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by

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Slicks on Ocean Surface Downwind from Coral Reefs ^{1/}

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During general investigations of certain atolls of the northern Marshall Islands in 1952 (Fosberg, 1955) a phenomenon was noticed that seems worthy of the attention of oceanographers and geologists, although no explanation is offered for it. This is the occurrence of narrow, elongate strips of smooth water, resembling the effect produced by a film of oil on the surface, extending downwind from the coral reefs.

This appearance was first noticed in the lagoon of Ujae Atoll on March 4, 1952, and was observed repeatedly thereafter for more than a week along the windward reef in the southern half of the atoll. A brisk trade wind was blowing, and the surface of the lagoon was covered by a close pattern of ripples, wavelets, and small waves. Perpendicular to the reef and exactly in the direction of the wind were numerous parallel linear streaks, varying from a few centimeters to a meter in width, of perfectly smooth water. These extended several hundred yards downwind. In them there was an abrupt smoothing of the surface disturbance of the water and usually a small accumulation of small bubbles and flecks of foam in a broken line near the center of the streak. The streaks seemed to be of different ages, the younger ones having very clearly defined edges, the older ones becoming broken up or braided in pattern. They tended to become more broken up as the distance from the reef increased, also broader with distance. On a very rough day their boundaries were not clear, and the choppiness was not altogether smoothed out. On a day with only a very gentle breeze the whole streak was not straight but a bit irregular. At about 300 m. from the reef, on the calmer day the streaks became as much as 6 to 8 m. wide. On March 9 similar streaks were seen in the open sea to the leeward of the north end of Ujae Atoll, downwind from Bikenkar and Enelamoj Islets and their connecting reef. These were very well developed, even directly in the lee of the islets. The largest seemed to correspond to large reentrants or surge channels in the reef.

On March 18 similar streaks were seen on Wotho Atoll, in the south part of the lagoon inside the east reef, some opposite the open reef, some inward from the long sand islet on this reef. On March 21 a very good opportunity was afforded to study these streaks inside the north reef of Wotho, west of Eneobnak Islet. Here are several channels crossing the reef, broad toward the seaward side of the reef, narrowing toward the western projection of the islet and sweeping westward around this projection before entering the lagoon. On the reef they run between flats of reef conglomerate and rubble tracts lying on the reef flat. A fairly strong current was flowing inward from the sea to the lagoon. In these channels the slicks described above were

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very prominent, following the direction of the wind rather than that of the current, though these directions were only a few degrees apart. Although previous observations were all made from small boats, here it was possible to examine the streaks much more closely while wading in waist-deep water. Careful examination revealed no iridescence, whatever. The boundaries were extremely sharp. There was a suggestion of a difference in the feel of the water in the streaks from that nearby, but nothing very tangible or describable. There was no difference in taste or flavor. An attempt was made to follow the streaks to their sources, which seemed to be in the rubble tracts to windward, but this was unsuccessful, as the streaks gradually became invisible in the very quiet water as the rubble tract was approached. There was nothing in the rubble tract to suggest an origin for this phenomenon. There seemed little chance that oily material from the open sea could be responsible for the phenomenon here, though such an origin could not be excluded.

On March 24 similar streaks were seen in the open sea to the leeward of the south half of Bikar Atoll. They were quite numerous, but where the observations were made, from the deck of the ship a quarter to half a mile from the reef, they were rather braided and broken up, but some were still fairly strong. On March 25, at Pokak Atoll, the northernmost of the Marshalls, such slicks were conspicuous at sea on the leeward side of the leeward reef, especially near the single channel through the reef. They extended for several miles downwind, becoming very diffuse at that distance. Here they were only observed from the deck of the ship.

All of the above observations were made in the spring, in a season of strong trade winds. Another visit was made to Pokak and Bikar in July and August, in much calmer weather. A special attempt was made to observe this phenomenon further, but then it was much more difficult to see the slicks clearly. What appeared to be the same type of streaks were seen several times; however only once, on August 9, were unequivocal observations made. This was in the lagoon of Bikar Atoll where a few not especially clear or sharp streaks were seen inside the windward reef between Almeni and Jaboero Islets. There seems no doubt that the phenomenon occurs during these calmer months, but because of the weakness of surface disturbance there is so little contrast that the slicks do not show up very well.

The above observations form all of the factual data to be considered. There seems little doubt that the phenomenon is a real one that is reasonably constantly associated with coral reefs, at least in the northern Marshalls area. That it was not seen near any of the eight other atolls visited earlier in the same expedition is probably simply the result of attention not having been called to it previously. The expedition did not primarily concern itself with the ocean but with reefs and islets. After the slicks were first noticed they could usually be found in any similar situation to the leeward of reefs in brisk weather.

The appearance of these slicks strongly suggests the presence of minute quantities, perhaps monomolecular films, of some substance that strongly alters the surface tension of the sea water. The smoothing out of ripples is abrupt, localized, and of considerable duration, not shifting and inconstant as would be expected of phenomena due solely to wind interacting with the surface of the water (see Langmuir, 1938). The dependence of slick formation on the presence of films of organic matter on the surface of the water has been stressed by most authors who have discussed such phenomena in recent years (Dietz and LaFond, 1950; Ewing, 1950a, 1950b). The combined influence of organic films and effects of strong winds, as suggested by Ewing (1950a, b) should not be disregarded as a possibility, though the "braided" appearance of old slicks contrasted with the sharpness of new ones parallel and simultaneous with them is hard to reconcile with any wind-induced phenomenon. The nature of the pattern observed in the Marshall Islands does not at all resemble the pattern of light and dark bands in the Gulf of Panama discussed by Woodcock and Wyman (1947) as shown in their photographs in plates 6 to 8.

The arrangement of the streaks, at irregular intervals running down wind from the reef, suggests the possibility of frequent emission of minute quantities of some oily material from the reef or from some organism connected with the reef. F. S. MacNeil (in conversation at the time) reported seeing small emissions of bubbles coming out of reefs in places. The possibility has not been overlooked that these slicks may be due to waste oil (from steamships) that may be washed over the reef from the windward side. This, however, seems precluded by the observation of the same phenomenon to leeward of long islets where no water could possibly come over from the windward side. These islands are, also, far from lanes of heavy ocean traffic at the present time. There seems little doubt that these streaks originate on the reef itself.

These facts are placed on record in the hope that either a convincing solution to the problem of the origin of the slicks may occur to someone else or that further investigation may be deemed worth while.

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