**June 22, 2000**

**Final Report: Years 1 & 2 (April 1996 – May 1998)**

# RECOVERY OF ROCKY INTERTIDAL ASSEMBLAGES FOLLOWING THE WRECK AND SALVAGE OF THE F/V *TRINITY*

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**Summary**

The grounding and subsequent salvage of the F/V *Trinity*, a 51 foot, steel hull seiner, at Point Pinos, on the Monterey Peninsula on April, 20 1996 resulted in a total of 251 $m^2$ of physical damage and 287 $m^2$ of chemical damage to the rocky intertidal habitat. As a part of the Monterey Bay National Marine Sanctuary Intertidal Monitoring Program, biological damage and recovery are being investigated to understand the recovery process. A potential restoration technique is also being tested to enhance recovery. This report presents results of these studies from April 1996 to May 1998.

Physical damage, caused by crushing and scraping, exposed fresh vertical and horizontal surfaces removed some of the macroflora and macrofauna. Two rubble beds (one in the mid and one in the low intertidal) were also formed where the vessel crushed boulders into small pieces. A pit was formed (in the mid/high intertidal) in the sand by two large tires used to cushion the vessel. Spilled diesel fuel and possibly hydraulic fluid and engine oil likely caused surf grass bleaching and blade loss. More research is needed to further understand the human induced and natural bleaching phenomena in plant assemblages.

Recovery on newly exposed, horizontal surfaces within three assemblages (low intertidal surf grass, mid intertidal mussel, and mid/high intertidal red algae) are being quantitatively assessed. Plots were established in the disturbed areas, adjacent intact assemblages (wreck controls) and intact assemblages outside of the potential chemical spill area (spill controls). The spill controls were considered the undisturbed natural condition for an assemblage unless no significant difference could be found between the spill controls and the wreck controls. If no difference was detected, the survey of spill controls was discontinued and the wreck controls were considered the undisturbed natural condition for comparison. Recovery of rubble beds, newly exposed vertical rock surfaces and a sand pit were qualitatively assessed. To examine the feasibility of using transplanted boulders with intact assemblages as a restoration technique to enhance recovery of damage habitats, nine small (15-30 cm) and nine large (40-60 cm) boulders were transplanted to a rubble bed. Survival and reproductive condition of species on boulders was qualitatively assessed.

Recovery within damaged plots has been slow. After six surveys (June, August and December of 1996; May and December of 1997 and May 1998) some of the species that dominate each natural assemblage have colonized. Prior studies in these assemblages noted variable recovery with predictions of recovery ranging "from one to more than six years" for the red algal assemblage to "probably greater than 10 years" for the mussel assemblage (Kinnetic Laboratories Inc., 1992). Some studies have suggested colonization of open space is more rapid on the lower shore. Colonization of disturbed plots in the low intertidal surfgrass assemblage has been most rapid while that in the mid/high intertidal red algal assemblage has been the least.

Algal recruitment is occurring in the two rubble beds. One of these beds, located in the mid intertidal, is being colonized slowly, probably because continued disturbance from loose rubble is limiting successful recruitment. High wave action will eventually wash the loose rubble from the bed exposing the stable surface beneath which is more suitable for colonization. Recruitment in the low intertidal rubble bed has been more rapid, possibly because smaller rocks were washed out of the bed and colonization is more rapid. A low intertidal vertical rock face, exposed by fracture during the wreck, appears to be recovering more rapidly than any other disturbed habitat, perhaps because it is a stable, low intertidal surface. Since its formation, sand has shifted in and out of the sand pit with high wave action suggesting that initial damage from the wreck was minimal. Nevertheless, to minimize damage, it would be better to remove equipment while it is not being

used for salvage operations. As of the May 1998 survey, 15 of 18 transplanted boulders remained. The results suggest that future transplants be done with large boulders since the initial survival of the dominant species was greater on them. However, transplants should not be placed in an area where they are subject to sand and rock scour. Present funds maintained this project through May 1998 and potential exists for using future mitigation funds to support the study until recovery occurs.

## Introduction

On Saturday evening, April 20, 1996, the F/V *Trinity*, a 51 foot, steel hull seiner, capsized while rounding Point Pinos near Monterey, California (Figure 1). The vessel ran aground on a rocky shore consisting of intertidal granite outcrops with sparse flat, horizontal benches covered with algae and invertebrates and a sand beach on the inland edge. Most, if not all, fuel and lubricating oils spilled into Monterey Bay. The vessel was salvaged by rolling it landward through the intertidal zone and hauling it away by truck.

Physical damage to rocky intertidal habitat resulted from the initial grounding and subsequent salvage operation. The low intertidal surf grass (*Phyllospadix* spp.) assemblage was disturbed when the vessel grounded, and mid intertidal mussel (*Mytilus californianus*) and mid/high intertidal red algal (dominated by *Endocladia muricata/Mastocarpus papillatus*) assemblages were damaged during salvage. The impacts of grounding and rolling during salvage broke and fragmented the intertidal granite substratum and exposed fresh rock surfaces. Grinding by the vessel as it rocked in the waves during these events also removed sessile organisms and, in some areas, ground rock into rubble piles. Two large tires used to cushion the vessel during rolling were left in place overnight in the surf, causing displacement of beach sand and rock abrasion. Pollution that occurred from spilled oils was addressed by comparing habitat adjacent to and distant from the wreck site by other agencies.

As a part of the Monterey Bay National Marine Sanctuary Intertidal Monitoring Program, biological damage resulting from the grounding event is being investigated to better understand the mechanisms and time course of natural recovery. In addition, a possible future restoration technique is being tested by translocating boulders with their natural biological assemblages into disturbed areas. Present funds supported research through May 1998. Mitigation funds from future damage to rocky intertidal habitats in the MBNMS may be used to continue this study until full recovery has occurred.

## Methods

### Quantitative Sampling Design

Overall damage to rocky intertidal assemblages was assessed by measuring areal coverage and type (scraped rock, fractured rock, rubble, etc.) of damage. Rates of recovery within the surf grass, mussel, and red algal assemblages were determined quantitatively by sampling the species composition and percent cover of sessile organisms in 0.25 x 0.25 m plots within areas where new rock surfaces were exposed and comparing these data to those from control plots. Sampling was done in June, August and December of 1996, May and December of 1997, and May 1998. Five plots were established in the surf grass assemblage, five in the mussel assemblage, and three in the red algal assemblage. To standardize sampling and limit variability, all plots were established on flat, relatively horizontal surfaces. Initial site inspection indicated that, given the nature of the damage, it would be difficult to find space for more replicates on flat surfaces. Less space was available on vertical and rough surfaces. Each damaged plot was matched with an adjacent, undamaged control plot with a similar tidal height and slope (wreck control). An additional set of control plots (spill controls) were randomly established outside of the wreck site but in the same assemblages. These serve to control for the effects of spilled diesel and oils which may have potentially affected the wreck controls. Five of each control (wreck control, spill control) were established in the surf grass and mussel assemblages and 3 in the red algal assemblage. Sampling of the spill controls was ended when there was no significant difference between the spill and wreck controls (discussed further below). Plots were permanently marked at 0.30 x 0.30 m corners with Splash Zone™.

Percent cover was determined using the point quadrat technique described by Foster et al. (1991). A clear plastic plate, 0.25 x 0.25 cm with a grid of 100 equally spaced holes was mounted above the center of plots. Sampling was done by lowering a pin through randomly selected holes and noting the sessile organisms and/or abiotic substrata contacted. Multiple contacts under a single point were sampled by moving aside successive layers of organisms. Multiple contacts of the same species under a given point were not recorded because this is nearly impossible to do with densely branched species. Some species with high cover would create a dense canopy over some plots. Cover of species beneath this canopy were identified by moving the canopy cover aside and noting the species beneath that contacted the pin. The large brown alga, *Egregia menziesii*, was sometimes attached outside of the plot but would lay within the plot. Cover from those individuals attached outside of the plot were distinguished separately from those attached within the plot. Analyses in this report include cover estimates for *E. menziesii* plants attached inside of the plot. This enabled us to make comparisons of colonization rates within disturbed and control plots. Representative species that could not be identified in the field were collected from the adjacent area and identified in the lab. Plots were photographed in May/June 1996, 1997 and 1998. Species and abiotic substrata with average cover greater than 10% for any of the sampling dates are graphically presented. In addition, species with cover that are less than 10% but have ecological significance are also graphically presented.

Following completion of the June 1996 survey, precision estimates (SE/mean) were calculated to determine the overall optimal number of random points to survey in each quadrat. Initially, fifty random points/quadrat were sampled. Each species in a plot with coverage greater than 10% was included in the analysis. Therefore, precision estimates were calculated for some species more than once. A Matlab™ program was used to calculate precision estimates for each species by graphing the mean precision of 100 random draws of each sample size. The optimal number of random points was calculated as the lowest value, from all species analyzed within all plots, beyond which there was very little change in precision. This number of random points was sampled on subsequent surveys.

Rates of Recovery

Recovery of damaged assemblages and the condition of the wreck controls in comparison to the spill controls were determined using the Bray-Curtis Percent Similarity Index (Bray and Curtis, 1957). The spill controls were initially considered the undisturbed natural condition, defined as the range of percent similarities among spill control plots in the same assemblage (spill control plot 1 vs. spill control plot 2; spill control plot 1 vs. spill control plot 3, etc. for a total of 10 possible comparisons in the surf grass and mussel assemblages; and 3 comparisons for the red algal assemblage). The number of comparisons in the surf grass and mussel assemblages versus the red algal assemblage differed because there were 5 of each plot type established in the former and 3 in the latter.

After the first sampling in June, a 1 factor ANOVA was used to determine if there was a significant difference between the percent similarities within the wreck control plots vs. percent similarities within spill control plots (10 comparisons for each control in the surf grass and mussel assemblages and 3 comparisons for each control in the red algal assemblage) vs. percent similarities between wreck and spill control plots (25 comparisons for the surf grass and mussel assemblages and 9 comparisons for the red algal assemblage). If there was no difference among the wreck, spill and wreck/spill similarities after this first survey, the spill controls were dropped from future sampling and the wreck controls considered the undisturbed natural condition. For wreck and spill control plots that were dissimilar from one another on the last sampling date, a similar test was repeated. However, since, we are confident that the spill controls represent the undisturbed natural condition, we decided to modify the analysis to test for the significant difference of percent similarities within spill controls vs. similarities of the spill to the wreck controls. We feel that this test will more clearly determine if wreck control plots are actually recovered. Percent similarities between plots were compared instead of percent cover of species since percent similarity enabled comparison of one plot to another with a single value based on all species. Assumptions of normality and homoscedasticity were met for all data.

On subsequent surveys, recovery of the damaged plots and wreck controls (that were significantly different from spill controls after the first sampling) were assessed by calculating the percent similarities of each damaged or wreck control plot to the mean composition of the plots that were considered the natural condition plots. Plots with similarities within the range of percent similarities of the spill control plots to each other were considered recovered. When wreck control plots recover, they will be considered the undisturbed natural condition since they are adjacent to the disturbed plots and experience the same subtle physical and biological parameters.

Qualitative Assessment of Recovery

Because of differences in substratum, recovery within new rubble beds and freshly created vertical surfaces is likely to differ from that on stable, horizontal surfaces. However, lack of funding prohibited quantitative sampling. Therefore, qualitative assessment of species composition and cover of sessile organisms was done visually and documented with photos within and adjacent to rubble beds, fresh vertical surfaces, and a sand pit. Percent cover of sessile organisms was defined as: Low cover - $< 25\%/0.0625m^2$; Medium cover - $25\text{-}50\%/0.0625m^2$; High cover $> 75\%/0.0625m^2$. Abundance of motile invertebrates was classified as: Low abundance $< 10/0.0625m^2$; Medium abundance $10\text{-}100/0.0625m^2$; High abundance $> 100/0.0625m^2$.

Test of a Restoration Technique

To examine the feasibility of restoring damaged areas by translocating natural assemblages, nine small (~15-30 cm diam.) and nine large (~40-60 cm diam.) natural boulders with undamaged, attached assemblages were translocated into damaged rubble areas; away from quantitative sampling plots. The boulders originated from unaffected mid intertidal algal assemblages north and south of the rubble bed at the same tidal height and exposure. The boulders were stabilized with Splash Zone™ in June 1996, and surveyed through May 1998. Photographs were taken of each boulder on each sampling date. Cover and plant condition were qualitatively estimated to determine if species in the assemblages survived translocation and developed reproductive structures. The latter would indicate whether such translocated assemblages would be a potential propagule source in future restoration efforts.

**Results**

Field Work Accomplished

Two preliminary surveys were conducted on May 9 and May 20, 1996 to measure the areal extent of damage in the different assemblages and note early colonizers. However, no quantitative data was collected on these dates. From June 3 to June 6, permanent plots were established and cover estimated, rock transplants were stabilized and their cover was estimated, and two rubble beds, an exposed vertical face, a sand pit and their adjacent, intact assemblages were qualitatively described. On the subsequent 5 surveys (August 27 to 29, 1996; December 8 to 11, 1996; May 25 to 27, 1997; December 14 to 16, 1997 and May 27 to 29, 1998) plots were surveyed and cover on transplants, rubble beds, vertical faces, a sand pit and adjacent assemblages qualitatively described. All plots were photographed in May/June each year and transplants, rubble beds and vertical faces were photographed at each sampling date.

