Pre- and Post Restoration Assessment of Benthic Communities
Collaborative Agreement 2009-0211
Interim Report – Oct 31, 2010

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Progress:
Sample Progress: Table 1 summarizes the status of all samples. Despite the problems with hiring we believe we will finish on schedule.

The grazing rate estimates shown in the earlier report have not changed. We will complete the grazing estimates for 2007-2009 when we get the samples back from the contractor.

Preliminary Findings:
We have received the taxonomic data for most of 2006 and have done a preliminary analysis of the data to examine the temporal and spatial differences in the benthic community structure and to identify the species responsible for the variability. A discussion of the method used and some preliminary results follows:

2006 Benthic Community Analyses: Benthic communities at all locations that have been processed for all seasons were compared using non-parametric multi-dimensional scaling (NMDS, Clarke 1993) with PRIMER 6 (Clarke and Warwick 2001). Abundance data for all species were fourth-root transformed and Bray-Curtis similarities computed between each pair of stations. The resulting matrix was ordinated by non-metric multi-dimensional scaling to display the variation among the assemblages. The resulting graph plots samples that have the most similar benthic communities close together and those that have the most different benthic communities further apart. The Bray-Curtis similarities are shown here at the 40% and 60% levels. Note, analysis of the July data is limited due to the reduced number of samples available at this time.

There is a distinct difference in the benthic community structure north (NDB) and south (SDB) of Dumbarton Bridge (Figure 1a and 1b). Once the embayments are separated the communities are grouped mostly by depth with the break at the 2m at MLLW level (Figure 1b). This depth was chosen as a marker for clustering because it is the depth that the bird ecologists use to designate the level above which most birds feed (Susan De La Cruz, USGS BRD, personal comm.). Therefore we might expect to see the most separation in the benthic communities by depth following the fall bird migration when some species in the shallow water are expected to be heavily preyed upon. This proved to be true. The April 2006 benthic communities were mostly grouped by depth within the 60% similarity clusters except for the few shallow water stations that are included in the channel grouping. These “shallow” stations are at or near the 2m depth contour so it is not surprising that their benthic communities might be a mix of those found both shallower and deeper than 2m. The shallowest stations were all clustered in the bottom of the NDB 40% similarity cluster. The data from the two embayments also showed some overlap in April; this does not yet appear to be true with the data currently available in the either July or October.

We have examined the species with the highest abundances and those that contribute most to the differences shown in Figures 1a and 1b. All but two of these species are common bird prey. Two species were common in both embayments of the system. *Heteromastus filliformis*, a deposit-feeding polychaete that feeds on deeply deposited organic matter, is more common in the shallower water than in the >2m at MLLW locations in both embayments. As shown by its increase in abundance this worm had a recruitment period between April and October (Figure 2). The second common species was *Ampelisca abdita* which showed an opposite seasonal pattern to that of *H. filliformis*. As reported by Nichols and Thompson (1985) *Ampelisca abdita*, a tube-dwelling, filter-feeding amphipod, is more common in the deep water in winter and spring than in the rest of the year when it moves back onto the mudflats. Nichols and Thompson suggested that this occurs due to the lower salinity water on the mudflats in winter/spring. Once on the mudflats its abundance appears to decline as seen by the drop in abundance between April and October. This pattern was observed in both embayments (Figure 3).

The southern embayment had more bivalves than the northern embayment. *Corbula amurensis* , a filter-feeding exotic bivalve was common and showed the previously described pattern of increasing in density through the year (Thompson et al 2008) before they are grazed down in fall/winter by the birds and fish in the shallow water (Figure 4). *Macoma spp.*, deep dwelling bivalves that both deposit and filter-feed, show patterns similar to those of *C. amurensis* (Figure 5).

The northern embayment was dominated by surface deposit feeders (*Sabaco elongatus*, *Nippoleucon hinnumensis*, and Corophidae amphipods). We would expect this pattern only where labile organic accumulates on the sediment surface. This may take the form of phytoplankton that isn't consumed or fecal matter from pelagic and benthic organisms. *S. elongatus* is a very long (up to 1m long), tube-dwelling, head-down deposit feeding worm that depends on mud and organic particles falling or being drawn into its tube at the sediment surface. It has highest abundance in the deeper water and is rarely found in the southern embayment (Figure 6). *S. elongatus*, along with *C. amurensis* and *Gemma gemma* (a small bivalve not shown here) appear to be defining species in separating the benthic communities between and within the embayments. This will be determined once all of the data is complete.

N. hinnemensis is a surface deposit feeding cumacean that is more common in the shallow water in the northern embayment (Figure 7). The Corophiudae amphipods are tube dwelling amphipods that both deposit feed and filter feed. There are two species (*Monocorophium insidiosum* and *Monocorophium acherusicum*) that are difficult to differentiate as juveniles and females. The plots shown here are of the combined abundance of the juveniles and females of both species. Their abundance is much higher in the northern embayment is, in general higher in the shallow water, and is quite low in spring (Figure 8). Both *N. hinnemensis* and the *Corophidae* are commonly consumed by the migratory shorebirds (A. Rowan, USGS BRD, personal comm.) and thus their presence in the shallow water habitat is not surprising.

Expenditures:
We have hired a technician (Sept. 27, 2010) and he is well trained and sorting samples at the USGS laboratory. His time will be billed to this account starting in October 2010. We are in the process of hiring another part time technician. We will write another contract to our taxonomist to cover the cost of the unplanned for sorting in her shop.

