

of mantle evolution, since oceanic basalts, which are the best indicators of mantle composition, can be identified only with great difficulty at times earlier than Mesozoic, the age of the oldest ocean floor.

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#### References and Notes

1. P. C. Bateman and C. Wahrhaftig, *Calif. Div. Mines Geol. Bull.* **190**, 105 (1966); E. S. Larson, Jr., *Geol. Soc. Am. Mem.* **29** (1948).
2. R. G. Gastil, R. P. Phillips, E. C. Allison, *Geol. Soc. Am. Mem.* **140** (1975).
3. P. B. King, "Tectonic map of North America" (U.S. Geological Survey, Washington, D.C., 1969).
4. —, *U.S. Geol. Surv. Prof. Pap.* **628** (1969); *The Evolution of North America* (Princeton Univ. Press, Princeton, N.J., 1977).
5. P. C. Bateman, *Calif. Geol.* **27**, 3 (1974).
6. L. T. Silver, F. G. Stehli, C. R. Allen, *Bull. Am. Assoc. Pet. Geol.* **47**, 2054 (1963); J. J. Criscione, T. E. Davis, P. Ehlig, in *Mesozoic Paleogeography of the Western United States* (Pacific Section, Society of Economic Paleontologists and Mineralogists, Tulsa, Okla., 1978), pp. 385–396.
7. A. R. Palmer, in *Cambrian of the New World*, C. H. Holland, Ed. (Wiley, New York, 1971), pp. 1–79; A. J. Eardley, *Structural Geology of North America* (Harper and Row, New York, 1962).
8. A. E. Ringwood, *Composition and Petrology of the Earth's Mantle* (McGraw-Hill, New York, 1975); S. R. Taylor, in *Island Arcs, Deep Sea Trenches, and Back-Arc Basins*, M. Talwani and W. C. Pitman III, Eds. (American Geophysical Union, Washington, D.C., 1977); — and A. J. R. White, *Nature (London)* **205**, 271 (1965); W. A. C. Baragar and A. M. Goodwin, *Oreg. Dept. Geol. Miner. Ind. Bull.* **65**, 121 (1969).
9. W. R. Dickinson, *Rev. Geophys. Space Phys.* **8**, 813 (1970).
10. R. W. Kistler and Z. E. Peterman, *Geol. Soc. Am. Bull.* **84**, 3489 (1973).
11. —, *U.S. Geol. Surv. Prof. Pap.* **1071** (1978).
12. H. P. Taylor and L. T. Silver, *U.S. Geol. Surv. Open-File Rep.* **78-701** (1978), p. 423.
13. D. J. DePaolo and G. J. Wasserburg, *Geochim. Cosmochim. Acta* **43**, 615 (1978).
14. G. Hanson, unpublished data.
15. D. J. DePaolo, P. Gromet, R. Powell, L. T. Silver, *Geol. Soc. Am. Abstr. Programs* **7**, 309 (1975).
16. L. P. Gromet, thesis, California Institute of Technology (1979).
17. D. J. DePaolo and H. P. Taylor, unpublished data.
18. J. B. Koenig, compiler, "Geologic map of California, Death Valley Sheet" (O. P. Jenkins edition, California Division of Mines and Geology, Sacramento, 1963).
19. D. A. Papanastassiou, D. J. DePaolo, G. J. Wasserburg, *Proc. 8th Lunar Sci. Conf.* (1977), p. 1639.
20. D. J. DePaolo, thesis, California Institute of Technology (1978).
21. L. T. Silver, T. O. Early, T. H. Anderson, *Geol. Soc. Am. Abstr. Programs* **7**, 375 (1975).
22. The  $\epsilon_{Nd}$  and  $\epsilon_{Sr}$  values are the deviations in parts per  $10^4$  of the  $^{143}Nd/^{144}Nd$  and  $^{87}Sr/^{86}Sr$  ratios, respectively, from the values estimated for the total earth. The estimated value for  $^{143}Nd/^{144}Nd$  in the total earth today ( $T = 0$ ) is 0.511836 (normalized to  $^{150}Nd/^{142}Nd = 0.2096$ ) and is based on measurements of meteorites [G. L. Lugmair, N. B. Scheinin, K. Marti, *Earth Planet. Sci. Lett.* **27**, 79 (1975)]. The estimated value of  $^{87}Sr/^{86}Sr$  is 0.7045 and is based on an interpretation of correlated variations in these ratios in young basalts [see (23); R. K. O'Nions, P. J. Hamilton, N. M. Evensen, *Earth Planet. Sci. Lett.* **34**, 13 (1977)]. The respective  $\epsilon$  values as measured on a rock sample are defined as follows:

