The environmental impact of organotin anti-fouling paints in Western Australia

Report of the
Environmental Protection Authority
of Western Australia

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WEST AUSTRALIAN (2nd ED)
9.11.90

Clampdown on boating paints

MARINE life believed to be poisoned by anti-fouling paints could pose a public health risk, Environment Minister Bob Pearce warned yesterday.

He announced new restrictions on marine anti-fouling paints containing the toxic chemical tributyl tin (TBT).

TBT, used to prevent marine growth on ship and boat hulls, was extremely toxic to marine life, according to an Environmental Protection Authority report released by Mr Pearce.

But he said other aquatic animals were at risk when the chemical reached high levels in the water.

"TBT contamination may be responsible for poisoning of shellfish, such as oysters and mussels," Mr Pearce said.

"If too much TBT in mussels and oysters is taken in the human diet, it is likely that people could be affected."

The EPA has recommended that TBT be banned on boats under 25m long to protect enclosed waters like the Swan River and other WA estuaries.

Vessels bigger than 25m should use paints with much lower leaching rates of TBT, but this allowance would be reviewed, the report said.

Mr Pearce said problems existed where boats using TBT-based paints were concentrated.

The report said the worst pollution was near slipways at yacht clubs in the Swan River where scrapings of old paint reached the water.

- INVEST

GOVERNMENT MEDIA OFFICE
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SUNDAY TIMES (1st ED)
11.11.90

Yacht club water danger to people

P13

A CHEMICAL toxic to marine life has been found near four major Swan River yacht clubs at levels thousands of times higher than accepted safe limits.

Tests by the Environmental Protection Authority found high levels of a toxin from marine anti-fouling paints used to prevent growth on hulls.

The EPA has now called for the organotin anti-fouling paints, primarily tributyl tin, to be banned.

By CHRIS MANLY

The authority said the toxins were harmful to marine life and could pose a public health risk.

The high readings were found near the East Fremantle, Royal Freshwater Bay, South of Perth and Royal Perth Yacht clubs.

The EPA wants the use of organotin paints banned on vessels with hulls less than 25m long.

It found that of the 6000 recreational boats operating in Perth alone, between 60 and 80 per cent used organotin paints.

In 1988 there were 60 boat mooring facilities in WA with the prospect of a 50 per cent increase in the next two years, the EPA said.

TBT toxins build up in the flesh of marine life such as mussels and oysters.

EPA investigations division chief Colin Sanders said existing and planned aquaculture industries would be saved from the toxic TBTs because of the EPA move. More tests would be conducted on mussels in Cockburn Sound.

An EPA report said: "The siting and management of aquaculture projects should be carried out with due regard for the risk of TBT contamination."

The authority also wants:

- A crackdown on dry dock cleaning procedures to prevent toxic substances being washed into waterways.
- All substitute paints to be tested for effects on marine life and the extent to which they accumulate.
- Tests to determine the acceptable consumption levels of organotin compounds.
- A State-wide survey of organotin compounds in sediments, sheltered bays and anchorages.

— INVEST
— EPA
— BAE

Summary and recommendations

Marine fouling is the growth of marine plants and animals that occurs on the hulls of boats. Fouling results in increased drag and therefore, increased fuel costs. Anti-fouling paints are applied to the hulls of these vessels to inhibit fouling and function by slowly leaching toxic ingredients into the water that kill marine growth attached to the vessel. However, the leaching of some types of anti-fouling paints can cause elevated concentrations of toxic substances in marine waters resulting in harmful effects to a wide range of marine life. These effects range from physical deformities to interference with reproductive processes and have in the past caused large commercial losses to the aquaculture industry. Since the mid-1960s, the most effective and commonly used anti-fouling paint has contained organotin compounds and, in particular, tributyl tin (TBT).

Evidence from field studies and trials on shellfish (such as oysters) around the world have shown conclusively that TBT is harmful, even at extremely low concentrations. Many of the reported incidences of TBT contamination have occurred in marinas, enclosed or semi-enclosed embayments, estuaries and around slipways and boat maintenance yards, that is, in areas of restricted flushing with a high concentration of vessels using TBT.

These concerns have led to selective restrictions on the use and sale of TBT anti-fouling paints in many countries, including France, Great Britain, the USA and, more recently, in most states of Australia. These restrictions have been motivated by a desire to protect both the general marine environment and valuable aquaculture industries, such as those producing oysters and mussels, from this form of pollution.

To address the potential environmental problems associated with TBT contamination, the Environmental Protection Authority of Western Australia (EPA) has reviewed the use and sale of organotin anti-fouling paints in Western Australia, with particular emphasis on TBT.

This report includes information on the environmental impact of organotin in the marine environment in general, with specific reference to Western Australia. Also included is a preliminary assessment of the state of TBT contamination in selected aquatic environments around Perth, Western Australia. A more detailed account of TBT contamination in the aquatic environment of Western Australia is currently being undertaken by the Environmental Protection Authority. The report concludes with a set of recommendations which state that restrictions should be placed on the sale and use of organotin-based anti-fouling paints in Western Australia.

The major sources of TBT are the hulls of vessels anti-fouled with organotin-based paints, marine structures such as pylons, fish cages, nets and pots that use organotin-based anti-fouling paints and organotin paint residues and wastes from ship maintenance yards.

To maintain consistency with current international and interstate practice, measures to minimise the use of organotin-based anti-fouling paints in Western Australia should include:

(i) regulations to prohibit the use of organotin-based anti-fouling paints on all vessels less than 25m in length, marine structures and fish cages, nets and pots. This will restrict contamination in relatively small semi-enclosed water bodies such as estuaries, rivers, ports, harbours, marinas, yacht clubs, and small coastal embayments;

(ii) regulations to limit the rate of leaching of TBT in anti-fouling paints on vessels greater than 25m that are anti-fouled or registered in Western Australia, to levels less than 5 micrograms organotin/cm^2/day. This will restrict contamination in relatively large semi-enclosed ports, coastal embayments, harbours, estuaries and rivers.