The first contract for $24,910 has been obligated and the taxonomist has billed at least $5800 against it. Ms. McCormick tends to bill in large increments, and may have done so at the end of the fiscal year. If not we expect a large bill to come in very soon and we will then write another contract for the rest of the work.

References
Clarke, KR. 1993. Non-parametric multivariate analyses of changes in community structure. Australian Journal of Ecology. 18:117-143.

Clark, K.R., Warwick, RM. 2001. Change in marine communities: an approach to statistical analysis and interpretation. 2nd Edition. PRIMER-E. Plymouth Marine Laboratory, Plymouth, U.K, 172pp.

Nichols, FH, Thompson, JK. 1985. Persistence of an introduced mudflat community in South Francisco Bay, California: Marine Ecology Progress Series v. 24, p. 83-97.

Thompson JK, Koseff JR, Monismith SG, Lucas LV, 2008. Shallow water processes govern system-wide phytoplankton bloom dynamics: A field study. Journal of Marine Systems 74: 153-166.

Sample Date	Total Number of Samples	% Sorted	% Identified	Comments
Mar-93	22	0	0	
Jul-93	22	0	0	
Sep-93	22	0	0	
Apr-94	22	59	*	
Jul-94	22	5	*	
Oct-94	22	0	0	
Feb-95	22	64	*	
Jun-95	22	91	*	
Sep-95	22	64	*	
Apr-06	32	100	78	**
Jul-06	25	100	52	**
Oct-06	38	100	68	**
Oct-07	25	20	0	**
Mar-08	25	88	0	**
Jul-08	25	60	0	**
Oct-08	25	72	0	**
Jul-09	25	52	0	**

* USGS partial identification; taxonomist has not yet seen the samples

** minimum percentage, as of Sept 30, 2010

Table 1. Status of samples.

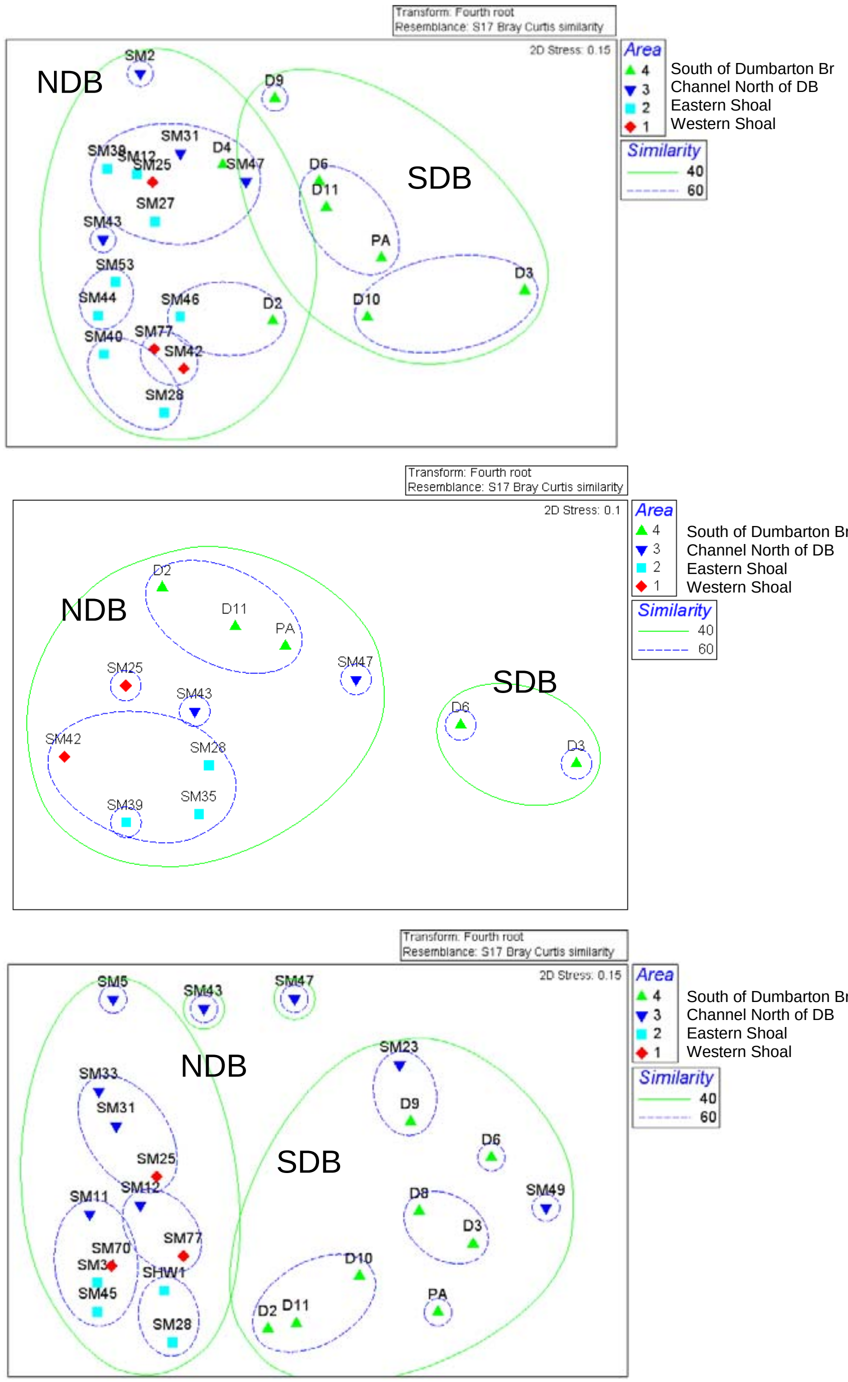


Figure 1a. Results of non-metric multi-dimensional scaling for the three sampling periods in 2006. NDB: north of Dumbarton Bridge embayment. SDB: south of Dumbarton Bridge embayment. This order will be maintained throughout the figures with the northern embayment being in the left cluster and the southern embayment in the right cluster.

