A PRACTICAL CHEMICAL METHOD FOR KILLING MUSSELS AND OTHER OYSTER COMPETITORS

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BACKGROUND

During the summer of 1959 there was an unusually heavy set of mussels (Mytilus edulis) on many oyster beds along the Connecticut shore of Long Island Sound. The mussels threatened to smother oysters, especially young ones, and to damage the beds by accumulating on them large amounts of silt. As a result, several oyster companies requested information on how to kill the mussels either on the beds or during transplanting operations.

Meanwhile, to save the crop of oysters, one company used deckhands to remove mussels manually as the oysters were transplanted. Dredged-up bottom material, which averaged 332 mussels per bushel, could be processed by deckhands in about 17 minutes per bushel at a labor cost of 42.5 cents. When mussels averaged only 156 per bushel, the material could be processed in 6 to 7 minutes, at a labor cost of 15 to 17.5 cents per bushel. Working at this rate, however, deckhands removed only about 57 percent of the mussels; this means that about 140 mussels per bushel were left in bottom material in which the original count was 332.

Fig. 1 - Deck hands at culling board on a boat removing mussels manually from oysters and other dredged-up material.

Later in the summer, after mussels grew larger, about 80 percent of them were removed by hand (fig. 1). It is estimated that to remove 95 to 100 percent of mussels averaging 332 per bushel, deckhands would have to spend approximately 48 minutes, at a labor cost of $1.20 per bushel.

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It was shown several years ago by V. L. Loosanoff (personal communication) and co-workers, J. E. Hanks, A. E. Ganaros, and L. W. Shearer, that the dye Victoria Blue will kill mussels, annelids, tunicates, gastropod embryos, and other invertebrates. MacKenzie and Shearer (in press) have since reported in detail its effects on Polydora websteri and other annelids. Victoria Blue is virtually insoluble in sea water but forms a suspension of fine particles when it is stirred. It has been used routinely for 5 years to kill mussels, tunicates, and annelids in hatchery troughs at Milford Laboratory.

Victoria Blue was not recommended to the industry as a practical means of killing mussels for two reasons. First, it was believed that such competitors had to remain in a solution of the dye for several hours to acquire a toxic dosage. Thus, mussels were immersed for 3 hours in a dye concentration of 10 parts per million to kill them. Obviously, it would be impractical for an oysterman, who may handle several hundred bushels of oysters a day, to hold them for such a long period in large tanks of the dye. The second, and even more important consideration, was that oysters, themselves, during a long immersion, may open and receive a lethal dosage of Victoria Blue.

EXPERIMENTAL

Use of a chemical would be practical for an oysterman if it were sufficient to dip the dredged material, composed of oysters and mussels, in a tank of the chemical solution aboard his boat, and then store the material so treated on deck while he finishes loading and later proceeds to another ground to plant it. In this type of handling an oyster has an advantage over a mussel because its shells are closed completely while immersed in the solution, whereas a mussel has an open slit between its shells at the byssal notch through which the byssal threads protrude, and through which the chemical may reach the body tissues of the mussel. Hoping to take advantage of this anatomical difference, we dipped mussels in solutions of Victoria Blue (Niagara-3475) for 5 seconds and then stored them in air. Examination of mussels soon after this treatment showed, as suspected, particles of dye at the edge of the mantle

Fig. 2 - Deck hand on oyster boat using method, which consists of dipping bottom material (foreground) for 5 seconds in weak chemical solution, draining it briefly, and then storing it on deck of boat (background).

near the notch, in the fluid within the mantle cavity of the mussels, and on the gills and other parts of their bodies. Later, these parts were dyed blue. Probably a portion of the dye had entered the mussels during the immersal period but most of it was retained on the byssal threads and gained access to the mussel along these threads while it was stored in air.

Since there are a number of preparations known as Victoria Blue, we conducted experiments to determine which of these is most toxic to mussels. Victoria Blue B is the strongest one. In a test with it in a 5-percent suspension, 100 percent of mussels were killed by a 5-second dip and a 24-hour drying period. In similar tests with Niagara-3288, 91 percent died; Niagara-3475 killed 66.7 percent; Victoria Blue 4R, 17.6 percent; Victoria Blue R, 6.3 percent; and Victoria Blue B Base did not kill any mussels. Victoria Blue B was tried at 5 different concentrations and percentage mortalities of mussels were recorded as follows: 4-percent suspension, 100; 3-percent suspension, 95; 2-percent suspension, 88; 1-percent suspension, 55; and 0.5-percent suspension, 38.

