Draft report on the effects of a ship grounding on an intertidal community near Bolinas Point

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To: Ben Becker, Point Reyes National Seashore

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Subject: Christopher M vessel grounding report

Introduction

On May 14, 2005, the Christopher M came aground in the mid-intertidal approximately 500 meters south of the Bolinas Point (Figure 1) site used by the Coastal Biodiversity Team from UC Santa Cruz (http://cbsurveys.ucsc.edu/).

Figure 1: Ship wreck site and location of Coastal Biodiversity sites near to wreck site.

The Coastal Biodiversity team was contacted by Ben Becker, Director and Marine Ecologist at the Pacific Coast Science and Learning Center, Point Reyes National Seashore. We agreed to carry out surveys of the intertidal ecological community at the wreck site to aid is assessing the impact resulting from the wreck. On May 27th, 2005 the wreck site (herein labeled BPW = “Bolinas Point Wreck”) was initially surveyed. Note that we had just surveyed a reference site (BP = “Bolinas Point”) 500 meters upcoast on May 11 and 12th, 2005. BPW and BP were resurveyed on October 17th & 18th and November 2nd & 3rd, respectively.

Methods

Qualitative sampling: At each site notes were taken about conditions at the site that might affect the sampling.
Quantitative Field Methods: Methods were largely based on the design used in the Coastal Biodiversity surveys (details in http://cbsurveys.ucsc.edu/sampling/sampling.html) consisting of three basic sampling protocols: point intercept, quadrats and swath sampling. At the site a baseline was established above the marine biological zone parallel to shore. A series of transects were established perpendicular to this baseline that extended to the water. For the point intercept method points were space uniformly along each transect and the species below the point was recorded. For the quad method quadrats (50 x 50 cm) were placed in the low, mid and high zones along each transect and all mobile species were counted in each quadrat. The table below describes the sampling done at each site for all surveys used in the analyses. The lengths of the sampling transects were between 150 and 178.5 meters for the Bolinas Point site and between 104 and 124 meters for the Bolinas wreck site.

Table 1: sampling scheme for point contact sampling

Bolinas Point Site			**Distance along baseline**										
Transect	**Month**	**Year**	**0**	**3**	**6**	**9**	**12**	**15**	**18**	**21**	**24**	**27**	**30**
Length	May	2005	171	172.5	180	178.5	177	177	177	177	177	177	177
Length	Nov	2005	163.5	163.5	163.5	156	163.5	162	150	150	150	150	150
Interval of sampling between points on each transect = 1.5 meters													

Bolinas Wreck Site			**Distance along baseline**										
Transect	**Month**	**year**	**0**	**5**	**10**	**15**	**20**	**25**	**30**	**35**	**40**	**45**	**50**
Length	May	2005	124	----	123	----	119	----	118	----	116	----	117
Length	Oct	2005	109	108	104	105	105	107	108	108	108	106	107
Interval of sampling between points on each transect = 1 meter													

The result of this sampling is a standardized sampling of all common space holders on the reef. This sort of sampling has allowed us to clearly characterize sites along the entire temperate west coast of North America.

