Antifouling Paints: Use on Boats in San Diego Bay and a Way to Minimize Adverse Impacts

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ABSTRACT / High concentrations of copper and tributyltin, two biocides used in antifouling paints, are found in harbors. Efforts are necessary to reduce the adverse impact of biocides from antifouling paints, but little is known about the actual use of such material. I surveyed the operators of 435 boats berthed in San Diego Bay, to determine what paints and maintenance procedures were being used. More than 90% of the respondents used conventional leaching paints. These paints contain 40% to 65% copper compounds and 3% to 7% tributyltin compounds. Few respondents used copolymer paints. Those who did use copolymer paints seemed to repaint less frequently than those using conventional leaching paints. Professional maintenance companies do not initiate repainting as frequently as individuals doing their own maintenance. It appears that the input of antifouling biocides to harbor waters could be reduced by at least one-third simply by educating boat-owners about the chemical mechanisms involved in antifouling paints, by explaining the environmental and economic advantages of using slow-release paints, and by encouraging them not to repaint until their paint's useful life has expired.

Organotin compounds are used widely in US industry and agriculture, where they appear often in wood preservatives for decks, exterior siding, and fences (Champ 1986). In the 1960s the organotin compounds tributyltin (TBT) oxide and tributyltin fluoride were part of a public health project to eradicate freshwater mollusks. The compounds were so successful they were included in antifouling paints. TBT-based paints inhibit the growth of barnacles and sessile mollusks, and thus are effective deterrents to members of the mature fouling community. However, they do not inhibit the early fouling stages, characterized by algal growth, as well as copper-based biocides do.

The toxic molecule (TBT) is composed of a tin (Sn) atom covalently bonded to three butyl (C6H9−) moieties. The neutrally charged compounds commonly used in antifouling paints number about eight (Kuch 1986). The free TBT ion is leached from the paint matrix, providing toxicant at the paint surface to inhibit growth of fouling organisms.

There are two general types of antifouling paints: conventional paints (either contact leaching or ablative matrix) and copolymer paints. Contact leaching paints have an insoluble resin matrix with the biocide (TBT and/or cuprous oxide) dispersed within. The free associated biocide near the paint surface diffuses into the water leaving microscopic pores in the matrix. Water permeates the pores causing further dissolution of biocide. An ablative paint is comprised of a soluble matrix. The matrix breaks down over time, releasing the biocide deep within the paint coating. Neither matrix reliably controls biocide release. Thus, copolymer paints were developed.

Copolymer paints have an intrinsically different biocide release mechanism. The hydrophobic resin matrix in which cuprous oxide may be dispersed is comprised of tributyltin methacrylate/methylmethacrylate. At the paint–seawater interface a saponification reaction occurs cleaving the TBT from the copolymer matrix. TBT and any other biocides dispersed in the paint matrix are released, generating an active biocide at the paint film surface. The matrix, relieved of TBT, becomes water soluble and dissolves, creating a new paint–seawater interface, and the process repeats.

The introduction of TBT to the environment has caused severe damage to mariculture in Europe and the US (Alzieu and Heral 1984, Short and Thrower 1986). Direct economic and environmental impacts from TBT have not been measured in the southwest United States. However, Stang and Seligman (1986) showed that San Diego Bay, a heavily used military and recreational harbor, contains high TBT concentrations. At the time of this writing, only North Carolina has regulated the use of antifouling paint containing TBT. Legislatures in California, Oregon, Virginia, and Washington State are considering legislation now.

No systematic study exists of antifouling paint use, either the type of paint or its effectiveness on various vessels (Kuch 1986). In this study, I surveyed oper-
tors of vessels less than 33 m in length to determine what type and quantities of antifouling paint they were using. This information is necessary for development of strategies to minimize biocide input to harbor waters. It can also be used in assessing the impact of legislative action on boaters.

Methods

I used a simple questionnaire (Appendix) to conduct a casual survey of boats in San Diego Bay. The questionnaire was distributed to two groups of prospective respondents. One group comprised people working on their boats at the docks. (In the rest of this article, I refer to this group as owner-maintained.) The second group comprised the operators of boat-maintenance companies. I asked them to complete questionnaires for boats they routinely maintained.

I analyzed data from completed questionnaires with the BMDP Statistical Software Package. The data file was checked manually for data-entry errors. I used program 1d to remove all missing values, for providing a second check on data-entry errors, and for generating descriptive statistics of frequency, mean, and standard deviation for all variables. Program 2d determined the frequency distribution of each variable. Groups of each variable were then established from the distribution. Cross-tabulations and chi-square analysis of associations among variables were performed with program 4f (Dixon 1985).

The quantity of paint applied to a given length boat varies with the underwater surface area and with the thickness of the paint film. Estimates of the amount of paint used were made from information provided by boatyard operators. I assigned a paint quantity to each boat based on the average amount of paint boatyard painters said was used on a boat of that length.

Results

The respondents completed questionnaires representing 435 boats—some 8% of the number of slips and moorings in San Diego Bay. Some 75% of the questionnaires represented sailboats; the rest represented power boats.

Of the 435 questionnaires, 148 (or 34%) came from individuals working on boats, 128 (or 29%) came from maintenance company A, and 159 (or 37%) came from maintenance company B. A third maintenance company did not complete individual questionnaires for the 130 boats it maintains but did provide general information.

Of the 435 boats, 296 (or 68%) were between 7.9 and 12 m long (26 and 40 ft). About 87% of all the boats had glass-fiber hulls, and about 7% were wood hulls (Table 1). Some 75% of the boats had Proline 1088 paint on their hulls, and 10% had Interlux Bottomkote. Both of these are conventional leaching paints.

There was no correlation with either type of paint or size of boat and frequency of repainting. Table 2 shows frequency of hull painting compared with respondent group, while Table 3 shows frequency of hull painting compared with hull material. The owner-maintained group tends to repaint more frequently than the maintenance services. Wood and steel hulls were repainted more frequently than fiberglass; only 15% of the wood and steel hulls were maintained by maintenance services.

Maintenance companies clean hulls on a 30-d or 60-d cycle. The owner-maintained group cleans more randomly: about 56% clean the hull every 30 d, and about 19% clean it more frequently. Hull-cleaning frequency did not vary significantly between sail and power boats, nor did it vary with the type of paint used or with the way in which boats were used.

I narrowed the data analysis to fiberglass hulls because they are the most common. The relationship between hull-cleaning frequency and repainting interval for fiberglass hulls is shown in Table 4. Part A shows the frequency distribution in percentage of all data for fiberglass boats, while part B is based on owner-maintained boats only. Again, maintenance services do not repaint as frequently as the owner-maintained group. The data in Table 4B indicate that cleaning frequency does not affect repainting frequency, as repainting intervals are fairly evenly distributed among boats cleaned every 30 d.

Few questionnaires were received for boats painted with copolymer paints. I could not make a statistically valid comparison of paint type with frequency of maintenance. The data suggest, however, that boats bearing copolymer paints are cleaned less frequently, and repainted less often, than are boats protected by conventional leaching paints.

The paints were divided by biocide content into three groups: copper only, primarily copper with some TBT, and primarily or entirely TBT. More than 90% of all boats bear a paint in which the biocide was primarily copper with some TBT. The only significant deviation from this occurred among aluminum-hulled boats; on these a copper-free paint was used always.

Among owners of boats with fiberglass hulls, 50% indicated that they used a specific paint because of its antifouling characteristics. About 17% of the owners indicated the paint they used had been recommended