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NOTE CONCERNING HUMAN RESPIRATORY IRRITATION ASSOCIATED WITH HIGH CONCENTRATIONS OF PLANKTON AND MASS MORTALITY OF MARINE ORGANISMS¹

BY

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There is increasing evidence that high concentrations of plankton are sometimes associated with mass mortality among marine animals (Taylor, 1917, see ref's pp. 14-16; Marchand, 1928; Brongersma-Sanders, 1947; Gunter, et al., 1947).

Human respiratory irritations, also concurrent with mass mortality of fish, have been recorded by Taylor (1917), Lund (1934-35), and Gunter, et al. (1947). The respiratory irritant, commonly termed a gas, is said to produce hard coughing and a burning sensation in the nose, throat and lungs. This irritation is reported to occur in persons near the shore during onshore winds, as well as on the open sea.

This paper gives support to the work of Somner, et al. (1937), which indicates that certain dinoflagellates produce irritating or poisonous effects when present in high concentrations. It is the purpose of this paper to list qualitative subjective tests which show that the above-mentioned respiratory irritation is associated with the presence in the inhaled air of minute drops originating in sea water discolored by high concentrations of dinoflagellates.

The presence of sea water nuclei in oceanic air under ordinary conditions is well known (Owens, 1926; Jacobs, 1937, 1939; Cunningham, 1942; and Dessens, 1947). These nuclei are sometimes crystalline, sometimes liquid, depending upon the relative humidity of the ambient air. This phase change usually occurs somewhere between 60 and 75% relative humidity (Owens, 1926; Wright, 1939; and Dessens, 1947). The nuclei vary in radius from about 0.3 to 30 μ . These aerosols from the sea are probably formed by bursting bubbles from breaking waves in a manner similar to that shown to occur in effervescing H₂O (Stuhlman, 1932). Zobell (1940) has found that marine bacteria exist in oceanic air and he suggests that they are carried into the air by sea water nuclei produced by spray. Therefore it is reasonable to suppose

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that other organisms or products of the sea are also carried up from the sea surface film by these spray drops.

At the request of the United States Fish and Wildlife Service, the author visited Venice, Florida in July 1947 when great numbers of fish were dying along the local shores of the Gulf of Mexico. Light offshore winds prevailed at this time and reports of human respiratory irritations² had recently ceased. Since the presence of this irritation was reported as associated with "red water," dying fish and onshore winds, it was reasonable to test some of the discolored water. During July and August 1947 the following simple tests and experiences were recorded.

Samples of sea water of a deep reddish shade were taken on July 24, 1947, about 5 miles offshore³ at Lat. 27° 14' 15" N., Long. 82° 39' 10" W. These samples were unconcentrated sea water collected by dip-bucket. They were found to contain from 15 to 56 million dinoflagellates per liter. (The greatest number, *i. e.* 56 x 10⁶ dinoflagellates per liter, is about four times the maximum reported by Allen [1941] in a twenty years' statistical study of marine dinoflagellates of southern California). These dinoflagellates were about 25 microns in diameter and were identified as *Gymnodinium* sp. by F. G. Walton Smith and Paul S. Galtsoff (personal communications). When sea water containing 56 x 10⁶ dinoflagellates per liter was sprayed into the nose and throat with a hand atomizer, coughing and a burning sensation in the nose and throat resulted. This effect is apparently similar to that experienced along local beaches during onshore winds. This test was repeated many times with the same results. Relatively clear sea water from another local area produced no similar irritation.

During July 24 and 25, 1947, the author and two companions spent about five hours at sea, near and immediately over large patches of "red water." For long periods of time we worked over tubs of this water, over nets slimy with concentrated plankton and decks awash with spilled "red water." Winds during this time did not exceed 3 m/sec and there were no white caps on the sea surface. We noted no respiratory trouble of any kind throughout this period. However, on the afternoon of the 24th a thunder squall with heavy rain and a force 5 wind (from the east) passed over. During this squall, of about 30 minutes duration, the sea surface became streaked with foam, which was presumably caused by breaking waves and the impact of heavy rain on the surface water. During the latter part of the passage of

² Detailed information concerning the objective symptoms of this respiratory irritation may be secured from Dr. T. S. Thompson, M.D., Box 224, Venice, Florida.