(iii) a request to relevant federal agencies to initiate action to restrict the amount of organotin (and in particular TBT) that enters the aquatic environment from vessels anti-fouled in countries and Australian states that do not yet control the use and sale of organotin-based anti-fouling paints. This is required because some countries and states of Australia do not yet prohibit the use of organotin-based anti-fouling paints on vessels less than 25m in length and still allow the use of organotin-based anti-fouling paints that have leaching rates in excess of 5 micrograms organotin/cm^2/day. Hence, the threat of organotin contamination in estuaries, rivers, ports, harbours, marinas and small coastal embayments that are used as anchorages for these vessels would still remain.

(iv) a requirement that all boat slipping facilities servicing vessels using organotin-based (or other toxic) anti-fouling paints, or treating boats with organotin-based (or other toxic) anti-fouling paints, be licensed under the Environmental Protection Act (1986). This should ensure that such

practices are carried out in a manner that eliminates the entry of toxic wastes into the aquatic environment.

Recent results from interstate surveys show that even after restrictions, such as described above, TBT levels can remain high, possibly due to continuing release of TBT from contaminated sediments or from large vessels still using organotin-based anti-fouling paints.

A preliminary assessment of the degree of TBT contamination in the Swan River and Cockburn Sound indicates that significant contamination of sediments and mussels is generally associated with the presence of large vessels or high densities of small vessels.

The results of preliminary studies on the chronic toxicity of tributyl tin compounds to rats have been reviewed by the World Health Organisation (WHO, 1989). Those studies suggest that the long-term consumption of tributyl tin compounds consumed in food could be harmful to humans at levels such as those that have been found in the seafood of some of the more heavily contaminated areas of the Western Australian marine environment.

Hence an assessment of acceptable levels of organotin compounds (and in particular TBT) in food for human consumption should be undertaken and a strategy formulated to ensure that TBT levels in the environment are at acceptable levels. Further, in view of the implications for human health and aquaculture, it is also recommended that there be a state-wide survey of TBT levels in water, sediment and biota of enclosed or semi-enclosed embayments that are used as anchorages, and that any restrictions be subject to periodic review.

The following recommendations are made:

Recommendation 1

The Environmental Protection Authority recommends that a regulation be introduced under Section 123 of the Environmental Protection Act (1986) to prohibit the use of anti-fouling paints which contain organotin on (i) vessels which have hull length less than 25m, and (ii) structures in enclosed or semi-enclosed water bodies such as estuaries, rivers, ports, harbours, marinas, yacht clubs and relatively small semi-enclosed embayments.

Recommendation 2

The Environmental Protection Authority recommends that a regulation be introduced to require that for vessels with hull length greater than 25m, only anti-fouling paints which do not exceed a release rate of 5 μg (micrograms) organotin/cm^2/day after the first 14 days that a freshly painted vessel is immersed in the water can be sold or used. During the initial 14 day period leaching from the vessel must be less than 210 μg organotin/cm^2/day.

Recommendation 3

The Environmental Protection Authority recommends that a regulation be introduced to require that the sale of all existing stocks of anti-fouling paints containing organotin with leaching rates greater than 5 μg organotin/cm^2/day be prohibited after 30 days from the date of proclamation, and that the use of these paints be prohibited after 90 days from the date of proclamation of the regulation.

Recommendation 4

The Environmental Protection Authority recommends that a regulation be introduced to prohibit the retail sale of organotin additives used to create anti-fouling paints.

Recommendation 5

The Environmental Protection Authority recommends that a regulation be introduced to require that succinct, clearly readable labelling be added to organotin-based marine anti-fouling paint containers to the effect "NOT TO BE APPLIED TO VESSELS WITH HULL LENGTH LESS THAN 25m".

Recommendation 6

The Environmental Protection Authority recommends that the Western Australian government requests the Federal government of Australia to initiate action with countries or Australian states that do not yet restrict the use of organotin-based anti-fouling paints, in order to restrict TBT contamination of Western Australian waters by international and interstate vessels that would not be subject to controls on the use and sale of organotin-based anti-fouling paints.

Recommendation 7

The Environmental Protection Authority recommends that a regulation be introduced to require that all boat slipping facilities servicing vessels using organotin-based (or other toxic) anti-fouling paints, or treating boats with organotin-based (or other toxic) anti-fouling paints, be licensed as 'prescribed premises' under Part V of the Environmental Protection Act (1986), and that blasting, scraping and general hull maintenance operations be carried out in a manner that does not cause the entry of toxic substances into the aquatic environment.

Recommendation 8

The Environmental Protection Authority recommends that all new alternative anti-fouling paints or substances and those anti-fouling paints already on the market be tested on a nation-wide basis for their toxic effects on bio-accumulating species such as shellfish, and that the results of such tests be documented.

Recommendation 9

The Environmental Protection Authority recommends that an assessment of acceptable levels of organotin compounds (and in particular TBT) in food for human consumption should be undertaken by relevant health authorities.

Recommendation 10

The Environmental Protection Authority recommends that there be a state-wide survey of levels of organotin compounds (and in particular TBT) in sediments, water and biota of enclosed or semi-enclosed embayments of Western Australia that are used as anchorages.

1. Introduction

Fouling is the growth of marine plants and animals that occurs on the hulls of boats when they are in contact with water. Fouling results in increased drag and therefore increased fuel costs. Anti-fouling paints are applied to the hulls of these vessels to inhibit fouling. Since the mid-1960s, the most effective and commonly used anti-fouling paint has contained organotin compounds and, in particular, tributyl tin (TBT). Protection of the coated surface by killing or inhibiting growth of attached fouling organisms is obtained as a result of the slow and continuous diffusion of TBT into the surrounding water.

There has been growing international concern over the biological effects, both lethal and sub-lethal, that result from the use of these paints. At extremely low concentrations, organotins have toxic effects on a number of non-target aquatic animals, particularly filter-feeders, because of the ability of these organisms to bio-accumulate low concentrations in the water to toxic levels in the animal. The United States Environmental Protection Agency (USEPA) has reviewed laboratory testing and field trials which established chronic toxicity levels of TBT to fish at 200 ng/L (nanograms per litre, or parts per trillion) in water, bivalves at 20 to 50 ng/L, gastropods at 50 ng/L, crustaceans at 140 to 190 ng/L, and algae at 100 to 350 ng/L (USEPA, 1988). In addition, many aquatic invertebrates appear to be sensitive to TBT toxicity at even lower levels (Maguire, 1987).

