Assessment of potential impacts to rocky intertidal community following the Refugio Beach Oil Spill, Santa Barbara County

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Introduction

On May 19, 2015, a two foot diameter underground pipeline owned by Plains All America Pipeline (Line 901) ruptured and an estimated 2934 barrels (123,228 gallons) of crude oil were released (U.S. DOT, 2016). A significant portion of the oil reached the Pacific Ocean in the vicinity of Refugio State Beach after flowing through culverts and across upland areas. Shorelines down coast of the release site, including Refugio State Beach and El Capitan State Beach, received the heaviest coastal oiling. As the oil was transported and spread on the ocean surface by currents and winds, the marine environment along many more miles of southern California coast were oiled. Line 901 oil coated shores predominantly down coast within the first several miles of the release site within hours of the spill primarily due to along shore transport of the oil by currents, surge and surf action. By May 28th unusually heavy tar ball stranding was reported in Ventura County near Carpinteria and Oxnard. Floating oil and tarballs attributed to the Line 901 release were identified as far south as Los Angeles County, more than 100 miles from the release site. In this report, the incident is referred to as the Refugio Beach Oil Spill (RBOS) or the "spill".

As described below, a key concern was the potential for impact to rocky intertidal communities located within the spatial footprint of the spill. The concern regarding the rocky intertidal habitats was based on a number of factors including: (1) the location of the pipeline rupture, which was on land and spilled across the intertidal then entered coastal waters, (2) the behavior of the oil, which initially floated, and then stuck to solid objects such as intertidal rock and organisms exposed at low tide, and (3) impacts of previous spills, such as Cosco Busan (Raimondi et al., 2009b), Dubai Star, (Raimondi et al., 2011) and the 1969 Santa Barbara Spill, where intertidal habitats were among the most severely affected. The Bureau of Ocean Energy Management (BOEM, formerly Minerals Management Service) recognized the specific vulnerability of intertidal habitats following the Exxon Valdez Oil Spill and has been a core funder of the Multi Agency Rocky Intertidal Network (MARINe) since 1992. This monitoring program covers much of the west coast of the United States and was designed in part to provide baseline information to inform the assessment of impacts resulting from oil spills affecting intertidal habitats.

Rocky intertidal ecosystems are incredibly diverse, exhibit spectacular patterns of zonation, house a suite of fascinating and ecologically/economically important seaweed and animals, accommodate extensive biological interactions, are affected by numerous temporally and spatially variable abiotic conditions, and are more easily accessed than subtidal marine ecosystems. Because of these attributes, rocky intertidal habitats hold disproportionate scientific value based on the ecological theory that has arisen from investigations in this system. The ecological paradigms that have stemmed from rocky intertidal research include: Paine's (Paine 1966) work on keystone predation, Sousa's (Sousa 1979) work on the intermediate disturbance hypothesis, Connell's (Connell 1961) work on the importance of competition, Lubchenco's (1978) work on alternate stable states, and Dayton's (Dayton 1971) work on the importance of abiotic conditions (e.g. wave action) to the structure of marine communities. Another important attribute of rocky intertidal ecosystems is their attractiveness to the public for the recreational, cultural, and economic services they provide. During low tides, rocky shores are easily accessible, allowing the public to interact with a natural ocean ecosystem without the need for expensive and technical equipment, such as a boat or SCUBA gear. An incredibly high number of local residents and tourists are drawn to this unique opportunity to see marine life in its natural state. Furthermore, intertidal systems are utilized and valued both historically and presently for cultural significance by First Nations people. Additionally, a regular component of K-12 school programs in coastal cities is field trips to rocky intertidal ecosystems, with buses bringing huge numbers of school kids to wander over the rocks in search of creatures so extraordinary that intellectual exploration is unavoidable. This combination of ease of access, diverse biological communities, massive increase of visitation especially by children, coupled with the evolution of a culture of "tidepool etiquette" has led to a shift in the attitudes of the public with respect to marine conservation.

Despite an increasing public appreciation of rocky intertidal systems, these habitats remain gravely threatened and subject to massive local and regional anthropogenic perturbations, such as overexploitation, pollution, habitat alteration, species invasions, and climate change related impacts (sea level, ocean acidification, hypoxia, temperature increases, etc.), among other threats. Although seemingly ubiquitous, rocky intertidal ecosystems are quite a narrow linear feature of the coastal habitat. Based on extensive mapping by our MARINe (Multi Agency Rocky Intertidal Network; www.pacificrockyintertidal.org) surveys, the estimate of total rocky intertidal habitat in California is only ~5 square kilometers. This small overall footprint designates rocky intertidal habitats as the rarest of ecosystem types and makes them particularly sensitive and vulnerable to anthropogenic disturbances and stressors, including oil spills.

Within rocky intertidal communities, species have a variety of life histories that affect the assessment of potential causes of change. Shorter lived species like *Chthamalus* (barnacle), *Ulva* and *Porphyra* (opportunistic seaweeds) are often associated with disturbance, while longer lived species like algae and mussels tend to be associated with more stable environments. Hence, communities with higher cover of more ephemeral species are often considered to be indicative of recent or ongoing perturbation. Clearly, perturbations can be due to both natural and anthropogenic causes and hence the design of the sampling program is critical for separating these two general mechanisms of change.

Here we report on a project designed to determine the extent, if any, of impacts to the rocky intertidal community resulting from either oiling or cleanup activities resulting from the Refugio Beach Oil Spill. As with our other oil-spill assessments (Raimondi et al. 2009b, 2011), this is a multipronged effort that relies on a variety of approaches. Potential impact was assessed using three extensive data sets:1) MARINe long term monitoring data that capture abundance of key intertidal species over time and have been collected in the region since 1992, 2) Biodiversity surveys that capture abundance and distribution of intertidal organisms throughout a site, and 3) data gathered using MARINe RAPID assessment protocols that were developed specifically for oil spills, particularly for sites where long-term or biodiversity surveys were not done (Raimondi et al. 2009a, 2012).

Methods

Objective

The key objective of the rocky intertidal assessment for the Refugio Beach Oil Spill was to determine the impact (i.e. injury) to the ecological community in the littoral zone resulting from oil or cleanup related activities. Here injury is defined as in other NRDA contexts as the loss of ecological function and service (often estimated as species cover or abundance in intertidal community assessments) integrated over time to recovery. In order to parameterize the injury model, three measured or estimated values are required: (1) the species and site specific loss rate, (2) the area over which the loss occurred (based on an extrapolation of the site specific measured estimates), and (3) the recovery rate for the affected ecological communities. Based on previous recent assessments (Cosco Busan, Dubai Star), the most effective and efficient approach to fulfilling this objective includes the following phases (see Figure 1 and Table 1 below).

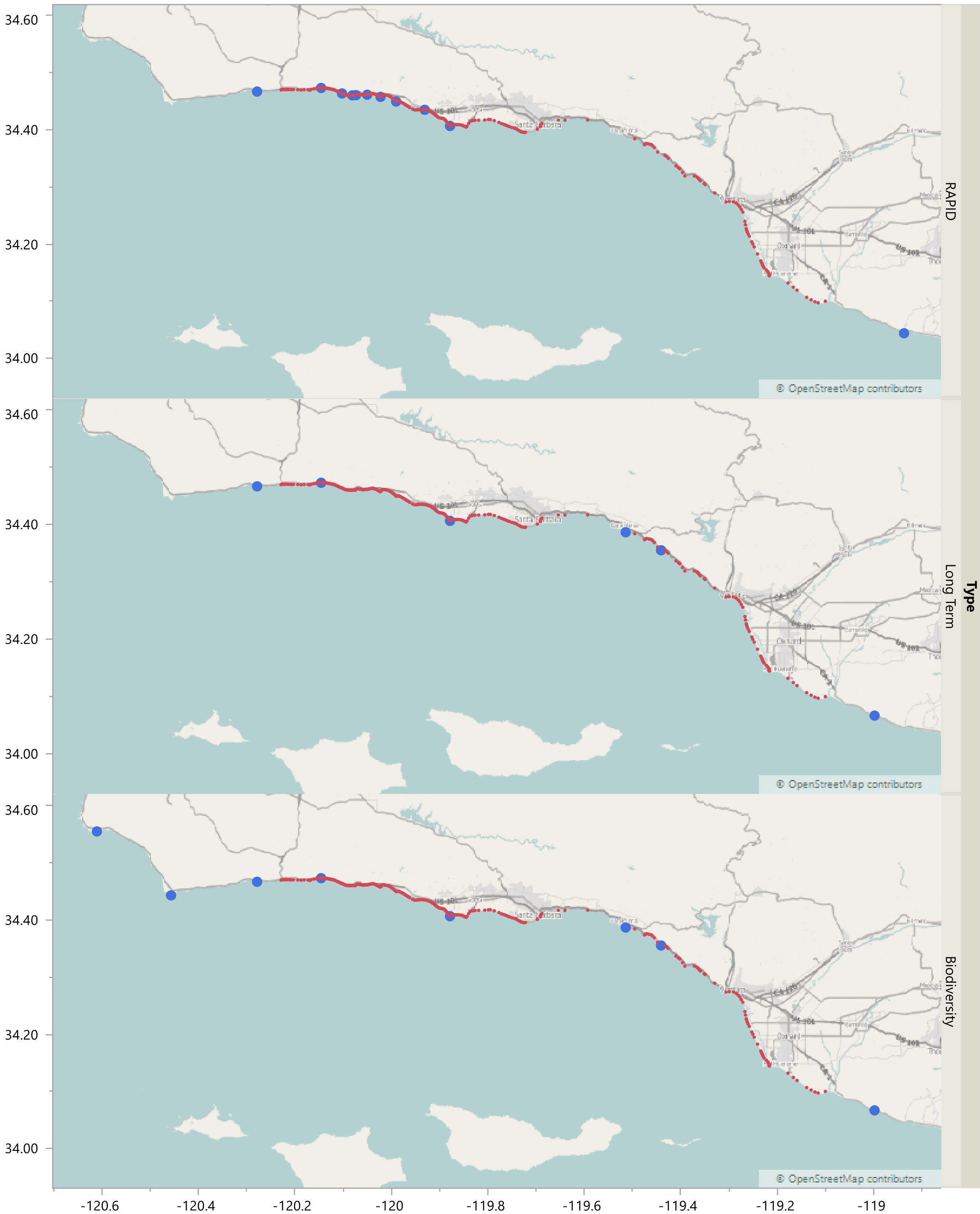

Figure 1: Map of study sites by type of assessment: Top = RAPID Sampling, Middle = Long Term Monitoring sampling, Bottom = Biodiversity sampling. Blue symbols are sampling locations. Red polygons represent SCAT (Shoreline Countermeasure/Cleanup Assessment Team) sections assessed to have Heavy, Moderate, Light or Very Light oiling.

Type	Site	Site Code	Latitude	Longitude	Periods sampled	Transect orientation	Transects sampled
RAPID	Arroyo Hondo	ARHO	34.47344	-120.14540	3	Vertical	4
RAPID	Alegria	ALEG	34.46714	-120.27818	3	Vertical	4
RAPID	Tajigas	TAJ	34.46386	-120.10213	3	Vertical	4
RAPID	Corral Canyon	CORC	34.46160	-120.04995	3	Horizontal	6
RAPID	Refugio	REF	34.46083	-120.07322	3	Vertical	4
RAPID	Refugio West	REFW	34.46052	-120.08083	3	Vertical	4
RAPID	El Capitan	ELC	34.45785	-120.02224	3	Vertical	5
RAPID	Edwards Point	EDPT	34.44971	-119.99002	3	Vertical	5
RAPID	Ellwood	ELWD	34.43519	-119.93078	3	Vertical	4
RAPID	Coal Oil Point	COPT	34.40686	-119.87829	3	Vertical	6
RAPID	Sequit Point	SEQ	34.04323	-118.93700	3	Vertical	4
Long Term	Arroyo Hondo	ARHO	34.47344	-120.14540			
Long Term	Alegria	ALEG	34.46714	-120.27818			
Long Term	Coal Oil Point	COPT	34.40686	-119.87829			
Long Term	Carpinteria	CARP	34.38704	-119.51408			
Long Term	Mussel Shoals	MUSH	34.35557	-119.44074			
Long Term	Old Stairs	OLDS	34.06622	-118.99810			
Biodiversity	Boat House	BOAT	34.55521	-120.61030			
Biodiversity	Arroyo Hondo	ARHO	34.47344	-120.14540			
Biodiversity	Alegria	ALEG	34.46714	-120.27818			
Biodiversity	Government Point	GOVP	34.44334	-120.45655			
Biodiversity	Coal Oil Point	COPT	34.40686	-119.87829			
Biodiversity	Carpinteria	CARP	34.38704	-119.51408			
Biodiversity	Mussel Shoals	MUSH	34.35557	-119.44074			
Biodiversity	Old Stairs	OLDS	34.06622	-118.99810			
Biodiversity	Point Dume	PTDU	34.00036	-118.80703			

Table 1: Site names and locations by type of sampling. Also shown are the number of period sampled transect orientation and number of transects sampled for the RAPID sampling.

1) *<u>Use of RAPID protocols</u>: RAPID assessments were done in three periods, described below. These were during and immediately after the spill, six months after the spill and one year after the spill.*
   Phase
   a. **Field assessment during oiling (Period 1)**. This may include assessments occurring prior to or during and immediately following oil exposure. Typically two types of sites are sampled: those where there are previous data and those where there has been no previous data collection. A primary goal is to ensure that current data are compatible with previously collected data. These sites should include two states, if possible: sites that are oiled and those that may serve as reference sites. The MARINe RAPID protocol was used in the Refugio spill and

was developed to meet the goals listed above. Six sites were sampled using this protocol. Four of the sites have been sampled in the past and two were new.

b. **Field assessment directly after oiling (also Period 1)**. Because assessment in the intertidal is restricted to days with appropriate low tides, it is often the case that additional sampling needs to be done beyond that conducted during the "active" spill/cleanup period. There are two general situations when this should happen: (1) when an insufficient set of sites was sampled to allow for characterization of the extent or loss associated with the spill (due to insufficient time or because oil was still accumulating at existing or new sites during neap tides, when sampling cannot occur) and (2) to document loss due to cleanup.
c. **Scoring of photos and initial assessment of loss**. During an oil spill, time is of the essence. Hence, in order to complete field sampling quickly, much of the RAPID assessment is based on the use of photographs to document the state of the ecological community. Following phases a and b2, the images should be scored and integrated with the other data collected during the RAPID assessments. These data then need to be integrated with the MARINe database to allow for an assessment of direct loss associated with oiling and cleanup.
d. **Field assessment to determine additional loss and rate of recovery (Period 2 and Period 3).** Loss is often delayed, especially in spills where oiling is patchy. Therefore, another field assessment is useful to determine if there are delayed or indirect effects. This assessment is also very useful for documenting additional loss and/or rate of recovery for losses documented in phases a-c. As noted above, the oil related injury is based on both loss and recovery. Recovery can be estimated based on studies that have been done in the past for experimental disturbances or for previous oil spill assessments where recovery was determined. However, recovery is spatially and temporally variable and unless there have been recent studies in the area of impact, the cost of getting recovery information specific to this event is not likely to be cost effective. The protocols are similar to those in phases a and b.
e. **Final scoring of photos, assessment of injury and write up.** Here the images from phase d will be scored, data integrated into the database, final assessment including injury determination will be completed and a write up of the project will be completed.

For the Refugio Beach Oil Spill, RAPID sampling and photo plot scoring was done in three periods (Table 2): May/June 2015 (Period 1) and two time points after the spill to investigate delayed or persistent effects (Fall 2015= Period 2 and May/June 2016= Period 3; one year after spill). Descriptions and photos of the RAPID sites are presented in Appendix 1. The general methods (see tables 1 and 2) were to (1) delineate either vertical or horizontal transects at each site, aligned to a marked baseline. Most transects were vertical, that is, running from low to high intertidal. At Corral Canyon transects ran along shore and were placed at three locations: high, mid and low intertidal. This was done because of the configuration of the reef. (2) Take a series of photos at designated location along each transect (here ranging from 3 to 20, with an average of ~10. The number of photoplots was based on the length of the transect, (3) take notes for each photoplot and, (4) score each photo in the lab using 100 uniformly placed points. The detailed methods for the RAPID assessment follow Raimondi and Miner (2009) from their report from an NRDA workshop on the assessment of impact from oiling in the rocky intertidal. This report is included as Appendix 2.

Site Code	Period	Month	Year
ALEG	Period 1	5	2015
ARHO	Period 1	5	2015
ARHO	Period 1	6	2015
TAJ	Period 1	6	2015
REFW	Period 1	6	2015
REF	Period 1	5	2015
REF	Period 1	6	2015
CORC	Period 1	6	2015
ELC	Period 1	5	2015
ELC	Period 1	6	2015
EDPT	Period 1	6	2015
ELWD	Period 1	5	2015
ELWD	Period 1	6	2015
COPT	Period 1	5	2015
COPT	Period 1	6	2015
SEQ	Period 1	6	2015

Site Code	Period	Month	Year
ALEG	Period 2	10	2015
ARHO	Period 2	10	2015
TAJ	Period 2	11	2015
REFW	Period 2	10	2015
REF	Period 2	11	2015
CORC	Period 2	10	2015
ELC	Period 2	11	2015
EDPT	Period 2	12	2015
ELWD	Period 2	12	2015
COPT	Period 2	10	2015
SEQ	Period 2	12	2015

Site Code	Period	Month	Year
ALEG	Period 3	5	2016
ARHO	Period 3	5	2016
TAJ	Period 3	5	2016
REFW	Period 3	6	2016
REF	Period 3	5	2016
CORC	Period 3	5	2016
ELC	Period 3	6	2016
EDPT	Period 3	5	2016
ELWD	Period 3	5	2016
COPT	Period 3	6	2016
SEQ	Period 3	5	2016

Table 2: Sampling done at RAPID sites for three periods.

2) *Use of Long Term Monitoring sites (LTM):* MARINe has been sampling in the area of the Refugio spill since 1992 (Figure 1, Table 1). The details of the sampling can be found in www.pacificrockyintertidal.org. The methods are also included as Appendix 3. Descriptions and photos of the LTM sites are presented in Appendix 1. These are sites that have been sampled continuously over time (many sites back to 1992). Here permanent plots or transects are sampled, where each plot is marked with permanent markers. These plots were set up explicitly to provide baseline information in case of an oil spill. Sampling in these plots is similar to that for RAPID plots.
3) *Use of Coastal Biodiversity Sites (CBS),* At many sites in the region of the Refugio Beach Oil Spill, MARINe has done spatially explicit biodiversity sampling (Figure 1, Table 1). The details of the sampling can be found in www.pacificrockyintertidal.org. The methods are also included as Appendix 4. Descriptions and photos of the CBS sites are presented in Appendix 1. Biodiversity sampling is done at our long term sites, using a spatially explicit grid, and point intercept sampling at each point in the grid. All sampling is done in the field. Biodiversity sampling provides the ability to species distributions at each site in x,y,z space.

Key questions addressed: Our primary goal was to determine if there was any general and quantitative evidence of impact to the marine community resulting from exposure to oil or cleanup activities; this goal was the driver for the analyses described below. We are using the words “general” and “quantitative” purposely because we want to distinguish our analytical framework from qualitative observations made on site. There is no question that there were impacts to certain species and certain locations. We have many photos of oil on species, which support the conclusion that there were impacts from the spill. In addition to the documentation of specific evidence of impacts we also used data from our sampling and historic information to assess the level of impact that could be attributed to the spill.

RAPID sampling- Because rocky intertidal communities are dynamic and because there are many forms of disturbance that affect the communities, it is often difficult to detect a clear signal of impacts relating to low levels of oiling. In prior assessments of these communities, we have found that there is usually high statistical power to detect differences between sites or before and after a significant event (e.g. MPA implementation, Oil Spills) by assessing the community as a whole first. Then, if there is an indication of a meaningful difference, we can decompose the multivariate analysis by looking at contributing species. We used a PERMANOVA and cluster analysis (using Bray Curtis similarities) approach to test the idea that sites with oiling (and cleanup) differed from those that did not. The model used was:

Community similarity = Oiling+ Period sampled+ Site(Oiling) + Oiling*Period sampled +Site(Oiling)*Period sampled

In the model, sites were nested within "Oiling" because a site could not be both oiled and not oiled. The key terms in the model are Oiling and Oiling*Period sampled. A significant result for one or both of these terms could be an indication of effects due to oiling.

Long Term Monitoring - Here we made use of long term data sets available for 6 sites that were varying distances from the location of the spill, but still within the general spill affected area (Figure 1). Because of the long term data records we were able to assess year to year changes in communities at sites, using Bray Curtis matrices, to determine if community level change differed more than expected near the time of the oil spill. Here, for each site, we compared the community in time t to the community in time t-1 year.

Biodiversity sampling – Here, we used our biodiversity monitoring datasets to examine patterns of community similarity among sites. Specifically, we were interested in determining if these patterns were disrupted after the spill, and if so, was the alteration aligned with predicted impacts resulting from a spill or cleanup. We used cluster analysis based on group averages and Bray-Curtis similarity matrix.

Results

RAPID sampling – A total of 11 sites were sampled over the three sampling periods. 1566 photoplots were scored to compile the dataset used in the analyses described below.

To give context to the results below we present Figures 2 and 3 (also compare to Figure 1, which shows SCAT assessed RBOS footprint). Figure 2 shows the percent of plots at each site that had any detectable oiling over the three sample periods. As noted above, Period 1 was May and June, 2015 (Table 2) , which was during and just after the spill. Period 2, describes sampling 6 months after the spill, in October and November, 2015. Period 3 was 1 year after the spill. Most of the oiling detected in our biological sampling was found in periods 1 and 2. While period 2 was six months after the spill, some or all the new oil could have come from oil balls or oiling being spatially redistributed.

Here “oiling” is distinguished from what has been called “Tar” in our long term sampling. Tar ordinarily comes from local seeps and, is heavier than oil and almost always looks weathered. Figure 3 shows, for all sites and periods, the percent of plots that had species that were oiled. Based on these results, we think that it is clear that oiling from the RBOS covered portions of ecological communities from Tajiguas to Coal Oil Point.

The results of the PERMANOVA are shown in Table 3. Period and Site (nested within oiling status) were significant ($p<0.001$) level and oiling was significant at the $p<0.10$ level. Importantly the interaction between oiling and period was very significant ($p=0.003$) indicating that the relationship between community assemblage and time varied as a function of whether the site was oiled or not. This is shown in the Figure 4, which is an ordination of the mean and 95% confidence ellipse of the mean for communities over time that were either oiled on not. Recall that periods 1 and 3 were in spring of 2015 and 2016, respectively, while period 2 was in Fall, 2015. This figure shows that there is a strong effect of season regardless of oiling (Spring 2015 and 2016 are similar to each and different from Fall 2015). In addition, oiled communities differed from communities that were not oiled (oiled communities are all on the left and not oiled ones are all on the right). The significant interaction between period oiling can be explained as follows. Oiled and not oiled communities differed immediately after the spill (period 1 in Spring, 2015). The difference widened in period 2 (Fall, 2015) and then contracted somewhat by Spring 2016 (relative to Spring, 2015 right after the spill). These results are also shown in detail for each site in the cluster analysis depicted in Figure 5. What is clear in the cluster analysis is that while there is a general pattern of oiled sites differing from those not oiled, some sites do not exhibit this pattern. In order to assess the effects more generally we compared sites that were oiled to those that were not for all periods. Here we show the percent of substrate that was oiled per plot and percent of species existing in the plot that were oiled (Figure 6).

Given the community differences between oiled and not oiled sites, we investigated the relationship between presence of oiling and individual species percent cover. Here we selected a group of species from the 66 species that we found in the plots. The selected species represented a range of longevity and also those that have sufficient representation to be indicators of potential impact. They included (from longest to shortest lived): owl limpets, *Lottia gigantea*; the sea mussel, *Mytilus californianus*; the red alga, *Endocladia muricata*; acorn barnacles *(Balanus* and *Chthamalus*), and ephemeral red algae, *Porphyra* and *Ulva*. These results are shown in Figure 7.

The key results from the analyses of the RAPID plots are that: (1) there was considerable site to site variation (Figure 2,3, 5), (2) more substrate and species were oiled at the sites that were within the RBOS oiling footprint than at sites that were not (Figure 6), (3) the biological community differed between oiled and not oiled sites and that pattern changed over time (biggest difference in period 2, Table 3 and Figure 4), and (4) most species examined were more common in sites that did not experience oiling (Figure 7). The key exceptions were the ephemeral species *Ulva* and *Porphyra*, which show no pattern with respect to period or oiling.

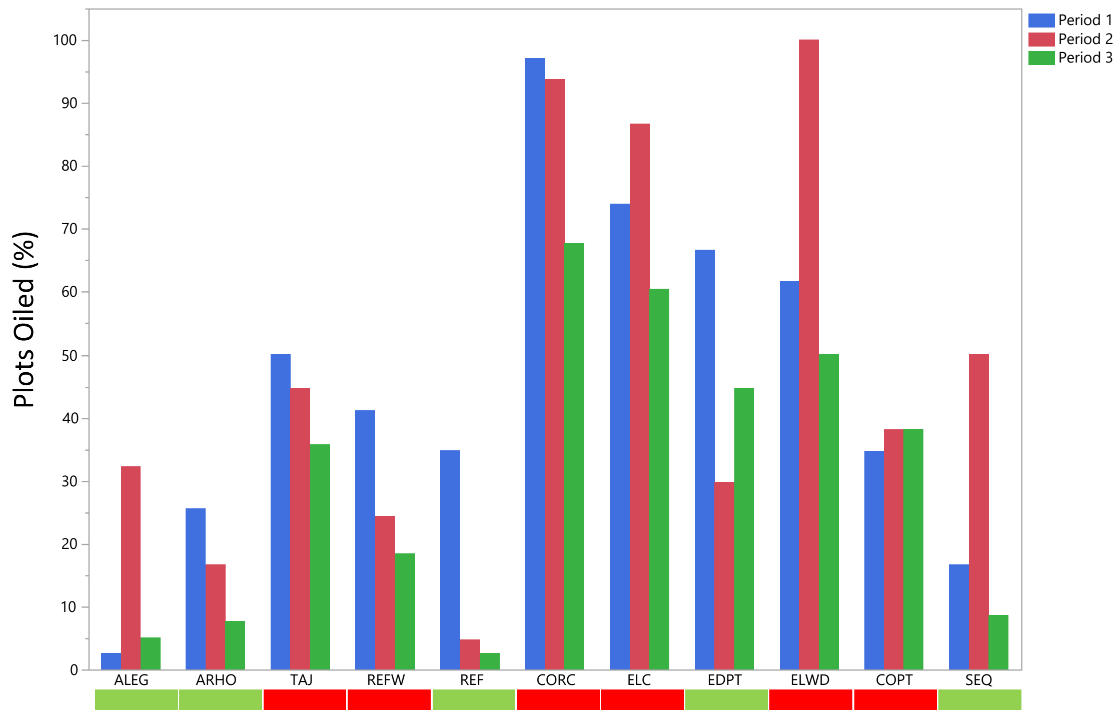

Figure 2: Percent of plots that had oiling on species or substrate for all RAPID sites and all three periods. Sites are ordered from North to South. Red (oiled) and green (not oiled) bars below site names indicate if the site was oiled or not oiled.

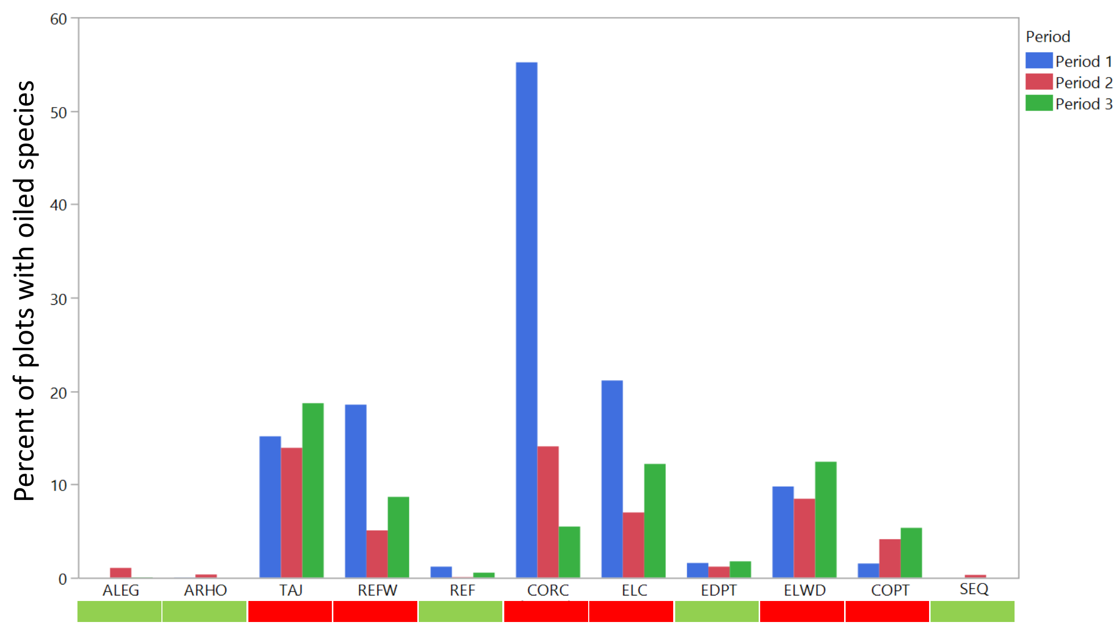

Figure 3: Percent of plots that had oiled species for all RAPID sites and all three periods. Sites are ordered from North to South. Red (oiled) and green (not oiled) bars below site names indicate if the site was oiled or not oiled,

PERMANOVA table						
Source	**df**	**SS**	**MS**	**Pseudo-F**	**P(perm)**	**Unique perms**
Period	2	78990	39495	22.041	0.001	999
Oiling	1	92728	92728	2.2041	0.092	999
site_code(Oiling)	11	7.35E+05	66804	37.281	0.001	998
Period x Oiling	2	11357	5678.5	3.1689	0.003	999
Res	1549	2.78E+06	1791.9			
Total	1565	3.77E+06				

Table 3: Result of PERMANOVA analysis on RAPID data. Site code is nested in oiling and is a random effect. All other terms are fixed effects.

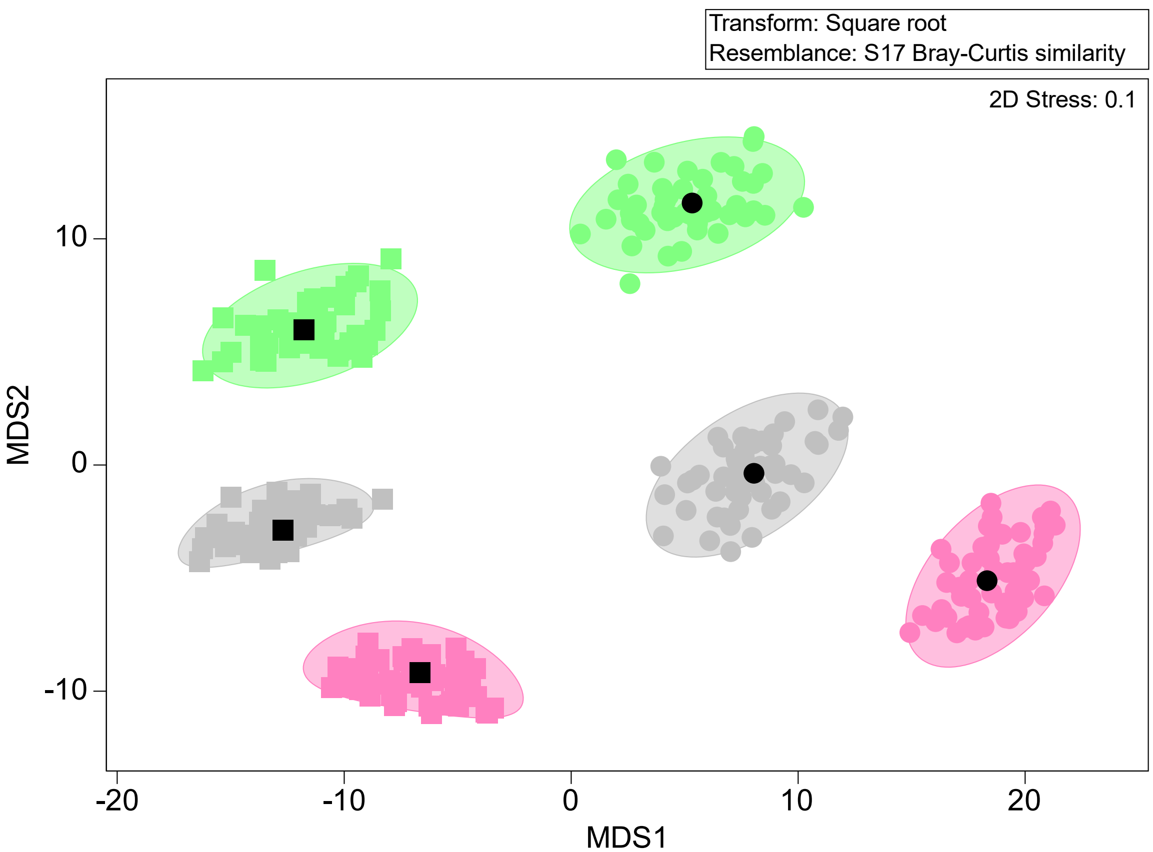

Figure 4: MDS plot showing permutation based mean and 95% confidence ellipses for the Period and Oiling status. Circles depict sites with no oiling and rectangles depict sties with oiling. Gray, pink and green represent periods 1-3, respectively

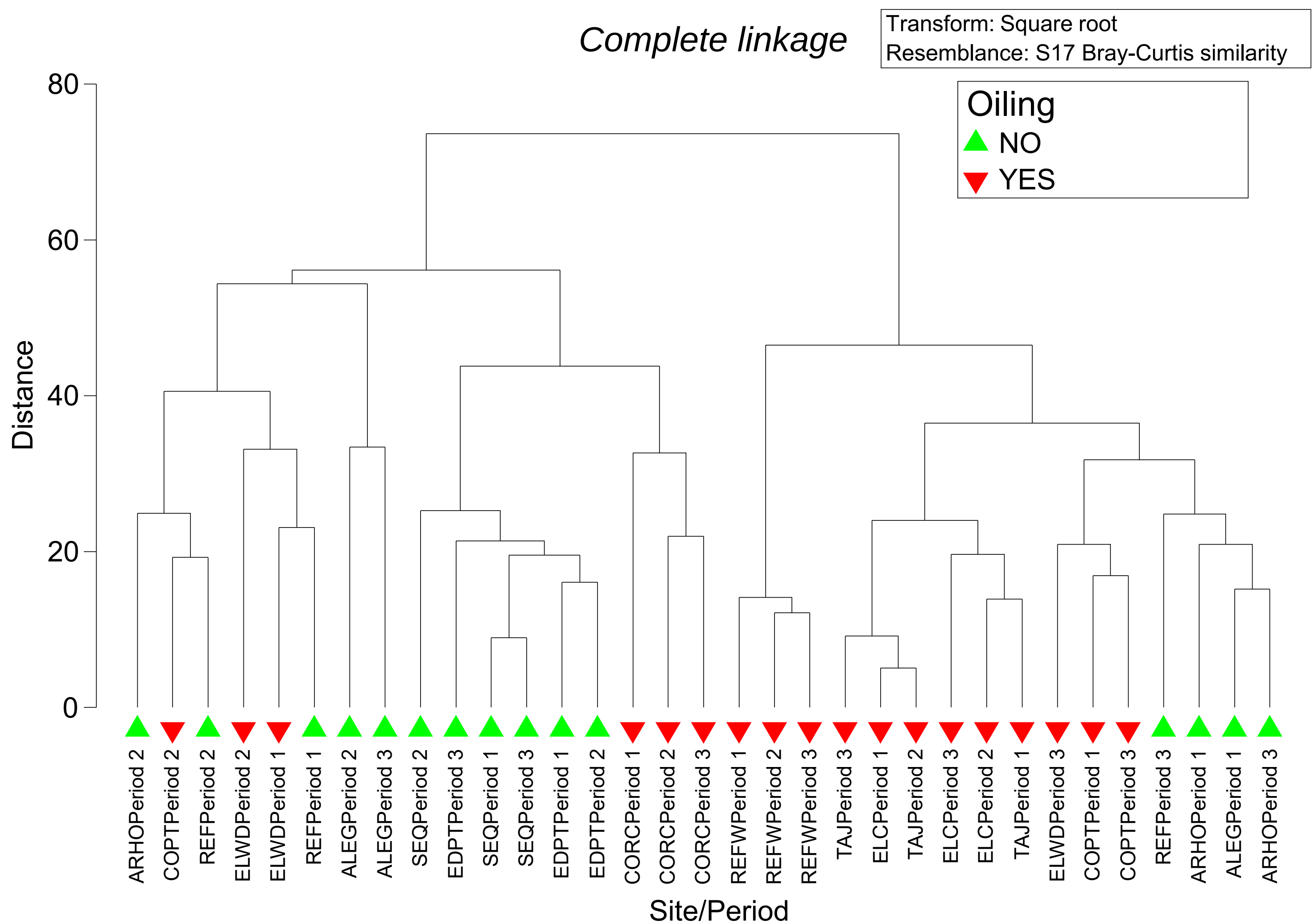

Figure 5: Cluster analysis for data collected in RAPID surveys. Each sample name contains the site code and period of sampling. See Table 3 for PERMANOVA results.

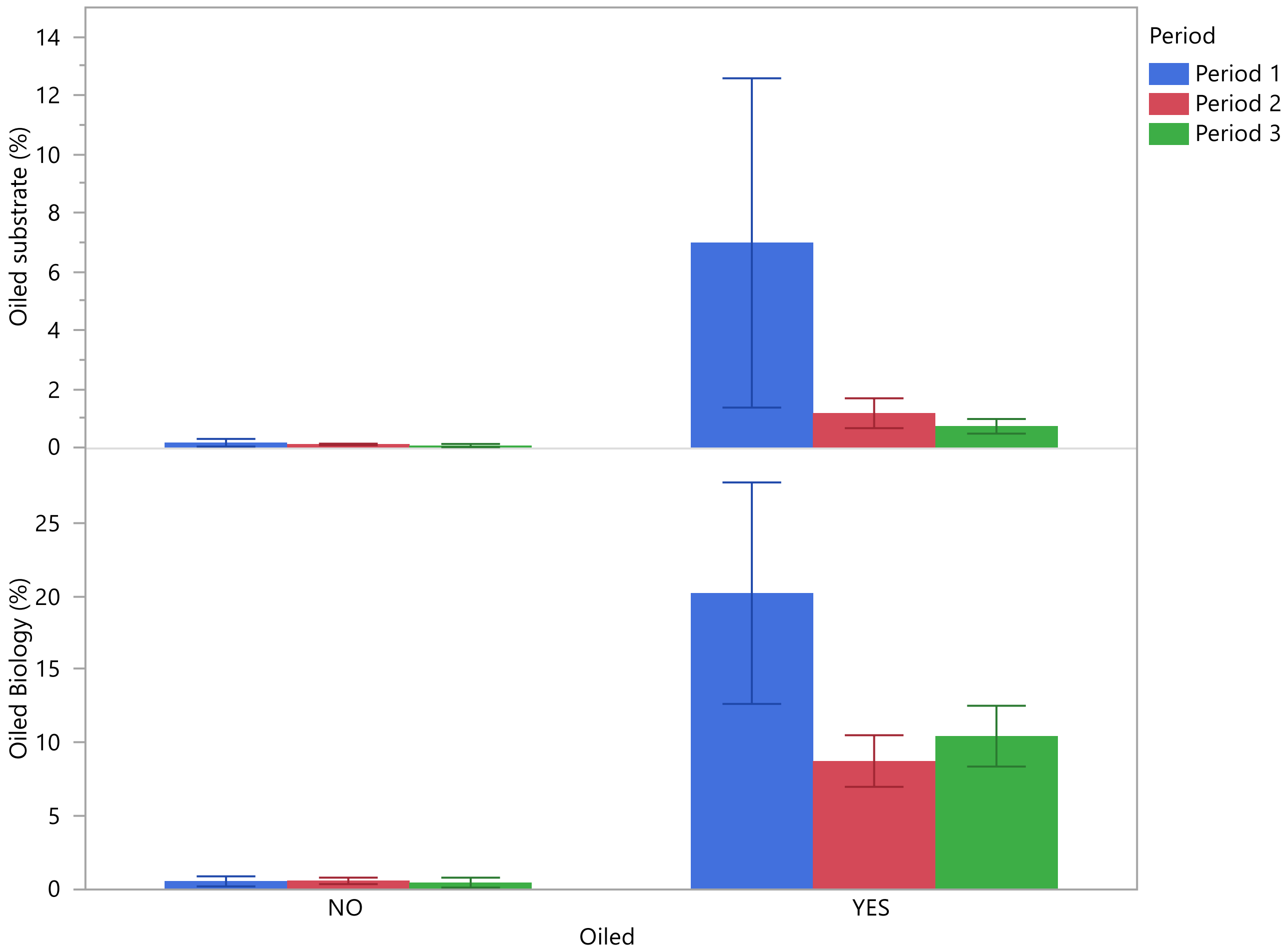

Figure 6: Top, Percent of substrate in each plot that was oiled. Bottom, Percent of biological cover in each plots that was oiled.