General Overview

A preliminary qualitative survey on May 20 to determine the type and areal coverage of damage at the site revealed that physical damage occurred to 251.1 $m^2$ of area (Table 1). Diesel fuel and lubricating oil possibly caused bleaching of 287.9 $m^2$ of surfgrass. This survey was done 4 weeks after the spill and thus may not represent the full extent of visible diesel fuel and lubricating oil damage. By August, the bleached portion of the surf grass blades had senesced and new blades were growing from the root mass.

Precision estimates showed that 30 random points per quadrat was appropriate for estimating the percent cover of sessile species and abiotic substrata in permanent plots (Figure 2).

This value represents the number of random points where the change in precision was minimal. Appendix I shows a list of all species encountered at the wreck site during surveys.

Quantitative Recovery Within Permanent Plots

Low Intertidal Surf grass (*Phyllospadix* spp.) Assemblage

No significant differences were detected in the percent similarities between the wreck controls, spill controls and combined wreck to spill controls ($F=0.048$; $p=0.953$; $df=2$) at the first sampling. Therefore, the spills controls were not surveyed after June 1996 and the wreck controls were considered the undisturbed natural condition for this assemblage.

On May 9, 1996, two and half weeks after the F/V *Trinity* grounded itself, newly exposed rock surfaces in the low intertidal surf grass (*Phyllospadix* sp.) assemblage were bare. By May 20, 30 days after the disturbance, these surfaces had approximately 100% cover of the chain forming diatoms *Berkeleya* sp. and *Beelerochea* sp. (S. Tanner, Pers. comm.). The diatoms *Licmorpha* sp. and *Shizanema* sp. were also present but rare. The first quantitative survey on June 4, 1996 revealed that average diatom cover within the five disturbed plots was 75% and the diatoms appeared less dense than in the prior survey (Figure 3). The brown blade alga, *Petalonia fascia*, was the first macroalgal species to colonize the disturbed surf grass plots (Figure 3). By August 27, eighteen weeks after the disturbance, the diatoms and *P. fascia* had disappeared and *Egregia menziesii* recruits were present (6% average cover). *Porphyra perforata*, an opportunistic early colonizer (Kinnetic Laboratories Inc., 1992), had an average cover of 15%. Surveys in December, 36 weeks after the disturbance, revealed that longer lived and later successional species had begun to establish within the disturbed plots. The calcareous red algae, *Corallina vancouveriensis* and non-geniculate corallines were initially observed on this date at 12 and 29% cover respectively.

*Corallina vancouveriensis* continued to increase and peaked at 49% in December 1997 and declined slightly by May 1998. Some of what was possibly first observed as non-geniculate corallines in December 1997, may actually have been *Calliarthron chelosporioides* which had established in disturbed plots by May 1998 (Figure 3). *Egregria menziesii* cover continued to increase, since first observed in August 1997, peaking in cover by May 1997 (24%) and nearly disappearing thereafter (Figure 3). Overall open space cover remained relatively low in disturbed plots, except for December 1996 and May 1998. However, *Phyllospadix scouleri*, the dominant and indicative species of the assemblage, was barely present. One disturbed plot had 7% cover of *Phyllospadix scouleri* on the last date. Of the sessile animals found in the controls, only *Phragmatopoma californica* had begun to reestablish by December 1997 (Figure 3).

When the natural condition (wreck control) plots, were first surveyed in June 1996, they consisted primarily of surf grass, *Phyllospadix scouleri* (87%; Figure 3). Several organisms occurred in the "understory" of the surf grass including *Corallina vancouveriensis*, sponges and tunicates (6%, 28% and 16% average cover respectively). Cover of *P. scouleri* remained relatively stable through the next two surveys, but declined by approximately 30% as of the last three surveys (Figure 3). *Corallina vancouveriensis* cover followed the same pattern (but less abundant) as seen in disturbed plots by increasing to 49% by December 1997 then dropping slightly by May 1998. *Calliarthron chelosporioides* also colonized the natural condition plots in May 1998 but not as much as in the disturbed plots. The sand tube worm *Phragmatopoma californica* was initially rare (2%) in natural condition plots but has steadily increased through the last survey to 28%. Tunicate cover peaked after the second survey (28%) but has steadily declined to 7%. *Prionitis lyallii* was first noted in August 1996 and has remained within plots since then (Figure 3). *Prionitis lyallii* may not have been observed on the first survey date due to seasonal variability.

As of the May 1998 survey, 2 of the 5 disturbed plots fell within the natural condition recovery envelope even though species such as *Phyllospadix scouleri*, *Prionitis lyallii*, tunicates and *Phragmatopoma californica* that appear to be indicative of the mature natural condition assemblage are still rare (Figure 4).

Mid Intertidal Mussel (*Mytilus californianus*) Assemblage

June 1996 survey data were used to determine if cover in wreck control plots was different from the natural condition plots (spill controls). Comparison of Bray-Curtis percent similarities between the wreck, spill controls and wreck to spill controls for this assemblage revealed a significant difference (F=32; p=0.00; df=2). Therefore the spill controls were considered the undisturbed natural condition. However, since the spill controls were placed in a mussel bed that is 0.6 m lower than the wreck controls, natural variation between the wreck and spill control plots, and not the effects of oil, may account for the difference. A similar analysis was done using May 1998 data. This analysis compared the similarities within the spill controls to the similarities of the wreck to spill controls with a t-test. A significant difference between the spill controls vs. wreck to spill controls (T=5.020, p<.001, df=1) was detected. Therefore the spill controls were still considered the undisturbed natural condition and survey of the wreck controls will continue.

On May 9, the newly exposed rock surfaces (where plots were established one month later) were bare. By May 20, green filamentous algae (hereafter termed, GFA), had colonized the damaged rock surfaces. No quantitative survey was done on the first two dates and is not shown on the graph. On the first quantitative survey in June 1996, GFA cover was 98% (Figure 5). A sample of GFA collected in June consisted of the filamentous green algae *Urospora pencilliformis*, *Ulothrix pseudoflacca*, *Chaetomorpha californica* as well as the diatom *Licmorpha* sp. and a ribbon like pennate diatom (in order of decreasing abundance). By August, GFA had disappeared and was replaced by *Porphyra perforata* (58% cover, Figure 5). In addition, rocks were dislodged within 3 of 5 damaged plots exposing fresh surfaces. Average algal cover on these newly exposed surfaces on the damaged plots was 21%. These surfaces, as well as some of the originally exposed surfaces, were covered with a mix of the green algae *Ulva californica* and *Enteromorpha* sp. (combined cover 49%, Figure 5). By December 1996, average cover had decreased to 25% and 3% for *Porphyra* and the *Ulva/Enteromorpha* mix respectively. Additional rock dislodgement occurred in disturbed plots exposing more rock in May and December 1997. *Ulva/Enteromorpha* colonized the newest newly exposed surfaces by May 1997 (3%). *Porphyra perforata* cover declined to 1% by the May 1998 survey. *Mazzaella flaccida* appeared in plots in May 1997 (5%) and declined in cover through May 1998. *Balanus glandula* appeared in plots by May 1997 and has continued to increase through the last survey.

The wreck control plots remained relatively constant over the two years of survey. *Porphyra perforata* cover was the most dynamic ranging from 7 - 53% (Figure 5). *Mazzaella flaccida*, increased to 20% by August 1996 and declined to 1% by the last survey. *Mytilus californianus* cover remained relatively constant increasing from 54 to 69% through the surveys (Figure 5).

Within the natural condition (spill control) plots, mussel cover remained high ranging from 91 - 100% through May 1998. On the last survey in May 1998, one natural condition (spill control) plot was devoid of all mussels. Since we could not determine whether or not this was caused by humans, we excluded this plot from percent cover and similarity analyses. *Corallina* *vancouveriensis* steadily declined on surveys from 13 to 5% through the study (Figure 5). *Egregia menziesii* was present in August 1996 but disappeared by December 1996.

Bray-Curtis percent similarity analyses revealed that the disturbed *Mytilus* assemblage has not recovered. Bray-Curtis values for disturbed plots did not fall within the natural condition, spill control, recovery envelope (Figure 6). However, the similarity of disturbed to natural condition plots is increasing each survey. Bray-Curtis values for wreck controls did not fall within the recovery envelope for four of the six surveys (Figure 6). However, as of the May 98 survey, one wreck control plot fell within the recovery envelope.

Mid/High Intertidal Red Algal (*Endocladia muricata/Mastocarpus papillatus*) Assemblage

There was no significant difference among percent similarities within the wreck controls, spill controls or combination of wreck to spill controls in this assemblage based on the June 1996 survey data ($f=1.021$; $p=0.390$; $df=2$). Therefore, sampling of the spill controls was discontinued and the wreck controls considered the undisturbed natural condition.

Colonization of the horizontal disturbed rock surfaces in the red algal assemblage has been slow but steady. No colonizers were observed on May 9 or 20, or when plots were established and surveyed on June 4, 1996 (Figure 7). *Porphyra perforata* was present in August 1996 (27% cover) and increased slightly in December 1996 (33% cover) but did not colonize plots much more and was barely observed in one or two plots by May 1998 (1%; Figure 7). The red alga, *Mazzaella flaccida* and anenome, *Anthopleura elegantissima*, were sparse in the last three to four surveys. *Mastocarpus papillatus* was the first recruit observed that is indicative of the late successional, intact assemblage (December 1996; 1%). Cover of this species increased through the last survey in

May 1998 to 10%. *Endocladia muricata*, another species indicative of the intact assemblage, first appeared in May 1997 (3%) and increased through the last survey to 19%.

Cover in the wreck controls was diverse relative to disturbed plots. Open space was relatively high by the first survey in June 1996 (36%) but declined and remained steady through December 1997 (Figure 7). By the last survey open space cover was the highest at 42%. High open space cover coincides with the lowest cover values of *Mastocarpus papillatus* and the alternate phase "Petrocelis" from all surveys. *M. papillatus* cover peaked in August 1996 and has steadily declined through the last survey. "Petrocelis" cover steadily increased through May 1997 and declined to its lowest level from all surveys by May 1998 (30%; Figure 7). *Endocladia muricata* cover remained steady through the surveys ranging from 13 – 21%. Other red algae such as non-geniculate corallines, *Porphyra perforata*, *Mazzaella cordata*, *M. flaccida* and *M. affinis* as well as the green alga, *Cladophora columbiana* were present throughout the 2 years of survey. The abundance of the anenome, *Anthopleura elegantissima* was also relatively constant throughout the study.

Based on percent similarities, damaged plots in the red algal assemblage plots did not begin to fall within the natural condition recovery envelope until the last survey when values for 2 of the 3 plots were within the natural condition recovery envelope (Figure 8).

Qualitative Recovery Within Rubble beds, an Exposed Vertical Face and a Sand Pit.

Mid Intertidal Rubble Bed

During the salvage operation, a large (3 x 12 m) rubble bed in the mid intertidal was formed adjacent to and below the disturbed red algal assemblage. Boulders beneath the vessel were crushed into small pieces killing the attached organisms when the vessel laid over night in this location. In May 1996, crushed loose rubble, 4-20 cm in diameter, was spread throughout the bed and *Tegula funebralis* was present. The first qualitative visual cover survey in June 1996 revealed that some of the small 4 cm cobbles had washed out of the bed and newly exposed surfaces were covered with a barely visible thin green film (Table 2). Species found in the disturbed bed as well as an undamaged, adjacent assemblage on the ocean fringe and landward edge of the bed are described for all survey dates in Table 2.

By the August survey, the rubble bed consisted of loose rocks ranging in size from 8 - 30 cm scattered throughout the bed. The green film covering newly exposed rocks was still present. Algae had colonized the loose rocks as well as some stable rock beds. Colonizers observed on the loose and stable rocks in the disturbed bed and adjacent intact assemblages are described in Table 2. By December 1996, cover on loose rubble and stable rocks was similar to the August 1996 survey (Table 2).

By May 1997, loose cobbles 3 – 25 cm. in diameter were still present throughout the whole bed. "Solid" or attached bed rock beneath the thin layer of cobble was thought to be stable but even this was fragmenting. Rock surfaces newly exposed as a result of this fragmentation were covered with the green film observed on the first surveys. Some of the boulder transplants were dislodged as a result of the fragmentation and were reattached. It appears as if this type of disturbance to granite may cause unique patterns of damage simply because cracks in the rock from the original disturbance may be deep, causing continual dislodgment to occur. Even though, loose cobble was abundant in the bed, 40% of these cobbles had a slight amount of growth on them. Cover on these loose rocks as well some of the stable bed rock is described in Table 2.

As of the December 1997 survey, most of the smallest 3 – 5 cm. cobbles were not visible possibly due to burial by a layer of sand 3 – 4 cm deep deposited in pockets. Overall, living cover was low likely due to sand and rock scour from the winter storms. Newly exposed stable surfaces and unattached boulders, resulting from the previous weeks' winter storms, were covered with a dark green algal film. Species on other disturbed but stable and attached surfaces are listed in Table 2. Many of the transplanted rocks had very low cover presumably from rock and sand scour. Cover in the intact assemblage on the ocean fringe and landward edge of the bed are listed in Table 2. The May 1998 survey revealed that most cobbles less than 3 cm had washed out of the bed. Rocks 3 - 60 cm still remained within the bed. More of the underlying stable bed rock layer was exposed by this date (Table 2). Benches that appear to have been exposed for longer periods of time have higher cover on them. Species in the intact adjacent assemblage on the ocean fringe and land ward edge bed are listed in Table 2.

