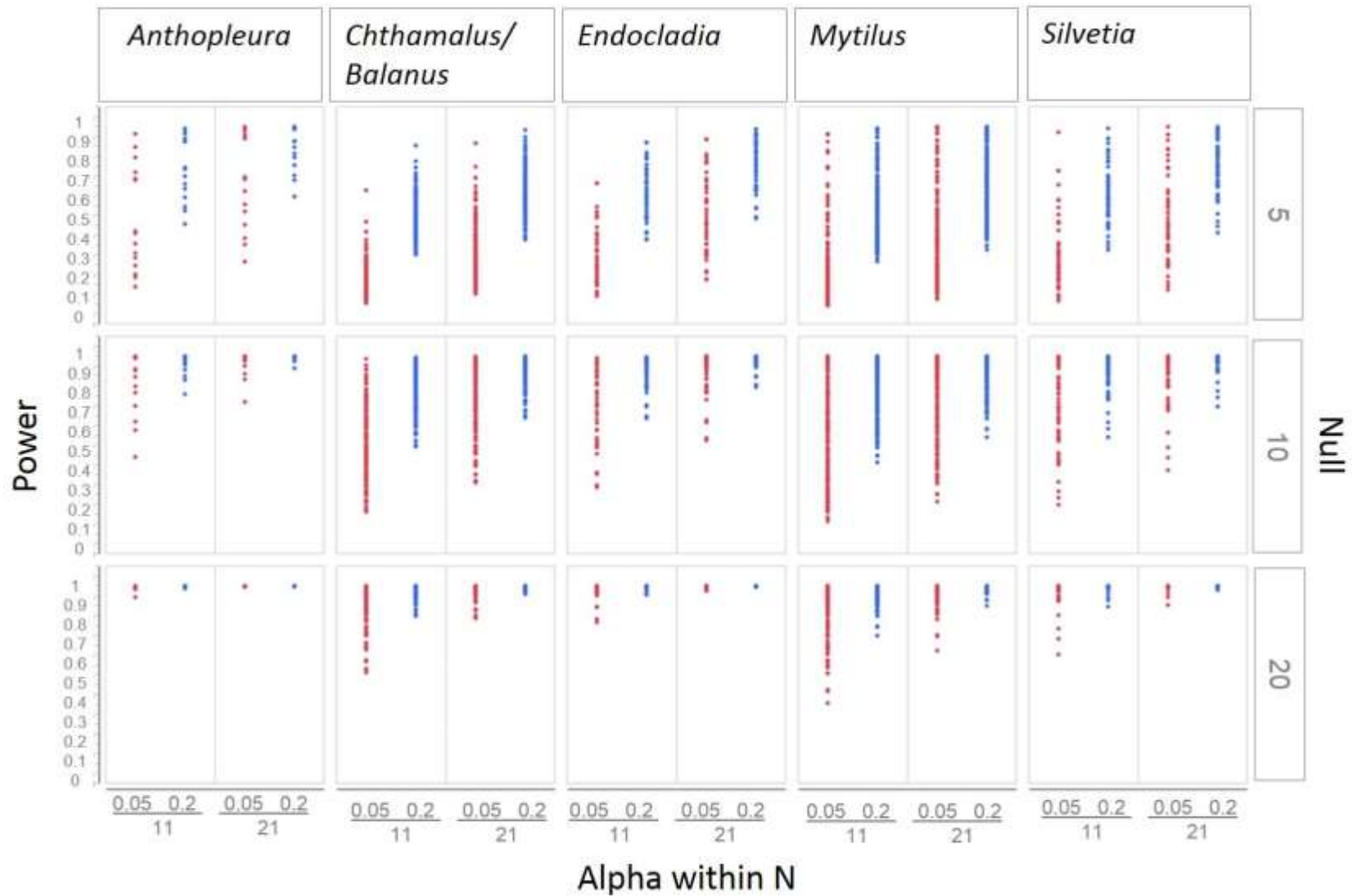


Figure 33. Power (y-axis left) as a function of replicates (N equals 11 or 21) and alpha (0.05 red points, or 0.2 blue points) on the x-axis. Null on the right y-axis is the effect size (null equals 5, 10, and 20) for each of five selected species. Each point represents the power resulting from a BACIP analysis for a pair of sites (one impact site and one control site).

The utility of sites and species to be used as appropriate controls or reference in BACIP analyses is defined as achieving 80% power and is summarized in Tables 3 and 4. Table 3 shows the results of an analysis to determine the utility of each site as a control under the 20, 20, 20 rule, assuming alpha, beta, and effect size values are equal to 0.2. The total number of samples (11) represents once a year sampling and is half of the total samples in the data set. Each cell represents a combination of sites (one control and one impact) for each of the five selected target species. Cells with pink fill depict combinations that have a power of at least 80%. The column labeled N shows the number of sites that could be used with 80% power for the impact site and selected species. The maximum number of sites achieving 80% power (maximum N) varies based on the number of sites that have plots sampling for a particular species. Table 4 provides more detail, showing the number of control sites for a given impact site that yield at least 80% power under the given power parameters.

Statistical power of 80% was achieved for all species analyzed and for all but three sites. All sites that sample *Anthopleura* (six sites) are appropriate control sites because *Anthopleura* plots have consistent cover over time across all sites and so yield a high statistical power. *Chthamalus/Balanus* plots are less consistent than *Anthopleura*, though they are sampled at more (19) sites. All sites have an appropriate control, with the exception of Mussel Shoals (MUSH). *Endocladia* is sampled at 10 sites and each location is an appropriate (achieves 80% power) control site to between five and all other sites. *Mytilus* is sampled at 20 sites and shows the most variance of all the selected photoplot target species sampled, ranging between zero and 16 other sites as appropriate controls. Carpinteria (CARP) and Mussel Shoals (MUSH) have no other control pairs that achieve 80% power. *Silvetia* was sampled at 11 sites and all sites have between 5 and 10 other sites that can serve as a control.

Table 3. Sites that could serve as control sites for BACIP analyses. The table is divided by five selected photoplot target species. Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum alpha = 0.2, beta = 0.2 (power = 0.8), and effect size of 10% (relative effect of ~20%). Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Species	Site	N	N ALEG	N ARHO	N BOA	N CARP	N CAY	N COPT	N CRCO	N DAPT	N HAZ	N MUSH	N OCC	N OLDS	N PCOVE	N PSN	N PTFM	N SHB	N SHCO	N STA	N TRIS	N WHPT
<i>Anthopleura</i>	ALEG	5	0	0	1	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
	BOA	5	1	0	0	1	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
	CARP	5	1	0	1	0	0	1	0	0	0	1	0	1	0	0	0	0	0	0	0	0
	COPT	5	1	0	1	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0
	MUSH	5	1	0	1	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0
	OLDS	5	1	0	1	1	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0
<i>Chthamalus/ Balanus</i>	ALEG	15	0	1	1	1	1	0	1	1	1	0	1	1	1	1	0	0	1	1	1	1
	ARHO	7	1	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	1	0	1	1
	BOA	10	1	0	0	0	1	0	0	1	0	0	1	0	0	1	0	1	1	1	1	1
	CARP	12	1	1	0	0	0	0	1	1	0	0	0	1	1	0	1	1	1	1	1	1
	CAY	12	1	0	1	0	0	0	0	1	1	0	1	1	0	1	0	1	1	1	1	1
	CRCO	11	1	1	0	1	0	0	0	1	0	0	1	1	1	0	0	0	1	1	1	1
	DAPT	12	1	0	1	1	1	0	1	0	0	0	1	1	1	0	0	0	1	1	1	1
	HAZ	8	1	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	1
	MUSH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	OCC	13	1	0	1	0	1	0	1	1	1	0	0	1	1	1	0	0	1	1	1	1
	OLDS	13	1	1	0	1	1	0	1	1	0	0	1	0	1	0	0	1	1	1	1	1
	PCOV	12	1	0	0	1	0	0	1	1	1	0	1	1	0	0	1	0	1	1	1	1
	PSN	8	1	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	1
	PTFM	6	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	1
	SHB	7	0	0	1	1	1	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1

Table 3 (continued). Sites that could serve as control sites for BACIP analyses. The table is divided by five selected photoplot target species. Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum alpha = 0.2, beta = 0.2 (power = 0.8), and effect size of 10% (relative effect of ~20%). Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Species	Site	N	N ALEG	N ARHO	N BOA	N CARP	N CAY	N COPT	N CRCO	N DAPT	N HAZ	N MUSH	N OCC	N OLDS	N PCOVE	N PSN	N PTFM	N SHB	N SHCO	N STA	N TRIS	N WHPT
<i>Chthamalus/ Balanus (continued)</i>	SHCO	17	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1	1
	STA	14	1	0	1	1	1	0	1	1	1	0	1	1	1	1	0	0	1	0	1	1
	TRIS	16	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	0	1	1	0	1
	WHPT	17	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	0
<i>Endocladia</i>	BOA	9	0	0	0	0	1	0	0	0	1	0	1	1	1	0	0	1	1	1	0	1
	CAY	8	0	0	1	0	0	0	0	0	1	0	1	1	1	0	0	0	1	1	0	1
	HAZ	9	0	0	1	0	1	0	0	0	0	0	1	1	1	0	0	1	1	1	0	1
	OCC	9	0	0	1	0	1	0	0	0	1	0	0	1	1	0	0	1	1	1	0	1
	OLDS	9	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	1	1	1	0	1
	PCOV	8	0	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0	1	1	0	1
	SHB	5	0	0	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	1	0	0
	SHCO	8	0	0	1	0	1	0	0	0	1	0	1	1	1	0	0	0	0	1	0	1
	STA	9	0	0	1	0	1	0	0	0	1	0	1	1	1	0	0	1	1	0	0	1
	WHPT	8	0	0	1	0	1	0	0	0	1	0	1	1	1	0	0	0	1	1	0	0
<i>Mytilus</i>	ALEG	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
	ARHO	16	0	0	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1
	BOA	13	0	1	0	0	1	1	0	1	1	0	1	1	1	1	1	0	0	1	1	1
	CARP	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	CAY	12	0	1	1	0	0	0	1	1	1	0	1	0	1	1	1	0	1	1	1	0
	COPT	13	0	1	1	0	0	0	0	1	1	0	1	1	1	1	1	1	0	1	1	1
	CRCO	10	0	1	0	0	1	0	0	1	0	0	1	0	0	1	1	1	1	0	1	1
	DAPT	15	0	1	1	0	1	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1

