CONTROL OF BENTHIC PROCESSES BY OXYGEN AND TOPOGRAPHY

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N00014-92-J-1857

LONG TERM GOALS:

Our goal is to identify the processes determining abundance, distribution, and composition of infaunal assemblages in bathyal settings including seamounts and continental margins. Effects of topography, oxygen availability and organic matter supply are of primary concern.

SCIENTIFIC/TECHNICAL OBJECTIVES:

Research this year continues examination of the nature and causes of shifts in benthic community structure across the oxygen minimum zone (OMZ) on the Oman Margin, Arabian Sea. Our objectives were to (a) distinguish community-level effects of low bottom-water oxygen concentration, water depth, hydrodynamic regime and organic enrichment on the structure of margin assemblages (b) examine biogenic sediment features as community structuring agents (c) evaluate oxygen controls on bioturbation (d) test biofacies models constructed for ancient low oxygen environments using modern faunas and (e) generate data for a model that examines oxygen influence on trophic pathways.

APPROACH:

Studies are based on boxcore and multicore samples collected from 7 stations on the Oman margin (100-3400 m) during Fall 1994. Macrofaunal assemblages are being characterized with respect to abundance, biomass, vertical distribution, species composition, faunal lifestyles, feeding patterns and diversity. These properties are assessed with respect to cross-margin trends, association with hydrographic and sediment characteristics, and relationship to protozoan (foraminiferan) community trends. They are also compared to patterns of community structure in better-oxygenated settings. Pigment, Pb-210 and faunal data are being integrated with other sediment biogeochemical properties (in collaboration with C. Smith, R. Goerike, A. Patience and G. Wolf) to evaluate bioturbation patterns across the margin. Standing stock and bioturbation data will contribute to inverse modeling efforts (with J. Gage and P. Eldredge) aimed at

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
30 SEP 1997		**00-00-1997 to 00-00-1997**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Control of Benthic Processes by Oxygen and Topography	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of California, San Diego,Scripps Institution of Oceanography,Marine Life Research Group,La Jolla,CA,92093**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT	b ABSTRACT	c THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**3**	

producing descriptions of material flows between trophic levels in high and low oxygen regimes.

TASKS COMPLETED:

1. Sorting and identification of macrofaunal samples from 700, 1000, 1250 and 3300 m stations. Faunal identifications of specimens from 400 m and 850 m stations.
2. Rarefaction analyses of macrofaunal diversity at all stations.
3. Examination of cirratulid mudball autecology and synecology at the 850 m station.
4. HPLC analysis of pigments in sediment cores from all stations (with R. Goerike, SIO).
5. Convene AGU session (with J. Gage) on benthic processes in low-oxygen environments. Results were presented at this session and at a Discovery 211 cruise workshop.

RESULTS:

Several key patterns emerged for the Oman margin macrobenthos. (a) Polychaetes dominated the macrofauna within the OMZ, accounting for over 90% of all individuals between 400m and 1000m. Molluscs and crustaceans became common below the OMZ, at 1250 m and below. (b) Macrofaunal density maxima occured within the OMZ between 700 and 900 m. Biomass maxima also occurred within the OMZ, but were disjunct (700 and 1000 m). (c) Diversity was lower in the OMZ (400-1000 m) than outside. Diversity increased steadily to 1250 m, then fell somewhat at 3300 m. Species dominance exhibited the reverse pattern. The relationships of diversity to water depth, organic matter availablity and oxygen are apparently complex. (d) Biogenic dwelling structures (tubes, mudballs and cocoons) are very common within the OMZ. They may offer protection against high densities of bottom-foraging spider crabs present between 600 and 1000 m.

Bioturbation within the OMZ appears low. Bioturbating fauna are most abundant below the OMZ. The sessile, tube-building, surface feeding fauna within the OMZ are less likely to mix sediments. Sediment Pb-210 inventories are low and mixing rates appear small. However, subsurface pigment maxima within the top 10 cm suggest that large, non-local mixing events may be common.

Sediment pigment concentrations were highest in cores from 400 m and 3400 m, and lowest in heavily winnowed 100-m and 1000-m sediments. Samples contained many chlorophyll a and b degradation products but no undegraded chlorophyll was present. New cholorphyll a degradation products were observed in sediments, including likely pyrophaeophorbide a carotenoid esters. These represented approximately 10% of all chorophyll a degradation products in the upper 20 cm.

IMPACTS:

Faunal observations in modern OMZs can be used to test paleo- biofacies models and to understand effects of declining oxygen concentrations in the world's oceans. The macrofauna present at 400 m (oxygen < 0.2 ml/l) indicate that soft-bodied polychaetes dominate the OMZ. Molluscan taxa with calcareous shells are rare, but can occur at very low oxygen levels, whereas echinoderms apparently cannot. The observation of abundant dwelling structures (domichnia) support one side of a controversy concerning the influence of oxygen on ichnofacies in ancient environments. Global trends towards ocean warming and increased enrichment may increase the extent and severity of low oxygen in the world's oceans. Our results suggest this will lead to shifts in taxonomic composition (increasing polychaetes) and reductions in faunal diversity and bioturbatiion.

TRANSITIONS ACCOMPLISHED AND EXPECTED:

Field work in the Arabian Sea has been concluded and sample sorting is nearing conclusion. While faunal identification continues, we have begun to share and integrate data with other investigators to examine sediment biogeochemical processes, bioturbation, and material flows. As we enter the final year of the project we are beginning to place the Oman margin into a global context and compare OMZ and margin environments from around the world.

RELATIONSHIPS TO OTHER PROJECTS:

Our Arabian Sea studies are being carried out in collaboration with United Kingdom investigators John Gage (Dunstaffnage Marine Lab) and Andy Gooday (Southampton Oceanography Center) and Univ. of Hawaii investigator Craig Smith under the auspices of a NATO Collaborative Research Grant (renewed this year), and an NSF International Programs Grant. We are also working with Ralf Goerke who is funded by NSF to study pigments in the Arabian Sea water column. Oman Margin OMZ results are being compared to data from other OMZs (eastern Pacific studies previously funded by ONR), other continental margins (NSF- funded research on the North Carolina margin), and to shallow-water, organically enriched environments (NOAA funded studies of salt marshes and tidal flats).