TRIBUTYLTIN (TBT) COMPOUNDS IN THE MARINE ENVIRONMENT AROUND SUVA

A Report Prepared for the Fiji Environmental Management Committee

R. J. Morrison and Johnson Seeto

University of the South Pacific

using data provided by

D.V. Ellis, Biology Dept., Victoria University, B.C., and

Carol Stewart, Chemistry Dept., University of Auckland

The attack of timber-hulled boats by marine borers, such as the Teredo worm, and the attachment of barnacles, sea grass, hydroids and other marine organisms to all types of ships hulls can seriously impede the running of the vessel. Protection of ship hulls against such attack has been going on since the 1760s, first using copper sheets, then paints containing copper powder and later paints containing various other poisons (arsenic, mercury, DDT, etc.). Use of many of these later substances was stopped when the dangers to the applicators became apparent. During the Second World War organotin compounds, which had previously been developed for agricultural pesticide use, were adopted for marine use, and they have proved very effective as anti-fouling agents.

The organotin based marine paints contain up to 20% of a suitable tributyltin or triphenyltin poison which is slowly leached into the water in the immediate vacinity of the hull. The effective lifetime of these paints is usually 1-2 years, after which the hull must be repainted. The advantage of tin-based antifouling paints are:

(1) they kill copper resistant organisms

(2) they are readily chemically bonded to the paint base, usually acrylic, to produce a copolymer which when applied properly in several layers extends the lifetime of the antifouling system to at least 4 years

(3) they are available in several colours which, apart from the aesthetic value, allows boat owners to keep track of how much antifouling remains

(4) they can be safely used on aluminium hulls.

This latter point is important because the use of copper materials on aluminium requires considerable care. As noted in Seaspray magazine (April 1989, Vol 44 (3)) "It needs only a speck of copper to come into contact with the aluminium for electrolysis (corrosion) to begin". "Within 6 months you'll have a hole in the bottom of your boat".

The first environmental problems encounted with the use of organotin paints were in France in the late 1970s when biologists conclusively demonstrated that TBT released from the antifouling coatings used for recreational craft caused significant declines in the oyster species, Crassostrea gigas, the basis of much of the European oyster fishery. This was followed by studies in United Kingdom which showed that marked reductions in the populations of the European dog whelk, Nucella lapillus, could be correlated to TBT induced imposex, i.e., the development of male reproductive appendages in gentically female animals. Concentrations of the order of 20 ng/L would produce this condition. These impacts on "non-target" organisms are typical of the unwanted side-effects of many pesticides. Additional examples of this effect have since been confirmed in Sweden, USA, Canada and Singapore. Until recently the only serious studies of TBT in the South Pacific were from New Zealand where DSIR scientists and Dr. Steve de Mora of Auckland University and his students and colleagues have investigated the amount of TBT in the marine environment around Auckland. Thier results showed that levels of TBT were "unacceptable" and that the rate of decomposition was slower than previously expected.

As a result of the discoveries summarised above many countries now regulate the use of TBT antifouling paints. In New Zealand, for example, an amendment to the Pesticides Act (1989) limits the use of TBT paints to vessels 25 m in length or greater, with the exception of the craft having aluminium hulls. Only slow release (as per USA standard) paints will be approved, TBT paints will only be effective on vessels that spend most of the time in motion. New Zealand boat owners and builders/suppliers have raised serious objections to the new law arguing that most organotin material entering the marine environment comes from container vessels traversing the world and over which the local legislation has no jurisdiction.

In addition to the imposex problem TBT compounds are toxic. Acute or chromic toxicity for a range of organisms (mainly bivalves) lies in the range 0.5-1 ug/L. LC_{so} values for various fish have been determined in the range 0.02-0.08 mg/L. TBT compounds have been tested for carcinogenic properties with no positive results to date. The toxicity lies in the ability to bind certain proteins and the subsequent derangement of mitochondrial functions.

TBT compounds exhibit high bioaccumulation characteristics. Bioconcentration factors of 1000 - 10,000 have been reported (i.e., the concentration in an organism is up to 10,000 times the concentration in the surrounding water). Significant

concentrations of TBT may be retained in contaminated bivalves for several months even when placed in clean water. Bioaccumulation has been shown to occur rapidly when the water concentration exceeds about 50 ng/L (areas not exposed directly to antifouling paints should not reach this valve).

From a human perspective, the low values of TBT in uncontaminated areas should not pose serious health risks. It is likely that the high senstivity of most bivalves causing early mortality will minimise the problem. However, all organisms obtained from waters close to direct TBT input are likely to contain concentrations that make them unsuitable for human consumption.