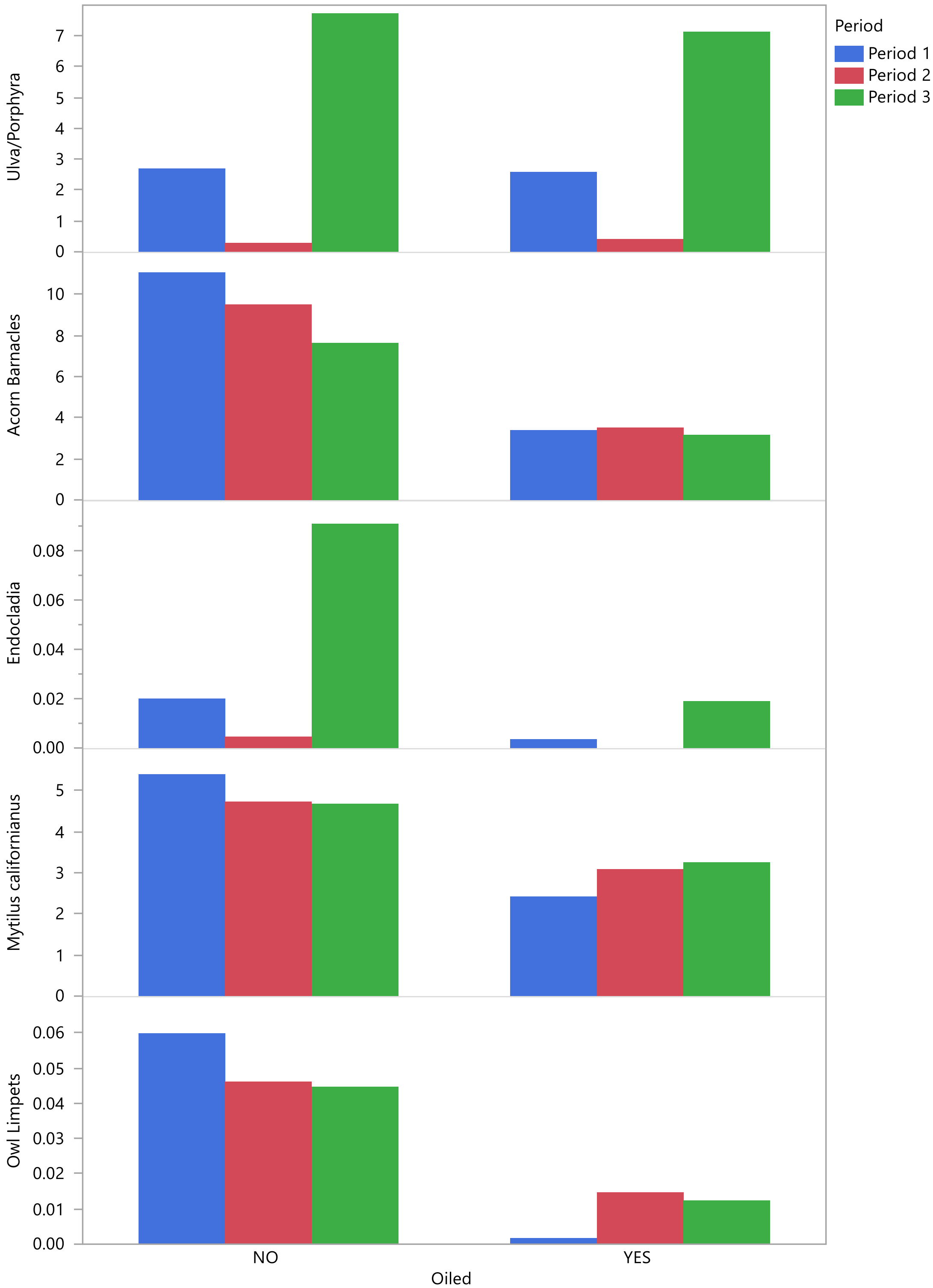

Figure 7: Percent cover of select species over three periods. Sites are combined into two groups: oiled or not oiled. Species from are ordered from top to bottom based on longevity.

Long Term Monitoring – The results of the assessment of long term sites are shown in Figure 8. Of the 6 sites, only Coal Oil Point showed a significant change in community similarity for the two year period just before and just after the Refugio Beach Oil Spill. This is important because among the six sites assessed it is the only one that was subject to heavy or moderate oiling in the RBOS. We note, however, that Coil Oil Point historically has shown large community level changes over time (e.g. 2002-2003). The species (or substrate) contributing most to the change are shown in Figure 9. Rock increased in 2015 then decreased in 2016, *Ulva* increased slightly in 2016 then increased more in 2017. Barnacles (*Chthamalus/ Balanus*) increased considerably from 2015-2016 then decreased in 2017. *Mytllus* decreased from 2014 to 2015 and then stayed flat until rising in 2017.

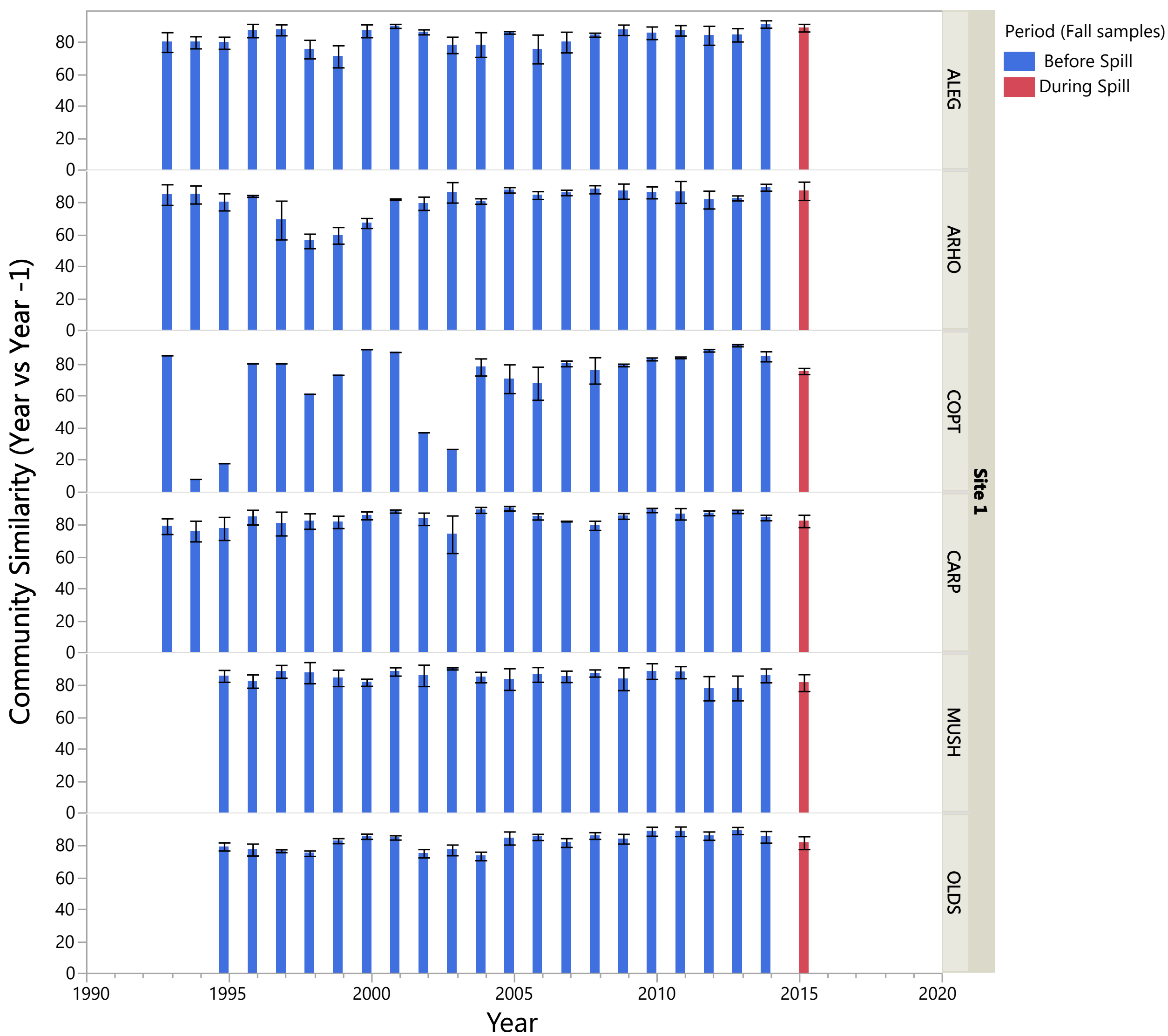

Figure 8: Patterns of long term community similarity at 6 sites. Period after spill is designated in red. Each bar shows the community similarity relative to the previous year. Error bars and 95% confidence intervals. Sites are ordered from North to South.

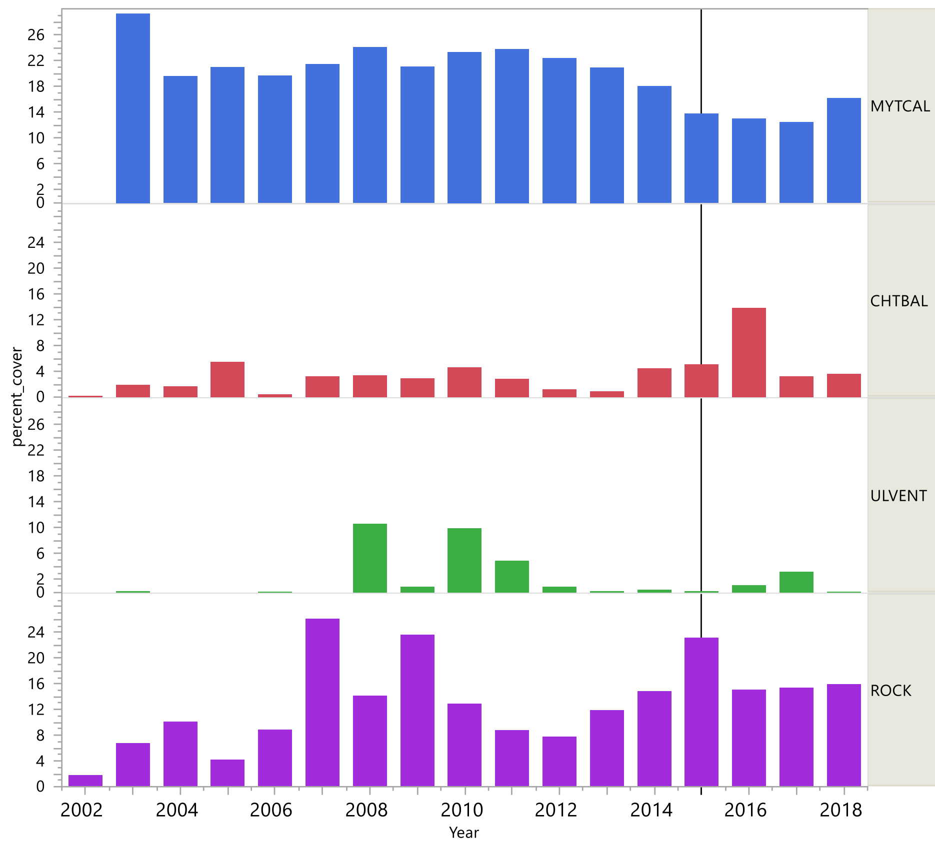

Figure 9: Cover of four species at Coal Oil Point over time. MYTCAL = *Mytilus californianus*, CHTBAL = *Chthamalus/Balanus*, ULVENT = *Ulva spp*, The vertical line indicates the year of the RBOS.

Biodiversity Sampling – The results of the cluster analysis for the biodiversity monitoring sites are shown in Figure 10. This figure shows all sites and all years that the sites were sampled. One pattern is that, in general, sites cluster together. This means, for example, all three years that Arroyo Hondo was sampled cluster together, meaning that the communities in any year at Arroyo Hondo were more similar to communities in other years than to any other site/year combination sampled. For convenience, we simplified the analysis by stratifying years into two periods: pre and post spill. This cluster analysis is shown in Figure 11. Here all sites cluster together, with the exception of Coal Oil Point, which was the one site in this group that was heavily or moderately oiled during the RBOS. Coal Oil Point is dramatically different between the two periods. The species that contribute to this difference are shown in Figure 12. One key result here is that there are more ephemeral and short lived species and less long-lived species in the post spill vs. pre spill surveys. Examples of species that increased post-spill include short-lived opportunistic ephemeral taxa such as *Ulva*, *Endarachne*, diatoms, *Ceramium,* and *Scytosiphon.* However, *Phyllospadix torreyi,* which is a long –lived species also increased post-spill, although this might not be a “real” trend, but rather an artifact of lower sand cover in the post-spill period, since surfgrass tends to be buried by sand. By contrast, many of the species that decreased post-spill are longer lived species such as the mussel, *Mytilus californianus,* the barnacle species *Chthamalus spp.* and the anemones *Anthopluera elegantissima* and *Anthopleura sola.*

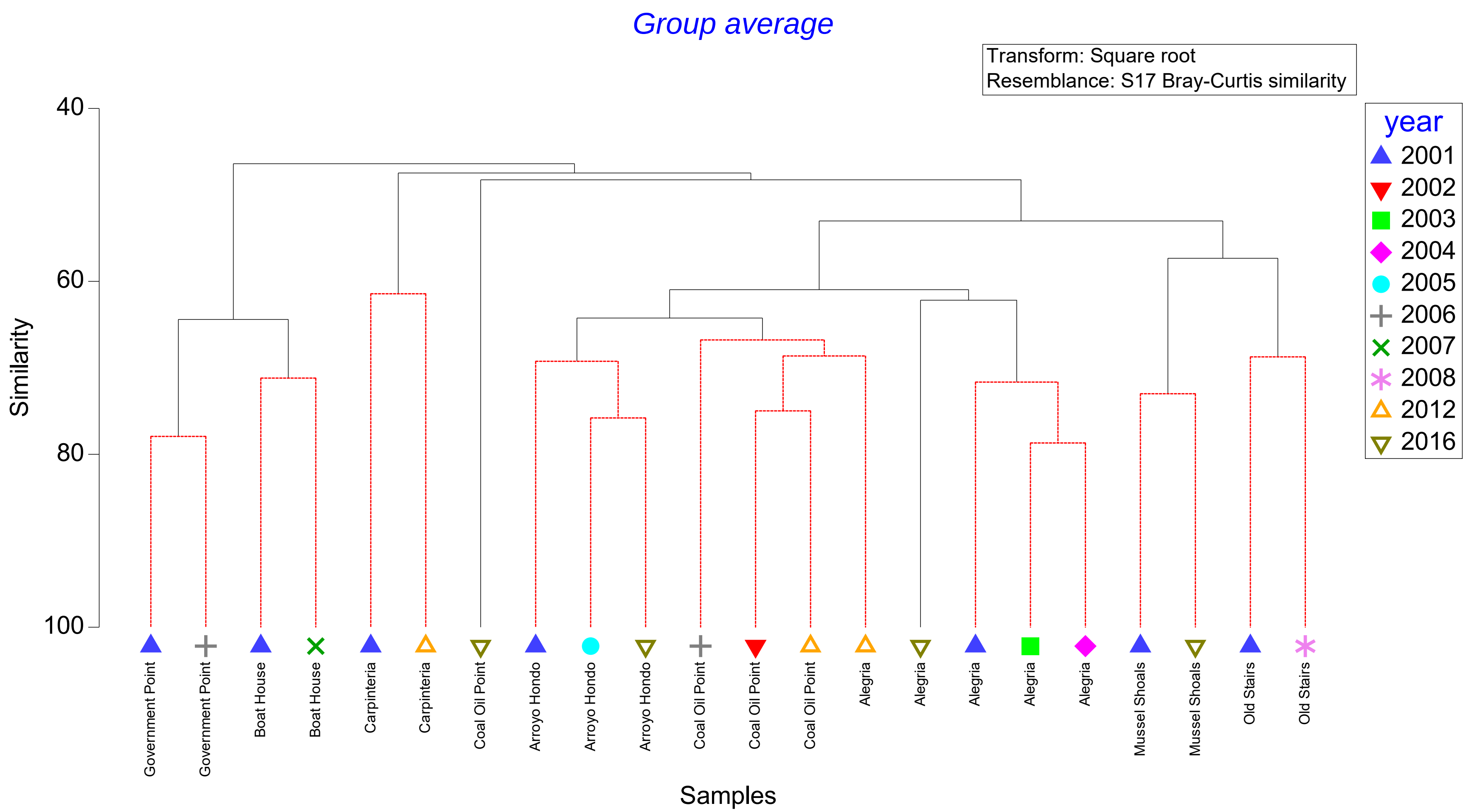

Figure 10: Cluster analysis for Biodiversity sites near to the oil spill location. Years are show by symbol and color.

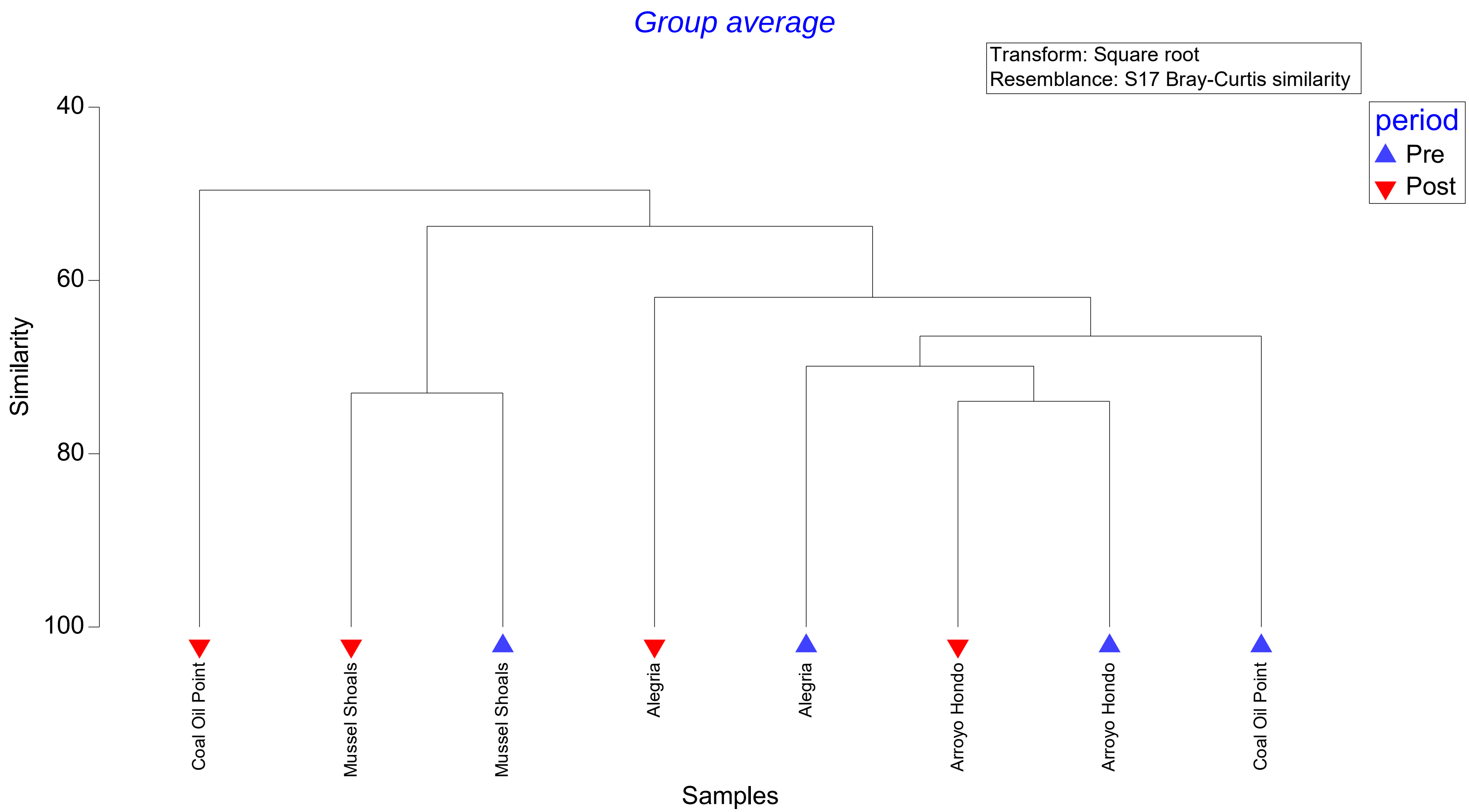

Figure 11: Cluster analysis for Biodiversity sites near to the oil spill location. Two periods are show here: Pre and post spill.

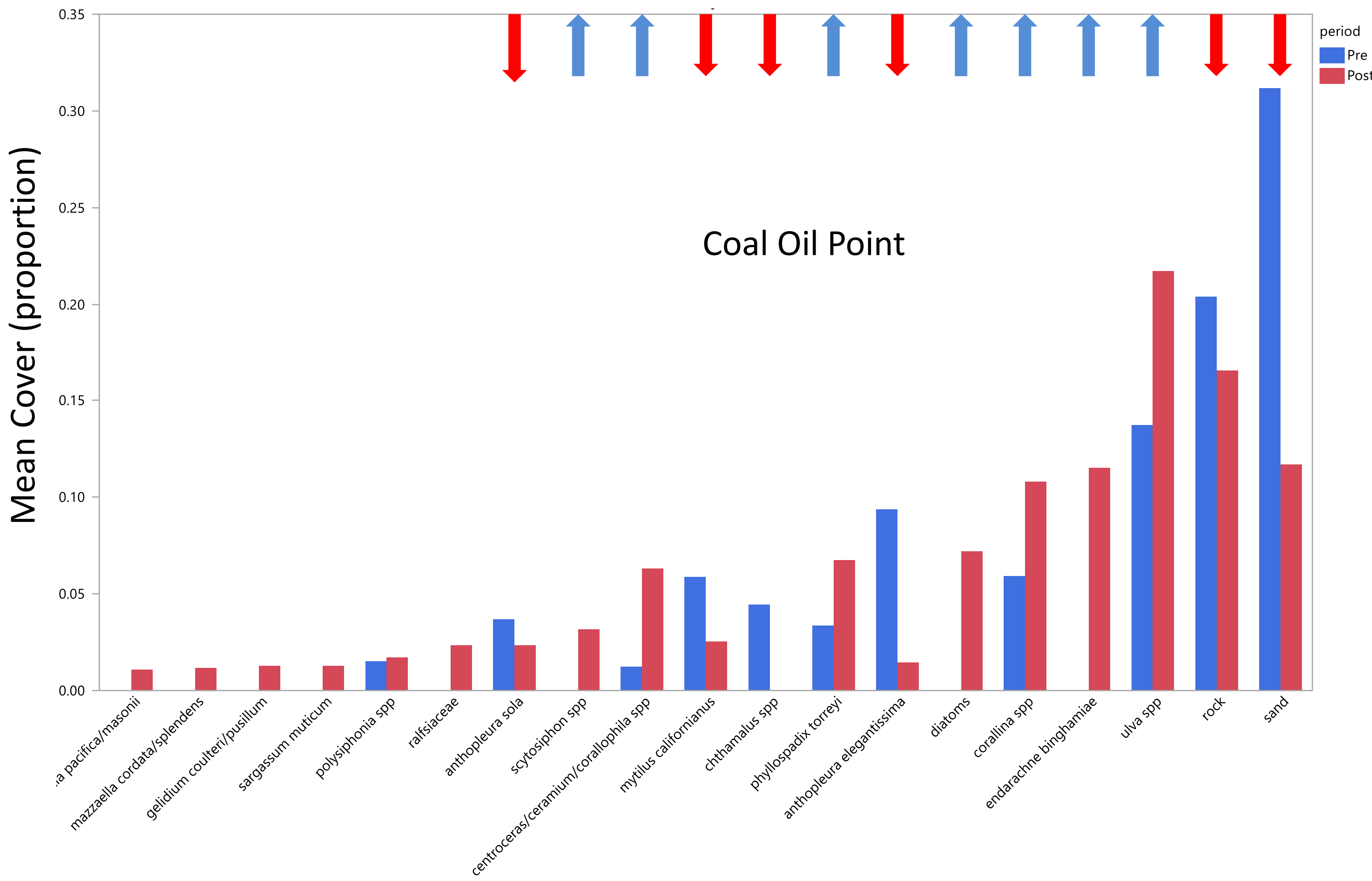

Figure 12: Cover (Proportion) of most common species at Coal Oil Point pre and post oil spill. Arrows indicate the direction change for species discussed in text. Rock and Sand are also shown because changes in these two substrate categories can have profound effects on the cover of rocky intertidal species as all species sampled are rock associated.

Discussion

As noted earlier in the report our primary goal was to determine if there was any ***general and quantitative*** evidence of impact to the marine community resulting from exposure to oil or cleanup activities. We used the words “general” and “quantitative” because we wanted to distinguish our analytical framework from qualitative observations made on site. There is no question that there were impacts to certain species in specific locations.

Like virtually all unforeseen perturbations, assessment designs for oil spills, especially those where the spill is relatively small, are problematic for a number of reasons, all relating to attribution of cause of change. There are usually two specific problems. First, there is often no pre-spill data so simple measurement of species or community change is impossible. Second, even in situations where there may be pre-spill data, there is often not much and hence little ability to determine if change following a spill is outside the natural variability of the system. For the RBOS, there was a relative wealth of information for rocky intertidal community that could be used to assess potential impacts. Still, it was essential to use a multi-pronged approach, where each prong complimented and added to the information provided by the other prongs. These “prongs” can be thought of as the monitoring approaches used: RAPID surveys, where all data came from post RBOS surveys and the Long Term Monitoring (LTM) and Coastal Biodiversity Surveys (CBS), where there were results from pre-RBOS surveys.

The Multi Agency Rocky Intertidal Network (MARINe) was developed in part to provide baseline information that could be used to assess impacts related to anthropogenic perturbations including oil spills. The two core protocols for MARINe are the LTM and CBS surveys, each provides unique and important information as described in Appendices 3 and 4. The geographic origin of MARINe is Santa Barbara County, where monitoring initiated in 1992. The MARINe network of sites is the most spatially expansive temporally broad intertidal monitoring program in the world. However, we recognized early on that in the event of an oil spill, the vast majority of locations affected by the spill would not be MARINe sites. Rather the MARINe sites would act as sentinel sites for all sites affected. To spatially complement the LTM and CBS sites and especially to address NRDA concerns we developed the RAPID protocols that are explicitly and strategically invoked if there is an oil spill.

The results of the surveys and analyses described above suggest that there were impacts to intertidal species resulting from the Refugio Beach Oil Spill. This is based primarily on a community based analyses, which generally are the most powerful approaches for such assessments. Our analyses over three sample periods (Table 3) indicated that sites that were oiled differed from those that were not oiled during the RBOS. In addition, there was a significant interaction between site type (oiled and not oiled) and period sampled (Spring 2015, Fall 2015 and Spring 2016). Examination of the community results (Figures 4 and 5) indicated that the interaction was driven at least in part by a decrease in the difference in communities in oiled and not oiled sites between Spring 2015 and Spring 2016. Oiling as a metric differed greatly between sites that were characterized (SCAT determination) as being oiled or not (Figures 2 and 3). Oiled sites had a higher percentage of plots that showed oiling (Figure 2), with the level of oiling general decreasing over time. The percent of biological cover that was oiled showed the same pattern (Figure 3). Moreover, we found that the most common and long-lived sessile and mobile “indicator” species (mussels, barnacles, *Endocladia* and owl limpets) in the sampled intertidal areas showed reduced cover in oiled vs not oiled sites (Figure 7).

LTM and CBS surveys included only one site that was substantially oiled by the RBOS. That site was Coal Oil Point. Analyses of both LTM (Figure 9) and CBS (Figure 11) data indicated that the community at Coal Oil Point may have been impacted by RBOS. Importantly, the pattern of change for species driving the change in the community pre and post spill are what are predicted based on past spills (Raimondi et al. 2009). In general, ephemeral species increased and long lived species decreased post spill (Figure 12). It must be noted that Coal Oil Point is a very dynamic site (see Figure 8 and years 1994, 1995, 2002 and 2003 for some examples), subject to considerable sand burial and scour, so some caution must be applied to the a conclusion of impact related to the RBOS.

In conclusion, the results of the set of studies discussed above together with observations in the field clearly indicate that during the RBOS: (1) oiling occurred in the intertidal zone, (2) oiling occurred on species inhabiting the intertidal zone, (3) patterns of species abundance in oiled compared to unoiled sites were consistent with effects found in other oil spills and with theoretical predictions of disturbance and, (4) many of those oiling and species abundance patterns (#3) were still present a year after the spill.

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Appendix 1: Site photos and descriptions

Government Point is comprised of consolidated bedrock with moderate relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Alegria is comprised of consolidated sandstone and mudstone bedrock, boulder fields, and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock, boulder fields, and sandy beach.

Arroyo Hondo is comprised of consolidated sandstone and mudstone bedrock and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Tajiguas is comprised of consolidated bedrock, boulder fields, and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Refugio West is comprised of consolidated bedrock, boulder fields, and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock, boulder fields, and sandy beach.

Refugio is comprised of consolidated bedrock, boulder fields, and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock, boulder fields, and sandy beach.

Corral Canyon is comprised of consolidated bedrock with moderate relief. The area surrounding the site is consolidated bedrock and sandy beach.

El Capitan is comprised of boulder fields and sandy beach with high relief. The area surrounding the site is a mixture of boulder fields and sandy beach.

Edwards Point is comprised of boulder fields with high relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Ellwood is comprised of consolidated bedrock, boulder fields, and cobble beach with high relief. The area surrounding the site is consolidated bedrock, boulder fields, and cobble and sandy beach.

Coal Oil Point is comprised of consolidated sandstone and mudstone bedrock, boulder fields, and cobble beach with low relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Carpinteria is comprised of consolidated sandstone and mudstone bedrock and sandy beach with moderate relief. The area surrounding the site is a mixture of consolidated bedrock and sandy beach.

Mussel Shoals is comprised of consolidated sandstone bedrock, riprap, boulder fields, and sandy beach with moderate relief. The area surrounding the site is a mixture of boulder fields and sandy beach.

Old Stairs is comprised of bedrock, boulders and sand with moderate relief. The area surrounding the site is a mixture of boulders and sand.

Appendix 2: Background & rationale for rocky intertidal oil spill damage assessment protocol (RAPID)

Background & Rationale for Rocky Intertidal Oil Spill Damage Assessment Protocol

Goals

The overarching goal of this workshop is to develop a design that that maximizes the ability to detect injury under the logistical constraints imposed by each unique circumstance. We have proposed a design based on the recognition that all assessments are constrained by the need to respond rapidly with limited time and resources to initially canvas the affected region and establish long-term monitoring studies. During the workshop, we will present the design, implement it at field sites with different habitat characteristics and then discuss how it should be improved before putting it into practice. Our draft proposal will then be revised and returned to you.

Damage assessment requires determining several types of information: 1) extent of oiling, 2) initial damage, 3) recovery and 4) scaling the injury. SCAT maps provide a broad overview of the extent of oiling. However, our experience suggests that more detail on the extent and quantity of oiling at chosen study sites is needed to provide a stronger link between oiling and damage. We will describe our proposed approach to quantify oiling at the site. However, the lack of oil at the study sites visited during the workshop requires that we simulate our methods in the field.

Our main focus is to present a design that quantifies 1) initial mortality, 2) longer term sub lethal impacts and 3) long-term recovery so 4) the injury can be scaled. We begin by discussing the strengths and weaknesses of potential study designs, any of which may have to be adopted due to the circumstances of the spill. We then describe several broad categories of injuries that we will consider during this brief workshop. We describe methods for quantifying some of them and will put them into practice in the field. Field experience with the methods is intended to provide first hand knowledge of the study system and a fuller understanding of the benefits and limitations of the methods for later discussion and evaluation.

Complementary laboratory experiments can be conducted to demonstrate the effects of oil on foundation or other key species of the community. Standard bioassays are conducted to compare the effects of oil (e.g., concentrations, age) on organisms that are not exposed to oil (controls). These bioassays have been well-described elsewhere and are not included in the workshop.

Study design

Damage assessments rely on a statistical (probabilistic) approach to the assignment of causation. This is fairly uncomplicated when there is an opportunity to design the sampling approach around a treatment or set of treatments that are imposed spatially and temporally by an investigator. However, when the treatment or treatments are imposed in an unplanned fashion, assessment can be extraordinarily complicated and fraught with assumptions. This is exactly the situation that often occurs in the case of an oil spill. The main issues that complicate assessment are:

1) Absence of or unbalanced replication of treatments (i.e. oiled vs. non-oiled)

a. Misuse of inferential statistics – e.g. how to apply statistics when there is no replication

b. Impacts to statistical power – low replication leads to low power

2) Nonrandom allocation of treatment replicates

a. Spatial segregation of variance – e. g. oiling is in a specific region and all reference areas are spatially segregated from that region

b. Treatment confounding – e.g. oiled sites potentially affected by other sorts of impacts (e.g. storm water discharges)

3) The primacy of alpha. Because the burden is to show effect rather than to show that no effect occurred there is an implicit assumption of the primacy of type I statistical error, which is also called alpha (α) relative to type II error: beta (β). Alpha is the probability that one mistakenly concludes an effect exists when it does not, whereas beta is the probability that one concludes that there is no effect when there truly is one. This primacy of alpha means that the control of this type of error is considered to be paramount and has been assumed in science (although not unchallenged) but in more applied work there is a distinct evolution of this assumption. In NRDA, this assumption remains in force. One key decision that must be made is what the critical value of alpha should be. In 'traditional' inferential statistics this value has been 0.05. Such a stringent value in the face of often constrained sampling design and low replication may critically compromise the assessment by crippling the statistical power. Recent theory suggests a balance between alpha and beta should be the goal in such assessment. Exactly what that balance should be will be a topic of discussion at the workshop.

Many different methods for assessing rocky intertidal communities have been developed, but time, gear, and personnel constraints make most unsuitable for a pre-spill assessment. There is often little to no warning that a spill is going to occur, the location of the spill is remote, and researchers have varying degrees of expertise and equipment resources. The challenge, then, is to develop a protocol that can be applied during a limited period of time and yet produce scientifically defensible data. For rocky intertidal habitats, our goal was to develop a sampling design that is rapid, repeatable, and returns quantifiable data for characterizing the species composition of the rocky intertidal community and the abundance or status of key species at a site. The protocol outlined in the following section provides a standardized sampling procedure valid for detecting impacts to multiple types of rocky intertidal habitats in a quick and comprehensive manner for natural resource damage assessments.

<u>Selection of Target Species</u>

Species and communities are selected for assessment based on five main characteristics:

1) Representation in the community. One goal in any assessment is to characterize the affected community. Hence, the species selected should be representative of the community. Furthermore, it is important to consider not just the species present in a community, but also the size and age of populations. Species with differing life history traits (e.g. age of first reproduction, larval period, fecundity)

may be affected very differently by oiling and importantly show very different patterns of recovery from injury.

2) The ecological importance of the species or community. In particular, assessing effects on species that play key roles as keystone predators or habitat-formers (foundation species) is important because of the numerous indirect effects that injury to these species will cause.

3) The economic importance (harvested species) or species with special status (e.g. black abalone). Species of economic/harvestable importance on west coast rocky shores include abalone, some crab species, mussels, and some gastropods.

4) The susceptibility of the species or community to effects from oiling. This is often not known but can be inferred by known susceptibility of other like species.

5) Logistical constraints or opportunities. Some species may be important and susceptible to effects from oiling yet virtually impossible to assess because of their life history or habits.

One of the major challenges in assessing biological injury due to oiling is distinguishing oil-induced changes in species' abundance from those due to natural variation. The approaches used to infer causation can be lumped generally into two groups: 1) **spatial comparisons**, where certain aspects of intertidal communities (e.g. species composition, abundance of key species) are compared **among multiple sites** to determine whether oiled sites are more similar to one another than un-oiled sites, and 2) **temporal comparisons**, where comparisons are made across multiple sampling events often **within a single site**. These and variants of both approaches are diagramed in Figure 1 and described below.

Spatial Comparisons

In the first approach (among site), the goal is to determine if the species composition (or abundance of key species or other community attribute) of a site can be distinguished simply as a function of the degree of oiling. Here locations are considered to be replicates, but we know that lots of things might be different among rocky intertidal locations, besides just the degree of oiling (wave exposure, substrate type, proximity to freshwater inflow, upwelling, etc.), and the analysis needs to account for this. An assumption of this approach is that the degree of oiling is not perfectly confounded with a major location variable, thus sampling must be done at many sites in both oiled and un-oiled (reference) locations with each type of habitat, wave exposure, etc. Non-oiled locations should be selected to be as similar to oiled sites as possible. If data prior to the oiling event are available then assessment of similarity can be done based on biological information, otherwise physical site characteristics must be used as proxies.

The among-site approach requires extensive sampling of each site to adequately characterize the range of variation in both oiling and natural variation of communities across different types of habitat. Even in the absence of oil, under sampling sites that are actually quite different could result in the conclusion that they are similar due to chance under-representation of species at one site and over-representation at the other. Under sampling can also result in false similarity if species that are relatively uncommon (yet still ecologically important) are missed.

Temporal Comparisons

The second approach that can be used to assess the potential direct and indirect impacts resulting from an oil spill involves comparing species composition (or abundance of key species or other community attribute) relative to baseline information **at that site and a reference site**. This is what might be called a BACI (Before-After-Control-Impact) design. A weaker variant is ACI – where there are no before data. A much more powerful variant is M-BACI (multiple BACI) where there are multiple impact and reference sites all with data that were collected prior to the oil spill.

This approach requires less sampling than spatial comparisons, provided that plots are marked so that precise locations can be resampled. Resampling the same individuals or exact locations over time provides the strongest evidence of change.

There are a number of ways to estimate baseline conditions.

1) Compare data on composition immediately after oiling ("just oiled") with composition some length of time after oiling has occurred (ACI). This approach can be used to assess damage and recovery. It does not allow for comparison to pre-oiling conditions (because the data do not exist) but does allow for assessment of the degree of variation in sites that have vs. have not been oiled (useful when pre-oiling data are unavailable). If long-term data are available at un-oiled sites, but are not directly comparable to the sampling proposed here, these can still be used to assess whether any observed changes in cover are related to natural phenomena.
2) Compare data on composition among the pre-spill period, immediate post spill, and longer-term after spill periods to assess recovery (BACI or MBACI). Compare magnitude of temporal change at impacted site(s) with un-oiled sites. While this is perhaps most ideal type of data (closest to a "gold standard"), it is also the least likely to be available due to lack of data on pre-spill conditions at most places.

Specific approaches used for damage assessment comparisons:

1) Correlate degree of oiling with community composition at a single snapshot in time. Continued mortality and recovery rates would not be measured.

Logic. If oiling has an effect, sites with oiling will be more similar to each other and very different from un-oiled sites.

Example. If mussels are sensitive to heavy oiling, heavily oiled sites should have fewer mussels than non-oiled or lightly oiled sites despite variation in other factors across sites. Environmental variables can be used as covariates in the analysis if they are not overly confounded with oiling.

2) Compare temporal patterns among sites with varying degrees of oiling above and beyond natural seasonal or interannual variability in non-oiled sites. Continued mortality and recovery rates could be measured.

Logic. If oiling has an effect, sites impacted by oiling will show a larger change (e.g., losses due to mortality) and more variability (e.g., different size classes or stages of succession) than non-impacted sites. Oiled sites may show directional changes in composition as succession proceeds, although this can be complicated if there are indirect or more chronic effects of oiling on species involved.

Example. If mussels are sensitive to heavy oiling, heavily oiled sites should initially have fewer mussels than non-oiled or lightly oiled sites despite variation in other factors across sites. Continued mortality could be detected at oiled sites but would not be evident at non-oiled sites. Recruitment of mussels or other organisms into space that was previously occupied by mussels would result in increased size variation of mussels or shifts in abundance and composition of other species at oiled sites during recovery but not at non-oiled sites where space was not opened by mussel mortality. Mussels may or may not fully reoccupy space at oiled sites depending on environmental conditions and supply of recruits (e.g., the prevalence of different types of larvae or algal spores that happen colonize space first). Because mussels are a foundation species (providing habitat for many others), this would have a large affect on the community.

