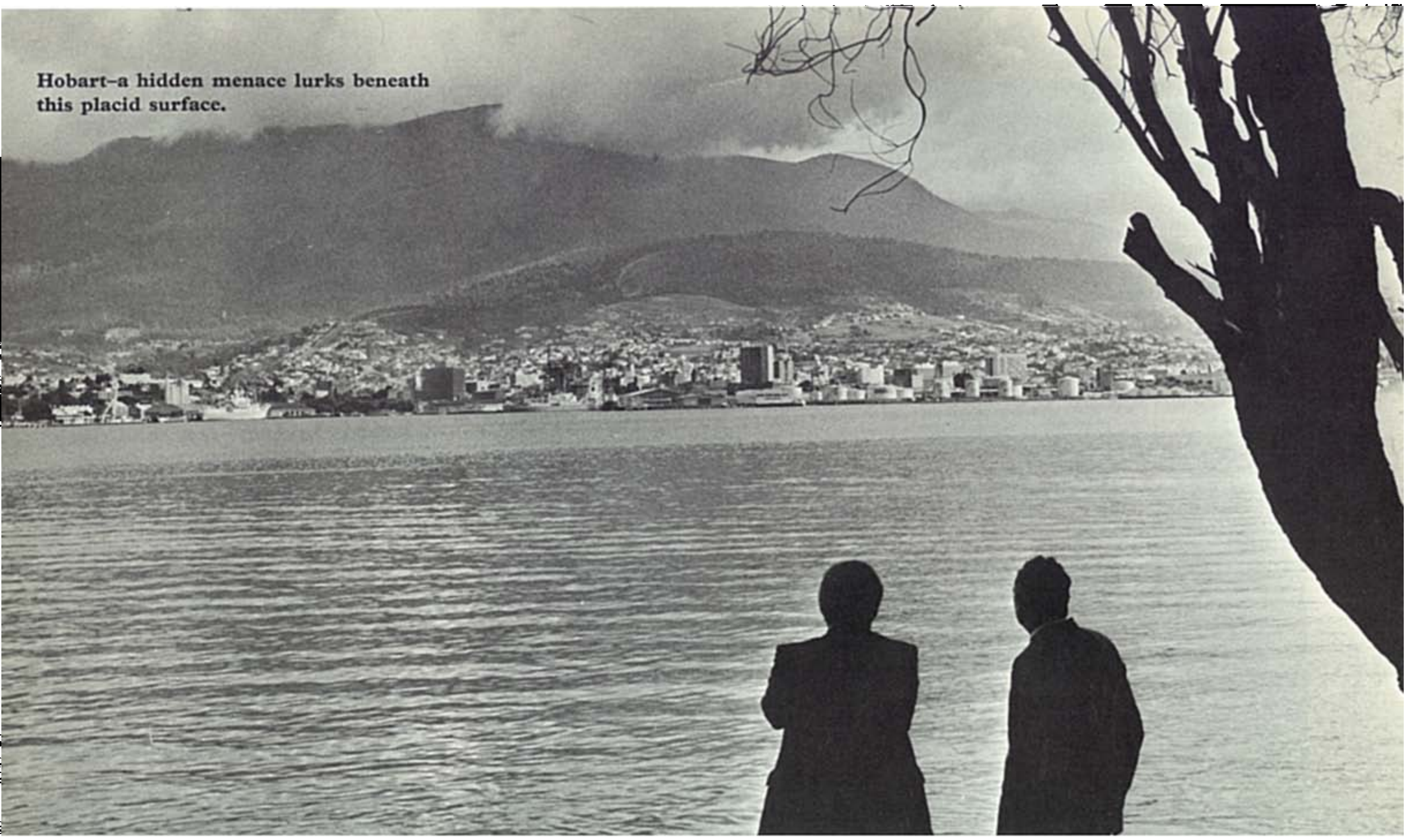


Hobart–a hidden menace lurks beneath this placid surface.

Toxic metals in Tasmanian rivers

. . . a meal of six oysters from Ralph's Bay may provide the gourmet with enough zinc to make him vomit.

It all began with oysters — they were making people sick. During the late 1960s, several people began growing oysters in Ralph's Bay at the bottom of the Derwent estuary. They used the Pacific oyster — a much larger shellfish than our native Australian oysters — and this type grew particularly well. Problems began to appear in 1970, when the first oysters came on sale: they made people vomit.

For a while nobody could find out why. Feeding the oysters to volunteers showed that drinking wine with the oysters made things worse, but did not give a clue to the problem. Tests for bacterial and algal infections (common causes of food poisoning) also revealed little reason for concern, so the illness remained a puzzle.

Then a new idea emerged. Could zinc be causing the sickness? Doctors know that large doses of zinc sulphate produce vomiting. Upstream from Hobart is a large zinc-refining plant, also the majority of roofs in the city are made of galvanized iron; perhaps the oysters contained large amounts of the metal? What's more, oysters are known to be able to concentrate zinc and other metals from the surrounding water by several thousand times.

Preliminary tests on 12 oysters from the Derwent and Tamar Rivers showed high levels of zinc, copper, and cadmium, all of which can cause vomiting when taken in too-large doses. So a major study of metal levels in oysters began.

Only later, when high concentrations of these metals had been confirmed, did attention turn to swimming fish, and reveal high levels of that particularly unwelcome metal, mercury.