Table 3 (continued). Sites that could serve as control sites for BACIP analyses. The table is divided by five selected photoplot target species. Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum alpha = 0.2, beta = 0.2 (power = 0.8), and effect size of 10% (relative effect of ~20%). Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Species	Site	N	N ALEG	N ARHO	N BOA	N CARP	N CAY	N COPT	N CRCO	N DAPT	N HAZ	N MUSH	N OCC	N OLDS	N PCOVE	N PSN	N PTFM	N SHB	N SHCO	N STA	N TRIS	N WHPT
<i>Mytilus</i> (continued)	HAZ	13	0	1	1	0	1	1	0	1	0	0	1	1	1	1	1	0	0	1	1	1
	MUSH	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	OCC	16	0	1	1	0	1	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1
	OLDS	10	0	1	1	0	0	1	0	0	1	0	1	0	1	1	1	0	0	1	1	0
	PCOV	15	0	1	1	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	1	1
	PSN	16	0	1	1	0	1	1	1	1	1	0	1	1	1	0	1	1	1	1	1	1
	PTFM	16	0	1	1	0	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	1
	SHB	11	1	1	0	0	0	1	1	1	0	0	1	0	1	1	1	0	1	0	0	1
	SHCO	11	0	1	0	0	1	0	1	1	0	0	1	0	1	1	1	1	0	0	1	1
	STA	13	0	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0	0	0	1	1
	TRIS	15	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	1	1	0	1
	WHPT	14	0	1	1	0	0	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0
<i>Silvetia</i>	BOA	9	0	0	0	0	0	0	1	1	1	0	0	0	0	1	1	1	1	1	1	0
	CAY	5	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	1	0
	CRCO	10	0	0	1	0	1	0	0	1	1	0	0	0	0	1	1	1	1	1	1	0
	DAPT	10	0	0	1	0	1	0	1	0	1	0	0	0	0	1	1	1	1	1	1	0
	HAZ	9	0	0	1	0	0	0	1	1	0	0	0	0	0	1	1	1	1	1	1	0
	PSN	9	0	0	1	0	1	0	1	1	1	0	0	0	0	0	0	1	1	1	1	0
	PTFM	7	0	0	1	0	0	0	1	1	1	0	0	0	0	0	0	1	1	0	1	0
	SHB	8	0	0	1	0	0	0	1	1	1	0	0	0	0	1	1	0	1	0	1	0
	SHCO	9	0	0	1	0	0	0	1	1	1	0	0	0	0	1	1	1	0	1	1	0
	STA	8	0	0	1	0	1	0	1	1	1	0	0	0	0	1	0	0	1	0	1	0
	TRIS	10	0	0	1	0	1	0	1	1	1	0	0	0	0	1	1	1	1	1	0	0

Table 4. Summary of sites that could serve as control sites for BACIP analyses done with a combination of parameter values. The table is divided by five selected photoplot target species. Each cell in the parameter-specific columns with a nonzero value (also with pink fill) is a BACIP site pair that results in a power equal to 0.8 and shows the total number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling, respectively.

Species	Site	N Rows	N (11,0.05,5)	N (11,0.05,10)	N (11,0.05,20)	N (11,0.2,5)	N (11,0.2,10)	N (11,0.2,20)	N (21,0.05,5)	N (21,0.05,10)	N (21,0.05,20)	N (21,0.2,5)	N (21,0.2,10)	N (21,0.2,20)
<i>Anthopleura</i>	ALEG	37	0	1	5	0	5	5	0	4	5	2	5	5
	BOA	53	3	4	5	3	5	5	3	5	5	5	5	5
	CARP	52	1	5	5	3	5	5	3	5	5	5	5	5
	COPT	50	1	4	5	3	5	5	3	5	5	4	5	5
	MUSH	42	0	4	5	0	5	5	0	4	5	4	5	5
	OLDS	50	1	4	5	3	5	5	3	5	5	4	5	5
<i>Chthamalus/ Balanus</i>	ALEG	123	0	2	18	0	15	18	0	13	18	3	18	18
	ARHO	102	0	2	16	0	7	18	0	4	18	2	17	18
	BOA	112	0	1	17	0	10	18	0	9	18	4	17	18
	CARP	112	0	1	16	0	12	18	0	9	18	2	18	18
	CAY	119	0	3	17	2	12	18	1	10	18	3	17	18
	CRCO	112	0	1	16	0	11	18	0	9	18	3	18	18
	DAPT	117	0	1	17	0	12	18	0	12	18	3	18	18
	HAZ	102	0	0	17	0	8	18	0	6	18	0	17	18
	MUSH	62	0	0	1	0	0	18	0	0	18	0	7	18
	OCC	115	0	2	15	0	13	18	0	10	18	3	18	18
	OLDS	119	0	3	17	0	13	18	0	10	18	5	17	18
	PCOV	116	0	2	17	0	12	18	0	11	18	2	18	18
	PSN	105	0	2	13	1	8	18	1	6	18	3	17	18
	PTFM	99	0	0	15	0	6	18	0	6	18	1	17	18
	SHB	99	0	0	16	0	7	18	0	3	18	2	17	18
	SHCO	132	0	4	17	0	17	18	0	16	18	7	17	18

Table 4 (continued). Summary of sites that could serve as control sites for BACIP analyses done with a combination of parameter values. The table is divided by five selected photoplot target species. Each cell in the parameter-specific columns with a nonzero value (also with pink fill) is a BACIP site pair that results in a power equal to 0.8 and shows the total number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling, respectively.

Species	Site	N Rows	N (11,0.05,5)	N (11,0.05,10)	N (11,0.05,20)	N (11,0.2,5)	N (11,0.2,10)	N (11,0.2,20)	N (21,0.05,5)	N (21,0.05,10)	N (21,0.05,20)	N (21,0.2,5)	N (21,0.2,10)	N (21,0.2,20)
<i>Chthamalus/ Balanus (continued)</i>	STA	126	0	5	17	1	14	18	0	12	18	6	17	18
	TRIS	126	0	3	17	0	16	18	0	15	18	4	17	18
	WHPT	132	0	4	17	0	17	18	0	15	18	7	18	18
<i>Endocladia</i>	BOA	83	0	7	9	3	9	9	3	9	9	7	9	9
	CAY	73	0	5	9	1	8	9	1	8	9	5	9	9
	HAZ	77	0	5	9	2	9	9	2	9	9	5	9	9
	OCC	82	0	6	9	3	9	9	2	9	9	8	9	9
	OLDS	82	0	5	9	4	9	9	4	8	9	7	9	9
	PCOV	64	0	1	9	0	8	9	0	8	9	2	9	9
	SHB	54	0	0	9	0	5	9	0	4	9	0	9	9
	SHCO	79	0	7	9	2	8	9	1	8	9	8	9	9
	STA	73	0	3	9	1	9	9	1	9	9	5	9	9
	WHPT	69	0	3	9	0	8	9	0	8	9	5	9	9
<i>Mytilus</i>	ALEG	63	0	0	5	0	1	16	0	0	16	0	6	19
	ARHO	157	0	11	17	6	16	19	5	16	19	11	18	19
	BOA	150	2	10	17	5	13	19	5	13	19	10	18	19
	CARP	63	0	0	0	0	0	18	0	0	18	0	8	19
	CAY	113	0	1	16	0	12	19	0	10	19	1	16	19
	COPT	145	0	8	17	5	13	19	5	13	19	10	17	19
	CRCO	109	0	0	16	0	10	19	0	9	19	0	17	19
	DAPT	134	0	4	18	1	15	19	1	15	19	5	18	19
	HAZ	148	1	9	17	7	13	19	5	12	19	9	18	19
	MUSH	81	0	0	12	0	0	18	0	0	18	0	14	19

Table 4 (continued). Summary of sites that could serve as control sites for BACIP analyses done with a combination of parameter values. The table is divided by five selected photoplot target species. Each cell in the parameter-specific columns with a nonzero value (also with pink fill) is a BACIP site pair that results in a power equal to 0.8 and shows the total number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling, respectively.

Species	Site	N Rows	N (11,0.05,5)	N (11,0.05,10)	N (11,0.05,20)	N (11,0.2,5)	N (11,0.2,10)	N (11,0.2,20)	N (21,0.05,5)	N (21,0.05,10)	N (21,0.05,20)	N (21,0.2,5)	N (21,0.2,10)	N (21,0.2,20)
Mytilus (continued)	OCC	150	0	9	17	5	16	19	4	16	19	9	17	19
	OLDS	115	0	4	14	0	10	18	0	10	18	5	17	19
	PCOV	137	0	7	16	1	15	19	1	15	19	8	17	19
	PSN	159	1	10	17	6	16	19	6	16	19	12	18	19
	PTFM	161	4	9	17	8	16	19	8	13	19	11	18	19
	SHB	112	0	1	16	0	11	19	0	9	19	1	17	19
	SHCO	113	0	1	16	0	11	19	0	10	19	1	17	19
	STA	146	2	8	17	4	13	19	4	13	19	10	18	19
	TRIS	128	0	2	17	0	15	19	0	14	19	5	18	19
	WHPT	136	0	4	18	2	14	19	2	14	19	6	19	19
Silvetia	BOA	74	0	3	9	1	9	10	1	8	10	4	9	10
	CAY	56	0	0	7	0	5	10	0	5	10	1	8	10
	CRCO	93	0	7	10	5	10	10	4	10	10	7	10	10
	DAPT	87	1	6	10	3	10	10	2	9	10	6	10	10
	HAZ	89	0	7	10	4	9	10	1	9	10	9	10	10
	PSN	89	1	6	10	4	9	10	3	9	10	7	10	10
	PTFM	66	0	1	9	1	7	10	1	5	10	3	9	10
	SHB	75	0	4	9	1	8	10	0	8	10	5	10	10
	SHCO	84	0	6	10	2	9	10	1	9	10	7	10	10
	STA	76	0	3	10	2	8	10	2	7	10	4	10	10
	TRIS	81	0	5	10	1	10	10	1	9	10	5	10	10

2.4.2.1 Surfgrass transects (*Phyllospadix*)

The statistical approach taken for *Phyllospadix* was identical to that taken for photoplot species. The sampling approach is different in the field, and as a result, we assess this species separately. Figure 34 and Tables 5 and 6 depict the same information as in Figure 33 and Tables 3 and 4 for photoplot species.

