Bull. Environ. Contam. Toxicol. (2003) 71:881–886

DOI: 10.1007/s00128-003-8803-3

Bulletin of Environmental Contamination and Toxicology

Phytotoxic Effects of Antifouling Compounds on Nontarget Plant Species

H. Okamura,[1] T. Nishida,[2] Y. Ono,[3] W. J. Shim[4]

[1] Kobe University of Mercantile Marine, Fukaeminami 5-1-1 Higashinada, Kobe 658-0022, Japan
[2] Faculty of Agriculture, Shizuoka University, Ohya 836 Shizuoka 422-8529, Japan
[3] Faculty of Environmental Science and Technology, Okayama University, Tsushima 2-1-1, Okayama 700-8530, Japan
[4] Korea Ocean Research and Development Institute, Ansan Post Office Box 29 Seoul 425-600, Korea

Received: 12 November 2002/Accepted: 8 July 2003

Biofouling is the result of the growth of a variety of microorganisms, plants and animals on submerged structures. Since organotin biocides have been strictly regulated throughout the world in the late 1980s, other antifouling compounds have been needed as replacements. The alternatives to organotins are mainly copper-based coatings containing organic biocides that act as boosters to improve the efficacy of the formulation. However, only limited data are available on the environmental occurrence, fate, toxicity, and persistence of these biocides (Voulvoulis *et al.* 2002). Residues of the organic booster biocides have been detected mainly in marine environments, although some have been found in freshwater environments. The environmentally persistent biocides, Diuron and Irgarol 1051, were the only organic booster biocides detected in the UK coastal environment (Thomas *et al.* 2001). In freshwater environments, Irgarol 1051 was found in Lake Geneva, Switzerland (Toth *et al.* 1996) and Diuron was detected in fishery harbours in Lake Biwa, Japan, although it is not certain whether the latter originated from ship antifouling paints (Okamura *et al.* in press). It is, therefore, important to estimate the impacts of these chemicals on both freshwater and marine organisms.

Ecotoxicity studies of these alternative antifouling agents have mainly focused on marine organisms. We have investigated the environmental toxicity of some alternative antifouling compounds towards a variety of organisms other than those against which they are targeted (non-target organisms). The ecotoxic effects of Irgarol 1051 and its major degradation product were evaluated by bioassays using freshwater species such as microalgae, duckweed, terrestrial plants, and crustaceans, as well as marine species such as bacteria, seaweed, and crustaceans (Okamura *et al.* 2000a and 2000b). Several antifouling compounds that are probably in use in Japan were investigated by a fish bioassay using juvenile rainbow trout and suspension-cultured fish cells (Okamura *et al.* 2002) and by sea urchin eggs (Kobayashi and Okamura 2002). There are, however, limited data on the toxic effects of the biocides on non-target plant species. The purpose of this study was to evaluate the phytotoxic effects of antifouling compounds by a battery of bioassays using non-target freshwater species.

Correspondence to: H. Okamura