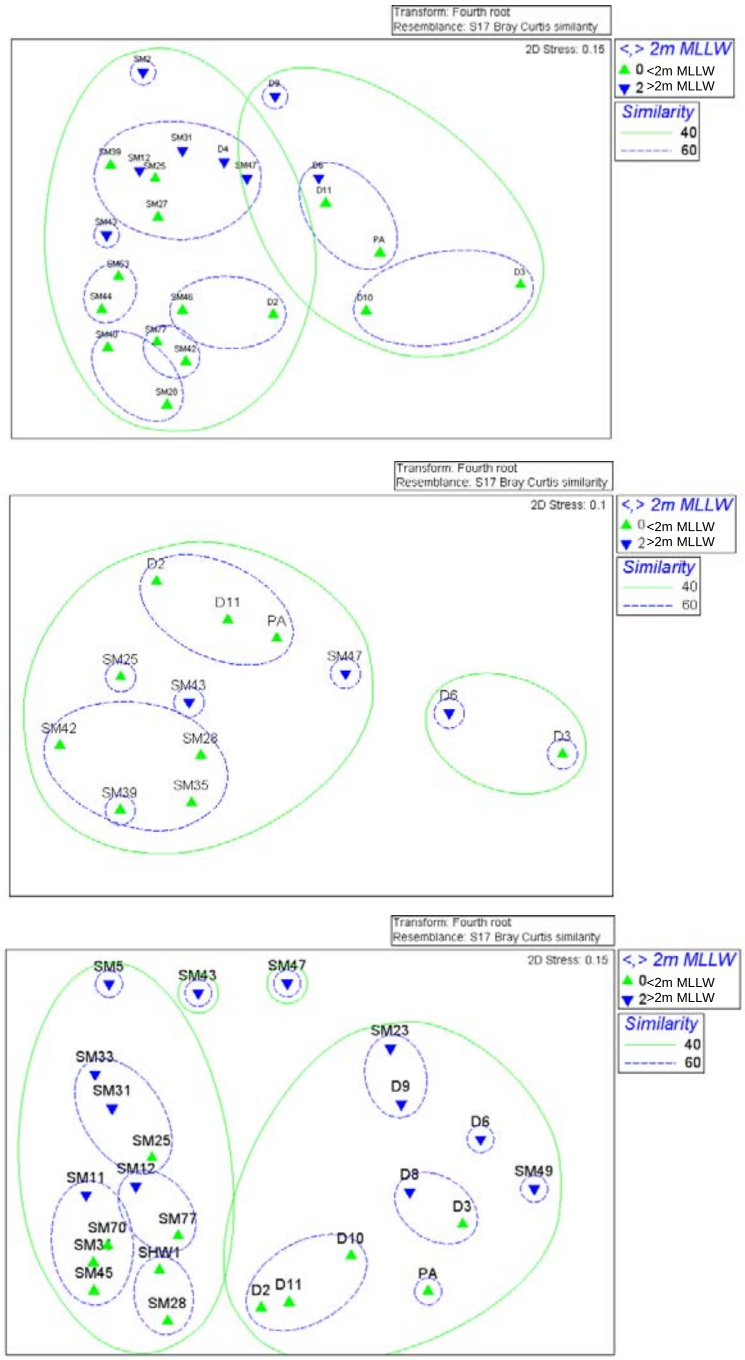


Figure 1b. Results of non-metric multi-dimensional scaling for the three sampling periods in 2006 showing the stations with their depths relative to the 2m at MLLW isobath.