In a field test, conducted in cooperation with a local oyster company, approximately 150 bushels of dredged-up bottom material, which contained 332 mussels per bushel, were dipped in a 0.5-percent suspension of Victoria Blue for 5 seconds and stored in air for 24 hours (fig. 2). In this test Niagara-3475 was used because it was available in large quantities. The results were poor; only 40 percent of the mussels died. We were encouraged, nevertheless, because every live mussel we opened had some of its organs stained blue. This showed that the dye was getting inside the mussels although it was not poisonous enough to cause the death of all of them.

In testing other chemicals we found that copper sulfate will kill mussels and several other oyster competitors, including annelids, Crepidula, and tunicates. We conducted an experiment using copper sulfate at concentrations of 0.5, 1.0, 2.5, and 5.0 percent. Mussels and oysters of 3 year classes were dipped for 5 seconds and then stored in air for approximately 6 hours, 24 hours, and 48 hours. One-year-old oysters used in this test averaged 22 mm. in length; 2-year-olds, 54 mm.; and 3-year-olds and older, 84 mm. One set of controls was not dipped but was kept in air for approximately 1 day; the other set was not dipped but cleaned of mussels manually and shoveled twice onto a screen which normally removes loose single mussels from the material dredged from oyster beds.

Fig. 3 - Dying mussels and healthy 2-year-old oysters after treatment in one-percent solution of copper sulfate.

In concentrations of copper sulfate of 0.5 and 1.0 percent, regardless of the length of storing period, mortality of 2- and 3-year-old oysters was not greater than in controls, while the percentages of mussels which died were high (table 1, fig. 3). However, mortality of 1-year-old oysters was greater as a result of the treatment than in controls. Copper sulfate solutions at strengths of 2.5 and 5.0 percent killed nearly all mussels, but also killed

many oysters. These experiments show, therefore, that solutions of copper sulfate employed to control mussels should be less than 2.5 percent. We recommend solutions containing between 0.5 to 1.0 percent, if mussels can be kept out of water for 24 hours or longer after dipping, and 1.0 to 2.0 percent solutions if they can be stored only a few hours. Young oysters, measuring 22 mm. in length or less, are too small to dip in the solution even if it contains only 0.5 percent of copper sulfate.

Oysters and mussels used in this experiment were handled roughly. They were dredged up, shoveled into baskets, dipped, and then dumped into bags for storage aboard the boat. Apparently oysters which have been handled roughly close their shells more tightly and have a better seal between their bodies and the outside. In another experiment in which 2-year-old oysters were taken gently from a suspended tray, one at a time, dipped for 5 seconds in a 1.0-percent copper sulfate solution, and dried for 24 hours, a 40-percent mortality was recorded.

Table 1 - Percentage Mortality of 1-Year-Old Mussels and of Oysters of 3 Year Classes After Being Dipped for 5 Seconds in Different Concentrations of Copper Sulfate and Then Stored in Air

Percentage Concentration of Copper Sulfate	Hours of Storage	Mussels	Age of Oysters		
			1 Year	2 Years	3 Years
TREATED					
0.5	6	89	10	1	0
	30	89	22	6	0
	54	94	22	5	5
1.0	5.5	93	20	2	2
	30	99	17	3	7
	54	98	24	5	7
2.5	5	99	40	11	12
	30	100	30	22	6
5.0	4	100	53	33	44
	27	100	63	50	39
CONTROL					
Not dipped	29		15	3	0
Cleaned of mussels manually, not dipped	24		14	2	0
	48		10	5	0

We have also tried dipping mussels in a saturated salt solution because Loosanoff (1957) and Shearer and MacKenzie (in press) have shown that short immersions in a saturated salt solution were effective in killing a variety of oyster competitors. However, a 5-second dip followed by 24 hours of drying will not kill mussels. Most other species of competitors and also some predators, nevertheless, were killed by dipping for 5 seconds in salt solutions 98 to 100 percent saturated. The minimum drying periods necessary to achieve complete mortality under these conditions are given in table 2. Comparing these data with the papers cited above on the effects of salt, it can be seen that prolonged immersal in a salt solution kills animals much faster than storage in air following a 5-second dip. For example, experimental groups of Molgula manhattensis were killed by a continuous immersal of 5 to 10 minutes, while it took 2 hours of drying after a 5-second dip to kill them. For starfish, it was 3 minutes against 8 hours. It is usually more feasible, however, for the oysterman, to store dipped material on deck for as long as 8 hours than it is to hold the material in tanks of chemical for 5 to 10 minutes.