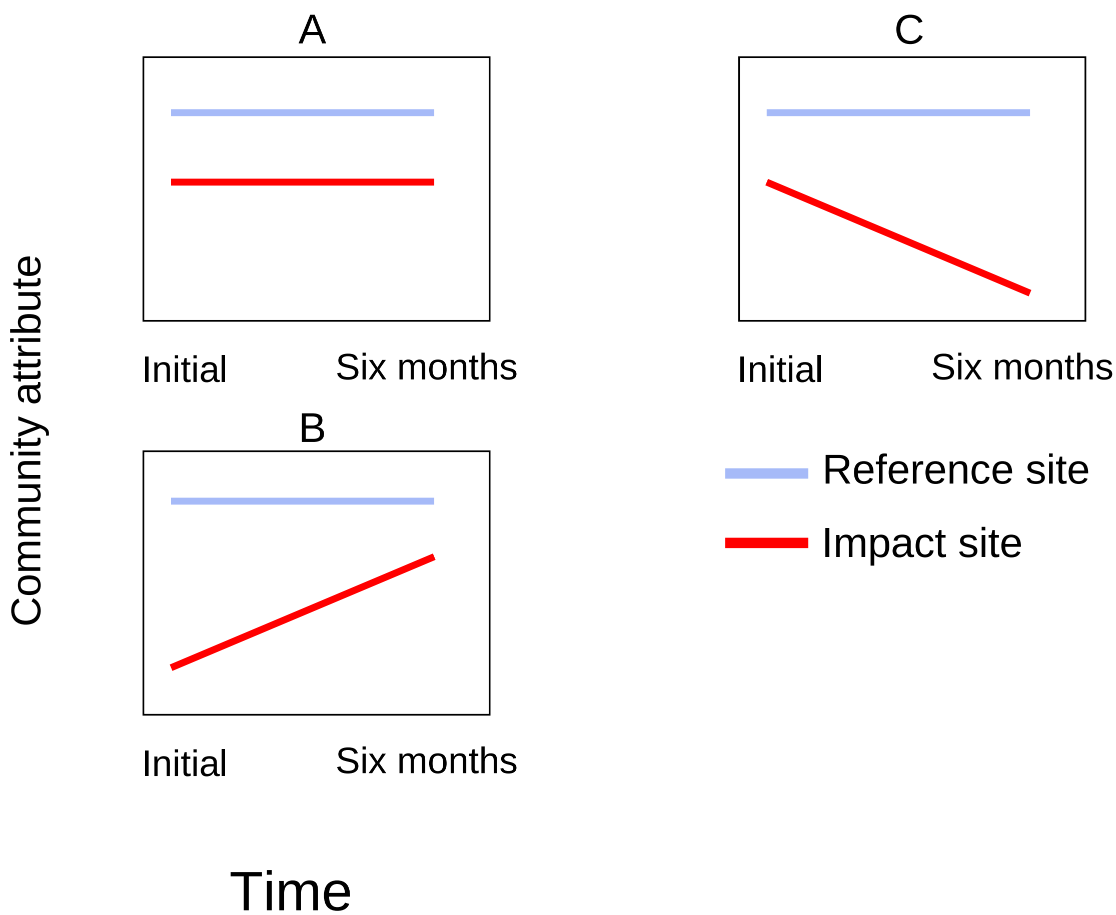
Analytical Model Except for obvious physical damage to a reef, assessing the degree of impact is very difficult in the absence of baseline and reference location data. In this case we have very good reference data from the BP site 500m distant, which was sampled just prior to the ship wreck. There are no baseline data for the wreck site. We therefore came up with a process to assess impact used the existing BP site as baseline for the two questions we were asked to address:

1) Is there any evidence of an impact to the intertidal community beyond the obvious physical damage done by the vessel?
2) Is there any evidence of a longer term or chronic impact?

For question one, we compared BP and BPK sites and related that difference to the expected differences that can be generated by looking at pairs of sites within biogeographic areas. These expected differences were generated using Coastal Biodiversity datasets.

For question two we took a more complex approach. We assumed that the temporal responses of both sites (BP and BPK) in the absence of an impact at BPK would mirror one another. If the wreck had an impact on the community the responses would have one of the patterns shown in Figure 2 (below).

