KECK GEOLOGY CONSORTIUM

21ST KECK RESEARCH SYMPOSIUM IN GEOLOGY
SHORT CONTRIBUTIONS

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Brennan Jordan (University of South Dakota), Bob Wiebe (Franklin & Marshall College), Paul Olin (Washington State U.)
Students: Michael Bernstein, Elizabeth Drewes, Kamilla Fellah, Daniel Hadley, Caitlyn Perlman, Lynne Stewart

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Students: Evan Anderson, Anna Lavarreda, Ken O'Donnell, Walter Persons, Jessica Williams

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Greg Wiles (The College of Wooster)
Students: Erica Erlanger, Alex Trutko, Adam Plourde

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Tim Ku (Wesleyan University) Suzanne O'Connell (Wesleyan University), Anna Martini (Amherst College)
Students: Erin Algeo, Jennifer Bourdeau, Justin Clark, Margaret Selzer, Ulyanna Sorokopoud, Sarah Tracy

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ULYANA SOROKOPOUD: Wesleyan University
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PHYSICAL AND ECOLOGICAL EVOLUTION OF PUERTO MOSQUITO BAY, PUERTO RICO: A STUDY OF MOLLUSCAN FAUNAS

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INTRODUCTION

Molluscan faunas obtained from five cores taken in Puerto Mosquito Bay provide a detailed record of rapid transgression that set the stage for subsequent physical and ecological evolution of the bay. Regional studies suggest that sea level reached the present day inner shelf of Puerto Rico about 4000 years ago (Hubbard, 1997 and Pretice, 2004). As the bay filled with sediment, ecological succession and morphological changes of the physical margins of the bay occurred. The molluscan assemblages make it possible to determine relative roles of aggradation, filling up of available accommodation space, and lateral migration of marginal facies, followed by mangroves, toward the center of the bay.

METHODS

Sediments were collected from Puerto Mosquito Bay using a percussion corer and a vibracorer. The percussion cores were collected in clear polycarbonate tubes, capped, and transported back to the temporary lab on Vieques. To obtain longer cores, a vibracorer was anchored to a pontoon and cores were collected in aluminum pipes. Care was taken to keep cores upright and stable in transport back to the lab, so as to preserve all possible stratigrahic information. Cores were extruded or cut in half and described by common facies, color, texture, and presence/absence of mollusks or other distinguishing features. Cores were then divided into 2 or 5 cm sections based on heterogeneity of the sedimentary facies.

Once sectioned, samples were bagged, labeled, and boxed for further analysis and storage at Franklin and Marshall College and Wesleyan University. At Wesleyan, samples were dried, crushed, and analyzed for bulk calcium carbonate and organic carbon. Sediment ages were constrained by analyzing bulk sediments for ^{210}Pb and plant remains and mollusk shells for radiocarbon. Selected intervals from the shelly sections of cores were rinsed through three graduated sieves (4.0, 2.0, and 1.168 mm). The largest fraction was used for the faunal analysis reported here. Shells and fragments in samples from each depth interval were sorted and the species present were identified based on the faunal studies of Abbott (1974) and McLean (1951). The shells are very well preserved, with little abrasion or encrustation by epifaunal organisms. Consequently, this study focused principally on the species composition rather than the limited reliable taphonomic data.

Species abundances at each depth level were recorded and plotted as stacked histograms, providing a visual representation of species distribution with depth (Figure 1). Cluster analyses were used to study the patterns of abundance of species as they reflect depositional environments. In order to compare samples, intervals of the core with numbers of specimens large enough to give meaningful results must be defined. This is normally done using lithology but in this case, insufficient lithological differences were observed to employ this criterion. Here, samples were grouped in three different ways: (1) six consecutive samples were combined together, (2) samples including prominent indicator species were combined, and (3) samples with a degree of overlap in species composition between adjacent intervals that was greater than 50% (the proportion of species in a sample in common with the previous sample)