$$\epsilon_{Nd}(0) = \left[ \frac{^{143}Nd/^{144}Nd_{\text{meas}}}{^{143}Nd/^{144}Nd_{\oplus}(0)} - 1 \right] \times 10^4$$

and

$$\epsilon_{Sr}(0) = \left[ \frac{^{87}Sr/^{86}Sr_{\text{meas}}}{^{87}Sr/^{86}Sr_{\oplus}(0)} - 1 \right] \times 10^4$$

where the subscript  $\oplus$  signifies the value for the earth. In a similar manner, the initial ratios for a rock of age  $T$  may be expressed as follows:

$$\epsilon_{Nd}(T) = \left[ \frac{^{143}Nd/^{144}Nd_{\oplus}(T)}{^{143}Nd/^{144}Nd_{\oplus}(0)} - 1 \right] \times 10^4$$

$$\epsilon_{Sr}(T) = \left[ \frac{^{87}Sr/^{86}Sr_{\oplus}(T)}{^{87}Sr/^{86}Sr_{\oplus}(0)} - 1 \right] \times 10^4$$

where the subscript  $I$  refers to the initial value,  $^{143}Nd/^{144}Nd_{\oplus}(T) = ^{143}Nd/^{144}Nd_{\oplus}(0) - 0.1936 [e^{\lambda_{Sm}T} - 1]$ ;  $^{87}Sr/^{86}Sr_{\oplus}(T) = ^{87}Sr/^{86}Sr_{\oplus}(0) - 0.0839 (e^{\lambda_{Rb}T} - 1)$ ;  $\lambda_{Sm} = 0.00654$  per  $10^9$  years; and  $\lambda_{Rb} = 0.0139$  per  $10^9$  years.