³ "Red water" from this area was found to contain unusually high concentrations of phosphorus (see Ketchum and Keen, 1948).

this squall we experienced coughing and a burning sensation in the nose and throat. After the wind subsided and the white caps and foam streaks disappeared, the respiratory irritation also disappeared. Thus the presence of an irritant in the free air over the "red water" seemed to be correlated with increased wind and with the presence of breaking waves and foam. Sampling of aerosols at this time was prevented by the rain.

About 20 cm.³ of the sea water containing 56×10^6 dinoflagellates per liter was passed through a Jena fritted glass bacteria filter which had 1 to 1.5 micron openings. This filtrate produced the same irritation as did the unfiltered water when it was sprayed into the nose and throat with an atomizer. No particulate matter was seen in this filtrate under the microscope, using a magnification of $500\times$.

Samples of the "red water" were placed in shallow aluminum pans and heated. At temperatures varying from 80° to 90° C, clouds of fine bubbles formed in this water. These bubbles rose to the surface and burst, causing the hissing sound of effervescence. Coincident with the formation of these clouds of small bursting bubbles, the vapor rising from the surface produced involuntary coughing and a burning sensation in the nose and throat. When the heat source was removed, the bubbling quickly ceased and the irritating effects of the vapor also ceased. Upon reapplication of the heat and the reformation of the clouds of fine bubbles, the irritating effect of the vapor was again present. When the relatively clear sea water was heated in this manner, no irritating effects could be detected upon inhaling the vapors.

Small (1 x 10 mm.) glass slides, covered with a hydrophobic film, were exposed for 10 seconds at a height of 2 cm. above various vessels, some containing clear sea water and others containing "red water," under different conditions of temperature and effervescence. Table I

TABLE I.

| T°C | "Red Water" | | | | "Relatively Clear Sea Water" | | | |
|--------------------------|------------------|------------------|------------|----------|------------------------------|---------|------------|----------|
| | Bubbling | | No Bubbles | | Bubbling | | No Bubbles | |
| | 26° | 85°-95° | 26° | 85°-95° | 25° | 85°-95° | 25° | 85°-95° |
| Drop diameters (microns) | 15-80 (estimate) | 15-80 (estimate) | no drops | no drops | 15-80 | 15-80 | no drops | no drops |
| Respiratory Irritation | Yes | Yes | No | No | No | No | No | No |

shows the conditions under which drops were or were not deposited on these glass slides, the size range of these drops,⁴ and the occurrence of

⁴ The isopiestic technique used to cause these small drops to assume their original concentration and size under the microscope will be described in a later publication.