3) Compare change before vs. after incident in long-term monitoring sites that are in oiled vs. non-oiled areas (or finer degrees of oiling). Continued mortality and recovery rates could be measured.

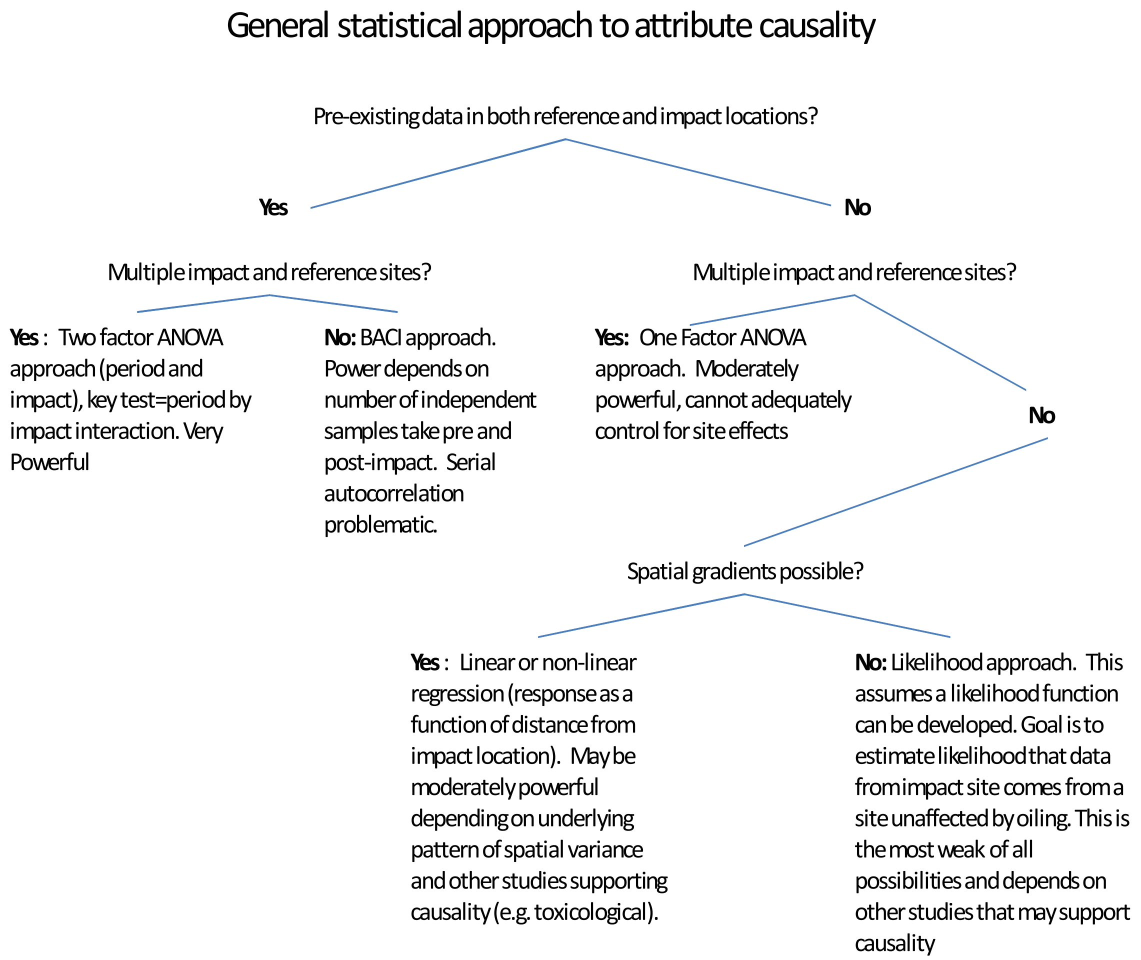
Logic. If oiling has an effect, sites impacted by oiling will change upon exposure to oil whereas un-oiled sites will not show the same changes. Continued monitoring would not be necessary to demonstrate the initial impact of oil, but it would be necessary to document continued change at the oiled sites and to compare recovery rates at oiled and non-oiled sites.

Example. If mussels are sensitive to heavy oiling, mussel abundance at heavily oiled sites should decrease at the time of oiling whereas it should not decrease at non-oiled or lightly oiled sites despite variation in other factors across sites. Continued mortality and recruitment of mussels or other organisms into space that was previously occupied by mussels could be detected and recovery rates could be measured to assess duration of the injury. Duration will depend in large part on the spatial scale of injury: small patches can recover quickly (several years) as a result of migration of individuals from the surrounding community; larger patches require larval recruitment and can take some time to fully recover if larval supply is low or variable among years.

It is likely that all three of the approaches outlined above would be needed to assess damage from an oil spill depending on the circumstances of the spill. All three approaches can be effective depending on the magnitude of the oiling effect, the degree of natural variation among sites and the level of replication within and among sites. All things being equal, #1 is the least effective, but also the easiest to accomplish. It is likely that there will be a subset of sites for which #2 can be applied and even fewer for which #3 can be applied, as this depends on the availability of pre-existing data, accessible in a usable form.

Temporal comparisons are required to directly measure recovery rates and should be incorporated into study designs when feasible. This type of design will capture both initial decreases in abundance due to mortality or other metrics as well as expected increases in abundance or other changes during the recovery period.

Figure 1



Types of Injuries

1) Lethal effects – rapid decreases due to mortality

Approach: Lethal effects can be documented by either spatial (one-time) surveys or temporal, (repeated) surveys of resident organisms at multiple ("replicate") oiled and non-oiled sites or sites exposed to a range of oiling. Spatial comparisons will capture sudden or very rapid losses from mortality, whereas temporal comparisons have the added benefit of being able to capture continued mortality.

Example metrics

A. Abundance of species of special interest

- *Susceptibility to oiling*. Species vary in their susceptibility to oiling, depending on their physiological tolerance as well as their location in the intertidal zone. Species that are most sensitive or prone to oiling would provide especially good indicators of an effect of oiling. Shore crabs are especially sensitive to fouling because oil can clog their gills and many species live in the upper intertidal zone where oil is often deposited as the tide recedes.

- *Key species*. Species also differ in their importance to the community or ecosystem. Two types of key species are foundation species, which create (biogenic) habitat for many other organisms that would not occur in the community otherwise, and keystone predators, which reduce the abundance of competitively dominant species. Mussels form dense beds that form structure for many smaller mobile species of worms and crustaceans that live in the interstices. The predatory seastar, *Pisaster ochraceus*, preys predominantly on mussels, eliminating them from the lower intertidal zone and opening bare space for other sessile species to colonize. Without *Pisaster,* mussels could reduce the diversity of the sessile animal and seaweed community living directly on the rocks. Key grazers like crabs, limpets, chitons and snails remove fast growing algae and accelerate recovery to stands of perennial habitat-forming seaweeds.

B. Abundance of size classes or sexes of species of interest

The age and sex of individuals within a species can differ in their susceptibility to oiling due to their sensitivity or zonation, just as species differ in their susceptibilities. Young individuals, or those living high in the intertidal where oil tends to accumulate may be especially susceptible. On rocky shores, crabs, seastars, abalone and other mobile species are often assessed. In addition, certain species of algae, notably fucoids, have been shown to be very sensitive to oiling and size structure is a metric that has been used to assess impact and recovery. As with many of the assessments, ancillary information may be immensely useful. For example, determination of reproductive status for crabs (female) is easy and potentially of great use.

C. Biogenic habitat characteristics

The extent of biogenic habitat affects the abundance and richness of species in the community. For example, the thickness of mussel beds or size of individual mussels in the bed and the frond size of canopy forming algae affects the abundance and number of species living there in addition to the areal coverage of these beds. These relationships are usually non-linear, with threshold levels required before certain species will colonize these habitats.

D. Species richness (numbers of species)

Many species are susceptible to oil, and as a consequence, fewer species are expected to live at oiled sites than non-oiled sites. Greater species richness itself can increase the total standing biomass on rocky shore communities and enhance resilience of a community from disturbance. Thus reduced diversity can further impede recovery.

E. Community composition (identities of species)

Species differ in their susceptibility to oil depending on their tolerance and zonation. Consequently, species composition is expected to differ between oiled and non-oiled sites. In particular, large mortality events associated with oiling can result in the community shifting to an early successional state as recovery begins. This state is dominated by weedy, colonizing species that often provide poor habitat for many associated species. These species are not so much resistant to effects of oiling as they are able to rapidly exploit available space vacated due to the acute effects of oiling once the oil is gone.

2) Sub lethal effects – longer-term decreases in attributes of living organisms

Approach: Sub lethal effects are documented by temporal monitoring of resident organisms at multiple oiled and non-oiled sites. This can be accomplished either by measuring many different individuals per sampling time to estimate changes in the characteristics of the population or by measuring fewer marked individuals at each time and site. For the species that can be reliably marked and relocated (sessile organisms), tracking marked individuals can provide a strong link with relatively little effort.

Example metrics

A. Physiological stress

Physiological stress of individuals that survived oiling can be indicated by biochemical and physiological biomarkers. These biomarkers provide the most sensitive measure of oiling, and are especially useful at detecting effects at lightly oiled sites or lingering effects after the community may otherwise appear to have recovered. Like ecological measures, these biochemical and physiological measures must be correlated with oil exposure or another biomarker of oil exposure to distinguish them from other factors that might cause the observed effect.

B. Growth

The added stress or reduced ability to acquire and assimilate food for animals and sunlight for plants is expected to reduce growth rates at oiled compared to non-oiled sites. Energy acquired by organisms that would otherwise be available for growth may be diverted to deal with detoxification. For key habitat forming species such as mussels or seaweeds, reduced growth can reduce their value as habitat because this value is usually non-linearly size dependent. Additionally, predation on many of these species is size dependent and once they reach a certain size they are relatively immune from predators. Thus reduced growth of these species can have community wide-consequences by reducing availability of appropriate habitat for other organisms and reducing rates of community recovery after any disturbance.

C. Reproduction

- *Reproductive output* (number of embryos or gametes including gonad index). Reduced reproductive output can result from the combined effects of stress from oil and limited ability to gather food at oiled compared to non-oiled sites. Reproductive output can be measured by counting the numbers of embryos by brooding invertebrates, such as barnacles, crabs and shrimp. Because the external body walls of crustaceans are rigid, a strong relationship between the size of the individual and the number of embryos has been described for a number of species. Any such predescribed relationship would be expected to apply to non-oiled sites, but the number of embryos should be much less than expected at oiled sites for any given size. This approach can be used without a predescribed relationship simply by comparing output at oiled vs. non-oiled sites. Other examples include counting the number of egg cases attached by snails or fishes to the substrate per unit area or quantifying the Gonad Somatic Index (GSI) of mussels.

- *Developmental abnormalities*. Early life stages (gametes, embryos, larvae, spores, settlers) are well known to be most sensitive to oiling and other stressors. A particularly convenient measure of reproductive impairment is to quantify the number and type of reproductive abnormalities in broods. Embryos brooded outside the body walls of adults are exposed to oil in the environment as well as the chemicals being passed on from the adult to the offspring through lipids. Previous studies have documented a relationship between the amount of contaminants, developmental abnormalities, hatching success and larval survival. Determining the percentage of abnormal embryos is the easiest of these measures to accomplish.

D. Recruitment of propagules (larvae or spores)

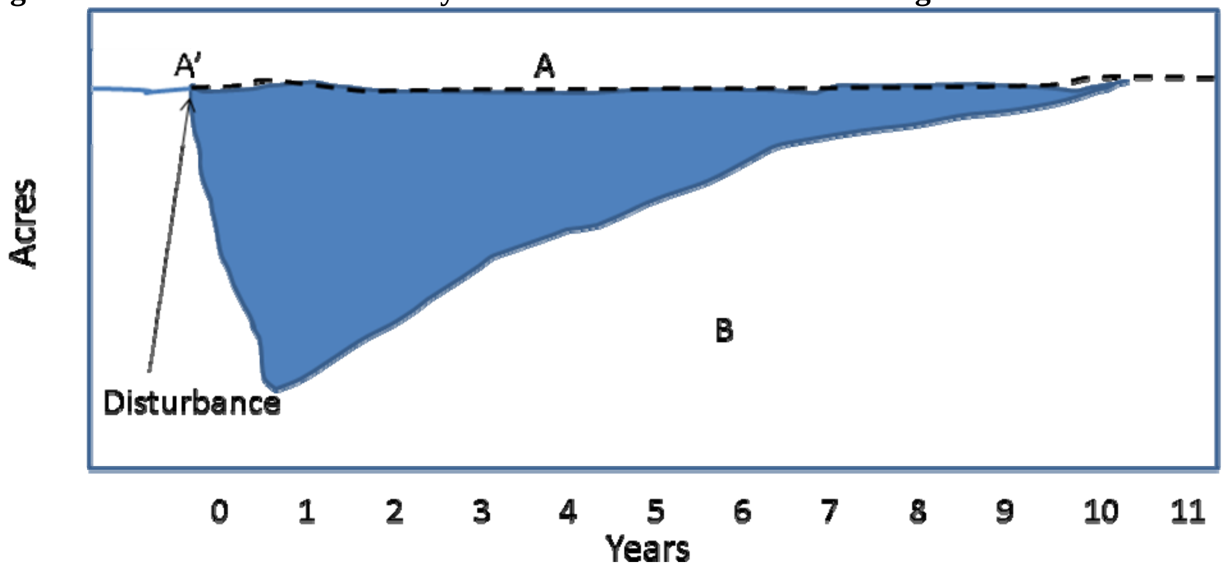
Recruitment of propagules is expected to be less at oiled sites if larvae avoid settling there in favor of non-oiled substrate or because of loss of preferred habitat (many organisms preferentially settle with conspecifics or with specific other species that provide appropriate habitat (e.g., mussel larvae settle and survive best in adult beds or turf algae). Additionally, oiling could affect recruitment if newly settled individuals die soon after settlement because of lack of appropriate density or size of habitat forming organisms. Quantifying effects on number of surviving juveniles (recruitment) is an important metric because it directly affects recovery rates from both natural disturbances and oiling induced mortality.

Scaling Injury

Scaling of ecological injury occurs after assessment of causation. If there is an impact to the community due to oiling then it follows that that there needs to be an assessment of injury.

Consider the figure below (Figure 2). Line B represents the acres of say a species that is disturbed at year =0. Line A represents the abundance the species would have had if the site had not been disturbed. This can be estimated based on control locations or based on a long time series that pre-dates the disturbance (A' is the value at the point of disturbance). The integration of the area between the lines is an estimate of the loss of resource value caused by the disturbance (Injury). The units of the injury here is acre-years. If the assessment of loss can be delayed until recovery is complete, and if there is information from undisturbed sites that can be used to indicate what the species' dynamics would have been at the disturbed site, then estimation of loss of resource value should be a relatively simple endeavor. However, it is usually the case that the assessment will need to be completed before full recovery. This very much complicates the assessment because of the need to estimate recovery potential at the affected site

Figure 2: Effect of rate of recovery on loss of resource value following a disturbance.



Modeling (as opposed to calculating) injury and recovery relies on the following terms:

1) **Estimate of loss given a particular level of oiling (O_{ij}, where i is the loss for species i at oiling level j)**. This value should be based on the quantitative surveys described in this document. Loss will usually be expressed in terms of percent loss and may be relative to a particular level of oiling (e.g. loss of 20% of mussel community in areas with oiling levels of 20-40%).
2) **Estimate of amount of affected species or assemblage per unit length of coast (A_i)**. For example there could be 1 acre of mussel habitat per mile of rocky coast.
3) **Estimate of amount of affected habitat of a given coverage of oil (H_j)**. For example there could be 22 miles of rocky coastline that had 20-40% cover of oil.

The initial impact to a species i for oiling level j is then simply:

$$I_{ij} = O_{ij}A_iH_j.$$

4) **Estimate of rate that affected species or community recovers from the impact (R_i, this assumes recovery rate is the same for all levels of oiling, otherwise R_{ij})**. For example you could assume that the mussel bed recovers at a rate of 20% per year. These values will generally come from the literature.

The recovery curve over time (t) then can be estimated as (this is one class of curves that relies on invariant recovery rates):

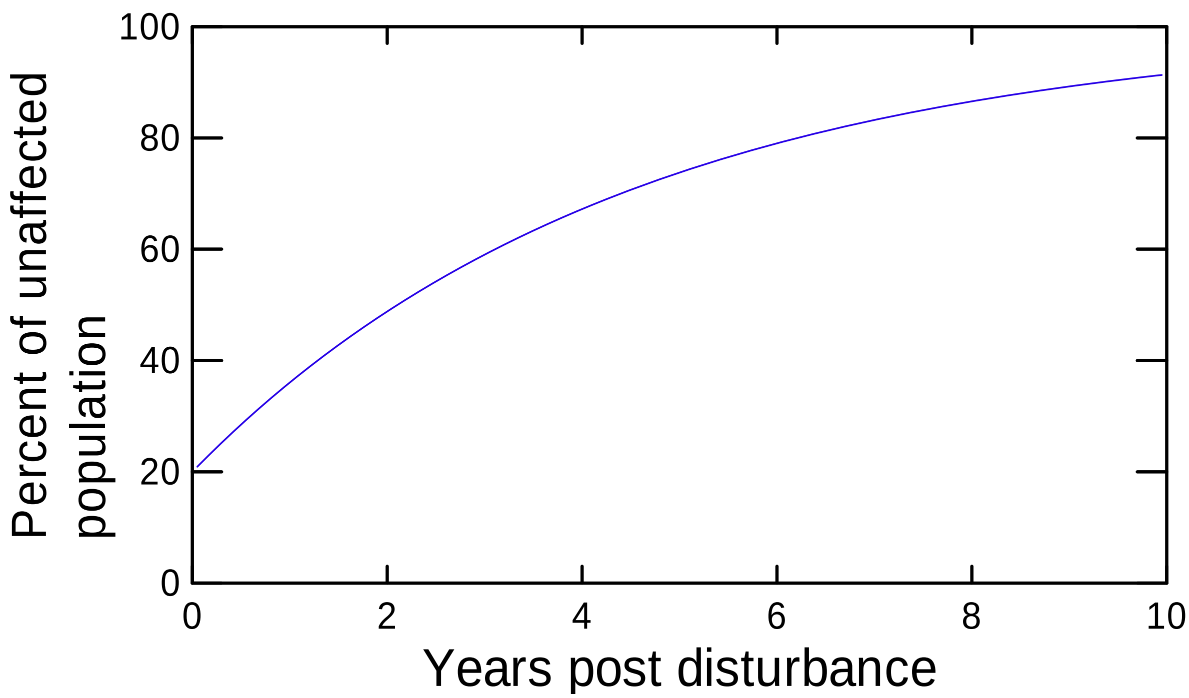
$$C_{ij}(t) = (1-O_{ij}) + (O_{ij}-(O_{ij}*(1-R_{ij}^{t})))$$

The injury curve in terms of say, area can then be expressed as:

$$I_{ij}(t) = A_iH_j[(1-O_{ij}) + (O_{ij}-(O_{ij}*(1-R_{ij}^t)))]$$

As an example assume that loss O_{ij} = 80% and recovery R_{ij} = 20% per year, then $C_{ij}(t)$ is:

Figure 3: Recovery as a function of years since disturbance ($C_{ij}(t)$). Here loss O_{ij} = 80% and recovery R_{ij} = 20% per year. Hence $C_{ij}(t) = 20\% + (80\%-(80\%*(1-20\%)^t))$



Finally, Injury can then be estimated (rather than calculated) as (recall that A' is the estimate of the unaffected state, Figure 2):

$$A't - \int I_{ij}(t)$$

Protocol Summary

The rocky intertidal protocol consists of several subsections, not all of which may be appropriate for every site. It begins with choosing a sampling location(s) within a segment and setting up the site, choosing a set-up that has a baseline either perpendicular or parallel to the shore, depending on the shoreline width and aspect. Next a general site assessment is made and photographic pans documenting the site are taken. Photoplot transects are done, in which the percent cover of species can be scored in the lab by overlaying a grid of 100 points on a computer monitor. Small motile invertebrates are counted in quadrats, and larger seastars and abalone are counted in swaths along transects. Additional size class measurements may be done for select species, and individuals may be collected for gonad assessment, and tissue analysis. Post-sampling procedures are also described in the protocol.

The sampling protocol outlined in this document was designed for use immediately following an oil spill, where a rapid approach that returns defensible data is necessary. The frequency of subsequent sampling events is not specifically stated because it is dependent on many factors, including species of interest, timing of the event, the type of oiling and cleanup that has occurred, but the methods outlined here are appropriate for assessing long-term damage and recovery, as well as initial damage.

Sampling Protocol for Oil Spill Damage Assessment In the Rocky Intertidal

I. Definitions

a. **Segment**—a region of coastline usually defined by authorities managing a spill. Each segment is given a unique code. Segments can be variable in coastal length.

b. **Site**—the area(s) of a segment selected for sampling, using the techniques described below, typically 50 meters in length.

c. **Baseline Transect**—a meter tape line run either perpendicular or parallel to shore (see site set-up below), from which all sampling transects are run.

d. **Sampling Transect**—meter tape lines run off of baseline at equally spaced intervals, upon which all sampling methods are based.

e. **Quadrat –** typically a 50 x 75 cm rectangle used for photoplots and for counts of smaller mobile species. This size and shape is based on photo orientation and typical levels of photo resolution.

II. Gear Set-up/General Sampling Information

a. See Appendix I for sampling equipment list.

b. Gather hardcopies of maps and images of segment to take into the field. The maps will be annotated in the field to document the extent of oiling and types of habitats present.

c. GPS unit—make sure it is in tracking mode, time zone is correct, and set datum to WGS84. Clear track log and waypoints every night after downloading information to the spatial data team.

d. Digital Camera

   i. Make sure that date and time are accurate (do not use date stamp feature as this may obscure portions of photo pans).
   ii. Photos need to be numbered sequentially throughout the entire incident (do not start with #1 each day), and detailed photo log should be recorded to identify each photo
   iii. Navigate to page in GPS unit that shows date & time and take photo, making sure time/date are readable (photo #1)
   iv. PHOTOS SHOULD NOT BE ERASED for any reason. Retake site pans/photoplots if necessary, but do not erase "mistakes".

III. Choosing Sampling Location(s)

a. With GPS in tracking mode, walk entire segment of coast. Note GPS coordinates of segment endpoints and capture endpoints with GPS unit waypoints.

b. Note dominant habitat(s) (e.g. rocky bench, rip-rap, cobble field), and any unusual features (e.g. large debris washed ashore, heavy oiling, river input, storm water outfall).

c. Photograph anything unusual, as well as both ends of the segment showing features that will help to identify segment boundaries. Pans showing dominant habitat types should be taken to show that selected site(s) are representative of segment.

d. Site placement should be done in area(s) that best represent segment. If multiple <u>dominant</u> habitat types exist (e.g. segment is 40% rocky bench, 60% boulder field), or if physical differences are apparent in different sections of similar habitat (e.g. wave exposed/protected), then multiple sites should be done within a segment to represent these differences.

e. If possible, locate site near distinctive feature that can be easily relocated (e.g. prominent rock, tree, street sign), or choose two points that can be used to triangulate to start of baseline transect. Mark baseline start with epoxy if no distinctive feature present. Note site location on segment maps/photos.

IV. Site Set-up

The sampling schemes described below assume that 50 m of contiguous rocky habitat are available for site set-up. If this is not the case (particularly common on the open coast), the protocol can be modified to fit within a smaller stretch of coastline (e.g. 30 m), or the site can be split into 2 sections.

a. If possible, run baseline transect near a distinctive feature or epoxy marker. Determine the distance and direction from the feature to the start of the baseline. If possible use two features and triangulate. As noted, epoxy markers or installed bolts can serve as the feature. When the shoreline is bedrock mark both ends of the baseline transect with epoxy or bolts. If shoreline is relatively narrow (more typical of bay habitat), baseline transect is typically run perpendicular to shore. If shoreline is wide and gently sloped (more typical of open coast), baseline should be run parallel to shore above the high zone.

   i. **Baseline Transect Perpendicular to Shore**—run 3, 50 meter transects (can be shorter if 50 m not possible) roughly perpendicular to baseline through the middle of the high, mid and low zones. If the tide will not descend to the low zone then use those areas that will be available. The three preferred tide zones will typically correspond to a set of species. For example: (1) the high zone is often associated with *Chthamalus* spp (barnacle species), *Ulva* (green algae) and Littorines (small snails), (2) the mid zone is often characterized by mussels and fucoid algae, (3) the low zone is often characterized by mixed red algal species, surfgrass, and feather boa kelp (outer coast). Transects should be parallel to each other and as representative of the site as possible. **Record where each transect crosses the baseline** (e.g. at 5m, 12m, 18m).

   ii. **Baseline Transect Parallel to Shore**—run 11 transects roughly perpendicular to baseline, from high zone, just above the intertidal biology, through low zone at equal intervals. 11 transects are used because extant MARINe biodiversity surveys use 11 transects and can be used as reference or impact sites if similar procedures are used. The standard baseline transect length is 50m, but this can be adjusted, or broken into 2 sections depending on shore length. Length of perpendicular transects will depend on width of shore.

b. Draw rough sketch of site, including any distinctive natural or man-made features, layout and length of transects (GPS coordinates, where sampling transects cross the baseline transect and compass bearings), and any triangulation distances & bearings that will aid in relocating transects. See examples, Appendix II. Photos should also be taken of the site set-up. Photos at the beginnings and ends of each transect, as well as views looking down sampling transect lines help in relocating transects and photoplots.

V. General Site Assessment

a. Fill out **Shoreline Assessment Form**—documents physical features of site and extent of oiling. See Appendix III for detailed description of how to fill out this form. It is important to **read these instructions before visiting a site**, so that site features and oiling can be properly documented. NRDA cards can be used as references to determine extent of oiling.

b. Fill out **Species Log**—a list of species that should be searched for at every site. Additional species can be added.

VI. Photoplot Transects

a. **Baseline Transect Perpendicular to Shore**

   i. Run 3, 50 meter transects roughly perpendicular to baseline through the middle of the high, mid and low zones. See Site Set-up above for zone descriptions and what to do if tide will not get very low. Transects should be parallel to each other and as representative of the site as possible. **Record where each transect crosses the baseline** (e.g. at 5m, 12m, 18m).

   ii. Place 50 x 75 cm gray PVC quadrat at 5 m intervals along each transect, starting at 0 m (11 photoplots per transect). Gray PVC should be used instead of white to prevent underexposure of darker areas within the quadrat. Orient all quadrats below the transect with the longest edge along transect and the upper left corner at the meter mark (see example map). It is important to be consistent with quadrat placement to allow for repeatability. Note quadrat orientation on photo data sheet.

   iii. Photograph each quadrat. Frame so that there is a small border around the quadrat. Record each photo location (high, mid or low transect and distance along transect) on photo log.

   iv. If photoplot location is topographically complex (i.e. not flat), and interstitial areas are out of focus, take additional, zoomed in photos to capture these areas. Record on photo log.

   v. If algal canopy is present (e.g. Fucus zone), photograph top layer first, then move canopy aside and photograph understory layer.

   vi. Using Photo Notes Sheet, take notes for each photoplot, showing locations of species that might be difficult to ID in photo. It is especially important to note species or features that might be confused with oil (e.g. dark algal crusts, dried Porphyra, blue green algae, dark rock), and to note any oil or tar in plot.

b. **Baseline Transect Parallel to Shore**

   i. Run 11 transects roughly perpendicular to baseline at 5m intervals, from high zone through low zone. Transect lengths will vary depending on shore width. Record length of each transect on site map.

   ii. Place 50 x 75 cm quadrat at evenly spaced intervals along each transect, starting at 0 m to obtain 11 photoplots per transect (divide transect into 10 even segments and place quadrat at beginning of each segment). Orient all quadrats along the upcoast edge of each transect with the longest side along transect and the upper left corner at the meter mark (see example map). It is important to be consistent with quadrat placement to allow for repeatability.

iii. See steps iii-vi above

VII. Site Pans

a. The person doing site pans should carry the GPS unit with them (still in tracking mode), and record GPS coordinates of photo locations. If possible, photograph entire site and surrounding areas upcoast and downcoast, from a high vantage point (e.g. cliff, high rock outcrop). Ideally this would be done from both the upcoast and downcoast ends of the 50 m site. The purpose of these pans is to capture the habitat features of the site and surrounding areas and show that it is representative of the dominant habitat in the segment. **Record all photos with number and brief description on photo log.**

b. Take closer-range pans (10-20 m) from fixed points within a site that will be easy to re-locate. Photo pans consist of several sequential, overlapping photographs taken in a circular fashion. Pans typically begin facing upcoast and proceed clockwise or counterclockwise in a half-circle (180 deg.) or full-circle (360 deg.), depending on the extent of the intertidal habitat surrounding the photopoint (e.g. it is not necessary to photograph the ocean from the low zone photopoints).

c. Suggested photo pan locations for each set-up are listed below. In addition to these, pans taken from easy to document, higher elevation locations within a site are useful. Document all photo pan locations with notes and GPS coordinates, and mark on site map.

i. Good photopoints for the perpendicular baseline set-up include 1) the intersection of the baseline transect and high zone transect, 2) the 25 m and 3) 50 m mark of the high zone transect, 4) the intersection of the baseline and the low zone transect, and the 5) 25m and 6) 50 m mark of the low zone transect.

ii. Good photopoints for the parallel baseline set-up include 1) the intersection of the baseline and the 0 m transect, 2) the end the 0 m transect, 3) the intersection of the baseline and the 25 m transect, 4) the end of the 25 m transect, 5) the intersection of the baseline and the 50 m transect, and 6) the end of the 50 m transect.

VIII. Motile Invertebrates

a. Baseline Transect Perpendicular to Shore

i. Place 50 x 75 cm quadrat in 5 evenly-spaced locations (e.g. 1m, 11m, 21m, 31m, 41m, 49m for 50 m transects) along the high, mid, and low transects (15 quadrats total). Quadrats should have the same orientation as photoplots, but in cobble habitats, quadrats should not be placed in the same locations along the transects as photoplots to avoid disturbing photographed areas (use same location in bench habitats, but take photos of plots before sampling motile invertebrates). **Note transect (high, mid, low) and location along transect on datasheet for each quadrat**. In rip rap areas that have large boulders and many deep and large crevices, move the position of the quadrats so that they lay mostly on rock and not voids. For all habitat types, avoid large tidepools.

ii. All motile invertebrate species that meet the guidelines outlined under "Selection of Target Species" in the Background/Rationale section (e.g. crabs, snails, but not worms, amphipods) should be counted. Counts or percent cover estimates should also be made for sessile invertebrates that meet these guidelines and might be missed by photoplots, such as those attached to the undersides of cobble (e.g. rock oysters, tunicates, sponges). Counts should be done for distinct individuals (e.g. oysters), and percent cover estimates should be made for colonial species (e.g. tunicates, sponges). Cobble should be lifted and examined, as well as the underlying substrate. Species that are very common (e.g. littorines) can be sub-sampled, but make sure to **note sub-sampled area.**

iii. Limpets are categorized into 3 size classes: small (<5mm), medium (5-15mm) and large (>15mm)

iv. Using calipers, measure width of shell at its widest point for snails and width of carapace at its widest point for crabs to nearest mm.

v. Note sex of crabs and presence of eggs where possible.

vi. If oil/tar is present under boulders/cobble, make quantitative assessment of abundance/cover. A good way to make this assessment is to take the average of two samplers' estimates.

b. Baseline Transect Parallel to Shore

i. For each transect, divide total length into 3 sub-sections for high, mid and low zones (based on species present), and place 50 x 75 cm quadrat randomly within each sub-section by using stop watch to select meter mark for placement (33 quadrats total per site). Quadrats should have the same orientation as photoplots. If quadrat placement overlaps with photoquadrat locations, they should not be disturbed until areas have been photographed. **Note transect number, zone (high, mid, low) and location along transect on datasheet for each quadrat**. In rip rap areas that have large boulders and many deep and large crevices, move the position of the quadrats so that they lay mostly on rock and not voids. For all habitats, avoid tidepools.

ii. See ii-vi above

IX. Seastar/Abalone Swaths-other major species

Most of this section is based on seastars and abalone **but you must be flexible and adapt to the habitats that you are sampling.** For example, if there is an abundance of gum boot chitons (*Cryptochiton stelleri*), they should be counted because, based on their life history, they are likely to be impacted by oiling.

In addition, crabs are sensitive to oiling but are nocturnal requiring that they be surveyed a night. The same protocol could be followed to count, measure and sex *Pachygrapsus crassipes*. This crab is large, quick and lives in the mid to upper intertidal zone, although it can occur lower on the shore foraging or releasing larvae into the water. Crabs freeze when a flashlight shines on them long enough to capture them by hand. Crabs do not flee as long investigators are quiet.

a. Baseline Transect Perpendicular to Shore

   i. Sample a 2 meter wide swath along each of the transects. Count all seastars and note species. Seastars counted in swaths should be restricted to those species that are relatively large in size (e.g. *Pisaster ochraceus*, *Pycnopodia helianthoides*, *Patiria miniata*), although juveniles of these species should be counted in addition to the larger adults. Smaller species (e.g. *Leptasterias* spp., *Henrecia* spp.) will be captured in motile invertebrate quadrats. All abalone species should be counted.

b. Baseline Transect Parallel to Shore

   i. Count and measure all seastars and abalone occurring within a 1m swath on either side of each transect (for a total of 11, 2m wide swaths). Use a ruler to measure the radial size of seastars (middle of star to tip of longest arm), and the length of abalone to the nearest 10 mm. Seastars counted in swaths should be restricted to those species that are relatively large in size (e.g. *Pisaster ochraceus*, *Pycnopodia helianthoides*, *Patiria miniata*), although juveniles of these species should be counted in addition to the larger adults. Smaller species (e.g. *Leptasterias* spp., *Henrecia* spp.) will be captured in motile invertebrate quadrats. All abalone species should be counted.

X. Interstitial species of mussel beds

Many species live within mussel beds obscured from view. To quantify the abundance and species composition of this assemblage, remove mussels and collect all other species in three 25 x 25 cm patches in 5 oiled and 5 non-oiled areas at each site. Place the mussels in a bucket as they are removed. Quickly collect all other organisms left on the substrate and place them in a labeled Ziploc bag. Sort thru the remaining mussels and place any other organisms into the bag with the rest of the organisms.

XI. Rockweed Size Estimates

Rockweeds (fucoids): the length from the holdfast to the tip of the longest frond should be measured with a ruler or seamstress tape. Individuals within quadrats in the fucoid zone should comprise the sampling, and the number of individuals measured within each quadrat should be evenly distributed so that measurements are obtained from a large sampling of quadrats. Measure at least 50 individuals. If there are too few individuals (N<50) then sample additional quadrats within the appropriate zone. These additional quadrats should be selected to fill in half way between the original ones.

XII. Sub lethal Effects

The goal of such studies is to detect sub lethal effects that could ultimately affect populations or communities; hence attributes such as growth and reproductive output are particularly important. Species used should reflect either the ecological importance of the species, its susceptibility to oiling or logistical constraints (e.g. the ease of assessing growth or reproductive output). Here we focus on growth and recruitment because these most clearly affect recovery or documentation of injury within a site. Reproductive impairment, while potentially severe and documentable, may not be easily scaled since it is often not clear where the larvae of adults at a site ultimately go, and thus difficult to assess the consequences of any loss of reproductive output of individuals within a site. Organisms that release fully developed juveniles from egg cases or brooding females such as gastropods (Nucella), or amphipods or plants with non-motile spores (e.g.

fucoids) would be the best candidates for such work if it were desirable, though the consequences of such phenomena could be estimated by measuring recruitment (see below)

a. **Growth**

Notch mussels to quantify growth in oiled and non-oiled areas with each site and among sites using standard protocols. Briefly, use a file to notch the leading edge of the mussel (at the opposite end from the umbo) where new shell is formed. Notch at least 10 average-sized mussels in oiled areas and 10 in non-oiled areas at each oiled site and 20 individuals from unoiled sites. Notched mussels must be relocated after 1 year to measure the change in size. Only notch mussels in photoquadrats to help relocate photoquadrats, and only notch one mussel per photoquadrat to assess growth rates across each study site.

b. **Reproduction**

i. *Reproductive output.* Collect 10 average sized adults of each target species from oiled areas and 10 from non-oiled areas (crabs, mussels, barnacles) at oiled sites and 20 from non-oiled sites to determine reproductive output. For small crabs and barnacles count the number of embryos per individual. For large crabs, remove embryos from the females and place in a flask with a known volume of water (depends on the size of the broods). Aerate vigorously and count the number of embryos in 10 aliquots. Measure the widest part of the carapace for all crabs and the widest basal diameter for barnacles. For mussels measure the longest and widest dimensions of the shell and use the standard GSI protocols for mussels.

ii. *Developmental abnormalities*. Determine the percentage of reproductive abnormalities for each crab collected to determine reproductive output. Remove about embryos from the external portion of the brood, where they are most exposed to oil, and place them in a Bulgarov (plankton sorting) tray. Count the number of each type of abnormal embryo and classify the stage of development for the first 200 embryos observed. Eight types of abnormalities have been identified: arrested, asynchronous, grainy, white globules, abnormal eye, abnormal yolk, pink and opaque. The stage of development depends on the amount of yolk and formation of the embryo: early (largely yolk), mid (eyespots present) and late well developed embryo with a heartbeat). A link between abnormality type and oiling has not yet been established for species on this coast. In addition to finding expected correlations between the degree of oiling and abnormalities in oiled and non-oiled locations in the field, a bioassay could be conducted to solidify the link between oiling and the number and type of abnormalities.

c. Recruitment

Direct assessment of recruitment of targeted species is desirable, but often not feasible within the constraints of sampling. Recruitment of many species can be documented using photoplots by zooming in on images in the lab.

i. Recruitment into areas that were vacated by dead organisms is necessary for communities to recover from spills. Larvae may not recruit to oiled areas and bypass them for non-oiled areas slowing recovery rates. Monitoring larval recruitment onto passive collectors or cleared areas will estimate the number of recruits settling into oiled and non-oiled sites. There is along history of recruitment studies on barnacles and mussels, but it also can be done for algae.

ii. Take one photoquadrat (10 x 10 cm) in each of the 10 cleared areas of mussel beds per site (see interstitial surveys above) each time the site is revisited. Count the number of new barnacle and mussel recruits in each photo in the laboratory. Take care to mark the photoquadrat to ensure that the same area is photographed in return visits. This will enable recruitment to be measured over time. It also will enable the growth of barnacle and mussel recruits to be measured.

iii. Anchoring settlement plates immediately adjacent to clearances will provide a separate measurement of recruitment that is not affected by the presence of other individuals. Recruitment can either be limited as the space fills up or it can be facilitated by the presence of conspecifics; barnacles and mussels preferentially settle in the presence of conspecifics. Plates will be returned to the lab for counting using a dissecting microscope and clean plates will be deployed.

XIII. Chemical Analysis

Only HAZWOPER-trained personnel wearing Nitrile Gloves and Tyvek suits should handle oil or oil-contaminated materials to minimize oil contamination of personnel and clothing. It is likely that a SCAT team will collect samples of oil/tar in all segments potentially impacted by a spill, but these guidelines are included in case collection is necessary.

If your gloves become contaminated with oil, change them before collecting any further samples.

All samples should be labeled with the following information:

Sampler identification (name of sampler)
Date and time
Lat and Long coordinates (or common name of the beach)
GPS Way Point number

For mussel, kelp and other sample types contained in foil (and double Zip-Loc bagged), place the label in between the two bags. For oil/tar ball samples in glass jars, place the sticky label on the jar such that part of the label overlaps the lid, and then double wrap the label and lid with clear binding tape. If you don't have I-Chem labels that came with the jars, use white label tape (wrap it twice around the jar) write directly on the label tape before using the clear binding tape.

Record other ancillary information/data in your field notebook (including the GPS Way Point and Latitude and Longitude or other beach identifier/common name), and complete your agency-specific Chain-of-Custody form. On that form, indicate the sample type (oil, mussel, marsh grass, etc.), and mark the form requesting alkylated-PAH (sometimes referred to as Petroleum Fingerprinting) and Total Petroleum Hydrocarbons (TPH – usually obtained by flame ionization detector/gas chromatography FID/GC).

Oil and tar balls

Oil and tar balls can be collected with wooden tongue depressors (preferable since they are disposable) or pre-cleaned spatulas. Samples should be placed in chemically clean 2 oz jars (I-Chem[1]), labeled, sealed to ensure they are not further disturbed for Chain-of-Custody purposes and kept in a cooler out of the sun. If possible, a bag of ice should be placed in the cooler to help keep samples cold, but this is not critical.

1 If I-Chem jars are not available, unused 1-pint Mason Jars (available at any supermarket) may also be used.

Intertidal Sediments

Intertidal sediments can be collected using the same approach as described for oil and tar balls, except 4 oz I-Chem jars (again see Footnote 1) should be utilized to obtain a larger sample size (50-100 g are desired). If your cooperative group decides that sediment toxicity tests are desired, significantly larger quantities are required (2-3 kg) so several 1-liter I-Chem jars (or equivalent) will be needed for sample collection.

