MAWSA INC

THE SHORT-TERM EFFICACY OF

Fernstrum Material

TO RESIST ZEBRA MUSSEL INFESTATIONS

A report to

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by

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INTRODUCTION

The zebra mussel, Dreissena polymorpha, was first found in Lake St. Clair in June 1988 but was probably introduced in the summer of 1985 (Hebert et al, 1989; Mackie, 1991a). In five years the species has spread throughout Lake St. Clair, Lake Erie, Lake Ontario and has numerous localized populations in the remaining Great Lakes. It has also began to appear in more inland watersheds, such as the Trent-Severn System and the Rideau Canal in Ontario, the Genessee River and the Hudson River in the State of New York, the upper Mississippi River, and in sewage treatment discharge canals in the city of Chicago.

The most significant impact of zebra mussel introductions has been upon those portions of the aquatic environment utilized by man (Mackie et al. 1989). In the Great Lakes the most significant impacts have been: (i) biofouling of industrial and domestic intake structures and pipelines by causing reductions in bore size, reductions in flow, electro-corrosion of steel and cast iron conduits, and tainting and contamination of water upon massive die-offs; (ii) encrusting hulls of boats and sailing vessels; (iii) encrusting fishing gear (e.g. gill nets, trap nets) rendering them useless; (iv) encrusting navigational buoys to the point that they sink below the water surface; (v) blocking intakes of outboard motors; (vi) forming shoals of shell debris on beaches to the point that their aesthetic and recreational values have been reduced; and (vii) displacing native bivalve fauna, especially unionid clams. Since most of the impact has been upon surfaces (e.g. items (i) to (v) above), there has been a renewed interest by various manufacturers to develop coatings (e.g. paints), surface barriers (e.g. waxes) or materials (e.g. metal plates with copper-nickel alloys) that will prevent or resist zebra mussel infestations.

In the summer of 1990 Mackie (1990) examined the efficacies of 18 different products to resist infestations by zebra mussels over a short-term (four month) period. Eight of the products were waxes, four were coatings and six were materials. Fifteen products were supplied as coupons, two as pipes or tubes and one (i.e. copper) as both coupons and pipes. A four month period was chosen because it included one recruitment event (birth period) of the zebra mussel and allowed sufficient time to determine the effects of the products on the growth rates of mussels. The four-month study concluded that of all the products tested, copper material and a coating, Epco-Tek 2000 which contained 65% copper, were the most efficacious over the short term. Although wax surface barriers had large numbers of mussels attached, the numbers of mussels were significantly smaller and the byssal attachment was significantly weaker than on materials (e.g. PVC, acrylic, most plastics) which are known to be heavily biofouled by zebra mussels.

The purpose of the present study is to determine the short-term efficacy of a new product, **Fernstrum material**, supplied by R. W. Fernstrum & Company specifically for preventing zebra mussel biofouling. The composition of the product is unknown to MAWSA Inc. Short-term efficacy is defined here as the ability of a product to: (1) resist zebra mussel infestation; (2) resist tenacious attachment of the byssus to the product by the zebra mussel; and/or (3) to limit or prevent growth of those mussels that do attach to the product for at least one recruitment event, typically 4 months. These three criteria were examined because some products, such as waxes, already on the market are designed for making the removal of biofoulants (including algae) an easier task. Such products may not resist zebra mussel fouling but may make their removal much easier. Hence, a measure of tenacity of the zebra mussel's byssal apparatus to the product is as important as the total number infesting the product. Also, some products (e.g. copper and aluminum or coatings with copper) may not only resist zebra mussel attachment, but may impair the growth of mussels that do attach. This criterion would be of interest particularly to those who wish to know the maximum size developed by mussels which attach to products in/on various surfaces. For example, many fishing and coastguard vessels are dry-docked at the end of every sailing season and owners may wish to leave the cleaning of their hulls until the dry-dock period if they know that the growth of mussels is impaired enough to warrant this strategy.

MATERIALS AND METHODS

Fernstrum material was supplied by R. W. Fernstrum & Company as coupons measuring 55 mm high x 130 mm long and approx. 1 mm thick. A total of twenty-four coupons for each product was supplied. These were divided into eight groups, with three replicates in each group. Four groups of three were pulled in the summer of 1991, as described below; the remaining four groups are to be pulled in the summer of 1992 for a long-term efficacy test if results warrant such a study.

For a comparative measure of non-efficacy (Mackie, 1990), an acrylic sheet (3 mm thick) was cut into coupons of the same dimensions as the Fernstrum material. The acrylic was used not only as a control for wax surface barriers (which were tested with the Fernstrum material), but to provide evidence that settlement of zebra mussel postveligers did occur, which is also necessary to verify the efficacy (or non-efficacy) of Fernstrum material. Copper material was used as a comparative measure of efficacy since copper is known to completely resist zebra mussel attachment (Mackie, 1990). A sheet (1.60 mm thick) of copper was cut into coupons of the same length and height described above for the the Fernstrum material.