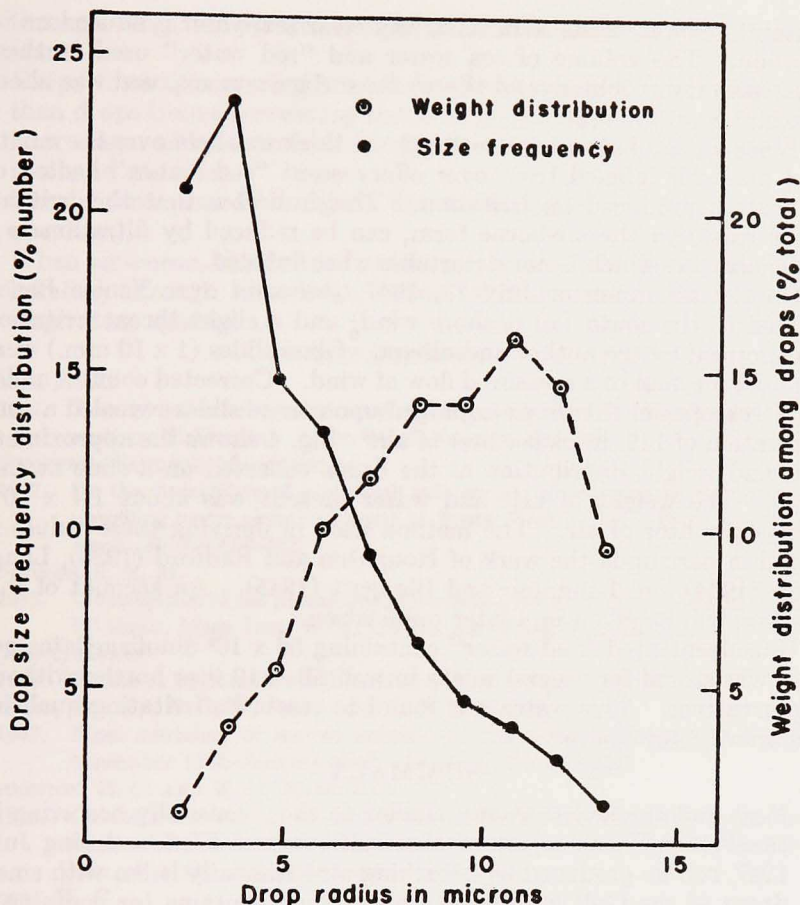


Figure 4. Approximate distribution of size and weight of sea water aerosols over Venice Beach, Fla., July 28, 1947. Sampling height 2 m, 50 m back from the edge of the sea. Wind velocity 4.2 m/sec south. Surf light.

respiratory irritation resulting from inhaling air from immediately over the various water samples.

In order to produce effervescence at room temperatures, a Pasteur-Chamberlain unglazed porcelain filter was placed in "red water," and air was forced through it under a pressure of 1.6 kg/cm². Clouds of fine bubbles were produced which, upon rising to the surface and bursting, formed a haze of drops in the air. Breathing this haze produced irritation of the nose and throat, though this effect was not as intense as that resulting from breathing vapor over effervescing heated "red

water." Similar tests with relatively clear sea water produced no irritation. The volume of sea water and "red water" used in these tests was about 2 liters and the water surface area exposed was about 200 cm².

When a pad of absorbent cotton 2 cm. thick was held over the mouth and nose, air inhaled from over effervescent "red water," heated or unheated, produced no irritation. This indicates that the irritant, as it exists in the air-borne form, can be reduced by filtration to a concentration which is not detectable when inhaled.

On the afternoon of July 28, 1947, the wind over Venice Beach shifted to the south (an onshore wind) and a slight throat irritation was noticed by the author and others. Glass slides (1 x 10 mm.) were exposed, normal to a measured flow of wind. Corrected counts (under a microscope) of the drops impinged upon these slides revealed a concentration of 112 drops per liter of air.⁵ Fig. 4 shows the approximate size and weight distribution of the drops collected on a slide at this time. The weight of salt and water present was about 1.4×10^{-7} grams per liter of air. The method used in deriving these values is based in part upon the work of Houghton and Radford (1938), Langmuir (1944) and Langmuir and Blodgett (1945). An account of this method will be given in a later publication.

Unconcentrated "red water" containing 56×10^6 dinoflagellates per liter was stored for several weeks in well filled 19 liter bottles without preservatives. This water was found to retain its irritating qualities apparently unimpaired.

SUMMARY

1. Nose and throat irritations, similar to those naturally occurring in the Venice Beach region of the Gulf coast of Florida during July 1947, can be produced by breathing air artificially laden with small drops of the Gulf of Mexico water which contains (or contained) 56×10^6 dinoflagellates per liter.
2. The presence of naturally produced drops of sea water in the air along Venice Beach, Florida, during a time when respiratory irritation occurred, is indicated. Approximate drop size range and concentration is given.
3. Simple experiments show that respiratory irritation is always associated with the presence of small drops of "red water" in the air.
4. "Red water" stored without preservative for several weeks retained its irritating qualities apparently undiminished. The persistence of the irritant through weeks of storage without preservative and

⁵ During heavy surf conditions, with onshore wind, concentrations as high as 3,000 drops per liter of air have been measured by the author.

through large temperature changes indicates a rather stable substance.

5. Drops from effervescing heated "red water" were more irritating than drops from effervescing water at room temperature, and these later drops seemed more irritating than spray drops produced by the hand atomizer.
6. The irritant passed through a fine bacteria filter (1 to 1.5 micron openings).
7. When air-borne, the irritant can be so reduced in concentration, by inhaling through absorbent cotton, that it ceases to affect the respiratory system.

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