Figure 2: Some hypothetical outcomes



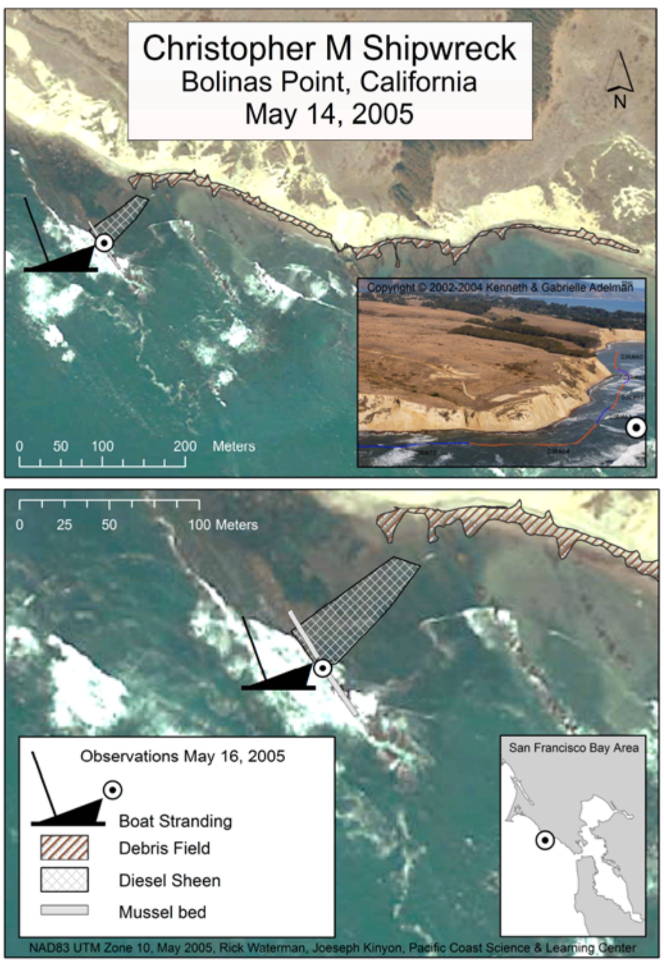
Pattern A could indicate an impact that has not changed over time. Alternatively it could simply reflect typical site to site differences that occur naturally. We address this in method 1 (above). In both patterns B & C there is a change at the impact site relative to the reference site. In B there is evidence of recovery. In C there is evidence of longer term effects of the impact. Clearly there are more scenarios than presented here; these are shown to indicate the type of assessment we did to evaluate the possibility of an ecological impact resulting from the wreck.

Analytical models We used two major forms of analysis to evaluate the data collected in our surveys. First we used normal univariate approaches (2 –factor ANOVA, site and period as fixed factors) to evaluate effects to single taxa. Second we used ordination, multidimensional scaling, followed by ANOSIM and SIMPER to compare biological communities between sites and over time. ANOSIM uses a reampling approach to calculate the probability that the ordinated communities are similar, while SIMPER uses a resampling approach to determine the species that contribute significantly to the separation of communities (e.g. which species contribute most to the differences between BP and BPW).

Description of results and injury

Point Reyes observers provided the map below, which depicts the wreck and debris field.

Figure 3: map of wreck site and debris field



During our sampling we also took photos that show localized debris and damage to biological communities.

Figure 4: Photos of Bolinas point Wreck site showing debris and damage to biological communities

As noted below most of the obvious damage occurred along transect 40 (shown above.) Based on our assessment of the physical damage to the reef we estimate the area of direct injury to be between 30 and 100 square meters (best estimate 50 square meters). This is the area directly and immediately affected by the physical damage caused by the boat or debris. This does not include any effects due to diesel or other petroleum fouling (discussed below).

<u>Is there any evidence of an impact to the intertidal community beyond the obvious physical damage done by the vessel?</u>

We looked at four groups of taxa specifically at the request of the Point Reyes National Seashore; these were surfgrass, *Fucus,* erect corallines and encrusting corallines to assess impacts from diesal or other petrochemical fouling (Table 2). Surfgrass, Fucus and Erect corallines were more abundant at the BP site than BPW site regardless of period sampled.

Encrusting corallines were more abundant at the BPW site regardless of period. Importantly there was no interaction between site and Time sampled. This means that the difference in abundance of taxa between BP and BPW sites did not change over the six month period. Hence there was no evidence (for these taxa) of long term, chronic or indirect impact (Figure 2B, C above). This does not rule out the possibility that there were impacts to the BPW site that have not been remedied over the six month period (Figure 2A).