23. D. J. DePaolo and G. J. Wasserburg, *Geophys. Res. Lett.* **3**, 249 (1976).
24. D. J. DePaolo and R. W. Johnson, *Contrib. Mineral. Petrol.* **70**, 367 (1979).
25. Studies of oceanic basalts have shown that  $\epsilon_{Nd}$  and  $\epsilon_{Sr}$  are strongly correlated, with the approximate relationship  $\epsilon_{Sr} = -2.7 \epsilon_{Nd}$  for  $\epsilon_{Nd} > -2$  [D. J. DePaolo, *Earth Planet. Sci. Lett.* **43**, 201 (1979)].
26. The  $T_{CHUR}$  is a model age which represents the time when a rock would have had the same value of  $^{143}Nd/^{144}Nd$  as the total earth. It is defined as  $T_{CHUR} = \frac{1}{\lambda_{Sm}} \ln \left[ 1 + \frac{^{143}Nd/^{144}Nd_{\text{meas}} - ^{143}Nd/^{144}Nd_{\oplus}(0)}{^{147}Sm/^{144}Nd_{\text{meas}} - ^{147}Sm/^{144}Nd_{\oplus}(0)} \right]$ .  $T_{UR}$  is the analogous model age defined for Rb-Sr.
27. M. A. Lanphere, *J. Geol.* **72**, 381 (1964); —, G. J. Wasserburg, A. L. Albee, G. R. Tilton, in *Isotopic and Cosmic Chemistry*, H. Craig, S. L. Miller, G. J. Wasserburg, Eds. (North-Holland, Amsterdam, 1963), pp. 269–320.
28. J. H. Stewart, C. H. Stevens, A. E. Fritzsche, Eds., *Paleozoic Paleogeography of the Western United States* (Pacific Section, Society of Economic Paleontologists and Mineralogists, Tulsa, Okla., 1977).
29. L. T. Silver and T. H. Anderson, *Geol. Soc. Am. Abstr. Programs* **6**, 955 (1974).
30. M. T. McCulloch and G. J. Wasserburg, *Science* **200**, 1003 (1978).
31. D. C. Presnall and P. C. Bateman, *Geol. Soc. Am. Bull.* **84**, 3181 (1973).
32. K. Muehlenbachs and R. N. Clayton, *J. Geophys. Res.* **81**, 4365 (1976); T. J. Wolery and N. H. Sleep, *J. Geol.* **84**, 249 (1976); R. T. Gregory and H. P. Taylor, Jr., *J. Geophys. Res.*, in press; M. T. McCulloch, R. T. Gregory, G. J. Wasserburg, H. P. Taylor, Jr., *ibid.*, in press.
33. D. J. DePaolo and G. J. Wasserburg, *Geophys. Res. Lett.* **4**, 465 (1977).
34. C. J. Hawkesworth, R. K. O'Nions, R. J. Pankhurst, P. J. Hamilton, N. M. Evensen, *Earth Planet. Sci. Lett.* **36**, 253 (1977).
35. D. J. DePaolo and G. J. Wasserburg, *Geophys. Res. Lett.* **3**, 743 (1976).
36. P. J. Hamilton, R. K. O'Nions, N. M. Evensen, *Earth Planet. Sci. Lett.* **36**, 263 (1977); A. Zindler, C. Brooks, N. T. Arndt, S. Hart, *U.S. Geol. Surv. Open-File Rep.* **78-701** (1978), p. 469; P. J. Hamilton, N. M. Evensen, R. K. O'Nions, J. Tarney, *Nature (London)* **277**, 25 (1979); P. J. Hamilton, N. M. Evensen, R. K. O'Nions, H. S. Smith, A. J. Erlank, *ibid.* **279**, 298 (1979).
37. D. J. DePaolo, *Geochim. Cosmochim. Acta*, in press; S. B. Jacobsen and G. J. Wasserburg, *J. Geophys. Res.* **84**, 7411 (1979).
38. S. B. Jacobsen and G. J. Wasserburg, *J. Geophys. Res.* **84**, 7429 (1979).
39. I thank R. W. Kistler and Z. E. Peterman, who provided well-documented samples of Sierra Nevada rocks and unpublished data on their chemical compositions and occurrence. I thank G. N. Hanson for unpublished trace element data. Field, petrologic, and isotopic studies conducted by L. T. Silver at the California Institute of Technology greatly influenced the course of this investigation. All of the new analyses reported here were conducted at the Lunatic Asylum of the Charles Arms Laboratory, California Institute of Technology, through the cooperation of G. J. Wasserburg. This work was supported by NSF grants EAR78-12966 and EAR76-22494.

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## Foraminifera: Distribution of Provinces in the Western North Atlantic

**Abstract.** All published distributional data on recent benthic foraminifera of the North American Atlantic continental margin were archived into computerized catalogs. Cluster analysis of these data delimited seven large, marginally overlapping provinces exhibiting a congruous relationship with western North Atlantic water masses. The single major latitudinal faunal change occurs at Cape Hatteras.

Benthic foraminifera occur abundantly in all marine environments. The number of living foraminifera usually exceeds  $10^6$  per square meter, and wet-weight biomass estimates range from 0.02 to over 10 g/m<sup>2</sup> (1). Because of the biologic and geologic importance of the foraminifera, a vast literature exists on their distribution. During the last 130 years, we know of 142 papers that were published on the distribution of recent benthic foraminifera from the eastern continental margin of North America. Analysis of such a large data set by traditional methods of preparing maps or tables for all taxa is impossible. To obtain a synthesis of the foraminiferal distribution along the eastern margin of North America, one of the most completely studied areas in the world, we compiled a computerized catalog of the published occurrences (presence or absence data) from New-

foundland to the Bahamas (2). The catalog archives the distribution of 1303 species names from 542 localities. Through synonymization, achieved by reference to published illustrations and specimens lodged in the U.S. National Museum collections, and by consultation with several researchers on benthic foraminifera, the number of species names was reduced to 876. We report here the outcome of a cluster analysis of these data and relate the resulting distributions to major water masses. As far as we know, this is the first study to use all available data to synthesize distributional patterns over an entire continental margin.