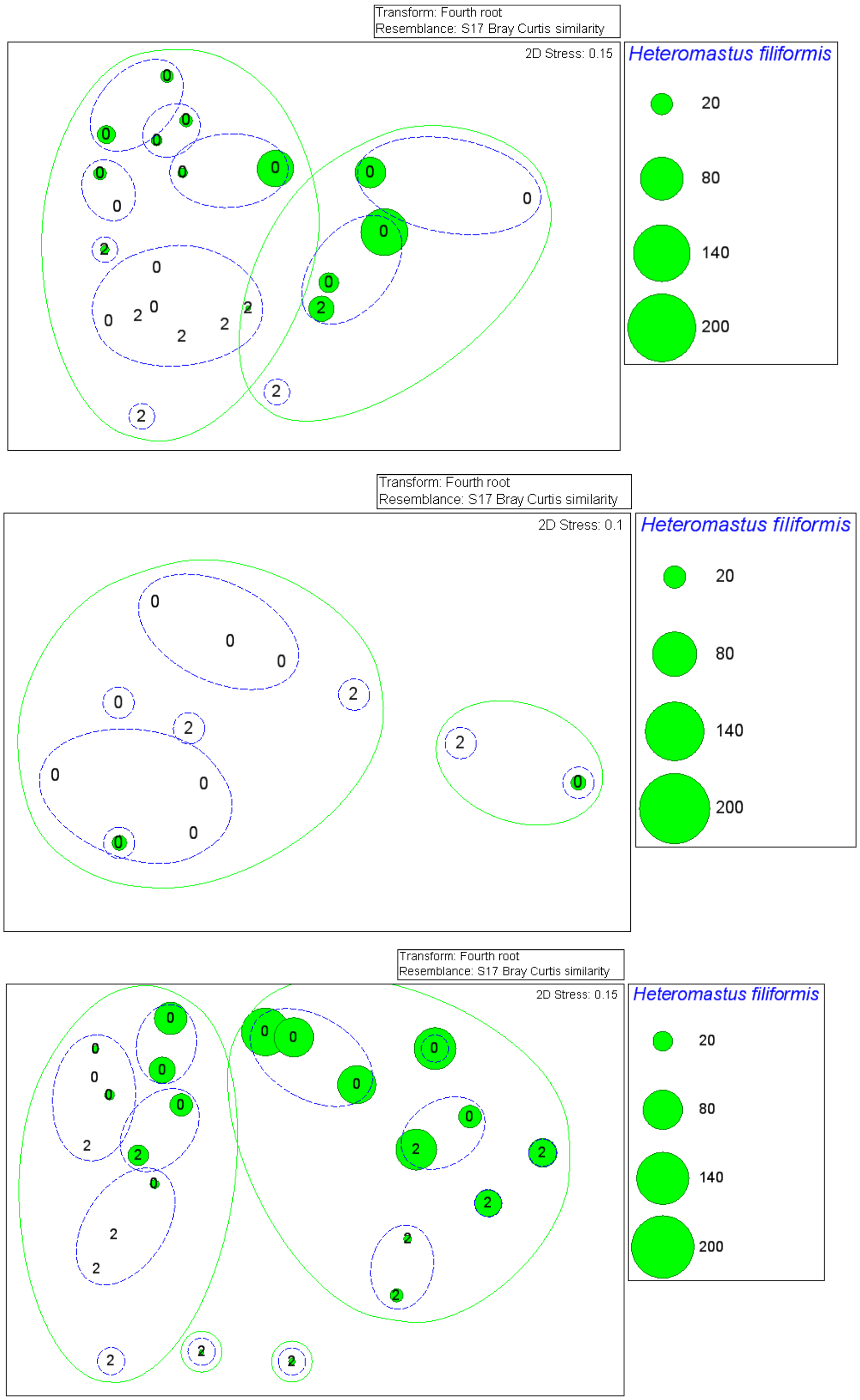


Figure 2. *Heteromastus filliformis* abundance as clustered and shown on ordination axis.