Table 2: ANOVA results for 4 taxa (2 factor ANOVA, Time and site considered fixed factors)

Taxa	**Source**	**P-value**	**Notes**
Surfgrass	Site (BP vs BPW)	**0.008**	More abundant BP than BPW regardless of period
Surfgrass	Time (initial vs later)	**0.013**	More abundant in the later period than the initial
Surfgrass	Interaction (site*time)	0.116	Abundance relationship between BP and BPK does not vary with period
Fucus	Site (BP vs BPW)	**0.0002**	More abundant BP than BPW regardless of period
Fucus	Time (initial vs later)	0.688	No temporal effect
Fucus	Interaction (site*time)	0.465	Abundance relationship between BP and BPK does not vary with period
Erect Corallines	Site (BP vs BPW)	**0.000001**	More abundant BP than BPW regardless of period
Erect Corallines	Time (initial vs later)	0.083	No temporal effect
Erect Corallines	Interaction (site*time)	0.967	Abundance relationship between BP and BPK does not vary with period
Encrust Corallines	Site (BP vs BPW)	**0.000004**	More abundant BPK than BP regardless of period
Encrust Corallines	Time (initial vs later)	**0.004**	More abundant in the initial period than the later one
Encrust Corallines	Interaction (site*time)	0.259	Abundance relationship between BP and BPK does not vary with period

Ordination showed that the communities sampled in quadrats and by point intercept differed between BP and BPW in both periods and that each site showed differences over time (Table 3). The value in the dissimilarity column is a scalar that can be used for comparisons (more below).

Table 3: Results from ANOSIM comparisons

Survey Type	**Comparison**	**P-Value**	**Dissimilarity**
Point Intercept	BP vs BPW, Period 1	0.001	34.53
Point Intercept	BP vs BPW, Period 2	0.001	42.29
Point Intercept	Period 1 vs Period 2, BP	0.001	36.16
Point Intercept	Period 1 vs Period 2, BPW	0.023	40.94
Quadrat	BP vs BPW, Period 1	0.003	56.91
Quadrat	BP vs BPW, Period 2	0.001	42.99
Quadrat	Period 1 vs Period 2, BP	0.001	53.86
Quadrat	Period 1 vs Period 2, BPW	0.001	60.89

The species that contributed to the differences shown (SIMPER analysis) above are given in Appendix 1 (an attached set of excel files). It is worth noting that for both the quadrat data, line 40 at BPW was completely different from all other sample areas. Recall that line 40 was in the area of impact. We present the graphical results of the ordination (cluster analyses) below.

Figure 4: Cluster analysis for quadrat data. Note the coding on the X axis: First letter indicates period (I=Initial, S = six month later), second letter indicates site (B=BP, W= BPW), last characters indicate transect. Notice how different transect 40 is during the initial survey at BPW site.