Low Intertidal Rubble Bed

A second rubble bed, hereafter named the lower rubble bed, was located in the low intertidal zone adjacent to a flat rock bench covered with *Mytilus californianus*. This rubble bed consists of a bed rock layer with newly exposed and undamaged surfaces and a pile of unattached broken boulders ranging in diameter from 10 - 100 cm. This bed (1 x 2.5 m) is considerably smaller than the upper bed. Some of the boulders in this bed appear to have been dislodged and washed into the area from the adjacent damaged *Mytilus* bed. Other boulders within the bed are likely from breakage of rocks in the area. Interestingly, some of these boulders had intact growth on one or two sides while the other sides were newly exposed and bare. Species coverage in this bed was first described in June 1996 when newly exposed rock surfaces within the bed were covered with a thin brown film (high cover) and *Tegula funebralis* (high abundance). Growth on intact rock surfaces on attached rocky benches as well as undamaged surfaces of boulders is described in Table 3.

As of the August 1996 survey, some of the smaller rocks within the rubble bed had washed away. However, a high abundance of the largest (40 – 100 cm) loose boulders remained. Some boulders still had growth upon only 1 or 2 sides, possibly a result of more breakage of large boulders into smaller fragments. Four red algal species were observed on the 1 or 2 newly exposed and undisturbed surfaces (Table 3). By December 1996, it was evident that the largest (40 – 100 cm) boulders within the rubble had moved since macro-algae could be seen on the underside of some of these rocks. Most of these disturbed rocks were still covered with undamaged growth on one or two sides. Seven species were observed on the undamaged sides of the boulders (Table 3). The other sides of these rocks had a thin, barely visible green film growing on them.

By May 1997, rocks within the bed ranged in size from 5 – 100 cm in diameter. The smallest rocks may have been the result of breakage of larger boulders. Originally damaged surfaces were recruited by three species (Table 3). Surfaces newly exposed due to new breakage were bare. Six species were noted on the undamaged, intact sides of boulders and stable rock benches (Table 3). By December 1997, few small (3 – 10 cm) cobbles were present in the bed. Overall, the damaged stable substrata were being colonized much more rapidly than damaged surfaces on shifting boulders. The damaged surfaces on the stable bench were not distinguishable from undamaged surfaces (Table 3). Large (40 – 100 cm) boulders located nearby consisted of very few colonizers. This is likely the result of the fact that they had been tumbled by the winter storms inhibiting recruitment. Evidence for their movement comes from the fact that macro-algal growth was again seen on the undersides of several large rocks (Table 3). By May 1998, the stable rock, where damaged and undamaged surfaces had been indistinguishable six months prior, was covered with 95% growth (Table 3). Large, unattached, 40 – 100 cm, boulders continued to show signs of being overturned.

Exposed Vertical Face

A newly exposed vertical face was formed when a large chunk of rock was sheared from the edge of a flat rocky bench. No growth was observed on May 1996. However, by June 1996, chain forming diatoms covered the damaged surface. The intact, adjacent assemblage had medium cover of *Chondracanthus spinosus* and *Mazzaella flaccida* and low cover of *Chondracanthus canaliculatus*, *Corallina vancouveriensis*, *Endocladia muricata* , *Mastocarpus papillatus*, *Mazzaella affinis* and *Sarcodiotheca gaudichaudii*. The August 1996 survey revealed that recruitment was rapid. Four *Egregia menziesii* had recruited to the face as well as *Mazzaella flaccida* and *Porphyra perforata* (medium cover); non-geniculate corallines, *Phragmatopoma californica* and Spirorbids (low cover). Limpet abundance was low. The adjacent assemblage had high cover of *Chondracanthus canaliculatus* and *Mazzaella flaccida*; medium cover of *Chondracanthus spinosus* and *Egregia menziesii*; and low cover of *Corallina vancouveriensis*, *Mastocarpus jardinii*, *Microcladia borealis* and "Petrocelis".

In December 1996, the exposed face had medium cover of *Egregia menziesii* (8 individuals) and low cover of *Chondracanthus spinosus*, *Gastoclonium coulteri*, *Mazzaella flaccida*, non-geniculate coralline, *Phragmatopoma californica*, *Porphyra perforata* and spirorbids. Limpet abundance was low. The adjacent, intact assemblage had high cover of *Mazzaella flaccida* and non-geniculate corallines; medium cover of *Gastroclonium coulteri*; and low cover of *Chondracanthus canaliculatus*, *Chondracanthus spinosus*, *Corallina vancouveriensis*, *Cryptopleura* sp., *Endocladia muricata*, *Microcladia borealis*, *Osmundea spectabilis* and "Petrocelis". *Tegula funebralis* abundance was low.

The May 1997 survey revealed that the damaged vertical surface was still being colonized yet there was still high cover of open space. Species noted to colonize the rock were *Egregia menziesii* (3 individuals) in medium cover; *Chondracanthus canaliculatus*, *Chondracanthus spinosus*, *Corallina vancouveriensis*, *Gastroclonium coulteri*, *Gelidium arborescens/purpuratus*, *Mastocarpus papillatus*, *Mazzaella flaccida*, "Petrocelis", *Rhodymenia pacifica* and spirobids in low cover and *Lottia* sp. in low abundance. The adjacent assemblage consisted of *Mazzuella flaccida* (high cover), *Chondracanthus canaliculatus*, *Egregia menziesii* and *Rhodymenia pacifica* (medium cover); *Chondracanthus spinosus*, *Corallina vancouveriensis*, *Cryptopleura* sp., *Endocladia muricata*, *Gastroclonium coulteri*, *Iridaea cordata*, *Mastocarpus papillatus*, *Mazzaella affinis*, *Mazzaella leptorhynchos*, "Petrocelis", non-geniculate corallines, *Porphyra perforata*, and *Pelvetia compressa* (low cover).

By December 1997, the damaged surface had a high cover of open space and many grazers. Species noted colonizing the surface were *Egregia menziesii* (2 indviduals), *Chondracanthus spinosus*, *Corallina vancouveriensis*, *Gastroclonium coulteri*, *Mazzaella heterocarpa*, *Osmundea spectabilis*, "Petrocelis", and a colonial tunicate in low cover. *Collisella scabra*, *Lottia gigantea*, *Lottia pelta*, *Tegula funebralis* and *Tetraclita rubescens* were in low abundance. In the adjacent assemblage there was no open space visible. Cover was composed of *Corallina vancouveriensis*, *Gastroclonium coulteri* and *Iridaea cordata* (medium cover); *Egregia menziesii*, *Chondracanthus* *canaliculatus, Chondracanthus spinosus, Cryptopleura* sp., *Endocladia muricata, Gelidium arborescens/purpuratus*, non-geniculate corallines and "Petrocelis" (low cover).

As of the last survey in May 1998, open space was still high on the rock surface. Species noted colonizing the rock were *Calliarthron chelosporioides, Corallina vancouveriensis, Chondracanthus spinosus, Endocladia muricata, Mazzaella flaccida, Osmundea spectabilis* and *Cladophora columbiana* in low cover and *Tetraclita rubescens* in low abundance. The adjacent assemblage was covered with *Gastroclonium coulteri, Mazzaella flaccida* and non-geniculate corallines in medium cover, and *Chondracanthus canaliculatus, Corallina vancouveriensis Cryptopleura violacea, Endocladia muricata, Gelidium arborescens/purpuratus, Mazzaella leptorhynchos, Mazzaella spinosus* and "Petrocelis" in low cover. *Tegula funebralis* and *Lottia* sp. were in low abundance.

Sand Pit

The 3.5 x 5.5 m pit is adjacent to the damaged red algal assemblage and is bordered on the land ward side by fine sand while the border on the ocean side is composed of 40 cm diameter boulders. The other two borders are vertical rock walls. The tires displaced sand and boulders forming the pit and scraped a 1 $m^2$ section of one of the vertical rock walls removing sessile algae and invertebrates. By May 1996, the pit was filled with sand and 2-3 boulders, 40 cm in diameter. Neither these boulders nor the scraped vertical wall had been colonized. By June 1996, some sand had washed out of the pit, but there was still no growth on the 2-3 boulders or the vertical wall. An adjacent, intact assemblage on the vertical wall had low cover of *Mastocarpus papillatus*, "Petrocelis", *Endocladia muricata* and *Pelvetia compressa*. Sand cover in the pit remained unchanged in August 1996. No growth was observed on the scraped vertical rock wall and the adjacent assemblage remained unchanged since the June 1996 survey. As of December 1996, more sand had washed out of the pit and the scraped boulders had disappeared. However, new boulders, with *Mastocarpus papillatus* and "Petrocelis" growing on them, were present. The origin of these boulders is unknown, but they may have washed into the pit or were uncovered when sand shifted. The vertical rock wall had been colonized by *Mastocarpus papillatus* and *Mazzaella flaccida* (medium cover) and *Anthopleura elegantissima* (low cover). The adjacent assemblage on the vertical wall remained unchanged since the last survey.

By May 1997, there was slightly more sand in the pit than the previous survey and rocks and boulders, 10 – 50 cm in diameter, were within the pit. The smaller rocks had no cover on them but cover on larger (>40cm) boulders consisted of *Mazzaella leptorhynchos* in high cover; *Chondracanthus canaliculata*, *Gelidium arborescens/purpuratus*, *Mastocarpus papillatus*, *Mazzaella flaccida*, *Phyllospadix* sp. and *Anthopleura elegantissima* in low cover and *Tegula funebralis* in medium abundance. The adjacent wall that was originally scraped showed no signs of damage. Cover was high but not but not described in terms of species present.

By the December 1997 survey, more sand had moved into the pit and boulders were half exposed. Cover on these boulders consisted of *Mastocarpus papillatus*, *Mazzaella leptorhynchos* and *Anthopleura elegantissima*. No sign of remaining damage was noticeable on the vertical wall. As of the May 1998 survey, some sand had shifted out of the pit. Large boulders were slightly more exposed and colonized by *Mazzaella leptorhynchos* in low cover.

Test of a Restoration Technique

To determine the effectiveness of transplanting rocks to damaged areas as a potential restoration technique, nine small and nine large boulders were placed within the mid intertidal rubble bed. The adjacent habitat where boulders were taken from is dominated by *Mastocarpus papillatus*, *Mazzaella leptorhynchos*, "Petrocelis" and *Gelidium pusillum*. Boulders were examined on each of the six survey dates to determine if attached species survived and reproduced. As of May 1998, 15 of 18 boulders remained. Some new species appeared on boulders after the transplant. These may have been from an adjacent propagule source, or from growth of preexisting microscopic phases. In the event of a large scale disturbance however, an adjacent propagule source may not be present and growth from microscopic phases is likely highly variable. Therefore, even though we list all species present on boulders throughout the study, we are only assessing survivorship and reproduction of macroscopic species originally occurring on the transplants.

On large boulders, *Mastocarpus papillatus*, "Petrocelis", *Mazzaella leptorhynchos*, *Gelidium arborescens/purpuratus* and *Anthopleura elegantissima* appear to have survived the transplants (Table 4). *Mastocarpus papillatus* and "Petrocelis" were originally found on all nine boulders in June 1996. In December 1996, *Mastocarpus* was still growing on all nine boulders and was reproductive. By May 1997, *Mastocarpus* remained on 7 of the 9 boulders but disappeared from all but 2 of these 7 boulders by May 1998. "Petrocelis" was found on 8 of the 9 boulders in December 1996. By May 1997, "Petrocelis" was observed on 7 of the 9 boulders from which it was originally observed. However, by May 1998 "Petrocelis" could not be seen any large boulders. However, three boulders had "Petrocelis" consistently growing on them except for one survey date (May 1998). *Mazzaella leptorhynchos* was observed on 7 of 9 large boulders in June 1996 and on 3 of those 7 by December 1996. By May 1998, *M. leptorhynchos* was noted only on 2 of the original 7. However, there were three additional boulders where *Mazzaella leptorhynchos* was observed on all but one date. *Gelidium arborescens/purpuratus* was growing on 5 of 9 boulders in June 1996. As of December 1996, 4 of these 5 rocks still had *Gelidium* growing on them. By May 1998, *Gelidium* was observed growing on 1 of 5 original boulders. The aggregating anenome, *Anthopleura elegantissima* was originally observed on 6 of 9 boulders in June 1996 (Table 4). By December 1996, *Anthopleura* was growing on 4 of these 6 rocks. By May 1998, 2 of the six rocks had *Anthopleura* individuals attached on them. The green alga, *Cladophora columbiana*, and the coralline red alga, *Corallina vancouveriensis* did not survive well on boulders. Both were found on 2 of 9 boulders in June 1996 but were gone by December 1996. One large boulder disappeared as of December 1997.