For the cluster analysis, computer limitations forced us to reduce the number of localities to 350 by randomly deleting localities. These 350 localities contained 791 species. We analyzed this data matrix in the Q-mode by clustering Jaccard

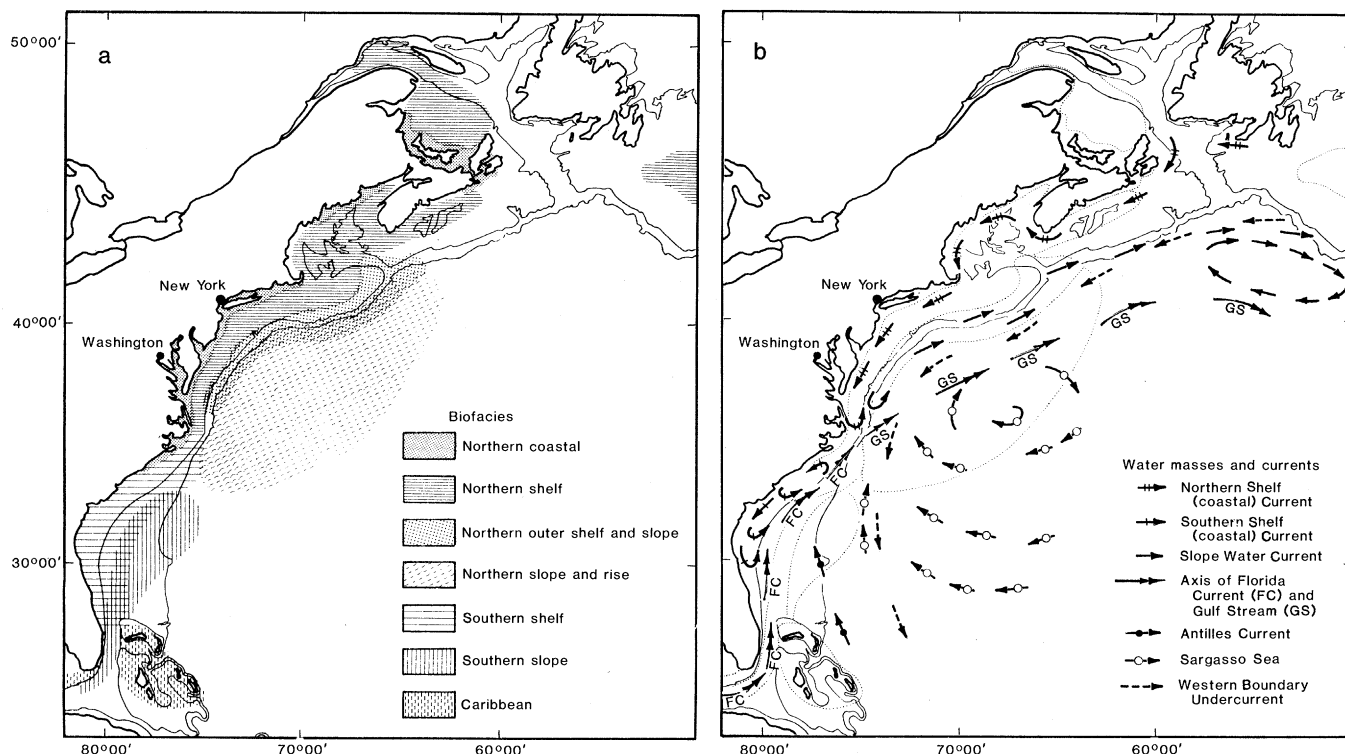


Fig. 1. (a) Recent benthic foraminiferal provinces on the Atlantic continental margin of North America; 200- and 2000-m submarine contours are shown. (b) Current patterns of the water masses on the Atlantic continental margin of North America (17). The distribution of provinces is indicated by dotted lines; 200- and 2000-m submarine contours are shown.

coefficients by the weighted pair-group method (3).