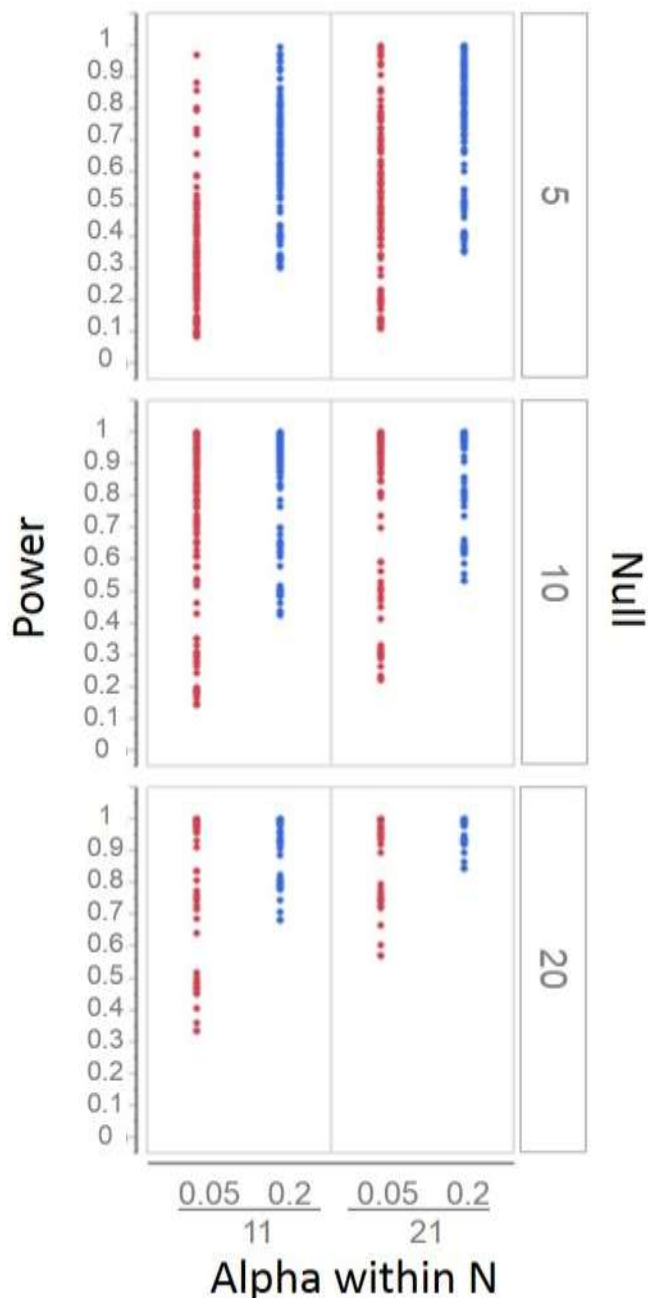


Figure 34. Power (y-axis left) as a function of replicates (N equals 11 or 21) and alpha (0.05 red points, or 0.2 blue points) on the x-axis. Null on the right y-axis is the effect size (null equals 5, 10, and 20) for surfgrass, *Phyllospadix*. Each point represents the power resulting from a BACIP analysis for a pair of sites (one impact site and one control site).

Table 5. Sites that could serve as control sites for *Phyllospadix* in BACIP analyses. Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum $\alpha = 0.2$, $\beta = 0.2$ (power = 0.8), and effect size of 10%. Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Site	N	N ALEG	N ARHO	N CARP	N CAY	N COPT	N CRCO	N DPT	N MUSH	N PCOV	N PSN	N PTFM	N SHB	N STA
ALEG	11	0	1	1	1	0	1	1	1	1	1	1	1	1
ARHO	9	1	0	1	0	0	1	0	1	1	1	1	1	1
CARP	11	1	1	0	1	0	1	1	1	1	1	1	1	1
CAY	10	1	0	1	0	0	1	1	1	1	1	1	1	1
COPT	1	0	0	0	0	0	0	1	0	0	0	0	0	0
CRCO	11	1	1	1	1	0	0	1	1	1	1	1	1	1
DAPT	11	1	0	1	1	1	1	0	1	1	1	1	1	1
HAZ	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MUSH	11	1	1	1	1	0	1	1	0	1	1	1	1	1
PCOV	11	1	1	1	1	0	1	1	1	0	1	1	1	1
PSN	11	1	1	1	1	0	1	1	1	1	0	1	1	1
PTFM	11	1	1	1	1	0	1	1	1	1	1	0	1	1
SHB	11	1	1	1	1	0	1	1	1	1	1	1	0	1
STA	11	1	1	1	1	0	1	1	1	1	1	1	1	0

Table 6. Summary of sites that could serve as control sites for BACIP analyses for *Phyllospadix* done with a combination of parameter values. Each cell in the parameter-specific columns with nonzero values (also with pink fill) is a BACIP site pair that results in a power equal to or greater than 0.8 and shows the number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling respectively.

Site	N	N (11,0.05,5)	N (11,0.05,10)	N (11,0.05,20)	N (11,0.2,5)	N (11,0.2,10)	N (11,0.2,20)	N (21,0.05,5)	N (21,0.05,10)	N (21,0.05,20)	N (21,0.2,5)	N (21,0.2,10)	N (21,0.2,20)
ALEG	109	1	9	12	5	11	12	2	11	12	9	12	13
ARHO	79	0	1	11	0	9	12	0	8	12	1	12	13
CARP	102	1	7	11	3	11	12	2	11	12	8	11	13
CAY	91	0	4	11	0	10	13	0	10	12	6	12	13
COPT	53	0	1	4	0	1	12	0	1	12	1	8	13
CRCO	105	0	8	12	3	11	13	1	11	12	9	12	13
DAPT	117	3	9	12	7	11	12	6	11	12	9	12	13
HAZ	17	0	0	0	0	0	4	0	0	0	0	0	13
MUSH	89	0	4	11	0	11	12	0	11	12	4	11	13
PCOV	101	1	6	12	2	11	12	1	11	12	8	12	13
PSN	114	1	10	11	6	11	13	4	11	12	10	12	13
PTFM	97	0	6	11	2	11	12	1	10	12	8	11	13
SHB	111	1	9	11	5	11	12	5	11	12	9	12	13
STA	101	0	6	11	3	11	13	2	11	12	8	11	13

2.4.2.3 Mobile plots and transects

Owl limpet (Lottia)

The statistical approach taken for *Lottia* was identical to that taken for photoplot species. The sampling approach is different in the field and, as a result, we assess this species separately. Figure 35 and Tables 7 and 8 depict the same information as in Figure 33 and Tables 3 and 4 for photoplot species.

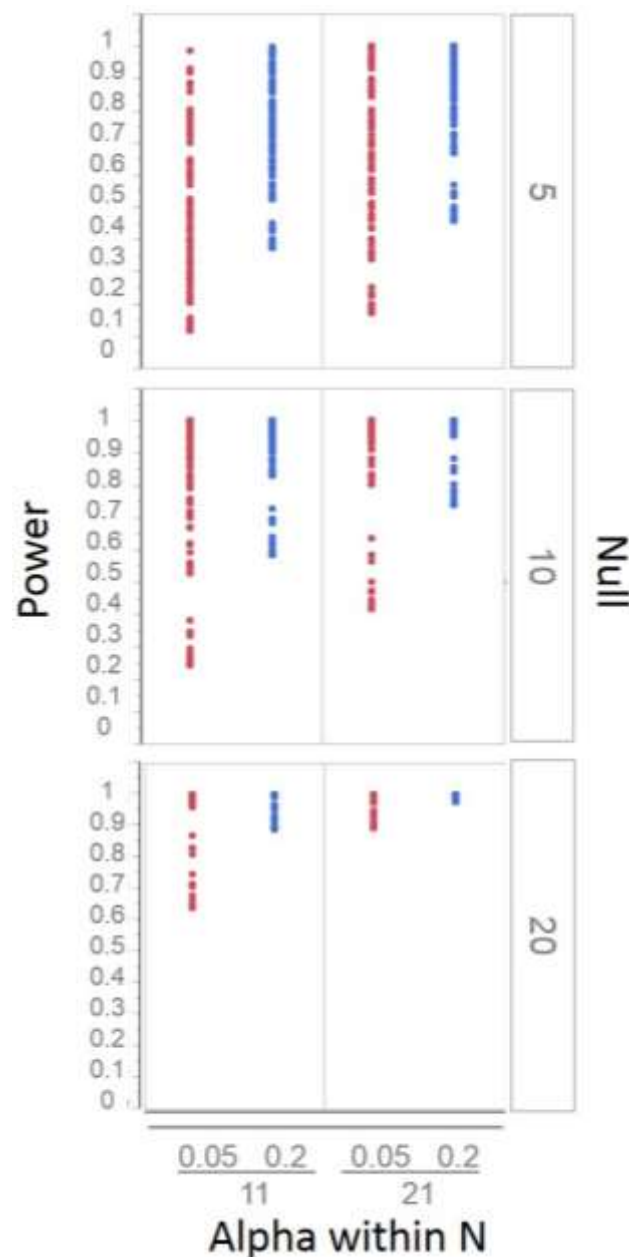


Figure 35. Power (y-axis left) as a function of replicates (N equals 11 or 21) and alpha (0.05 red points, or 0.2 blue points) on the x-axis. Null on the right y-axis is the effect size (null equals 5, 10, and 20) for owl limpet, *Lottia*. Each point represents the power resulting from a BACIP analysis for a pair of sites (one impact site and one control site).