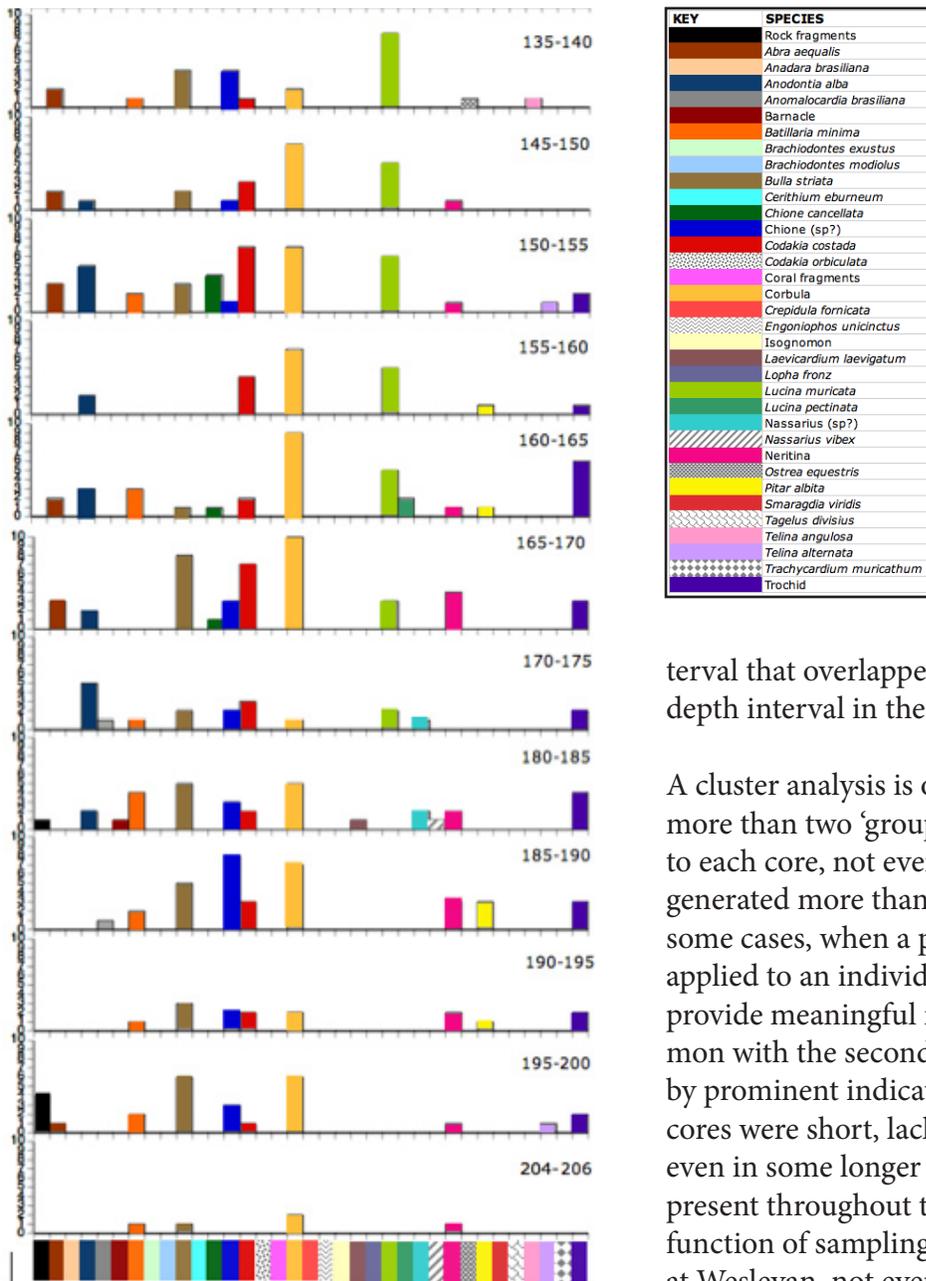| KEY	SPECIES
	Rock fragments
	Abra aequalis
	Anadara brasiliana
	Anodontia alba
	Anomalocardia brasiliana
	Barnacle
	Batillaria minima
	Brachiodontes exustus
	Brachiodontes modiolus
	Bulla striata
	Cerithium eburneum
	Chione cancellata
	Chione (sp?)
	Codakia costada
	Codakia orbiculata
	Coral fragments
	Corbula
	Crepidula fornicata
	Engoniophos unicinctus
	Isognomon
	Laevicardium laevigatum
	Lopha fronz
	Lucina muricata
	Lucina pectinata
	Nassarius (sp?)
	Nassarius vibex
	Neritina
	Ostrea equestris
	Pitar albita
	Smaragdia viridis
	Tagelus divisius
	Telina angulosa
	Telina alternata
	Trachycardium muricathum
	Trochid