Mussels

Determining body burdens of chemicals that comprise the oil strengthens the link between oiling and measured biological responses at oiled and non-oiled sites. A minimum of 20 mussels (~3-8 cm) should be collected as a composite sample when available from a monolayer cluster of mussels. Photograph the collection area with an overview and close-up, record location with GPS, mark with epoxy and mark location on site map. The mussels can be picked by Nitrile-gloved hand directly off the rocky substrate (creosote treated pilings should be avoided). Place the mussels on solvent-rinsed aluminum foil (dull side) and thoroughly seal. Place aluminum foil wrapped mussels inside a Zip-Loc bag, and place that bag plus a sample label (use a Sharpie pen on water-proof paper) inside a second Zip-Loc bag. That is, the aluminum-foil wrapped mussels are double bagged with the sample label inside the outer bag. Attach evidence tape to each sample bag and label outside of each bag with sample ID using a sharpie. Samples should be stored cool in a cooler (see oil and tar balls protocol) until they are transferred to the sample custodians listed above.

Other Substrates

Larger samples of oiled beach wrack, oiled bird feathers, etc. can be handled by wrapping with solvent-rinsed aluminum foil and double-bagged using the mussel protocol. Snails, eelgrass, marsh grass, etc. can be placed inside glass jars. Samples should be stored on ice in a cooler (see oil and tar balls protocol) until they are transferred to the sample custodians listed above.

XIV. Post-Sampling Procedures

a. Download GPS track and waypoints daily, save a copy to CD, and send to spatial data team.

b. Download photoplot and site pan images daily. Save a complete copy of photos for the day on a CD **before viewing. Do not delete any photos and do not change the file names** assigned by the camera because they will be considered altered for legal proceedings, and the photos cannot be easily correlated with the GPS track log.

Appendix I: Equipment List

- ☐ Maps & Photos (e.g. Google Earth) of Segment Area with Segment ID's
- ☐ HAZWOPER Certification Card
- ☐ Permits
- ☐ List of relevant phone #s, emergency contacts, etc.
- ☐ I.D., business cards
- ☐ Site Directions
- ☐ Rocky Intertidal Sampling Protocol

Data Sheets (Print all on **Waterproof** Paper**):**

- ☐ Shoreline Assessment Form with instruction sheet
- ☐ Field Log/General Site Conditions
- ☐ Species Log
- ☐ Photo Log
- ☐ Photoplot Notes and Guidelines
- ☐ Motile Invertebrates
- ☐ Motile Invertebrates in Bay
- ☐ Seastar/Abalone Swaths
- ☐ Rockweed Size
- ☐ Mussel Tissue
- ☐ Chemical Analysis
- ☐ Blank Paper for Site Maps
- ☐ Chain of Custody Forms

Sampling Gear

- ☐ GPS
- ☐ 2 High resolution Digital Cameras
- ☐ Cell Phone
- ☐ Marine Epoxy
- ☐ Scraper (for cleaning rock for epoxy)
- ☐ Kneepads (4)
- ☐ Calipers (4)
- ☐ Rulers (2)
- ☐ Stopwatch
- ☐ Lumber Crayons (2)
- ☐ Flashlights (4)
- ☐ Headlamps (enough for each person to have 1)
- ☐ Spare Batteries (for camera, lights, & GPS)
- ☐ Compass
- ☐ Transect tapes: 50m (3-5)
- ☐ Transect tapes: 30m (up to 6)
- ☐ Transect tapes : 100m (1)
- ☐ Quadrats of grey PVC: 0.5m x 0.75m (3)
- ☐ Small PVC square or dry erase board (to use in photos)
- ☐ Dry Erase Marker
- ☐ Clipboards (4)
- ☐ Pencil – mechanical (5)
- ☐ Sharpie
- ☐ Rubber bands (for clipboards to keep data sheets from blowing
- ☐ Backpacks for gear (2)
- ☐ Baby oil (helps to get oil/tar off)
- ☐ Large Trash Bags (for contaminated clothes, foulies, boots, etc.)

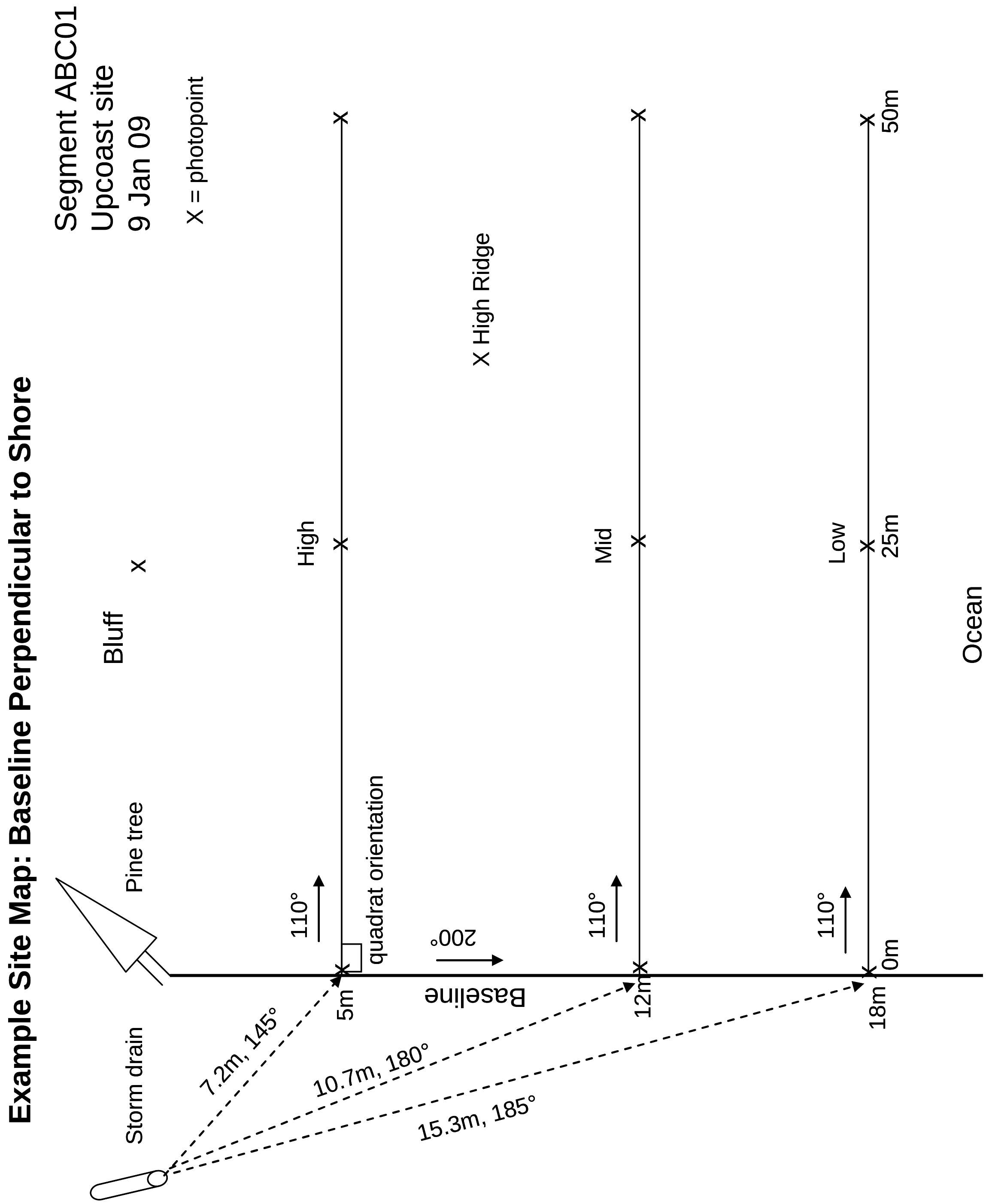
Chemical Analysis Collection Materials

- ☐ Nitrile gloves
- ☐ Aluminum foil: solvent-rinsed
- ☐ Ziploc bags: gallon-sized
- ☐ Soft-sided cooler: 14"x12"x7"
- ☐ Disposable instant ice bags or blue ice packs: 5"x7"
- ☐ Wooden sticks (for collecting oil/tar samples)
- ☐ Evidence Tape

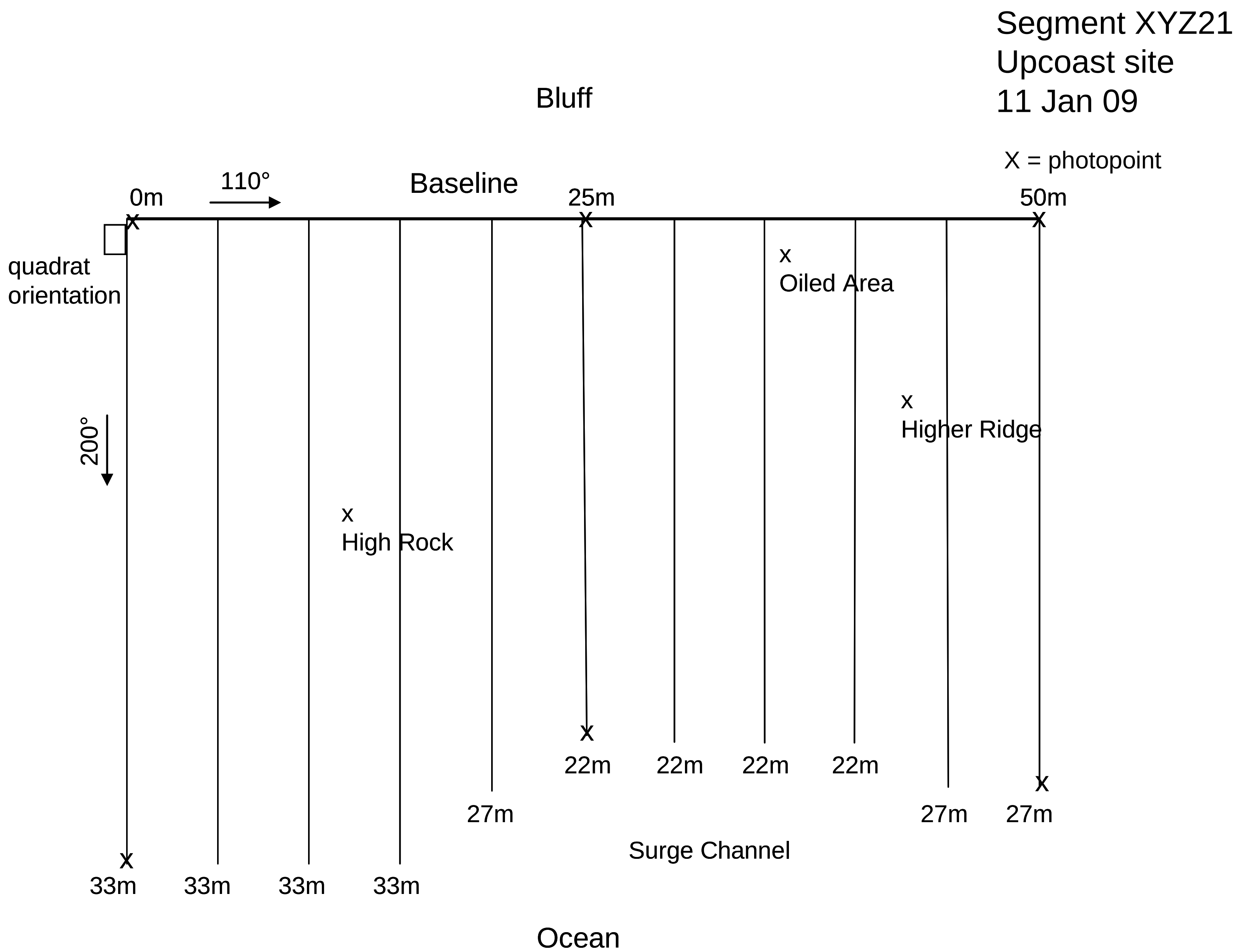
Personal Gear

- ☐ Foulies
- ☐ Boots
- ☐ Tyvek
- ☐ PFD's
- ☐ Hardhats
- ☐ Duct Tape
- ☐ Watch (for generating random #s)

Appendix II: Sample Site Maps



Example Site Map: Baseline Parallel to Shore



Appendix III: Datasheets

SHORELINE ASSESSMENT FORM for ____________________________ Spill Page ___ of ___

1. GENERAL INFORMATION	Date (dd/mm/yy)	Time (24h standard/daylight)	Tide Height
Segment ID:			L/M/H
Segment Name:		hrs to hrs	H/M/L
Survey By: Foot / Boat / Helicopter / Overlook /_______		Sun / Clouds / Fog / Rain / Snow / Windy	

2. SURVEY TEAM No. ___ Name	Organization	Phone Number

3. SEGMENT Total Length ______m/yd Length Surveyed ______m/yd Differential GPS Yes/No

Start GPS: LAT ___________ deg. ___________ min LONG ___________ deg. ___________ min

End GPS: LAT ___________ deg. ___________ min LONG ___________ deg. ___________ min

4. SHORELINE TYPE Select only ONE Primary (P) and ANY Secondary (S) types present

	Rocky Cliffs		Riprap
	Exposed Man-made Structures		Exposed Tidal Flats
	Wave-cut Platforms		Sheltered Rocky Shores
	Fine-Medium grained Sand Beaches		Sheltered Man-made Structures
	Coarse-grained Sand Beaches		Sheltered Tidal Flats
	Mixed Sand and Gravel Beaches		Wetlands
	Gravel Beaches		Other ______________________________

5. OPERATIONAL FEATURES Oiled Debris? Yes / No Type___________ Amount________bags

Direct backshore access? Yes / No Access restrictions ____

Alongshore access from next segment? Yes / No Suitable backshore staging? Yes / No

6. SURFACE OILING CONDITIONS Begin with "A" in the lowest tidal zone

Zone ID	Tidal Zone				Oil Cover Length	Oil Cover Width	Oil Cover Distr.	Oil Thickness					Oil Character						
	LI	MI	UI	SU	m /ft	m /ft	%	PO	CV	CT	ST	FL	FR	MS	TB	TC	SR	AP	No

7. SUBSURFACE OILING CONDITIONS Use letter of Zone location plus Number of trench, e.g., "A1"

Trench No.	Tidal Zone				Trench Depth	Oiled Interval	Subsurface Oil Character						Water Table	Sheen Color	Clean Below?
	LI	MI	UI	SU	cm / in	cm-cm/in-in	OP	PP	OR	OF	TR	No	cm / in	B,R,S,N	Yes/No

8. COMMENTS **Cleanup Recommendations; Ecological/Recreational/Cultural Issues/Wildlife Obs.**

Sketch: Yes / No Photos: Yes / No (Roll#_____Frames_____) Video Tape: Yes / No (Tape#______)

August 2000

Calibration IS VERY IMPORTANT! Do a calibration exercise to make sure that all teams are consistently using the same terminology and estimations.

Units: Use either metric (m, cm) or English (yd, ft, in). Circle the units used.

Tide Height: Circle the two letters indicating the progression of the tidal stage during the survey.

Segment/Survey Length: Always record both lengths on the first survey, especially where the SCAT team creates the segments in the field. On repeat surveys, always enter in the Survey Length, especially if only part of the segment is surveyed.

Start/End GPS: Use of decimal degrees is preferred, but be consistent among teams.

SURFACE OILING CONDITIONS

Zone ID: Use a different ID for each different oil occurrence, e.g., two distinct bands of oil at mid-tide and high-tide levels, or alongshore where the oil distribution changes from 10 % to 50%. Describe each different occurrence on a separate line.

Tidal Zone: Use the codes to indicate the location of the oil being described, as in the lower (LI), mid (MI), or upper (UI) intertidal zone, or in the supra (SU) tidal zone (above the normal high tide level).

Distribution: Enter the estimated percent of oil on the surface, or codes for the following intervals:

C	Continuous	91-100% cover
B	Broken	51-90%
P	Patchy	11-50%
S	Sporadic	<1-10%
T	Trace	<1%

Surface Oiling Descriptors - Thickness: Use the following codes:

PO	Pooled Oil (fresh oil or mousse > 1 cm thick)
CV	Cover (oil or mousse from >0.1 cm to <1 cm on any surface)
CT	Coat (visible oil <0.1 cm, which can be scraped off with fingernail)
ST	Stain (visible oil, which cannot be scraped off with fingernail)
FL	Film (transparent or iridescent sheen or oily film)

Surface Oiling Descriptors - Type

FR	Fresh Oil (unweathered, liquid oil)
MS	Mousse (emulsified oil occurring over broad areas)
TB	Tarballs (discrete accumulations of oil <10 cm in diameter)
TC	Tar (highly weathered oil, of tarry, nearly solid consistency)
SR	Surface Oil Residue (non-cohesive, oiled surface sediments)
AP	Asphalt Pavements (cohesive, heavily oiled surface sediments)
No	No oil (no evidence of any type of oil)

SUBSURFACE OILING CONDITIONS

Oiled Interval: Measure the depths (from the sediment surface) to top / bottom of subsurface oiled) layer. Enter multiple oil layers on separate lines.

Subsurface Oiling Descriptors: Use the following codes:

OP	Oil-Filled Pores (pore spaces are completely filled with oil)
PP	Partially Filled Pores (the oil does not flow out of the sediments when disturbed)
OR	Oil Residue (sediments are visibly oiled with black / brown coat or cover on the clasts, but little or no accumulation of oil within the pore spaces)
OF	Oil Film (sediments are lightly oiled with an oil film, or stain on the clasts)
TR	Trace (discontinuous film or spots of oil, or an odor or tackiness)

Sheen Color: Describe sheen on the water table as brown (B), rainbow (R), silver (S), or none (N).

Tier II Rocky Intertidal Study Field Log

(Fill in all blanks.: **----**=No Data; **0**=None: **L**=Low; **M**=Med; **H**=High; or Actual Value)

Site:_____________________ Date:________ Time:_____ to _____ Low Tide:_____(ft) at _____(hr)
Participants (Recorder 1st):____

____

Weather and Sea Conditions (affecting quality of sampling)(use codes listed above)
Swell/Surge:________ Wind:________ Rain:_______ Recent Rain:_______ Water Temp (°C):_______
Substratum Changes (sediment=sand, gravel, cobble) (magnitude at site)
Sediment Level:_______ Scour:_______ Rock Movement:_______
Debris and Pollutants (magnitude at site):
Plant Wrack:_____ Driftwood:_____ Shells:______ Dead Animals:______ Trash:______ Oil/Tar:_____
Notes on Physical Conditions:____

____
____
____
____
____

Birds and Mammals (maximum # seen at any one time during the sampling)(see bird/mammal list for other species)

Pelican	Great Egret			CA Sea Lion
Cormorant	Snowy Egret			Harbor Seal
Gull	Lg Shorebird			Elephant Seal
Tern	Sm Shorebird			Sea Otter
Oystercatcher	Other Birds			Dog
Blue Heron				

Bird/Mammal Notes:____

____

Humans (maximum # seen at any one time during the sampling; note behavior) Reef:________ Sand:________

____

Plot Marker Loss/Repair Notes:____

____
____

Latitude and Longitude :____

____

Other Notes:____

____
____
____
____
____
____
____
____
____
____
____
____
____

Survey Checklist

Fucus:___ **Point Contacts**___ Parallel Transect ___ Perpendicular Transects:___
Mobile invert counts:___ High:__ Mid:__ Low:__ **Crab search**:___ Time-Search:___ Area-Search:___
Seastar Search:___ Time-Search___ Area search:___
GPS:___ Photos:__ Tracking:__ **Mussel Collection**:___

Tier II Rocky Intertidal Field Study Field Log Definitions

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.
None (0): None were found within the defined site boundaries.
Low (L): Relatively few or low levels were found within the defined site boundaries.
Med (M): Medium numbers or moderate levels were found within the defined site boundaries.
High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions (emphasis on those affecting quality of sampling)

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.
Wind: L = ≤10 knots M = 11-20 knots H => 20 knots
Rain: L/M/H relative amounts of precipitation at the site during the survey.
Recent Rain: Evidence or knowledge of L/M/H amounts of rain at the site within the past few days.
Water Temp: Actual seawater temperature (°C) or L = ≤14°C (57°F) M = 15-18°C H = >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.
Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.
Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.
Driftwood: L/M/H levels of sticks, branches, and logs within the site.
Shells: L/M/H levels of dead shells, especially mussel shells.
Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.
Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.
Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Birds and Mammals

Core categories are listed and must be scored. Record maximum number seen at any one time during the sampling, preferably upon arrival at site. Other more specific categories or species may be added, but must define linkage to core taxa. Only score species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Humans

Record maximum number of people seen at any one time during the sampling. Especially check at low tide. Separate counts for people on rock and on sand. Note relevant behaviors. Note also if people present upcoast or downcoast of the site.

Plot Marker Loss/Repair, Other Notes, and Survey Checklist

These are optional categories. Information may or may not be added to the database as text entries.

Intertidal Habitat Species Log

Team Leader___________________ Recorder_____________________
Sampler_________________

GENERAL INFORMATION	Date (dd/mm/yy)	Time (24h standard/daylight) :	Tide Height:
Segment ID			L/M/H
Segment Name		hrs to hrs	H/M/L
GPS Location	LAT _________________________ LONG _________________________		
Pan Photograph taken	______yes _____no		

Appearance (ND=No Data √=Healthy **F**=Fertile/Flowers **B**=Bleached **D**=Damaged:
L=Low level **M**=Med level **H**=High level)

Species	Common Name	Appearance	Notes
ALGAE/PLANTS			
Cladophora columbiana			
Ulva/Enteromorpha	Sea lettuce		
Egregia menziesii			
Eisenia arborea	Feather boa kelp		
Endarachne/Petalonia			
Fucus gardneri	Northern rockweed		
Halidrys dioica/Cystoseira spp.			
Hesperophycus californicus	Olive rockweed		
Laminaria spp			
Pelvetiopsis limitata	Dwarf rockweed		
Sargassum muticum			
Scytosiphon spp.			
Silvetia compressa	Golden rockweed		
Endocladia muricata	Turfweed		
Chondracanthus canaliculatus			
Mastocarpus papillatus	Turkish washcloth		
Mazzaella affinis			
Mazzaella spp.(= Iridaea spp.)	Iridescent weed		
Porphyra sp.			
Phyllospadix scouleri	Flat and wide (2-4mm) leafs		
Phyllospadix/torreyi	Cylindrical and wiry leafs		
INVERTEBRATES			
Anthopleura elegantissima/sola	Green anemone		
Phragmatopoma californica	Honeycomb tube worm		
Mytilus californianus and galloprovenciallis	California mussel		
Littorina spp	Periwinkle		
Limpets			
Haliotis cracherodii	Black abalone		
Tegula spp	Snail		
Chthamalus spp/Balanus spp			
Tetraclita rubescens	Pink barnacle		
Pollicipes polymerus	Gooseneck barnacle		
Pisaster ochraceus	Ochre seastar		
Asterina miniata	Bat star		
Strongylocentrotus purpuratus	Purple sea urchin		
Hemigrapsus spp			
Pachygrapsis crassipes	Striped shore crab		
Pagurus spp.	Hermit crabs		
Ligia occidentalis	Rock louse		

1.2b Rocky Intertidal Habitat Species Log PAGE 2

Appearance (ND=No Data √=Healthy **F**=Fertile/Flowers **B**=Bleached **D**=Damaged:
L=Low level **M**=Med level **H**=High level)

Species	Common Name	Appearance	Notes

Rocky Intertidal Photo Log

Site: ______________________ Camera: ______________ Date ______________

Sampler ______________________ Recorder ______________________

Photo#	Plot/Area Photographed	Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
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49		
50		

Rocky Intertidal Photo Log

Site: ______________________ Camera: ______________ Date: ______________

Sampler: ______________________ Recorder: ______________________

Photo #	Plot/Area Photographed	Notes
51		
52		
53		
54		
55		
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97		
98		
99		
100		

Photoplot Data Sheet

Site______________________ Date________________ Target Assemblage___________________ Photographer_________________

Observer________________________________ Photo #s:___________

1 **2** **3**

4 **5**

<u>Algal Species:</u>

FG=Fucus	**HE**=Hesperophycus	**SI**=Silvetia
PL=Pelvetiopsis	**EM=**Egregia	**SC**=Scytosiphon
AN=Analipus	**CP**=Colpomenia	**HS**=Hedophyllum
OB=other brown	**EP**=Endarachne/Petalonia	
UE=Ulva/Entero.	**CL**=Cladophora	**OG**=other green
EN=Endocladia	**MP**=Mastocarpus pap	**MZ**=Mazzaella aff.
MS=Mazzaella spp	**CO**=Chondrocanthus can.	**GE**=Gelidium
PS=Porphyra	**CW**=Cryptosiphonia woodii	**NE**=Neorhodomela
OR=other red	**AC**=articulated corallines	**CC**=coralline crust
PY=Phyllospadix	**NC**=non-coralline crusts	

<u>Invertebrate Species:</u>

AE=Anthopleura	**MY**=Mytilus	**SP**=Septifer
CB=Chthamalus/Bal	**T**=Tetraclita	**SB**=Semibalanus
PO=Pollicipes	**PI**=Pisaster	**PH**=Phragmatopoma
LG=L. gigantea	**LI**=limpets	**CI**=chitons
TF=Tegula	**LT=**Littorine	**OI**=other inverts

<u>Other:</u>

R =Rock	**S** =Sand	**TR** = Tar

** Estimate % cover for species difficult to distinguish (e.g. Mastocarpus papillatus & Mazzaella affinis)

UCSC 5/30/03

Mobile invertebrates for northern MARINE sites

Plot Type:________________________ Site:__________________________

Counter:_________________________ Date:_________________________

	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5
Species counted in whole plot (can be sub-sampled if abundant)* For hermits, I.D. 1st 10 & multiply % by total.					
Lepidochitona hartwegii					
Nuttalina spp.					
Mopalia spp.					
Lepidochitona dentiens					
Pachygrapsus crassipes					
Pagurus samuelis					
Pagurus hirsutiusculus					
Pagurus granosimanus					
Ocenebra circumtexta					
Large limpets (>15mm) (excluding L. gigantea)					

Species counted and measured (1st 10 encountered only) in whole plot (can be sub-sampled if abundant)*

	#	sizes	#	sizes	#	sizes	#	sizes	#	sizes
Nucella emarginata										
Nucella canaliculata										
Acanthina spp.										
Tegula funebralis										
Lottia gigantea										

Species sub-sampled in 3 20x20cm quadrats placed in UL, middle & LR of plot** Count limpets on rock (R) and mussels (M) separately.

	R	M	R	M	R	M	R	M	R	M
limpet < 5mm										
limpet 5-15 mm										

Sample in 10x10 cm section of 20x20 cm quadrat**

Littorina spp.															

Additional Species (count if present)

Tegula brunnea
Tegula gallina
Amphissa versicolor
Epitonium tinctum
Ceratostoma nuttalli
Haliotis cracherodii***
Haliotis fulgens
Pisaster ochraceus***
Pisaster giganteus
Patiria miniata
Leptasterias hexactis
S. purpuratus
S. franciscanus
Mexacanthina lugubris
Stenoplax spp.
Tonicella lineata
Lepidochitona spp.
Lepidozona spp.
Fissurella volcano

***include measurement

* If plots are sub-sampled, multiply # out and record count for whole plot.

** Do not multiply # out for these spp., just note sub-sampled area if different from that listed so #s can be converted in lab.

Mobile Invertebrate counts: In-Bay

Site: ______________________

Date: ______________________

Name: ______________________

Oil Level (choose one): 0, L (low), M (med.), H (high)

Zone (choose one): L, M, H

Transect:						
Zone:						
Oil Level:						
Tegula funebralis						
Pagurus Spp.						
Pachygrapsis crassipes						
Lottia gigantea						
Large Limpet (>5mm)						
Med. Limpet (5-15mm)*						
Small Limpet (<5mm)*						
Littorines*						

*sub-sample in top-left square of quadrat if abundant.

Wrtie in other species present (e.g. Cancer spp., Chitons, etc.)

Other Notes:

Seastar & Abalone Data Sheet **Coastal Biodiversity Survey** **SWAT**

DATE **SITE** **SAMPLER**

***record # and code for other species (halcra, halruf, pisgig, pychel,astmin, henspp, derimb)

Transect #		**Transect #**		**Transect #**	
Location	# pisoch ***	Location	# pisoch ***	Location	# pisoch ***

DFG REQUEST FOR ANALYSIS AND CHAIN OF CUSTODY RECORD

Page_____ of _____

Sampler Ph #	Send Results To	Lab Number
Address	Address	Field Number
City Zip CA	City Zip CA	Lab Storage
	Copies To	Spill Title
Date Required/Reason	Address	Suspect
Shipped Via	City Zip	Index-PCA

☐ Fish & Wildlife Loss · Date:__________ Region:__________

☐ DFG Code Violation:____________________

☐ Suspected or Potential Problem

☐ Routine Analysis

Analysis Requested >>>

Water Temp: F or C pH: DO: mg/L Conductivity: u mhos/cm

Sample Identification/Location (Draw map on separate sheet if necessary)	Collection		Petroleum Fingerprint	Trace Elements (Specify Below)	Pesticides (Specify Below)						Petroleum	Sample Type				Number of Containers				Preservation		
	Date	Time										Water	Filtered Water	Soil	Tissue	Plastic	Glass	VOA Vial		Temp	Acid	

Problem Description

Suspect/Incident Location

Comments/Special Instructions

Pollution Action Kit: Yes☐ No☐

Glove Size: Large ☐ Medium ☐

Hazmat Shipper Requested: Yes☐ No☐

Samples Reliquished By (Signature)	Print Name	Date	Received By (Signature)	Print Name	Date

☐ *Pesticide Investigations Lab*
1701 Nimbus Road
Rancho Cordova, CA 95670

X *Petroleum Chemistry Lab*
1995 Nimbus Road
Rancho Cordova, CA 95670

☐ *Water Pollution Control Lab*
2005 Nimbus Road
Rancho Cordova, CA 95670

LAB COPIES: WHITE, CANARY, PINK SUBMITTER: GOLDENROD FG 1000 (Rev. 9/01)

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Mussel Label

Sample ID____________
Date: ___________ Time: __________
Segment ID___________________________
Segment Name________________________
Spill Name: __________________________
Team Leader__________________________
Recorder_____________________________
Sampler______________________________
Analysis (Check): PAH____ Oil Fingerprint____
Species_________________________
Number of mussels_______ Photo #s_________
GPS location: LAT___________________
LONG_____________________

Appendix 3: Long term monitoring protocals

Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network

(November 2008)

John M. Engle

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network

(November 2008)

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Santa Barbara, CA 93106

Prepared under MMS Cooperative Agreement No. 14-35-0001-30761
Marine Science Institute
University of California
Santa Barbara, CA 93106

U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region
Camarillo, California

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1. INTRODUCTION

1.1 Multi-Agency Rocky Intertidal Network Monitoring Program Background

Periodic monitoring of the condition and dynamics of rocky shore marine life is critical for detecting and understanding community dynamics in order to develop management measures to anticipate and reduce acute or chronic environmental impacts. **Goals of long-term rocky intertidal monitoring include the following:**

- Maintain an historical perspective of important resources.
- Document the effects of long-term climatic changes.
- Enhance understanding of the extent of temporal variation in natural systems.
- Determine compliance with standards or regulations.
- Provide an early warning of abnormal conditions.
- Help assess and reduce environmental impacts.
- Identify trends that may reflect cumulative impacts.
- Guide development and evaluation of impact mitigation measures.
- Provide information to assist in natural resource damage assessments.

The Bureau of Land Management (BLM) (now the Minerals Management Service (MMS)) funded detailed rocky intertidal monitoring at 22 sites in southern California over a 3-4 year period in the mid to late 1970's (Littler 1977, 1978, 1979). However, costs for these intensive surveys precluded their long-term continuation. Channel Islands National Park (CINP) was created in 1980, with a mandate to inventory and monitor biological resources. As a result, they developed a permanent, cost-effective rocky shore monitoring program based on semi-annual surveys of target species assemblages in fixed plots or transects. This innovative program was expanded to the Cabrillo National Monument (Point Loma, San Diego) in 1990. In 1992, as a result of regulatory responsibilities and an increased public concern for oil spills after the EXXON VALDEZ spill in Alaska, MMS funded rocky intertidal monitoring sites in Santa Barbara County, with protocols modeled after the CINP methodology. The use of this core target-species/fixed-plot protocol was expanded to Ventura and Los Angeles Counties as well as Santa Cruz and Santa Catalina Islands (by the California Coastal Commission and Santa Barbara County) in 1994, to San Luis Obispo County (by MMS) and San Diego County (by the U.S. Navy) in 1995, and to Orange County (by MMS) in 1996.

With over 50 sites in central and southern California monitored by various institutions using similar, but slightly varying protocols, it became apparent that a more structured organization was needed for efficient, cooperative operation. The Multi-Agency Rocky Intertidal Network (MARINe) was created as a result of a workshop held at the University of California Santa Barbara (UCSB) in 1997 (Dunaway et al. 1997, Engle et al. 1997).

Objectives of MARINe include the following:

- Increase reliability, efficiency and cost-effectiveness of programs.
- Increase cooperation and communication among agencies and organizations.

- Enhance long-term support to ensure continuity of sampling.
- Provide opportunity for identification and rectification of data gaps.
- Allow more timely access to standardized data by all users.
- Integrate information for efficient analysis, synthesis and reporting.
- Permit evaluation of large-scale spatial and temporal patterns.
- Facilitate periodic review of ability of monitoring to achieve goals.
- Expedite linkages to other relevant programs.
- Enhance public outreach and interpretation programs.
- Assist in designing and critiquing restoration programs for impacted resources.
- Aid in framing research questions regarding cause and effect relationships.
- Increase public awareness of knowledge-based environmental management.
- Provide a cadre of trained biologists capable of rapid response to impacts.

The geographical area for MARINe ranged from San Luis Obispo County to San Diego County, including the Channel Islands. From 1999-2004, additional monitoring sites using the same core protocol were established north of San Luis Obispo County, primarily by the monitoring team from UC Santa Cruz, with funding from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), the Monterey Bay National Marine Sanctuary, and other organizations. MARINe was expanded to include northern California in 2005, Oregon in 2006 and Washington State in 2008. **Currently MARINe includes 98 core monitoring locations in California and Oregon, with 8 sites soon to be established in Washington State. (Table 1).**

MARINe is composed of partner organizations (Table 2) and monitoring groups (Table 3) that are directed by a Steering Committee, Science Panel, and Data Panel. The **MARINE Steering committee is made up of representatives of agencies and organizations committing resources to quantifying the health of rocky shore marine life and involved in joint assessment of intertidal monitoring data.** Major functions of the Steering Committee include ensuring long-term support of intertidal monitoring and providing oversight of the Science and Data Panels to make sure the goals of the Network are met. **Network goals include the following:**

- To support continuous long-term monitoring of rocky intertidal communities.
- To maximize coordination and communication among sponsoring groups.
- To increase access to the data collected for all users.
- To integrate intertidal surveys with other research efforts.
- To address questions that cannot be answered by individual projects.

1.2 Handbook Purpose

The purpose of this Handbook is to codify a standard set of core monitoring (target species/fixed plot) procedures for use at all MARINe monitoring sites. These standard

procedures should not be modified without network agreement. Agreed-upon changes will be incorporated into periodic updates of the Handbook and communicated to all monitoring groups.

Monitoring groups can opt to add procedures beyond the base monitoring. These optional procedures can be included in the Handbook for communication to other monitoring groups so that if they choose to carry out the optional surveys, they can conform to the same procedures. Data from optional procedures is not necessarily incorporated into the MARINe database, unless the effort to do so is deemed worthwhile and sufficient funding is available. Motile invertebrate counts are an example of an optional protocol.

The Handbook not only describes current protocols, but also documents variants of MARINe survey protocols previously used by particular monitoring groups or at certain sites. This provides historical perspective that is useful for data analysis. Additional information on protocols can be found in monitoring group study plans and handbooks (Ambrose et al. 1992, Engle & Davis 200b, Engle et al. 1994a,b, Richards & Davis 1988, Richards & Lerma 2003), as well as in data reports (Ambrose et al. 1995a,b, Davis & Engle 1991, Engle 2000, 2001, 2002, Engle & Adams 2003, Engle & Davis 2000a,c, Engle & Farrar 1999, Engle et al. 1998a,b, 2001, Miner et al. 2005, Raimondi et al. 1999, Richards 1986, 1988, 1998, Richards & Lerma 2000, 2002).

The Handbook provides a sole source for the standardized protocols that can be incorporated into each monitoring group's site-specific field manual. Field manuals should include such information as directions to the site; a site description that includes the site size, boundaries, and GPS coordinates; site maps showing prominent features and plot locations; print photos of plot locations; site safety considerations, and useful notes to efficiently locate and consistently sample the plots. **A supplement to this Handbook "Site Information for the Multi-Agency Rocky Intertidal Network" (Engle 2008) provides site and plot location information in case an oil spill or other circumstances require surveys by MARINe members who do not typically monitor the sites.** Information from the Supplement also is provided on the MARINe private website. Site-specific coordinates and sensitive species information should not be made available to the public to minimize collecting or other activities that may impact the sites.

The Unified Protocols Handbook also is designed to integrate with other MARINe information sources, including "Methods for Performing Monitoring, Impact, and Ecological Studies on Rocky Shores" (Murray et al. 2002), "MARINe Database User Guide" (Miner et al. 2007), and MARINe public and private websites.

2. TARGET SPECIES ASSEMBLAGE MONITORING SURVEYS

2.1 Monitoring Sites

Long-term MARINe monitoring sites have been established at representative rocky intertidal reefs along the U.S. West Coast and Channel Islands based on monitoring objectives and available funding. Criteria utilized for specific site selection include the following:

- Areas representing the geographic range of the California coastline.
- Areas representing major ecological communities along the California shoreline.

• *Biology*: emphasis on community differences north and south of major biogeographic change areas, such as Pt. Conception.

• *Geology*: with respect to rock type, size, slope, and topography (relief, rugosity, etc.).

• *Oceanography*: with respect to water temperature, wave exposure, currents, and nutrients (upwelling).

• *Meteorology*: with respect to air temperature, sun exposure, wind, and rain.

- Areas previously surveyed or monitored that provide historical data.
- Previously un-surveyed areas representing major data gaps.
- Areas of special human interest

• Areas of concern with regard to human impacts, especially those vulnerable and/or sensitive to oil spills.

• Areas with relatively pristine habitats.

• Areas containing unique habitats or species.

• Areas designated for protection by governmental agencies.

• Areas with concentrations of sport or commercial species.

• Areas visited for recreational, educational, or scientific purposes.

- Areas with optimum conditions for long-term monitoring.

• With sufficient abundances of the key species chosen for monitoring.

• With reasonable and safe access by road or by hiking.

• With moderate protection from waves so the intertidal zone can be worked safely at low tides.

• With adequate stable rock surfaces for establishing permanent plots.

• Without major sand or gravel scour, periodic sand burial, or other regular catastrophic disturbances.

Current MARINe sites are listed in Table 1, including County, year established, and protected are designation(s). Information about specific site locations (e.g., directions, GPS coordinates, site maps) can be found in the Supplement to this Handbook (Engle 2008) and on the MARINe Private Website. It is **MARINe policy not to provide site location details to the public to minimize possible interest in collecting species at these areas.**

2.2 Sampling Design: Target Species Assemblage/Fixed Plot Methodology

2.2.1 Target, Core, and Optional Species

Target Species: "Target" species (also called key or indicator species) are **species or species groups specifically chosen for long-term monitoring.** They dominate particular zones or biotic assemblages in rocky intertidal habitats. The **criteria for selecting target species include the following:**

- Species ecologically important in structuring intertidal communities.
  - Species that are competitive dominants or major predators.
  - Species that are abundant, conspicuous or large.
  - Species whose presence provides numerous microhabitats for other organisms.
  - Species that are slow growing and long-lived.
- Species that have interesting distributions along California coasts.
  - Species found throughout California shores.
  - Species characteristic of discrete intertidal heights.
  - Species that are rare, unique, or found only in a particular intertidal habitat.
  - Species approaching their biogeographic limits in California.
- Species that have been well studied, with extensive literature available.
- Species of special human interest.
  - Species vulnerable and/or sensitive to human impacts, especially from oil spills.
  - Species with special legal status.
  - Introduced or invasive species.
  - Species harvested by sport or commercial activities.
- Practical species for long-term monitoring.
  - Readily identifiable species.
  - Sessile or sedentary species of reasonable size.
  - Non-cryptic species.
  - Species located high enough in the intertidal to permit sufficient time to sample.

