LABORATORY EVALUATION OF RED-TIDE CONTROL AGENTS[1]

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Intense blooms of the dinoflagellate *Gymnodinium breve* Davis that occur at irregular intervals along the west coast of Florida (Feinstein, Ceurvels, Hutton, and Snoek, 1955) may cause extensive mortality of marine organisms. The blooms are popularly known as red tides because of the amber to red discoloration they impart to the water.

The Fish and Wildlife Service initiated studies in 1948 to determine the possibility of artificial means to reduce the occurrence or intensity, or both, of the red tides. Early tests indicated that copper, in concentrations as low as 0.03 p.p.m., is lethal to laboratory cultures of the red-tide organism. Rounsefell and Evans (1958), and Marvin, Lansford, and Wheeler (1961) demonstrated, however, that control by copper was not feasible under field conditions. The copper precipitated from solution after a few days and, consequently, was ineffective for control.

In 1959, scientists of the Bureau of Commercial Fisheries Biological Laboratory in Galveston, Tex., began a systematic evaluation of 4,306 compounds as red-tide toxicants. The initial phase of the study (Marvin and Proctor, 1964) involved testing each compound to determine its toxicity to *G. breve*. The final phase of the study, described here, evaluated some of the more toxic materials in the laboratory. We investigated only the compounds that we determined to be 100-percent lethal to *G. breve* within 24 hours at concentrations of 0.01 p.p.m. or less. A red-tide control agent must also be selectively toxic; it must kill the red-tide organism without harming other species.

The chemicals fulfilling the toxic requirement for red-tide control were tested for selectivity by determining their effects on juvenile forms of marine species living in Galveston Bay and adjacent coastal waters. The selectivity threshold concentration was set arbitrarily at 0.1 p.p.m. Chemicals that killed 50 percent or more of any test organism within 24 hours at or below this concentration were rejected. The five chemicals that passed the selectivity tests, their effects on the test organisms at the threshold concentration, and the species tested are noted in table 1.

[1] Contribution No. 215, Bureau of Commercial Fisheries Biological Laboratory, Galveston, Tex.
Note.—Approved for publication May 6, 1966.

TABLE 1.—*Percentage mortality of test organisms held 24 hours at toxicant concentration levels of 0.10 p.p.m.*

Chemical	Species[1]							
	Blue crab (megalops)	Striped mullet	Brown shrimp (postlarval)	Sailfin molly	Marsh periwinkle	Sheepshead minnow	Hermit crab	Atlantic croaker
Carbamic acid, diethyldithio-; tellurium salt	0	0	10	10	0	0	0	0
Carbamic acid, dimethyldithio-; ferric salt	10	0	0	0	0	40	0	0
Disulfide, bis(diethylthiocarbamyl)	0	0	10	0	0	0	0	20
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl)-; bis dimethylamino butyne monosalt	10	0	20	0	10	0	0	0
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl)-; cyclohexylamine mono salt	0	0	0	20	0	20	0	10

[1]Blue crab, *Callinectes sapidus* Rathbun; Striped mullet, *Mugil cephalus* Linnaeus; Brown shrimp, *Penaeus aztecus* Ives; Sailfin molly, *Mollienesia latipinna* LeSueur; Marsh periwinkle, *Littorina irrorata* Say; Sheepshead minnow, *Cyprinodon variegatus* Lacépède; Hermit crab, *Pagurus* spp.; Atlantic croaker, *Micropogon undulatus* (Linnaeus).

TABLE 2.—*Results of six toxicity tests in terms of percentage mortality of* G. breve *after 24 hours exposure*

Chemical	Test numbers for concentration of 0.01 p.p.m.						Test numbers for concentrations of 0.003 p.p.m.					
	1	2	3	4	5	6	1	2	3	4	5	6
Carbamic acid, diethyldithio-; tellurium salt	100	100	100	100	100	100	0	0	0	25	0	0
Carbamic aid, dimethyldithio-; ferric salt	100	100	75	100	100	25	0	0	0	50	0	0
Disulfide, bis(diethylthiocarbamyl)	100	100	75	100	100	0	0	0	0	50	0	0
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl)-; bis dimethylamino butyne mono salt	25	100	50	100	75	25	0	0	0	0	0	0
Sulfide, bis(2-hydroxy-3-bromo-5-chlorophenyl)-; cyclohexylamine mono salt	25	50	25	100	100	0	0	0	0	0	0	0

The selective chemicals were tested to determine their minimum toxic concentration levels to *G. breve*. Each toxicant was tested six times at 0.01 and 0.003 p.p.m. The results, in terms of mortality of *G. breve*, appear in table 2. Variation was considerable among the supposedly replicate sets of four of the chemicals. This suggests that the concentration of these four chemicals was close to the toxic threshold. At or close to the toxic threshold level, a slight variation in the concentration of a toxicant can have a pronounced effect on the mortality of organisms in cultures containing the toxicant.

Only one of the selective toxicants, carbamic acid, diethyldithio-; tellurium salt, consistently met the toxic requirement arbitrarily established for a control agent (R. T. Vanderbilt Co., Inc., 230 Park Avenue, New York City, N.Y. 10017; $2.13 per pound in 100-pound containers). This compound has two shortcomings, however: it killed 10 percent of the test organisms of two species (table 1); and its cost is prohibitive for massive use in the field.

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1967—O 219-992