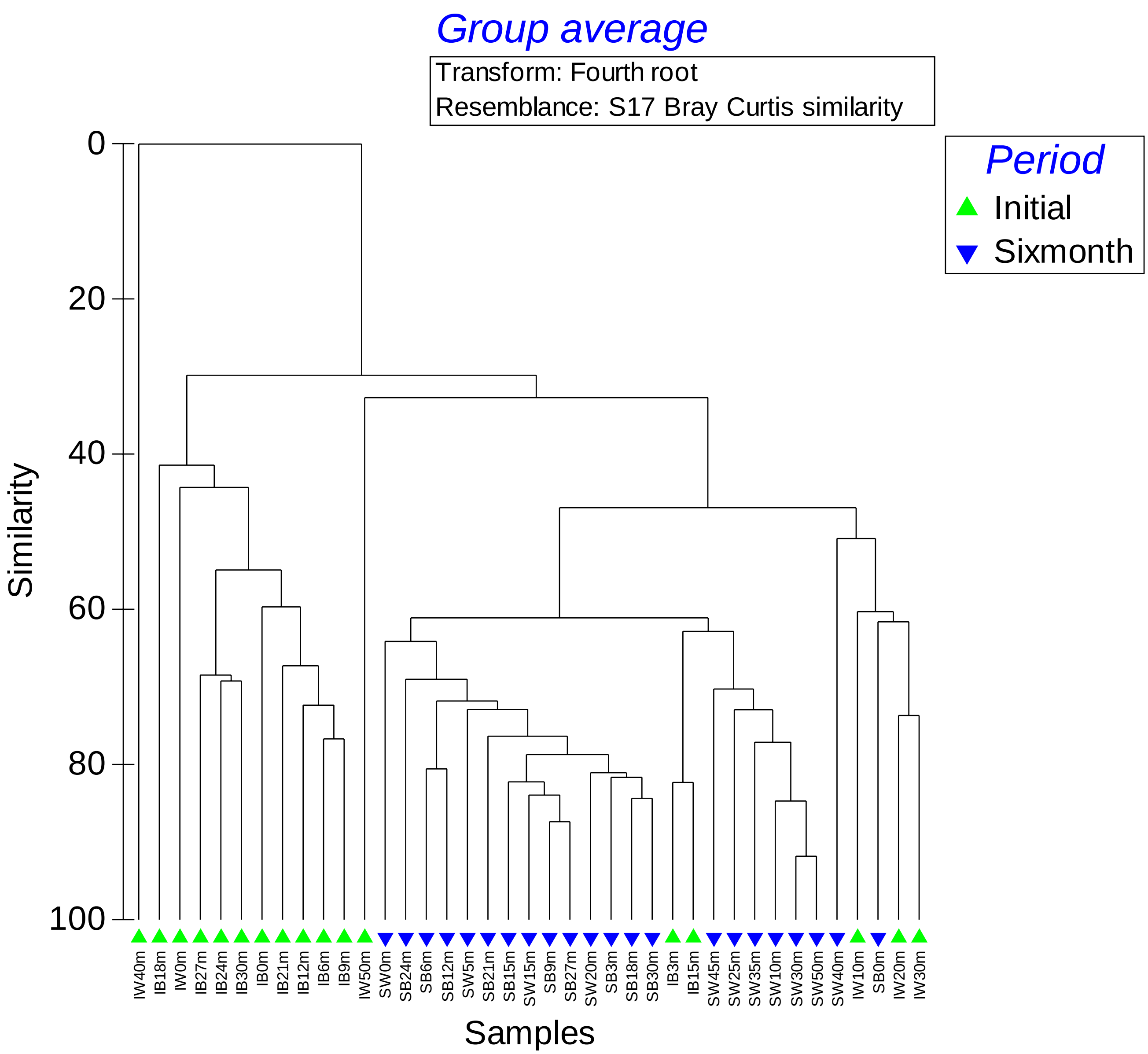
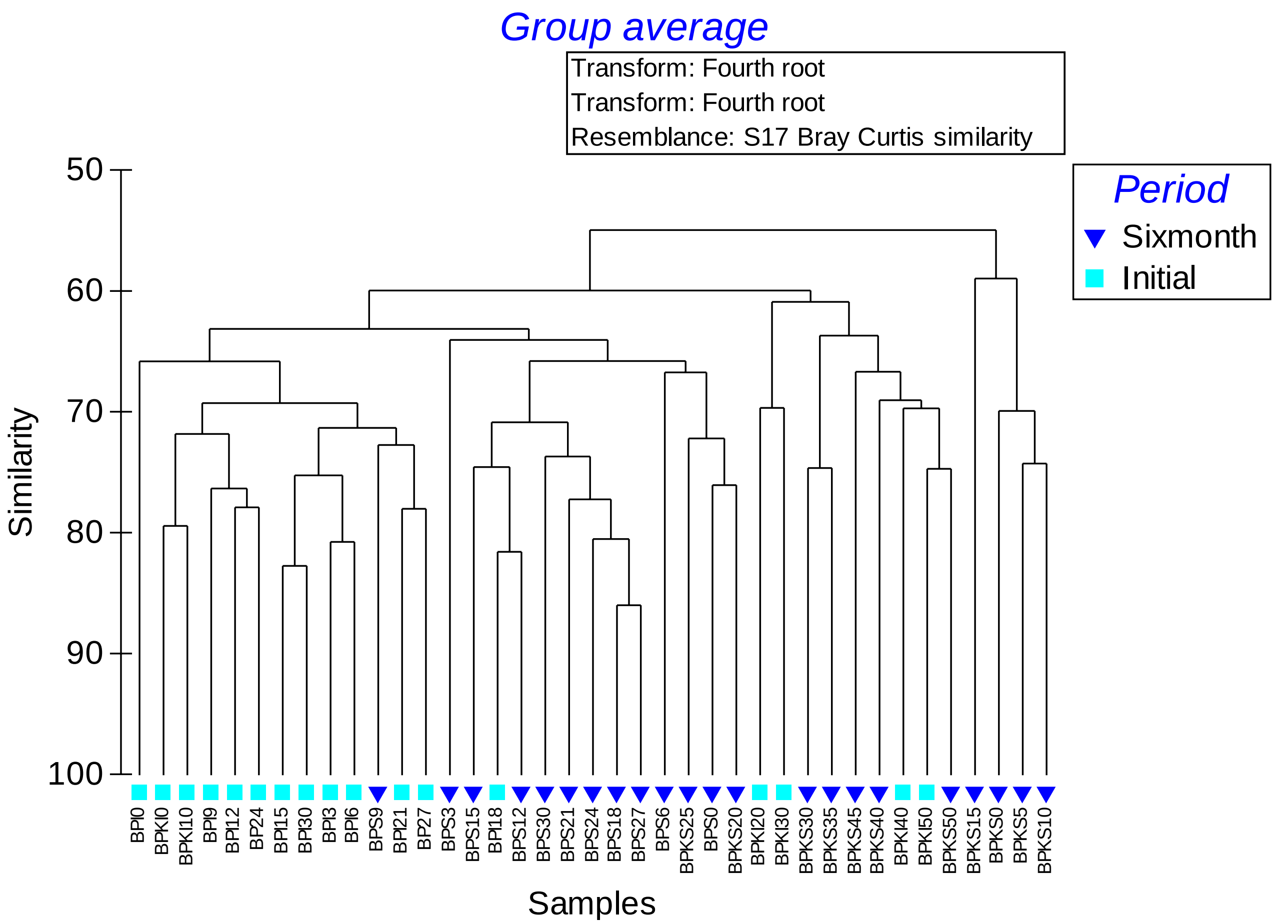
