Information Report

Seamount Acoustic Scattering

Nocturnal Emissions or Organismal Activities?

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The cover of the March 1 issue of *Eos* showed a time series of acoustic scattering above Southeast Hancock Seamount (29°48'N, 178°05'E) on July 17–18, 1984. In a comment on that cover Martin Hovland (*Eos*, August 2, p. 760) argued that gas or "other far reaching causes" may be involved in the observed acoustic signals. He favors a hypothesis that acoustic scattering observed above a seeping pockmark in the North Sea is a combination of bubbles, stable microbubbles, and pelagic organisms and infers that this may be a more general phenomenon and indeed plays a role in the attraction of organisms to seamounts.

Relevant to this issue is our fieldwork conducted and continuing over Southeast Hancock Seamount. Net samples clearly demonstrate that the scattering layers are composed of higher densities of micronektonic organisms, some of which are unique to the seamount ecosystem as opposed to surrounding oceanic waters; the latter species include the sternoptychid fish *Maurolicus muelleri* and the lophogastrid mysid *Gnathophausia longispina* [*Boehlert and Seki*, 1984; *Boehlert*, 1988].

These animals do migrate vertically on a diurnal basis, as do many other oceanic organisms; the form of the acoustically detected mass varies from night to night and is dependent upon current patterns (*C. Wilson*, Honolulu Laboratory, Hawaii, unpublished data). The vertical component of the scattering layers evident in the first and fourth panels of the *Eos* cover are temporary situations based upon vertical movements; the organisms cannot undergo "more horizontal spreading" at a different vertical layer without first getting there through vertical movements. In fact, our net sampling on the nights when the acoustic transects were taken suggests that the animals in the first panel are almost exclusively *M. muelleri*, whereas later migrators include several species of crustaceans. As shown in the second panel, the upper portion of the layer is deeper in the water column, indicating the layer has settled from its initial upward movement. The third panel shows scatterers before dawn extending close to the surface, and the fourth, rapid movement downward. The behavior of the layers is indicative of a biological rather than a gaseous origin.

While our net samples are unable to detect bubbles or stable microbubbles, I believe that the evidence is largely against their existence. Southeast Hancock Seamount is about 30 million years old [*Grigg*, 1988], and no volcanic or hydrothermal activity is evident there or on surrounding seamounts. As is characteristic of relatively shallow seamounts, sediment cover is lacking. Conditions supporting the formation of seeps or bubbles are thus not evident. If gaseous emissions exist, however, one might ask why they would only be nocturnal. One could conceive of a diel periodicity, but the movements of these layers correspond to changing isolumes, and thus, diel periodicity changes seasonally with day length, as does vertical migration in the open ocean [*Boden and Kampa*, 1967]. Moreover, unless the bubbles or stable microbubbles are photoreactive, they would neither disappear nor descend with the rising sun (fourth panel of *Eos* cover and the left panel of Figure 1). Our observations also suggest that continued acoustic scattering occurs off the flanks of the seamount in early morning (right panel of Figure 1).

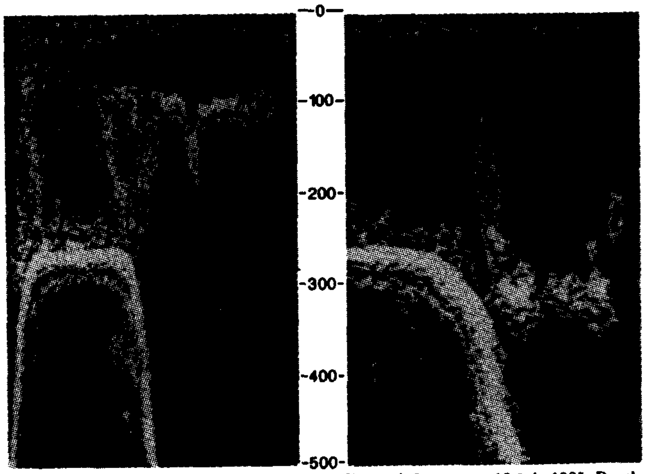

Fig. 1. Acoustic scattering around Southeast Hancock Seamount, 13 July 1985. Depth is in meters. The record is from a 38 kHz Simrad EQ-38 depth sounder photographed from a JRC Chromoscope. The left panel was taken at 0514 as the layer consolidated near 100 m and began its descent. The right panel, at 0654, shows scatterers off the flank of the seamount, well after sunrise. (Reference to the trade name Simrad does not imply endorsement by the National Marine Fisheries Service, NOAA.)

There is no doubt that acoustic scattering increases in association with emergent land and seamounts. *Hargreaves* [1975] conducted acoustic surveys throughout the Atlantic and observed higher levels near seamounts and islands. The well-known island mass effect, which suggests increased primary productivity around islands, may only occur around high islands [*Dandonneau and Charpy*, 1985]. Increased productivity of atolls has been hypothesized to occur through upward percolation of nutrients in limestone (analogous to seeps); this has been termed endo-upwelling by *Rougerie and Wauthy* [1986]. Acoustic evidence of increased biomass near isolated, oceanic seamounts abounds and has been observed at Southeast and Northwest Hancock Seamounts [*Boehlert and Seki*, 1984; *Boehlert*, 1988], Milwaukee Bank in the Emperor Seamounts, Fieberling Seamount off California [*Kozlov et al.*, 1982], and above several seamounts in the South Atlantic [*Kalinowski and Linkowski*, 1983]. All exhibit the pattern of enhanced scattering at night and vertical movements. Seamounts or banks closer to continental shelves do not necessarily show this pattern; *Genin et al.* [1988] demonstrate that resident predators actually deplete oceanic scattering layers above Nidever Bank off the California coast. A similar process probably occurs over oceanic seamounts for certain species [*Borets and Darnitsky*, 1983].

The increased abundance of pelagic organisms near seamounts may be due to several factors, but seepage of gas or liquids is a new idea. At Minami-Kasuga Seamount in the northern Mariana arc, active hydrothermal fields are characterized by abundant benthic macrofauna [*Vonderhaar et al.*, 1987], but earlier studies there showed that planktonic processes, including zooplankton abundance patterns, were a function of hydrographic conditions [*Genin and Boehlert*, 1985].

Current hypotheses on aggregation of pelagic organisms at seamounts have dealt with either enhanced in situ production or mechanisms of aggregation. Although nutrients [*Darnitsky et al.*, 1984] and chlorophyll [*Genin and Boehlert*, 1985] may be enhanced over seamounts through upwelling and retention, the time necessary to transfer any enhanced productivity to higher trophic levels may be longer than the residence time of topographically generated eddies akin to Taylor columns. Thus, other arguments suggest that advected energy (principally zooplanktonic and micronektonic prey organisms) is responsible for higher biomass over seamounts [see review in *Boehlert and Genin*, 1987]. There is little doubt that topographic effects of ocean currents have biological implications [*Wolanski and Hamner*, 1988]; aggregation of pelagic organisms is but one facet.

To conclude, the possibility of seeps and bubbles cannot be completely discounted in explaining increased acoustic scattering over and around seamounts. Further research will be necessary to investigate their effects on plankton and micronekton communities, but a variety of evidence (including that presented above) suggests that they are not the causative agent in the majority of seamount situations studied to date.

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