Figure 1. A stacked histogram representing the changes in species with depth for PM-13 from 135cm-206cm. The full length of the core is not represented in this image, rather only enough to represent how species change over depth. The maximum number of any one species in one depth interval in this core was 10, as seen on the vertical axis. It becomes clear that this type of visual depiction of data makes trends in species stand out more readily. For example, Lucina muricata (the species represented by lime green) is absent in throughout the bottom of the core, but appears at 175cm depth and continues to increase in abundance through the next 35cm of the core.

were combined together. Ultimately, the objective of establishing three different methods of clustering will be to compare the three grouping methods to one other—potentially providing new insight into the purely methodological aspect of this study. Prominent indicator species used in the second method of grouping samples were selected using the stacked histograms. In the third method of grouping samples, the number of species from one depth interval that overlapped with those of the next closest depth interval in the core was determined.

A cluster analysis is only meaningful if there are more than two 'groups' to compare. When applied to each core, not every method described above generated more than two groups—meaning that in some cases, when a particular grouping method was applied to an individual core it did not necessarily provide meaningful results. This was most common with the second method of grouping samples by prominent indicators, due to the fact that 1) some cores were short, lacking observable trends, and 2) even in some longer cores, prominent species were present throughout the core. This problem is also a function of sampling. When cores were processed at Wesleyan, not every depth interval of every core was taken for this study. Because this study was to focus on the shelly assemblages, depth intervals with little or no shell material were not included. Consequently, less disparity of facies is represented in the samples analyzed here than exists in the full set of core samples.

RESULTS

Five cores from Puerto Mosquito were analyzed and a representative histogram of the results is presented in Figure 1. The longest core analyzed was PM-22, taken on the present day eastern margin of the bay,
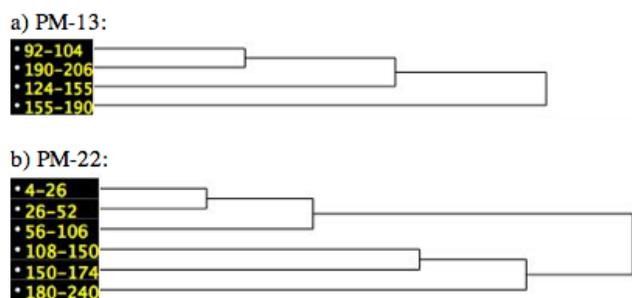
Figure 2. a) Dendrogram of PM-13 grouped by every six samples revealing similarities between adjacent depth intervals and similarities between non-adjacent depth intervals. and b) PM-22 dendrogram using the same grouping method and revealing species similarities in adjacent depth intervals.

close to the surrounding mangroves. The core, 240 cm long, displays distinctive trends in species abundance and presence/absence, recording the most complete history of Puerto Mosquito. The average number of individuals per interval, total number of individuals per core, number of species present out of the 35 species identified, top two most abundant species per core, and other general information drawn from the stacked histograms is summarized in Table 1.

	PM-13	PM-16	PM-19	PM-22	PM-23
Average number of individuals per interval	18	19	23	6.8	10.43
Total number of individuals	373	554	186	238	73
# species present out of 35 identified	22	25	20	24	14
Most abundant species	Corbula	Corbula	Neritina	*Lucina muricata*	*Lucina muricata*
Second most abundant species	*Lucina muricata*	*Chione cancellata*	Corbula	Corbula	Corbula
Depth span examined	92-206	15-186	10 to 76	4-240	36-72
Number of depth intervals analyzed	21	29	8	35	7
Depth interval size	5cm	Top half: 5cm, bottom half: 2cm	Top half: 10cm top, bottom half: 2cm	2 cm	Top: 2cm, middle: 5cm, bottom: 2cm

Table 1. A summary of data summarized from the stacked histograms of all five cores analyzed.