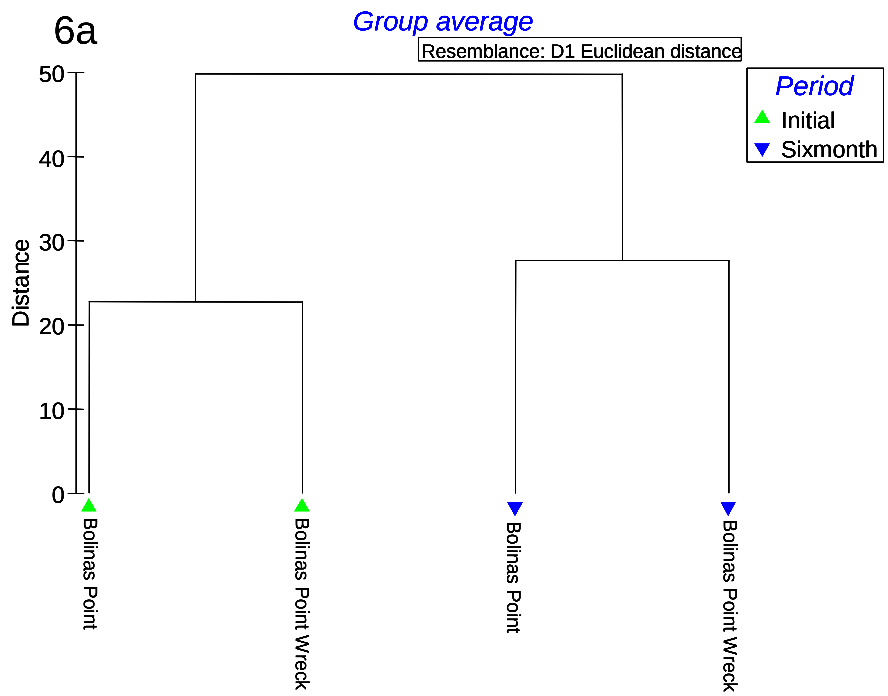