*Mastocarpus papillatus* and *Mazzaella leptorhynchos* survived transplantation on small boulders (Table 5). *Mastocarpus* was found on 6 of 9 boulders in June 1996 and was still growing upon 4 of the 6 by December 1996. By May 1998, *Mastocarpus* remained on 1 of the 6 boulders consistently through the study. However, *Mastocarpus* was present on 2 boulders for all but one survey date. *Mazzaella leptorhynchos* was growing upon all 9 boulders in June 1996 and 6 of the 9 by December 1996. By May 1998, *Mazzaella leptorhynchos* was noted on 1 of the 9 original boulders. However, *Mazzaella leptorhynchos* was present on five boulders for all but one survey date. *Gelidium arborescens/purpuratus* and "Petrocelis" do not appear to have survived transplantation. *Gelidium*, seen on 2 boulders in June 1996, was no longer present on these 2 by December 1996. "Petrocelis" was noted on 6 of 9 boulders in June 1996 but had disappeared from these 6 boulders by December 1996 (Table 5). As of May 1998, 2 of 9 small boulders had disappeared.

**Discussion**

Based on the natural recovery process thus far, full recovery of damaged habitats, especially newly exposed rock surfaces, will no doubt take much longer than two years. Bleaching and blade loss of 287 $m^2$ of *Phyllospadix scouleri* at the wreck site was possibly the result of spilled diesel and oil. Even though it is difficult to generalize on the effects of such a spill, blade loss from oil spills has been observed in some studies. Clark et al. (1973, 1978) noted blade loss of *Phyllospadix scouleri* and *Laminaria setchellii* and bleaching of *Corallina vancouveriensis*, *Prionitis lanceolata* and *Ceramium* sp. in Cape Flattery, Washington. Foster et al. (1971) also noted wide impact to *Phyllospadix torreyi* as a result of the Santa Barbara oil spill in California. However, natural physical disturbances such as extremely hot weather coinciding with extreme low tides can also result in the bleaching and blade loss of seaweeds (Foster et al., 1988). DeVogelaere (Pers. comm.) noted bleaching on portions of seaweed and surfgrass that were exposed at low tide while those portions of plants that were covered by water were not bleached. In addition, similar bleaching may result from freshwater runoff. We suggest, since bleaching was noted in a different pattern within the wreck area than adjacent sites, that damage was likely from spilled diesel and oil. However, no studies have quantitatively investigated recovery from bleaching. We recommend further studies in this area to better understand the dynamics of recovery of plants resulting from natural vs. human induced physical disturbances.

Quantitative Recovery

Damaged plots in the surf grass, mussel and red algal assemblages are being colonized, with species dominant prior to the disturbance. Colonization appears more rapid in the low intertidal surf grass versus mid intertidal mussel assemblages versus mid/high red algal assemblage. Each assemblage has 5 species common to both disturbed and natural condition plots. However, recovery can be highly variable due to the assemblage, season and size of a disturbance (cf. Foster et al., 1988). In a study by Kinnetic Laboratories Inc., (1992), recovery in cleared plots after six years was variable for the red algal and mussel assemblages but it was suggested that recovery in 1 x 2 m clearings in the red algal assemblage takes "from one to more than six years" and for the mussel assemblage, "probably greater than 10 years". In general, assemblages dominated by plants recover faster than those dominated by animals (Foster et al., 1988). Furthermore, plant dominated assemblages appear to recover more rapid in the low intertidal than in the high intertidal. However, surf grass seems to be an exception to this generality. If it is completely removed, seed recruitment may need facilitation by perennial algae to establish (Turner, 1983b). Our data initially support this pattern of recovery rate versus tidal height.

Surfgrass has barely begun to establish 2 years after the disturbance, yet other species have quite heavily colonized. In the natural condition plots within the surfgrass assemblage, cover of some species has either steadily increased or decreased over the 2 years of survey. These shifts may indicate this assemblage is also shifting towards later succesional species or is constantly changing. Another possibility is that cover may have been reduced due to the effects of storms and warmer waters during the 1997/98 El Niño. Furthermore, a precipitous decline in cover of dominant species such as *Phyllospadix scouleri* may indirectly affect the cover of species that grow beneath. Lastly, it is possible that cover of species within this habitat fluctuates on a long term cycle. Continued survey of this habitat will provide further insight into these possibilities. Even though two disturbed surf grass plots fell within the envelope by May 1998, we feel that it would be prudent to consider them not yet recovered since several species indicative of the natural condition assemblage have not established in disturbed plots.

In the mussel assemblage, statistical analyses revealed that Bray-Curtis values between wreck controls, spill controls and wreck to spill controls were significantly different from one another when tested in June 1996. A test between spill controls and wreck to spill controls were significantly different from one another in May 1998. However, some of the wreck control plots fell within the natural condition, spill control, recovery envelope (Figure 6). Since only a few of the plots fell within the recovery envelope, we feel that it would be best to continue to consider the spill controls the natural condition plots.

Disturbed plots in the *Mytilus* assemblage contain species that appear more closely related to the wreck controls. But this disturbed assemblage is far from recovered since *Mytilus californianus* was only found in one plot by May 1998. Wreck controls may also be recovering from chemical damage caused by the vessel. However, the proximity and similar tidal elevation of disturbed and wreck control plots (relative to spill controls) could also explain the similarities. We predict that if the wreck controls do not change much through the seasons relative to disturbed plots then we may assume that they are recovered and may be useful as the natural condition plots for comparison to disturbed plots. However, if cover and composition in the wreck controls continually shifts and seems to track the disturbed plots, perhaps wreck controls were also disturbed and are on the path to recovery. These possibilities suggest that the spill controls should remain the natural condition plots. Continued surveys will provide insight into this fascinating and dynamic question.

Even though 2 of 3 disturbed plots in the red algal assemblage fell within the recovery envelope by May 1998, few of the many species seen in wreck controls such as *Mazzaella splendens*, *M. flaccida*, *M. affinis*, "Petrocoelis" and *Cladophora columbiana*. appear in the disturbed plots. Furthermore, declining cover of *Mastocarpus* and "Petrocoelis" in the natural condition plots coupled with increasing cover of *Endocladia* and *Mastocarpus* in the disturbed plots resulted in high similarities among the plot types. If cover of *Mastocarpus* increases to levels seen on earlier surveys, disturbed plots may actually "fall" out of the natural condition recovery envelope. Nevertheless, colonization of late successional species into the damaged rock surfaces is progressing.

Qualitative Recovery

Colonization by perennial species has not occurred as rapidly in the mid intertidal rubble bed as in other habitats that were damaged. Continual shifting of sediment and rock in the bed appears to prevent establishment of sessile organisms. However, some species are able to colonize the larger rubble chunks as well as stable, non-moving substrata. This is most likely due the "sandpaper" effect of winter storms with sand and loose rock. We predict that eventually, most of the loose rubble in the bed will wash out of the area during high wave activity, exposing the stable granite beneath for colonization. No natural rubble beds are found in this area.

Colonization in the low intertidal rubble bed has occurred faster in some areas relative to the mid rubble bed, possibly the result of fewer loose rocks (<40 cm in diameter) shifting about in the bed. It appears as though these loose rocks may have been rapidly washed out of this bed exposing a stable and solid surface layer beneath. The relative absence of rocks (<40 cm in diameter) in this bed in combination with higher rates of recruitment on the lower shore are likely the reasons for the more rapid re-growth of organisms on the stable bed rock surface. Yet, there are some loose boulders (>40 cm in diameter), in another part of the bed which are being slowly colonized. These boulders appear to experience some movement preventing as rapid an establishment of colonizers.

Recovery of the newly exposed vertical face appeared faster than the rubble beds and upper assemblages, perhaps because it is a relatively unabraded, stable surface located in the low intertidal zone. Colonization of boulders within the sand pit, however, is slowly occurring. Prior to the disturbance, cover on boulders within the pit may have been low since high wave action is continually transporting sand in and out of the pit, likely inhibiting colonization. Species more adapted to surviving sand inundation are most likely to survive. However, the adjacent vertical wall that was abraded by the tires appears to be largely re-colonized, perhaps because it is not affected by shifting sands and boulders. We recommend that future salvage efforts remove vessels quickly to minimize disturbance, and that tires and other equipment used for salvage be removed when not in use to prevent unnecessary damage.

Test of a Restoration Technique

In habitats that have suffered large scale disturbances such as oil spills and clean-up, recovery may take many years. Transplantation of individuals on boulders to large scale disturbed habitats may be an effective way to enhance recovery (De Vogelaere and Foster 1993, De Vogelaere et al., 1997). We are investigating the ability of individuals on boulders to survive and produce successful progeny. Based on the six surveys, survival of the dominant species of the intact assemblage appeared initially higher on large boulders. Increased survival may be due to lower desiccation rates (De Vogelaere and Foster 1993). However, cover of species originally occurring on both large and small boulders was quite low by the last survey in May 1998. This precipitous decline in cover is possibly the result of scour from sand and rocks located within the mid intertidal rubble bed. Furthermore, since attached algae and invertebrates survived well through the first three surveys, we feel that the scour was the likely cause for the decline in cover.

Therefore, the transplantation and survival of species was successful. However, future transplants may survive better if placed in the damage area that does not have extensive sand and rubble. More funding is needed to provide further insight into this technique and to develop improved methods of restoration and recovery enhancement.


**Acknowledgments**

We would like to acknowledge S. Benson, D. Mckeever, J. Engel, M. White, E. Landrau, M. Edwards, M. Hanner, A. King, A. De Vogelaere, J. De Margniac, L. De Margniac, L. Merrick, S. Palacios, I. Sohn, M. Sullivan, S. Urner, M. Walder and A. Woolfolk for assistance in the field, S. Tanner for identifying diatoms and H. Price for assistance with preparation of this report. A. De Vogelaere provided valuable comments on an earlier draft of this report. This study was funded by a grant from the Monterey Bay National Marine Sanctuary Foundation.

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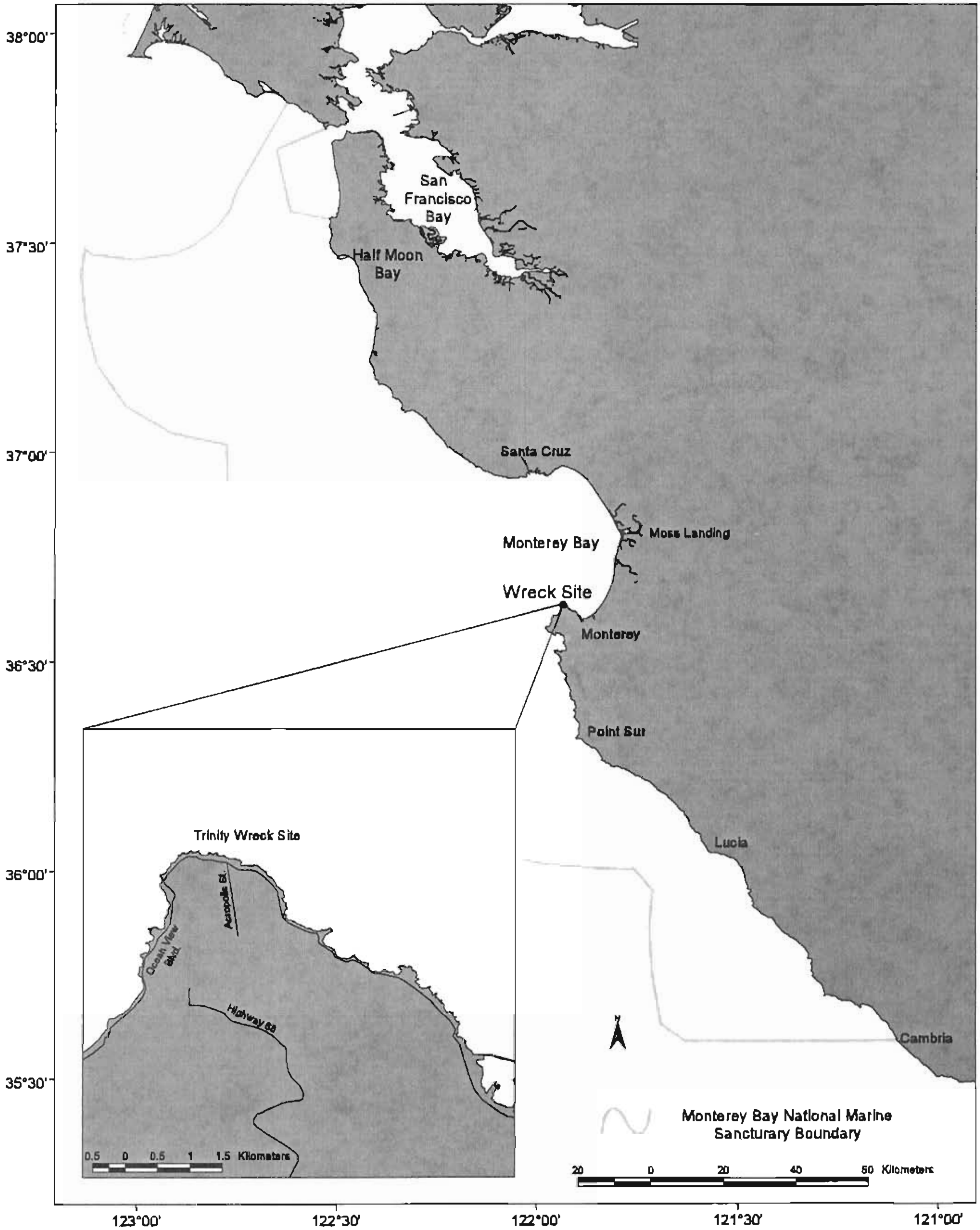


Figure 1. Location of the grounding of the Fishing Vessel Trinity. The gray border depicts the Monterey Bay National Marine Sanctuary boundary.