The coupons were randomly placed in racks made of 1.90 cm (0.75 in) diam CPVC pipe (Fig. 1). The racks were randomly placed in sleds (Fig. 2) made of 3.81 cm (1.5 in) diam ABS pipe and were designed so that racks could be inserted and removed by rotating a front bar. Since there were twelve different products (including those from other manufacturers) in coupon form, twelve coupons were randomly assigned to each of 24 individual racks. The 24 racks were placed in three sleds with eight racks per sled. Each sled was anchored by concrete blocks in the 0.67 m depth of Lake St. Clair (at Puce, Ontario) on June 16, 1991.

Racks with the Fernstrum material and acrylic and copper coupons were pulled on July 22, 1991, August 22, 1991, September 27, 1991, and November 4, 1991. Three coupons of each product were removed on each date. Since the coupons were first placed in Lake St. Clair on June 16, 1991, the exposure periods were approximately 1 month for coupons pulled on July 22, 1991, 2 months for those pulled on August 22, 1991, 3 months for those pulled on September 27, 1991, and 4 months for those pulled on November 4, 1991.

Measuring Numbers of Mussels per Product

The numbers of zebra mussels were determined for each side of the coupon using an acrylic template of 55 mm high x 130 mm long (the same size as the coupon) with 13 vertical columns of 1 cm wide x 55 mm long scratched onto one surface. This was placed over the coupon and the numbers of mussels in 5 columns (selected at random) was determined. The total number in 5 columns was multiplied by 2.6 for the total number per side; the total number per side was multiplied by 139.86 to express abundance as number per square metre. The number per square metre is a preferred unit of measurement because it allows comparison of numbers on coupons and pipes and products of any shape (e.g. filter screens). Since the number per side on many products was usually greater than 400, the template method saved a lot of time in counting. This was particularly true for some products which harboured several hundred small mussels in July. A preliminary test showed that the template method is within 5% of the actual number.

The average number per side on each coupon for each exposure time were compared using ANOVA and differences among products and exposure times were determined with Tukey's multiple range test. The effect of adjacent products (e.g possible galvanic effects when two metals, like copper and aluminum, are placed side by side) on numbers of mussels attaching to each product was determined by comparing numbers on left side with numbers on right side of adjacent coupons. In no instance did the neighbouring coupons affect numbers of mussels on any product tested (i.e. $P > 0.05$). All bars in Fig. 3 show 95% confidence intervals as vertical lines.

Measuring Growth of Mussels on Test Products

Twenty-five mussels were selected at random from each side of all coupons and measured for length (maximum anterior to posterior distance) with an ocular micrometer. The average size with a standard error was determined for each side on each coupon for each exposure time and compared statistically with ANOVA. Differences among products and among exposure times were determined with Tukey's multiple range test. All bars in Fig. 4 show 95% confidence intervals as vertical lines.

Measuring Byssal Resistance of Test Products

Both the "byssus resistance" and "tenacity" were determined for each product; the byssus resistance is defined here as the ability of a product to resist byssus attachment by zebra mussels. Byssus resistance is reported as a percent, that is the % of mussels, with their byssus, that can be removed from the surface when a sufficient pulling force is applied. A high byssus resistance is good. The opposite of byssus resistance is tenacity, or the ability of the mussels to adhere to the surface of your product. Tenacity is also expressed as a percent value. A high tenacity is bad because the mussels adhere to the surface of the product so strongly that the byssus detaches at the foot of the mussel before it detaches at the surface of the product when a sufficient pulling force is applied. As a result, the byssus remains attached to the product. Tenacity is calculated by subtracting from 100% the byssus resistance value.

To measure byssus resistance we randomly selected 25 mussels (or all of them if fewer than 25 were present) from each side of the coupons. Using a pair of watchmakers forceps we pried each specimen by the shell vertically from the plate until either the byssus detached at the plate or at the foot of the mussel. A product was scored as byssally resistant if the byssus detached at the coupon surface; the product was scored not resistant if the byssus detached at the foot of the mussel (i.e. the byssus was attached more strongly (tenaciously) to the coating than to the foot). The byssus resistance data were collected after enumerating the mussels on each coupon, or one to three days (usually day 2) after the products were pulled from Lake St. Clair. All mussels were kept alive by placing a wet towel over the racks. Preliminary tests showed that tenacity does not vary over three days if the mussels are kept alive; tenacity decreases over time if mussels are moribund.

Tenacity was not determined for the first exposure period because the mussels were too small to test without the shells breaking. For the second and subsequent exposure periods the tenacity test was performed within two days. Byssal resistance was compared among all products for the three exposure periods using ANOVA. Differences among products and exposure times were determined with Tukey's multiple range test. All bars in Fig. 5 show 95% confidence intervals as vertical lines.