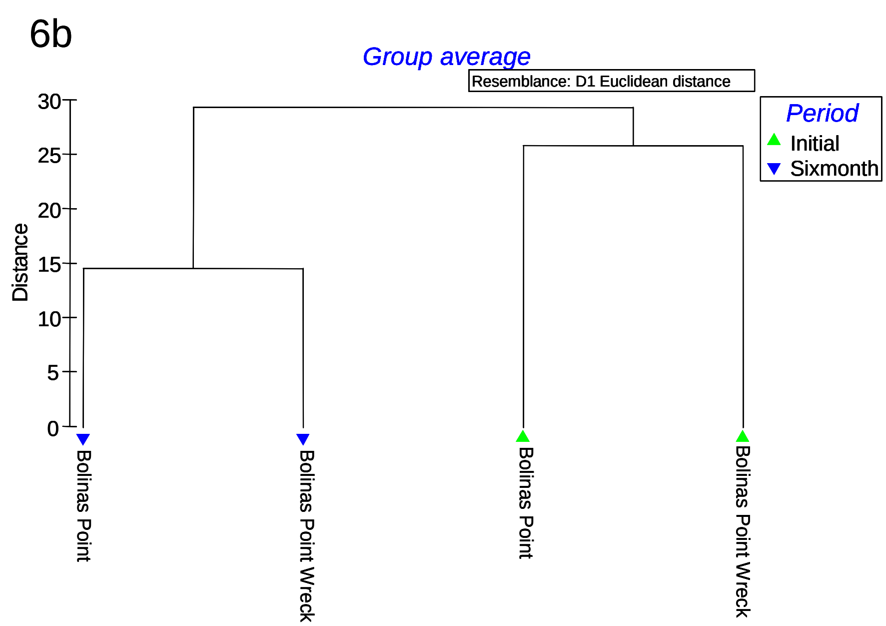
Figure 5: Cluster analysis of point intercept data. Here, first letters indicate sites (BP, BPK = Wreck site) and second code is period (I=Initial, S = six month later), finally transects are noted by the number at end of string.



The last comparison of interest involves looking at the response at the site level for comparison to trajectories shown in Figure 2. In the figures below we show the similarity on the basis of the whole site for data collected using point intercept and quadrat methods.

Figure 6a: Similarity of species compositions for quadrat data as a function of site and period. 6b: Similarity of species compositions for point contact data as a function of site and period.





For both point contact and quadrat data, analyses suggest that the source of variability in species abundances comes from period (seasonal effects). This means that on average the there is more variability associated with temporal change than due to the effect of the wreck. As noted, (1) this does not apply to the mussel community and (2) there could have been impacts at the wreck site that did not change over the course of the study (Figure 2A).

Conclusion

The data collected and analyses performed support the idea that the primary impact from the shipwreck on the intertidal community resulted from the initial physical damage to the reef. We estimate that area as being between 30 and 100 square meters. Much of the impact was to mussel beds, which can take a considerable period to recover. Results of our own studies and those done by the Minerals Management Service indicate that recovery of mussel beds after disturbance is on the order of 5-20 years. Apart from the direct physical impact to species,we found no evidence of impacts from diesel or petrochemical fouling over the six month period sampled. This conclusion is based on simple evaluation of specific species and also assessment of community response using multivariate statistics.