Table 7. Sites that could serve as control sites for *Lottia* in BACIP analyses for an effect size of 10% (top) and 5% (bottom). Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum $\alpha = 0.2$, $\beta = 0.2$ (power = 0.8), and effect size of 10%. Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Effect Size	Site	N	N ALEG	N BOA	N CARP	N CAY	N CRCO	N DAPT	N HAZ	N MUSH	N OLDS	N PCOV	N PTFM	N RMR	N SHCO	N STA	N WHPT
10	ALEG	13	0	1	1	1	1	1	1	1	1	1	1	1	0	1	1
10	BOA	13	1	0	1	1	1	1	1	1	1	1	1	1	0	1	1
10	CARP	13	1	1	0	1	1	1	1	1	1	1	1	1	0	1	1
10	CAY	13	1	1	1	0	1	1	1	1	1	1	1	1	0	1	1
10	CRCO	13	1	1	1	1	0	1	1	1	1	1	1	1	0	1	1
10	DAPT	13	1	1	1	1	1	0	1	1	1	1	1	1	0	1	1
10	HAZ	13	1	1	1	1	1	1	0	1	1	1	1	1	0	1	1
10	MUSH	13	1	1	1	1	1	1	1	0	1	1	1	1	0	1	1
10	OLDS	13	1	1	1	1	1	1	1	1	0	1	1	1	0	1	1
10	PCOV	13	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1
10	PTFM	13	1	1	1	1	1	1	1	1	1	1	0	1	0	1	1
10	RMR	13	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1
10	SHCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	STA	13	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1
10	WHPT	13	1	1	1	1	1	1	1	1	1	1	1	1	0	1	0
5	ALEG	10	0	1	1	1	1	1	1	1	0	1	1	0	0	1	0
5	BOA	9	1	0	0	1	1	1	1	1	0	1	1	0	0	1	0
5	CARP	4	1	0	0	0	0	0	0	1	0	0	1	0	0	1	0
5	CAY	7	1	1	0	0	1	1	1	1	0	0	0	0	0	1	0
5	CRCO	6	1	1	0	1	0	1	0	1	0	1	0	0	0	0	0
5	DAPT	8	1	1	0	1	1	0	0	1	0	1	1	0	0	1	0
5	HAZ	6	1	1	0	1	0	0	0	1	0	0	0	1	0	1	0
5	MUSH	10	1	1	1	1	1	1	1	0	0	1	1	0	0	1	0
5	OLDS	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 7 (continued). Sites that could serve as control sites for *Lottia* in BACIP analyses for an effect size of 10% (top) and 5% (bottom). Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum $\alpha = 0.2$, $\beta = 0.2$ (power = 0.8), and effect size of 10%. Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Effect Size	Site	N	N ALEG	N BOA	N CARP	N CAY	N CRCO	N DAPT	N HAZ	N MUSH	N OLDS	N PCOV	N PTFM	N RMR	N SHCO	N STA	N WHPT
5	PCOV	7	1	1	0	0	1	1	0	1	0	0	1	0	0	1	0
5	PTFM	7	1	1	1	0	0	1	0	1	0	1	0	0	0	1	0
5	RMR	2	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0
5	SHCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	STA	10	1	1	1	1	0	1	1	1	0	1	1	1	0	0	0
5	WHPT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 8. Summary of sites that could serve as control sites for BACIP analyses for *Lottia* done with a combination of parameter values. Each cell in the parameter-specific columns with nonzero values (also with pink fill) is a BACIP site pair that results in a power equal to or greater than 0.8 and shows the number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling, respectively.

Site	N	N (11,0.05,5)	N (11,0.05,10)	N (11,0.05,20)	N (11,0.2,5)	N (11,0.2,10)	N (11,0.2,20)	N (21,0.05,5)	N (21,0.05,10)	N (21,0.05,20)	N (21,0.2,5)	N (21,0.2,10)	N (21,0.2,20)
ALEG	142	3	12	13	10	13	14	10	13	14	12	14	14
BOA	136	3	11	13	9	13	14	8	13	14	11	13	14
CARP	126	0	11	14	4	13	14	2	13	14	13	14	14
CAY	128	2	9	13	7	13	14	5	13	14	11	13	14
CRCO	126	2	9	13	6	13	14	5	13	14	10	13	14
DAPT	127	0	11	13	8	13	14	3	13	14	11	13	14
HAZ	129	1	11	13	6	13	14	6	13	14	11	13	14
MUSH	138	2	11	13	10	13	14	9	13	14	12	13	14
OLDS	108	0	5	14	0	13	14	0	13	14	7	14	14
PCOV	129	0	10	13	7	13	14	6	13	14	12	13	14
PTFM	134	1	12	14	7	13	14	5	13	14	13	14	14
RMR	118	0	9	13	2	13	14	2	13	14	11	13	14
SHCO	51	0	0	4	0	0	14	0	0	14	0	5	14
STA	137	2	12	13	10	13	14	7	13	14	12	13	14
WHPT	99	0	1	14	0	13	14	0	13	14	2	14	14

Sea star (Pisaster)

The statistical approach taken for *Pisaster* was identical to that taken for photoplot species. The sampling approach is different in the field, and as a result, we assess this species separately. Figure 36 and Tables 9 and 10 depict the same information as in Figure 33 and Tables 3 and 4 for photoplot species.

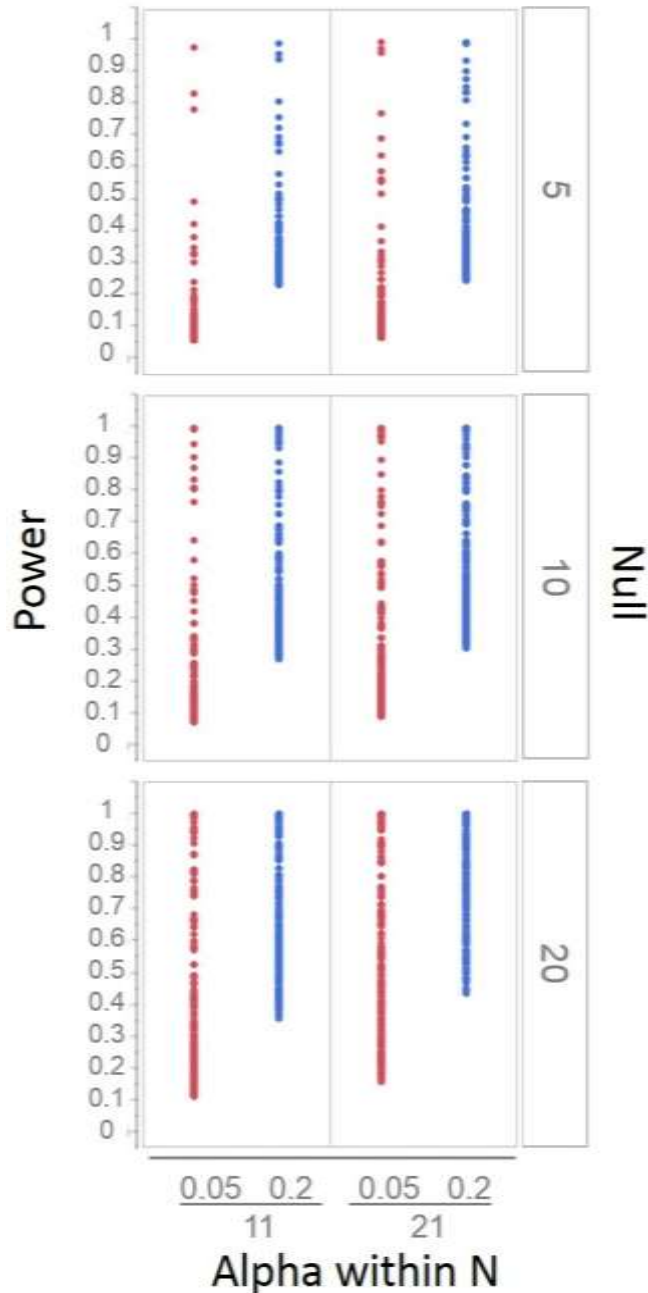


Figure 36. Power (y-axis left) as a function of replicates (N equals 11 or 21) and alpha (0.05 red points, or 0.2 blue points) on the x-axis. Null on the right y-axis is the effect size (null equals 5, 10, and 20) for sea star, *Pisaster*. Each point represents the power resulting from a BACIP analysis for a pair of sites (one impact site and one control site).

Table 9. Sites that could serve as control sites for *Pisaster* in BACIP analyses. Eleven temporal replicates are used for all comparisons, which indicates a sampling frequency of once a year. Each cell in the site-specific columns equal to one (also with pink fill) is a BACIP site pair that results in a minimum $\alpha = 0.2$, $\beta = 0.2$ (power = 0.8), and effect size of 10%. Each cell with pink fill is a site in the column heading [N (site code)] that could serve as a control site should an impact occur to the site in the respective row. The total number of sites that can serve as a control (pink cells) equals N.