Metals contaminating seafoods, of course, represent a health hazard. But their presence also has much wider implications. The metals had to come from somewhere, and what other effects could they be having on the estuary, and the plants and marine animals that grew there? Such questions revealed large gaps in what was known about the estuary, since many could not be answered (and still can't). In fact a proposal put forward by the River Derwent Pollution Committee to set up a computer model of the estuary had to be abandoned for lack of knowledge of flows, currents, and tides.

No one research group in Tasmania had all the skills and facilities needed to unravel what has happened in the Derwent and Tamar estuaries. So far, the process has been very much a cooperative effort involving Tasmanian State Government Departments, CSIRO, the Commonwealth Department of Science, and the University of Tasmania.

CSIRO discovered the high metal levels in oysters. Its Division of Food Research has a small group of scientists stationed at Hobart, who study processing problems in fish foods. Under the direction of Dr June Olley, leader of the group, Mr Stephen Thrower and Mr Ian Eustace carried out the analyses.

Samples of the big Pacific oysters came from a number of sites in the Derwent and Tamar estuaries, and from the north coast. Further samples of the small native oysters came from down the east coast. The researchers hoped to be able to compare metal levels in oysters from polluted waters with the 'background' metal levels in samples obtained from clean water.

Too much zinc

Almost immediately, it became clear that even in clean ocean waters oysters always contained much more zinc than the 40 p.p.m. (wet weight) permitted by the then-existing Tasmanian food regulations. Thus if oysters were to be grown anywhere at all in the State the levels permitted by the food regulations would have to be raised. A somewhat similar situation appeared to apply for copper too, but cadmium levels in clean water remained well below the existing limit of 5·5 p.p.m. (Since that time the National Health and Medical Research Council has recommended that the maximum permissible zinc concentration in seafoods be changed to 1000 p.p.m., and that for cadmium to 2 p.p.m.)

Oysters from two leases in Ralph's Bay at the bottom of the Derwent estuary yielded astonishingly high zinc concentrations of up to 21 000 p.p.m.—some 500 times greater than levels permitted by the existing food regulations. (Even those with the lowest zinc levels contained 10 times too much.) This quantity represented no less than 10% zinc on a dry-weight basis!

Cadmium and copper levels also proved high, but not in such spectacular proportions.

Analyses of oysters from two commercial leases located in the upper reaches of the Tamar estuary showed a similar picture, although zinc levels were not as high as in the Derwent. Mean cadmium concentrations from these two leases reached 14·6 and 7·2 p.p.m.—similar levels to the least contaminated of the Ralph's Bay samples. All samples from both the Derwent and Tamar estuaries contained more cadmium than the 2 p.p.m. that the food regulations now permit.

Further tests—involving digesting oysters in dilute hydrochloric acid or a mixture of the acid and the enzyme pepsin—simulated what would happen in the human stomach. The tests suggested that between 65 and 90% of the metals would be released within an hour of eating a meal. In addition, the largest oysters released zinc and cadmium most quickly.

Using this information, the CSIRO research group calculated that a meal of six oysters from Ralph's Bay might provide the gourmet with enough zinc to make him vomit. None of the oyster samples contained enough copper to make a man sick in one meal.

Cadmium's presence gave much more cause for concern than zinc's. Nobody likes to become ill, but at present medical authorities do not consider low levels of zinc in the diet to be particularly harmful. In fact, in Vietnam, wounded soldiers were fed large amounts of zinc to speed healing of their wounds.

The human body also needs copper, so small quantities of this element are not harmful either. But cadmium is very different. As far as we know, the body has no use for cadmium and even very small amounts tend to remain and build up over the years. Symptoms of poisoning by this metal may only appear many years later, and no cure is known.

Fish survey

If oysters contained large metal concentrations, it seemed likely that swimming fish would also. Nobody fishes the Derwent and Tamar estuaries commercially, but many amateur fishermen catch and eat the local fish. So another survey followed, but this time only in the waters of the Derwent estuary. This survey involved analysing 39 species of marine animals, 32 of which were free-swimming fish. The other 7 species consisted of sedentary bottom-living animals such as common mussels, native oysters, and starfish.

A local fisherman collected the samples from 64 sites, and once again the CSIRO Food Research group analysed them for their zinc, cadmium, and copper contents, and also for their manganese levels. Mr Kevin Wilson of the Australian Government Analytical Laboratories analysed the same samples for their mercury content. Analyses were made on muscle tissue, since that is the part of the fish normally eaten.

It is very difficult to measure mercury levels accurately to the nearest part per million, and so, to double-check, some of the samples were also sent to the laboratories of the Electrolytic Zinc Company. Present-day techniques probably slightly underestimate the amount of mercury present, but the fact that tests from both laboratories have given similar results makes the analysts reasonably certain that their results are correct.

