LETTERS

International matters

Readers from around the world discuss a bacterial pathogen of coralline algae (right), AZT trials in Thailand, Russian mathematics, and the treatment of foreign faculty in Japan. In other letters, Malthus is invoked, the United Nations is said to err, and biopolymer sequences are made available to all.

M & D LITTLER

CLOD Spreading in the Sea-Surface Microlayer

Mark M. Littler and Diane S. Littler (Reports, 3 Mar., p. 1356) report spreading of coralline lethal orange disease (CLOD), a bacterial pathogen of coralline algae. CLOD was initially observed in June 1993. By June 1994, it had spread across 6000 kilometers of ocean. Littler and Littler write that the biogeographic, seasonal, and abundance data, combined with the predominant current patterns, led them to postulate a current-borne northwesterly dispersal from an eastern South Pacific source.

The authors make the standard assumption that large-scale plankton dispersal is controlled by current movement (*1*). However, the predominant current patterns in the South Equatorial Current system do not explain the CLOD dispersal patterns. Currents at the first three sites were southwesterly while the infection was shown to spread toward the northwest, perpendicular to water movement (see also, *2*). Other possible mechanisms for dispersal include atmospheric transport and wind-driven transport in the sea-surface microlayer (*3*, *4*).

Prevailing mean annual winds in the region are northwesterly at a speed of about 5 meters per second (*2*). If CLOD dispersal were wind-borne, transport across 6000 kilometers would require only 2 weeks. This rapid transport and the difficulty of getting an infective dose aerosolized and deposited makes wind transport a similarly unlikely mechanism for spreading CLOD.

Average surface drift–to-wind speed ratios are 3.5 ± 0.7% (*4*). Surface drift acts parallel to the wind direction, regardless of underlying current direction (*5*). For an average wind speed of 5 meters per second, surface drift of the microlayer over 6000 kilometers would take approximately 400 days. This is within 10% of the time reported by Littler and Littler, but does not take into account the possibility of a favorable current for the last 1000 kilometers that would bring the values closer.

It appears from the data of Littler and Littler that wind-induced surface drift is the most probable mechanism of CLOD spread. As such, their data reveal a unique mechanism by which plankton inhabiting the microlayer are transported parallel to the wind, across or against current patterns. This theory is supported by reports showing the accumulation of plankton in the microlayer by adsorption to bubbles (*6*), changes in cell surface hydrophobicity, tactic responses (*7*), and redeposition after aerosol formation (*3*). Coralline algae and reefs, as near-surface ecosystems, should be particularly susceptible to this pathogen introduction mechanism and appear to make a good model for sea-surface microlayer transport of pathogens and other microbes over long distances and across water mass boundaries.

M. S. Hale
J. G. Mitchell
School of Biological Sciences,
Flinders University,
Adelaide, 5001, Australia

References

1. C. A. Hannan, *Limnol. Oceanogr.* **29**, 1108 (1984).
2. M. Tomczak and J. S. Godfrey, *Regional Oceanography: An Introduction* (Pergamon, Oxford, 1994).
3. R. W. Risebrough *et al.*, *Science* **159**, 1233 (1968).
4. P. Lange and H. Huhnerfuss, *J. Phys. Oceanogr.* **8**, 142 (1978).
5. I. Langmuir, *Science* **87**, 119 (1938); R. A. Weller *et al.*, *ibid.* **227**, 1552 (1985).
6. J. H. Paul and W. H. Jeffery, *Can. J. Microbiol.* **31**, 224 (1985).
7. A. S. Dietz, L. J. Albright, T. Tuominen, *ibid.* **22**, 1699 (1976).

Response: Hale and Mitchell shed some light on the possible causes of the known biogeographic range of CLOD. Our report recorded a distribution in 1994 that included the Cook Islands, Fiji, the Solomon Islands, and Papua New Guinea. Since then, we have received documentation (*1*) that CLOD also is common in the Samoa Islands. As Hale and Mitchell note, all of these except Papua New Guinea are exposed to predominantly southwest current patterns (*2*), whereas the island systems tend to be oriented with respect to one another in a southeast to northwest direction.

The observation of abundant CLOD in the Cook Islands and Fiji in 1994, but not recorded at the identical study sites during 1993 in Fiji, suggested to us a westward dispersal from an unspecified eastern Pacific source correlated with the predominant westward South Equatorial Current pattern. The sink rates we found for the larger CLOD particles showed values that appeared to be too rapid (0.8 to 1.6 centimeters per second) to support dispersal by current movement alone. The concept of dispersal by sea-surface microlayer transport (*3*, *4*) under the influence of predominant northwest winds acting at right angles to the south-tending current patterns opens the possibility of a CLOD source farther to the south and may explain how CLOD progressed northward and westward of the Cook Islands.

Mark M. Littler
Diane S. Littler
Department of Botany,
National Museum of Natural History,
Smithsonian Institution,
Washington, DC 20560, USA

References

1. P. Craig, personal communication.
2. M. Tomczak and J. S. Godfrey, *Regional Oceanography: An Introduction* (Pergamon, Oxford, 1994).
3. C. A. Hannan, *Limnol. Oceanogr.* **29**, 1108 (1984).
4. R. W. Risebrough *et al.*, *Science* **159**, 1233 (1968).

Littler, M.M. and D.S. Littler. 1995. CLOD spreading in the sea-surface microlayer: response. *Science* 270: 897-898, 1 photo.