Currently, there are **18 designated target species**: *Egregia menziezii, Fucus gardneri, Hedophyllum sessile, Hesperophycus californicus, Pelvetiopsis limitata, Silvetia compressa, Endocladia muricata, Neorhodomela larix, Phyllospadix scouleri/torreyi, Anthopleura elegantissima/sola, Mytilus californianus, Lottia gigantea, Haliotis cracherodii, Chthamalus dalli/fissus/Balanus glandula, Semibalanus cariosus, Tetraclita rubescens, Pollicipes polymerus,* and *Pisaster ochraceus* (Table 4). Other species or species groups "targeted" by some monitoring groups include: *Mastocarpus papillatus*, *Mazzaella* spp (=*Iridaea* spp), *Postelsia palmaeformis*, Red Algae (includes plots targeting *Gelidium spp* and "red algae", and transects targeting "turf"), *Balanus glandula* (separated from *Chthamalus fissus/dalli*), Tar, and Recovery. **Designated target species have the highest priority for monitoring. They are monitored at as many sites as possible**. If the species is present in sufficient numbers and it is logistically possible, plots or transects are established to monitor it every fall and spring in MARINe South or annually (in summer) above San Francisco in MARINe North. Anywhere from 1 to many target assemblages are monitored at a given site. More information on target species (e.g., photos and how to identify) can be found on the MARINe public website.

Core Species: "Core" species are those **species, species groups, or substrates that are scored using one or more survey methods by everyone in MARINe**. Core species must be reasonably and consistently identifiable using the designated scoring protocol (e.g., from lab-scored photos of fixed plots possibly supplemented by plot sketches/notes). They also must be important enough to warrant scoring for abundance trends. Some of these species only occur at northern sites, or conversely, southern sites, yet to ensure that we notice if they expand their range, we must score everywhere. Table 5 provides the official list of core species. All target species (shown in bold on the table) are core species. It is important that **scorers in all monitoring groups be able to identify and record all core species. Data sheets must include all core species**, though core species that are absent or rarely occur at a site can be de-emphasized. Entries for all core species will be required for data submission to the MARINe database. Definitions for core higher taxa and substrates are provided in Table 6.

Optional Species: "Optional" species are **non-core species or species groups that one or more monitoring groups choose to score at their sites; however, for various reasons, are not appropriate or feasible for all groups to score**. Since optional species will not be scored by everyone, regional comparisons of trends for these species will be limited or not possible. **Each monitoring group desiring to score optional species shall provide a list of these species to the MARINe data manager, along with mechanisms to translate optional species data to core species categories.** For example, if choosing to monitor *Codium fragile*, you would submit the optional species data which would be stored in the database as *Codium fragile*, but for standard regional comparisons of core species, would be lumped by the database to the next higher core species group "other green algae". **Choosing optional species requires a commitment to monitor the species consistently for a long period of time.** There is little value in scoring a species on an occasional basis (e.g., only when a particular person is available in the field to identify that species).

2.2.2 Fixed Plot Sampling Design

Background for Fixed Plot Sampling: Fixed plots are permanent areas of rocky intertidal habitat defined by epoxy or bolt markers. Fixed plots may be variable in size and shape, including square, rectangular (including band transects), circular, or even a one-dimensional transect line. The objective of MARINe core protocols is to monitor changes in abundances of target and core "species" within fixed plots over time (seasonal and annual). Fixed plots were chosen instead of randomly-located plots (in different locations for each sample) because intertidal assemblages are so heterogeneous that an impractically high number of replicate plots would be necessary to adequately detect temporal changes in species abundances in the midst of variability due to different plot placements for each sample season. Fixed plots reduce the high variability inherent in random plots and can be monitored easily and inexpensively; however, their dynamics cannot be extrapolated to larger areas without gathering additional larger-scale information. For in-depth discussion of the rationale and pros/cons of MARINe fixed plot sampling, see Ambrose et al. (1992, 1995b) and Murray et al. (2002).

MARINe Fixed Plot Types and Replicates: MARINe core fixed plot types include photoplots, point-intercept transects, circular plots, band transects, and irregular plots. The size and number of plots sampled with limited available effort is a compromise between gathering more detailed information about a limited segment of the resource versus sampling a wider range of resources (see Ambrose et al. (1992, 1995b), Drummond & Connell 2005, and Murray et al.

(2002). Tables 7-8 show the target species monitored (and # of replicate plots) at MARINe sites for each fixed plot methodology. Target species in these tables are listed as their 6-letter codes (see Table 4).

Photoplots: **Rectangular (50 x 75 cm; 0.375 m²)** photoplots are used to monitor the surface cover (top layer only) of relatively small, densely-spaced, sessile target and core species (Table 7). To minimize limited low-tide time in the field and provide a permanent visual record, these plots were designed to be photographed in the field, with photos scored in the lab. The plot size was designed to be the largest area that best utilized the rectangular 35 mm film frame, allowed a comfortable camera working height, and provided sufficient detail to identify target and core species. The MARINe standard is to monitor **5 replicate plots** per target species, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent photoplots and sufficient (relatively high) cover of the target species. Variations from photoplot size and number standards are noted in Table 7.

Point-Intercept Transects: Ten meter long point transects are used to monitor the cover of **surfgrass** (also red algal turf and boa kelp at a few locations) and associated core species (Table 8). These transects were designed to sample a larger area, by field-scoring what occurs under **100 points spaced at 10 cm intervals along a 10 m tape** stretched out between marker bolts. The MARINe standard is to monitor **3 replicate plots** per target species, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent transects and sufficient (relatively high) cover of the target species. Variations from point transect size and number standards are noted in Table 8.

Circular Plots: The number and size of **owl limpets** are monitored within permanent circular plots (**1 m radius, 3.14 m² area**), marked with a central bolt around which a 1 m long tape is circumscribed (Table 8). The size of the plot was designed to enclose enough owl limpets for size-frequency comparisons. The MARINe standard is to monitor **5 replicate plots** per site, placed in a stratified random manner throughout the owl limpet zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent circular plots and sufficient (relatively high) density of the target species. Variations from circular plot size and number standards are noted in Table 8.

Band Transects and Irregular Plots: The number and size of **ochre seastars and black abalone** are monitored within either band transects or irregular plots, the type and size of which is determined by what best encloses an area containing sufficient numbers of the target species for monitoring consistently (Table 8). The MARINe standard is to monitor **3 replicate plots** per site, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent band transects or irregular plots and sufficient (relatively high) density of the target species. Black abalone and ochre seastars are monitored in the same set of transects/plots at some sites. Variations from transect/plot size and number standards are shown in Table 8.

Plot/Transect Establishment Procedures: Permanent plots or transects are established during the initial set-up of a new monitoring site (or may be added to expand the surveys at an existing site). For maximum comparability among sites, **all of the MARINe target species that occur in sufficient abundances for adequate sampling should be monitored at each site** (except for those sites established for a particular species, such as black abalone). New sites should be chosen according to the desired criteria (see above), including filling in geographic coverage gaps and evaluating what target species are suitable for monitoring at the location. Site reconnaissance is necessary to evaluate suitability for monitoring, to decide which target species should be surveyed, and to determine possible locations for plots and transects. Gear recommended for setting up a site include quadrat frames, meter tapes, compasses, scrapers, wire brushes, portable hammer drill and drill bits, stainless steel bolts, marine epoxy (e.g., Z•SPAR A-788 Splash Zone Compound), and cameras.

Specific **plot/transect establishment procedures** may vary depending on the nature of the site and preferences of the monitoring group. The following are **recommended guidelines for standard practices** that can increase efficiency, enhance compatibility among MARINe sites, and ease data entry into the MARINe Database:

- **For each target species assemblage, identify all good plot/transect locations within its optimal zone** (area of high abundance), stratify the area of possible plots by differing physical conditions/locations, then randomly choose the desired number of plots/transects from each of the strata. For example, if 2 surfgrass areas (one twice as large as the other) occur at the site, identify all good transect locations within the 2 areas, then choose 2 transects randomly from the large area and 1 transect from the small area to establish the MARINe standard of 3 replicate transects per site. Using numerous quadrat frames or meter tapes as a guide helps in looking at the overall layout.

- When identifying good plot/transect locations, be aware that if setting up on an exceptionally low tide (or during unusually calm conditions) that **plots/transects established in the low intertidal may not be as accessible during future surveys**. Photoplots need to be relatively flat (though not necessarily horizontal) so that the entire plot falls within a similar focal plane, with minimal shadowing from crevices or projections. Also, remember that the plots/transects you set up are permanent, so consider ease of relocation and re-sampling during the setup. Plot markers, especially the primary plot marker, should be placed in prominent locations whenever possible. This is especially important in mussel beds to minimize disruption during plot establishment and to maximize ease of relocating plots.

- **The best plot markers are stainless steel hex bolts** epoxied into holes drilled into the rock. Bolt length and diameter depend on ease of rock drilling as well as bolt conspicuousness versus public safety (tripping hazard) and aesthetic considerations. If bolts eventually become overgrown, large bolts (e.g., 4-6 inch long, 3/8 inch dia) will be more easily found using a metal detector. If the rock is soft, use large, long bolts for best anchorage so they are not easily lost if the rock erodes or flakes away. In remote areas (few visitors) or in mussel beds (where mussels can overgrow bolts) have bolts project out from the rock surface to aid relocation. However, on public access reefs, bolts may need to be small or inconspicuous (even flush with the substrate), or use epoxy blobs instead of bolts (but relocation and maintenance efforts will be greater).

- To **install a plot marker**, clear an area of about 5 cm by 5 cm to bare rock using scrapers and wire brushes. For bolts, drill a central hole and epoxy the bolt firmly in the hole. For plain epoxy markers, press a blob of well-mixed epoxy onto the rock and form it into a smooth mound approximately 4-cm in diameter. Clean rock is important for good adhesion, but it does not have to be dry.

- **Plots should be marked in numerical order starting with #1 for each target species (ideally from upcoast to downcoast).** Notches cut into the top of each primary plot bolt to indicate plot number work well (e.g., 1 to 5 notches for the 5 replicate photoplots). However, careful mapping may be necessary to distinguish similar-numbered plots for each target species (e.g., to distinguish Plot #1 of mussels from Plot #1 of goose barnacles). For photoplots, a good standard is to put a bolt in all 4 corners, with the notched bolt in the upper left corner as you typically stand to take the photo (often with your back to the ocean). If the rock is hard to drill, you can omit the lower right bolt or if necessary, use epoxy instead of bolts for all but the upper left primary bolt corner. Wherever epoxy blobs are used, it is helpful to inscribe code letters (or the plot # if the primary plot marker) in the partially-cured blob to indicate marker location (e.g., "LR" for "Lower Right" photoplot corner. For transects, install the primary bolt at the upcoast end and mark the mid bolt and end bolt with standard marks to distinguish them ("/" or "no mark" for mid and "X" for end (cut across the bolt top) work well).

- After all plots and transects are set up, locate several representative locations (on prominent spots) to install large hex bolts (e.g., 6 inch long by ½ inch dia) that will serve as **reference markers for relocating plots in the future** (if necessary) **and for fixed photopoint monitoring** (see below). These reference bolts should be placed centrally to groups of plots/transects to facilitate measurements and to allow overview photo pans to include nearby plots/transects. The number of reference/photopoint bolts will depend on site size and plot/transect distributions. An abalone-only site may need only 1 reference, while a large site with multiple target species assemblages may need 5 references.

- Ideally 1-3 **permanent benchmarks** can be established along the upper shore at each site, such as the Bureau of Land Management (BLM) accomplished in 2002-2004 at 19 of the MMS-sponsored mainland sites (from San Luis Obispo County to Orange County) (see Section 3 of Site Information Handbook (Engle 2008)). The monuments are bronze tablets, with 2 inch diameter caps and 2 inch stems, epoxied into a ¾ inch drill hole, with a magnet set in the hole bottom. The caps are marked "BLM", with the monument name (e.g., CAY1) and the surveyed point in the center of a small circle at the center of the cap. The precise coordinates (Datum NAD83 (1998)) include height measurements accurate to 0.2 ft vertical.

Site Mapping: It is important to **document the site location as well as the specific location of all plots and transects**. This can be done through a combination of directions to site, GPS coordinates, inter-plot measurements, sketch maps, plot overview photos, and aerial photos.

<u>Site Directions</u>: Briefly record **how to get to the site** (by car, boat, or on foot) from the monitoring team institution or city/base station closest to the site. Include waypoint mileages and estimated time to reach site.

<u>GPS Coordinates</u>: Record at minimum, **3 principal GPS coordinates** for each site: First, **a single latitude/longitude coordinate pair that defines the location** - preferably close to the physical center of the site. Permanent marker locations, such as the BLM markers or our Reference markers are preferred, or use the location of a specific target species plot. Then, the **two coastal boundaries of the site (north/south or east/west) should be documented**, ideally centered between high and low tide zones, but they could be the positions of the northern- or western-most plot and the southern- or eastern-most plot. Use the most accurate GPS unit available. Be sure to document who took the reading and when, the specific location (e.g., BLM Ref 1, MARINe Ref 2, MYT Plot 5, PHY Transect 3 Center Bolt), the type of unit used and its

accuracy, and the datum used (preferably NAD83 or WGS84). If possible, **record latitudes/longitudes as degrees with decimal minutes and seconds** (otherwise the coordinates must be converted to this decimal format for database entry).

Inter-plot Measurements: These measurements are valuable for site mapping and to aid relocation of plots on future samplings. **Record at least 3 pairs of distance** (to nearest 0.01 m) **and bearing** (to nearest 5°) **measurements from primary plot/transect bolt (# bolt) to closest 3 other plot/transect primary bolts**, preferably running in different directions. Also measure distance and bearing to nearest reference bolt. Be sure to properly record “from” and “to” bolt #’s. Additional measurements should be taken for other bolts of transects, between the bolts of irregular plots, between reference bolts, and between upcoast and downcoast boundaries of the site (defined as upcoast-most plot to downcoast-most plot).

Sketch Maps: From as much of an overhead perspective as possible, sketch the prominent features of the site (e.g., pinnacles, ridges, pools, boulders), with approximate **plot/transect locations shown relative to each other and to the physical features**. Scale relationships on sketch maps can be improved by incorporating the inter-plot measurements in a second draft of the maps. Indicate with a dot the primary marker location for quadrats and transects. For large sites, separate maps can be prepared for different sub-areas. Maps can be scanned into digital format for labeling and other enhancements.

Plot/Transect Overview Photos: Take lots of site overview photos (with digital camera) with plot quadrat frames and transect meter tapes in position. Put orange cones on reference markers. Photos can range from **broad views of large portions of the site to individual overviews of each plot and transect**. For the latter, include the area around each plot/transect to document location relative to nearby features. Plan to make prints of the best photos, label the plot/transect numbers on the prints, and organize in photo sheets in a binder to take on future surveys to aid relocation efforts.

Aerial Site Photos: If possible, take aerial photos of the site during low tide, with plot quadrat frames and transect meter tapes in position. Put orange cones on reference markers. This may be accomplished easily if the site abuts a high cliff. Another possibility being tested is use of a relatively small camera-mounted blimp tethered to a person who pulls it over the site and triggers snapshots. **A good aerial photo could greatly improve the site map** (see above).

Criteria for Adding or Dropping Plots/Transects: Target species abundances might decline dramatically in one or more plots or transects, due to changes in the biological community (e.g., ecological changes or zone shifts) or due to substrate disturbance from storm swells (including rock breakouts and boulder movements). Depending on the severity and persistence of the loss, we may no longer be monitoring the target species (except for its paucity in the plots), even though it could still be present elsewhere at the site. The following are recommendations for how to deal with these types of situations:

- **Greatly reduced or total loss of target species cover within one or more plots or transects should not trigger a decision to stop monitoring these plots** (and the plot should continue to be named after the originally-targeted species even if a different species now dominates). Continued monitoring is important to confirm this major loss over time or perhaps document later recovery. **If the target species remains low/absent in its targeted plot(s) for an extended period of time (perhaps 3 years), but shows reasonable cover elsewhere at the site, plan to add new plot(s) in areas with good cover.** For example, if Rockweed Plots #1, #2, and

#5 lose all rockweed for 3 years (apparently due to a zone shift) and Plots #3 and #4 still have good rockweed cover, in the 4th year establish 3 additional plots (#6, #7, and #8) in areas with similar cover to Plots #3 and #4. From this point on, all 8 plots will be monitored. It is **important to keep the plot numbers consistent** so that one can choose to follow the original plots (#1-#5) through all time or switch after 3 years to follow the good cover plots (#3-4 and #6-8).

If large countable target species such as abalone or seastars become low in the targeted plots and throughout the site, continue monitoring the plots, but also **institute site-wide timed search** (see below) during each survey (like having the entire site as one plot). This situation occurred for black abalone monitoring at Channel Islands sites when withering syndrome caused mass mortalities (Richards & Davis 1993), with practically no recovery to date.

- The above plan also is recommended for **situations where one or more plots have been subject to physical disturbance** such as breakout of the rock surface or movement of a previously stable rock. Typically this results in major reductions in key species cover that may or may not recover over time. Disturbed plots should continue to be monitored to document recovery or lack of recovery over time (replace any missing markers). If the disturbance has substantially changed the microhabitat or tidal height zone such that it is unlikely that recovery of the key species will occur, then add a replacement plot (or plots) with similar cover of the target species to what the original plot would have had if the disturbance had not occurred (based on the remaining undisturbed plots).

Plot Marker Maintenance: **Bolt and epoxy markers need to be cleaned of fowling growth during each survey to aid relocation during the subsequent sampling**. This is especially important for sites sampled only once per year. Stiff plastic or wire brushes and old table knives work well for cleaning markers, taking care not to disturb the rest of the plot. Loose markers should be repaired with fresh epoxy and missing markers replaced. An easy way to note photoplot marker condition is to record it directly on the plot corners of the Photoplot Sketch Data Sheet (Form 3).

3. SURVEY PROTOCOLS

3.1 Field Log and Site Reconnaissance Protocol

During each site monitoring survey, it is important to complete a field log (i.e., who, what, when, where) as well as to observe and record general physical and biological conditions at the site. Additional site-wide categorization of target and other core species abundance, appearance, and recruitment is useful whenever time permits. These observations, along with the habitat overview photographs, **provide valuable perspective on site dynamics that aid interpretation of data from the fixed, plots and transects**.

3.1.1 Completing the Field Log and Conducting Site-Wide Reconnaissance

Core Procedure: Field log information and site reconnaissance characterization are recorded on the two-page field log data form (Form 1a,b,c: Prototype MARINe Rocky Intertidal Field Log). Field log **data that must be recorded (required by database) include site, date, survey time, low tide time and height, and names of survey participants.** Core physical data that should be recorded include weather and sea conditions (swell/surge, wind, rain, recent rain, and water temperature), substratum changes (sediment level, scour, rock movement), and debris/

pollutants presence (plant wrack, driftwood, shells, dead animals, trash, and oil/tar). Relevant biological features that should be recorded include site-wide presence of birds, marine mammals, or humans; and abundance, appearance, and recruitment of target species (primary emphasis) and other core species (secondary consideration). To facilitate standardization and data management, many data entries are restricted to specific category codes (e.g., low, med, high). These codes and other terms are defined in Form 1c. Any additional information can be written as notes. All **data entry blanks on the field log should be filled in with a code, actual value, notes, or a dashed line indicating "no data".**

Physical Conditions: Emphasis is placed on **conditions that could affect quality of sampling**. Some physical conditions recorded in previous years (e.g., cloud cover) were deemed not relevant because the site is visited only 2 days a year. Water temperature can be useful to compare with satellite sea surface temperature records or buoy/thermister data.

Birds and Mammals: Core categories are listed and should be scored. Record maximum number seen at any one time during the sampling, preferably upon arrival at site prior to sampler disturbance. Other more specific categories or species may be added; however, this requires specifying a core taxon for "lumping" the more specific entry during database entry unless the species/higher taxon has officially been designated as an "optional species" (see above for optional species discussion). For example, a bird recorded as "crow" would be lumped with "other birds" during database entry unless the monitoring group designated "crow' as an optional species. Only score species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Humans: Record **maximum number of people seen at any one time during the sampling**. Especially check at low tide. Separate counts for people on the site reef and on nearby sand beach. Note relevant behaviors.

Species Conditions: Give **highest priority to scoring target species**, particularly those monitored at the site. Core species should be scored if possible or indicate "no data". Other species can be added for scoring if desired; however, they will not be entered in the MARINe database unless they have been designated as "optional species" (see above). To score, **consider the site-wide condition of the species within its optimum zone(s).** It is not practical to score for turf or other non-discrete algae and most small invertebrates where determination would be too time-consuming.

Guidelines:

- On a descending tide, it may be practical to start the field log and site reconnaissance upon first arrival at the site because many observations can be recorded before the tide is low enough for performing other tasks. Additional notes can be added later during the monitoring, or even afterwards, when more time is available to organize thoughts or confer with others. The **reconnaissance may take 30-60 min by 1 person** (less time if 2 or more persons participate), depending on site layout and complexity. If time is short, jot notes on blank paper, then transcribe to the data sheet shortly after the survey.

- Useful things to note include: general appearance of algae and encrusting animals, damaged patches of reef, signs of disease, **changes observed since last visit**, absence of animals or algae that might occur at the site, whether anything was done different from the standard methods, and problems encountered with equipment or locating plots.

Variations from and Additions to Core Procedures:

- Plot Marker Loss/Repair and Other Notes: These are **optional categories** that provide for additional information as desired. For example, under plot markers, note any problems with lost markers or difficult to find plots, record any repairs completed or newly installed bolts or plots. Identify problems that need to be fixed on the next visit. This section does not need to be entered in database, but can be checked when planning the next sampling trip. Notes on physical and biological conditions will contain useful information that should be entered in the database (as text entries) if possible.

- Survey Checklist: The **optional** survey checklist is used by some monitoring groups (e.g., UCSB) to mark off procedures done at a site to ensure that all tasks were completed.

- Visitor and Bird Census: **CABR separately monitors visitors and birds** as follows: Whenever possible, the number of people and birds (by species or by 3 ecological categories: wading birds, shore birds, and sea birds) are counted in the 3 CABR sites within 30 min of the low tide on those days throughout the year when the low tide falls between 1000-1600 hrs and is < 0.5 ft above MLLW.

3.1.2 Managing Field Log and Site Reconnaissance Data

Data are recorded on two data sheets (Form 1a,b: Prototype **MARINe Rocky Intertidal Field Log**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, most data were not entered in any computer file. Now, **data are entered into the MARINe Microsoft Access database via a standardized data entry template** (see Bealer & Cooper 2003). This template requires field log information to be entered first, before other survey data can be entered. Field log and site reconnaissance data should be entered into the database entry template as soon as possible after the survey, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived.

3.2 Habitat Overview Photograph Protocol

As an adjunct to the fixed plot/transect sampling, **whenever possible, a habitat-level photographic record of the monitoring site should be made** during the seasonal survey to document larger-scale site conditions including habitat views of survey plots and transects, sand influence (beach level, scour or smothering effects), health of organisms (bleached plants, dead barnacles, etc.), interesting concentrations of species, recruitment events, extent of ephemeral algae, oil/tar presence and extent, evidence of people use and/or pollution, and any unusual phenomena. Periodic overview photos taken from the same viewpoint are particularly useful for putting individual permanent plots or transects into perspective with surrounding assemblages.

3.2.1 Photographing Habitats and Other Site Features

Core Procedure:

Fixed Photopoint Monitoring: Whenever possible, **sequential, overlapping habitat photos (approximately 5-10 m away) are taken (using either film or digital camera) while rotating the view area in a circular fashion from a fixed point marked with a bolt or epoxy**. Often the point is a reference bolt centered among a cluster of plots/transects (reference bolt also facilitates relocation of plot/transect markers via distance/bearing measurements (see above)). **Delineate all possible plots/transects that will appear in the view with quadrat frames or meter tapes (if conditions permit).** To ensure repeatability of view areas, specific procedures must be written for each photopoint, including horizontal start view, vertical view, and extent of angular pan. Pans typically begin facing north or some major feature, then proceed clockwise or counter clockwise to **encompass a half circle (180°)or full circle (360°)**, depending on the extent of intertidal habitat surrounding the photopoint. Full circle pans can be printed as 2 separate 180° pans.

Other Photographic Documentation: **Whenever possible, photograph plots and transects that are not in view from the fixed photopoints**. It is especially useful to include photos of owl limpet and abalone/seastar plots, and point-intercept transects since these are not photographed for sampling. Each plot/transect should be photographed from a standard (generally unmarked) view point whenever possible (e.g., transect overview photographed from 3 m upcoast of transect start end; owl limpet plot photographed from 5 m away perpendicular to the plot). In addition, repeatable or one-time **photos can be taken to document particular site conditions** such as reef damage, sand levels or scouring, plant/invertebrate appearance (e.g., bleaching or epiphytes), recruitment events, ephemeral conditions, oil/tar presence, pollution, people activities, and any unusual phenomena.

Guidelines:

- Photopoints should be indicated on site maps.

- Salt water and sea spray can ruin cameras. Protective cases should be used or the monitoring group must plan to replace the camera if/when the camera gets wet.

- The same digital camera used for photoplots also can be used for overview photos. Digital cameras provide immediate feedback on image quality and simplify the organization, storage, and analysis of photos. Panoramic photos can be stitched together using available software programs.

- **Repeatability of image view areas is greatly enhanced if you carry print sheets in the field (that show the sequence of standard photo images) to guide aiming the camera**.

- Try to **take photographs during times of lowest tide and best light conditions** (e.g., closest to midday or when overcast). Avoid shooting into the sun, especially when low tides occur in the late afternoon. Avoid including sky, ocean, and tidepools in the view if possible because bright sky and highly reflective water can wash out portions of the image while under-exposing shaded reef areas (creating silhouette effects).

- If necessary, a monopod can be used to stabilize the camera for panoramic sequences.

- Quadrat frames can be split into 2-sided frames if many plots need to be delineated.

Variations from and Additions to Core Procedures:

- Overview Video: Prior to 2002, overview videotape records (including observational narration) often were made at monitoring sites during the seasonal surveys using an 8 mm camcorder. These video recordings provided much of the same visual documentation as the current photo overviews. They consisted of an overview of the entire site if possible from one or more high cliff vantage points, beach level overviews of plots and surrounding habitats from fixed vantage points, and closer views of interesting phenomena. Complete procedures are described in Engle et al. (1994) and Engle and Davis (2000). The usefulness of video records for detecting population changes at the monitoring sites was evaluated by Rivas et al. (1997) and others within MARINe. Video advantages over film photos included in situ feedback on image quality, ease of recording extensive habitat areas, zooming features, and ability to add narration. However, disadvantages of video included coarse-grained images, susceptibility to flaring, and inconvenience of reviewing and analyzing videotapes. After extensive evaluation of video vs. film photo for habitat overview documentation, a switch was made to film photos in 2001/2002, primarily based on image quality and the ability to zoom in on high quality digital copies scanned from the film photo and stitch the scanned digital images together for panoramic views.

- Digital Photos: As the quality and affordability of digital cameras improved, they became an attractive alternative to film cameras. Digital cameras were tested in 2002 and approved for use by 2003. **By 2004, all monitoring groups were using digital cameras for field photography**.

3.2.2 Managing Habitat Overview Photographs

The same photo log is used as for photoplots (Form 2a,b: Prototype MARINe Rocky Intertidal Photo Log). This information is used for labeling the photos, but not entered into the computer database.

Film Photographs: After the film is developed and mounted into slides, the slides are labeled individually with site name, date, and image information. They are then arranged by site and photopoint or target species habitat into high quality polyethylene slide pages organized into notebooks and archived. **If duplicate slides exist, they should be stored in a separate location to minimize data loss in the event of some catastrophe such as fire or theft**. Eventually, all photo slides should be scanned at a relatively high resolution and copied to CD or DVD for archiving. A backup copy (on a hard drive or another CD/DVD) is recommended. One of the CD's or DVD's can be placed in a folder with the original datasheets and the other in a separate storage location.

Digital Images: The **protocol for managing digital images is still being developed**. Typically images are downloaded from the camera memory chip to a computer for organization and labeling. The images are backed up to CD or DVD for archiving. Photo database software programs are currently being evaluated.

3.3 Photoplot Protocol

Permanent photoplots are employed to monitor the cover of target species assemblages representing different intertidal zones (Tables 10-12). Plots are established at sites with sufficient cover of the target species for monitoring. Plots are sampled each spring and fall at sites south of San Francisco Bay and annually (in summer) at sites north of San Francisco Bay.

3.3.1 Photographing Photoplots

Core Procedure: The cover of target species as well as core and optional species (including higher taxa and substrates) is sampled by photographing **5 permanent 50 x 75 cm (0.375 m²) plots per target species** (see Table 7 for exceptions to plot size and number of replicates), then **scoring point contact occurrences by superimposing a uniform grid of 100 dots on the photo image**.

Camera set-ups include 35 mm Nikonos waterproof camera, land cameras, or digital cameras with or without waterproof housings – all with added single or double strobe lighting. A **quadrapod apparatus is used to support the camera at a constant height (1 m with a 35 mm lens) and orientation to ensure consistent framing of each plot**. The quadrapod, constructed of PVC pipe, consists of a bottom photoplot-sized frame (50 x 75 cm internal dimensions) connected to a smaller camera frame by 4 poles. The lens of the camera is aligned to provide coverage of the entire plot. The quadrapod is placed over each plot in a consistent orientation, typically with the permanent plot number marker in the upper left corner. The plot number (also site, date, and target species) is written or otherwise set up on the quadrapod such that it will be recorded by the plot photo.

Specific photographic procedures vary depending on camera/strobe set-ups and **should be established by each monitoring team**. Resulting images must be of sufficient quality to consistently recognize target and core species when scoring. Unattached drift plants (e.g., giant kelp blades), large motile invertebrates that are not scored in photoplots (e.g., *Aplysia*; record count if doing motile invertebrate protocol), invertebrate debris (e.g., lobster exoskeleton or loose mollusk shell), or flotsam (e.g., driftwood) are removed prior to photographing plots (see Guidelines below). Otherwise, plot photos are taken "as is" without moving live organisms. For each consecutive photograph, record target species, plot number, and plot-specific notes (Form 2a,b: Prototype MARINe Rocky Intertidal Photo Log).

Guidelines:

- It is **important to properly locate and orient each photo so the same plot is sampled through time**. Over-view plot print photos (with plot frame in place) aid plot location and orientation of quadrapod if plot corner markers are obscured or missing.

- Cleaning plot corner markers aids in keeping overgrowth down so plots can more easily be located during the next survey.

- If algae such as rockweed must be moved to locate plot markers, be sure to return them to their original position for the photo.

- Waterproof camera/strobe set-ups protect sensitive equipment from salt spray and seawater, but can be bulky. Waterproof housings are subject to fogging if moist air is present between camera lens and housing. Place desiccant packs inside housing to minimize this problem.

- **Bracketing exposures helps ensure a good exposure for scoring and provides back-up photographs of each plot**.

- Strobes, preferably mounted laterally away from the camera, provide fill-in lighting to reduce shadows. A photographic umbrella will further reduce shadowing.

- Painting the white PVC gray or using gray Schedule 80 PVC for the bottom quadrapod frame reduces flaring (particularly evident with digital media) that may over-expose plot margins.

- The best quality photos are obtained by optimizing ASA (low requires more light while high becomes increasingly grainy), Aperture (small needs more light while large has poor depth of field), and Shutter Speed (slow increases likelihood of blurring while fast needs more light).

- **Remove large or abundant top-layer active motile invertebrates** (including *Aplysia*, *Lithopoma*, *Tegula*, predatory snails, hermit crabs) from photoplots prior to photo/scoring **if their presence significantly blocks scoring of topmost sessile cover** layer. Record appropriate data for removed individuals if plot is going to be sampled for motile invertebrates.

- **Do not remove sedentary motile invertebrates** (including chitons, limpets, black abalone, ochre seastars, purple urchins), particularly since they may be harmed by removal and displacement.

Variations from and Additions to Core Procedures:

- See footnotes in Table 7 for variations to core procedures (e.g., plot size and # replicates).
- CSUF does not use a quadrapod; they hand hold the camera while straddling the plot.
- CSUF uses a photographic umbrella to minimize shadows in the plot.

3.3.2 Sketching Plots and Taking Notes

Core Procedure: If time and resources permit, **rough field sketches and notes** are made of the distribution of organisms and substrates in each plot to **clarify species identifications when the photos are scored in the lab** (Form 3a,b: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet). For example, species that seem reddish in the field may look black in slides, and lighter-colored species like crustose corallines may not be obvious in photos. Code letters are used to indicate species in the plot sketch. Sketches and notes should take only a brief time for each quadrat (perhaps 1-2 min; thus a site with 25 plots might take 1 person up to 1 hr to complete (including time to move between plots)).

Guidelines:

- There is a temptation to get too detailed and spend too much time on sketching and noting. Keep in mind that this is just an aid to scoring. If too much effort is devoted to this task, then one might as well have scored the plot in the field, with more accurate results.
- It is not necessary to sketch obvious target or other distinct species.
- **It is preferable that the person who will score the data makes the sketches and notes**.
- Things to sketch/note include rock surfaces that may be confused with tar or crusts, tar spots, coralline and non-coralline crusts, sand depth (is it 5 cm or greater?), obviously dead invertebrate parts (e.g., shells, barnacle tests, *Phragmatopoma* tube fragments), un-removed drift algae fragments, bleached coralline algae, species recruits, closed anemones, motile invertebrates, uncommon species, unusual conditions, and obvious epibionts and layering – particularly as they affect the target and core species (e.g., algae atop mussels).

- Species scattered throughout the plot can be noted but not sketched.
- If possible, estimate extent of cover for sketched species or substrates.
- For barnacle plots where *Chthamalus* and *Balanus* are not distinguished in photo scoring, record quick visual estimate of % cover of each of these barnacle species (nearest 5%) whenever possible.
- The sketches are a good place to record plot corner marker conditions.

3.3.3 Scoring Cover in Photoplots – General Procedures

Core Procedure: Photoplots are scored from photographs or digital images in the laboratory, supplemented when possible by field plot sketches and notes. **Digital image scoring has become the standard since 2002/2003** because computer software provides a more convenient method of scoring images (e.g., ability to zoom and to enhance image quality). For film photographs, each slide is projected onto a white board that is marked with a grid of one hundred evenly-spaced points (10 x 10). Species, higher taxa, or substrates beneath the points are identified and recorded. When scoring digital images, a **grid of one hundred evenly-spaced points (10 x 10) is created on the computer monitor** (using Adobe Photoshop), and placed on a separate layer. This allows the scorer to easily remove the dot to see what lies beneath. The image can then be saved with the "grid layer", clearly documenting the exact points scored. With either film or digital image scoring, grid size is manipulated to provide complete coverage of the plot within the quadrapod frame. Layering is not scored separately, so the total cover is 100%.

Film photographs of each photoplot have been scored in the lab by all groups from their initial survey dates until 2002/2003, except CINP has scored their photoplots in the field whenever practical since 1991, and UCSC began scoring acorn barnacle plots in the field in 2001 (see below). **If field scoring is done, the field protocol must be carefully specified to assure comparable results to photo scoring**. For example, discrepancies could arise because it is easier to identify species and to determine layering and epibiont conditions in the field versus lab. For consistency, it is preferable to use the same plan (either field or lab scoring) at given sites over time. If field scoring, plot photos should still be taken and "field scored" should be noted on the photoplot score sheet.

Variations from and Additions to Core Procedures:

- Switch to Digital Image Scoring: CSUF, UCSC, and UCLA began scoring digital photoplot images for all sites on a computer monitor in Fall 2002, except Bird Rock and Little Harbor photoplots were scored digitally beginning Spring 2003. UCSB began digital scoring in Spring 2003.
- Field Scoring: **CINP switched to field scoring whenever practical since 1991** for the following reasons: 1) Samplers sometimes had sufficient expertise and time in the field when sea conditions were mild enough to score in situ, 2) Field scoring is more accurate than scoring from photos, 3) Data are preserved if something happens to photos prior to lab scoring, and 4) Office demands made it difficult to find time for lab scoring. Plots are field scored using a collapsible 50 cm x 75 cm frame divided by 10 evenly-spaced string lines. With the frame over the plot, a narrow steel rod is placed across each string in sequence (using predetermined slots) to create 10 intersection points per string, making 100 points total under which organisms are

identified and recorded. Use of a multi-tally meter (tally-clicker) helps facilitate counting of multiple species.

- Acorn Barnacle Plot Field Scoring: **UCSC switched to field scoring of acorn barnacle plots in Spring 2001** in order to separately monitor live and dead (empty tests) *Chthamalus dalli/fissus*, *Balanus glandula*, and *Semibalanus cariosis*. They added the following categories to their optional species list for barnacle plots only: *S. cariosis* and dead *S. cariosis* (starting Fall 2000), live *C. dalli/fissus* and live *B. glandula* (starting Spring 2001), and dead *C. dalli/fissus* and dead *B. glandula* (starting Fall 2001). Acorn barnacle plots are scored in the field using a 50 cm X 75 cm frame with a 10 X 10 grid of evenly-spaced string lines. With the frame over the plot, a species, higher taxon, or substrate is identified below each of the 100 string intersection points.

3.3.4 Scoring Cover in Photoplots – Specific Procedures

Core Procedure: **Each of the 100 points within the photoplot is identified and scored as one of 46 categories of core species, higher taxa, or substrates** (Table 5 & Form 4: Prototype MARINe Rocky Intertidal Photoplot Slide-Scoring Data Sheet). Definitions for the lumped taxa and substrate categories are provided in Table 6. Monitoring groups can opt to score photos in greater taxonomic detail (e.g., some groups identify all organisms to the lowest level possible); however, finer-scaled data must be lumped to fit the core categories for database entry unless optional species have been formally registered with the database (requiring a commitment to consistently score the species in all surveys) (see above for optional species discussion). Prior to establishing core species, monitoring groups scored target species similarly, but secondary species categories varied somewhat among monitoring groups and through time (relational tables have been established in the MARINe database to document and standardize these lists, but the effort is not complete). An advantage of photos is that they can be rescored for standardization purposes or if a more thorough inventory becomes necessary (e.g., in the event of an oil spill). Layering is not scored separately, so the total percent cover is constrained to 100% (see below). **The following are core rules for photo scoring:**

- **Always score the top-most (visible) layer that is attached to the substrate (i.e., not an obvious epibiont) unless the top-most layer is a "weedy" species obviously overlaying a non-weedy species.** This rule applies regardless of the target or core species involved. The rule was formulated to work consistently for scoring from photos, supplemented when possible with rough plot sketches and brief notes. "Obvious" means that the layering can be discerned from the photograph or is clear from the brief field sketch/notes (e.g., a plot noted in the field to have 100% cover of mussels topped with weedy algae). Examples of epibionts include algae (e.g., crusts, articulated corallines, *Endocladia*) or invertebrates (e.g., barnacles or limpets) on live mussel shells or *Tetraclita* tests. Examples of "weedy" species include *Ulva*, *Enteromorpha*, *Endarachne*, *Porphyra*, and *Scytosiphon*. The top-most rule eliminates much of the uncertainty of trying to determine what lies below the upper layer, does not bias for or against target species, and generally keeps the photograph as the primary source of archival data (rather than some difficult to reconstruct combination of photo, plot sketch, and/or field scoring). This method will underestimate target species cover whenever the target species is covered by another species (e.g., by rockweeds or any plant whose attachment lies outside the plot). Such situations should be noted and considered when evaluating data trends. Though desirable, scoring cover of understory target species is too complex and time consuming to fall within the scope of this core laboratory-scored monitoring protocol. **Monitoring groups have the option to separately score epibionts or other layering; however, the current MARINe database is not capable of accepting the layered data**. Fortunately layering is not a major issue for most target species, except in plots where rockweeds occur.

- **Score sedentary motile invertebrates occurring under a photopoint as one of the following core categories: *Lottia gigantea*, limpet, chiton, *Pisaster ochraceus*, or other invertebrate.** Since black abalone and purple urchins are rarely encountered (if at all) in photoplots, they have not been designated as core species for this protocol. If encountered, they would be scored as "other invertebrate". **If an un-removed active motile invertebrate occurs under a photopoint, score what is likely underneath it if possible; otherwise, score the point as "unidentified"** (do not score the active motile invertebrate as "other invertebrate"). For example, the predatory snail *Mexacanthina* in CABR photoplots should be counted as an active motile invertebrate, not scored as sedentary invertebrate cover.

- **Score bleached crustose corallines (appearing white) as "crustose corallines", not "rock".** Bleached crustose corallines may still be alive, so assume they are live and score as such.

- **Score obviously dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock", "sand" or "tar" as "other substrates".** This "other substrates" category was established in 2004. In prior years, dead shells and tests were scored primarily as "rock". UCSC scores each dead barnacle species separately in the field as an optional category. It is a more accurate determination that can be done with experienced samplers scoring in the field; however, these data must be lumped to the core category "other substrates" when comparing data with other MARINe sites scored from photos. When scoring from photos, if it is not obvious whether white acorn barnacles are live or dead, they must be assumed to be live and scored as "*Chthamalus dalli/fissus/Balanus glandula*". Larger, dead *Tetraclita* tests might be obvious in a photo, and if so, should be scored as "other substrates".