Site	N	N ALEG	N ARHO	N BOA	N CARP	N CAY	N COPT	N CRCO	N DAPT	N MUSH	N OLDS	N PCOV	N PSN	N PTFM	N SHB	N STA	N TRIS	N WHPT
ALEG	8	0	1	0	0	0	1	0	1	0	1	1	1	1	1	0	0	0
ARHO	10	1	0	1	0	1	1	0	1	0	1	0	1	1	1	1	0	0
BOA	7	0	1	0	0	1	1	0	1	0	1	0	0	0	1	1	0	0
CARP	2	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
CAY	9	0	1	1	0	0	1	0	1	0	1	0	1	1	1	1	0	0
COPT	15	1	1	1	1	1	0	1	1	0	1	1	1	1	1	1	1	1
CRCO	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
DAPT	10	1	1	1	0	1	1	0	0	0	1	0	1	1	1	1	0	0
HAZ	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MUSH	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
OCC	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
OLDS	10	1	1	1	0	1	1	0	1	0	0	0	1	1	1	1	0	0
PCOV	2	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
PSN	8	1	1	0	0	1	1	0	1	0	1	0	0	1	1	0	0	0
PTFM	8	1	1	0	0	1	1	0	1	0	1	0	1	0	1	0	0	0
SHB	10	1	1	1	0	1	1	0	1	0	1	0	1	1	0	1	0	0
SHCO	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
STA	7	0	1	1	0	1	1	0	1	0	1	0	0	0	1	0	0	0
TRIS	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
WHPT	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0

Table 10. Summary of sites that could serve as control sites for BACIP analyses for *Pisaster* done with a combination of parameter values. Each cell in the parameter-specific columns with nonzero values (also with pink fill) is a BACIP site pair that results in a power equal to 0.8 and shows the total number of sites (N) that could serve as a control site should an impact occur to the site in the respective row. Column headings to the right of N represent combinations of power parameters (sample size, alpha, and effect size). Sample size equals 11 or 21 temporal replicates, which indicates once a year sampling or twice a year sampling, respectively.

Site	N	N (11,0.05, (11,0.05,1	N (11,0.05,1 (11,0.05,2	N (11,0.05,2 (11,0.05,1	N (11,0.05,1 (11,0.05,2	N (11,0.05,2 (11,0.05,1	N (11,0.05,1 (11,0.05,2	N (11,0.05,2 (11,0.05,1	N (11,0.05,1 (11,0.05,2	N (11,0.05,2 (11,0.05,1	N (11,0.05,1 (11,0.05,2	N (11,0.05,2 (11,0.05,1	N (11,0.05,1 (11,0.05,2
ALE	33	0	0	3	0	1	8	0	0	6	0	4	11
ARH	65	0	2	6	1	5	10	1	4	10	3	8	15
BOA	34	0	0	2	0	2	7	0	1	6	0	3	13
CAR	12	0	0	0	0	0	2	0	0	1	0	0	9
CAY	48	0	1	4	0	2	9	0	2	9	1	5	15
COP	11	2	8	11	4	11	15	3	8	15	8	12	16
CRC	13	0	0	0	0	0	1	0	0	1	0	0	11
DAP	58	0	3	6	0	3	10	0	3	10	3	6	14
HAZ	1	0	0	0	0	0	0	0	0	0	0	0	1
MUS	6	0	0	0	0	0	1	0	0	0	0	0	5
OCC	0	0	0	0	0	0	0	0	0	0	0	0	0
OLD	38	0	1	1	0	1	10	0	1	9	1	3	11
PCO	9	0	0	0	0	0	2	0	0	1	0	0	6
PSN	48	0	1	6	1	2	8	0	1	8	1	7	13
PTF	51	1	1	6	1	2	8	1	2	8	1	6	14
SHB	63	1	2	6	1	4	10	1	4	9	3	7	15
SHC	0	0	0	0	0	0	0	0	0	0	0	0	0
STA	38	0	1	2	0	2	7	0	2	7	1	3	13
TRIS	16	0	0	1	0	1	1	0	0	1	0	1	11
WHP	8	0	0	0	0	0	1	0	0	1	0	1	5

2.4.3. Utility of Sites and Species as Controls

The results of the models used above allow an examination of the utility of individual sites and species to an overall assessment of change. The key assumption of this examination is that a site or species must be useful in the context of a BACIP analysis. There may be other reasons to monitor a site or species, but those reasons are beyond the scope of this assessment. With respect to sites, the first priority is the usefulness of the site as a control site. Utility of a site, or the rank for exclusion, is based on the number of species useful as controls (Table 11). Rank for reduction is based on the number of species not useful for controls. Three sites (Occulto, Treasure Island, and Mussel Shoals) rank highest as the least useful for BACIP analyses because they have only three species that are useful to pair with other sites as controls. Other sites have between five and seven species. Mussel Shoals, Shaws Cove, and Hazards are the top three sites that have species not useful to other sites as controls. Possible reasons driving Mussel Shoals's outlier status in a BACIP is because Mussel Shoals is the only site sampled that contains both natural rock and rip rap rock surfaces. There is also low algal cover at the site and no targeted algal species.

Species useful as controls are those species at the site that can be used as a control for at least two sites and the more species that are useful as control species, the more useful the site is. A species that is not useful as a control for the same species at another site has no utility in a BACIP context. All photoplot species except the target species, *Mytilus*, Barnacles (*Chthamalus/Balanus*), *Endocladia*, *Silvetia*, *Anthopleura*, *Lottia*, *Phyllospadix*, and *Pisaster* should be dropped first. Other species are “orphan” species, which are not well represented in BOEM sites and as such have essentially no utility in a BACIP context. *Haliotis* was not included in the analysis but is sampled at eight northern sites and so is likely to be useful to future BACIP analysis. Other target species that are not well represented at many sites include *Hesperophycus* (two sites), *Mastocarpus* (three sites), *Mazzaella* (two sites), *Pollicipes* (3 sites), and *Postelsia* (two sites). All target species are equally important to this assessment.

Table 11. List of MARINE sites funded by the Bureau of Ocean and Energy Management. Table includes the number of target species at each site, the number of those species useful as controls, the rank of the site as a candidate for exclusion (1 = highest), and the rank of the sites as a candidate for reduction in the number of species sampled (1 = highest). This ranking is solely based on utility of site or species as a control in a BACIP analysis. Sites that were set up to sample only one target species were not included in this analysis.

Site	Site code	Number of target species	Number of species useful as controls	Rank for exclusion	Rank for reduction
Occulto	OCC	4	3	1	3
Treasure Island	TRIS	4	3	1	3
Mussel Shoals	MUSH	6	3	1	1
Arroyo Honda	ARHO	4	4	2	–
Coal Oil Point	COPT	4	4	2	–
White Point	WHPT	5	4	2	3
Shaws Cove	SHCO	6	4	2	2
Dana Point	DAPT	5	5	–	–
Point Sierra Nevada	PSN	5	5	–	–
Alegria	ALEG	6	5	–	3
Carpinteria	CARP	6	5	–	3
Crystal Cove	CRCO	6	5	–	3
Hazards	HAZ	7	5	–	2
Old Stairs	OLDS	6	6	–	–
Paradise Cove	PCOV	6	6	–	–
Point Fermin	PTFM	6	6	–	–
Shell Beach	SHB	6	6	–	–
Boat House	BOA	7	7	–	–
Cayucos	CAY	7	7	–	–
Stairs	STA	7	7	–	–

2.5. Conclusions and Recommendations

Effective resource management depends on understanding how biological communities fluctuate and change. This analysis was structured to be the scientific basis for understanding and considering potential program sampling design changes. Based on the resulting analysis, we evaluated alternative scenarios to the current spatial and temporal sampling design and quantified the statistical loss in our ability to detect change by reducing the sampling frequency and identifying sites that are less useful for BACIP based analyses. Trends and results from the CHIS are similar and their conclusions are largely relevant to this BOEM section. Below, the analysis is discussed in the context of answering the two BOEM program questions.

2.5.1. Conclusion—Minimum Detectable Effect size and Power Analysis

1. What is the statistical power of annual sampling and what is the cost (in terms of statistical power) of reducing biannual sampling of target organisms (e.g., selected sessile species in photoplots, sea stars, owl limpets, and surfgrass transects) to annual sampling?

Absolute differences in the MDES show that for almost all target species and site combinations, detection of effect sizes of 10% or less are achievable. Photoplot target species, which are measured in percent cover of plot, achieve relative effect sizes of 10% or less across most sites. At a 25% level only barnacles at Stairs, Endocladia at Occulto, Mytilus at Alegria, and Silvetia at Shell Beach lacked sufficient power. For Lottia, detection of effects (the absolute change in counts) is detectable for decreases of 10 animals or less. Lottia's relative change is detectable for decreases of 25% or less at all sites except Point Fermin.

Power estimated for combinations of parameter values for selected target species shows that the twice a year sampling protocol can consistently detect punctuated changes and frequently has the ability to detect a changes of less than 10% cover. Sampling remains effective at lower sampling numbers ($n = 11$) of once a year. For all effect sizes greater than 10%, there are combinations of impact and control sites that produce power of at least 80%. There are differences among sites and protocols, but 80% or greater power is achievable for most target species and for almost all sites. Assuming 80% power is the threshold, there is no obvious loss of power, assuming all sites are maintained.

Pisaster abundances are much more variable than other species and detection of effects (change in counts) is larger and more variable than for other selected target species. However, effects will be detectable for decreases of absolute number of 20 or less for most sites, and the relative change in abundance will be detectable for decreases of 25% or less for all sites, except Shaw's Cove. The actual ability to detect declines of less than 20 animals in the field is higher because the 1) actual number of sites within the whole MARINe network is larger than utilized in this analysis, and 2) personnel return to the same sites for multiple years and are looking for changes. This was tested in 2013 when Pisaster declines were noticed immediately across MARINe sites in Washington. By 2015, most sites showed a 90% decline in Pisaster at most sites within the BOEM network of sites due to an unprecedented outbreak of sea star wasting syndrome.

It is important that sites are sampled in the same season for a particular protocol, as this minimizes temporal variability in differences. Different protocols (e.g., photoplots vs. Phyllospadix transects) could be done in different seasons.

2.5.2. Conclusion—Utility of Sites and Species as Controls

1. Are the current sites and species sampled at these sites effectively distributed? Focusing on a punctuated impact (such as an oil spill), are some sites more statistically valuable as control or reference locations?