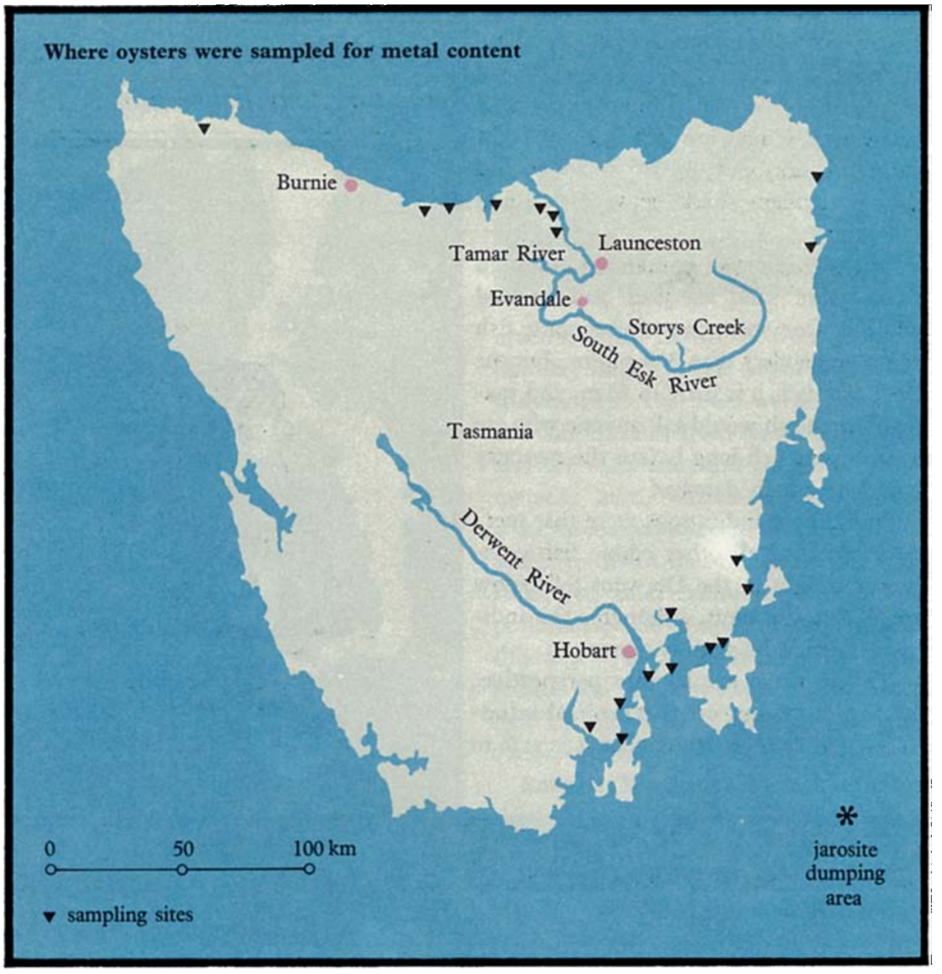
As before, the native oyster and also the common mussel—another edible shellfish—contained levels of zinc and cadmium unacceptably high for human consumption. Copper and manganese levels also proved higher than the background level found in shellfish collected from clean water.

Old Pacific oyster—about half life size!

In the swimming fish, none of the four metals examined even approached the maximum levels then permitted by the Tasmanian food regulations. Small variations in the zinc and copper levels did occur between different species, but compared with metal levels in the same species overseas no abnormal build-up of heavy metals seemed to be present.

Mercury

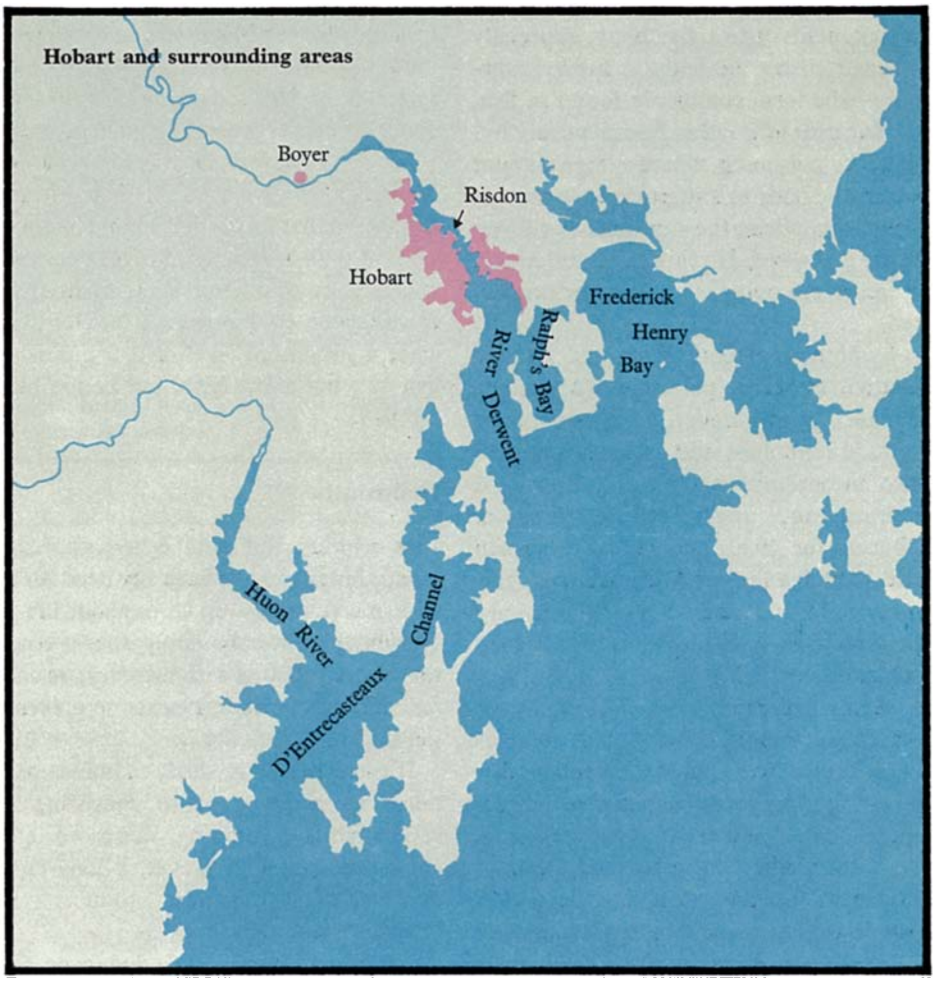
However, Mr Wilson's mercury analyses did give cause for alarm. The accepted maximum level for mercury in fish is 0·5 p.p.m. of its fresh wet weight. In Victoria, landing shark with a mercury content above this level was prohibited by law in 1972, and sharks are known accumulators of mercury. Perhaps, therefore, it is not so surprising that some individuals of all



What is a part per million?