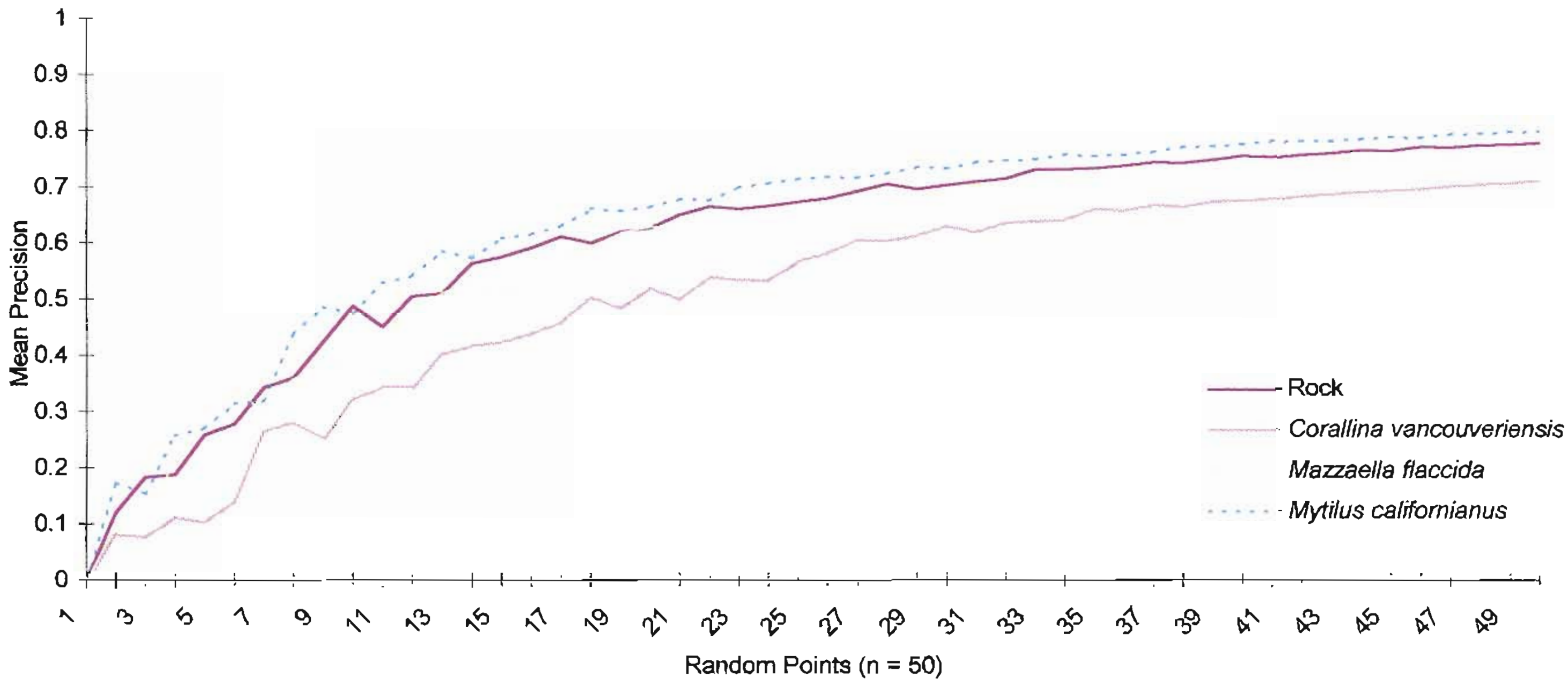


Figure 2. Example from one control plot to show how the optimal number of random points was calculated. Mean precision estimates from 2 - 50 random points, randomly drawn 100 times were calculated for each species or substratum with cover greater than 10% within each plot. An optimal number of 30 points was chosen since this was the highest number of points, from all species and substrata in each plot, beyond which the change in precision was minimal.

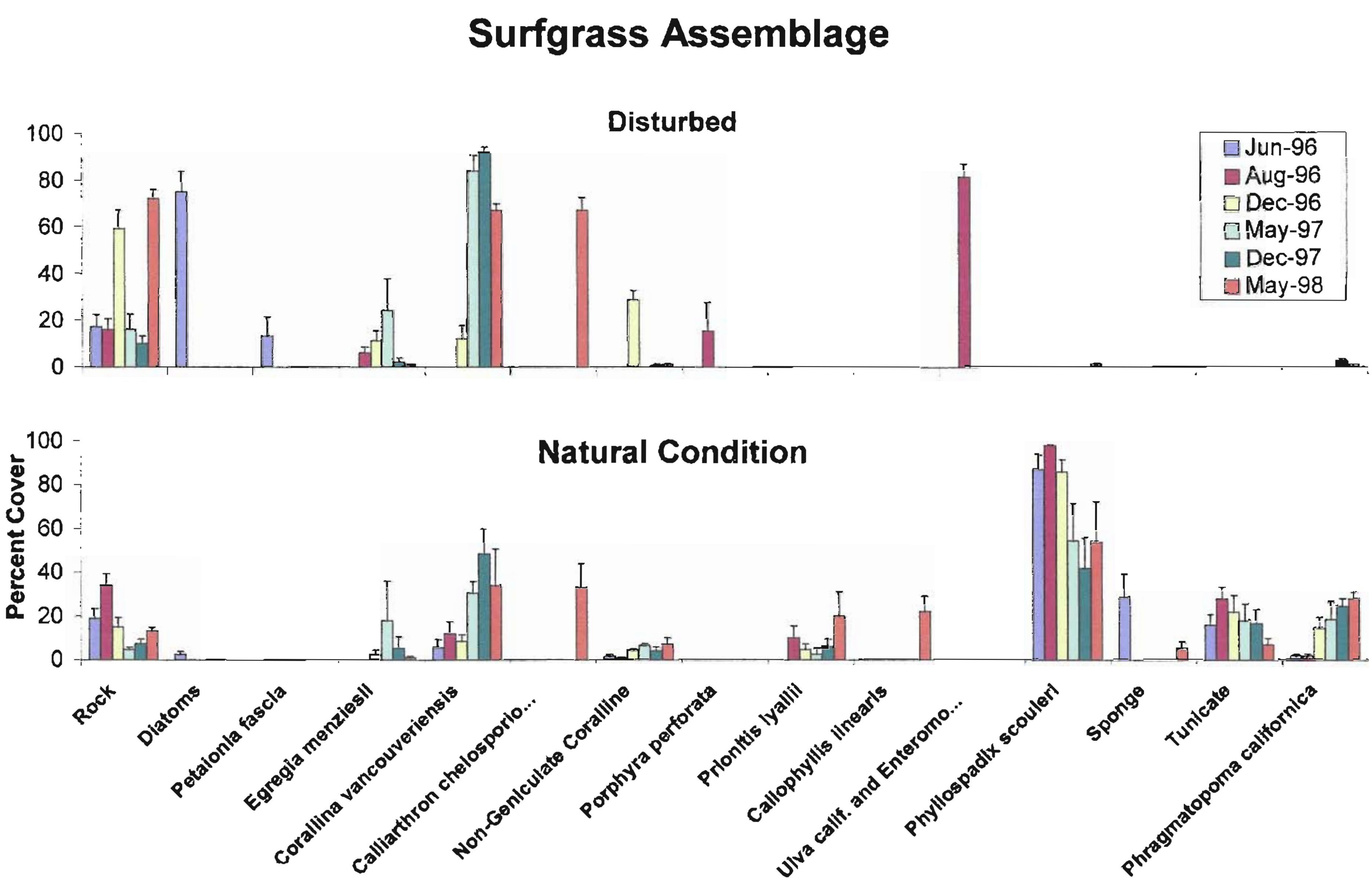


**Figure 3**. Mean percent cover (with SE; n = 5) of abundant species within disturbed and natural condition (wreck control) plots.

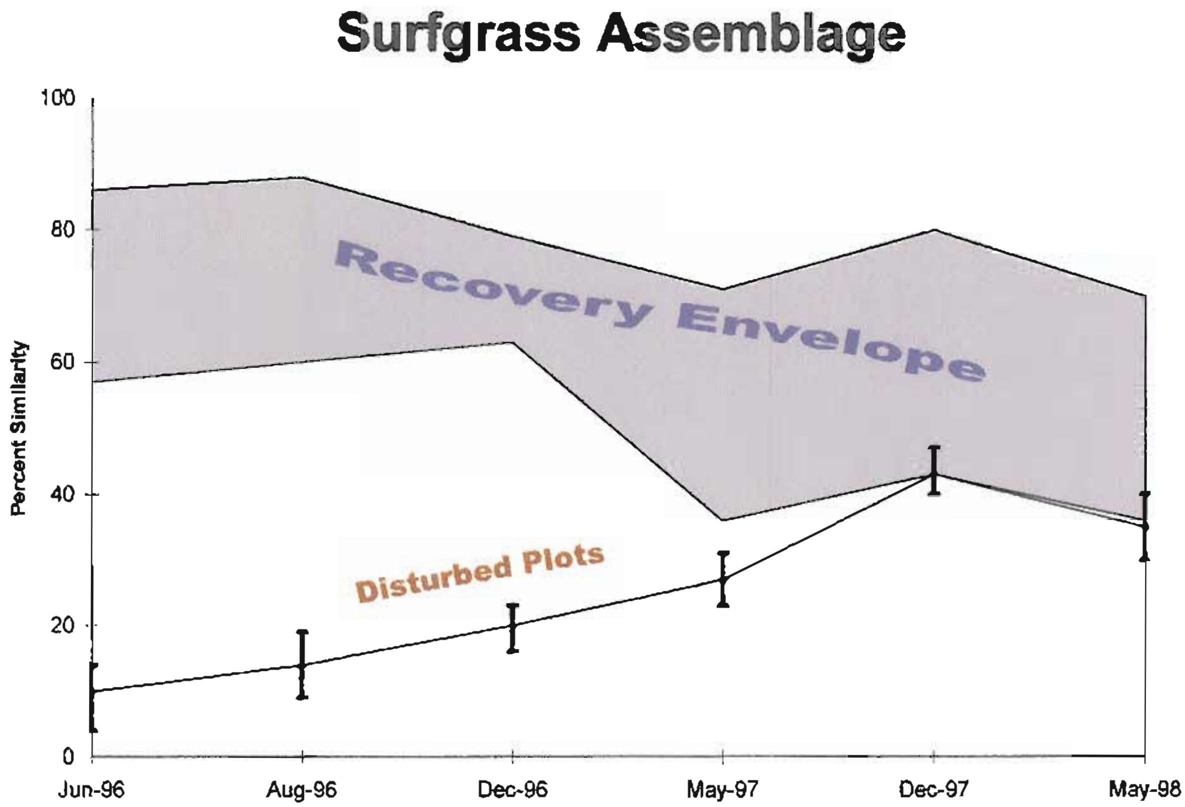


**Figure 4**. Recovery of disturbed plots in the surfgrass assemblage. The recovery envelope is the range of similarities among the wreck controls. Vertical bars are the range of similarities of disturbed plots to the mean similarity of the wreck control plots to each other.