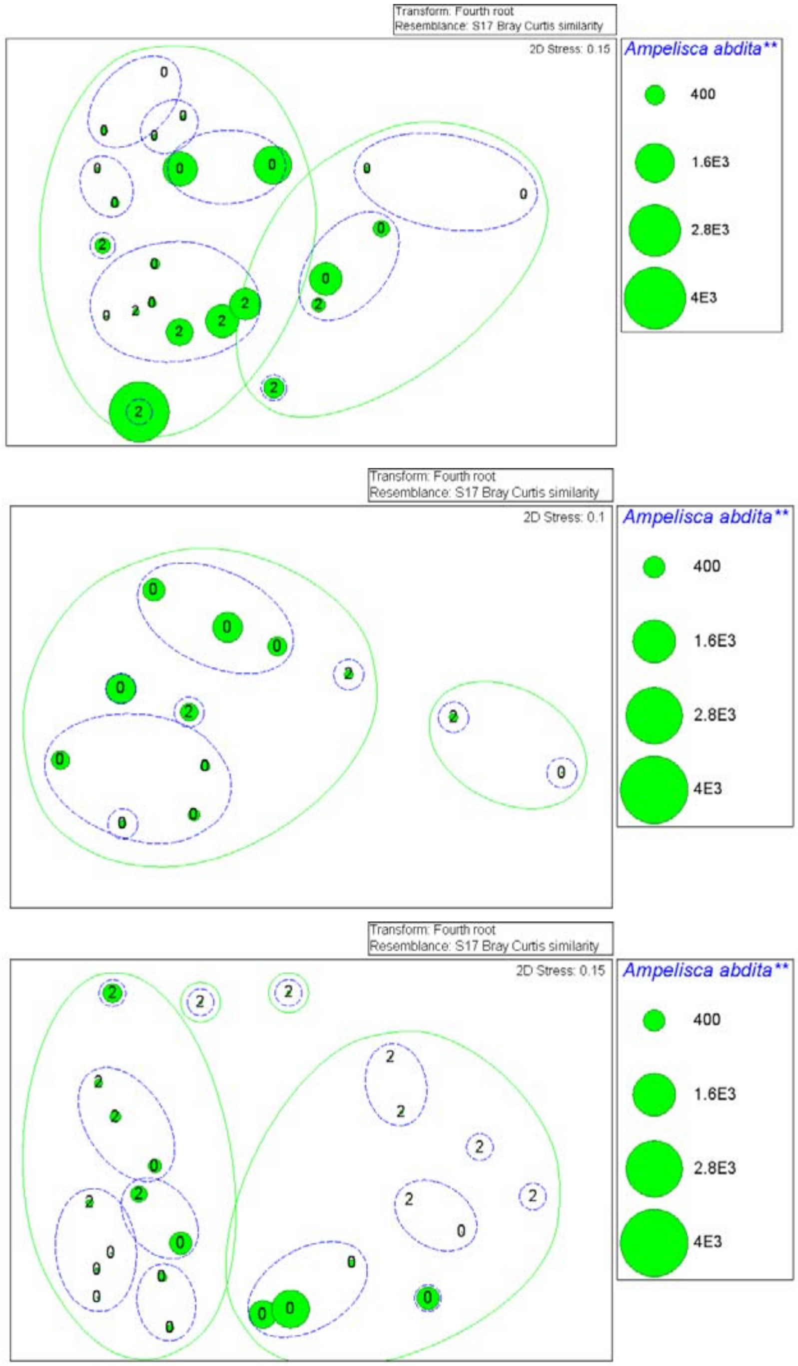
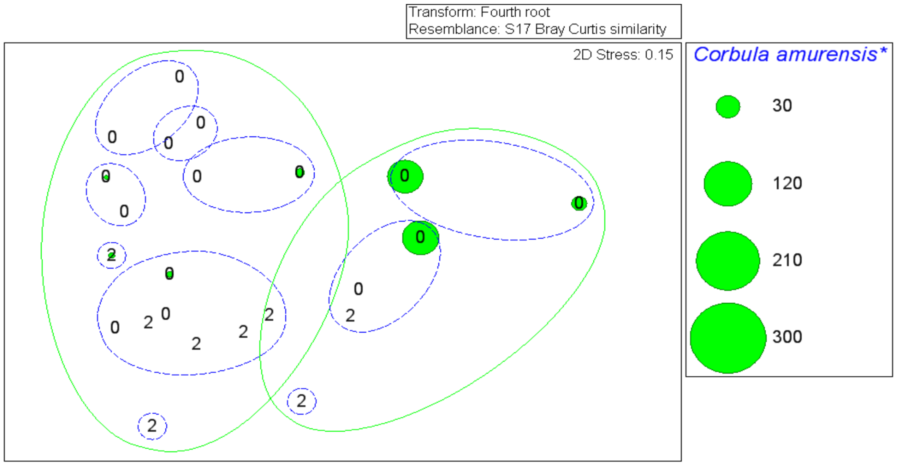
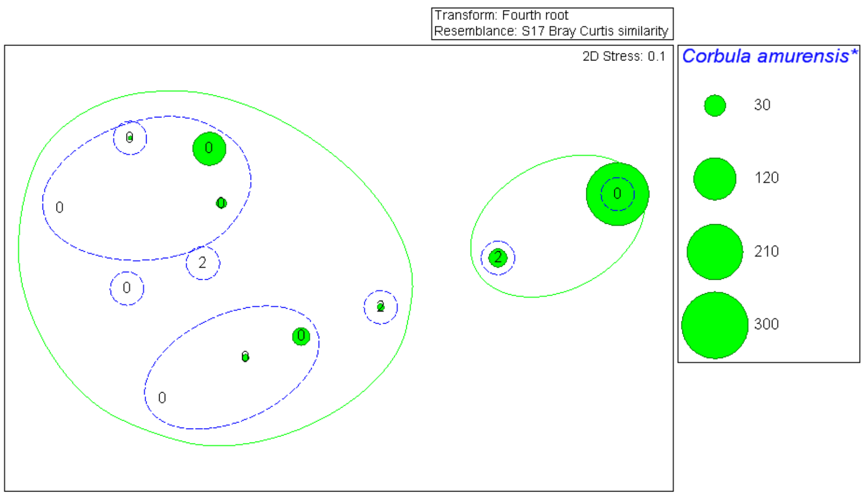


Figure 3. *Ampelisca abdita* abundance as clustered and shown on ordination axis.





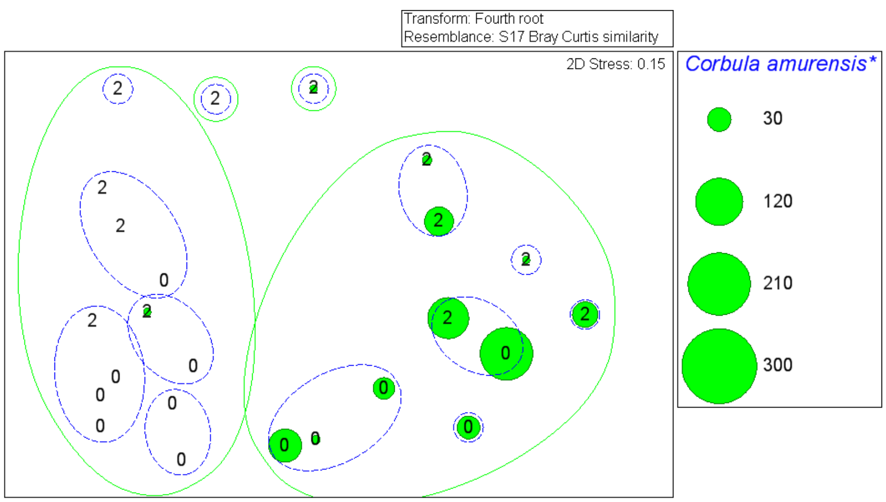


Figure 4. *Corbula amurensis* abundance as clustered and shown on ordination axis.