The term parts per million often confuses people, especially as it is often expressed in alternative forms. The term is being phased out of international scientific usage. Alternative ways of expressing parts per million follow:

1 p.p.m. = 1 milligram per kilogram (mg/kg)
1 p.p.m. = 1 microgram per gram (μg/g)
1 p.p.m. = 1000 parts per billion (p.p.b.)
1 p.p.m. = 0·0001%



shark species analysed from the Derwent estuary contained more than the permitted 0·5 p.p.m. wet weight. The six school shark analysed, for example, varied between 0·1 and 1·5 p.p.m., the eight gummy shark between 0·5 and 1·0, and the 18 elephant shark between 0·2 and 1·1 p.p.m.

Other edible fish containing too-high levels were sand flathead and spotted whiting. One specimen of porcupine fish contained no less than 3·8 p.p.m., but the flesh of this fish is toxic to Man, and toxins in the flesh would kill anyone who ate a porcupine fish long before the mercury could do much damage!

Preliminary indications were that mercury levels in all other edible fish commonly caught in the Derwent fell below the 0·5 p.p.m. limit, although a few individuals could be slightly above.

To get these results into perspective, it's worth pointing out that medical authorities generally consider that it is safe to eat one meal of fish per week even when the mercury contamination rate is double the permissible limit—1 p.p.m. rather than 0·5. Mr Everett, as Tasmanian Minister for the Environment, pointed out that, even in the island State of Tasmania, not many people eat fish that often. However, the person who is at risk is the amateur fisherman who may eat more.

. . . the person who is at risk is the amateur fisherman . . .

The Tasmanian Government has advised that one other social group, pregnant mothers, should not eat any fish caught in the Derwent.

Picture not clear

The findings of the oyster and fish surveys leave no doubt that zinc, mercury, and cadmium are problem metals in the Derwent estuary. Zinc and cadmium are also a problem in the Tamar estuary, while tests for mercury have yet to be carried out.

But these surveys were not designed to say anything about where these contaminants come from, or whether their levels

Mercury and cadmium – their effects on life

Mercury

No living things seem to have any use for mercury, and it is very toxic. In Man the metal builds up in the body, especially when it enters the body as methyl mercury—the form commonly found in fish.

Man can suffer either from acute methyl mercury poisoning, where a large amount enters the body in a short time, or chronic poisoning, where the substance builds up to the toxic level. No cure exists for methyl mercury poisoning, so it must be prevented.

Symptoms of both acute and chronic methyl mercury poisoning (Minamata disease) appear similar. These symptoms include numbness and tingling, progressive incoordination, loss of vision and hearing, and intellectual deterioration. (During the 1950s and 1960s, fishermen and their families at Minamata and Niigata in Japan suffered methyl mercury poisoning as a result of eating heavily contaminated fish.)

Methyl mercury can also cross the placental membrane and affect the unborn foetus (congenital Minamata disease). During the Minamata and Niigata epidemics, several affected children were born to mothers who seemed healthy. Minamata disease affected at least 168 people during these two epidemics, and 24 of these cases were infants or children with congenital Minamata disease. Fifty-two of the 168 people died.

Children suffering from congenital Minamata disease had symptoms similar to those of cerebral palsy. Some also were mildly spastic or severely intellectually retarded, or had seizures and other evidence of more general brain damage.

We don't know much about how methyl mercury affects wildlife. Swedish research has shown that fish with a methyl mercury content of 0·4–0·5 p.p.m. have poor balance and coordination. This finding has considerable environmental implications, since a maximum level of 0·5 p.p.m. in fish may not affect Man, but be too high for fish.

Cadmium

Like mercury, this metal is very toxic. No living things seem to have any need for it. The metal builds up throughout life in everybody, but only rarely does it reach toxic levels. Also as with mercury, no cure for cadmium poisoning exists, so prevention is the only answer.

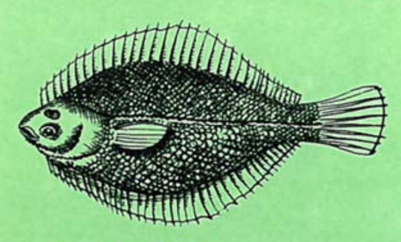
If eaten in a large dose, cadmium produces an acute response consisting of severe nausea, vomiting, diarrhoea, and abdominal pains. However, a long-term intake of small quantities produces very different symptoms.

For many years people living on the Jintsu river in Japan suffered from a disease popularly known as *itai-itai* (agony in Japanese). In the end it turned out that for many years they had been eating rice that had been irrigated with water contaminated with cadmium from nearby disused mining tips. The victims of this most painful disease suffered from, among other things, severe kidney disease and bone disorders.

The metal is also suspected of causing hypertension, cardiovascular disease, and cancer.

Oddly, zinc eaten at the same time as cadmium seems to reduce, or even prevent, some of the symptoms of cadmium poisoning.