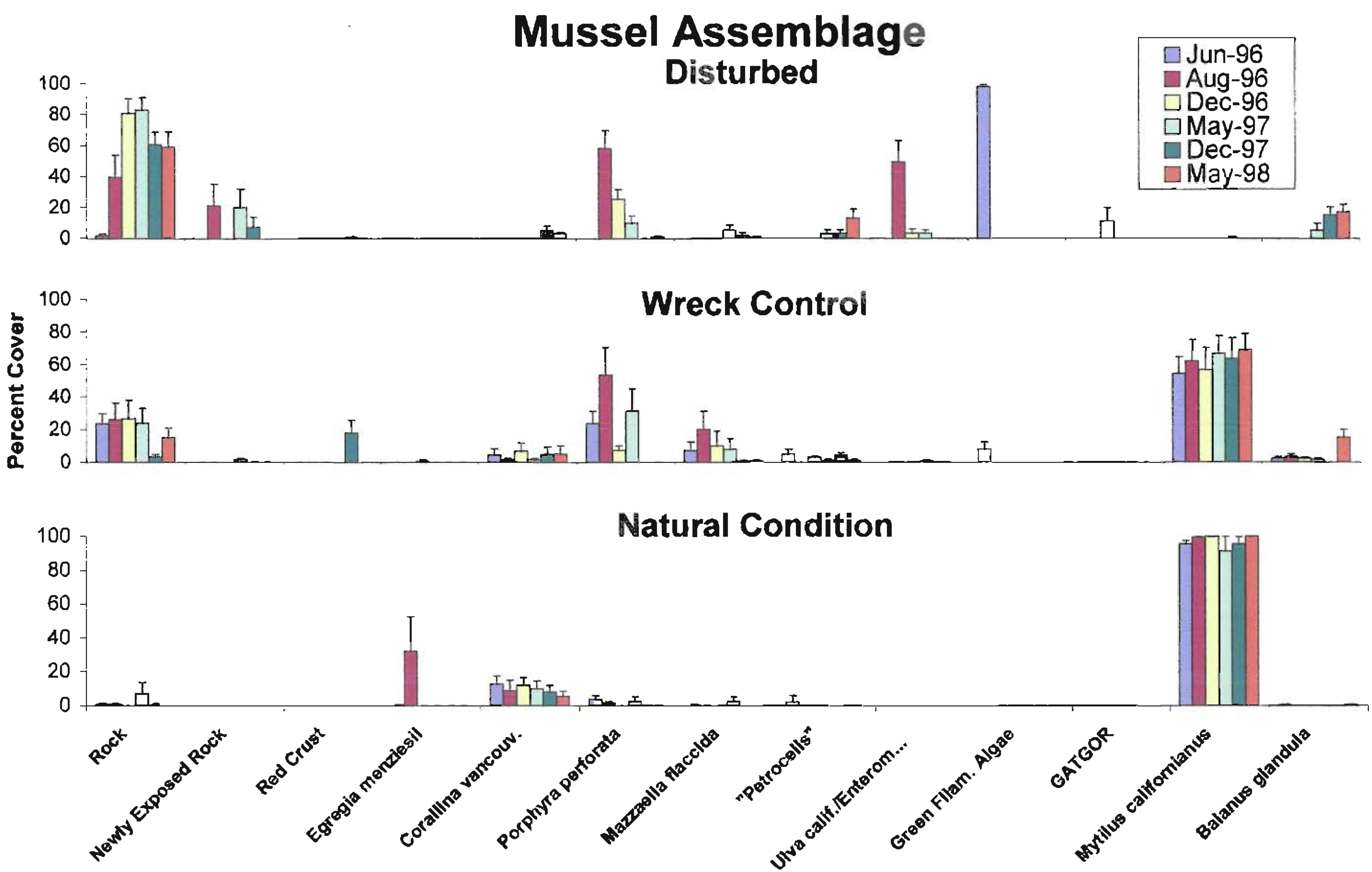


**Figure 5**. Mean percent cover (with SE; n = 5 for all plot types; except for May 1998 n = 4 for all plot types.) of abundant species within disturbed, wreck control and natural condition (spill control) plots.

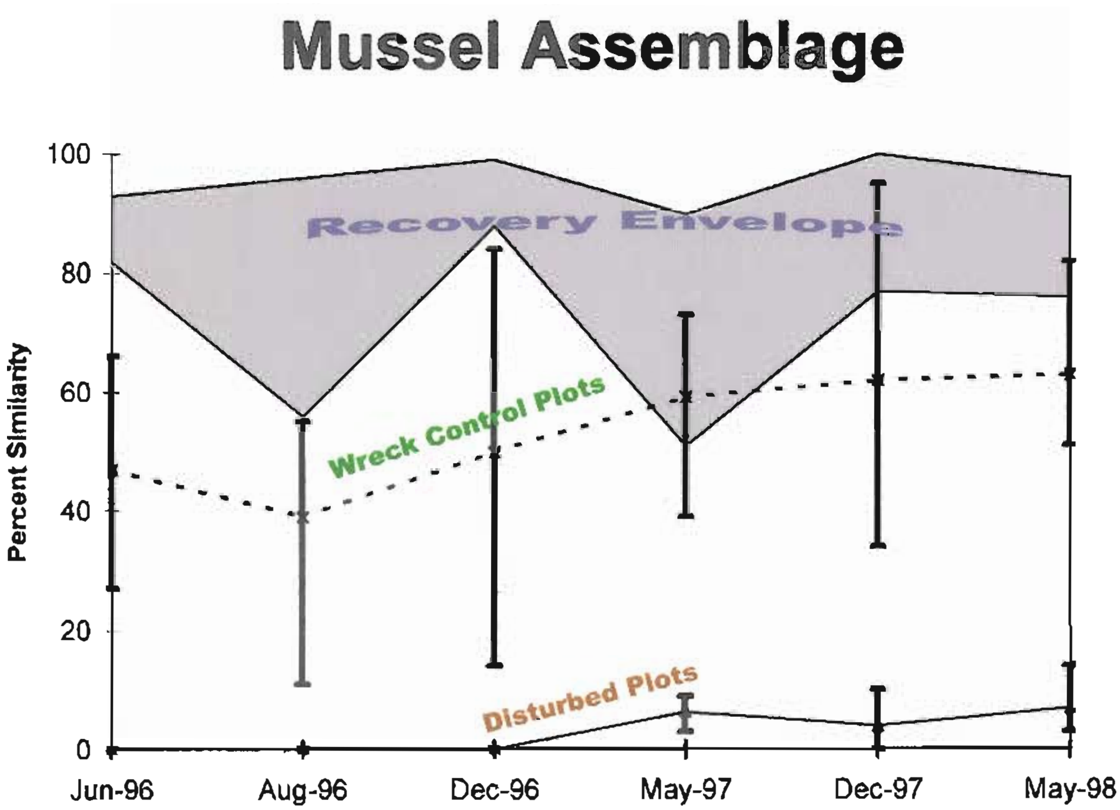


**Figure 6.** Recovery of disturbed and wreck control plots in the Mussel assemblage. The recovery envelope is the range of percent similarity indices (PSI's) among the natural condition (spill control) plots. Vertical bars are the range of (PSI's) of disturbed and wreck control plots when compared to the mean similarity of all natural condition (spill control) plots to each other.

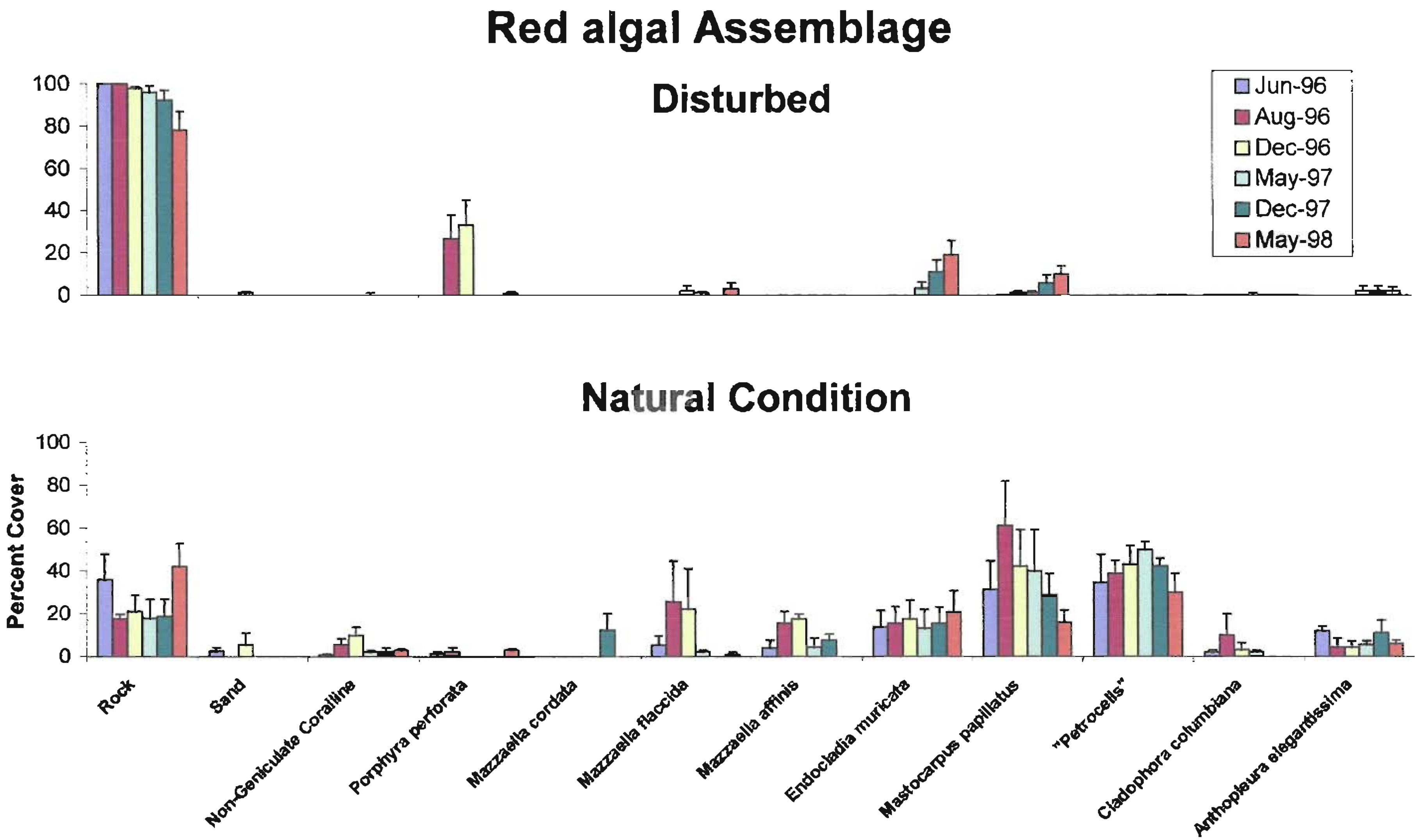


**Figure 7**. Mean percent cover (with se; n = 3 for both plot types) of abundant species within disturbed and natural condition (wreck control) plots.

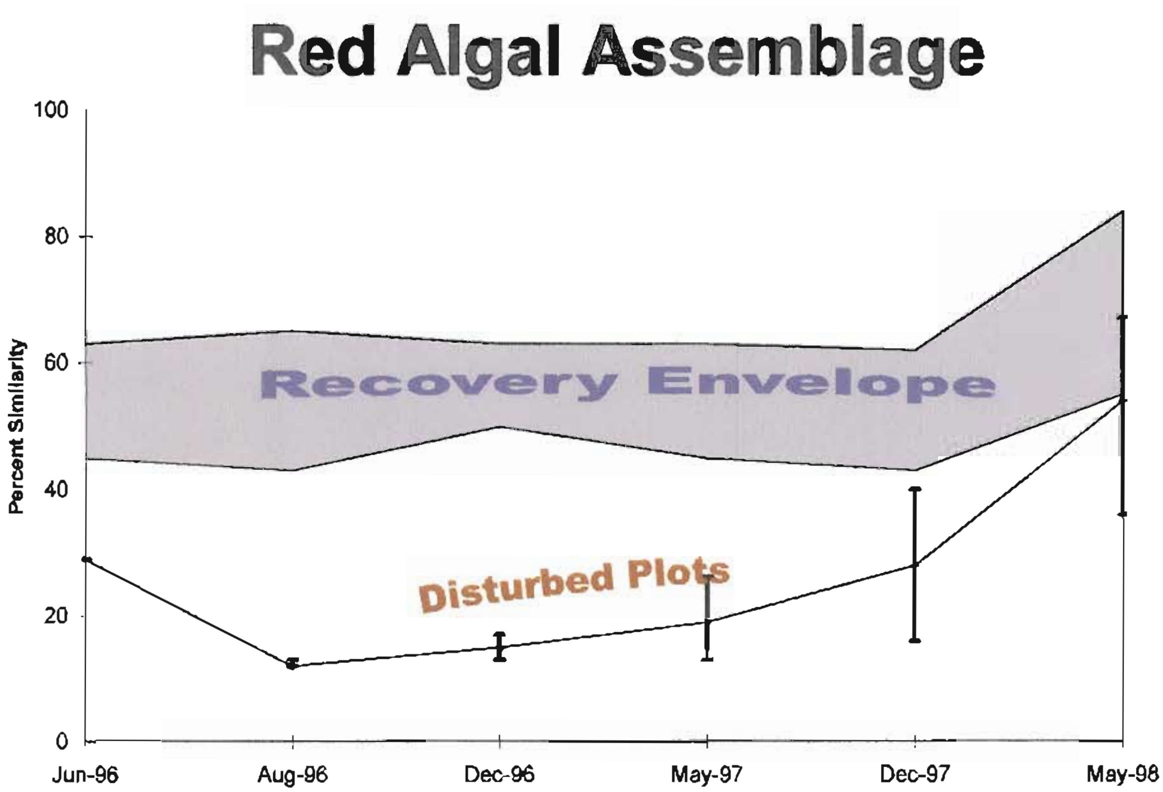


**Figure 8**. Recovery of disturbed plots in the red algal assemblage. The recovery envelope is the range of similarities among the wreck controls. Vertical bars are the range of similarities of disturbed plots to the mean similarity of the wreck control plots to each other.