THE LOCAL SITUATION

As part of joint research projects, two assessments of TBT in the Suva area were undertaken in 1990-91. The first, in August 1990, was by Professor Derek Ellis of the Biology Department, Victoria University, British Columbia. Professor Ellis is a world renowned authority on biological aspects of environment impact assessments. Working in collaboration with Johnson Seeto of USP/IMR, Professor Ellis investigated the local neogastopods Thais manicilla, Murex sp. and Morula sp. These were collected subtidally from the ammunition/dynamite house area off the RSYC because of its close proximity to the wharf area. Related whelks were collected for comparison from Naigani Island (a "clean" site)

Twenty specimens of Thais mancinella from the Suva harbour site were examined. In all the female specimens imposex had definitely occurred. This implies that TBT was present and the tissue of the animals was taken back to Canada for analysis. Samples of a related Thais from Naigani showed no evidence of imposex. Samples of Murex and Morula were taken back to Canada for further investigation.

In the second study, Dr Carol Stewart, a postdoctoral research fellow in the Chemistry Department, University of Auckland, visited Suva in April 1991 and worked with Philomena Gangaiya (USP/INR) and Johnson Seeto on the measurement of TBT concentrations in sediments and shellfish in the Suva area. Dr. Stewart's data are summarised in Table 1. (see also Figure 1). Dr. Stewart's comments on the data are as follows:

> "In general environmental TBT concentrations in Suva Harbour are similar to Auckland Harbour, with the exception of the extremely high results found in the intertidal and nearshore sediments near the main Suva slipway. Previous analysis of sediments S1 gave a result of 38000 ng/g TBT-tin, but analysis of another subsample gave a lower result of 15,200 ng/g TBT-tin. The small scale heterogeneity is most probably due to small flakes of TBT paint from the washdown water. In any

case, these results are higher than any I have ever seen in the literature. At the concentrations observed in shellfish, there is every reason to expect that adverse biological effects will be occuring.

The most appropriate step to take next is for a biologist to demonstrate the extent of TBT-induced ecological damage. This survey did not show how big the 'zone of influence' of TBT is likely to be, but is clear from studies in Auckland that the sphere of influence is much greater if you look at the biological (i.e., neogastropod imposex) rather than the chemical indicator of contamination.

However, an important difference between Suva and Auckland is that the much warmer seawater temperatures in Suva are likely to encourage relatively rapid degradation of TBT and hence limit its environmental persistence. The sediment cores collected beneath the Royal Suva Yacht Club certainly show that TBT does not persist far down the core (compared to depths of 45 cm in Auckland marina sediments) but we will have to wait until sedimentation rates for Suva Harbour become available to get much further with this line of enquiry. Another possibility is that because the tidal flushing is much greater at the RSYC, compared to our enclosed marinas in Auckland, TBT does not accumulate to concentrations high enough to inhabit biodegration.

Incidentally, in Auckland we have also noted that uncontrolled slipways and washdown yards are a major source of TBT to coastal waters. The New Zealand Ministry for the Environment has commissioned a report on the effectiveness of the Government's legislative restrictions an organotin paints. We included a recommendation that all such washdown facilities be required to install collection and treatment systems for their wastewaters. This has a broader justification, apart from TBT, in that the unnecessary input of all the other toxic components of antifoulants, such as copper oxide and thiocyanate, the organic 'boosters', the resin itself would be prevented."

TABLE 1

TBT concentrations in sediments and shellfish collected in Suva Harbour, April 1991

Sediments

Site	ng/g TBT-Sn (dry weight)
Slipways	
S1	15,200
S2	4,050
S3	361
S4	758
S5	37
S6	89
Navy area	
N1 (near slipway)	483
N2	164
Kings wharf	
K1	55
K2	64
K3	51
K4	66
K5	16
K6	74
K7 (near slipway)	364
Royal Suva Yacht Club (Sediment Core)	
0-2cm depth	18
2-4cm	44
4-6cm	28
6-8cm	41
8-10cm	14
10-12cm	n.d.
12-14cm	n.d.
14-16cm	n.d.
16-18cm	n.d.
18-20cm	n.d.

[detection limit = 5ng/g TBT-Sn]

Shellfish

Shed Island Site	
Crassostrea mordax	869
Thais mancinella	443
Morula spinosa	n.d.
Littorina scabra	n.d.
Shellfish bought at Suva Market	
Cawaki (Tripneustes gratilla)	n.d.
Kaikoso (Anadara scapha	90
Crassostrea mordax (mangrove oysters)	
Site 7	1260
Site 9	626
Site 10	3180

[detection limit = 15ng/g TBT-Sn]