In addition to the lethal effects of TBT, the sub-lethal effects may be sufficient to gradually alter populations of aquatic animals by interaction with metabolic process (TBT can damage membranes), behaviour (competition abilities, defence mechanisms, feeding strategies), and by deterioration of the environmental conditions that these animals live in (USEPA, 1988).

Gross TBT contamination occurs predominantly in areas of heavy boating and shipping activity. These activities are usually concentrated in relatively shallow, poorly flushed coastal waters and embayments. As such, these areas are often ecologically significant environments, supporting important fisheries and acting as regional nursery areas. TBT contamination has also been found to be associated with power station cooling water systems (Gabrielides *et al*, 1990).

Although the biological pathways of TBT in the environment are not well understood, significant amounts are accumulated by aquatic organisms at all trophic levels. The effects of TBT are widespread. Shell deformities of the commercially important oyster, *Crassostrea gigas* have been documented in France, England, and the United States of America and sexual deformities and possible population declines of the marine snail, *Nucella lapillus* have occurred in the United States and England (USEPA, 1988), and deformities and slow growth rates in the oyster, *Saccostrea commercialis*, have been found in Australia (Batley *et al*, 1989).

Ellis and Pattisina (1990) reported on the widespread occurrence of imposex (male genitalia imposed on females) in shoreline whelks and other Neogastropod molluscs from South East Asia, Canary Islands, Canada and United States of America and attribute the imposex to TBT contamination. Bryan *et al* (1988) investigated the incidence of imposex in the dog-whelk, *Nucella lapillus*, and concluded the cause to be TBT contamination from anti-fouling paints on boats, ships and mariculture net pens.

The results of these and other overseas studies undertaken on TBT anti-fouling paints have shown overwhelming evidence of the extreme toxicity of these paints to non-target organisms. These concerns have led to the banning of TBT anti-fouling paints on most vessels in France, Great Britain and recently in the United States of America. As a result, these countries have adopted marine water quality criteria for TBT concentrations in water ranging from 2 to 20 ng/L (nanograms per litre, or parts per trillion).

2. Regulations in other Australian states

In New South Wales, TBT anti-fouling paints have been banned from use on all boats less than 25 metres in length, including those with aluminium hulls. TBT paints for other uses must be registered and conform to a maximum leaching rate of 5 µg (micrograms) organotin/cm^2 of painted surface/day.

In mid-1989 the Victorian and Queensland Governments announced similar restrictions to those in NSW.

In Tasmania only organotin anti-fouling paints that conform to a maximum leaching rate of 4 µg organotin/cm^2/day can be registered and used on boats of any size. Permits are required, for boats greater than 25 metres, to use unregistered paints.

The Australian Capital Territory Government, which is responsible for the administration of the Jervis Bay area in New South Wales, has banned the use of TBT paints on vessels 25m and less in length under its Pesticide Act (1989).

South Australia and the Northern Territory are currently considering regulatory action.

Some Australian states intend to review the allowable leaching rate in the near future in the hope that improved technology and developments will lower leaching rates of effective anti-fouling paints. In March 1990 the Australian and New Zealand Environment Council (ANZEC) resolved to recognise a release rate of TBT of 5 µg organotin/cm^2/day as an interim measure for five years, and to review this leaching rate within five years, with a view to reducing it to 1 µg organotin/cm^2/day, if necessary.

3. The use of organotin in Western Australia

3.1 Volume of organotin paint sold

A survey to determine how much organotin anti-fouling paint was sold in WA was undertaken in 1989 by the Environmental Protection Authority, in collaboration with the Chemistry Centre of Western Australia.

It is estimated that approximately 30,000 litres of organotin paints are sold annually based on 1989 data. Recent information indicates that sales of organotin paints appear to be decreasing in anticipation of regulatory action by the Environmental Protection Authority of Western Australia.

3.2 Number of boats using organotin paint

Records from the Department of Marine and Harbours at November 1988, indicate there were approximately 1,000 permanent commercial moorings and approximately 6,000 recreational moorings in Western Australian waters. A survey was conducted to determine the number of commercial vessels using organotin anti-fouling paints. It was found that the majority of commercial boats used organotin paints.

A survey in the Perth region was conducted by the Environmental Protection Authority to determine the number of recreational boats using organotin as an anti-fouling paint. Between 60 and 80% of all 6000 recreational boats were found to use organotin paints.

3.3 Location of boats

Although WA has 14,000km of coastline, the majority of moored boats are located in only a few areas, usually where the population is concentrated. There are however, seasonal concentrations of boats at different areas along the coast, e.g., the Abrolhos Islands during the rock lobster season. Table 1 lists the location of most boat mooring areas and the number of commercial and recreational boats registered in Western Australia in 1989.

The Swan River has the highest concentration of boats in WA, with approximately 3,220 boats. Boat mooring facilities along the coast range in size from three to 650 boats.

In 1988 there were 60 boat mooring facilities (including marinas, boat harbours and boat mooring areas) and about 30 new proposed facilities in WA. If these new proposals were to proceed there would be a 50% increase in boat mooring facilities over the next few years.

There is very little available data on organotin levels in the aquatic biota or sediments from around these areas of high boat concentrations. In the Georges River, NSW, deformities have been observed in oysters adjacent to an area where 200 boats are moored (Batley *et al*, 1989). There are 10 boat mooring areas in WA with more than 200 boats.