Cluster analyses were run on samples grouped according to the methods described above for individ-

ual cores (Figure 2). These analyses show that adjacent depth intervals generally tend to have the most in common with one another (Figure 2b). However, in some cores, depth intervals that are not adjacent also share similarities (Figure 2a). Non-adjacency in PM-13 (Figure 2a) is largely due to its short length, influencing more modest differences species trends.

A cluster analysis run across the entire data is shown in Figure 3. These clusters bring out general similarities that occur across all cores, as opposed to similarities between samples from specific depth
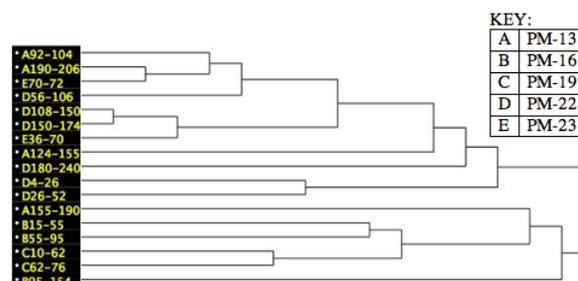

Figure 3. Dendrogram from hierarchical clustering of the entire data set based on the six-sample grouping method. Each of the five cores is represented with a letter A-E, based on the key above.

intervals within a given core. Broadly speaking, PM-13, 22, and 23 (A, D, and E respectively) form a related group just as PM-16, and 19 (B and C) also form a related group. Cores A, D, and E are abundant in Isognomon, barnacles, and Brachiodontes while cores B and C are abundant in *Chione cancellata*, *Neritinia*, and *Codakia orbiculata*. These cluster analyses, based on samples grouped by regular but arbitrary intervals are less likely to show significant groupings than analyses grouped by methods (2) and (3), defined above, with which they will be compared in the future, more complete analysis of these data.

DISCUSSION AND CONCLUSIONS

Radiocarbon dating of shells and organic matter from our cores, along with observations of the changes in species up through the cores (which represent changes in the environmental setting in which these species lived) reflect the rise of sea level

indicated by regional sea level curves. Radiocarbon dates from organic matter in terrigenous muds at the bottom of several cores range back to 3520 BP. The earliest evidence of environmental conditions supporting a diverse shelly fauna consists of two ^{14}C dates from molluscan shell, 1942 BP at 54-56 cm depth in PM-14, and 1370 BP at 46-48 cm depth in PM-12. Both were taken near the present day north shore of the bay, indicating that fully marine environments extended across the interior of the lagoon by this time. In conjunction with the stratigraphic section developed on the basis of a transect of five cores in Puerto Mosquito by D'Aluisio-Guerrieri (1988), these dates suggest a relatively rapid rise in sea level that caused flooding of the bays, creating accommodation space. Subsequently, sediment began to infill, more rapidly around the margins and less rapidly in the deepest central part of the bay.

Changes in sedimentation were accompanied by ecological succession and morphological changes at the margins of the bay. The abundance of *Codakia orbiculata* and *Chione cancellata* in the shelly intervals of the cores suggests that the bay was largely dominated by *Thalassia testundinum*, commonly known as turtle grass with which these species are associated. The appearance of epifaunal, mangrove associated Isognomon, Brachiodontes, and barnacles in the upper part of PM-22 shows the influence of *Rhizophora mangle* (Red Mangrove) encroaching from the margins of the bay toward the center of the lagoon as it filled in.

Cluster analyses run on individual cores reinforce the interpretation of infilling and ecological succession associated with sea level rise. The similarities of non-adjacent depth intervals most likely represent patchiness in horizontal distribution of environments.

The cluster analyses run across the entire data set also reinforce the interpretations made from individual cores. Cores A and D in Figure 3 are both located near present day margins of the bay, while E, though not at the margin, is close in proximity to A and D. These three cores are all significantly more abundant in species typical of shallower water

conditions and are also laden with epifaunal species, indicating close proximity to the perimeter of the bay. Because the margins of the bay shoaled more rapidly than the center of the bay, it is logical that these cores would abound in shallow water and epifaunal species. Cores B and C are close to one another, but are more central in the bay. These cores are more abundant in species typical of sea grass environments, where water is deeper. They are, for the most art, devoid of epifaunal species. This is consistent with the more central part of the bay, where the environment is more stable.

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