Preliminary data from experiments using a completely saturated salt solution containing an excess of salt crystals in suspension show that competitors and predators are killed with much shorter drying periods than are required using a saturated salt solution with no excess of salt crystals present. Thus, starfish dipped for 5 seconds in a saturated solution containing an excess of 250 grams of salt per liter were killed by 2 hours of drying following a 5-second dip. The greater the excess of salt, the quicker is the kill. With 500 grams in excess, only 30 minutes were required, and with 1,000 grams in excess, starfish were killed after only 5 minutes of drying. The probable explanation for this is that when a salt solution with no crystals is used, the body fluids leaving an animal by osmosis dilute it and thus weaken its strength. When excess crystals are present, however, the concentration of salt remains high assuring better results.

Table 2 - Minimum Periods of Storage in Air to Cause 100-Percent Mortality of Animals After They Were Dipped for 5 Seconds in Completely Saturated Salt Solutions With No Excess of Salt Crystals in Suspension

Species	Storage Time in Hours
Polydora websteri	3
Boring sponge	3
Molqula manhattensis	2
Botryllus sp.	1
Stylochus ellipticus	15 seconds
Crepidula fornicata	8
Crepidula plana	7
Mud crabs	1.5
Worm tubes	2
Urosalpinx cinerea (embryo cases)	6
Starfish	6
Obelia sp.	few seconds

Dipping material in a chemical solution followed by a period of storage in air is not a new method of killing predators and competitors of oysters. In Long Island Sound, Loosanoff

and Engle (1938) have killed starfish by dipping them in suspensions of common lime. Walne (1956), in England, dipped limed tiles, on which oysters and various competitors had set, for a few seconds in a 0.4-percent copper sulfate solution. He reported that most competitors, particularly tunicates, died after 1 to 2 hours of drying. Similarly, Loosanoff (1957) showed that starfish and boring sponges can be killed if they are sprayed with a saturated salt solution and then stored in air.

DISCUSSION

It would seem that the method of dipping and air storage of transplanted material can easily become a part of oyster culture because of its effectiveness in killing competitors and certain predators and because it is extremely cheap and simple. For example, in the field test conducted in cooperation with the local oyster company, to kill mussels by using Victoria Blue, 2 deckhands did the complete job, including mixing of the chemical and dipping approximately 150 bushels of bottom material into 25-gallon drums of the dye, in 3 hours. At $5.85 per pound for the dye and $1.50 an hour for labor, it cost 12 cents a bushel for the treatment, 6 cents for the chemical, and 6 cents for labor. This cost could have been lower if the deckhands had had more experience in performing this operation, and if excess dye had drained back into the drums for re-use.

The cost of treatment per bushel of dredged material would have been considerably lower, approximately 6 cents, if copper sulfate, which costs only 10 to 15 cents per pound, had been used. This conclusion is based on the following estimates: Twenty-five gallons of copper sulfate solution will treat 100 bushels of dredged material. Two pounds of this chemical in 25 gallons of sea water make a 1-percent solution. Thus, 20 to 30 cents worth of copper sulfate will be enough to treat 100 bushels of the material. Therefore, we recommend copper sulfate rather than Victoria Blue because it is much cheaper and easier to handle.

We also recommend that the treated material be drained after dipping.

The manager of the oyster company which cooperated with us in these experiments estimated that his company could handle more than 10 times as much material by using the dipping method than it can by removing mussels manually. If the boats were rigged in such a way that it were possible to dip each 10- to 15-bushel dredge load in a tank of chemical before emptying the dredge on deck, the method would add little work to transplanting operations.

LITERATURE CITED

LOOSANOFF, V. L. and ENGLE, J. B.
1938. Chemical Control of Starfish. Science, vol. 88, no. 2274, pp. 107-108.

LOOSANOFF, V. L.
1957. New Method for Control of Several Oyster Enemies and Competitors. Bull. Milford Biol. Lab., U. S. Fish and Wildlife Serv., vol. 21, no. 5, pp. 1-6.

MACKENZIE, C. L., Jr. and SHEARER, L. W.
In press. Chemical Control of Polydora websteri and Other Annelids Inhabiting Oyster Shells. Proc. Natl. Shellfish. Assoc.

SHEARER, L. W. and MACKENZIE, C. L., Jr.
In press The Effects of Salt Solutions of Different Strengths on Oyster Enemies. Proc. Natl. Shellfish Assoc.

WALNE, P. R.
1956. Destruction of Competitive Organisms on Artificial Oyster-Spat Collectors. Extr. du Journ. du Conseil Internatl. pour l'Explor. de la Mer. vol. 22, no. 1, pp. 75-76.

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