LOCATION	No. COMMERCIAL BOAT MOORINGS	No. RECREATIONAL BOAT MOORINGS
Metropolitan		
Aquarama	-	206
Barrack St jetties	13	-
Claremont YC	-	162
Club Marina	-	8
East Fremantle jetties	-	42
East Fremantle YC	-	102
East Side Angling Club, Fremantle	-	23
Fremantle FBH	255	-
Fremantle SC	-	650
Hillarys	-	229
Mounts Bay YC	-	28
Nedlands	-	43
Nedlands YC	-	10
Perth Flying Squadron	-	147
Pier 21 Marina	-	153
Royal Freshwater YC	-	292
Royal Perth YC Crawley	-	282
South of Perth YC	-	362
Swan YC	-	230
Two Rocks	79	74
Yanchep Lagoon	-	3
All other moorings in the Swan River	-	1108
Country		
Albany	82	137
Augusta	3	5
Bunbury	10	40
Carnarvon	52	21
Coral Bay	4	-
Denison	84	45
Esperance	35	35
Exmouth	12	-
Geraldton	180	80
Jurien	56	-
Kalbarri	24	20
Mandurah	20	400
Port Walcott	6	6

Table 1. Location and number of major commercial and recreational boat mooring areas in WA in 1989.

3.4 Slipways

Approximately 24 slipways and 103 boat ramps are located along the coastline or in the estuaries of Western Australia.

There appear to be three main sources of organotin associated with slipways and shipyards:

- Paint residues resulting from paint overspray, and 'near empty' used paint cans.
- Washdowns from slipway maintenance and hull cleaning operations.
- Removed paint chips and dust as a result of abrasive blasting and hydroblasting.

Of the 24 slipways in WA in 1989, there is only one which has a crossdrain to collect wastes.

3.5 Organotin levels in the aquatic environment of Western Australia

3.5.1 Review

Many nations and other states of Australia have adopted water quality criteria levels of between 2 and 20 ng/L of TBT in water. The current literature suggests that, at concentrations less than this, the risk to most aquatic organisms is negligible (USEPA, 1988; WHO, 1989). It should be noted however, that levels below 2 ng/L of TBT in water have been found to interfere with reproductive processes of some organisms, such as the female dogwhelk (Bryan *et al*, 1988).

Little information exists in the literature on the relationship between sediment TBT concentrations and concentrations of TBT in overlying water. The USEPA (1988) report that concentrations of TBT found in sediments may be 100 to 10,000 times higher than in the overlying water.

Batley *et al* (1989) measured TBT concentrations in the tissue of the Sydney rock oyster *Saccostrea commercialis* sampled from estuaries in New South Wales, Australia. They found that oysters with TBT tissue concentrations between 196 and 318 ng TBT per g (wet weight) had shell deformities and reduced tissue weights.

Little information exists in the literature on the effect to human health of TBT ingested in food. The results of preliminary studies on the chronic toxicity of tributyl tin oxide to rats have been reviewed by the World Health Organisation (WHO, 1989). Based on that review, WHO (1989) suggests that tributyl tin oxide levels in food for human consumption should not exceed 150 ng per g of food.

3.5.2 TBT contamination in selected Western Australian aquatic ecosystems

The following studies have been recently undertaken to assess the level of contamination of TBT in the mussels and sediments of selected aquatic environments in Western Australia. TBT levels in mussels are given as ng TBT per g wet weight and as ng TBT per g dry weight for sediments.

Environmental Protection Authority

The Environmental Protection Authority collected sediment samples from a number of yacht clubs in the Swan River during winter 1989. The four sites sampled were the East Fremantle, Royal Freshwater Bay, South of Perth and Royal Perth yacht clubs. At each location, three sites were sampled; one immediately in front of a slipway and two located over 50m apart under the mooring pens. At each site four sediment cores of 10cm thickness were collected within a 1 square metre area, and bulked to form one mixed sample.

Analyses were conducted by the Centre for Advanced Analytical Chemistry, CSIRO, Division of Fuel Technology, Lucas Heights Research Laboratories, Lucas Heights, New South Wales. All samples from the slipway sites had TBT concentrations above 1,500 ng TBT per g, ranging from 1,617 to 13,353 ng TBT per g. The samples collected from the mooring areas of the yacht clubs ranged from less than 1 to 904 ng TBT per g. These results indicate that TBT contamination was highest around the slipways, possibly due to the entry of TBT into the water from scraping, blasting, painting and general maintenance of vessels. TBT levels away from the slipways were lower, but still high enough to give cause for concern. It was not possible to obtain mussels for analysis from these areas as none could be found at the time of sampling.

In addition to the sediment samples collected at yacht clubs, a sampling site for sediments and mussels was also chosen in the mussel farm area in northwest Cockburn Sound. Sediments and mussels were analysed for TBT levels, with the sediments showing undetectable levels of TBT and the mussel analyses returning levels of approximately 72 ng TBT per g wet weight.

Department of Defence

A field investigation of TBT levels in sediments and mussels in Cockburn Sound (Figure 1) was undertaken by Environmental Management Services Pty Ltd (under contract to the Department of Defence) during December 1988 and April, June, July 1989. The data were provided to the Environmental Protection Authority on 6 June 1990. Five regions of the Sound were sampled; Careening Bay (HMAS Stirling RAN facilities), southern Mangles Bay (Rockingham), Sulphur Bay, Jervoise Bay (adjacent to the shipbuilding yards and Marine Support Facility shiplift, enclosed within the two breakwaters shown in Figure 1), and the mussel farm in northwest Cockburn Sound. Sediments were collected by removing the upper few centimetres (less than 5cm) over a 0.2 x 0.5 m^2