Again, we know very little about how cadmium affects living things other than Man. At the University of Tasmania Mr M. Cassidy, under the supervision of Dr Sam Lake, has shown that a local fish, *Galaxias* (often known as whitebait or native trout), cannot detect low concentrations of cadmium in streams. The metal upsets the fish's feeding behaviour, probably by blocking its sense of smell. Affected fish fed insect larvae picked them up but didn't eat them—presumably because the larvae didn't 'taste' like food. What's more, low concentrations of cadmium seemed to prevent the fish from forming into schools, thus making them more vulnerable to predators.



Flounder is safe to eat.

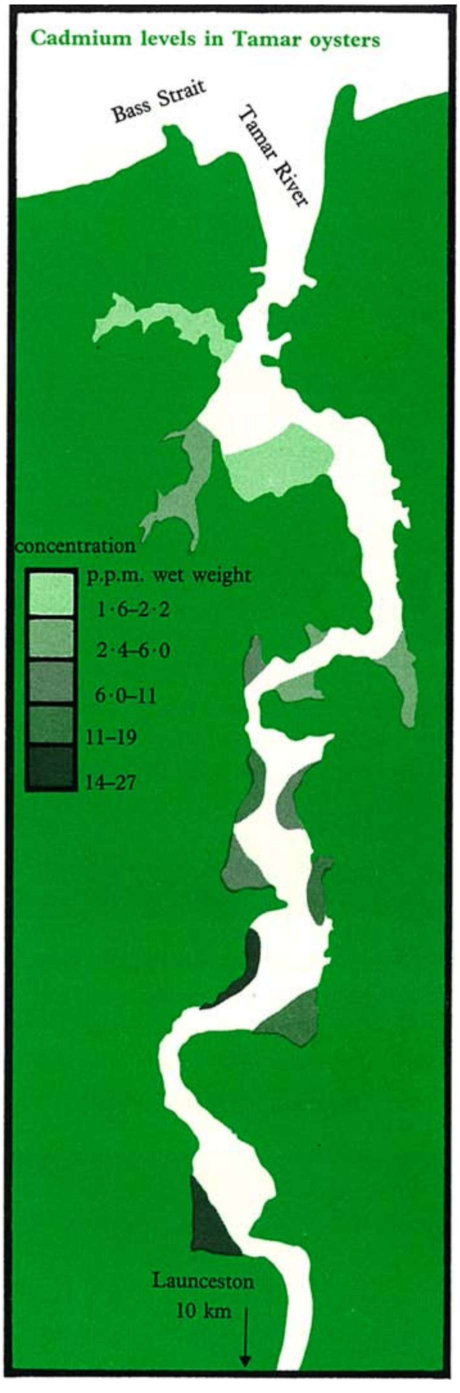
in the waters of the estuaries pose a threat other than through food. In other words they were not environmental studies. Up to now only a small amount of research has been done on the actual metal levels in the estuaries, and on the sources of pollution. The few sketchy facts available present a confusing picture.

Mr Geoff Ayling from the State Department of the Environment has recently analysed oysters collected from all the way along the 65-odd km of the Tamar River, from Launceston to its mouth. The zinc and cadmium levels both in the oysters and in samples of mud fell as the distance downstream from Launceston increased—implying that the sources of these metals lay in the direction of the town. However, the actual sources have not yet been identified, and very possibly a substantial proportion of this metal contamination derives from areas above Launceston.

At the University of Tasmania, a group of biologists led by Dr Peter Tyler and Dr Sam Lake has investigated metal pollution of the South Esk river. This river joins the North Esk at Launceston to form the Tamar. They have shown that these two metals, as well as copper, lead, iron, and manganese, enter the South Esk some 110 km further upstream—from tin and wolfram mine-workings on the Aberfoyle and Story's Creeks. The biologists have been able to detect these metals and track their biological effects as far as Evandale, about 70 km down-river. For instance, brown trout are common above the junction of the river and the Aberfoyle and Story's Creeks, but they disappear below this point, and do not reappear until about Evandale. Downstream from here they are again plentiful. But the implications of this finding for the Tamar have yet to be confirmed.

The situation on the Derwent is not

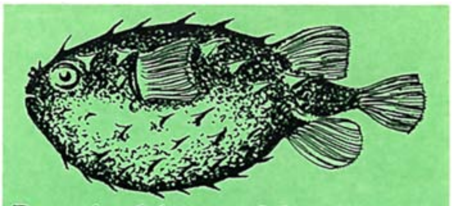
School shark often contain too much mercury.



Mean metal levels (p.p.m. wet weight) in Tasmanian oysters

	zinc	cadmium
north coast	561	3·0
east coast	486	<2·0
Frederick Henry Bay	2010	3·1
Ralph's Bay	7670	19·8
D'Entrecasteaux–Huon	698	2·2
Tamar River	1257	8·5

Upper limits allowed by Tasmanian food regulations: zinc 1000; cadmium 2·0



Porcupine fish—one of these had eight times too much mercury, but it's too poisonous to eat anyway.

much clearer. Upstream from Hobart is the very large Risdon works of the Electrolytic Zinc Co. This works treats zinc ore concentrates from western Tasmania and the mainland, and converts them to metallic zinc. Cadmium and mercury come as contaminants in the ores. Nobody seems to doubt that the works is a major source of zinc, cadmium, and mercury pollutants. The company is well aware of this and is spending more than $3m to reduce the losses at least to levels specified by the recently passed Tasmanian *Environmental Protection Act*.