Based on the results discussed in the above section, “Utility of sites and species as controls” and Table 11, there are six sites that are less useful as a control for BACIP analysis: Occulto, Treasure Island, Mussel Shoals, Coal Oil Point, White Point, and Shaws Cove. The reason for the limited utility is that the species at the site have dynamics unlike species at other sites. This means that dynamics at other sites are not useful for prediction at the focal site. Noting this, if we were to drop useful (in the BACIP context) sites, there is a large number of species and site combinations that are predictable from other species and site combinations.

There will be a clear and unmitigable effect simply due to the direct loss of sites. These will be a loss from the pool of sites for which an impact can be assessed. The other potential effect on power is due to the utility of the site as a reference site. Any site that is discontinued should be selected strategically to reduce the impact.

Photoplot target species most useful to BACIP analysis are species sampled at more than two sites. Target species Mytilus, Barnacles, Endocladia, Silvetia, and Anthopleura were found to be the most useful species.

2.5.3. General Recommendations

Recommendations are based on the following goals:

1. To maintain a robust monitoring program that maintains statistical power to detect relevant punctuated change to the community.
2. To reduce monitoring effort by identifying temporal sampling, sites or protocols that can be dropped given goal 1.
3. To maintain a logistically sustainable monitoring program given goals 1 and 2.
4. If possible, to align the monitoring effort with the general MARINe monitoring program so as to link to the MARINe network of sites, database, and logistic support.

Recommendations are to:

1. Sample each site once per year. Fall would be best but little would be lost if the sampling was done in the Spring, if logistic constraints and alignment with the MARINe program were better suited to Spring sampling.
2. Specifically, with alignment to the MARINe program and to increase ability to model community wide change, biodiversity protocol sampling should be formally integrated into

BOEM monitoring. This can be accomplished with time and effort savings gained by going to once per year sampling of long-term plots. This protocol typically requires one to three days of sampling per site. The rotation would be for each of the 16 core sites to be sampled two times in the five year period (season is not important). Vertical surveys should be conducted at the same time as biodiversity.

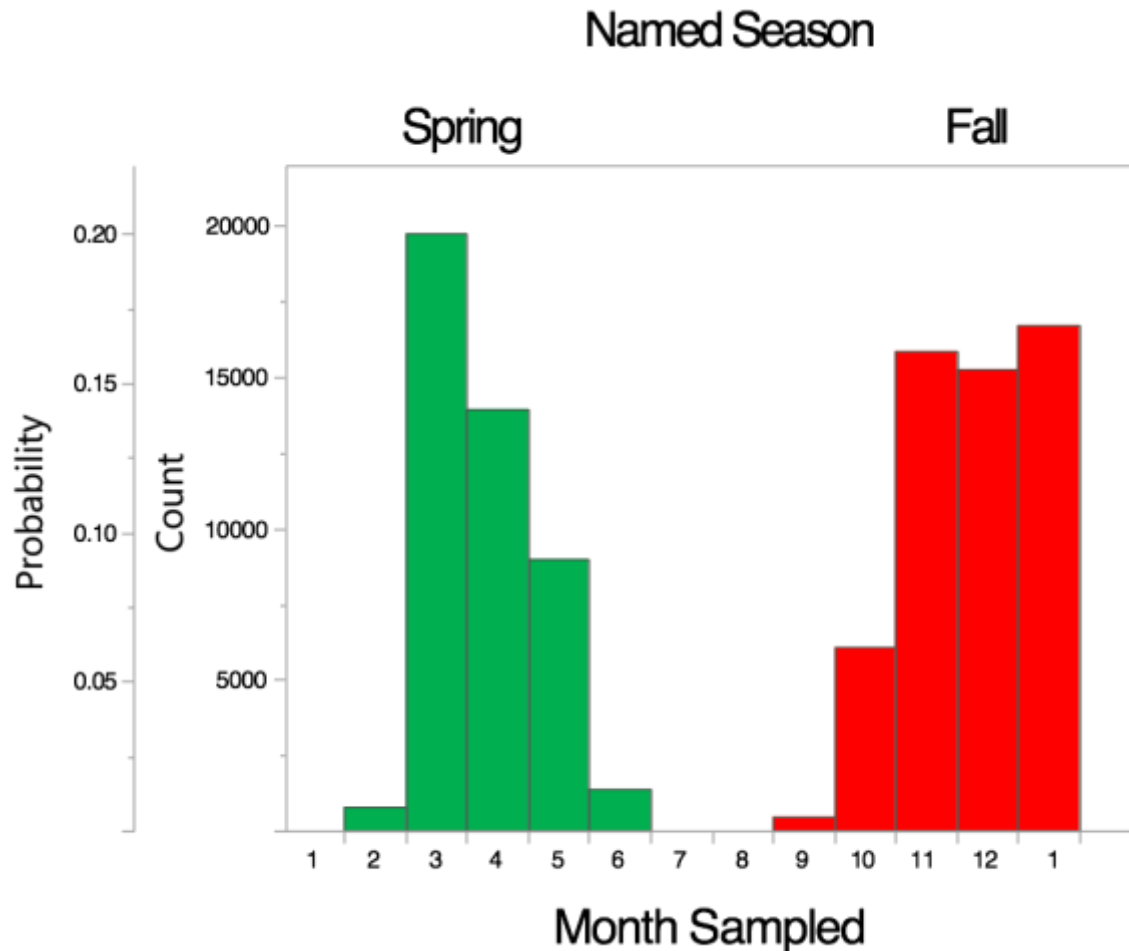
3. Literature Cited

- Blanchette, C. A., P. T. Raimondi, R. Gaddam, J. Burnaford, J. Smith, D. M. Hubbard, J. E. Dugan, J. A. Altstatt, and J. Bursek. 2015. Baseline characterization of the rocky intertidal ecosystems of the south coast study region. *In* South Coast Baseline Program Final Report: Rocky Intertidal Systems. For Ocean Science Trust and California Sea Grant, March 2015.
- Cameron, L., R. Sauvajot, and D. Kamradt. 2005. Mediterranean Coast Network – Vital signs monitoring plan. National Park Service Mediterranean Network Unpublished Report, Thousand Oaks, California.
- Channel Islands National Park Enabling Legislation. 1980. Pub. L. 114-38, title II, § 201, Mar. 5, 1980, 94 Stat. 74.
- Dailey, M. D., J. W. Anderson, D. J. Reish, and D. S. Gorsline. 1993. The southern California Bight: background and setting. In M. D. Dailey, D. J. Reish, and J. W. Anderson (eds.) *Ecology of the Southern California Bight, a synthesis and interpretation*. University of California Press, Berkeley.
- Engle, J. M., R. F. Ambrose, and P. T. Raimondi. 1997. Synopsis of the Interagency Rocky Intertidal Monitoring Network Workshop. OCS, MMS Study 1997-0012. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30761. <https://www.boem.gov/ESPIS/3/3502.pdf>
- Engle, J. M. 2008. Unified monitoring protocols for the Multi-Agency Rocky Intertidal Network. Marine Protocol Handbook. US Department of the Interior, Minerals Management Service: Pacific OCS Region, Camarillo, California.
- Lafferty, K. D. 2001. Channel Islands National Park intertidal monitoring program review, January 17-19, 2001. Channel Islands National Park, Unpublished Report, Ventura, California.
- Miner, C.M, Raimondi, P.T., Ambrose, R. F., J. M., S. N. Murray. 2005. Monitoring of Rocky Intertidal Resources along the central and southern California mainland: Comprehensive report (1992-2003) for San Luis Obispo, Santa Barbara, Ventura, Los Angeles, and Orange Counties. OCS, Study MMS 2005-071, Cooperative Agreement NO. 1435-01-02CA-85144. November 2005, Camarillo, California. <https://www.boem.gov/ESPIS/4/4377.pdf>
- Murray, S. N., R. Ambrose, M. N. Dethier. 2005. *Monitoring Rocky Shores*. University of California Press ISBN: 9780520247284, <https://www.ucpress.edu/book.php?isbn=9780520247284>
- Minchinton, T. E., and P. T. Raimondi. 2001. Long-term monitoring of rocky intertidal communities at Channel Islands National Park: Summary of spatial and temporal trends and statistical power analyses. University of California, Santa Cruz, Department of Ecology and Evolutionary Biology, Unpublished Report to the USGS.

- Minchinton, T. E., and P. T. Raimondi. 2005. Effect of Temporal and Spatial Separation of Samples on Estimation of Impacts. OCS, MMS Study 2005-002. Coastal Research Center, Marine Science Institute, University of California, Santa Barbara, California. MMS Cooperative Agreement Number 14-35-0001-30758. <https://www.boem.gov/ESPIS/4/4368.pdf>
- National Park Service. 1995. Inventory and monitoring guidelines NPS-75. US Department of the Interior, National Park Service, Washington, DC.
- Schoch, G. C., B. A. Menge, G. Allison, M. Kavanaugh, S. A. Thompson, and S. A. Wood 2006. Fifteen degrees of separation: Latitudinal gradients of rocky intertidal biota along the California Current. *Limnology and Oceanography* 51(6) 2564-2585.
- Richards, D. V. 2000. The status of rocky intertidal communities in Channel Islands National Park. Pp 356-358 in *Proceedings of the Fifth California Islands Symposium* (D. R. Browne, K. L. Mitchell, and H. W. Chaney, eds.). U.S. Minerals Management Service.
- Richards, D. V., and G. E. Davis. 1988. Rocky intertidal communities monitoring handbook, Channel Islands National Park, California. National Park Service, Ventura, California.
- Richards, D. V., and G. E. Davis. 1993. Early warnings of modern population collapse in black abalone *Haliotis cracherodii*, Leach, 1814 at the California Channel Islands. *Journal of Shellfish Research* 12(2):189-194.
- Stewart-Oaten, A., J. R. Bence, and C. W. Osenberg. 1992. Assessing effects of unreplicated perturbations: No simple solutions. *Ecology* 73(4):1396-1404.

Appendix A. Named Sample Season and Month Actually Sampled for Channel Islands National Park Sites

Each bar represents replicate plots sampled in a given month represented on the y-axis by the number of plots and by probability of sampling occurring in a particular month. Most spring plots (almost 20000, and 20%) were taken in March while fall plots were more evenly sampled within November, December, and January.