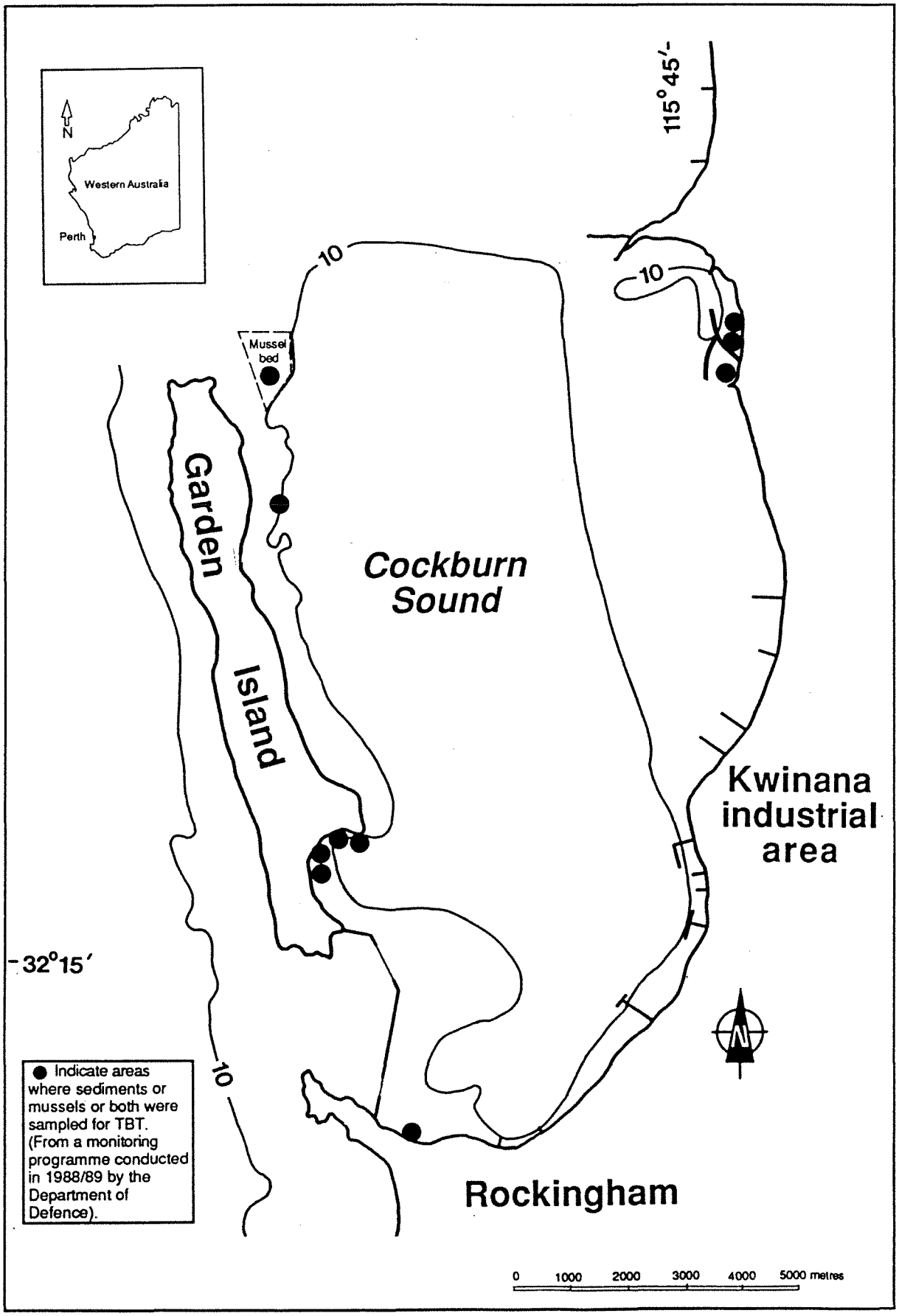

Figure 1. Cockburn Sound

area. The sample was then bulked and analysed. Analyses were conducted by CSIRO (as above, for EPA samples).

In Careening Bay, mussels were collected from pylons, used for the berthing of naval vessels. They returned levels of TBT in flesh ranging from 73 to 2,819 ng TBT per g. Mussels were also taken from a light beacon just south of the ship-berthing areas and they had a TBT level of 407 ng TBT per g. These results indicate contamination of mussels both within and near the ship-berthing facilities at HMAS Stirling. It is of interest to note that most of the sediment samples from that area returned relatively low levels of TBT. Dredging of the sediments was carried out over 10 years ago and therefore cannot be invoked as a reason for the relatively low levels of TBT in the sediments. However, it has been suggested that the low levels of contamination in the sediments could to be due to the vigorous sediment stirring by boat action in the ship-berthing region (Peter Waterman, pers. comm.).

Mussels and sediments were sampled from the end of a jetty in southern Mangles Bay, approximately 150 m offshore. Levels of TBT were 314 ng TBT per g in mussels and 159 ng TBT per g in sediments. There is a high density of recreational boats in this region of Mangles Bay during summer.

In Jervoise Bay, adjacent to and around the ship-building areas, levels of TBT found in mussels ranged from 338 to 407 ng TBT per g, and levels of TBT found in sediments ranged from 29 to 13,132 ng TBT per g.

Mussels and sediments were collected at the end of the Armaments Jetty, Sulphur Bay. Analyses returned TBT levels of 103 ng TBT per g in mussels and 791 ng TBT per g in sediments.

Mussels taken from the mussel farm in northwest Cockburn Sound (about 1km offshore and northeast of Beacon Head, Garden Island) returned TBT levels 30-43 ng TBT per g.

Based on the above results it is apparent that the contamination of sediments and mussels in some regions of the Swan River and Cockburn Sound is related both to the presence and density of vessels using TBT as anti-fouling paint and also to the slipping and maintenance (scraping, painting and sand-blasting) of such vessels.

3.5.3 Prognosis of future levels of TBT in Cockburn Sound waters

The waters of Cockburn Sound will continue to be utilised by vessels of all sizes, including Australian naval (Department of Defence, 1989) and international naval and commercial vessels greater than 25m in length. Proposed controls on the use and sale of organotin for vessels registered or anti-fouled in Western Australia will eliminate its use on vessels less than 25m in length, but larger vessels would still be able to use organotin-based anti-fouling paints, albeit at a reduced rate (less than 5 micrograms organotin/cm^2/day). In addition, internationally registered vessels from some countries and vessels registered in some states of Australia will still be able to use organotin-based paints with leaching rates higher than 5 micrograms organotin/cm^2/day. Hence, the threat of TBT contamination in coastal embayments remains.