RESULTS AND DISCUSSION

Fig. 3 shows that the **Fernstrum material** was very effective at preventing zebra mussel infestations in Lake St. Clair. No mussels were found attaching to the Fernstrum material throughout the summer. The material was as efficacious as copper which also had no mussel settlement throughout the summer. The maximum number of mussels attaching to acrylic was near 3000 m^{-2}, which is significantly lower than nearly 50,000 m^{-2} attaching to acrylic coupons in 1990 (Mackie, 1990). The reasons for the difference (smaller numbers in 1991 than in 1990) are: (1) The racks with the test coupons were placed in Lake St. Clair on June 16, 1991, which was immediately after or during a spring recruitment event, as the acrylic coupons placed in Lake St. Clair in August, 1990 verified; and (2) the acrylic coupons were not conditioned and did not have time to form a biofilm, essential for settlement, before the main recruitment event in 1991; therefore, the numbers settling on new acrylic slides set on

June 16, 1991 were smaller than on acrylic slides which had been conditioned since August, 1990. This is supported by the increasingly larger numbers of mussels attaching to the acrylic coupons as the summer progressed, although a part of the increase was due to a second recruitment event sometime between late July and mid-August, 1991 (Fig. 3). Based on the numbers of mussels attached to twelve products tested, the **Fernstrum material** at the end of 4 months was ranked as the best, with copper.

Since no mussels were found on the **Fernstrum material** it was not possible to measure the growth rate of mussels on the product. Based on mussels attached to acrylic, the mussels grew only 5 to 6 mm in the summer of 1991, which is about half the growth rate found in 1990 (Mackie, 1990). It is believed that the differences in the growth rates (and settling intensity) of mussels between 1990 and 1991 are due to the unusually warm summer temperatures in 1991 which may have inhibited or retarded growth and reproduction.

Because no mussels were found on the **Fernstrum material**, the product exhibited 100% byssal resistance, compared to 20 to 25% on the acrylic material (Fig. 5). The byssal resistance was as good as copper, which also had 100% byssal resistance. Wentzell (1989), the inventor of Epco-Tek 2000, an epoxy-based coating with 65% copper, believes the free electrons of copper in the coating play an important role in the repellant action to biofoulers. Epco-Tek 2000 is very effective at preventing zebra mussel biofouling on both short-term and long-term exposures (Mackie, 1990; 1991b). As described in the materials and methods, no measure of byssal resistance was obtained in July because of the small size of the mussels.

CONCLUSIONS AND RECOMMENDATIONS

Fernstrum material is highly recommended for preventing zebra mussel infestations over the short-term. It was highly effective at resisting byssal attachment (compared to acrylic). Based on the numbers of mussels attached, **Fernstrum material** was ranked the best, with copper, of twelve products tested.

Based on the above results, we recommend performing the long-term efficacy test with **Fernstrum material.** It should be noted again that settlement in 1991 was significantly smaller than in 1990. The study should be repeated to verify that the material would be as efficacious under heavy settlement events, for example greater than 50,000 m^{-2}/event.

REFERENCES

HEBERT, P. D. N., B. W. MUNCASTER, G. L. MACKIE. 1989. Ecological and genetic studies on Dreissena polymorpha (Pallas): A new mollusc in the Great Lakes. Can. J. Fish. Aq. Sci. 46: 1587-1591.

MACKIE, G. L. 1990. Short-term efficacies of different coatings, surface barriers and materials for resisting zebra mussel infestations. A report published by MAWSA Inc., 381 Elmira Road, Guelph, Ontario that examines the effectiveness of 18 different products (8 waxes, 4 coatings, 6 materials) for resisting zebra mussel infestations. 18 p. Available for $10.00.

MACKIE, G. L. 1991a. Biology of the exotic zebra mussel, Dreissena polymorpha, in relation to native bivalves and its potential impact in Lake St. Clair. In: M. Munawar and T. Edsall (eds.). Environmental Assessment and Habitat Evaluation of the Upper Great Lakes Connecting Channels. Hydrobiologia 219: 251-268.

MACKIE, G. L. 1991b. The long-term efficacy of Epco-Tek 2000 to resist zebra mussel infestations. A report to Hi-Tek Chemical Corporation on the long-term efficacy of Epco-Tek 2000 placed in

Lake St. Clair from June, 1990 to November, 1991. 11 p.

MACKIE, G. L., W. N. GIBBONS, B. MUNCASTER, I. GRAY. 1989. The zebra mussel, Dreissena polymorpha: A synthesis of European experiences and a preview for North America. 76 p + Appendices I & II. A report for the Ontario Ministry of Environment, Water Resources Branch, Great Lakes Section by B.A.R. Environmental. Available from Queen's Printer, Toronto. ISBN No. 0-7729-5647-2.

WENTZELL, J. M. 1989. Technical report. A report describing the theory behind the anti-foulant properties of Epco-Tek 2000. Available from Hi-Tek Chemical Corporation, 106 Taft Avenue, Hempstead, New York 11550. 3 p.