The cluster analysis indicated that there are seven large marginally overlapping areas or provinces, with a major latitudinal faunal change in the vicinity of Cape Hatteras (Fig. 1a). The diagnostic species associations of the provinces, too lengthy to be included here, will be presented elsewhere (4).

Cape Cod has been suggested as a major distributional barrier for benthic foraminifera (5). Although the northern limit of several southern forms is at Cape Cod (2, 5), there are close similarities between foraminiferal faunas to the north and south of the Cape. While discussing the more common species of benthic foraminifera on the Atlantic shelf, Sen Gupta (6) noted, as we do, the greatest latitudinal faunal change at Cape Hatteras. He described foraminiferal distribution, however, in terms of the traditional five macrofaunal provinces of the east coast of North America. These macrofaunal (mollusk, crustacean, bryozoan) biogeographic provinces (7) are as follows: Arctic (North Pole to Newfoundland), Nova Scotian (Nova Scotia to Cape Cod), Virginian (Cape Cod to Cape Hatteras), Carolinian (Cape Hatteras to Cape Canaveral), and Caribbean (south of Cape Canaveral). Our analysis, based on all available presence or absence data for all species of benthic fo-

raminifera, indicates that, for the shelf, the Nova Scotian and Virginian provinces should be grouped together. We recognize only the Nova Scotian-Virginian (Boreal), Carolinian, and Caribbean (Bahaman) provinces on the shelf off the east coast of North America, south of Newfoundland.

In deeper (slope and rise) water we recognize two northern provinces and one southern province. The latitudinal boundary between the northern and southern provinces is also in the vicinity of Cape Hatteras (Fig. 1a). Comparable data are not published for the macrofauna offshore and, indeed, some disagreement exists as to offshore macrofaunal provinces. For example, Ceramé-Vivas and Gray (8) believed that, at Cape Hatteras, the Virginian and Carolinian provinces could be distinguished nearshore and the Caribbean province offshore. Day *et al.* (9), however, did not recognize the existence of an offshore Caribbean province in this area.

At this point we cannot be certain if the discrepancy between the number of provinces for benthic foraminifera and macrofaunal groups is due to wider environmental tolerance on the part of foraminifera or to differences in methodology. In Jamaica, differences in species composition between a back-reef flat and a bay are dramatic for mollusks but only slight for foraminifera (10). A study of

biofacies in coastal California and the Yucatan, however, indicated that foraminifera and mollusks were both directly correlated with major habitats (11). To further complicate matters, Coomans (12), unlike most macrofaunal zoogeographers, grouped mollusks of the Nova Scotian and Virginian areas into a single Boreal province, a scheme identical to the one proposed here. The computerization of large sets of faunal and floral data and their subsequent analysis by techniques similar to those used here should, in the future, help to alleviate some of these discrepancies.

Foraminiferal distributions are the result of a complex interplay of many variables. A single environmental variable, such as temperature, cannot account for all the variability observed in distributions. Planktic foraminifera have a demonstrated relationship with the water masses in both the Pacific (13) and the Atlantic (14) oceans. Studies of benthic foraminifera from nearshore (15) and abyssal depths (16) also indicate a relationship with water masses rather than a single environmental variable. Our study, based on numerous samples containing very many species, suggests a congruous relationship between foraminiferal provinces and water masses over a complete continental margin. The current patterns of the major water masses in the western North Atlantic are shown

in Fig. 1b (17). The close association of provinces with water masses is apparent. We suggest that the northern coastal province is related to marginal waters, the northern shelf province to shelf (coastal) water, the northern outer shelf and slope province to slope water, and the northern slope and rise province to open Atlantic water characterized in the study area by the Western Boundary Undercurrent and the Gulf Stream. South of Cape Hatteras, the shelf province is related to southern shelf (coastal) water and the southern slope province (inner Blake Plateau) to water of the Florida and Antilles currents. The northern slope province is more closely similar to the southern slope province than to the northern shelf province, again indicating close association of provinces with water masses. In southern Florida a tropical province (the Bahaman) makes its first appearance and may be related to a change of the sedimentary environment (18) to a mainly carbonate regime.

A meaningful pattern thus results from the analysis of a large data set based on the work of 102 investigators over 130 years. The outcome presented here should encourage workers to compile and analyze similar data sets on other groups of organisms.