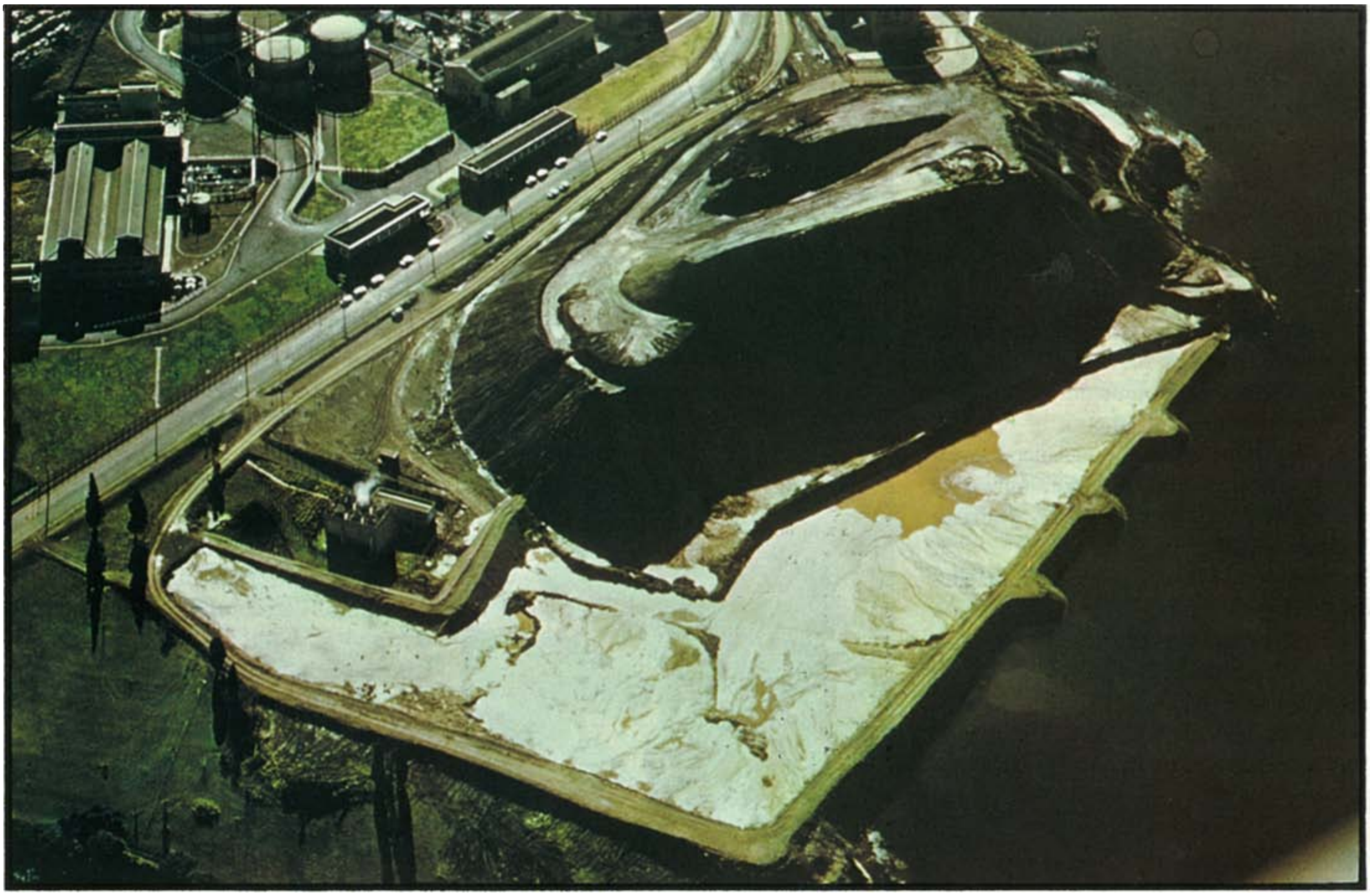
Another 30-odd km further upstream, Australian Newsprint Mills Ltd have their mill at Boyer. Some mercury does escape from this plant, but the amounts seem small. Also, the company uses nearly 100 000 tonnes of 0·3% zinc hydrosulphite per year to brighten its paper pulp, and this zinc probably does ultimately reach the river. The zinc hydrosulphite has very little cadmium contamination since it is manufactured from electrolytic-grade zinc.

A N M uses mercury in electrolytic cells, to produce chlorine and caustic soda for use in making newsprint. Small quantities also enter the mill in raw materials and chemicals used at the plant. The company estimates that each year 67 kg of mercury enter the river. This amount represents only a fraction of present losses from the E Z works.

A N M formerly used phenyl mercuric acetate to kill slimes forming in the paper-making machinery, but it stopped this practice in 1968 when it realized that the compound was harmful to the environment.

Emission levels set

In Tasmania, the *Environmental Protection Act* has been in force since the middle of last year. This *Act* sets limits on the maximum amounts of problem metals permitted in the effluents coming out of any factory. The permitted levels are very low, being 5·0 mg per litre for zinc, 0·01 mg for cadmium, and 0·002 mg for mercury. Existing companies such as A N M and E Z have been given 4 years to reduce



Primary residue heap at the Electrolytic Zinc Company.

Dumping jarosite at sea.

their effluent levels to those specified in the *Act*. The E Z Company is confident that it can meet this deadline, and already it has reduced the levels quite substantially. It will spend more than \$$\frac{3}{4}$ million of its \$3 million budget for reducing metal losses on bringing mercury losses down to the low levels the *Act* specifies.