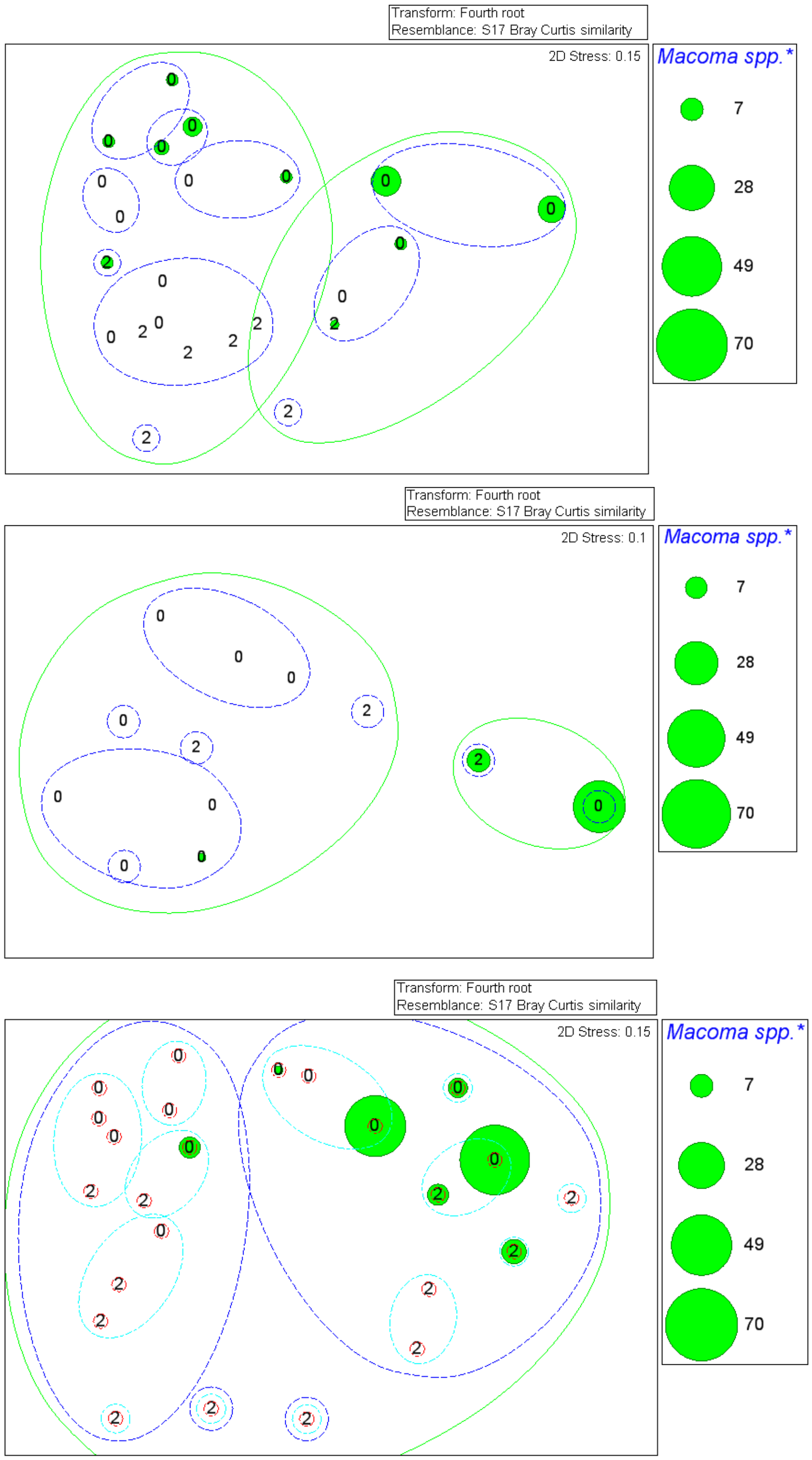


Figure 5. *Macoma spp.* abundance as clustered and shown on ordination axis.