**Table 1**. Areal extent and type of physical damage caused by the F/V Trinity

| Disturbance Type | Total Area ($m^2$) |
|---|---|
| Rubble Bed | 134.5 |
| Newly Exposed Horizontal Rock Face | 34.5 |
| Newly Exposed Vertical Rock Face | 16.0 |
| Scraped Horizontal Rock Face | 23.7 |
| Scraped Vertical Rock Face | 23.1 |
| Sand Pit | 18.7 |
| Total | 251.1 |

Rubble Bed - Rocks crushed into smaller pieces exposing new surfaces
Newly Exposed Horizontal Rock Face - Horizontal surfaces exposed from crushing
Newly Exposed Vertical Rock Face - Vertical surfaces exposed from crushing
Scraped Horizontal Rock Face - Surface of rock was scraped by the vessel but new rock was not exposed
Scraped Vertical Rock Face - Surface of rock was scraped by the vessel but new rock was not exposed
Sand Pit - Formed by two large tires rising and falling in the surf

**Table 2. Results of qualitative species assessments in disturbed and intact habitats in the mid intertidal rubble bed.**

**June-96**

**Disturbed**

Cover

| Low | Medium | High |
|---|---|---|
| ------ | ------ | Thin green film |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | ------ | ------ |

**Intact Adjacent Ocean Fringe and Landward Edge**

Ocean Fringe

Cover

| Low | Medium | High |
|---|---|---|
| *Gelidium arborescens/pupuratus* | *Endocladia muricata* | *Mazzaella affinis* |
| | *Mazzaella leptorhynchos* | *Mastocarpus papillatus* |
| | "Petrocelis" | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | *Tegula funebralis* | ------ |

Landward Edge

Cover

| Low | Medium | High |
|---|---|---|
| *Gastroclonium coulteri* | ------ | *Anthopleura elegantissima* |
| *Mazzaella leptorhynchos* | | *Endocladia muricata* |
| "Petrocelis" | | *Mastocarpus papillatus* |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | ------ | ------ |

## Table 2. Mid Rubble Bed - Continued

### August-96

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| *Gastroclonium coulteri* | ------- | Thin green film |
| *Gelidium* sp. | | |
| *Mastocarpus papillatus* | | |
| *Mazzaella leptorhynchos* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------- | ------- | *Tegula funebralis* |

#### Intact Adjacent Ocean Fringe and Landward Edge

Ocean Fringe

Cover

| Low | Medium | High |
|---|---|---|
| *Cladophora columbiana* | *Mastocarpus papillatus* | *Endocladia muricata* |
| *Mastocarpus jardinii* | *Mazzaella flaccida* | *Mazzaella affinis* |
| *Mazzaella leptorhynchos* | | "Petrocelis" |
| *Porphyra perforata* | | |
| *Pelvetia compressa* | | |
| *Anthropleura elegantissima* | | |
| *Balanus glandula* | | |
| *Cthamalus dalli* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------- | ------- | ------- |

Landward Edge

Cover

| Low | Medium | High |
|---|---|---|
| *Cladophora columbiana* | *Mazzaella flaccida* | *Endocladia muricata* |
| *Gastroclonium coulteri* | *Mazzaella leptorhynchos* | *Mastocarpus papillatus* |
| *Mazzaella affinis* | | "Petrocelis" |
| *Anthropleura elegantissima* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------- | *Tegula funebralis* | ------- |

# Table 2. Mid Rubble Bed - Continued

## December-96

### Disturbed

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Chondracanthus canaliculatus* | ------ | ------ |
| *Gelidium* sp. | | |
| *Mastocarpus papillatus* | | |
| *Mazzaella leptorhynchos* | | |
| *Prionitis* sp. | | |
| spirorbids | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ------ | *Tegula funebralis* | ------ |

### Intact Adjacent Ocean Fringe and Landward Edge

Ocean Fringe

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Endocladia muricata* | *Mastocarpus papillatus* | ------ |
| *Gastoclonium coulteri* | | |
| *Mazzaella affinis* | | |
| *Mazzaella flaccida* | | |
| "Petrocelis" | | |
| *Anthopleura elegantissma* | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| *Tegula funebralis* | ------ | ------ |

Landward Edge

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Mazzaella flaccida* | *Mastocarpus papillatus* | ------ |
| *Mastocarpus jardinii* | *Mazzaella affinis* | |
| *Anthropleura elegantissima* | *Mazzaella leptorhynchos* | |
| spirorbids | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ------ | ------ | ------ |

# Table 2. Mid Rubble Bed - Continued

## May-97

### Disturbed

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Corallina vancouveriensis* | ------- | *Mastocarpus papillatus* |
| *Gelidium arborescens/purpuratus* | | |
| non-geniculate coralline | | |
| "Petrocelis" | | |
| *Mazzaella affinis* | | |
| *Mazzaella flaccida* | | |
| *Mazzaella leptorhynchos* | | |
| *Anthopleura elegantissma* | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ------- | ------- | *Tegula funebralis* |

### Intact Adjacent Ocean Fringe and Landward Edge

Ocean Fringe

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Mazzaella affinis* | *Endocladia muricata* | ------- |
| *Mazzaella flaccida* | *Balanus glandula* | |
| *Mazzaella leptorhynchos* | | |
| "Petrocelis" | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ------- | *Anthopleura elegantissma* | ------- |
| | *Tegula funebralis* | |

Landward Edge

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Mazzaella flaccida* | *Mastocarpus papillatus* | *Mazeella affinis* |
| *Gastroclonium coulteri* | *Mazeella leptorhynchos* | |
| "Petrocelis" | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| *Anthropleura elegantissima* | ------- | ------- |

# Table 2. Mid Rubble Bed - Continued

## December-97

### Disturbed

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Gelidium arborescens/purpuratus* | ——— | ——— |
| *Mastocarpus papillatus* | | |
| *Mazzaella leptorhynchos* | | |
| "Petrocelis" | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| *Anthopleura elegantissma* | *Anthopleura elegantissma* | ——— |
| *Collisella scabra* | *Tegula funebralis* | |

### Intact Adjacent Ocean Fringe and Landward Edge

Ocean Fringe

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Corallina vancouveriensis* | Mastocarpus papillatus | "Petrocelis" |
| *Mazaella affinis* | | |
| non-geniculate corallines | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ——— | Anthopleura elegantissma | ——— |

Landward Edge

Cover

| Low | Medium | High |
| --- | --- | --- |
| *Pelvetia compressa* | *Endocladia muricata* | ——— |
| *Mazaella affinis* | "Petrocelis" | |
| non-geniculate corallines | | |

Abundance

| Low | Medium | High |
| --- | --- | --- |
| ——— | ——— | *Anthopleura elegantissma* |
| | | *Cthamalus dalli* |

## Table 2. Mid Rubble Bed - Continued

### May-98

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| *Mazzaella leptorhynchos* | *Anthopleura elegantissma* | *Mazzaella leptorhynchos* |
| *Gelidium arborescens/purpuratus* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | *Tegula funebralis* | ------ |

#### Intact Adjacent Ocean Fringe and Landward Edge

Ocean Fringe

Cover

| Low | Medium | High |
|---|---|---|
| ------ | *Endocladia muricata* | ------ |
| | *Mazzaella leptorhynchos* | |
| | *Anthopleura elegantissma* | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | *Tegula funebralis* | ------ |

Landward Edge

Cover

| Low | Medium | High |
|---|---|---|
| *Endocladia muricata* | *Mastocarpus papillatus* | ------ |
| *Gelidium arborescens/purpuratus* | | |
| *Mazzaella leptorhynchos* | | |
| *Anthopleura elegantissma* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ------ | ------ | ------ |

## Table 3. Qualitative Species Assessment in Disturbed and Intact Habitats in the Low Intertidal Rubble Bed.

### June-96

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| ------- | ——— | Thin Brown Film |

Abundance

| Low | Medium | High |
|---|---|---|
| ——— | ——— | ——— |

#### Undamaged Surfaces on Rock Bench and Adjacent Large Boulders

Cover

| Low | Medium | High |
|---|---|---|
| *Corallina vancouveriensis* | *Gastroclonium coulteri* | ——— |
| *Gelidium pusillum* | *Mazzaella leptorhynchos* | |
| *Mazaella leptorhynchos* | *Mazzaella affinis* | |
| non-geniculate coralline | *Mazzaella flaccida* | |
| "Petrocelis" | | |
| *Prionitis* sp. | | |
| *Serpulorbis squamigerus* | | |
| *Acrosiphonia* sp. | | |
| *Anthopleura elegantissima* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| ——— | ------- | ——— |

### August-96

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| *Chondracanthus canaliculatus* | ——— | ——— |
| *Gastroclonium coulteri* | | |
| *Mazzaella leptorhynchos* | | |
| *Mazzaella flaccida* | | |

#### Undamaged Surfaces on Rock Bench and Adjacent Large Boulders

Cover

| Low | Medium | High |
|---|---|---|
| *Chondracanthus canaliculatus* | *Mazzaella flaccida* | ——— |
| *Gastroclonium coulteri* | Non-geniculate coralline | |
| *Mazzaella leptorhynchos* | *Pelvetia compressa* | |
| | *Prionitis lyallii* | |

Abundance

| Low | Medium | High |
|---|---|---|
| ——— | *Tegula funebralis* | ------- |

## Table 3. Low Rubble Bed - Continued

### December-96

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| — | — | — |

Abundance

| Low | Medium | High |
|---|---|---|
| — | — | Thin Green Film |

#### Undamaged Surfaces on Rock Bench and Adjacent Large Boulders

Cover

| Low | Medium | High |
|---|---|---|
| *Gastroclonium coulteri* | *Mazzaella affinis* | — |
| *Gelidium* sp | *Mazzaella flaccida* | |
| Non-geniculate coralline | *Mazzaella leptorhynchos* | |
| *Porphyra perforata* | | |
| Spirorbids | | |
| *Anthopleura elegntissima* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| — | *Tegula funebralis* | — |

### May-97

#### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| *Mazzaella flaccida* | — | — |
| *Mazzaella heterocarpa* | | |
| *Mazzaella leptorhynchos* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| — | — | — |

#### Undamaged Surfaces on Rock Bench and Adjacent Large Boulders

Cover

| Low | Medium | High |
|---|---|---|
| *Endocladia muricata* | — | — |
| *Mastocarpus papillatus* | | |
| *Porphyra perforata* | | |
| *Mytilus californianus* | | |
| *Tetraclita rubescens* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| *Lottia* sp. | — | — |

# Table 3. Low Rubble Bed - Continued

## December-97

### Disturbed

Cover

| Low | Medium | High |
|---|---|---|
| *Corallina vancouveriensis* | *Mazzaella affinis* | ——— |
| *Gastroclonium coulteri* | | |
| *Mazzaella cordata* | | |
| *Mazzaella heterocarpa* | | |
| *Mazzaella leptorhynchos* | | |
| Non-geniculate coralline | | |
| "Petrocoelis" | | |

Abundance

| Low | Medium | High |
|---|---|---|
| *Anthopleura xanthogrammica* | *Tegula funebralis* | ——— |
| *Nucella emarginata* | | |
| *Volcano fissurella* | | |

### Undamaged Surfaces on Rock Bench

(species on large intact boulders is below)

Cover

| Low | Medium | High |
|---|---|---|
| *Corallina vancouveriensis* | *Mazzaella affinis* | ——— |
| *Gastroclonium coulteri* | | |
| *Mazzaella cordata* | | |
| *Mazzaella heterocarpa* | | |
| *Mazzaella leptorhynchos* | | |
| Non-Geniculate Coralline | | |
| "Petrocoelis" | | |

Abundance

| Low | Medium | High |
|---|---|---|
| *Anthopleura xanthogrammica* | *Tegula funebralis* | ——— |
| *Nucella emarginata* | | |
| *Volcano fissurella* | | |

### Undamaged Surfaces on Large Intact Boulders

Cover

| Low | Medium | High |
|---|---|---|
| *Corallina vancouveriensis* | ——— | ——— |
| *Gelidium aborescens/purpuratus* | | |
| *Mastocarpus papillatus* | | |
| "Petrocoelis" | | |
| Spirorbids | | |
| *Tetraclita rubescens* | | |

Abundance

| Low | Medium | High |
|---|---|---|
| *Lottia pelta/scabra* | *Tegula funebralis* | ——— |

# Table 3. Low Rubble Bed - Continued

## May-98

### Disturbed

| Cover | | |
|---|---|---|
| Low | Medium | High |
| *Gastroclonium coulteri* | ——— | *Mazzaella leptorhynchos* |
| *Mastocarpus papillatus* | | |
| *Mazzaella flaccida* | | |
| Non-Geniculate Corallines | | |
| *Rhodymenia pacifica* | | |
| *Prionitis lyallii* | | |

| Abundance | | |
|---|---|---|
| Low | Medium | High |
| *Anthopleura xanthogrammica* | ——— | ——— |
| *Tegula funebralis* | | |

### Undamaged Surfaces on Rock Bench
(species on large intact boulders is below)

| Cover | | |
|---|---|---|
| Low | Medium | High |
| *Gastroclonium coulteri* | ——— | *Mazzaella leptorhynchos* |
| *Mastocarpus papillatus* | | |
| *Mazzaella flaccida* | | |
| Non-geniculate Corallines | | |
| *Rhodymenia pacifica* | | |
| *Prionitis lyallii* | | |

| Abundance | | |
|---|---|---|
| Low | Medium | High |
| *Anthopleura xanthogrammica* | ——— | ——— |
| *Tegula funebralis* | | |

### Undamaged Surfaces on Large Intact Boulders

| Cover | | |
|---|---|---|
| Low | Medium | High |
| *Endocladia muricata* | *Tetraclita rubescens* | ——— |
| *Mazzaella leptorhynchos* | | |
| "Petrocoelis" | | |

| Abundance | | |
|---|---|---|
| Low | Medium | High |
| *Lottia gigantea* | ——— | ——— |
| *Tegula funebralis* | | |