The E Z Company has a further problem. For the past 50 years a heap of primary residue, which contains about 20% zinc, has been accumulating beside the river. In windy weather dust can blow off this now very large pile—especially when sudden squalls hit the area and the pile cannot be hosed down with water in time. The company does not know the extent of pollution from this cause.

Fears had been aroused that the dust might be affecting the health of local residents because of the lead it contains. However Professor Harry Bloom at the University of Tasmania showed that the dust particles were too big to enter the alveoli of the lungs, so this fear seems to have been allayed.

The primary residue is now being treated to recover more of the zinc by what is known as the jarosite process. Jarosite, the end-product, contains some soluble zinc and cadmium, both of which the company hopes to remove in future, but very little lead. Each year, the company produces 187 000 tonnes of this jarosite, which since November 1973 has been dumped at sea some 80 km south-east of Hobart just beyond the edge of the continental shelf in water 1500–2000 metres deep.

Permission to dump over the edge of the continental shelf must come from the Commonwealth Department of Transport. Mr Brian Newell and Mr Graham Major, of the CSIRO Division of Fisheries and Oceanography, took samples in the area from naval frigates before dumping started, and have taken further samples since that time to see if dissolved metal levels in the sea are rising as a result of the dumping. The scientists have had some indications that an on-shore current flows from November to March—a fact that may need taking into account when reviewing the agreement.

This agreement also laid down that the

crew of the dumping vessel, the *Anson*, must take samples of clean water from the dumping area before dumping the jarosite. *Anson*'s crew take this sample from the ship's bow, using a special sampling bottle that Mr Major has designed. This bottle is sealed and filters the sea-water sample automatically. The collected material is sent to the Australian Government Analyst's Laboratory at Hobart, where Mr Wilson tests the metal levels in the filtered-off solids. In spite of some technical problems with the bottle, it is hoped that these samples will indicate any long-term metal increases in the dumping area.

Where do the metals go?

At present not enough knowledge exists for the Tasmanian authorities to have much idea as to where the metal pollutants in the Derwent and Tamar estuaries go. Consequently many of the effluent requirements of the *Environmental Protection Act* have had to be arrived at by educated guesswork and a desire to err on the safe side. Currently the authorities know that certain quantities of metals are discharged into the estuaries, and that oysters and fish become contaminated. But what happens in between? The answer to this question could solve a lot of problems.

For example, Swedish research has shown that well over 90% of mercury in fish occurs in the particularly toxic form methyl mercury. But any mercury entering the rivers from naturally occurring sources or from industry does so in an inorganic form. Where does methylation occur?

Again Swedish research seems to have given the answer—the process occurs in bacteria on the estuary bottoms. To make matters worse, mercury may kill off bacterial strains that cannot methylate the metal. So the process of forming methyl mercury may become steadily more efficient as the methylating bacteria multiply. Bottom-feeding marine animals probably eat the bacteria, and are eaten in their turn by other fish—the methyl mercury becoming more concentrated at each step. There is some local evidence for this idea too.

Dr David Ratkowsky of the CSIRO Division of Mathematical Statistics made statistical analyses of the mercury levels found in the Derwent fish. His results suggested that the highest mercury concentrations did indeed occur in predatory fish-eating fish such as shark and flathead.

If the theory is correct, then Hobart's sewerage system may be playing a considerable part in the methylation process. The city of Hobart is remarkable in that practically all its suburbs are sewered, but the discharge goes straight into the Derwent estuary. Some outlets have primary treatment, but this merely reduces the unsightliness of the sewage; it does not reduce its organic matter content. Thus, much of the Derwent has a very high bacterial content—so high in fact that large areas are considered unfit for swimming. Very possibly mercury methylation occurs in these bacteria. So establishing sewage treatment plants that massively reduce the amount of organic matter entering the estuary could well reduce the effects of mercury.

Incidentally, some 40% of Hobart's sewage effluent enters the Derwent from an outlet about 5 km downstream from the Risdon works of the E Z Company. Also, untreated blood and other organic wastes enter the river from the abattoir located just upstream. It seems not unlikely that the historical quirk that placed these different sources of contaminants close together has compounded the problem.

Answers to such theories will emerge over the next few years as information comes in. The Department of the Environment is now studying metal concentrations in sediments, in the water, in material suspended in the water, in plankton, and in fish. Meanwhile other projects being carried out with close cooperation between the State Government, the University, and CSIRO should increase our understanding of how mercury and cadmium accumulate in marine animals, and how they affect human health.

In addition, a survey of mercury levels found in fish around the whole Tasmanian coast will define which areas can be safely used for commercial fishing. The main fish to be caught will be flathead—not an important commercial fish, but a predator that concentrates mercury and so indicates the metal's presence. Australian salmon and rock lobster will probably be included also.

The discovery of metal pollution in Tasmania came as a nasty shock, but it has at least stimulated a lot of research that will greatly increase our ability to assess the hazards posed by metal pollution.

More about the topic

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Heavy metals in Tasmanian oysters in 1972. S. J. Thrower and I. J. Eustace.

Metals — wet or dry?

Once in a while a newspaper reports that some staggering amount of a metal such as mercury, zinc, or cadmium has been found in seafood. The article often goes on to compare these levels with the very much smaller concentrations permitted by the food regulations. Usually what has happened is that the newspaper has quoted results expressed as parts per million dry weight, and compared them with the regulations, which are always given for seafood (and all other foods) as eaten—that is, as wet weight. And so the figures may be as much as five times too high.