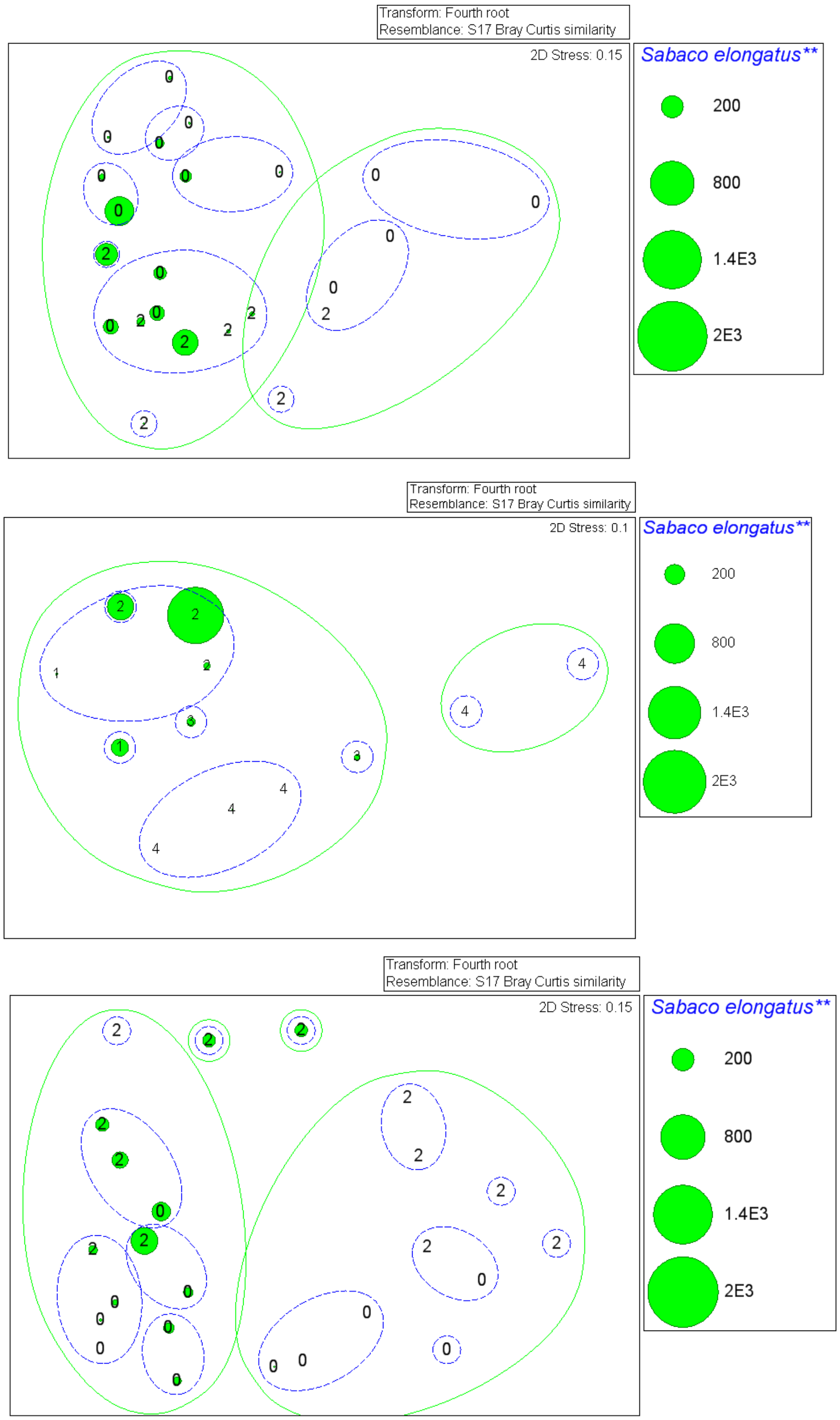


Figure 6. *Sabaco elongatus* abundance as clustered and shown on ordination axis.