- **Epoxy corner markers and bolts should be scored as "rock".**

- **When sand is present under a point in the photo, if you can positively identify what is under the sand, then score the underlying core species or "rock"; otherwise score "sand".** This means that "sand" will be scored whenever sand thickness is greater than just a thin layer with patches of rock or some core species showing through.

Guidelines:

- If *Chthamalus* occurs as an epibiont on *Tetraclita*, score the point as "*Tetraclita*".

- If one species of rockweed overlays another species of rockweed, simply score the top layer as is, without moving either species. If a rockweed is obviously overlaying a mussel, score the rockweed because it is the top layer, is not an epibiont, and is not a "weedy" species.

- **If plant species are attached outside the plot but draping over target or core species in the plot, score the overlying species (if it is not a "weedy" species) without regard to place of attachment.** For example, in the rare case where *Egregia* drapes across a mussel plot, leave it in place and score it as the top-layer species (but note on the Sketch Data Sheet what it is covering). Ideally one would like to follow the target or core species despite over-draping, but in practice it would be too complex for field samplers to record and would likely lead to inconsistencies.

Variations from and Optional Additions to Core Procedures:

- Prior to establishing core species, non-target species categories varied among monitoring groups and through time. Relational tables have been established in the MARINe database to document and relate these species variations to core categories, but the effort is not complete (see Database User Guide: Bealer & Cooper 2003).

- CSUF scores all species layers evident in plot photos, but only transfers to the MARINe database those data that fit core rules.

3.3.5 Managing Photoplot Data and Photographs

Photoplot Data: The Photo Log and Photoplot Sketch Data Sheets are completed in the field (Forms 2 & 3), but not entered into the computer database. With either lab or field point scoring, data are recorded on data sheets (Form 4: Prototype **MARINe Rocky Intertidal Photoplot Slide Scoring Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Photoplot data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived.

Photographs: After the film is developed and mounted into slides, the slides are labeled individually with site name, date, target species and plot number. They are then arranged by site and target species into high quality polyethylene slide pages organized into notebooks and archived. **If duplicate slides exist, they should be stored in a separate location to minimize data loss in the event of some catastrophe such as fire or theft.** Eventually, all photo slides should be scanned at a high resolution and copied to CD or DVD for archiving. A backup copy (on a hard drive or another CD/DVD) is recommended. One of the CD's or DVD's can be placed in a folder with the original datasheets and the other in a separate storage location.

Digital Images: The protocol for managing digital images is still being developed. Typically images are downloaded from the camera memory chip to a computer for organization and labeling. The images are superimposed with the dot grid in Adobe Photoshop for scoring. Original images and dot grid sets of images are backed up to CD or DVD for archiving. Photo database software programs are currently being evaluated.

Digital Photoplot Image File Naming Standard: The rationale for the photoplot file name standard includes the following:

- Photo file name must be easy to understand and implement and compatible with typical database style.

- Photo file names should not use spaces or special characters. Underscore is OK as a separator.

- For simplicity and reducing possibility of errors, photo file names should include only lower case letters.
- Even though a photo database can organize files based on key words, etc, it is best if file names are descriptive and display in a logical order. However, not all information needs to be included in the file name (directories can be used to separate some broad categories), and the file name should not be lengthy (<20 characters preferred).
- There are 6 main types of info that have been incorporated into MARINe photoplot file names. This hierarchy (in order from general to specific) is as follows:

1) **Site**: use our standardized 3-5 letter codes (lowercase) to conform with the database.

2) **Target Species**: Use the first 3 letters (lowercase) of the target species plot names in the database (see Table 7). Using fewer than 3 letters could lead to ambiguities, while more letters unnecessarily lengthens the file name.

3) **Plot Number**: Plot identifiers should conform to consecutive #'s starting with "1" if possible (e.g., 1, 2, 3, 4, 5 ...). Other unique and consistently applied plot #'s can be used (e.g., 212, 213,…); however, for simplicity in labeling, mapping, and database operations, we should strive to convert to the "1, 2, 3, 4, 5" format when feasible.

4) **Date (Season/Year)**: Most of core MARINe sampling takes place semi-annually, in fall and spring, though some northern sites are sampled annually, in summer. Due to the nature of our sampling schedules (including limited # of adequate low tide periods, site access limitations and weather delays), we have defined 3 sampling seasons (no winter), each 4 months long as follows: "Fall = October-January, Spring = February-May, and Summer = June-September (This does not quite match the calendar year; thus a sample in January 2005 would be listed as a Fall 2004 sample).

Seasons will be abbreviated as lowercase 2-letter codes (Fall = fa, Spring = sp, Summer = su) and years will be abbreviated as the final 2 digits (e.g., 1997 = 97, 2004 = 04). Using these codes means the file names as listed in alphanumeric order will group all Fall photos, followed by all Spring photos, and then all Summer photos. Also years in the new century (2000's) will sort out before the 1900's. This partial breakdown of chronological order was not considered significant enough to change to lengthier and less intuitive file names since the eventual implementation of a photo database will allow all kinds of sorts, including chronological.

5) **Photo Replicate:** For each photoplot sampling, there will be at least 2 photos to store: 1) the photo used for scoring and 2) that same photo overlain with the grid of 100 dots). In addition there may be 1-2 or more other photos, often representing different exposures (e.g., 1 more overexposed and 1 more underexposed) (Note: we should not label and organize photos that we are unlikely to use, such as duplicate exposure or poor quality extra photos). To differentiate the various photos for a given plot, we will add a single lowercase letter after the year in the file name as follows:

"a" = scored photo (no dot grid)

"b", "c", "d", "e", or "f" = additional photos taken (e.g., different exposures)

"g" = scored photo overlain with dot grid

6) **Photo Variants**: For some plots, there may be photos taken from different perspectives or of different subsections of the plot. For example, if plot lies over a ledge, 1 photo may be taken with the frame mostly horizontal and another photo taken more vertically. Another example: CSUF takes separate photo of each ¼ of the barnacle plots to get better resolution for scoring. To differentiate these types of photos in the relatively few circumstances when they occur, we will add an appropriate code at the end of the file name, such as (these example codes could be changed if other designations are found to be more appropriate):

"horiz" = horizontal or "vert" = vertical

"ul" = upper left, "ur" = upper right, "ll" = lower left, or "ul" = lower right quadrants

Based on the above criteria, the MARINe photoplot digital photo name standard is:

"site" "_" "target species" "plot #" "_" "season" "year" "replicate" "_" "variant"

Photoplot File Name Examples:

psn_maz2_fa04a.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "a" (scored photo)

psn_maz2_fa04b.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "b" (different exposure)

psn_maz2_fa04g.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "g" (dot grid photo)

shco_sil5_sp05a.jpg = Shaws Cove, Silvetia Plot #5, Spring 2005, Replicate "a" (scored photo)

shco_cht3_sp05a_ul.jpg = Shaws Cove, Chthamalus/Balanus Plot #3, Spring 2005, Replicate "a" (scored photo), upper left quadrant

care_pol4_fa03b_vert.jpg = Cardiff Reef, Pollicipes Plot #4, Fall 2003, Replicate "b", vertical emphasis

bml_myt1_su04g.jpg = Bodega, Mytilus Plot #1, Summer 2004, Replicate "g" (dot grid photo)

3.4 Point-Intercept Transect Protocol

Permanent point-intercept transects are employed to **monitor the cover of 3 target species: *Phyllospadix scouleri/torreyi* (33 sites), *Egregia menziezii* (3 sites), and Red Algae (turf algae, including articulated corallines and other red algae) (7 sites)** (Table 8). Transects are established at sites with sufficient cover of the target species for monitoring.

3.4.1 Scoring Cover on Point-Intercept Transects

Core Procedure: The cover of target species, as well as secondary core and optional species/taxa/substrates, is sampled each spring and fall by scoring point-intercepts along 3 permanent 10 m transects (see Table 8 and below for exceptions). Transects, which are marked at both ends (and often the center) with stainless steel bolts, usually are separate, but may run end to end depending on the shape and expanse of the target species habitat. Each transect is sampled by scoring occurrences under 100 points uniformly distributed at 10 cm intervals (10 cm, 20 cm, 30 cm …1000 cm) along a meter tape laid out along the transect. **Rules for scoring are as follows:**

Each of the 100 points along the transect meter tape is located and scored as one of 24 categories of core species, higher taxa, or substrates (Table 5 & Form 5). Only the topmost (visible) layer that is attached to the substrate (i.e., not an obvious epibiont) is scored, except that surfgrass is also scored separately when it is covered by another non-

epibiont species (see below). For example, if *Egregia* drapes across articulated corallines, leave it in place and score it as the top-layer species. Definitions for the lumped taxa and substrate categories are provided in Table 69. Monitoring groups can opt to score transects in greater taxonomic detail; however, finer-scaled data must be lumped to fit the core categories for database entry unless optional species have been formally registered with the database (requiring a commitment to consistently score the species (if present) in all surveys) (see above). Some monitoring groups previously recorded each point in order along the transect from start to end (generally north to south). This was deemed not necessary, so for efficiency the core method is to simply record the number of "hits" in each category without regard to position along the transect.

***Phyllospadix* is scored in either of 2 categories: "*Phyllospadix* Overstory" and "*Phyllospadix* Understory".** This procedure, initiated in Fall 2002, documents surfgrass even when it is covered by another species. Total transect cover will be greater than 100% whenever understory surfgrass is scored. Since any amount >100% cover represents understory surfgrass only, compatibility with previous "top-layer only" scoring is maintained. Scoring other understory species, though possible in the field, would be tedious and impractical (especially when transects are periodically awash) given personnel and time constraints. Except in San Diego County, all transects target surfgrass, so it is logical to deal with layering only when surfgrass is covered by another plant (e.g., *Egregia*). The categories "*Egregia* on *Phyllospadix*" or "*Phyllospadix* on *Egregia*" were scored by UCSC during 2002; thereafter, this practice was discontinued.

Score obviously dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock", "sand" or "tar" as "other substrates". This "other substrates" category was established in 2004. In prior years, dead shells and tests were scored primarily as "rock".

Epoxy corner markers and bolts should be scored as "rock".

When sand is present under a point along the transect, score "sand" whenever the sand cover is 2 cm or greater; otherwise score "rock" or the underlying core species. This is determined by probing with the index finger, with 2 cm roughly being the distance from fingertip to the first joint. Note that the field-scored transect definition of "sand" is different than that for lab-scored photoplots (see above).

In addition to scoring point intercepts, abundance (none, low, med, high) of the following surfgrass epiphyte and appearance conditions are categorized for the transect areas: *Smithora* and *Melobesia* epiphyte cover, bleached and abraded appearance, and presence of flowers. Other notes may be recorded.

Guidelines:

- Minimize disturbance of surfgrass or algae along transects when laying out meter tapes. If vegetation must be moved to locate marker bolts, be sure to return it to its original position.

- Wave surge can rearrange surfgrass and other algae along the transect depending on the extent of low tide and sea conditions. Try to survey the entire transect during a period when the tape and grass are undisturbed. If this is not possible, get help to hold the tape in place and score during the calm periods.

- "Surfgrass" is scored under a point no matter what its appearance (bleached, abraded, etc.). Leaves, flowers, and rhizomes all are scored as "surfgrass".

- If possible, photograph each transect (lengthwise) during the seasonal monitoring to document the species assemblage and appearance.

Variations from and Additions to Core Procedures

- The footnotes in Table 8 describe variations to the core protocol with respect to transect length and number of replicates.

- Line-Intercept: The original method for scoring transects (developed at the CABR sites) used line-intercepts, where the sampler scored the core taxa and substrates lying under the entire edge of the 10 m transect tape. Line cover extents were rounded off to the nearest centimeter, thus 1000 separate segments were scored, then divided by 10 to get % cover. **UCSB and CABR scored line intercepts for all transects at their San Diego County sites until Fall 2000, when both groups switched to the point intercept method to standardize with other monitoring groups** (Pete Raimondi had compared the 2 methods and found that the point-intercept sub-sampling (100 versus 1000 data points) yielded similar cover results for surfgrass). Line-intercept data have been entered in the MARINe database, as percentage values just like the point-intercept values.

- Surfgrass Thickness: **As an optional procedure, UCSC collects information on thickness of the surfgrass layer.** Each transect is divided into ten 1 m long segments. If the entire segment is covered by surfgrass, surfgrass layer thickness is measured in the segment middle. If surfgrass covers only a portion of the segment, thickness is measured in the middle of the covered portion. To measure surfgrass thickness, lowermost through uppermost layers are compressed together (not bunched), then measured with calipers. These data have not been entered in the MARINe database.

- Surfgrass Species Separation: **As an optional procedure, UCSC records the percent cover of *Phyllospadix torreyi* vs. *Phyllospadix scouleri* along each transect** by estimating the proportion of each species for surfgrass covered areas. Overlapping morphological characters (e.g., leaf width 1-2 mm for *P. torreyi* vs. 2-4 mm for *P. scouleri*) and paucity of flower stalks (which can distinguish the 2 species) make species separation difficult. If transect sections contain surfgrass that is difficult to identify, the percentage of each species is based on the proportion of the transect that can be confidently identified. These data have not been entered in the MARINe database.

- **CSUF scores all species layers in point transects**, but only transfers to the MARINe database those data that fit core rules.

3.4.2 Managing Point-Intercept Transect Data

Data are recorded on data sheets (Form 5: Prototype **MARINe Rocky Intertidal Point-Intercept Transect Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see

Database User Guide: Bealer & Cooper 2003). Point-transect data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD's or DVD's.

3.5 Owl Limpet Plot Protocol

Permanent plots are employed at **43 MARINe sites** to monitor the density and size distribution of owl limpets (*Lottia gigantea*) (Table 8). Plots are established at sites with sufficient densities for monitoring.

3.5.1 Counting and Measuring Owl Limpets in Plots

Core Procedure: The density and size distribution of owl limpets are monitored each spring and fall to follow population dynamics within **5 permanent 1 m radius circular plots** per site (see Table 8 and below for exceptions). Plots were established in areas of high density to obtain as many counts and measurements for size-frequency as possible (preferably >20 individuals/plot for a total of >100 per site). Therefore, plot densities reflect maximum densities rather than average densities at each site. Plots are marked with one center bolt, notched to indicate the plot number. Limpets are measured within a circle (1 m radius, 3.14 m^2 area) projected around each bolt.

To survey a plot, a 1 m length of line or tape is attached to the center bolt and arced around to form a circle. The **maximum length of all owl limpets ≥15 mm** found within that circle (including those touched by the 1 m mark) are measured with calipers to the nearest millimeter, then temporarily marked with a yellow forestry crayon to avoid scoring duplication. If a limpet cannot be measured directly by the calipers (due to tight crevices or other irregularities), its size is estimated. **Limpets are never removed from the rock**. The measurement tape is either pulled taught along the topography of the substrate (i.e., if a limpet can be touched by the end of the line, it is included) or laid more loosely along the topographic contours (CINP & UCSC) to determine which limpets lie within the circle, with the method of choice employed consistently at each site. Some monitoring groups (e.g., UCSB) include limpets in narrow crevices within the circle even if the limpet cannot be touched by the line.

Guidelines:

- **It is important that each monitoring group documents its rules for delineating owl limpet plot boundaries so that plots are surveyed consistently.**
- To ease decisions about plot boundaries for plots on irregular rock surfaces, take a print photo (if possible) of each plot with a line or series of markers indicating the plot boundary, then use the prints in the field to confirm plot edges. Add notes about plot irregularities if necessary.
- Observers must refine their search image to locate owl limpets in narrow crevices and those covered with barnacles or algae. It helps to look through the plot from different angles of view. It is good practice to have a second scorer search the plot for limpets possibly missed by the first scorer. Also, *Lottia gigantea* may be confused with other large limpets (especially large *L. pelta* or *L. limatula*).

- Plot observations should be recorded on the data sheet, including obvious scars from missing limpets and any evidence of predation.

- If possible, photograph each owl limpet plot at least once a year to document the species assemblage and appearance.

Variations from and Additions to Core Procedures

- See footnotes in Table 8 for variations to core procedures (e.g., plot size, shape, and # replicates).

- Small owl limpets: The 15 mm minimum size for counting and measuring owl limpets was implemented during the initial design of this monitoring (at CABR) to reduce variability associated with increasing difficulty in locating and identifying smaller sizes of *Lottia gigantea*. Small owl limpets can be hidden in tiny crevices and may look similar to other limpet species, except to experienced samplers. **As an optional protocol, UCLA has recorded all owl limpets ≥ 10 mm since 1999, and UCSC records all limpets identified with no minimum size.** Data for owl limpets <15 mm shell length have been entered in the MARINe database; however, such data can result in incompatible comparisons of mean sizes and size-frequency histograms.

- **CINP samples annually in fall, unless the site is visited only in spring**.

3.5.2 Managing Owl Limpet Plot Data

Data are recorded on data sheets (Form 6: Prototype **MARINe Rocky Intertidal Owl Limpet Data Sheet**). Prototype data sheets can be used “as is” or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Owl limpet data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD’s or DVD’s.

3.6 Black Abalone and Ochre Seastar Monitoring Protocol

Permanent plots or transects are employed to monitor the density and size distribution of black abalone (*Haliotis cracherodii*) and ochre seastars (*Pisaster ochraceus*) (Table 8). Plots/transects were established at sites with sufficient densities for monitoring. At most other sites, timed searches are used to document the absence or rarity of these species.

3.6.1 Counting and Measuring Black Abalone and Ochre Seastars

Core Procedure: The number and size of black abalone and ochre seastars are monitored each spring and fall within irregularly-shaped plots or along band transects, depending on site topography. **3-5 plots/transects generally were established in areas of high density to obtain as many counts and measurements for size-frequency as possible** (preferably >20 individuals/plot for a total of > 60-100 animals per site; primarily for black abalone). Irregular plots are marked by four or more "corner" bolts, one of which is notched as the plot number bolt.

These markers were placed on conspicuous (i.e., higher) rock features to ease relocation efforts, thus plot boundaries may include habitat unsuitable for abalone or seastars. For this reason, **irregular plots were not intended to provide densities for comparison between sites**. They were designed to provide temporal comparisons within a site. Seastar transects are 2 x 5 m; abalone transects are 1 x 10 m (see Table 8 and below for exceptions). Transects are marked at both ends (and often in the center) by bolts. At some sites, the same plots or transects are used to monitor both species.

To survey a plot or transect, once the tide is low enough, a meter tape (or line) is laid out along the transect length or around the irregular plot perimeter. Transects are surveyed by moving a 1 m wand down each side of the 2 x 5 m transects or down the center of the 1 x 10 m transects. All seastars or abalone present (wholly or in part) under the path of the wand are recorded and measured. For irregular plots, the entire area encompassed by the boundary tape (or line) is searched carefully. Seastars and abalone are included if any part of the animal is inside the plot.

Abalone shell lengths are measured with calipers or a ruler to the nearest 5 mm for animals <40 mm and the nearest 10 mm for larger abalone (CINP measures to the nearest mm). Each abalone is temporarily marked with a yellow forestry crayon to avoid duplication. Sometimes it is necessary to estimate lengths for abalone lodged deeply in cracks or otherwise inaccessible. Abalone are never removed from the rock. **Seastars are measured from the center of the disc to the tip of the longest ray with calipers to the nearest 5 mm for animals <10mm and the nearest 10 mm for larger seastars.** Often sizes must be estimated because seastars typically are wedged in tight spots with rays curved. Seastars should never be "straightened" or removed from the rock. CINP began measuring *P. ochraceus* in 2002 using estimated size classes (<50, 50-100, >100 mm). Starting Spring 2003, CINP switched to different size classes (<75, 75-150, >150 mm). UCLA and UCSC began recording seastar sizes in Fall 2000.

Guidelines:

- **Each monitoring group should document its rules for delineating abalone/seastar plots or transects so that areas are surveyed consistently**.

- Observers must refine their search image to locate abalone and seastars in deep or narrow crevices. Use a waterproof flashlight if necessary to see into dark areas. It helps to look through the plot from different angles of view. It is good practice to have a second scorer search the plot for abalone/seastars possibly missed by the first scorer.

- At some sites, seastar counts may be variable because these motile invertebrates move outside the plots/transects. If plot/transect boundaries are extended to reduce this variability, separate counts for old and new plots/transects are necessary to maintain compatibility with prior data.

- If possible, photograph each abalone/seastar plot or transect at least once a year to document the species assemblage and appearance.

Variations from and Additions to Core Procedures:

- The footnotes in Table 8 describe variations to the core protocol with respect to plot and transect sizes and shapes and number of replicates.

- In 2003 UCLA added large irregular plots for seastars at Arroyo Hondo, Carpinteria, and Old Stairs (3 replicates each). These plots are monitored in addition to the existing band transects (but scored separately) to provide larger search areas for seastars.

- <u>Other abalone and seastar species</u>: As an optional procedure, some monitoring groups also record number and sometimes size data for green abalone (*H. fulgens*), bat stars (*Patiria miniata*), sun stars (*Pycnopodia helianthoides)*, giant-spined stars (*Pisaster giganteus*), and fragile stars (*Astrometis sertulifera*).

- <u>Ochre Seastar Color</u>: As an optional procedure, UCSC has recorded color categories (orange or not orange (purple/brown)) of *Pisaster ochraceus* since Spring 1996. UCLA began recording these colors in Fall 1999.

<u>3.6.2 Timed Search Protocol</u>

Core Procedure: Site-wide timed searches have been **employed at locations where abalone and seastars have been absent or exist in too few numbers to monitor within replicated plots or transects**. The purpose of timed searches is to document absence/rarity or to recognize a population increase such that monitoring in replicated plots could be instituted. This method is primarily qualitative (indicating levels of abundance) because time limitations prevent a thorough search of the entire site and low tide/swell conditions affect the lower boundary accessible for searching. To survey (around the time of low tide), one person spends 30 min (or 2 persons 15 min each) searching appropriate abalone/seastar habitats (e.g., crevices and pools) along the low intertidal zone throughout the defined site (between upcoast and downcoast boundaries) for possible occurrences of ochre seastars or black abalone. Numbers encountered and sometimes size measurements are recorded.

Guidelines:

- **It is important that each monitoring group documents its rules for delineating timed search boundaries so that areas are surveyed consistently**.

- Observers must refine their search image to locate abalone and seastars in deep or narrow crevices. Use a waterproof flashlight if necessary to see into dark areas.

- If abalone or seastars show up in moderate numbers during timed searches over several sampling seasons, consider setting up fixed irregular plots (3 replicate plots) of sufficient size for adequate long-term quantitative monitoring.

Variations from and Additions to Core Procedures:

- <u>Other abalone and seastar species</u>: As an optional procedure for timed search sites, some monitoring groups also record number and sometimes size data for green abalone (*H. fulgens*), bat stars (*Patiria miniata*), sun stars (*Pycnopodia helianthoides)*, giant-spined stars (*Pisaster giganteus*), and fragile stars (*Astrometis sertulifera*).

- <u>Ochre Seastar Color</u>: As an optional procedure, some monitoring groups record color categories (orange or not orange (purple/brown)) of *Pisaster ochraceus*.

3.6.3 Managing Black Abalone and Ochre Seastar Plot Data

Data are recorded on data sheets (Form 7: Prototype **MARINe Rocky Intertidal Abalone and Seastar Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Abalone/seastar data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD's or DVD's.

3.7 Northern Sea Palm Monitoring Protocol

Northern Sea Palms (*Postelsia palmaeformis*) are counted within grid transects at some sites in central and northern California where there are sufficient abundances for monitoring (Table 8). At other sites, presence or relative abundance of northern sea palms is noted during site-wide species reconnaissance and recorded on the Field Log (Form 1b).

3.7.1 Counting Northern Sea Palms in Grid Transects

Core Procedure: The density of Northern Sea Palms are monitored each spring and fall (or annually) to follow population dynamics in permanent grid transects whose size and number vary by site. Meter tapes are laid out between permanent bolts to define the survey area. Each area is subdivided into a grid of 1m x 1m quadrats (except 1m x 1.5m at Mal Paso & 1m x "swath to water line" at Scott Creek & Sand Hill Bluff). Within each quadrat, all intact *Postelsia* stipes are counted and recorded. The relative abundances of recruits and adults are noted.

Site-specific grid arrangements are as follows:

Fogarty Creek: 1 area: a 9m transect line with 1m x 1m quadrats in each direction (18 quadrats total).

Shelter Cove: 3 areas: each made up of a 5m long transect line with 1m x 1m quadrats in each direction (30 quadrats total).

Sea Ranch: 2 areas: A 5m transect line and a 7m transect line, both with 1m x 1m quadrats in each direction (24 quadrats total).

Scott Creek: 2 areas: A 20m transect line with a swath quadrat to water line every 1m, and a 6x4 m grid with 1m x 1m squares, with the last row being swath quadrats to the water line (44 quadrats total).

Sand Hill: 1 area: a 7m x 20m grid with 1m x 1m squares, and the offshore row of quadrats being swaths to the water line (140 quadrats total).

Mal Paso: 1 area: a 12m transect line with 1m x 1.5m quadrats in each direction (24 quadrats total).

Bodega Bay: 2 areas: a 10m transect line and a 9m transect line, both with 1m x 1m quadrats in each direction 38 quadrats total).

Point Sierra Nevada: 1 area: a 6m transect line with 1m x 1m quadrats in each direction (12 quadrats total).

3.7.2 Managing Northern Sea Palm Data

Data are recorded on data sheets (Form 8: Prototype **MARINe Rocky Intertidal Northern Sea Palm Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the standard data and maintain an order consistent with database entry. Northern Sea Palm data have not yet been incorporated into the MARINe Microsoft Access database; however, the database has been designed to facilitate the addition of these data. All data sheets are organized into notebooks and archived.

3.8 Motile Invertebrate Monitoring Protocol

The number and in some cases sizes of select motile invertebrates are monitored within the photoplots at sites where the monitoring group has sufficient experienced samplers and time to conduct this survey (Table 9). Though not a core procedure, the protocol has been tested and standardized for those monitoring groups choosing to use it. The **standard protocol was implemented in 2002/2003** (variations were tested in earlier years) by UCSC, CINP, UCLA, and CSUF. UCSB and CNM chose not to use this protocol due to sampling effort/expertise limitations. CINP conducts motile invertebrate surveys only once per year (in spring), alternating this protocol with owl limpet size/counts (in fall). The other **groups switched from semi-annual sampling to annual (in spring) in 2004** to reduce sampling effort and because analysis indicated motile invertebrates exhibited little seasonal variation in abundance.

3.8.1 Counting and Measuring Motile Invertebrates in Photoplots

Standard Procedure: The density of **16 motile invertebrates species or higher taxa** are monitored each spring and fall (or annually) to follow population dynamics in many of the permanent 50 x 75 cm photoplots at each site (Table 9). The **systematic plot searches are facilitated by subdividing the quadrat frames into 4 equal subsections with string**. Abundant species are sub-sampled.

Core motile invertebrate species/higher taxa by category include: gastropods (*Acanthina* sp., *Fissurella volcano*, limpets (excluding *Lottia gigantea*), *Littorina* spp., *Lottia gigantea*, *Nucella emarginata*, *N. canaliculata*, *Ocenebra circumtexta*, *Tegula brunnea*, *T. funebralis, T. gallina*), chitons (*Lepidochitona hartwegii*, *Mopalia* spp., *Nuttalina* spp.), and crabs (*Pachygrapsus crassipes*, *Pagurus* spp.) (see Table 5).

Limpets < 5 mm and limpets 5-15 mm are sub-sampled in three 20 x 20 cm quadrats, which are placed in upper left, middle, and lower right corner of each photoplot. Sub-sample counts are facilitated by subdividing the 20 x 20 cm quadrat frames into 4 equal subsections with string. If limpets are super-abundant, (as commonly occurs with the < 5 mm category), they can be sub-sampled in a 10 x 10 cm section of the 20 x 20 cm quadrat. If no limpets are counted in the 20 x 20 cm areas and limpets are present in the plot, then the entire photoplot is counted. Counts of limpets that are done in either the smaller 20 x 20 cm or 10 x 10 cm areas must be noted on the data sheet. Sub-sampled limpet counts will be extrapolated to the full 50 x 75 cm photoplot area (counts in 20 x 20 cm areas are summed and multiplied by 3.125, counts in 10 x 10 cm areas are summed and multiplied by 12.5).

Littorines are sub-sampled in a 10 x 10 cm section of the 20 x 20 cm sub-sampling quadrats. If no littorines are found in the 10 x 10 cm area, and littorines are present in the plot, then counts should be done in the entire 20 x 20 cm quadrats. As with limpets, counts from sub-sampled areas will be extrapolated to the full 50 x 75 cm photoplot area.

Sizes of the first 10 individuals encountered in each plot are measured to the nearest mm for the following 7 gastropod species: *Acanthina* spp., *Lottia gigantea*, *Nucella emarginata*, *N. canaliculata*, *Tegula brunnea*, *T. funebralis*, and *T. gallina*. Measured species will vary slightly among regions since only those that are abundant enough to get useful size data should be measured.

Guidelines:

- Sampling in plots with foliose algae that need to be rearranged to find motile invertebrates should be done after plot photos and photo notes have been taken.

- Motile invertebrates can be removed from plots and placed in a container for counting, but should be returned to the plot when sampling is completed. Forceps are useful for extracting whelks from crevices and from amongst mussels.

- It is not possible to locate all cryptic or tiny individuals in complex plots. Practical time limits should be placed on search efforts.

- A tally counter can be used to keep track of counts.

- Sampling often works best by conducting multiple searches through the plot, concentrating your search image on one or two species during each search.

Variations from and Additions to Core Procedures:

- Optional Species: The following optional species can also be counted in photoplots: gastropods (*Amphissa versicolor, Epitonium tinctum, Ceratostoma nuttalii, Haliotis cracherodii, H. fulgens,* Mex*acanthina lugubris)*, chitons (*Lepidochitona* spp., *Lepidozona* spp., *Stenoplax* spp., *Tonicella lineata*), seastars (*Patiria miniata*, *Leptasterias hexactis, Pisaster ochraceus*, and *P. giganteus*), and sea urchins (*Strongylocentrotus purpuratus* and *S. franciscanus*.

- The 1st 10 Pagurus spp. are identified to species by UCSC. This ratio is multiplied out for the total # counted.

- UCSC keeps separate counts of limpets occurring on rock vs. those occurring on *Mytilus* and *Pollicipes*.

- CINP samples annually in spring, except in fall only at Santa Barbara Island (to avoid disturbing nesting pelicans in spring) and semi-annually at Anacapa Island to evaluate rat removal effects (rats may have been foraging on small motile invertebrates. ANME is sampled only when there is enough time, since it is not expected to be much different from adjacent ANMW. When time is short at SCOC, may score 3 plot types in 1 season and 2 plot types in the other season.

3.8.2 Managing Motile Invertebrate Data

Data are recorded on data sheets (Form 9: Prototype **MARINe Rocky Intertidal Motile Invertebrate Data Sheet**). Prototype data sheets can be used “as is” or may be slightly modified to meet specific needs of monitoring groups so long as they capture the standard data and maintain an order consistent with database entry. Motile invertebrate data have not yet been incorporated into the MARINe Microsoft Access database; however, the database has been designed to facilitate the addition of these data. All data sheets are organized into notebooks and archived.

3.9 Invertebrate Recruitment Protocol

Though not a core procedure, white barnacle (*Chthamalus dalli/fissus/Balanus glandula*) and California mussel (*Mytilus californianus*) recruitment have been monitored at many MARINe sites (Table 10). Barnacle recruitment is monitored by scoring settlement on 5 10 x 10 cm PVC plates (covered in safety-walk) screwed into the substrate next to the white barnacle photoplots. The PVC plates are retrieved during each field survey (replaced with clean plates) and scored in the lab. White barnacle recruitment also is monitored in 10 x 10 cm clearings (wire-brushed to bare rock). Settlers are counted in the field during each survey, then the small plot is re-cleared. Mussel recruitment is monitored by scoring settlement into "Tuffy" mesh balls screwed into the substrate next to the mussel photoplots. The Tuffys are retrieved during each field survey (replaced with clean ones) and scored in the lab.

3.9.1 Field scoring barnacle clearings and collecting barnacle plates and mussel Tuffys

Clearings:

- Choose 5 random fields of view per clearing. Fields should represent entire clearing so try to pick one field per corner and one in center.
- In each field of view use scope or hand lens (magnifying glass) to count by species all barnacles and cyprids found.
- If the density of barnacles in the clearing is low and the field of view method does not accurately reflect actual density, count entire plot. A hand lens or magnifying glass is useful for this.
- Randomly measure 10 *Chthamalus* and 10 *Balanus* per clearing. Preferably, measure 2 from each field of view.
- Measure 1 cyprid of each species per clearing (if present).
- Use the metal brush and probe to clear the plot of all barnacles when done counting.

Plates:

- Remove each plate with nutdriver and store in "plate rack" (4" long bolt with 4 "spacer" nuts of larger diameter than bolt threading and 1 nut to secure plates on "rack").
- Replace each plate with clean plate using nutdriver.

Tuffys:

- Remove each Tuffy with nutdriver and store in labeled bag.
- Replace each Tuffy with clean Tuffy using nutdriver.

3.9.2 Lab scoring barnacle plates and mussel Tuffys

3.10 Intertidal Temperature Loggers

Though not a core procedure, intertidal temperature loggers have been deployed at many MARINe sites (Table 11). These small units ("Stowaways", "Tidbits", or "Pendants" from Onset Corporation) **record automated ambient temperatures (sea or air depending on**

tide height) at pre-set time intervals (usually every 15 min). Typically they are housed in capped PVC tubes bracketed to the rock, **in the mid-mussel zone or just below the mussel zone.** The units are changed out (or downloaded to an “Optic Shuttle”) during the monitoring survey. After data are downloaded, the unit can be reset to use again. They may be triggered by a magnet to start sampling when deployed at a site. Battery life for the ~$100 Tidbits is about 5 years; once batteries fail, units are discarded. Battery life for the ~$50 Pendants is about 1 year; battery can be replaced by user. Start use dates should be noted and units (Tidbit) or batteries (Pendant) replaced after end of specified battery life span to prevent loss of data. Data managers can process the temperature records to separate submerged periods from times when the units are exposed to air.

4. MARINE DATA MANAGEMENT

Data sheets, maps, photographs, videotapes, and computer files are managed as described for each survey method (see above). Data entry, error checking and correction, and other data management procedures for the Microsoft Access database are described in the **MARINe Database User Guide** (Miner et al. 2007).

5. REFERENCES

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Table 1: MARINe Core Monitoring and PISCO Biodiversity Survey Sites

SITE	County	PISCO Biodiversity			MARINe Core Survey				In or Near (<2mi) ASBS	In or Near (<2mi) CFG MPA	In or Near (<2mi) NOAA Mussel Watch Station	Other Designation #1	Other Designation #2
		Site Code	Initial Date	Re-Sample Date	Site Code	Region North	Region South	Initial Date					
ALASKA			-	-		-	-						
Graves Harbor	Skagway	3001	8/03	7/07		-	-	-					
Yakobi	"	3002	8/03	7/07		-	-	-					
Port Mary	Sitka	3003	8/03			-	-	-					
Puffin Bay		3009	7/07			-	-	-					
Coronation Island		3010	7/07			-	-	-					
BRITISH COLUMBIA						-	-	-					
Tow Hill		3008	6/05			-	-	-					
Hippa Island		3007	6/05			-	-	-					
Duck Island		3006	6/05			-	-	-					
Palmerston		3004	8/03	6/07		-	-	-					
Little Ohiat		3005	8/03	6/07		-	-	-					
WASHINGTON													
Cannonball Island	Clallam	1	7/02	6/06									
Chilean Memorial	Clallam	2	7/02	6/07									
Taylor Pt	Jefferson	3	7/02	7/03, 6/04									
Starfish Pt	Jefferson	4	7/02	6/06									
OREGON													
Ecola	Clatsop	5	6/01	6/05	**ESP**	**X**		6/01				Ecola State Park	
Fogarty Creek	Lincoln	6	6/01	7/03, 6/04	**FOG**	**X**		8/00					
Bob Creek	Lane	7	6/01	5/07	**BOB**	**X**		7/00					
Cape Arago	Coos	8	6/01	6/05	**ARG**	**X**		8/00				Cape Arago State Park	
Burnt Hill	Curry	9	5/02	5/06	**BRN**	**X**		6/02					
N. CALIFORNIA													
Enderts	Del Norte		None		**END**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
Damnation Creek	"	52	6/04		**DMN**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
False Klamath Cove	"		None		**FKC**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
Cape Mendocino	Humboldt	10	5/02	4/06	**MEN**	**X**		6/04					
Shelter Cove	"	11	7/01	4/06	**SHT**	**X**		6/04	King Range Nat Conser Area		Point Delgado Shelter Cove	King Range Nat Conser Area	
Kibisillah Hill	Mendocino	12	7/01	6/03, 5/07	**KIB**	**X**		6/04				Mendocino Headlands State Park	
Stornetta Ranch	"	53	5/04	5/07	**STO**	**Xa**		7/05			1.3mi SE Pt Arena Lighthouse		

Sea Ranch	"	13	8/01	6/05	**SEA**	**X**		su 04	1.1mi SE Del Mar Ldg ER		0.2mi NW Sea Ranch Fort Ross Cove*	Sea Ranch Preserve	
Bodega	Sonoma	14	7/01	7/03, 5/04	**BML**	**X**		4/01	Bodega Marine Life Refuge	Bodega State Marine Res	1.0mi N Bodega Bay Entrance		
Santa Maria Creek	Marin	15	5/02	5/05	**SMC**	**X**		5/06				Point Reyes National Seashore	
Bolinas Pt	"	16	5/02	5/05, 2/08	**BOL**	**X**		11/05	Duxbury Reef Res		1.4mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Bolinas Pt Wreck	"	59	5/05	10/05					Duxbury Reef Res		1.2mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Alder Creek	"	71	2/08						Duxbury Reef Res		0.5mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Slide Ranch	"		None		**SLR**	**X**		6/06				Golden Gate Nat Recreation Area	
Pt Bonita	"		None		**PTB**	**X**		su 06				Golden Gate Nat Recreation Area	
Alcatraz Island	San Francisco	58	2/05										
Mussel Flat SE Farallon	"	57	2/05						Farallon Island	Farallon Is State Marine Cons Area	0.2mi W Farallon Is East Landing		
C. CALIFORNIA													
Fitzgerald	San Mateo	17	11/02	11/06					James Fitzgerald Marine Reserve				
Pebble Beach	"		None		**PEB**	**Xa**		su 04				Gulf of Farallones Nat Marine Sanctuary	Pescadero/Bean Hollow State Beach
Pigeon Pt	"	18	11/02	10/06	**PPT**	**Xa**		2002				Gulf of Farallones Nat Marine Sanctuary	Pigeon Pt Light State Historic Park
Franklin Pt	"		None		**FRA**	**Xa**		2004	1.6mi NW Ano Nuevo Pt/Is	Ano Nuevo State Mar Cons Area		Monterey Bay Nat Marine Sanctuary	
Año Nuevo	"	19	6/02	4/08					Ano Nuevo Point & Island	Ano Nuevo State Mar Cons Area	0.5mi NE Ano Nuevo Island	Monterey Bay Nat Marine Sanctuary	Ano Nuevo State Park
Scott Creek	Santa Cruz	20	1/00	1/03, 12/06	**SCT**	**X**		5/99		Greyhound Rk State Mar Cons. Area		Monterey Bay Nat Marine Sanctuary	
Davenport Landing	"	62	10/07		**DAV**	**X**		10/07		1.8miSE Greyhound Rock SMCA		Monterey Bay Nat Marine Sanctuary	
Sandhill Bluff	"	21	1/00	5/04	**SAD**	**X**		11/99		1.9mi NW NBSMR		Monterey Bay Nat Marine Sanctuary	
Wilder Ranch	"	63	10/07		**WIL**	**X**		10/07		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Wilder Ranch State Park
Terrace Pt	"	22	1/00	1/03, 1/06	**TPT**	**X**		5/99		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Natural Bridges State Park
Natural Bridges	"	64	10/07		**NAT**	**X**		10/07		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Natural Bridges State Park
Hopkins	Monterey	23	2/00	1/03, 12/06	**HOP**	**X**		12/99	Pacific Grove Marine Gardens	Lovers Point State Mar Res	0.6mi SE Pacific Grove Lovers Point	Monterey Bay Nat Marine Sanctuary	
Pt Pinos	"	66	11/07		**PIN**	**X**		11/07	0.4mi W PacGrove Marine Gardens	Asilomar State Mar Res	1.55mi NW Pacific Grove Lovers Point	Monterey Bay Nat Marine Sanctuary	