A method similar to that previously used by Batley *et al* (1989) is followed here to calculate the steady-state (long-term) concentration of TBT in a given volume of water from a constant and continuous source of TBT. It is assumed that 10 vessels having respective hull areas of 1000 m^2 will leach TBT into Cockburn Sound at a rate of 5 micrograms of TBT per cm^2 of hull area per day. A range of flushing times for Cockburn Sound of 10 to 50 days, after Steedman and Craig's (1979) numerical model results, has been used for this analysis. The assumption that Cockburn Sound is typically well-mixed is made in the first instance. In addition, it is assumed that TBT leaches from the hulls of vessels at a continuous and constant rate. As half lives of greater than 6-7 days are typical, a degradation rate of TBT in water of 10 percent is adopted (ie one tenth of the TBT in a control volume of water will be degraded in one day).

Using the above information an approximate range of 1-2 ng/L is predicted for the average concentration of TBT in the waters of Cockburn Sound given the above range of flushing times and rates of loading of TBT. It is to be noted that this analysis has averaged the net loading of TBT into Cockburn Sound waters throughout the whole volume of this water body. In addition, a relatively low leaching rate of TBT from the hulls of vessels has been assumed. International and interstate vessels, not subject to controls on TBT leaching rates, will continue to use Cockburn Sound and could leach TBT at rates higher than that assumed in this analysis. The hydrodynamic characteristics of the flushing of the minor embayments into the central waters of Cockburn Sound is not well understood at present. Hence, there remains the possibility that TBT levels in some of the smaller embayments of Cockburn Sound (such as Jervoise Bay and Careening Bay) may be higher than those predicted, above.

The waters of Cockburn Sound are ideal for mariculture and currently there are three mussel farm leases in operation. The spat for these farms is also collected in Cockburn Sound. Mussel spat is extremely sensitive to low levels of TBT in the water and 50% will die at TBT levels of 40 ng/L (Maguire, 1987). Sub-lethal effects are therefore occurring at levels below this. At 80 ng/L, a reduction in length growth rate occurs in the adult mussel *M.edulis* (Maguire, 1987). Oyster spat (*C. gigas*) exhibits adverse effects to TBT levels as low as 2 ng/L (Maguire, 1987). Hence, continued monitoring of the levels of TBT in the waters, sediments and biota of Cockburn Sound is advisable.

3.5.4 Monitoring of organotin in the aquatic environment of Western Australia

Apart from the surveys of TBT levels in the sediments and biota of the Swan River and Cockburn Sound, conducted during 1988/1989 (see Section 3.5.2, above), little monitoring of TBT contamination has been conducted in the aquatic environment of Western Australia.

More recently however, Australian Marine Systems Pty Ltd has begun to monitor levels of TBT in mussels, sediment and water in the waters enclosed by the southern of the two breakwaters that protect ship yards and facilities in Jervoise Bay. Five sites are being monitored at six-monthly intervals. In addition, the Department of Defence has an ongoing commitment to monitor levels of TBT in the naval waters of Cockburn Sound.

Therefore, only a limited amount of monitoring of TBT levels is presently planned for the aquatic environment of Western Australia. In view of this it is suggested that there be a state-wide survey of organotin compounds (and in particular TBT) in sediments, water and biota of enclosed or semi-enclosed embayments of Western Australia that are used as anchorages.

3.6 Implications for aquaculture in Western Australia

Apart from aquaculture in Cockburn Sound there are about 30 other aquaculture industries currently in operation in WA to date with the majority located in the south-west of the State in protected or poorly flushed water bodies (Table 2). Many of these water bodies contain marine structures (such as jetties) and are popular for recreational boating. In addition, fish nets, cages and pots are commonly used for the taking of fish and crustacea. There are some areas, for example Albany and Cockburn Sound, where shellfish industries exist and boat mooring facilities catering for large vessels are in relatively close proximity. The proposed regulations for TBT will greatly restrict TBT contamination from small vessels and marine structures but will still allow large vessels (greater than 25m in length) and internationally registered vessels using organotin-based anti-fouling paints to sail in coastal waters and semi-enclosed embayments. Hence, with the potential for an increase in the number of boat mooring and port facilities and aquaculture industries, the situation could become critical.

WA's coastline is generally very exposed and has only a limited number of protected bays and estuaries. Inevitably aquaculture and boat mooring areas will compete for these protected areas. The siting and management of aquaculture projects or ventures should be carried out with due regard for the risk of TBT contamination.

3.7 Alternative anti-fouling paints

Greater restrictions on the use of organotin anti-foulants overseas, and recently in Australia, provide a strong incentive for the development of alternative technologies. Some international paint companies are phasing out organotin paints and manufacturing copper-based paints, as these probably offer the greatest potential short term resolution of finding suitable alternatives. Many paint manufacturers are already using copper ablative anti-foulants and copper copolymers with performance proven to approach that of organotin anti-foulants. These include a copper anti-foulant which may be suitable for aluminium boats.

Chemically-active alternatives are known to still be toxic and as such are still an issue.

Due to the decline in the number of companies manufacturing organotin paints and the development of alternative anti-foulants these alternatives should be tested for their effect on the environment, before they are allowed on the market. These tests should be undertaken on both new alternatives and those non-organotin paints already on the market.

It appears sensible that all new anti-fouling paints and those non-organotin paints on the market be tested for their effect on bio-accumulating species such as shellfish. Further, the development of non-toxic alternatives should be pursued as a matter of priority and encouraged.

Type of Aquaculture	Location
oyster farm	Oyster Creek, Carnarvon
oyster farm	Oyster Harbour, Albany
oyster farm	Princess Royal Harbour, Albany
oyster farm	Irwin Inlet
oyster farm	Wilson Inlet, Denmark (proposed)
oyster farm	Broke Inlet (proposed)
scallop and oyster farm	Wylie Bay, Esperance
blue mussel farm	Geographe Bay
blue mussel farm	Cockburn Sound
trout farm	Pemberton
trout farm	Treen Brook, Pemberton
trout farm	Frenchman Bay, Albany
trout hatchery and salmon farm	Windy Harbour, Manjimup
sea trout and salmon farm	Frenchman Bay, Albany
fish farm	Hardy Inlet, East Augusta
fish farm	Wittecarra Gully, South Kalbarri
fish hatchery	Dampier
fish farm	Lagoon Drive, Yanchep
prawn farm	Gascoyne, Carnarvon
prawn farm	East Wyndham
prawn farm	Sam Creek, Point Samson
yabbie farm	Gingin
yabbie farm	Bullsbrook
marron farm	Dwellingup
marron farm	Gingin and Roleystone
artemia farm	East Derby
algal farm	East Carnarvon
algal farm	Hutt Lagoon, Port Gregory

Table 2. Location and type of aquaculture industries operating and proposed in WA.