Appendix B. Example Code for Power Analysis: Example Species—*Lottia*

```
CLOSE / all
```

```
USE "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\Lottia.syz"
```

```
REM all years all samples  
rem create means of year and NOBS  
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\Means' / AG  
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
CSTATISTICS SURVEYYEAR NOBS / MEAN
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases' /  
VARIABLE  
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
CSTATISTICS NOBS / N  
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases.syz"  
LET N=NOBS  
drop NOBS STATISTICS$  
dSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases'
```

```
REM -- Following commands were produced by the MERGE dialog:  
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all  
years\Lottia"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SURVEYYEAR  
NOBS) "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all  
years\Means.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
ME1SURVEYYEAR ME2NOBS) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\means_Joined'
```

```
rem create products and cross products  
LET Ydif = ME2NOBS -NOBS  
LET xdif=ME1SURVEYYEAR -SURVEYYEAR
```

```
LET cpxy=XDIF*YDIF
LET XDIF_SQ=XDIF^2
```

```
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz" / TYPE=REC
```

```
rem create slopes
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS CPXY XDIF_SQ / SUM
REM -- End of commands from the CSTAT dialog
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
LET slope=SU1CPXY /SU2XDIF_SQ
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
```

```
REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\slopes.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SU1CPXY
SU2XDIF_SQ SLOPE) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz"(ISLANDNAME$ SITECODE$
SITENAME$ ZONE$ SURVEYYEAR NOBS ME1SURVEYYEAR ME2NOBS YDIF XDIF
CPXY XDIF_SQ) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'
```

```
rem create intercept
LET INTERcept = ME2NOBS-ME1SURVEYYEAR * SLOPE
LET y_expected = INTERCEPT +SURVEYYEAR *SLOPE
LET y_residual= NOBS-Y_EXPECTED
LET y_residual_sq= Y_RESIDUAL^2
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'
```

```
REM -- Following commands were produced by the CSTAT dialog:
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\y_resid_sq' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS Y_RESIDUAL_SQ / SUM
```

```
REM -- make summary file:
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\summary stats' /
AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS ME1SURVEYYEAR ME2NOBS SLOPE INTERCEPT SU2XDIF_SQ / MEAN
```

```
REM -- Following commands were produced by the MERGE dialog:
```

```
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\y_resid_sq.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SU1Y_RESIDUAL_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\summary stats.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE ME4INTERCEPT ME5SU2XDIF_SQ) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Summary_Final'
REM -- End of commands from the MERGE dialog
```

```
rem rename variable
```

```
LET SUM_Yresid_sq= SU1Y_RESIDUAL_SQ
LET mean_surveyyear=ME1ME1SURVEYYEAR
LET Mean_NOBS=ME2ME2NOBS
LET slope =ME3SLOPE
LET INTERcpet= ME4INTERCEPT
LET SUM_xdif_sq= ME5SU2XDIF_sq
drop SU1Y_RESIDUAL_SQ ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE
ME4INTERCEPT ME5SU2XDIF_SQ
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'
```

```
REM -- Following commands were produced by the MERGE dialog:
```

```
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
```

```
SUM_YRESID_SQ MEAN_SURVEYYEAR MEAN_NOBS SLOPE INTERCPET
SUM_XDIF_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\cases.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ N) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'
```

```
LET Test$="20 yr 2 samples/YR"
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\20 yr 2
samples_YR'
```

```
CLOSE/all
```

```
REM all years Fall
rem create means of year and NOBS
CLOSE / all
```

```
USE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Lottia.syz"
```

```
SELECT SEASONNAME$="Fall"
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Means' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS SURVEYYEAR NOBS / MEAN
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases' /
VARIABLE
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS NOBS / N
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases.syz"
LET N=NOBS
drop NOBS STATISTICS$
dSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases'
```

```
REM -- Following commands were produced by the MERGE dialog:
```

```
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Lottia"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SURVEYYEAR
NOBS) "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Means.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1SURVEYYEAR ME2NOBS) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\means_Joined'
```

```
rem create products and cross products
LET Ydif = ME2NOBS -NOBS
LET xdif=ME1SURVEYYEAR -SURVEYYEAR
LET cpxy=XDIF*YDIF
LET XDIF_SQ=XDIF^2
```

```
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz" / TYPE=REC
```

```
rem create slopes
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS CPXY XDIF_SQ / SUM
REM -- End of commands from the CSTAT dialog
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
LET slope=SU1CPXY /SU2XDIF_SQ
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
```

```
REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\slopes.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SU1CPXY
SU2XDIF_SQ SLOPE) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz"(ISLANDNAME$ SITECODE$
SITENAME$ ZONE$ SURVEYYEAR NOBS ME1SURVEYYEAR ME2NOBS YDIF XDIF
CPXY XDIF_SQ) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
```

```

DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

rem create intercept
LET INTERcept = ME2NOBS-ME1SURVEYYEAR * SLOPE
LET y_expected = INTERCEPT +SURVEYYEAR *SLOPE
LET y_residual= NOBS-Y_EXPECTED
LET y_residual_sq= Y_RESIDUAL^2
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

REM -- Following commands were produced by the CSTAT dialog:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\y_resid_sq' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS Y_RESIDUAL_SQ / SUM

REM -- make summary file:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\summary stats' /
AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS ME1SURVEYYEAR ME2NOBS SLOPE INTERCEPT SU2XDIF_SQ / MEAN

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\y_resid_sq.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SU1Y_RESIDUAL_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\summary stats.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE ME4INTERCEPT ME5SU2XDIF_SQ) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Summary_Final'
REM -- End of commands from the MERGE dialog

rem rename variable
LET SUM_Yresid_sq= SU1Y_RESIDUAL_SQ
LET mean_surveyyear=ME1ME1SURVEYYEAR

```

```

LET Mean_NOBS=ME2ME2NOBS
LET slope =ME3SLOPE
LET INTERcpet= ME4INTERCEPT
LET SUM_xdif_sq= ME5SU2XDIF_sq
drop SU1Y_RESIDUAL_SQ ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE
ME4INTERCEPT ME5SU2XDIF_SQ
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'

```

```

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SUM_YRESID_SQ MEAN_SURVEYYEAR MEAN_NOBS SLOPE INTERCPET
SUM_XDIF_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\cases.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ N) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'

```

```

LET Test$="20 yr 1 sample/YR Fall"
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\20 yr 1
sample_YR_Fall'

```

```

CLOSE/all

```

```

REM all years SPRING
rem create means of year and NOBS
CLOSE / all

```

```

USE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Lottia.syz"

```

```

SELECT SEASONNAME$="Spring"

```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Means' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS SURVEYYEAR NOBS / MEAN
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases' /
VARIABLE
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS NOBS / N
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases.syz"
LET N=NOBS
drop NOBS STATISTICS$
dSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\cases'
```

```
REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Lottia"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SURVEYYEAR
NOBS) "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Means.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1SURVEYYEAR ME2NOBS) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\means_Joined'
```

```
rem create products and cross products
LET Ydif = ME2NOBS -NOBS
LET xdif=ME1SURVEYYEAR -SURVEYYEAR
LET cpxy=XDIF*YDIF
LET XDIF_SQ=XDIF^2
```

```
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz" / TYPE=REC
```

```
rem create slopes
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
```

```

CSTATISTICS CPXY XDIF_SQ / SUM
REM -- End of commands from the CSTAT dialog
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
LET slope=SU1CPXY /SU2XDIF_SQ
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\slopes.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SU1CPXY
SU2XDIF_SQ SLOPE) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz"(ISLANDNAME$ SITECODE$
SITENAME$ ZONE$ SURVEYYEAR NOBS ME1SURVEYYEAR ME2NOBS YDIF XDIF
CPXY XDIF_SQ) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

rem create intercept
LET INTERcept = ME2NOBS-ME1SURVEYYEAR * SLOPE
LET y_expected = INTERCEPT +SURVEYYEAR *SLOPE
LET y_residual= NOBS-Y_EXPECTED
LET y_residual_sq= Y_RESIDUAL^2
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

REM -- Following commands were produced by the CSTAT dialog:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\y_resid_sq' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS Y_RESIDUAL_SQ / SUM

REM -- make summary file:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\summary stats' /
AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS ME1SURVEYYEAR ME2NOBS SLOPE INTERCEPT SU2XDIF_SQ / MEAN

```

```

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\y_resid_sq.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SULY_RESIDUAL_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\summary stats.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE ME4INTERCEPT ME5SU2XDIF_SQ) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Summary_Final'
REM -- End of commands from the MERGE dialog

```

```

rem rename variable
LET SUM_Yresid_sq= SULY_RESIDUAL_SQ
LET mean_surveyyear=ME1ME1SURVEYYEAR
LET Mean_NOBS=ME2ME2NOBS
LET slope =ME3SLOPE
LET INTERcpet= ME4INTERCEPT
LET SUM_xdif_sq= ME5SU2XDIF_sq
drop SULY_RESIDUAL_SQ ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE
ME4INTERCEPT ME5SU2XDIF_SQ
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'

```

```

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SUM_YRESID_SQ MEAN_SURVEYYEAR MEAN_NOBS SLOPE INTERCPET
SUM_XDIF_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\cases.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ N) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"

```

```

LET Test$="20 yr 1 sample/YR Spring"

```

```
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\20 yr 1  
sample_YR_Spring'
```

```
CLOSE/all
```

```
rem create means of year and cover
```

```
REM all years random sampling of seasons once per year  
rem create means of year and NOBS  
CLOSE / all
```

```
USE "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\Lottia.syz"
```

```
rem randmom sampling  
LET z=ZRN()  
LET RAND=ZCF(z)  
SELECT RAND>0.5
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\Means' / AG  
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
CSTATISTICS SURVEYYEAR NOBS / MEAN
```