China Rocks	"	67	11/07		**CHI**	**X**		11/07		0.3mi S Asilomar State Mar Res		Monterey Bay Nat Marine Sanctuary	
Stillwater Cove	"	24	2/01	4/05	**SWC**	**X**		4/00	Carmel Bay	Carmel Bay State Mar Cons Area	Carmel Bay Arrowhead Point*	Monterey Bay Nat Marine Sanctuary	
Carmel Pt	"		None		**CAR**	**Xa**		2004	Carmel Bay	Carmel Bay State Mar Cons Area	Carmel Bay Arrowhead Point*	Monterey Bay Nat Marine Sanctuary	
Point Lobos	"	25	2/01	3/05	**PTL**	**X**		5/99	Point Lobos Ecol Reserve	Point Lobos State Mar Res	0.3mi NW Pt Lobos Weston Beach*	Monterey Bay Nat Marine Sanctuary	Point Lobos State Park
Mal Paso	"		None		**MAL**	**Xa**		6/00		0.1mi S Pt Lobos State Mar Res		Monterey Bay Nat Marine Sanctuary	
Garrapata	"	65	11/07		**GAR**	**X**		11/07		0.9mi S Pt Lobos State Mar Res		Monterey Bay Nat Marine Sanctuary	Garrapata State Park
Soberanes	"		None		**SOB**	**Xa**		su 04				Monterey Bay Nat Marine Sanctuary	Garrapata State Park
Andrew Molera	"	26	2/01	3/03, 2/04	**MOL**	**X**		11/99		Point Sur State Mar Res		Monterey Bay Nat Marine Sanctuary	Andrew Molera State Park
Partington Pt	"	54	11/03	4/04	**PAR**	**Xa**		su 04	Julia Pfeiffer Burns Underwater Park		Partington Point Julia Burns ASBS*	Monterey Bay Nat Marine Sanctuary	Julia Pfeiffer State Park
Lucia	"	55	4/04									Monterey Bay Nat Marine Sanctuary	
Mill Creek	"	27	2/01	11/03, 4/04	**MCR**	**X**		5/99				Monterey Bay Nat Marine Sanctuary	
Pacific Valley	"		None		**PVA**	**Xa**		su 04				Monterey Bay Nat Marine Sanctuary	
Duck Ponds	"	56	11/03	2/08								Monterey Bay Nat Marine Sanctuary	
Pt Sierra Nevada	San Luis Obispo	28	4/01	4/03, 4/04	**PSN**		**X**	10/95		1.1mi N Piedras Blancas St Mar Res		Monterey Bay Nat Marine Sanctuary	Hearst Ranch State Park
Piedras Blancas	"	68	1/08		**PBL**		**X**	11/97 9/07		Piedras Blancas State Mar Res		Monterey Bay Nat Marine Sanctuary	BLM Field Station
San Simeon Point	"	61	9/07		**SSP**		**X**	9/07			San Simeon Point	Monterey Bay Nat Marine Sanctuary	access via Hearst Property White Rk State Beach
Vista del Mar (previously called "San Simeon" **SIM**)	"	69	12/07 1/08		**VDM**		**X**	su04 9/07		Cambria State Mar Cons Area		Monterey Bay Nat Marine Sanctuary	San Simeon State Park
Cambria (Rancho Marino)	"	29	6/01	7/05	**RMR**		**Xa**	2001		White Rk State Mar Cons Area		Rancho Marino Univ Calif Reserve	
Cayucos	"	30	5/01	2/08	**CAY**		**X**	10/95				Estero Bay State Park	
Hazards	"	31	4/01	3/05	**HAZ**		**X**	10/95				Montano de Oro State Park	
Diablo	"	70	12/07 1/08		**DIA**		**X**	11/07		Point Buchon State Mar Res			
Shell Beach	"	32	3/01	3/06	**SHB**		**X**	10/95					
Occulto	Santa Barbara		None		**OCC**		**X**	3/92				Vandenberg Ecological Reserve	

Purisima	"		None		**PUR**		**Xa**	11/93		1.0mi NW Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Stairs	"	33	3/01	3/03, 2/04	**STA**		**X**	3/92		Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Lompoc	"	60	3/07							Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Boat House	"	36	3/01	3/07	**BOA**		**X**	3/92		0.6mi E Vandenberg State Mar Res		Vandenberg Ecological Reserve	
<u>S. CALIFORNIA</u>													
Government Pt	"	35	5/01	3/06	**GPT**		**X**	3/92			Point Conception		
Alegria	"	38	5/01	5/03, 5/04	**ALEG**		**X**	3/92					
Arroyo Hondo	"	37	5/01	4/05	**ARHO**		**X**	3/92			0.2 mi W Arroyo Hondo Canyon Mouth**		
Coal Oil Point	"	39	3/02	3/06	**COPT**		**X**	3/92				Coal Oil Point Univ Calif Reserve	
Carpinteria	"	40	6/01		**CARP**		**X**	3/92			Carpinteria State Beach**	Carpinteria State Beach	
Mussel Shoals	Ventura	41	5/01		**MUSH**		**X**	11/94					
Old Stairs	"	42	5/01	3/08	**OLDS**		**X**	11/94	Mugu Lagoon to Latigo Point		Old Stairs**		
Paradise Cove	Los Angeles	43	4/01	2/06	**PCOV**		**X**	11/94	Mugu Lagoon to Latigo Point		1.2 mi NE Point Dume Mussel Site		
Whites Pt	"	44	5/01	3/08	**WHPT**		**X**	11/94			0.2 mi SE Royal Palms Mussel Site		
Pt Fermin	"	45	6/01		**PTFM**		**X**	10/99		Point Fermin State Mar Park			
Crystal Cove	Orange	46	4/01	5/03, 5/04	**CRCO**		**X**	11/96	Irvine Coast Mar Life Refuge	Irvine Coast State Mar Cons Area	Crystal Cove State Park**	Crystal Cove State Park	
Shaws Cove	"	47	5/01	4/05	**SHCO**		**X**	10/96	1.5mi SE Irvine Coast MLR; 0.3mi W Heisler Park Ecol Reserve	Heisler Park State Mar Res			
Treasure Island	"		None		**TRIS**		**X**	10/96					
Dana Pt	"	48	5/01	2/06	**DAPT**		**X**	12/96		Dana Point State Mar Cons Area	Dana Point**		
Cardiff	San Diego		None		**CARE**		**X**	10/97		0.2mi S Cardiff- San Elijo State Mar Cons Area	Cardiff Reef**	Cardiff State Beach	
Scripps	"	49	3/02	2/06	**SCRE**		**X**	10/97	San Diego Marine Life Refuge	San Diego-Scripps State Mar Cons Area	Scripps Reef; 1.9mi NE Pt La Jolla Mussel**	Scripps Univ Calif Coastal Reserve	
Navy North	"		None		**NANO**		**X**	2/95				US Navy	
Navy South	"		None		**NASO**		**X**	3/95			0.2mi N Point Loma "Lighthouse" Mussel	US Navy	
Cabrillo Zone I	"	50	3/02	5/04	**CAB1**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	
Cabrillo Zone II	"		None		**CAB2**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	
Cabrillo Zone III	"	51	3/02		**CAB3**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	

SAN MIGUEL ISL													
Otter Harbor	Santa Barbara		None		**SMOH**		**X**	4/85	San Miguel Island		San Miguel Island Otter Harbor**	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Harris Point	"		None		**SMHP**		**X**	4/85	San Miguel Island	Harris Point State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Cuyler Harbor	"	101	11/01	12/02	**SMCH**		**X**	4/85	San Miguel Island	Harris Point State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Crook Pt	"	100	11/01		**SMCP**		**X**	4/85	San Miguel Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SANTA ROSA ISL													
NW Talcott	Santa Barbara	201	12/01	12/04	**SRNW**		**X**	11/86	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Fossil Reef	"	200	12/01	12/04	**SRFR**		**X**	3/88	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
East Pt	"	204	12/01	12/04	**SREP**		**X**	12/86	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Ford Pt	"	203	12/01		**SRFP**		**X**	12/85	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Johnsons Lee	"	202	12/01	12/02, 12/04	**SRJL**		**X**	12/85	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SANTA CRUZ ISL													
Fraser Pt	Santa Barbara	300	1/02	1/03, 1/04	**SCFC**		**X**	9/94	Santa Cruz Island		Santa Cruz Island Fraser Point	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Orizaba	"		None		**SCOC**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Scorpion	"		None		**SCSR**		**X**	9/94	Santa Cruz Island	Scorpion State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Forney	"	301	1/02				**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Prisoners	"	305	4/02	4/03, 1/04	**SCPH**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Trailer	"	302	1/02	1/06	**SCTR**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Valley	"	304	1/02	1/06					Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Willows	"	303	1/02	1/06	**SCWA**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
ANACAPA ISL													
Middle East	Ventura		None		**ANME**		**X**	3/82	Anacapa Island	Anacapa Island State Mar Res	Anacapa Island North Middle Island**	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Middle West	"	402	10/01	12/05	**ANMW**		**X**	3/82	Anacapa Island	Anacapa Island State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park

Frenchys Cove	"	401	10/01	12/05	**ANFC**		**X**	3/82	Anacapa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Cat Rock	"	400	12/05		**ANCR**		**X**	3/82	Anacapa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SAN NICOLAS ISL													
Thousand Springs		700	2/03	2/07					San Nicolas Island			US Navy	
Marker Poles		701	2/03	2/07					San Nicolas Island			US Navy	
SANTA BARBARA ISL													
Landing Cove	Santa Barbara	500	11/01	11/06	**SBLC**		**X**	3/85	Santa Barbara Is			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Sea Lion Rookery	"	501	12/01	11/06	**SBSL**		**X**	3/85	Santa Barbara Is	Santa Barbara Island State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
CATALINA ISL													
Bird Rock	Los Angeles	600	4/02	1/04, 4/07	**CTBR**		**X**	2/82	Santa Catalina Is		Bird Rock		
Little Harbor	"	601	4/02	4/07	**CTLH**		**X**	12/94	Santa Catalina Is				
BAJA CALIFORNIA													
La Buffadora		1001	2/03										
La Chorera		1002	2/03										
Punta Baja		1003	2/03										
El Tivo, Natividad I			3/07										
Punta Prieta, Natividad I			3/07										
Babencho Grande, Natividad			3/07										
El Nido, Natividad I			3/07										
La Cueva, Natividad I			3/07										
La Plana, Natividad I			3/07										
Punta Rompiente		1004	2/03										
Punta San Roque		1005	2/03										
Punta Abreojos		1006	2/03										
MAINLAND MEXICO													
Punta Borascosa		2001	3/03										
Pelican Pt		2002	3/03										
Punta Libertad		2003	3/03										
Punta Cerro Prieto II		2004	3/03										

Note: Biodiversity survey dates based on 4/15/08 Coastal Biodiversity website (http://cbsurveys.ucsc.edu/).
ASBS = Area of Special Biological Significance (California State Water Board)
CFG MPA = California Department of Fish and Game Marine Protected Area
xa = Abalone only monitoring site
*New Mussel Watch sites to be established 2008/09
**New Mussel Watch sites established 2007/08

Table 2. MARINe Partners

Primary Sponsors

- U.S. Minerals Management Service
- Channel Islands National Park
- Partnership for Interdisciplinary Studies of Coastal Oceans

Major Sponsors

- Cabrillo National Monument
- California Ocean Protection Council
- Golden Gate National Recreation Area
- Monterey Bay National Marine Sanctuary
- Point Reyes National Seashore
- Redwoods National and State Parks
- Southern California Coastal Water Research Project
- California Coastal Commission (past)
- County of Santa Barbara (past)
- San Diego Association of Governments (past)
- United States Navy (past)

Other Sponsors

- Cabrillo Marine Aquarium
- California Department of Fish and Game
- California State Water Quality Control Board
- National Center for Ecological Analysis and Synthesis
- National Park Service Northeast Temperate Network
- Tatman Foundation
- Tenera Environmental

MARINe Partners (continued)

Contributors

- California State University Fullerton
- Gulf of the Farallones National Marine Sanctuary
- Santa Barbara Channelkeeper
- University of California Berkeley
- University of California Los Angeles
- University of California Santa Barbara
- University of California Santa Cruz
- University of Southern California

Collaborators (past and presesent)

- Bodega Bay Marine Laboratories
- Bureau of Land Management California Coastal Monument
- California Coastal Commission
- California Coastal Conservancy
- California Polytechnic University, San Luis Obispo
- California State Parks and Recreation
- California State University Humboldt
- California State University Los Angeles
- Channel Islands National Marine Sanctuary
- County of San Luis Obispo
- County of Ventura
- Los Angeles County Natural History Museum
- Moss Landing Marine Labs
- NOAA National Status and Trends Program
- Santa Monica Bay Restoration Commission
- Scripps Institution of Oceanography
- Southern California Coastal Ocean Observing System
- Stanford University: Hopkins Marine Station
- University of California Natural Reserve System

Table 3. MARINe Monitoring Groups

Monitoring Group	Monitoring Regions
Olympic Coast National Marine Sanctuary (**OCNMS**)	Wahington State sites in OCNMS outside OLYM
Olympic National Park (**OLYM**)	Washington State sites in OLYM and San Juan Island National Historic Park
University of California Santa Cruz (**UCSC**)	Sites from Pt Conception north to Oregon & all biodiversity sites
Point Reyes National Seashore	Sites within Point Reyes National Seashore
Golden Gate National Recreation Area	Sites within Golden Gate National Recreation Area
University of California Santa Barbara (**UCSB**)	San Diego County & Santa Catalina Island
Channel Islands National Park (**CINP)**	Santa Barbara, Anacapa, Santa Cruz, Santa Rosa, & San Miguel Islands
MMS Intertidal Team (**MINT**)	San Luis Obispo, Santa Barbara, Ventura, & LA Counties
University of California Los Angeles (**UCLA**)	Southern Santa Barbara, Ventura, & LA Counties
California State University Fullerton (**CSUF**)	Orange County
Cabrillo National Monument (**CABR**)	Cabrillo National Monument sites (San Diego)

Table 4. Standardized Names for Target Species Plots

		Official Target Species for MARINe			
Plot Name	**Plot Type**	**Scientific Name**	**Common Name**	**6-Letter Code**	**3-LetterBrief**
Plants					
Egregia	Transect	*Egregia menziesii*	Boa Kelp	EGRMEN	EGR
Fucus	Photoplot	*Fucus gardneri*	Northern Rockweed	FUCGAR	FUC
Hedophyllum	Transect	*Hedophyllum sessile*	Sea Cabbage	HEDSES	HED
Hesperophycus	Photoplot	*Hesperophycus californicus*	Olive Rockweed	HESCAL	HES
Pelvetiopsis	Photoplot	*Pelvetiopsis limitata*	Dwarf Rockweed	PELLIM	PEL
Silvetia	Photoplot	*Silvetia compressa*	Golden Rockweed	SILCOM	SIL
Endocladia	Photoplot	*Endocladia muricata*	Turfweed	ENDMUR	END
Neorhodomela	Photoplot	*Neorhodomela larix*	Black Pine	NEOLAR	NEO
Phyllospadix	Transect	*Phyllospadix scouleri/torreyi*	Surfgrass	PHYOVR	PHY
Invertebrates					
Anthopleura	Photoplot	*Anthopleura elegantissima/sola*	Green Anemone	ANTELE	ANT
Mytilus	Photoplot	*Mytilus californianus*	California Mussel	MYTCAL	MYT
Lottia	Size/Count	*Lottia gigantea*	Owl Limpet	LOTGIG	LOT
Haliotis	Size/Count	*Haliotis cracherodii*	Black Abalone	HALCRA	HAL
Chthamalus/Balanus	Photoplot	*Chthamalus dalli/fissus/Balanus glandula*	White Barnacle	CHTBAL	CHT
Semibalanus	Photoplot	*Semibalanus cariosus*	Thatched Barnacle	SEMCAR	SEM
Tetraclita	Photoplot	*Tetraclita rubescens*	Pink Barnacle	TETRUB	TET
Pollicipes	Photoplot	*Pollicipes polymerus*	Goose Barnacle	POLPOL	POL
Pisaster	Size/Count	*Pisaster ochraceus*	Ochre Seastar	PISOCH	PIS
		Other Species "Targeted" by Some Monitoring Groups			
Plot Name		**Scientific Name**	**Common Name**	**6-Letter Code**	**3-LetterBrief**
Plants					
Mastocarpus	Photoplot	*Mastocarpus papillatus*	Turkish Washcloth	MASPAP	MAS
Mazzaella	Photoplot	*Mazzaella spp (=Iridaea spp)*	Iridescent Weed	MAZSPP	MAZ
Postelsia*	Size/Count	*Postelsia palmaeformis*	Northern Sea Palm	POSPAL	POS
Red Algae	Photoplot Transect	(includes plots targeting *Gelidium* & Red Algal & transects targeting Turf)	Red Algae	REDALG	RED
Invertebrates					
Balanus	Photoplot	*Balanus glandula*	Northern Barnacle	BALGLA	BAL
Other					
Tar	Photoplot		Tar	TAR	TAR
Recovery	Photoplot		Recovery	RECOV	REC
*note these data are not yet in database, and will likely be added to tblSpeciesCountSize (# of plants counted in 2 m swaths or in grids)					

Table 5. MARINe Core Species, Higher Taxa, and Substrates

(Target species are shown in bold.)	Photoplots	Transects	Size & Counts	Field Log Recon	Motile Inverts
GREEN ALGAE					
Cladophora columbiana	X			X	
Ulva/Enteromorpha	X			X	
Other Green Algae (any greens not listed above)*	X	X			
BROWN ALGAE					
***Egregia menziezii* (Boa Kelp)**	X	X		X	
Eisenia arborea	X	X		X	
Endarachne/Petalonia	X			X	
***Fucus gardneri* (= *F. distichus*)(Northern Rockweed)**	X			X	
Halidrys dioica/Cystoseira spp	X	X		X	
***Hedophyllum sessile* (Sea Cabbage)**	X	X		X	
***Hesperophycus californicus (= H. harveyanus)*(Olive Rockweed)**	X			X	
***Pelvetiopsis limitata* (Dwarf Rockweed)**	X			X	
***Postelsia palmaeformis* (Northern Sea Palm)**			X	X	
Sargassum muticum	X	X		X	
Scytosiphon spp	X			X	
***Silvetia compressa* (= *Pelvetia fastigiata*)(Golden Rockweed)**	X			X	
Other Brown Algae (any browns not listed above)*	X	X			
RED ALGAE					
Chondracanthus canaliculatus (= Gigartina canaliculata)	X			X	
***Endocladia muricata* (Turfweed)**	X			X	
***Mastocarpus papillatus* (blade)(Turkish Washcloth)**	X			X	
Mazzaella affinis (= Rhodoglossum affine)	X			X	
***Mazzaella* spp.(= *Iridaea* spp.)(Iridescent Weed)**	X			X	
***Neorhodomela larix)* (Black Pine)**	X			X	
Porphyra sp	X			X	
Articulated Corallines (Erect Corallines)	X	X			
Crustose Corallines (Encrusting Corallines)	X	X			
Other Red Algae (any reds not listed above)*	X	X			
ALGAE/PLANTS					
***Phyllospadix scouleri/torreyi* (Surfgrass)**	X	X		X	
Non-Coralline Crusts (reds and browns)	X	X			
Other Plant/Algae*	X	X			
ANEMONES					
***Anthopleura elegantissima/sola* (Green Anemone)**	X	X		X	
POLYCHAETE WORMS					
Phragmatopoma californica	X	X		X	
MOLLUSKS					
Acanthina spp					X
Fissurella volcano					X
***Haliotis cracherodii* (Black Abalone)**			X	X	
Katharina tunicata			X		
Lepidochitona hartwegii					X
Littorina spp				X	X
***Lottia gigantea* (Owl Limpet)**	X		X	X	X

Table 5. MARINe Core Species (cont.)

(Target species are shown in bold.)

	Photoplots	Transects	Size & Counts	Field Log Recon	Motile Inverts
MOLLUSKS (cont.)					
Mopalia spp					X
***Mytilus californianus* (California Mussel)**	X	X		X	
Nucella emarginata					X
Nucella canaliculata					X
Nuttalina spp					X
Ocenebra circumtexta					X
Tegula brunnea					X
Tegula funebralis					X
Tegula gallina					X
Tegula spp				X	
Limpets	X				
Large Limpets > 15mm (excluding *L. gigantea*)					X
Medium Limpets 5-15mm					X
Small Limpets < 5mm					X
Chitons	X				
BARNACLES					
***Balanus glandula* (Northern Barnacle)**	X**				
***Chthamalus dalli/fissus & Balanus glandula* (White Barnacle)**	X			X	
***Pollicipes polymerus* (Goose Barnacle)**	X			X	
***Semibalanus cariosus* (Thatched Barnacle)**	X			X	
***Tetraclita rubescens* (Pink Barnacle)**	X			X	
Barnacles		X			
Other Barnacles (any barnacles not listed above)*	X				
ECHINODERMS					
***Pisaster ochraceus* (Ochre Star)**	X	X	X	X	
Henricia spp			X		
Strongylocentrotus purpuratus				X	
CRUSTACEANS					
Ligia occidentalis				X	
Pachygrapsis crassipes					X
Pagurus spp					X
INVERTEBRATES					
Other Invertebrates (Other Animals) (any inverts not listed above)*	X	X			
SUBSTRATES					
Rock (Bare Rock)	X	X			
Sand	X	X			
Tar	X	X		X	
UNDETERMINED					
Other Substrate (e.g., dead mussel shells or barnacle tests)	X	X			
Unidentified (cannot tell if plant, invert or substrate)	X	X			

* The specific definitions of these categories are different for photoplots compared to transects.

** Core species for MARINe North only.

Table 6. Definitions for Core Higher Taxa and Substrates.

Articulated (Erect) Corallines: erect, jointed, calcified, red algae of the Family Corallinaceae, with flexible, articulate fronds arising from crustose bases.

Barnacles: adults or juveniles of any barnacle (Phylum Arthropoda, Class Crustacea, Subclass Cirripedia) species.

Chitons: adults or juveniles of any chiton (Phylum Mollusca, Class Polyplacophora) species.

Crustose (Encrusting) Corallines: thin, flattened, calcified, crust-like red algae of the Family Corallinaceae, having no erect, articulated fronds. Bleached crustose corallines (white) are scored as well because they may be alive.

Limpets: adults or juveniles of any limpet (Phylum Mollusca, Class Gastropoda, Family Acmaeidae) species, including *Lottia gigantea*.

Non-Coralline Crusts: any thin, flattened, crust-like red or brown algae that are not calcified species of the Family Corallinaceae.

Other Invertebrates (Other Animals): any invertebrates not listed or not identifiable in other more specific categories on the score sheet.

Other Barnacles: any barnacles not listed or not identifiable in other more specific categories on the score sheet.

Other Brown Algae: any brown algae not listed or not identifiable in other more specific categories on the score sheet (score "non-coralline crusts" separately).

Other Green Algae: any green algae not listed or not identifiable in other more specific categories on the score sheet.

Other Plant (Other Algae): any plants (algae) not listed or not identifiable in other more specific categories on the score sheet.

Other Red Algae: any red algae not listed or not identifiable in other more specific categories on the score sheet (score "non-coralline crusts" separately).

Rock (Bare Rock): bare, unconsolidated substrates larger than sand/gravel (including cobble, rocks, and boulders) and all consolidated substrates (i.e., bedrock) that contain no obvious living organisms or tar (epoxy corner markers and inconspicuous blue-green algal films are scored as "rock").

Sand: granular, particulate (fine sand to gravel) substrate. Photoplots: score "sand" unless you can positively identify what lies under the sand in the photo. Transects: score "sand" whenever sand cover is 2cm or greater.

Tar: fresh or weathered oil or tar coating on the substrate.

Unidentified: cannot tell if plant, invertebrate, or substrate.

Table 7. Target Species Monitored in Photoplots at MARINe Core Sites.

MAINLAND	**Start**	**FUCGAR**	**HESCAL**	**PELLIM**	**SILCOM**	**ENDMUR**	**NEOLAR**	**MAZSPP**	**MASPAP**	**REDALG**	**ANTELE**	**MYTCAG**	**BALGLA**	**CHTBAL**	**SEMCAR**	**TETRUB**	**POLPOL**	**TAR**
Oregon	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Clatsop Co.																		
Ecola	2001			5			5					5	5					
Lincoln Co.																		
Fogarty Creek	2000	5		5			5					5	5					
Lane Co.																		
Bob Creek	2000	5		5		5						5	5					
Coos Co.																		
Cape Arago	2000	5		5		5						5	5					
Curry Co.																		
Burnt Hill	2002			5		5						5	5					
California																		
Del Norte Co.																		
Enderts	2004			5		5						5		5				
Damnation Creek	2004	5				5						10*		5				
*5 plots are surrounded by freshwater (upcoast) and 5 are regular marine (downcoast)																		
False Kalamath Cove	2004	5		5		5						5		5				
Humboldt Co.																		
Cape Mendocino	2004	5		5		5			5			5		5				
Shelter Cove	2004	5		5		5						5		5	5			
Mendocino Co.																		
Kibesillah Hill	2004	5		5		5			5			5		5				
Stornetta																		
Sea Ranch	2004	5		5		5	5					5		5				
Sonoma Co.																		
Bodega	2001			5		5						5		5				
Marin Co.																		
Santa Maria Creek	2006			5								5						
Bolinas Point	2005																	
Slide Ranch	2006																	
Point Bonita	2006																	
San Mateo Co.																		
Pebble Beach	2004																	
Pigeon Point	2002																	
Franklin Point	2004																	
Santa Cruz Co.																		
Scott Creek	1999	5			5	5						5		5				
Davenport Landing	2007																	
Sand Hill Bluff*	1999			5								5	5	5				
*UCSC PISCO monitors 2 "Recovery" plots at Sand Hill Bluff set up SP03																		
Wilder Ranch	2007																	
Terrace Point	1999				5				5			5	5	5				

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
Santa Cruz Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Natural Bridges	2007																	
Monterey Co.																		
Hopkins	1999				5	5			5			5	5	5				
Point Pinos	2007																	
China Rocks	2007																	
Stillwater	2000				5	5			5			5		5				
Carmel Point	2004																	
Point Lobos	1999				5	5			5			5		5				
Mal Paso	2000																	
Garrapata	2007																	
Soberanes	2004																	
Andrew Molera	1999	5			5	5						5		5				
Partington Cove	2004																	
Mill Creek	1999				5	5			5			5		5				
Pacific Valley	2004																	
San Luis Obispo Co																		
Pt Sierra Nevada	1995		5		5			5	5			5		5				
Piedras Blancas	1997																	
San Simeon Point	2007																	
Vista del Mar	2007																	
Rancho Marino	2001																	
Cayucos	1995		5		5	5						5		5				
Hazard's	1995				5	5		5				5		5				
Diablo	2007																	
Shell Beach	1995				5	5			5			5		5				
Santa Barbara Co																		
Occulto	1992					5						5		5				
Purisima	1993																	
Stairs*	1992				5	5						5		5				
*UCSC monitors 6 “Recovery” plots at Stairs																		
Boat House	1992				5	5					5	5		5				
Government Point	1992				5	5						5		5			5	
Alegria	1992										5	5		5			5	
Arroyo Hondo	1992											5		5				
Coal Oil Pt.	1992										5	5*						
*5 MYTCAL plots added SP03																		
Carpinteria	1992										5	5		5			5	
Ventura Co.																		
Mussel Shoals	1994										5	5		5				
Old Stairs	1994					5					5	5		5				
LA Co.																		
Paradise Cove	1994					5						5		5				
White's Point	1994					5						5		10*				
*5 plots emphasize *Chthamalus* spp. and 5 emphasize *Balanus glandula*, but both barnacle species are scored as *Chthamalus/Balanus*																		

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
LA Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Point Fermin	1999				5							5		5				
Orange Co.																		
Crystal Cove	1996				5							5		5				
Shaws Cove	1996				5	5						5		5				
Treasure Island	1996				5							5		5				
Orange Co.																		
Dana Point	1996				5							5		5				
San Diego Co.																		
Cardiff Reef	1997											10*		5			5	
*5 plots located on onshore reef and 5 on offshore reef																		
Scripps Reef	1997				5							5		5			5	
Navy North	1995				5							5		5		5	6[1]	
Navy South	1995				5							5		5		5	6[1]	
Cabrillo I	1990				5							5		5		5	6[1]	
Cabrillo II	1990				5							5		5		5	6[1]	
Cabrillo III	1990				5							5		5		5	6[1]	
ISLANDS																		
San Miguel I.																		
Otter Harbor	1985				5[2]	5[3]						5		5				
Harris Point	1985		5[2]			5[3]						5		2		3		
Cuyler Harbor	1985				5[2]	5[3]						5		5				
Crook Point	1985				5[2]	5[3]						5		5				
Santa Rosa I.																		
NW Talcott	1986				5[2]	5[3]						5		5				
Fossil Reef	1988				5[2]	5[3]						5		5				
Johnson's Lee	1985					5[3]						5		5				
Ford Point	1985					5[3]						5		5				
East Point	1986				5[2]	5[3]						5		5				
Santa Cruz I.																		
Fraser	1994		5		5	5						5		5			5	5
Trailer	1994		5		5							5		5				
Willows	1994		5		5	5						5						
Orizaba	1994		5		5							5		5		5		
Prisoner's	1994		5		5	5						5		5				
Scorpion	1994		5			5						5		5		5		
Anacapa I.																		
Middle West	1982				5[2,4]	5[3,4]						5[4]		5[4]				
Middle East	1982				3[2,4]	3[3,4]						3[4]		3[4]				
Frenchy's Cove	1982				5[2]	5[3]						5		5				
Cat Rock	1982				9[2,4]	9[3,4]						9[4]		9[4]				
Santa Barbara I.																		
Landing Cove	1985				5[2]					5*		5		5				
*In REDTUR plots, points scored as REDTUR are primarily *Gelidium* spp. and *Chondracanthus canaliculatus*.																		
Sea Lion Rookery	1985				5[2]	5[3]						5		5				

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
Santa Catalina I.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Bird Rock	1982				5*					5*		5*		5*		5	5	
*1 year trampling experiment followed by recovery monitoring from 1/82-F94 (21 SILCOM, 12 GELSPP, 12 CHTBAL, and 12 MYTCAL ¼ m2 plots (3 control, 3 light, 3 med, and 3 heavy trample (+ 3 Boots—SILCOM))). In F94, a subset of plots was converted to core MARINe monitoring.																		
Little Harbor	1982				5							5		5		5		

[1] 3 *Pollicipes* 1m X 10m transects at Cabrillo I, II, III converted to 6 photoplots starting S95; 6 plots established at Navy North & South to compare same number of replicates as Cabrillo.

[2] In some SILCOM plots and HESCAL plots, SILCOM and HESCAL were scored together as "rockweed."

[3] ENDMUR plots may include some *Gelidium* spp and *Chondracanthus canaliculatus* scored as ENDMUR.

[4] 8 or 9 plot replicates were initially established as part of a pre-monitoring experiment (3 Control, 3 Trample, 3 Scrape). Middle E & Middle W were originally one site.

Table 8. Target Species Monitored in Transects and Plots (not photoplots)

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
MAINLAND	EGRMEN	REDALG	PHYOVE	Owl Limpets		Black Abalone	Ochre Seastars	Northern Sea Palm
Oregon	#Transects &Start Year	#Transects &Start Year	#Transects &Start Year	# Plots & Type	Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year
Clatsop Co.								
Ecola			1 2001			**Abalone**	3 IP 2001	**Sea Palm**
Lincoln Co.						**Monitoring**		**Monitoring**
Fogarty Creek			3 2000			**Sites**	3 IP 2000	**Sites**
Lane Co.						**Not**		**Not**
Bob Creek			3 2000			**Indicated**	3 IP 2000	**Indicated**
Coos Co.								
Cape Arago			3 2000					
Curry Co.								
Burnt Hill			3 2002				3 IP 2002	
California								
Del Norte Co.								
Enderts							2 IP 2004	
Damnation Creek			2 2004				3 IP 2004	
False Kalamath Cove							2 IP 2004	
Humboldt Co.								
Cape Mendocino							3 IP 2004	
Shelter Cove							3 IP 2004	
Mendocino Co.								
Kibesillah Hill			3 2004				3 IP 2004	
Stornetta								
Sea Ranch							3 IP 2004	
Sonoma Co.								
Bodega							3 IP 2001	
Marin Co.								
Santa Maria Creek							3 IP 2006	
Bolinas Point			3 2006				3 IP 2006	
Slide Ranch								
Point Bonita								
San Mateo Co.								
Pebble Beach								
Pigeon Point								
Franklin Point								
Santa Cruz Co.								
Scott Creek			3 1999				3 IP 1999	
Davenport Landing								
Sand Hill Bluff			2 1999	3 CP	1999			
Wilder Ranch								
Terrace Point				5 RP	1999		3 IP 1999	
Natural Bridges								
Monterey Co.								
Hopkins			3 1999	5 CP	1999		3 IP 1999	
Point Pinos								
China Rocks								
Stillwater			3 2000	5 CP	2000		3 IP 2000	
*Abalone sampled in 2 irregular plots established SP02 and in existing seastar plots.								
Carmel Point								
Point Lobos				5 CP	1999		3 IP 2003	
Mal Paso								
Garrapata								
Soberanes								
Andrew Molera			3 1999				3 IP 1999	
Partington Cove								
Mill Creek			3 1999	5 RP	1999		3 IP 1999	
Pacific Valley								
San Luis Obispo Co.								
Pt. Sierra Nevada			3 1995				3 IP 1995	
*Abalone sampled in 2 seastar plots in addition to 3 abalone plots.								
Piedras Blancas								
San Simeon Point								

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
	EGRMEN	REDALG	PHYOVE	Owl Limpets		Black Abalone	Ochre Seastars	Northern Sea Palm
San Luis Obispo Co.	#Transects &Start Year	#Transects &Start Year	#Transects &Start Year	# Plots & Type	Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year
Vista del Mar				5 CP	2004			
Rancho Marino				5 CP	2002	**Abalone**		**Sea Palm**
Cayucos			3 1995	5 CP	1995	**Monitoring**	3 IP[1] 1995	**Monitoring**
Hazard's			3 2001	5 RP	1995	**Sites**	3 IP[1] 1995	**Sites**
Diablo						**Not**		**Not**
Shell Beach			3 1999			**Indicated**	3 IP[1] 1995	**Indicated**
Santa Barbara Co.								
Occulto							1 IP 2000	
Purisima								
Stairs			3 1992	5 CP	1992		3 IP 1992	
Boat House				5 CP	1992		3 IP[1] 1992	
Government Pt.			3 1992	5 CP	1992		3 IP[1] 1992	
Alegria			3 2002	5 CP	1992		3 IP 2002	
Arroyo Hondo			3* 1992				3 BT[2] 1992	
*3rd PHYOVE transect added SP01.								
Coal Oil Pt.			3 1992					
Carpinteria			3 1992	5 CP	2001		3 BT[2] 1992	
Ventura Co.								
Mussel Shoals			3 1994	5 CP	2002		3 IP 1994	
Old Stairs				5 CP	1994		3 IP[2] 1994	
Los Angeles Co.								
Paradise Cove			3 1994	5 CP	1994		3 IP 2002	
White's Point				5 CP	2003			
Point Fermin			3 1999	5 CP	2003		3 IP 2003	
Orange Co.								
Crystal Cove			6* 1996	5 CP	1996		TS 1996	
*PHYOVE transects initially established as 3 20m transects; Transects divided into 6 10m transects in SP97.								
Shaws Cove				5 CP	1996		TS 1996	
Treasure Island							TS 1996	
Dana Point				5 CP	1996		TS 1996	
San Diego Co.								
Cardiff Reef		3[3] 1997	3[3] 1997	5 CP*	1997		TS 1997	
*Owl limpet plots are 3m diameter.								
Scripps Reef		3[3] 1997	3[3] 1997	5 CP	1997		TS 1997	
Navy North		3[3]* 1995	4[3]** 1995	6 CP[4]	1995		TS 1995	
Navy South		3[3]* 1995	4[3]** 1995	6 CP[4]	1995		TS 1995	
*3rd PHYOVE transect added SP02; **2 transects located on inshore reef and 2 transects located on offshore reef.								
Cabrillo I	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
Cabrillo II	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
Cabrillo III	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
ISLANDS								
San Miguel Island								
Otter Harbor				5 CP[5]	2001		5 IP[1] 1985	
Harris Point				5 CP	2001		5IP+1BT[1]	
Cuyler Harbor							TS 1994	
Crook Point				3 IP[5]	1987		5 IP[1] 1985	
Santa Rosa Island								
NW Talcott			3 2001	5 CP	1993		5 IP 1986	
Fossil Reef				5 CP	1999		1 BT 1988	
Johnson's Lee				5 CP*	1988		5IP+1BT[1]	
Ford Point				5 CP*	1988		5 IP[1] 1985	
East Point			3 2002				TS 1994	
Santa Cruz Island								
Fraser			3 1994	5 CP*	1994		TS 1994	
Trailer			3 1994	5 CP	1994		TS 1994	
Willows				5 CP	1994		TS 1994	
Orizaba							TS 1994	
Prisoner's							TS 1994	
Scorpion							TS 1994	
Anacapa Island								
Middle West							TS 1994	

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
	EGRMEN	REDALG	PHYOVE	Owl Limpets		Black Abalone	Ochre Seastars	Northern Sea Palm
Anacapa Island	#Transects &Start Year	#Transects &Start Year	#Transects &Start Year	# Plots & Type	Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year
Middle East								
Frenchy's Cove				3 CP	1999	**Abalone**	TS 1994	**Sea Palm**
Cat Rock				3 CP	1999	**Monitoring**	5 IP[1] 1982	**Monitoring**
Santa Barbara						**Sites**		**Sites**
Landing Cove						**Not**	1 BT 1985	**Not**
Sea Lion Rookery						**Indicated**	5 IP[1] 1985	**Indicated**
Santa Catalina								
Bird Rock				1 IP*	1998		TS 1994	
*Single owl limpet irregular plot = bedrock dike. No other suitable plot locations.								
Little Harbor							TS 1994	

CP = Circular Plot (2m diameter), **RP** = Rectangular Plot (1.5m X 1m plots), **IP** = Irregular Plot, **BT** = Band Transect (2m X ~8m band).
TS = Timed Search, **GT** = Grid Transect (w/ multiple $1m^2$ or other size quadrats)

[2] 3rd IP added 2004.

[3] Transects scored using Line-Intercept method (1cm increments for 10m line thus 1,000 segments) from site establishment through SP00.

[4] 3 plots on inshore cliff & 3 on offshore rocks @ Cabrillo sites; 6 plots on cliff faces @ Navy sites for similar # replicates.

Table 9. Motile Invertebrate Monitoring at MARINe Sites.

See Table 4 for full target species plot name; sampling frequency semi-annual, except annual (spring) for island sites (starting 2002), Ventura/LA County (starting 2004), and annual (summer) for sites from Sonoma County north to Oregon; start Year represents 1st year using standard protocol. Sites may have protocol testing data for prior year(s).