Table 4. Species on large (40-60cm) boulders transplanted into a rubble bed. (x = species present; r = reprod. sp.)

| Date | Boulder # | *Mastocarpus papillatus* | *Mastocarpus jardinii* | "Petrocelis" | *Endocladia muricata* | *Tegula funebralis* | *Mazzaella leptorhynchos* | *Chondracanthus canaliculatus* | *Chondracanthus affinis* | *Mazzaella flaccida* | *Mazzaella cordata* | *Gelidium arb/purpuratus* | Red Crust | non-genic coralline | *Corallina vancouveriensis* | *Cladophora columbiana* | *Gastroclonium coulteri* | *Cryptopleura* sp. | Green Film | Brown Film | *Phragmatopoma californica* | *Anthopleura elegantissima* | Limpets | Tunicate | Sand w/in Algae | *Serpulorbis squamigerus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun-96 | | | | | | x | | | | | | | | | | | | | x | | | | | | x | |
| Aug-96 | | | x | x | | | x | x | | | | x | | x | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | x | | x | | | x | | | x | | | | | | x | | | | | |
| Jun-97 | 1 | x | | x | | x | x | x | x | x | | x | | | | x | | | | | | | | | | |
| Dec-97 | | x | | x | | x | x | | | | | x | x | x | | | | | | | x | x | | | | |
| May-98 | | x | | | | x | x | | x | | | x | | | | | | | | | | | | | | |
| Jun-96 | | x | | x | | | x | | | | | | | x | | x | | | x | x | | x | | | | |
| Aug-96 | | x | | x | | x | x | | | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | x | | | | | | | | x | | | | | | | | | | | |
| Jun-97 | 2 | x | | x | | x | x | | | | x | x | | x | | | | | | | | | | | | |
| Dec-97 | | | | x | | x | r | | | | | | x | x | | | | | | | | x | | | | |
| May-98 | | | | | | x | x | | | | | | | | | | | | | | | x | | | | |
| Jun-96 | | x | | x | | x | x | | x | | | x | | | | | | | | x | | x | | | | |
| Aug-96 | | x | | x | | x | x | | | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | x | | | | | | | | | | | | | | | x | x | | | |
| Jun-97 | 3 | x | | x | | x | x | | | | | x | | | | | | | | | | | | | | |
| Dec-97 | | | | x | | x | x | | | | | | x | x | | | | | | | | x | | | | |
| May-98 | | x | | | | x | x | | | | | | | | | | | | | | | x | | | | |
| Jun-96 | | x | | x | | x | x | | | | | x | | | x | x | | | | | | x | | | | |
| Aug-96 | | x | | x | | x | x | | | | | | | | | | | | | | | x | | | | |
| Dec-96 | | x | | x | | x | | | | | | x | | | | | | | | | | x | | | | |
| Jun-97 | 4 | x | | x | | x | x | | x | | | x | | | | x | | | | | | x | | | | |
| Dec-97 | | | | | | x | x | | x | | | | x | x | | | | | | | | x | | | | |
| May-98 | | x | | | | x | x | | | | | | | | | | | | | | | x | | | | |
| Jun-96 | | x | | x | | x | x | | | | | | | x | | | | | | | | x | | | | |
| Aug-96 | | x | | x | | x | x | | x | | | x | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | | | | | | | | | | | | | | | | x | | | | |
| Jun-97 | 5 | x | | x | | | x | | | x | | x | | | | | | | | | | x | | | | |
| Dec-97 | | | | | x | | x | | | | | | x | | x | | | | | | | x | | | | |
| May-98 | | | | | | | x | | | | | | | | | | | | | | | x | | | | |
| Jun-96 | | x | | x | | x | | | | | | x | | | | | | | | x | | x | | | | |
| Aug-96 | | x | | x | | x | x | | | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | x | | | | | x | | | | | | | | | x | x | x | | | |
| Jun-97 | 6 | x | | x | | | | | x | | | x | | | | | | | | | | | | | | |
| Dec-97 | | x | | x | | x | | | | | | | x | x | x | | | | | | | x | | | | |
| May-98 | | | | | | x | | | | | | | | | | | | | | | | x | | | | |
| Jun-96 | | x | | x | | | | | x | | | x | | x | | | x | | | | | | | | | |
| Aug-96 | | x | | x | | x | | | x | | | x | | x | | | | | | | | | | | | |
| Dec-96 | | x | | x | | | x | | x | | | x | | | | | | | | | | x | x | | | |
| Jun-97 | 7 | | | x | | | x | | x | | | x | | | | | | | | | | | | | | x |
| Dec-97 | | x | | | | x | | | | | | x | x | | | | | | | | | x | | | | x |
| May-98 | | | | | | x | x | | | | | | | | | | | | | | | | | | | x |
| Jun-96 | | x | | x | | | x | | | | | x | | x | x | | | x | | | | | | | | |
| Aug-96 | | x | | | | x | | x | x | | | x | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | | | x | | | x | | x | | | | | | | | | x | | | |
| Jun-97 | 8 | x | | x | | | | | x | x | | x | | x | | | | | | | | | | | | |
| Dec-97 | | MISSING | | | | | | | | | | | | | | | | | | | | | | | | |
| May-98 | | MISSING | | | | | | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | x | | x | | | x | | | | | | | x | | | | | | | | | | x | | |
| Aug-96 | | x | | x | | x | x | | x | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | | | x | | | | | | | | x | x | | | | | | | | | | | |
| Jun-97 | 9 | x | | | | x | x | | x | x | | | | x | | | | | | | | | | | | |
| Dec-97 | | x | | | | x | x | | | | | | x | x | x | | | | | | x | | | | | |
| May-98 | | | | | | x | x | | | | | | | | | | | | | | | | | | | |

Table 5. Species on small (15-30cm) boulders transplanted into a rubble bed. (x = species present; r = reprod. sp.)

| Date | Boulder # | *Mastocarpus papillatus* | *Mastocarpus jardinii* | "*Petrocelis*" | *Endocladia muricata* | *Tegula funebralis* | *Mazzaella leptorhynchos* | *Chondracanthus canaliculatus* | *Chondracanthus affinis* | *Mazzaella flaccida* | *Mazzaella cordata* | *Gelidium arb/purpuratus* | Red Crust | non-genic coralline | *Corallina vancouveriensis* | *Cladophora columbiana* | *Gastroclonium coulteri* | *Cryptopleura sp.* | Green Film | Brown Film | *Phragmatopoma californica* | *Anthopleura elegantissima* | Limpets | Tunicate | Sand w/in Algae | *Serpulorbis squamigerus* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Jun-96 | | x | | x | | x | x | | | | | x | | | | | | | x | | x | | | | | |
| Aug-96 | | x | | | | | x | x | | | | x | | | | | | | | | | | | | | |
| Dec-96 | | | | | | x | x | | x | | | x | | x | x | | | | | | | | | | | |
| Jun-97 | 1 | x | | x | | | | x | | | | | | | | | | | | | | | | | | |
| Dec-97 | | x | | | | x | x | | | | | | | | x | | | | | | | x | | | | |
| May-98 | | x | | | | x | x | | | | | x | | | | | | | | | | | | | | |
| Jun-96 | | | | | | | x | | x | x | | | | x | | | | | | | | x | | | | |
| Aug-96 | | x | | | | x | x | x | | x | | x | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | x | | | | | x | | | x | | | | | | | | | | | |
| Jun-97 | 2 | x | | x | | | x | | | x | | x | | x | x | | | | | | | | | | | |
| Dec-97 | | x | | | | x | x | | | | | | | | x | | | | | | | | | | | |
| May-98 | | r | | | | x | r | | | | | x | | | | | | | | | | | | | | |
| Jun-96 | | x | | x | | x | x | | | | | | | | | | | | x | | | | | | | |
| Aug-96 | | | | | | x | x | | x | | | | | | | | | | | | | | | | | |
| Dec-96 | | | | | | x | x | | x | | | | | x | | | | | | | | x | | | | |
| Jun-97 | 3 | x | | x | | x | x | | | | | x | | | | | | | | | | | | | | |
| Dec-97 | MISSING | | | | | | | | | | | | | | | | | | | | | | | | | |
| May-98 | MISSING | | | | | | | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | x | | x | | | x | | | | | | | | | | | | | | x | x | | | | |
| Aug-96 | | x | | | | | x | | | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | | | x | x | | | | | x | | | | | | | | | | | | | | |
| Jun-97 | 4 | x | | x | | x | x | | | | | | | | | | | | | | | | | | | |
| Dec-97 | | x | | | | x | | | | | | | x | | | | | | | | | x | | | | |
| May-98 | | x | | | | x | x | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | x | | | | | x | | | x | | | | | | | | | | | | x | | | | |
| Aug-96 | | x | | | | | x | | | | | x | | | | | | | | | | | | | | |
| Dec-96 | | x | | | | x | | | | | | | | | | | | | | | | | | | | |
| Jun-97 | 5 | x | | | | x | x | | | | | x | | | | | x | | | | | x | | | | |
| Dec-97 | | x | | | | x | x | | | | | | x | | | | | | | | | x | | | | |
| May-98 | | | | | | x | x | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | | | x | | | x | | | | | x | | x | | | | | | | | | | | | |
| Aug-96 | | x | | | | x | x | | x | x | | x | | | | | | | | | | | | | | |
| Dec-96 | | x | | | | | x | | x | x | | | | | | | | | | | | x | | | | |
| Jun-97 | 6 | x | | x | | | x | | | x | | x | | | | | | | | | | x | | | | |
| Dec-97 | | x | | | | x | | | x | | | x | x | x | x | | | | | | | | | | | |
| May-98 | | x | | x | | x | x | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | x | | | | | x | | | | | | | x | | | | | | | | | | | | |
| Aug-96 | | x | | | | x | x | | | x | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | x | | x | | | | | | | | | | | | | | | | | | | | |
| Jun-97 | 7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dec-97 | | x | | | | x | x | | x | | | | x | x | | | | | | | | x | | | | |
| May-98 | | x | | | | x | x | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | x | | x | | | x | | | | | | | x | | | | | | | | | | | | |
| Aug-96 | | x | | | | x | x | | x | | | | | | | | | | | | | | | | | |
| Dec-96 | | x | | | | x | x | | x | | | x | | | | | | | | | | | | | | |
| Jun-97 | 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dec-97 | | | | | | x | x | | | | | | | x | | | | | | | | | | | | |
| May-98 | | | | | | x | x | | | | | | | | | | | | | | | | | | | |
| Jun-96 | | | | x | | x | x | | | | | | | x | | | | | | | | | | | | |
| Aug-96 | | x | | | | x | x | | | | | x | | | | | | | | | | x | | | | |
| Dec-96 | | x | | | | x | | | | | | | | | | | | | | | | | | | | |
| Jun-97 | 9 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Dec-97 | | x | | x | | x | | | | | | | x | x | | | | | | | | | | | | |
| May-98 | MISSING | | | | | | | | | | | | | | | | | | | | | | | | | |

Appendix I

List of species found in study area from April 1996 to May 1998.

**Substrata**
Rock
Sand
Diatoms

**Brown Algae**
brown Film
*Egregia menziesii*
*Pelvetia compressa*
*Petrospongium rugosus*
*Petalonia fascia*
*Scytosiphon dotyi*

**Red Algae**
*Calliarthron chelosporioides*
*Callophyllis linearis*
*Chondracanthus canalliculatus*
*Chondracanthus spinosus*
*Corallina vancouveriensis*
*Crptopleura sp.*
*Endocladia muricata*
*Gastroclonium coulteri*
*Gelidium pusillum*
*Gelidium* sp.
*Gelid. arborescens/purpuratus*
*Iridaea cordata*
*Mastocarpus jardinii*
*Mastocarpus papillatus*
*Mazzaella affinis*
*Mazzaella flaccida*
*Mazzaella heterocarpa*
*Mazzaella leptorhynchos*
*Mazzaella lineare*
*Mazzaella sp.*
*Microcladia borealis*
non-genic coralline
*Osmundea spectablilis*
"Petrocelis"
*Porphyra perforata*
*Prionitis lyalli*
red blade
red film
red algal filament
*Rhodymenia pacifica*
*Rhodymenia sp.*
*Sarcodiotheca gaudichaudii*
*Smithora naiadum*

**Green Algae and Surf Grass**
*Acrosiphonia coalita*
*Cladophora columbiana*
GFA (mix of green filamentous algae including, *Urospora pencilliformis*, *Ulothrix pseudoflacca* an *Chaetomorpha californica*)
green film
*Phyllospadix scouleri.*
*Ulva lobata*
*Ulva californica and Enteromorpha sp.*

**Invertebrates**
*Aglaophenia latirostris*
*Anthopleura elegantissima*
*Aplidium californica*
*Aplidium* sp.
*Balanus glandula*
*Corynactis californica*
*Cthamalus dali*
*Distaplia occidentalis*
*Epiactis prolifera*
*Eudistoma diaphenes*
*Eudistoma psammion*
*Euherdmania claviformis*
*Eurystomella bilabiata*
Mussel w/hairs
*Mytilus californianus*
*Phragmatopoma californica*
*Policipes polymerus*
*Ritterella rubra*
Serpulid
*Serpulorbis squamigerus*
Spirobids
*Tegula funebralis*
*Tetraclita rubescens*
*Trididemnum opacum*