4. Recent developments

4.1 Environmental Protection Authority

In 1988, the Environmental Protection Authority began a review of the use and sale of organotin anti-fouling paints in Western Australia. That review culminated in the formulation, by the Environmental Protection Authority, of a draft position on the issue in mid-1989. The intent of that position was essentially to:

- prohibit the use of organotin-based anti-fouling paints on vessels less than 25m in length, thus restricting the level of contamination in marinas, estuaries, rivers and small water bodies; and
- restrict the allowable rate of leaching of TBT in anti-fouling paints from all other (greater than 25m) vessels to relatively low levels.

The Environmental Protection Authority's draft position was widely publicised in the media and sent via letter to 170 relevant state and federal agencies (such as the federal Advisory Committee on Agricultural Chemicals, the state Pesticides Advisory Committee), the Royal Australian Navy, local government (Health Surveyors), major paint manufacturers and distributors (WA and interstate), major conservation organisations, boat clubs, etc. A six month period for public comment ended on 15 December 1989 and approximately 25 submissions were received by the Environmental Protection Authority. There were no major objections to the Environmental Protection Authority's draft position.

4.2 Australian and New Zealand Environment Council

The Australian and New Zealand Environment Council (ANZEC) has recently discussed the issue and has recommended that TBT be controlled in its use and sale. ANZEC's position is that the use of anti-fouling paints that contain organotin should be prohibited on all vessels less than 25m in length and that, for all larger vessels, only anti-fouling paints that do not exceed a release rate of 5 micrograms organotin/cm^2/day be sold or used. ANZEC further recommended that this leaching rate be reviewed within five years, with a view to reducing it to 1 microgram organotin/cm^2/day if necessary.

4.3 Royal Australian Navy

The Royal Australian Navy no longer uses TBT as an anti-foulant on boats less than 25m in length. For vessels greater than 25m in length, the Navy is switching to slow-release self-polishing co-polymer paints of organotin base with release rates of less than 5 micrograms organotin/cm^2/day. The Navy is also pursuing a long-term testing programme of other alternatives through the Defence Science and Technology Organisation.

4.4 Manufacturers, users and associated representatives

Recent information from distributors indicates that sales of organotin paints appear to be phasing down in anticipation of regulations. The Australian Paint Manufacturers Federation Inc endorsed the Environmental Protection Authority's current position on the issue.

4.5 Legislative position

In Western Australia, the Pesticides Advisory Committee (PAC) controls the registration of all pesticides. Anti-fouling paints, like all paints, must conform to the Uniform Paint Standard issued by the National Health and Medical Research Council in 1981. In Western Australia, this standard was incorporated into legislation under the Toxic and Hazardous Substances Regulations to the Health Act, 1911.

It is now required that all new anti-fouling paints be assessed by the Advisory Committee on Agricultural Chemicals (ACAC), formerly called the Technical Committee on Agricultural Chemicals (TCAC). The secretariat of the ACAC is based at the Department of Primary Industries and Energy, Canberra.

The ACAC evaluates a product's suitability for registration. It provides advice of its assessment and evaluation to the Australian Agricultural and Veterinary Chemicals Council, which was constituted under the Commonwealth Agricultural and Veterinary Chemicals Act.

When the ACAC is satisfied that a product can be 'cleared', it provides advice to that effect to each of the individual Australian state's pesticides advisory committees, (the PAC in Western Australia).

The protocol of requirements under which ACAC considers a product for clearance is detailed in the first edition (September 1989) of 'Requirements for Clearance of Agricultural and Veterinary Chemicals', Australian Agricultural and Veterinary Chemicals Council (AAVCC), Australian Government Publishing Service, Canberra.

In that document (AAVCC, 1989) the guidelines for organising data in submissions for product clearance include environmental chemistry and toxicology. For aquatic organisms, these guidelines require environmental toxicology data on both acute and short term effects, as well as special studies.

5. Recommendations of the Environmental Protection Authority

Studies undertaken in Australia and overseas on the causes of pollution of the marine environment by organotin compounds, and in particular by tributyl tin (TBT) compounds, have identified the following major sources of TBT (WHO, 1989 and USEPA, 1988):

(i) Recreational and commercial vessels less than 25m in length

These vessels typically use TBT-based anti-fouling paints. The net leaching of TBT compounds

from this source into the marine environment is greatest where the density of these vessels is highest, such as in estuaries, rivers, ports, harbours, yacht clubs and other relatively small semi-enclosed embayments which are relatively poorly flushed. Most vessels less than 25m in length that use Western Australian waters are registered and anti-fouled in Western Australia.

(ii) Marine structures , fishing nets, cages and pots

The leaching of TBT compounds from anti-fouling paints applied to marine structures (such as jetties and pylons) and fishing apparatus (nets, cages and pots) can cause significant TBT contamination of waters in poorly flushed embayments such as lakes, estuaries, rivers, lagoons and small semi-enclosed embayments.

(iii) Commercial and naval vessels greater than 25m in length

These vessels typically use TBT-based anti-fouling paints. The major effects of the leaching of TBT compounds into the marine environment from large vessels are generally confined to water bodies such as major ports, harbours and relatively large coastal embayments (eg Cockburn Sound). It is to be noted that some relatively small coastal embayments are also used as anchorages for large vessels (eg Princess Royal Harbour, Albany).