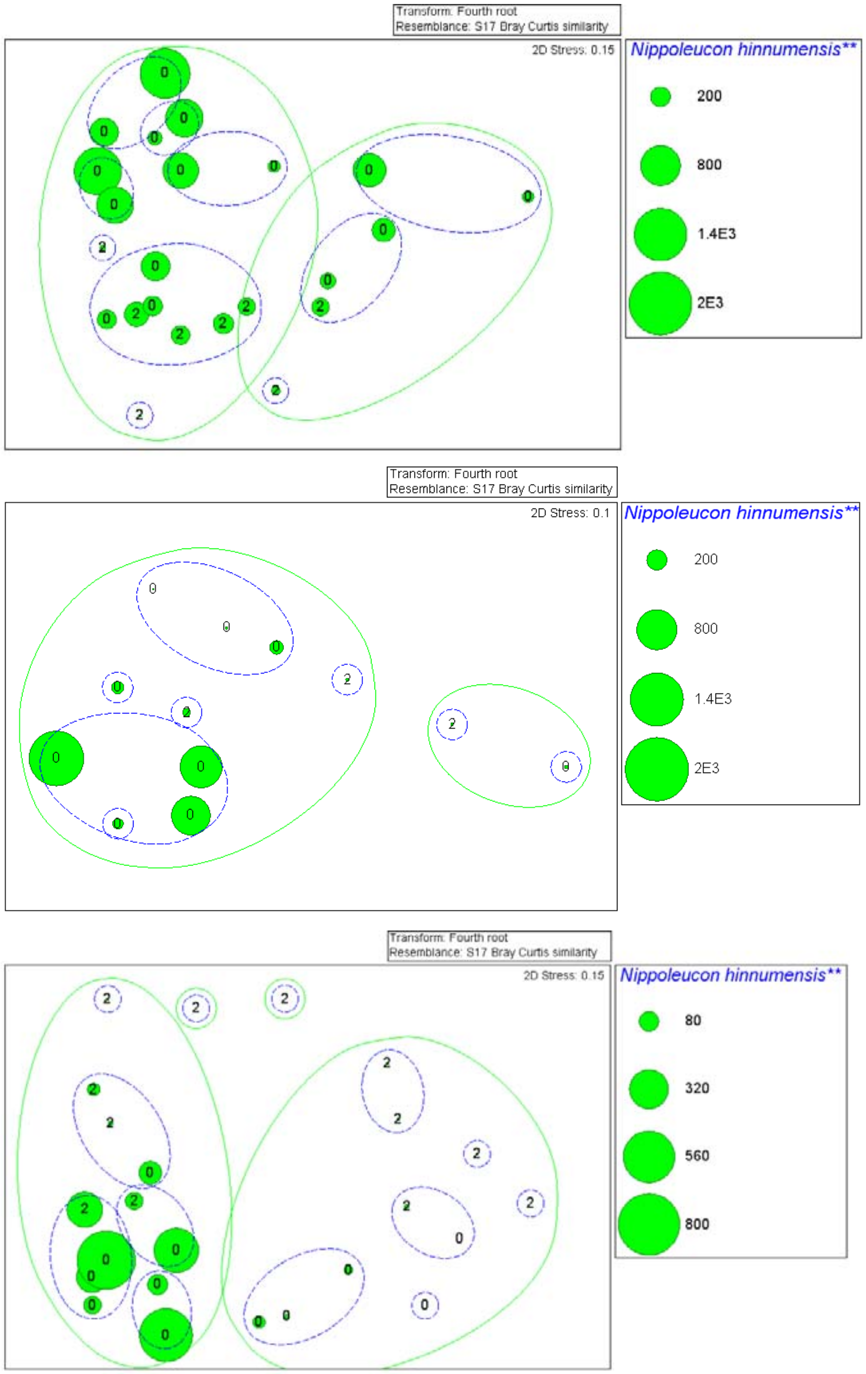


Figure 7. *Nippoleucon hinnumensis* abundance as clustered and shown on ordination axis.

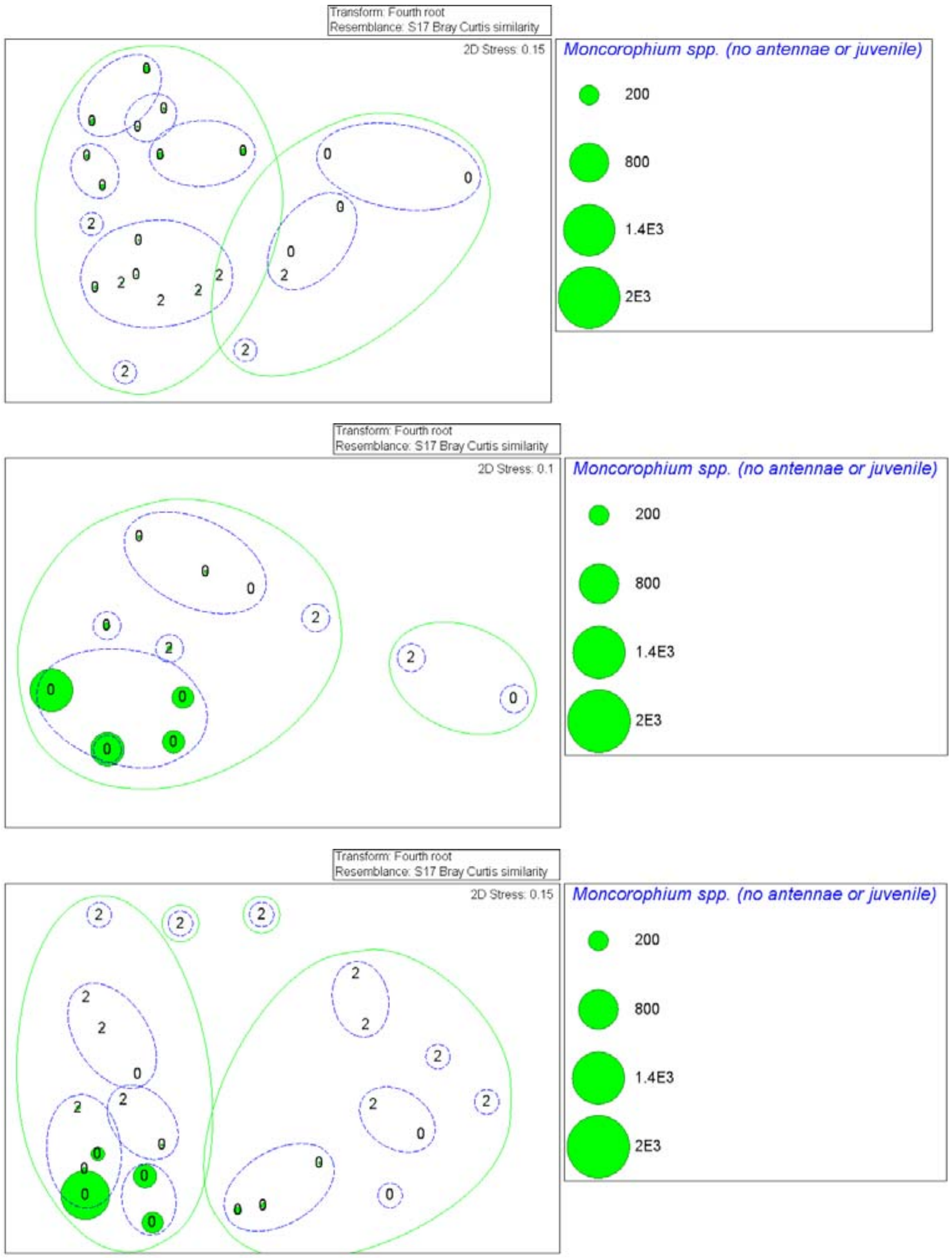


Figure 8. Corophidae abundance as clustered and shown on ordination axis.