```
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases' /  
VARIABLE  
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$  
CSTATISTICS NOBS / N  
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases.syz"  
LET N=NOBS  
drop NOBS STATISTICS$  
dSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and  
seastar monitoring\NPS regression\Lottia all years\cases'
```

```
REM -- Following commands were produced by the MERGE dialog:
```

```
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Lottia"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SURVEYYEAR
NOBS) "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Means.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1SURVEYYEAR ME2NOBS) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\means_Joined'
```

```
rem create products and cross products
LET Ydif = ME2NOBS -NOBS
LET xdif=ME1SURVEYYEAR -SURVEYYEAR
LET cpxy=XDIF*YDIF
LET XDIF_SQ=XDIF^2
```

```
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz" / TYPE=REC
```

```
rem create slopes
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS CPXY XDIF_SQ / SUM
REM -- End of commands from the CSTAT dialog
ACTIVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
LET slope=SU1CPXY /SU2XDIF_SQ
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\slopes.syz"
```

```
REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\slopes.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ SU1CPXY
SU2XDIF_SQ SLOPE) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts.syz"(ISLANDNAME$ SITECODE$
SITENAME$ ZONE$ SURVEYYEAR NOBS ME1SURVEYYEAR ME2NOBS YDIF XDIF
CPXY XDIF_SQ) / ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
```

```

DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

rem create intercept
LET INTERcept = ME2NOBS-ME1SURVEYYEAR * SLOPE
LET y_expected = INTERCEPT +SURVEYYEAR *SLOPE
LET y_residual= NOBS-Y_EXPECTED
LET y_residual_sq= Y_RESIDUAL^2
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\means_Joined_crossproducts_slopes'

REM -- Following commands were produced by the CSTAT dialog:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\y_resid_sq' / AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS Y_RESIDUAL_SQ / SUM

REM -- make summary file:
SSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\summary stats' /
AG
BY ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
CSTATISTICS ME1SURVEYYEAR ME2NOBS SLOPE INTERCEPT SU2XDIF_SQ / MEAN

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\y_resid_sq.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SU1Y_RESIDUAL_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\summary stats.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE ME4INTERCEPT ME5SU2XDIF_SQ) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\Summary_Final'
REM -- End of commands from the MERGE dialog

rem rename variable
LET SUM_Yresid_sq= SU1Y_RESIDUAL_SQ
LET mean_surveyyear=ME1ME1SURVEYYEAR

```

```

LET Mean_NOBS=ME2ME2NOBS
LET slope =ME3SLOPE
LET INTERcpet= ME4INTERCEPT
LET SUM_xdif_sq= ME5SU2XDIF_sq
drop SU1Y_RESIDUAL_SQ ME1ME1SURVEYYEAR ME2ME2NOBS ME3SLOPE
ME4INTERCEPT ME5SU2XDIF_SQ
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'

```

```

REM -- Following commands were produced by the MERGE dialog:
MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SUM_YRESID_SQ MEAN_SURVEYYEAR MEAN_NOBS SLOPE INTERCPET
SUM_XDIF_SQ) "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all
years\cases.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$ N) /
ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz'

```

```

LET Test$="20 yr rand samp/YR"
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\20 yr rand
samp_YR'

```

```

CLOSE/all

```

```

rem append cases
APPEND "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\20 yr 2
samples_YR.syz" "C:\DATA\GRANTS\National Park Service Intertidal
Review and seastar monitoring\NPS regression\Lottia all years\20 yr
1 sample_YR_Fall.syz" / MATCH
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\appendA_F'
APPEND "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\appendA_F.syz"
"C:\DATA\GRANTS\National Park Service Intertidal Review and seastar

```

```

monitoring\NPS regression\Lottia all years\20 yr 1
sample_YR_Spring.syz" / MATCH
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\appendA_F_S'
APPEND "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\appendA_F_S.syz"
"C:\DATA\GRANTS\National Park Service Intertidal Review and seastar
monitoring\NPS regression\Lottia all years\20 yr rand samp_YR.syz"
/ MATCH
DSAVE 'C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\appendA_F_S_R'

let key=1
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"

rem input years into dataset
INPUT Years
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
~
LET key =1

```

```

DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\key.syz" /
TYPE=RECT

```

```

MERGE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all years\key.syz"(YEARS
KEY) "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"(ISLANDNAME$ SITECODE$ SITENAME$ ZONE$
SUM_YRESID_SQ MEAN_SURVEYYEAR MEAN_NOBS SLOPE INTERCPET SUM_XDIF_SQ
N TEST$ KEY) / KEY

```

```

REM -- End of commands from the MERGE dialog
DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final.syz"

```

```

let St_ERR_slope= sqr(((1/(N-2))*sum_yresid_sq)/sum_xdif_sq)
LET PCT_CHANGE=.04
LET alpha=.2
LET CHANGE_Yr =PCT_change*MEAN_NOBS

```

```

IF TEST$ ="20 yr ev_oth_YR/SP" then let SORT = 6
IF TEST$ ="20 yr ev_oth_YR/Fall" then let SORT = 5
IF TEST$ ="20 yr 1 sample/YR Fall" then let SORT = 4
IF TEST$ ="20 yr 1 sample/YR Spring" then let SORT = 3
iF TEST$ ="20 yr 2 samples/YR" then let SORT = 1
IF TEST$ ="20 yr rand samp/YR" then let SORT = 2
SORT SORT
ORDER TEST$ / SORT=NONE DATA

```

```

IF TEST$ ="20 yr 2 samples/YR" then let POWER=1-TCF((TIF(1-
alpha,(2*YEARS-2))-
(Change_yr/((st_err_slope*(n^.5))/(2*years)^.5))),2*years-2)
IF TEST$ ="20 yr 1 sample/YR Fall" then let power=1-TCF((TIF(1-
alpha,(YEARS-2))-
(Change_yr/((st_err_slope*(n^.5))/(years)^.5))),years-2)
IF TEST$ ="20 yr 1 sample/YR Spring" then let power=1-TCF((TIF(1-
alpha,(YEARS-2))-
(Change_yr/((st_err_slope*(n^.5))/(years)^.5))),years-2)
IF TEST$ ="20 yr rand samp/YR" then let power=1-TCF((TIF(1-
alpha,(YEARS-2))-
(Change_yr/((st_err_slope*(n^.5))/(years)^.5))),years-2)

```

```

IF TEST$ ="20 yr ev_oth_YR/SP" then let power=1-TCF((TIF(1-
alpha,(YEARS/2-2))-
(Change_yr/((st_err_slope*(n^.5))/(years/2)^.5))),years/2-2)
IF TEST$ ="20 yr ev_oth_YR/Fall" then let power=1-TCF((TIF(1-
alpha,(YEARS/2-2))-
(Change_yr/((st_err_slope*(n^.5))/(years/2)^.5))),years/2-2)

DSAVE "C:\DATA\GRANTS\National Park Service Intertidal Review and
seastar monitoring\NPS regression\Lottia all
years\Summary_Final_Relative.syz"

```

```

LINE POWER*YEARS / ERROR OVERLAY GROUP = {TEST$} XLABEL = 'Years'
XMAX = 20 XMIN = 0 XTICK = 4 XPIP = 5 YLABEL = 'Power' YMAX = 1
YMIN = 0 YLIMIT = {0.8} YTICK = 10 YPIP = 2 LTITLE='Test' WIDTH = 7
LTITLE='Sampling' LLABEL = {'Twice per year', 'Once per year /
random', 'Once per year / Spring', 'Once per year / Fall', 'Once
every two years / Fall', 'Once every two years / Spring'} COLOR =
{Black, Red, Green, Blue, Aqua, PURPLE} DASH={ 1, 1, 1, 1, 1, 1}
rem end of graphs

```


Appendix C. Glossary of Abbreviations and Site Codes

Abbreviations

BACIP	Before After Control Impact Paired Analysis
CHIS	Channel Islands National Park
I&M	Inventory and Monitoring
MARINe	Multi-Agency Rocky Intertidal Network
MDES	Minimum Detectable Effect Size
MEDN	Mediterranean Network
NPS	National Park Service
SMCA	State Marine Conservation Area
SMR	State Marine Reserve
TNC	The Nature Conservancy

Channel Islands National Park Site Codes

CH	Cuyler Harbor, San Miguel Island
CP	Crook Point, San Miguel Island
CR	Cat Rock, Anacapa Island
EP	East Point, Santa Rosa Island
FC	Fraser Cove, Santa Cruz Island
FP	Ford Point, Santa Rosa Island
FR	Fossil Reef, Santa Rosa Island
HP	Harris Point, San Miguel Island
JL	Johnson's Lee, Santa Rosa Island
LC	Landing Cove, Santa Barbara Island
ME	Middle East, Anacapa Island
MW	Middle West, Anacapa Island
NWT	Northwest-Talcott, Santa Rosa Island
OC	Orizaba Cove, Santa Cruz Island
OH	Otter Harbor, San Miguel Island
PH	Prisoner's Harbor, Santa Cruz Island
SFC	South Frenchy's Cove, Anacapa Island
SLR	Sea Lion Rookery, Santa Barbara Island
SR	Scorpion Rock, Santa Cruz Island
TR	Trailer, Santa Cruz Island
WA	Willows Anchorage, Santa Cruz Island

Bureau of Ocean Energy Management Site Codes

ALEG	Alegria
ARHO	Arroyo Honda
BOA	Boat House
CARP	Carpinteria
CAY	Cayucos
COPT	Coal Oil Point
CRCO	Crystal Cove
DAPT	Dana Point
HAZ	Hazards
MUSH	Mussel Shoals
OCC	Occulto
OLDS	Old Stairs
PCOV	Paradise Cove
PSN	Point Sierra Nevada
PTFM	Point Fermin
RMR	Rancho Marino Reserve
SHB	Shell Beach
SHCO	Shaws Cove
STA	Stairs
TRIS	Treasure Island
WHPT	White Point

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 159/146400, June 2018

National Park Service
U.S. Department of the Interior



[Natural Resource Stewardship and Science](#)

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