MAINLAND	Start	FUC	HES	PEL	SIL	END	NEO	MAZ	RED	ANT	MYT	MYTdn	BAL	CHT	SEM	TET	POL	TAR
Oregon	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Clatsop Co.																		
Ecola																		
Lincoln Co.																		
Fogarty Creek																		
Lane Co.																		
Bob Creek																		
Coos Co.																		
Cape Arago																		
Curry Co.																		
Burnt Hill																		
California																		
Del Norte Co.																		
Enderts	2004			5		5					5			5				
Damnation Creek	2004	5				5					5	5		5				
False Kalamath Cove	2004	5		5		5					5			5				
Humboldt Co.																		
Cape Mendocino	2004	5		5		5		5			5			5				
Shelter Cove	2004	5		5		5					5			5	5			
Mendocino Co.																		
Kibesillah Hill	2004	5		5		5		5			5			5				
Stornetta																		
Sea Ranch	2004	5		5		5					5			5				
Sonoma Co.																		
Bodega	2002			5		5					5			5				
Marin Co.																		
Santa Maria Creek																		
Bolinas Point																		
Slide Ranch																		
Point Bonita																		
San Mateo Co.																		
Pebble Beach																		
Pigeon Point																		
Franklin Point																		
Santa Cruz Co.																		
Scott Creek	2002	5			5	5					5			5				
Davenport Landing																		
Sand Hill Bluff	2002			5							5		5	5				
Wilder Ranch																		
Terrace Point	2002				5			5			5		5	5				
Natural Bridges																		

	Start Year	FUC # Plots	HES # Plots	PEL # Plots	SIL # Plots	END # Plots	NEO # Plots	MAZ # Plots	RED # Plots	ANT # Plots	MYT # Plots	MYTdn # Plots	BAL # Plots	CHT # Plots	SEM # Plots	TET # Plots	POL # Plots	TAR # Plots
Monterey Co.					5	5		5			5		5	5				
Hopkins	2002																	
Point Pinos																		
China Rocks																		
Stillwater	2002				5	5		5			5			5				
Carmel Point																		
Point Lobos	2002				5	5		5			5			5				
Mal Paso																		
Garrapata																		
Soberanes																		
Andrew Molera	2002	5			5	5					5			5				
Partington Cove																		
Mill Creek	2002				5	5		5			5			5				
Pacific Valley																		
San Luis Obispo Co																		
Pt Sierra Nevada	2001		5		5						5			5				
Piedras Blancas																		
San Simeon Point																		
Vista del Mar																		
Rancho Marino																		
Cayucos	2001		5		5	5					5			5				
Hazard's	2001				5	5					5			5				
Diablo																		
Shell Beach	2001				5	5		5			5			5				
Santa Barbara Co																		
Occulto	2001					5					5			5				
Purisima																		
Stairs	2001				5	5			5		5			5				
Boat House	2001				5	5					5			5				
Government Point	2001				5	5					5			5				
Alegria	2001									5	5			5			5	
Arroyo Hondo	2001										5			5				
Coal Oil Pt.	2001									5	5							
Carpinteria	2001									5	5			5			5	
Ventura Co.																		
Mussel Shoals	2002									5	5			5				
Old Stairs	2002					5				5	5			5				
LA Co.																		
Paradise Cove	2002					5					5			5				
White's Point	2002					5					5		5	5				
Point Fermin	2002				5						5			5				
Orange Co.																		
Crystal Cove	2003				5						5			5				
Shaws Cove	2003				5	5					5			5				
Treasure Island	2003				5						5			5				

	Start	FUC	HES	PEL	SIL	END	NEO	MAZ	RED	ANT	MYT	MYTdn	BAL	CHT	SEM	TET	POL	TAR
Orange Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Dana Point	2003				5						5			5				
San Diego Co.																		
Cardiff Reef																		
Scripps Reef																		
Navy North																		
Navy South																		
Cabrillo I																		
Cabrillo II																		
Cabrillo III																		
ISLANDS																		
San Miguel I.																		
Otter Harbor	2002				5	5					5			5				
Harris Point	2002		5			5					5			5		5		
Cuyler Harbor	2002				5	5					5			5				
Crook Point	2002				5	5					5			5				
Santa Rosa I.																		
NW Talcott	2002				5	5					5			5				
Fossil Reef	2002				5	5					5			5				
Johnson's Lee	2002					5					5			5				
Ford Point	2002					5					5			5				
East Point	2002				5	5					5			5				
Santa Cruz I.																		
Fraser	2002		5		5	5					5			5			5	5
Trailer	2002		5		5						5			5				
Willows	2002		5		5	5					5							
Orizaba	2002		5		5						5			5		5		
Prisoner's	2002		5		5	5					5			5				
Scorpion	2002		5			5					5			5		5		
Anacapa I.																		
Middle West	2002				5	5					5			5				
Middle East	2002				5	5					5			5				
Frenchy's Cove	2002				5	5					5			5				
Cat Rock	2002				5	5					5			5				
Santa Barbara I.																		
Landing Cove	2002				5						5			5				
Sea Lion Rookery	2002				5	5					5			5				
Santa Catalina I.																		
Bird Rock																		
Little Harbor																		

Table 10. Barnacle and Mussel Recruitment Monitoring at MARINe Sites.

MAINLAND	*Chthamalus dalli/fissus/Balanus glandula*		*Mytilus californianus*	
Oregon	**# Plates/Clearings**	**Start Year**	**# Tuffys**	**Start Year**
Clatsop Co.				
Ecola				
Lincoln Co.				
Fogarty Creek				
Lane Co.				
Bob Creek				
Coos Co.				
Cape Arago				
Curry Co.				
Burnt Hill				
California				
Del Norte Co.				
Enderts				
Damnation Creek				
False Kalamath Cove				
Humboldt Co.				
Cape Mendocino	5[1]	2004		
Shelter Cove	5[1]	2004		
Mendocino Co.				
Kibesillah Hill	5[1]	2004		
Stornetta				
Sea Ranch	5[1]	2004		
Sonoma Co.				
Bodega	5	2004		
Marin Co.				
Santa Maria Creek				
Bolinas Point				
Slide Ranch				
Point Bonita				
San Mateo Co.				
Pebble Beach				
Pigeon Point				
Franklin Point				
Santa Cruz Co.				
Scott Creek	5	1999		
Davenport Landing				
Sand Hill Bluff	5	1999		
Wilder Ranch				
Terrace Point	5	1999		
Natural Bridges				
Monterey Co.				
Hopkins	5	1999		
Point Pinos				
China Rocks				
Stillwater	5	2000		
Carmel Point				
Point Lobos	5	1999		
Mal Paso				
Garrapata				
Soberanes				
Andrew Molera	5	1999		
Partington Cove				
Mill Creek	5	1999		
Pacific Valley				
San Luis Obispo Co.				
Pt. Sierra Nevada	5			
Piedra Blancas				
San Simeon Point				
Vista del Mar				
Rancho Marino				
Cayucos	5			
Hazard's	5			
Diablo				

	Chthamalus dalli/fissus/Balanus glandula		*Mytilus californianus*	
San Luis Obispo Co.	**# Plates/Clearings**	**Start Year**	**# Tuffys**	**Start Year**
Shell Beach	5			
Santa Barbara Co.				
Occulto	5			
Purisima				
Stairs	5			
Boat House	5			
Government Pt.	5			
Alegria	5		5	
Arroyo Hondo	5			
Coal Oil Pt.	5		5	
Carpinteria	5			
Ventura Co.				
Mussel Shoals	5			
Old Stairs	5			
Los Angeles Co.				
Paradise Cove	5			
White's Point	5			
Point Fermin				
Orange Co.				
Crystal Cove				
Shaws Cove				
Treasure Island				
Dana Point				
San Diego Co.				
Cardiff Reef				
Scripps Reef				
Navy North				
Navy South				
Cabrillo I				
Cabrillo II				
Cabrillo III				
ISLANDS				
San Miguel Island				
Otter Harbor				
Harris Point				
Cuyler Harbor				
Crook Point				
Santa Rosa Island				
NW Talcott				
Fossil Reef				
Johnson's Lee				
Ford Point				
East Point				
Santa Cruz Island				
Fraser	5	1994	5	1994
Trailer	5	1994	5	1994
Willows	5	1994	5	1994
Orizaba				
Prisoner's	5	1994	5	1994
Scorpion				
Anacapa Island				
Middle West				
Middle East				
Frenchy's Cove				
Cat Rock				
Santa Barbara Island				
Landing Cove				
Sea Lion Rookery				
Santa Catalina Island				
Bird Rock				
Little Harbor				

[1] Clearings only – no plates.

Table 11. Temperature Logger Deployment at MARINe Core Sites.

MAINLAND					
Oregon	**Shore Zone Location**	**Sampling Interval (min)**	**Deployment Mo/Year**	**Logger Type (e.g. Tidbit)**	**Logger Housing (e.g. PVC tube, epoxy mussel)**
Clatsop Co.					
Ecola					
Lincoln Co.					
Fogarty Creek					
Lane Co.					
Bob Creek					
Coos Co.					
Cape Arago					
Curry Co.					
Burnt Hill					
California					
Del Norte Co.					
Enderts	Below Mussel	15[1]	4/2004		
Damnation Creek	Below Mussel	15[1]	4/2004		
False Kalamath Cove	Below Mussel	15[1]	4/2004		
Humboldt Co.					
Cape Mendocino	Below Mussel	15	6/2005		
Shelter Cove	Below Mussel	15	6/2005		
Mendocino Co.					
Kibesillah Hill	Below Mussel	15	6/2005		
Stornetta					
Sea Ranch	Below Mussel	15	6/2005		
Sonoma Co.					
Bodega	Below Mussel	15	6/2005		
Marin Co.					
Santa Maria Creek					
Bolinas Point					
Slide Ranch					
Point Bonita					
San Mateo Co.					
Pebble Beach					
Pigeon Point (North)	Below Mussel	15	6/2000		
Pigeon Point (South)	Below Mussel	15	12/2003		
Franklin Point					
Santa Cruz Co.					
Scott Creek	Below Mussel	15	6/2001		
Davenport Landing					
Sand Hill Bluff	Below Mussel	15	12/1999		
Wilder Ranch					
Terrace Point	Below Mussel	15	12/1999		
Natural Bridges					
Monterey Co.					
Hopkins	Below Mussel	15	12/1999		
Point Pinos					
China Rocks					
Stillwater	Below Mussel	15	3/2000		
Carmel Point					
Point Lobos	Below Mussel	15	3/2004		
Mal Paso					
Garrapata					
Soberanes	Below Mussel	15	7/2003		
Andrew Molera	Below Mussel	15	12/1999		
Partington Cove					
Mill Creek	Below Mussel	15	4/2004		
Pacific Valley					
San Luis Obispo Co.					
Pt. Sierra Nevada	Below Mussel	15	2005		
Piedra Blancas	Below Mussel	15	2005		
San Simeon Point					
Vista del Mar					
Rancho Marino	Below Mussel	15	2005		
Cayucos	Below Mussel	15	2005		

Hazard's	Below Mussel	15	2005		
Diablo					
Shell Beach	Below Mussel	15	2005		
Santa Barbara Co.					
Occulto	Below Mussel	15	2005		
Purisima	Below Mussel	15	2005		
Stairs	Below Mussel	15	2005		
Boat House	Below Mussel	15	2005		
Government Pt.	Below Mussel	15	2005		
Alegria					
Arroyo Hondo					
Coal Oil Pt.					
Carpinteria					
Ventura Co.					
Mussel Shoals					
Old Stairs					
Los Angeles Co.					
Paradise Cove					
White's Point					
Point Fermin					
Orange Co.					
Crystal Cove	Above Mussel	5	10/2005		
Shaws Cove	Above Mussel	30	11/2005		
Treasure Island	Above Mussel	30	11/2005		
Dana Point	Above Mussel	5	9/2005		
San Diego Co.					
Cardiff Reef					
Scripps Reef					
Navy North					
Navy South					
Cabrillo I	Below Mussel	4	2000		
Cabrillo II	Below Mussel	4	2000		
Cabrillo III	Below Mussel	4	2000		
ISLANDS					
San Miguel Island					
Otter Harbor					
Harris Point	Mid Mussel	16*	1992		
*Housing lost winter 2000—no deployment since.					
Cuyler Harbor					
Crook Point	Mid Mussel	16[2]	1992		
Santa Rosa Island					
NW Talcott	Mid Mussel	16[2]	1992		
Fossil Reef					
Johnson's Lee	Mid Mussel	16[2]	1992		
Ford Point					
East Point	Mid Mussel	16*	1992		
*Housing lost winter 2004—no deployment since.					
Santa Cruz Island					
Fraser	Mid Mussel	16			
Trailer	Mid Mussel	16			
Willows	Mid Mussel	16			
Orizaba					
Prisoner's	Mid Mussel	16			
Scorpion					
Anacapa Island					
Middle West	Mid Mussel	16	1992		
Middle East					
Frenchy's Cove	Mid Mussel	16[2]	1992		
Cat Rock					
Santa Barbara Island					
Landing Cove	Mid Mussel	16	1992		
Sea Lion Rookery					
Santa Catalina Island					
Bird Rock					
Little Harbor					

[1] Switched to 20 min interval starting 8/05.
[2] Data gaps occurred since deployment date.

Form 1a: Prototype MARINe Rocky Intertidal Field Log

(Fill in all blanks.: **----**=No Data; **0**=None: **L**=Low; **M**=Med; **H**=High; or Actual Value)

Site:______________________ Date:___/___/___ Time:_____ to _____ Low Tide:_____(ft) at _____(hr)
Participants (Recorder 1st):____

Weather and Sea Conditions (affecting quality of sampling)(use codes listed above)
Swell/Surge:________ Wind:________ Rain:_______ Recent Rain:_______ Water Temp (°C):_______
Substratum Changes (sediment=sand, gravel, cobble) (magnitude at site)
Sediment Level:_______ Scour:_______ Rock Movement:_______
Debris and Pollutants (magnitude at site):
Plant Wrack:_____ Driftwood:_____ Shells:______ Dead Animals:______ Trash:______ Oil/Tar:_____
Notes on Physical Conditions:____

Birds and Mammals (maximum # seen at any one time during the sampling)(see bird/mammal list for other species)

Pelican	Great Egret			CA Sea Lion
Cormorant	Snowy Egret			Harbor Seal
Gull	Lg Shorebird			Elephant Seal
Tern	Sm Shorebird			Sea Otter
Oystercatcher	Other Birds			Dog
Blue Heron				

Bird/Mammal Notes:____

Humans (maximum # seen at any one time during the sampling; note behavior) Reef:________ Sand:________

Plot Marker Loss/Repair Notes:____

Other Notes:____

Site:______________________________ Date:___/___/___ Recorder____________________________

Form 1b: Prototype MARINe Rocky Intertidal Site-Wide Species Conditions

Species	Abundance	Appearance	Recruitment	Notes
Target Species shown in bold. **Optimum Intertidal Zone** (may occur in 1, 2 or 3 zones) **H**=High **M**=Mid **L**=Low	----=No Data **0**=Absent **R**=Rare **U**=Uncommon **P**=Present **C**=Common **A**=Abundant	----=No Data √=Typical (healthy) **F**=Fertile/Flowers **B**=Bleached **D**=Damaged **L**=Low level **M**=Med level **H**=High level	----=No Data **0**=Absent **L**=Low level **M**=Med level **H**=High level	
Cladophora columbiana				
Ulva/Enteromorpha				
Egregia menziezii				
Eisenia arborea				
Endarachne/Petalonia				
Fucus gardneri				
Halidrys dioica/Cystoseira spp.				
Hesperophycus californicus				
Pelvetiopsis limitata				
Sargassum muticum				
Scytosiphon spp.				
Silvetia compressa				
Endocladia muricata				
Chondracanthus canaliculatus				
Mastocarpus papillatus				
Mazzaella affinis				
Mazzaella spp.(= Iridaea spp.)				
Porphyra sp.				
Phyllospadix scouleri/torreyi				
Anthopleura elegantissima/sola				
Phragmatopoma californica				
Mytilus californianus				
Littorina spp				
Lottia gigantea				
Haliotis cracherodii				
Tegula spp				
Chthamalus spp/B. glandula				
Tetraclita rubescens				
Pollicipes polymerus				
Ligia occidentalis				
Pisaster ochraceus				
Strongylocentrotus purpuratus				
Tar				

Form 1c: MARINe Rocky Intertidal Field Log Definitions

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.

None (0): None were found within the defined site boundaries.

Low (L): Relatively few or low levels were found within the defined site boundaries.

Med (M): Medium numbers or moderate levels were found within the defined site boundaries.

High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.

Wind: L = ≤10 knots M = 11-20 knots H => 20 knots

Rain: L/M/H relative amounts of precipitation at the site during the survey.

Recent Rain: Evidence or knowledge of L/M/H amounts rain at the site within the past few days.

Water Temp: Actual seawater temperature (°C) or L: ≤14°C (57°F) M: 15-18°C H: >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.

Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.

Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.

Driftwood: L/M/H levels of sticks, branches, and logs within the site.

Shells: L/M/H levels of dead shells, especially mussel shells.

Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.

Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.

Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Site-Wide Species Conditions

Abundance: Relative numbers of individuals or cover of species, in 5 levels, with "Present" representing the middle level.

Appearance: Checkmark indicates typical "healthy" non-reproductive appearance. If appearance is not typical, pair noted appearance codes with level codes (FL, FM, FH, BL, BM, BH, DL, DM, DH). Score L/M/H relative levels of reproductive appearance (F) (plants showing evidence of fertility), bleaching (B) (plants only: e.g., appearing pale or translucent or red algae appearing greenish), or damage (D) (plants & animals: e.g., abraded, torn, broken, withered, diseased, injured, or dead individuals). It is possible to record multiple entries (e.g., *Silvetia* = FL, BL, & DM).

Recruitment: For appropriate species when evident, score L/M/H relative levels of recruit abundances (settlers that have become obvious since the previous sampling).

Form 2a: Prototype MARINe Rocky Intertidal Photo Log

Site:____________________________________ Camera:______________________ Roll No.:_________ Date:______________

Photographer:____ Recorder:____

Photo #	Plot/Area Photographed (if area, indicate viewpoint)	Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
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49		
50		

Form 2b: Prototype MARINe Rocky Intertidal Photo Log

Site:____________________________ Camera:____________________ Roll No.:________ Date:______________

Photographer:____________________________________ Recorder:____________________________________

Photo #	**Plot/Area Photographed** (if area, indicate viewpoint)	**Notes**
51		
52		
53		
54		
55		
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57		
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94		
95		
96		
97		
98		
99		
100		

Form 3a: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet

Site:_____________________ Date:__________ Photographer:_____________________ Roll #:_________

Target Species:______________ Observer:_________________________________ Photo #s:____ - ____

Plot 1 ( ) Notes:_____________________________

Plot 2 ( ) Notes:_____________________________

Plot 3 ( ) Notes:_____________________________

Green Algae: **CL**=Cladophora columbiana; **UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae: **EM**=Egregia; **EA**=Eisenia; **EP**=Endarachne/Petalonia; **FG**=Fucus; **HC**=Halidrys/Cystoseira; **HE**=Hesperophycus; **PL**=Pelvetiopsis; **SM**=Sargassum muticum; **SC**=Scytosiphon; **SI**=Silvetia: **OB**=Other Brown
Red Algae: **AC**=Articulated Corallines; **CC**=Crustose Corallines; **CO**=Chondracanthus can.; **EN**=Endocladia; **MP**=Mastocarpus pap.; **MZ**=Mazaella affinis; **MS**=Mazaella (Ididaea); **PS**=Porphyra spp;; **OR**=Other Reds
Algae/Plants: **PY**=Phyllospadix; **NC**=Non-Coralline Crusts; **OP**=Other Plants
Barnacles: **CB**=Chthamalus/Balanus; **TE**=Tetraclita; **PO**=Pollicipes; **BA**=Other Barnacles
Mollusks: **MY**=Mytilus; **LG**=Lottia gigantea; **LI**=Limpets; **CI**=Chitons
Invertebrates: **AE**=Anthopleura; **PH**=Phragmatopoma; **PI**=Pisaster ochraceus; **OI**=Other Invertebrates
Substrates: **R**=Rock, **S**=Sand, **T**=Tar

Form 3b: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet

Site:____________________ **Date:**_________ **Photographer:**_____________________ **Roll #:**_________

Target Species:_______________ Observer:__________________________________ Photo #s:____ - ____

Plot 4 ( ) Notes:______________________________

Plot 5 ( ) Notes:______________________________

Plot ( ) Notes:______________________________

Green Algae: **CL**=Cladophora columbiana; **UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae: **EM**=Egregia; **EA**=Eisenia; **EP**=Endarachne/Petalonia; **FG**=Fucus; **HC**=Halidrys/Cystoseira; **HE**=Hesperophycus; **PL**=Pelvetiopsis; **SM**=Sargassum muticum; **SC**=Scytosiphon; **SI**=Silvetia: **OB**=Other Brown
Red Algae: **AC**=Articulated Corallines; **CC**=Crustose Corallines; **CO**=Chondracanthus can.; **EN**=Endocladia; **MP**=Mastocarpus pap.; **MZ**=Mazaella affinis; **MS**=Mazaella (Ididaea); **PS**=Porphyra spp;; **OR**=Other Reds
Algae/Plants: **PY**=Phyllospadix; **NC**=Non-Coralline Crusts; **OP**=Other Plants
Barnacles: **CB**=Chthamalus/Balanus; **TE**=Tetraclita; **PO**=Pollicipes; **BA**=Other Barnacles
Mollusks: **MY**=Mytilus; **LG**=Lottia gigantea; **LI**=Limpets; **CI**=Chitons
Invertebrates: **AE**=Anthopleura; **PH**=Phragmatopoma; **PI**=Pisaster ochraceus; **OI**=Other Invertebrates
Substrates: **R**=Rock, **S**=Sand, **T**=Tar

Form 4: Prototype MARINE Rocky Intertidal Photoplot Slide-Scoring Data Sheet

Site:______________________________ Sampling Season:____________ Date Sampled:____________

Assemblage:________________________ Recorder:___________________ Date Scored:_____________

Core Taxa		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Cladophora columbiana	CLACOL						
Ulva/Enteromorpha	ULVENT						
Other Green Algae	OTHGRE						
•Egregia menziesii	**EGRMEN**						
Eisenia arborea	EISARB						
Endarachne/Petalonia	ENDPET						
Fucus gardneri	FUCGAR						
Halidrys/Cystoseira spp	HALCYS.						
Hedophyllum sessile	**HEDSES**						
•Hesperophycus californicus	**HESCAL**						
Pelvetiopsis limitata	PELLIM						
Sargassum muticum	SARMUT						
Scytosiphon spp	SCYSPP						
•Silvetia compressa	**SILCOM**						
Other Brown Algae	OTHBRO						
Chondracanthus canaliculatus	CHOCAN						
•Endocladia muricata	**ENDMUR**						
Mastocarpus papillatus	MASPAP						
Mazzaella affinis	MAZAFF						
Mazzaella spp.(= Iridaea spp.)	MAZSPP						
Neorhodomela larix	**NEOLAR**						
Porphyra spp	PORSPP						
Articulated Corallines	ARTCOR						
Crustose Corallines	CRUCOR						
Other Red Algae	OTHRED						
•Phyllospadix scouleri/torreyi	**PHYOVE**						
Non-Coralline Crusts	NONCRU						
Other Plant	OTHPLA						
•Anthopleura elegantissima/solis	**ANTELE**						
Phragmatopoma californica	PHRCAL						
•Lottia gigantea	**LOTGIG**						
•Mytilus californianus	**MYTCAL**						
Limpets	LIMPET						
Chitons	CHITON						
•Chthamalus spp/Bal glandula	**CHTBAL**						
•Pollicipes polymerus	**POLPOL**						
Semibalanus cariosus	**SEMCAR**						
•Tetraclita rubescens	**TETRUB**						
Other Barnacles	OTHBAR						
•Pisaster ochraceus	**PISOCH**						
Other Invertebrates	OTHINV						
Rock	ROCK						
Sand	SAND						
Tar	**TAR**						
Other Substrate	OTHSUB						
Unidentified	UNIDEN						

Form 5: Prototype MARINe Rocky Intertidal Point Intercept Transect Data Sheet

Site:__________________Date:_________Time:_______Sampler:________________Recorder:_______________

Directions: Record 100 point-intercepts (every 10 cm) along 10m transect lines. Target Species (circle): Boa Kelp Surfgrass Turf.

Species/Taxa/Substrate		Transect 1 ( )	Transect 2 ( )	Transect 3 ( )
Phyllospadix ***Overstory***				
Phyllospadix Understory				
Egregia menziesii				
Eisenia arborea				
Halidrys dioica/Cystoseira				
Hedophyllum sessile				
Sargassum muticum				
Crustose Algae	Coralline			
	Non-Coralline			
Articulated Corallines				
Other Algae	Red			
	Brown			
	Green			
Other Plant				
Anthopleura elegan/sola				
Phragmatopoma calif.				
Mytilus californianus				
Barnacles				
Pisaster ochraceus				
Other Invertebrates				
Rock				
Sand				
Tar				
Other Substrate				
Unidentified				
Total:				

For each entry box, add the tick marks or counts, record the sum, and circle it.

Use the following classifications for epiphyte cover/appearance estimates: (0, L, M, H)=(none, low, med, high)

Cover of *Smithora:*______ *Melobsia:*________ bleached/brown grass:________ Abraded:_______ Flowers:________

Notes:____

Form 6a: Prototype MARINe Rocky Intertidal Owl Limpet Data Sheet

Site:_____________________________ Date:__________ Time:_____________ Plot Size:______________

Measurers:_______________________________________ Recorders:___________________________________

Plot 1 ( )				Plot 2 ( )				Plot 3 ( )			
Size mm	#	**Size mm**	#	**Size mm**	#	**Size mm**	#	**Size mm**	#	**Size mm**	#
<15				<15				<15			
15		60		15		60		15		60	
16		61		16		61		16		61	
17		62		17		62		17		62	
18		63		18		63		18		63	
19		64		19		64		19		64	
20		65		20		65		20		65	
21		66		21		66		21		66	
22		67		22		67		22		67	
23		68		23		68		23		68	
24		69		24		69		24		69	
25		70		25		70		25		70	
26		71		26		71		26		71	
27		72		27		72		27		72	
28		73		28		73		28		73	
29		74		29		74		29		74	
30		75		30		75		30		75	
31		76		31		76		31		76	
32		77		32		77		32		77	
33		78		33		78		33		78	
34		79		34		79		34		79	
35		80		35		80		35		80	
36		81		36		81		36		81	
37		82		37		82		37		82	
38		83		38		83		38		83	
39		84		39		84		39		84	
40		85		40		85		40		85	
41		86		41		86		41		86	
42		87		42		87		42		87	
43		88		43		88		43		88	
44		89		44		89		44		89	
45		90		45		90		45		90	
46		91		46		91		46		91	
47		92		47		92		47		92	
48		93		48		93		48		93	
49		94		49		94		49		94	
50		95		50		95		50		95	
51		96		51		96		51		96	
52		97		52		97		52		97	
53		98		53		98		53		98	
54		99		54		99		54		99	
55		100		55		100		55		100	
56				56				56			
57				57				57			
58				58				58			
59				59				59			

Notes:____

____

Form 6b: Prototype MARINe Rocky Intertidal Owl Limpet Data Sheet

Site:________________________________ Measurers:____

Date:_____________ Time:____________ Recorders:____

Plot 4 ( )				Plot 5 ( )				Plot 6 ( )			
Size mm	#	Size mm	#	Size mm	#	Size mm	#	Size mm	#	Size mm	#
<15				<15				<15			
15		60		15		60		15		60	
16		61		16		61		16		61	
17		62		17		62		17		62	
18		63		18		63		18		63	
19		64		19		64		19		64	
20		65		20		65		20		65	
21		66		21		66		21		66	
22		67		22		67		22		67	
23		68		23		68		23		68	
24		69		24		69		24		69	
25		70		25		70		25		70	
26		71		26		71		26		71	
27		72		27		72		27		72	
28		73		28		73		28		73	
29		74		29		74		29		74	
30		75		30		75		30		75	
31		76		31		76		31		76	
32		77		32		77		32		77	
33		78		33		78		33		78	
34		79		34		79		34		79	
35		80		35		80		35		80	
36		81		36		81		36		81	
37		82		37		82		37		82	
38		83		38		83		38		83	
39		84		39		84		39		84	
40		85		40		85		40		85	
41		86		41		86		41		86	
42		87		42		87		42		87	
43		88		43		88		43		88	
44		89		44		89		44		89	
45		90		45		90		45		90	
46		91		46		91		46		91	
47		92		47		92		47		92	
48		93		48		93		48		93	
49		94		49		94		49		94	
50		95		50		95		50		95	
51		96		51		96		51		96	
52		97		52		97		52		97	
53		98		53		98		53		98	
54		99		54		99		54		99	
55		100		55		100		55		100	
56				56				56			
57				57				57			
58				58				58			
59				59				59			

Notes:____

____

____

____

Form 7: Prototype MARINe Rocky Intertidal Abalone and Seastar Data Sheet

Site:________________________ Sampling Date:__________ Sampling Season___________

Recorder:________________________________ Sampler:________________________________

Is This a Time Search? (check if yes):____ Time Period for Search: From_______to_______

Black Abalone

Length (mm)	Plot/Transect 1 ( )	Plot/Transect 2 ( )	Plot/Transect 3 ( )
5			
10			
15			
20			
25			
30			
35			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
All			

Ochre Seastars

Radius (mm)	Plot/Transect 1 ( )	Plot/Transect 2 ( )	Plot/Transect 3 ( )
5			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			
All			

Other Abalone (total # only – no sizes)

Species	Plot/Transect 1	Plot/Transect 2	Plot/Transect 3	Site

Other Seastars (total # only – no sizes)

Species	Plot/Transect 1	Plot/Transect 2	Plot/Transect 3	Site

Form 8: Prototype MARINe Rocky Intertidal Northern Sea Palm Data Sheet

Shelter Cove - *Postelsia*

Date________________

Plot 1 (blank bolt)- Upcoast to Downcoast 5m long

Name________________

Pp1

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

C

Plot 2 (2 notches)- Upcoast to Downcoast 5m long

Pp2

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

D

Plot 3 (3 notches)- Upcoast to Downcoast 5m long

Pp3

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

E

Form 9: Prototype MARINe Rocky Intertidal Motile Invertebrates Data Sheet

Plot Type:______________________ Site:________________________

Counter:______________________ Date:_____________________

	Plot 1	Plot 2	Plot 3	Plot 4
Species counted in whole plot (can be sub-sampled if abundant)* For hermits, I.D. 1st 10 & multiply % by total.				
Lepidochitona hartwegii				
Nuttalina spp.				
Mopalia spp.				
Fissurella volcano				
Pachygrapsis crassipes				
Pagurus samuelis				
Pagurus hirsutiusculus				
Pagurus granosimanus				
Ocenebra circumtexta				
Large limpets (>15mm) (excluding L. gigantea)				

Species counted and measured (1st 10 encountered only) in whole plot (can be sub-sampled if abundant)*								
	#	sizes	#	sizes	#	sizes	#	sizes
Nucella emarginata								
Nucella canaliculata								
Acanthina spp.								
Tegula funebralis								
Lottia gigantea								

Species sub-sampled in 3 20x20cm quadrats placed in UL, middle & LR of plot** Count limpets on rock (R) and mus								
	R	M	R	M	R	M	R	M
limpet < 5mm								
limpet 5-15 mm								

Sample in 10x10 cm section of 20x20 cm quadrat**												
Littorina spp.												

Appendix 4: Coastal biodiversity survey protocols

Coastal Biodiversity Survey Protocols

May, 2011

University of California
Santa Cruz
SWAT Team

Table of Contents

Coastal Biodiversity Survey Protocols

Selecting an appropriate location

The ideal location to establish a comprehensive survey is on a bedrock intertidal bench that 1) is at least 30m wide, 2) gently slopes from the high to low zone, and most importantly 3) contains a representative sample of the intertidal community of the entire site. If it is not possible to find a contiguous 30m stretch of coastline, the survey can either be split between two adjacent benches or setup along a contiguous 20m stretch of coastline. When split, the survey should be divided as evenly as possible between the two benches.

Set-Up

Once an appropriate area of shoreline has been selected, it is sampled using a series of parallel transect lines extending from the high zone to the low zone. To facilitate the setup of these lines, two permanent 30m horizontal baselines (parallel to the ocean) are first established. The upper baseline is placed in the high zone above the upper limit of the organisms, while the lower baseline, which should be parallel to the upper baseline, is established farther down the shore. Depending on the amount of beach traffic or site regulations, the ends of these lines are permanently marked with either hex or carriage bolts.

Once these two baselines have been established, parallel transect lines are run down the shore every three meters along the upper base line. To insure that these lines are parallel, they should intersect the appropriate meter mark on the lower baseline. In general the transect lines are allowed to follow the contours of the bench. When necessary, rocks are placed along the lines to prevent them from being shifted by heavy winds and a note is made of where each transect crosses the lower baseline.

To facilitate resurveys of the site, a map is drawn of the site showing the location of the bolts relative to notable landmarks or other, pre-existing permanent plots, GPS coordinates are recorded, and photographs are taken. The distance and bearing between the baseline end bolts are measured. When possible, measurements are also taken between the end bolts and any pre-existing permanent plots. Other information such as the compass heading of the vertical transects, coastal orientation and the sampling interval are also recorded. A rock sample is collected for determining geology of the bench.

Point-Contact Surveys

Each vertical transect is sampled using the point intercept method. Ideally 100 points are sampled on each transect line, so the interval between points should be 20cm for a 20m long transect, and 10cm for a 10m long transect. For each point two types of data are collected: data that are used to determine relative abundance (% cover), and data that are used to describe spatial distributions. The relative abundance data are collected by identifying all taxa that fall directly under each point, including rock, sand, and tar. If there is layering, the taxa occupying the different layers are identified and assigned a letter: A for the top layer, B for the second layer, and C for the third. (Note: For this survey, each layer must be a different taxa). If the point falls on an epibiont living on a recognized host species (Table 1), the epibiont is denoted by the letter E and the host by the letter H. [Note: Designating a species an epibiont/host does not preclude it from also being a layer. For example, if the point hits an epibiotic alga whose holdfast is not under the point, it is recorded as both a canopy (A) and as an epibiont (E). The host would be recorded as canopy (B) and host (H)]. Also recorded is whether the species under the point are found in pools, on cobble, or on boulders. A total of up to three taxa are identified under each point.

Table 1: List of recognized hosts.

Although many species are host to a few epibiotic species, for this survey only those species that offer substrate to a multitude of epibiotic species are considered hosts.

Balanus crenatus	*Jania crassa*
Balanus glandula	*Jania tenella*
Balanus nubilus	*Lithothrix aspergillum*
Bossiella spp	*Lottia gigantea*
Brachidontes/Septifer spp	*Megabalanus californicus*
Calliarthron spp	*Modiolus* spp
Chthamalus spp	*Mytilus californianus*
Corallina spp	*Mytilus galloprovincialis/trossulus*
Dendropoma lituella	*Petaloconchus montereyensis*
Dendropoma/Petaloconchus spp	*Pollicipes polymerus*
Dodecaceria fewkesi	*Pseudochama exogyra*
Dodecaceria spp	Sabellariidae
Encrusting coralline	*Semibalanus cariosus*
Haliptylon gracile	*Serpula vermicularis*

If fewer than three taxa are recorded under a point, then data are collected on the identity of the next one or two species closest to that point (Table 2). These data are used to describe the spatial distribution of species, and are not used when calculating relative abundances.

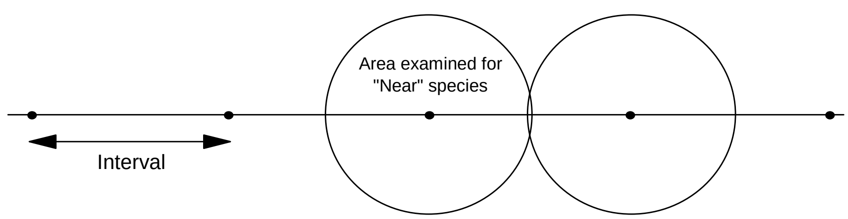
Table 2: Number of 'nearby' species recorded.

Taxa Recorded Under Point	**Number of 'Nearby' Species**
One taxa, (can be either an organism or bare space)	Two additional species
Two layers, with the bottom layer being bare space	Two additional species
Two layers, both of which are organisms	One additional species
Epibiont and Host	One additional species

Three layers, with the bottom layer being bare space	One additional species
Three layers, all of which are organisms	No additional species

These ‘nearby’ species must be different than those found under the point, and must fall within a circle centered over the point with a radius half the length of the sampling interval (Figure 1). Closeness is determined by location on the primary substrate. For example, if a frond of *Silvetia* is closer to the point than a barnacle, but its holdfast is farther away, the barnacle is considered the closer species. If all ‘nearby’ individuals are the same taxa as that found under the point, or there are no other ‘nearby’ species, ‘none’ is recorded. If the nearby species is an epibiont on a recognized host (Table 1), the host is denoted by the letter H and the epibiont the letter E. Again, note is made of whether these nearby species are found in pools, on cobble, or on boulders.

Figure 1: Diagram showing area examined for ‘near’ species.



Vouchers

When a species cannot be identified in the field, it is assigned an unknown number and a sample of it is collected. Samples are labeled with the date, site, name of sampler, transect line on which it is found, and the unknown number assigned to it. Samples are collected in seawater and are either immediately pressed (algae), and either desiccated or preserved in alcohol (invertebrates).

Mobile Invertebrate Quadrat Surveys

Although point-contact surveys are good at determining the abundance of spatially common species, they do not sample rare or spatially uncommon species very well. Because most mobile species are not spatially common, their abundances are determined in 50 x 50 cm quadrats placed at three locations along each transect. Each transect is first divided into three zones; the low zone is the area below the mussels, the mid-zone includes the mussels and the rockweeds (e.g. Silvetia, Pelvetiopsis), and the high zone is the area dominated by barnacles and littorines. Within each zone a quadrat is randomly placed on the transect, and all mobile species found within the quadrat are identified and counted. A random number table is used to select a number which represents the location (in meters) along a transect line where the quadrat should be placed. When a definitive high, mid, or low biological zone does not exist, one of the following protocols is followed: (in order of preference) 1) the quadrat may be offset from the transect line in order to capture the missing zone, 2) only two quadrats are sampled on the transect. For example, on a transect where no true high zone exists: 1) the quadrat may be placed just above the upper baseline in the high zone, and "offset" is noted as the location, 2) quadrats are sampled in only the mid and low zones. Sub-sampling may be used when there are more than one hundred individuals of one species in a quadrat. If the location of a quadrat is in a deep pool or in an area dominated by sand, a new location is selected. The only mobile species not counted are worms, *Neomolgus littoralis* (red mites), and amphipods.

Swath Counts

Sea stars play an important role in the intertidal community, but often they are also not spatially common. As such, their abundances are measured along a two-meter swath centered over each vertical transect. Sites utilizing a 20m baseline also measure along a two-meter swath. Within this swath, the abundance and location along the transect (to the nearest 0.5m) of the following sea stars is recorded: *Asterina miniata, Dermasterius imbricata, Echinaster* spp, *Evasterias troschelii, Heliaster kubinijii, Henricia leviuscula, Pharia pyramidata, Pisaster ochraceu*s, *Pisaster giganteus,* and *Pycnopodia helianthoides*. Sea stars measuring less than 5cm in total length are not counted. Species of *Leptasterias* are not counted in the swath counts, since these smaller stars are well represented in the quadrat surveys. Abundance and location are also recorded for individuals of *Cryptochiton stelleri, Haliotis cracherodii,* and *Haliotis rufescens*. The locations of any surge channels or pools that cannot be searched are also noted.

Topography

A three-dimensional map of the study area is created from topography measurements of each vertical transect line. A rotating laser leveler and a stadia rod are used to make the measurements. Ideally the laser leveler is positioned where the topography of all eleven transects can be measured. However, where this is not possible, and the laser leveler must be repositioned, it is important to make sure that several reference points are measured from both locations. This will ensure that the heights measured from the two locations will be compatible. Measurements are taken along each transect wherever there is a change in height. Thus, measurements are taken infrequently (every few meters) for gradual slopes, but more frequently (tens of centimeters) when necessary to capture the presence of smaller ridges and pools.

Modified Surveys

In some cases, biodiversity surveys will be completed using a modified set of protocols. Protocol modifications are typically made to the Point Contact Surveys only;

however a reduced number of transects may also be sampled for the other types of surveys. The type of survey completed is referenced in the data. Depending on what is desired for a specific project, there are 6 basic options for the types of modifications that can be made (Table 3).

Table 3: Survey Method Descriptions

Survey Method	**Description**
1) CBS standard (no modification)	CBS surveys are completed as described in the above survey protocols, with the full number of transects surveyed for all methods
2) CBS reduced	CBS surveys are completed as described in the survey protocols, with a reduced number of transects surveyed for one or more methods
3) CBS first point layering	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. The full number of transects are surveyed for all methods.
4) CBS first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location, and layering and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point, unless otherwise desired for a specific project. For example, if mussels are specifically of interest, layers over mussels may be ignored and mussels will be recorded at that point. In this case, the modification will be detailed in the project report and site notes. If epi/host relationships occur, the host species (the species attached to the substrate) is the organism recorded at this point. The full number of transects are surveyed for all methods.
5) CBS reduced first point layering	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. A reduced number of transects are surveyed for one or more methods.
6) CBS reduced first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location, and layering and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point (except if otherwise desired for a specific project as described in #4 above). If epi/host relationships occur, the host species (the species attached to the substrate) is the organism recorded at this point. A reduced number of transects are surveyed for one or more methods.

GPS Measurements

GPS measurements of latitude and longitude (WGS84) and height above mean sea level (meters above MSL GEOID03 Conus) are recorded at each permanent marker bolt. Trimble survey equipment is used, including a Zephyr antennae, ProXRT receiver, and Nomad computer running Terrasync software, all mounted upon a leveled bipod. The bipod is placed directly beside each bolt, and GPS measurements are recorded. Upon transferring the measurements to a personal computer, measurements are then post-processed using GPS Pathfinder Office software to increase precision. One bolt is selected as a “benchmark bolt,” upon which all topography measurements are to be correlated.

Stillwater Measurement

Sites that do not have GPS measurements must use a “stillwater measurement” to correlate to topography measurements. The topography measurements are converted to tidal heights (meters above MLLW) by taking a stillwater measurement (measuring sea level at low tide). Three locations are selected that are covered and uncovered by waves for equal amounts of time. The orientation of these locations should be towards the incoming tide. The height of these locations and the time the measurement was taken are recorded and later converted to actual tidal height values using a tidal table.