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#### References and Notes

1. K. M. Saidova, *Dokl. Akad. Nauk SSSR* **174**, 216 (1967); V. G. Wefer and G. F. Lutze, *Kiel. Meeresforsch.* **21**, 55 (1976); M. A. Buzas, *J. Mar. Res.* **36**, 617 (1978).
2. S. J. Culver and M. A. Buzas, *Smithson. Contrib. Mar. Sci.* **6**, 512 (1980).
3. R. R. Sokal and P. H. A. Sneath, *Principles of Numerical Taxonomy* (Freeman, San Francisco, 1963), p. 359; R. L. Kaesler, *Kans. Paleontol. Contrib.* **10**, 1 (1966); J. F. Mello and M. A. Buzas, *J. Paleontol.* **42**, 747 (1968).
4. S. J. Culver and M. A. Buzas, in preparation.
5. J. A. Cushman, *Cushman Lab. Foraminiferal Res. Spec. Publ.* **12**, 37 (1944); F. L. Parker, *Bull. Harv. Mus. Comp. Zool.* **100**, 213 (1948); *ibid.* **106**, 391 (1952); F. B. Phleger, *ibid.*, p. 318.
6. B. K. Sen Gupta, *24th Int. Geol. Congr. Sec. 8* (1972), p. 125.
7. J. D. Dana, *Rep. U.S. Explor. Exped. 1838-1842* **14**, 690 (1853); *Am. J. Sci.* **16**, 153 (1853); C. A. Hall, *Ecology* **45**, 226 (1964); F. J. S. Maturo, Jr., *Atti Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Milano* **108**, 261 (1968); J. E. Hazel, *U.S. Geol. Surv. Prof. Pap.* 529-E (1970), p. 21.
8. M. J. Cerrame-Vivas and I. E. Gray, *Ecology* **47**, 260 (1966).
9. J. H. Day, J. G. Field, M. P. Montgomery, *J. Anim. Ecol.* **40**, 93 (1971).
10. J. B. C. Jackson, *Mar. Biol.* **14**, 304 (1972); M. A. Buzas, in *Estuarine Interactions*, M. L. Wiley, Ed. (Academic Press, New York, 1978), p. 173.
11. J. E. Warme, A. A. Ekdale, S. F. Ekdale, C. H. Peterson, in *Structure and Classification of Paleocommunities*, R. W. Scott and R. R. West, Eds. (Dowden, Hutchinson & Ross, Stroudsburg, Pa., 1976), p. 143.
12. H. E. Coomans, *Beaufortia Ser. Misc. Publ. Zool. Mus. Univ. Amsterdam* **9**, 83 (1962).
13. J. S. Bradshaw, *Contrib. Cushman Found. Foraminiferal Res.* **10**, 25 (1959); F. L. Parker, *Sci. Rep. Tohoku Imp. Univ. 2nd Ser.* **4**, 71 (1960).
14. R. Cifelli, *J. Mar. Res.* **20**, 201 (1962); *Contrib. Cushman Found. Foraminiferal Res.* **18**, 113 (1967); \_\_\_\_\_ and R. K. Smith, *Smithson. Contrib. Paleobiol.* **4**, 52 (1970).
15. M. A. Buzas, *Limnol. Oceanogr.* **14**, 411 (1969); R. R. Lankford and F. B. Phleger, *J. Foraminiferal Res.* **3**, 101 (1973).
16. S. S. Streeter, *Quat. Res. (N.Y.)* **3**, 131 (1973); D. Schnitker, *Nature (London)* **248**, 385 (1974); G. P. Lohmann, *J. Foraminiferal Res.* **8**, 6 (1978); S. S. Streeter and N. J. Shackleton, *Science* **203**, 168 (1979); B. H. Corliss, *Mar. Geol.* **31**, 115 (1979); D. Schnitker, *Mar. Micropaleontol.* **4**, 265 (1979).
17. Data on currents were taken from: H. U. Sverdrup, M. A. Johnson, R. H. Fleming, *The Oceans: Their Physics, Chemistry and General Biology* (Prentice-Hall, Englewood Cliffs, N.J., 1946), p. 1060; F. C. Fuglister, *Tellus* **3**, 230 (1951); D. F. Bumpus, *Trans. Am. Geophys. Union* **36**, 601 (1955); H. J. McLellan, *J. Fish. Res. Board Can.* **14**, 213 (1957); *Oceanographic Atlas of the North Atlantic Ocean, Section I, Tides and Currents 700* (U.S. Navy Oceanographic Office, Washington, D.C. 1965), p. 75; C. Keen, J. E. Blanchard, M. J. Keen, in *The Encyclopedia of Oceanography*, R. W. Fairbridge, Ed. (Reinhold, New York, 1966), p. 299; B. C. Heezen, C. D. Hollister, W. F. Ruddiman, *Science* **152**, 502 (1966); E. D. Schneider, P. J. Fox, C. D. Hollister, H. D. Needham, B. C. Heezen, *Earth Planet. Sci. Lett.* **2**, 351 (1967); L. V. Worthington, *On the North Atlantic Circulation* (Johns Hopkins Univ. Press, Baltimore, 1976), p. 110.
18. J. D. Milliman, *U.S. Geol. Surv. Prof. Pap.* 529-J (1972), p. 40; \_\_\_\_\_, O. H. Pilkey, D. A. Ross, *Geol. Soc. Am. Bull.* **83**, 1315 (1972).
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## Detection, Pursuit, and Overgrowth of Tropical Gorgonians by Milleporid Hydrocorals: Perseus and Medusa Revisited