The unfortunate journalist need not feel too embarrassed, as he is in august company. The Swedish National Institute of Public Health, no less, once made the same mistake when recommending safe levels for mercury in seafoods. It based these recommendations on the experience of the Japanese following the Minamata and Niigata disasters. The Japanese quoted the mercury levels in oysters as dry weight, but the Swedes assumed them to be on a wet-weight basis. As a result, to start with they set levels that were criticized as being five times too high.

A fish containing 0·5 p.p.m. wet weight means that one million kg of this fish, as eaten, contains half a kg of mercury. Many lean fish such as cod contain about 80% water in their flesh, so only one-fifth of their fillets actually consist of solids. Thus a cod from the Thames estuary quoted as having an average wet weight mercury content of 0·36 p.p.m. has $5 \times 0{\cdot}36 = 1{\cdot}80$ p.p.m. on a dry-weight basis. Shark and Australian salmon probably have a similar conversion factor. Fatty fish species such as tuna or Jack mackerel may contain 20% fat or more and the conversion factor may drop to only 2·5.

These factors should be borne in mind whenever metal concentrations in seafoods are quoted. Unfortunately the scientific literature quite often does not specify whether the metal levels are quoted in wet or dry weights. Some authors take it for granted that they are talking about wet weights when food is the topic for discussion.—*Australian Fisheries*, 1972, **32** (12), 24–5.

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Standards for metals in foods – what do they mean?

The National Health and Medical Research Council recommends the following maximum levels for heavy metals in seafoods:

metal	*p.p.m. wet weight*
zinc	1000·0
cadmium	2·0
mercury	0·5
manganese	100·0
copper	30·0

The Council consists of Ministers of Health, from the Australian and State Governments, and representatives of the major independent medical associations. The States usually follow its recommendations of food standards and include them in their regulations.

The Council sets its standards after considering what is known throughout the world about the metal-in-question's toxic properties. As knowledge about the metals increases, the standards change.

For most foods the procedure is to take the value below which the metal has no known clinical effects, and to apply an arbitrary safety factor.

The human body can get rid of most metals, although some such as mercury, cadmium, and lead only very slowly. These three can therefore build up in the body even when a person only eats very little of them. With enough knowledge it is possible to calculate how much of a metal a person can eat in his or her food before the metal rises to toxic levels.

The Joint F A O–W H O Expert Committee on Food Additives has allocated 'provisional tolerable weekly intakes' for a number of toxic metals. The Committee suggests that these intakes represent the amount a person can safely eat each week.

The trouble is, we still don't accurately know the levels below which the toxic metals have no clinical effects. So the tolerable weekly intakes may be wrong. As we get to know more about the metals' medical effects, the tolerable weekly intakes, and hence also any food standards derived from them, will change.

Take mercury for example. The Australian Standard for this metal in seafoods is based on calculations of the Swedish National Institute of Public Health.

During the Japanese Minamata and Niigata tragedies, which were caused by too great an intake of methyl mercury, the lowest blood level of mercury for which clinical symptoms were recorded was 0·2 μg per g of blood. The Swedes therefore took this as the cut-off level.

Swedish research had shown that when radioactive mercury was fed to human volunteers as methyl mercury, only 6% was eliminated within 4–5 days, and the remaining 94% had a biological half-life of about 70 days. By contrast, inorganic mercury was mostly eliminated within 4–5 days, and the rest had a half-life of about 40 days. Thus, the human body gets rid of methyl mercury—the form in which more than 90% of mercury in fish occurs—very much more slowly than inorganic mercury.

The Institute of Public Health calculated that to maintain a blood level of 0·2 μg per g would require a daily intake of 0·3 mg of methyl mercury. Thus, allowing a safety factor of 10, an 'average' 70-kg man could safely eat 0·03 mg of mercury as methyl mercury per day, giving a tolerable weekly intake $0{\cdot}03\times7=0{\cdot}21$ mg.

Therefore, if fish in the man's diet were contaminated at the food standard level of 0·5 p.p.m. (0·0005 mg per g) he could eat $0{\cdot}21\div0{\cdot}0005,=420$ g, of fish per week.

Anybody eating ten times as much could show symptoms of mercury poisoning. Also, anybody eating only five times this amount of fish containing 1 p.p.m. could show symptoms.

These calculations assume that all mercury entering the body does so through seafood, which may not be entirely true. It most certainly would not be true for cadmium, which makes it especially tricky to work out meaningful regulations for cadmium contamination of occasional foods such as oysters.

The Joint F A O–W H O Expert Committee on Food Additives has proposed a provisional tolerable weekly intake of 0·5 mg of cadmium, and the National Health and Medical Research Council has accepted this figure. In Australia we may already take in 0·2–0·3 mg per week from our normal diet, and a further 0·1 mg may come from other sources such as air pollution and cigarettes. Thus the additional amount of cadmium that a person may take in from occasional foods such as oysters is only 0·1–0·2 mg per week. If these oysters are contaminated up to the food standard of 2 p.p.m., then he can safely eat only 50–100 g of oysters per week—that's only 5–10 of the big Pacific oysters.

'Methyl Mercury in Fish.' National Health and Medical Research Council. (Australian Government Publishing Service: Canberra 1973.)

'Heavy Metal Contaminants in Seafoods—Cadmium and Zinc.' National Health and Medical Research Council. (Australian Government Publishing Service: Canberra, in press.)