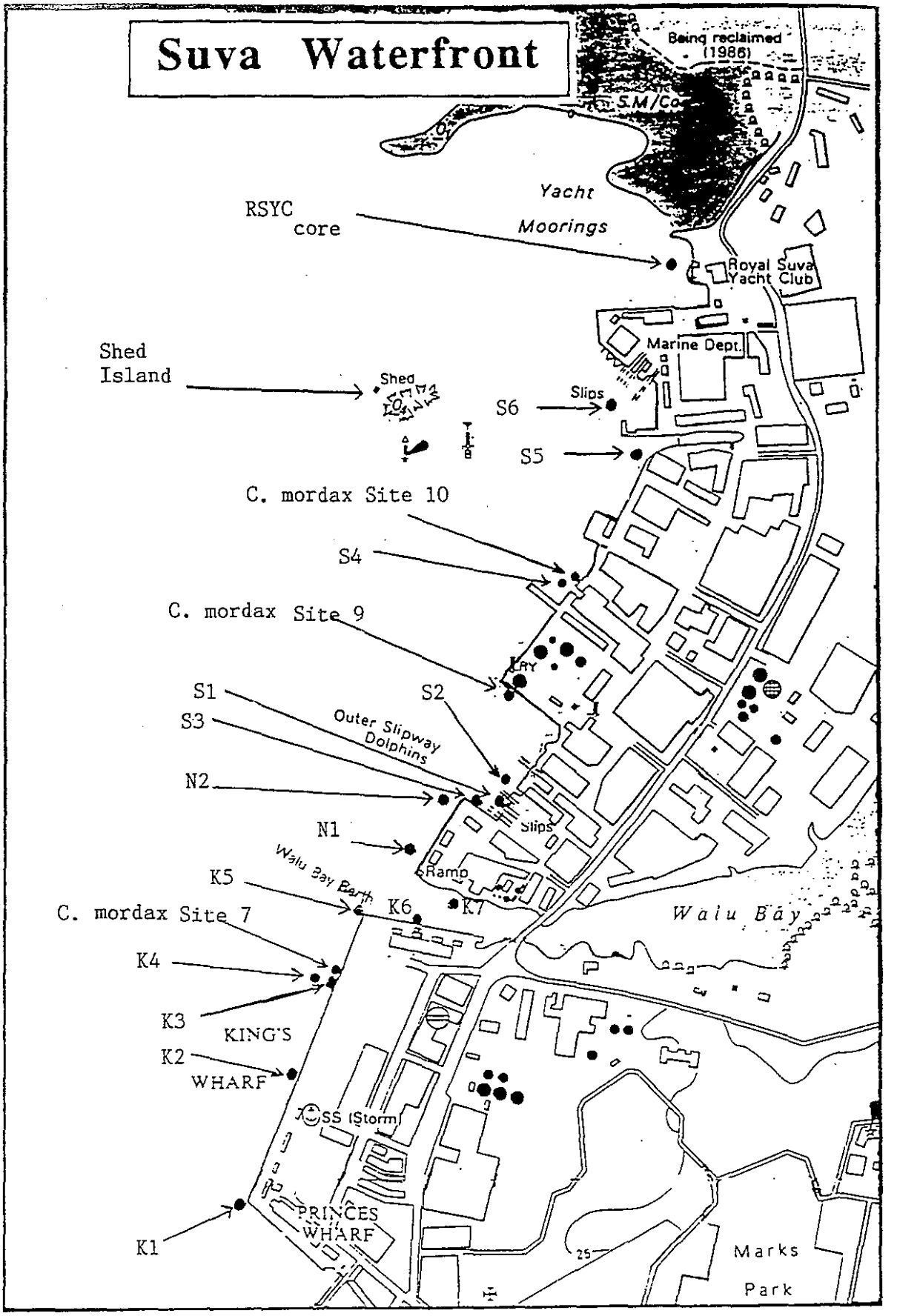

FIGURE 1. SAMPLE COLLECTION SITES FOR SUVA HARBOUR TBT STUDY

CONCLUSIONS AND RECOMMENDATIONS

The data above indicate that TBT contamination of areas around Suva harbour has occured. The extent of the impact of this contamination is uncertain. The effects of this impact on the local shellfish needs further study and possible impact on humans has yet to be assessed. It is therefore recommended that:

1. A study of the TBT levels be carried out in sediments and shellfish in all major harbours, marinas and slipways where TBT paints are used to determine whether a problem exists.

2. A survey of biological indicator organisms be carried out in the same areas to determine the 'zone of influence' of TBT contamination.

3. A survey of TBT levels in locally consumed fish and shellfish be carried out to determine local human intake of such contaminants and assess the health effects of this intake.

4. A survey be made of paint distributors/outlets to determine the amount of TBT based paints sold locally.

5. Consideration be given to restricting the use of TBT antifouling paints (and the types of paints) to vessels which are not moored for long periods.

6. Ship/boat repair/building facilities be required to install collection and treatment systems for washdown wastewaters.

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