**Abstract.** *Encounters leading to competitive interactions between colonies on coral reefs are to some extent accidents of patterns of recruitment and growth. In contrast, colonies of Millepora spp. actively detect nearby arborescent gorgonians and subsequently redirect growth in order to contact and overgrow them. Detection is dependent on water flow over the two colonies.*

Interactions between organisms are common and important ecological phenomena often affecting their fitness, distribution, and abundance. Many very different types of interaction, such as predator-prey, direct competition, parasite-host, and mating involve, and are preceded by, direct contact between organisms. The predictability of such encounters between potentially interacting organisms is an important ecological parameter. A species' ability to influence its interactions by precipitating or avoiding specific encounters will depend largely on its degree of mobility and behavioral complexity. Thus, interactions between many sessile organisms, such as plants and colonial animals, appear to be the result of patterns of recruitment and normal, vegetative growth (1, 2). Here I describe a competitive interaction between adult colonies of two common coral reef taxa in which the initial encounter results from mechanisms more often associated with mobile organisms: detection and pursuit (in the form of directed growth) of arborescent gorgonians by competitively superior (3) milleporid hydrocorals.

*Millepora alcicornis* (branched) and *M. complanata* (bladelike) normally produce erect, planar colonies oriented perpendicularly to water flow (4, 5). In contrast, colonies of both species pursuing nearby gorgonians redirect growth of varying numbers of specialized branches out of the colony plane, horizontally toward the target gorgonian. These at-

tack branches (6) elongate, bifurcating into handlike structures that eventually contact, abrade, encircle, and encrust branches of the target gorgonian, ultimately overgrowing the entire colony (Fig. 1, a and b).

A survey of this interaction on the shallow (7 m) fore reef of northern Jamaica reveals two characteristic patterns, substantiated by qualitative observations elsewhere in Jamaica and in Belize (C.A.). *Millepora* colonies produced attack branches exclusively toward nearby (within 30 cm) living colonies of many of the common gorgonian species, and never into open water or toward other potential substrata, such as dead gorgonians, live or dead coral, sponges, algae, or other *Millepora*. Attacks by *Millepora* exhibited a highly significant directional component. Of 75 recorded attacks, 95 percent originated from *Millepora* colonies down-current (in the oscillating wave surge) from target gorgonians (7). The observed specificity and directionality of attacks suggest that production of attack branches by *Millepora* is neither a device to randomly search for new substrata, nor a general response to any nearby object; rather it is a specific response to living gorgonians detected by water flow over them and onto *Millepora*.

I tested these hypotheses by experimentally inducing in situ production of attack branches from previously normal, planar, and noninteractive colonies of *M. alcicornis*. To determine whether