The following recommendations are made for structures or vessels registered or anti-fouled in Western Australia to restrict the level of organotin (and in particular TBT) contamination from the above sources (i, ii, and iii)

Recommendation 1

The Environmental Protection Authority recommends that a regulation be introduced under Section 123 of the Environmental Protection Act (1986) to prohibit the use of anti-fouling paints which contain organotin on (i) vessels which have hull length less than 25m, and (ii) structures in enclosed or semi-enclosed water bodies such as estuaries, rivers, ports, harbours, marinas, yacht clubs and relatively small semi-enclosed embayments.

Recommendation 2

The Environmental Protection Authority recommends that a regulation be introduced to require that for vessels with hull length greater than 25m, only anti-fouling paints which do not exceed a release rate of 5 μg (micrograms) organotin/cm^2/day after the first 14 days that a freshly painted vessel is immersed in the water can be sold or used. During the initial 14 day period leaching from the vessel must be less than 210 μg organotin/cm^2/day.

Recommendation 3

The Environmental Protection Authority recommends that a regulation be introduced to require that the sale of all existing stocks of anti-fouling paints containing organotin with leaching rates greater than 5 μg organotin/cm^2/day be prohibited after 30 days from the date of proclamation, and that the use of these paints be prohibited after 90 days from the date of proclamation of the regulation.

Recommendation 4

The Environmental Protection Authority recommends that a regulation be introduced to prohibit the retail sale of organotin additives used to create anti-fouling paints.

Recommendation 5

The Environmental Protection Authority recommends that a regulation be introduced to require that succinct, clearly readable labelling be added to organotin-based marine anti-fouling paint containers to the effect "NOT TO BE APPLIED TO VESSELS WITH HULL LENGTH LESS THAN 25m".

The proposed restrictions in Recommendations 1 to 5, above, would apply only to vessels anti-fouled or registered in Western Australia. Internationally and nationally registered vessels, that would not be compelled by these proposed restrictions, would continue to sail in the coastal waters of Western Australia and therefore the threat of organotin contamination in ports, harbours and coastal embayments that are used as anchorages for these vessels remains. To address potential problems of organotin contamination of Western Australian waters from these vessels the following recommendation is made.

Recommendation 6

The Environmental Protection Authority recommends that the Western Australian government requests the Federal government of Australia to initiate action with countries or Australian states that do not yet restrict the use of organotin-based anti-fouling paints, in order to restrict TBT contamination of Western Australian waters by international and interstate vessels that would not be subject to controls on the use and sale of organotin-based anti-fouling paints.

Another major source of organotin that pollutes the marine environment is in organotin wastes derived from blasting, scraping and general hull maintenance operations carried out at ship maintenance yards. Toxic wastes often wash down slipways and over sediment drains and traps and enter the adjacent marine environment. To eliminate this source of organotin pollution the following recommendation is made.

Recommendation 7

The Environmental Protection Authority recommends that a regulation be introduced to require that all boat slipping facilities servicing vessels using organotin-based (or other toxic) anti-fouling paints, or treating boats with organotin-based (or other toxic) anti-fouling paints, be licensed as 'prescribed premises' under Part V of the Environmental Protection Act (1986), and that blasting, scraping and general hull maintenance operations be carried out in a manner that does not cause the entry of toxic substances into the aquatic environment.

The proposed restrictions on the use and sale of organotin-based anti-fouling paints will lead to the use and development of alternatives. Because many known alternatives, and those likely to be developed, are chemically based, the threat of unacceptable contamination of the aquatic environment from toxic anti-fouling compounds remains. To this end the following recommendation is made.

Recommendation 8

The Environmental Protection Authority recommends that all new alternative anti-fouling paints or substances and those anti-fouling paints already on the market be tested on a nation-wide basis for their toxic effects on bio-accumulating species such as shellfish, and that the results of such tests be documented.

The results of preliminary studies on the chronic toxicity of TBT compounds to rats have been reviewed by the World Health Organisation. Those studies suggest that the long-term consumption of TBT in food could be harmful to humans at levels such as those that have been found in the seafood of some of the more heavily contaminated areas of the Western Australian marine environment. Health authorities in Australia do not have firm policies on this issue. Hence, the following recommendation is made.

Recommendation 9

The Environmental Protection Authority recommends that an assessment of acceptable levels of organotin compounds (and in particular TBT) in food for human consumption should be undertaken by relevant health authorities.

Recent results from interstate surveys show that even after restrictions, such as described in Recommendations 1 to 5, above, TBT levels can remain unacceptably high, possibly due to continuing release of TBT from contaminated sediments or from large vessels still using organotin-based anti-fouling paints. In view of this, the following recommendation is made.

Recommendation 10

The Environmental Protection Authority recommends that there be a state-wide survey of levels of organotin compounds (and in particular TBT) in sediments, water and biota of enclosed or semi-enclosed embayments of Western Australia that are used as anchorages.

6. Conclusions

The results of overseas studies on the effects of TBT anti-fouling paints on non-target organisms have shown overwhelming evidence of the extreme toxicity of these paints.

Adverse effects of TBT have included shell deformities of commercial oysters in France, Great Britain and the USA, sexual deformities and population declines of marine snails in south-east Asia, the North Atlantic and the north-east Pacific Oceans, and deformities and slow growth rates in oysters in Australia.

These concerns have led to selective restrictions on the use and sale of TBT anti-fouling paints in many countries, including France, Great Britain and the USA, and more recently in most states of Australia. These restrictions have been motivated by a desire to protect both the general marine environment and valuable aquaculture industries (such as oysters and mussels) from this form of pollution.

It is concluded therefore that the use and sale of organotin (and, in particular, tributyl tin [TBT]) -based anti-fouling paints in Western Australia should be restricted, as outlined in the recommendations in Section 5, above.

It is also concluded that a state-wide survey of TBT levels in water, sediment and biota of enclosed or semi-enclosed embayments that are used as anchorages for these vessels should be conducted, and that any restrictions be subject to periodic review.

In addition, an assessment of acceptable levels of TBT in food for human consumption should be undertaken and a strategy formulated to ensure that TBT concentrations in the environment are at acceptable levels.

7. References

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