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Healing the Derwent's murky blues

Twenty-five years ago, the people of Hobart were told the Derwent was the most polluted river in the world. Polluting practices have been curtailed since then, but much of the contamination remains buried in the river sediments. An integrated management program offers the next step towards restoration. **Bryony Bennett** revisits the story that *Ecos* first covered in 1974.

Alice Morris has amazing powers at her fingertips. With a few deft keyboard clicks she releases trillions of microscopic larvae and tracks their passage up and down Hobart's Derwent estuary. Not just any larvae, but those of the notorious northern Pacific seastar, *Asterias amurensis*.

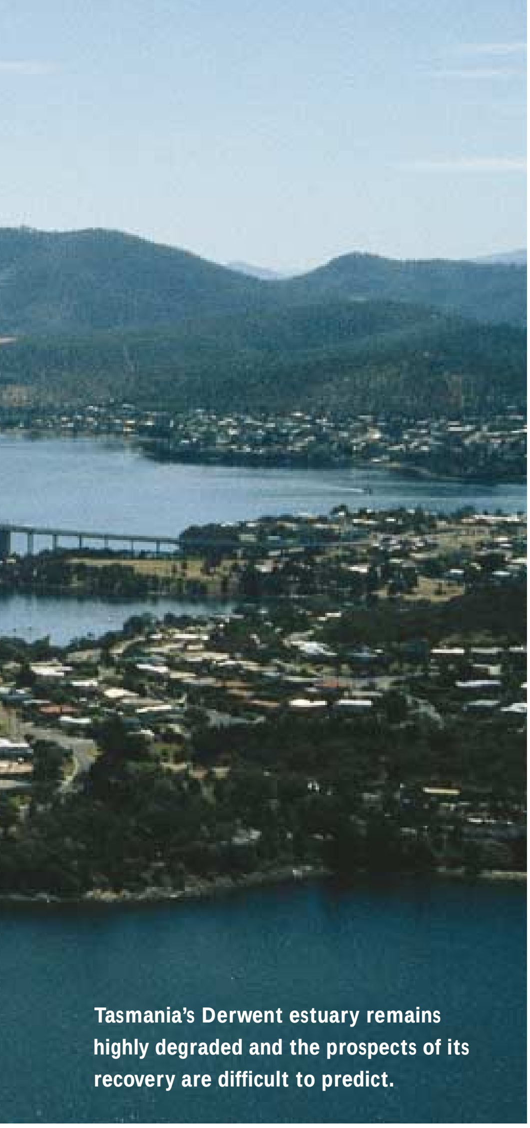
This moment crowns a three-year investigation into the fertility, ecology and larval behaviour of *Asterias*, an introduced species that has reached plague proportions in the Derwent. By modelling the movement of larvae through the estuary, Morris hopes to identify target populations for environmental control.

But the research also has broader significance. As well as reflecting 25 years of change in the way we understand and value the coastal environment, it highlights the vulnerability of a degraded ecosystem, and the daunting and costly cooperative effort required to undertake its repair.

In August 1974, the first issue of *Ecos* reported on the discovery of heavy metal pollution in the Derwent estuary. Four years earlier, people had become sick after eating oysters farmed in the lower estuary at Ralph's Bay. Analysis by CSIRO's Division of Food Research confirmed that zinc and cadmium levels in the oysters were a threat to human health. Excessive mercury levels were later found in certain species of fish.

Waste discharges from Electrolytic Zinc at Risdon, 15 kilometres upstream from Ralph's Bay, were blamed for the contamination. The company, now known as Pasminco, was established in 1917 and is one of the world's largest producers of zinc metals and alloys. Cadmium, mercury, lead and other trace metals come as contaminants in the zinc ores. Also implicated were effluent discharges from 13 sewage outfalls, and from the ANM paper mill at Boyer in the upper estuary.

The contamination of seafood in the Derwent came as a shock to the people of Hobart. It exposed how little was known about the effects of heavy metals on the estuarine ecosystem. Learning more about the problem was essential to controlling polluting practices, but there was strong opposition to the voicing of environmental concerns. What the Derwent needed

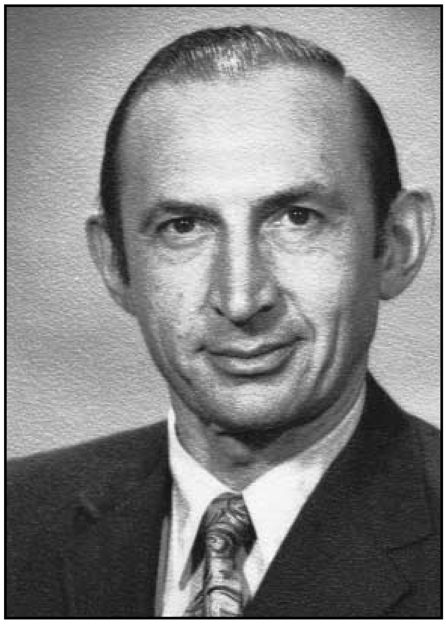


Tasmania's Derwent estuary remains highly degraded and the prospects of its recovery are difficult to predict.

was an environmental champion. And that's exactly what it found, in the form of Harry Bloom.

Bloom was professor of chemistry at the University of Tasmania. He had an international profile in the field of molten salt chemistry. When news of the Derwent's troubles emerged, Bloom made a decision to redirect his energies into understanding and controlling heavy metal pollution in the environment.

Professor Harry Bloom campaigned tirelessly to raise awareness about the contamination of the Derwent estuary, despite government and industry opposition. He also lobbied for the introduction of lead-free petrol and studied the effects of trace metals on human health. His efforts were chronicled in the Hobart *Mercury*, the source of the Kevin Bailey cartoons below. The cartoon below right was published in the mid 70s when a shortage of steel delayed restoration work on the Tasman Bridge.



Professor Barry Noller, deputy director of the National Centre for Environmental Toxicology in Brisbane, was one of several post-graduate students working with Bloom during this period. Others were Rob Dineen, manager of the environment and planning Scientific and Technical Group of the Tasmanian Department of Primary Industries, Water and Environment (DPIWE), and Dr Des Richardson, process and product support group advisor at Fletcher Challenge Paper (formerly ANM).

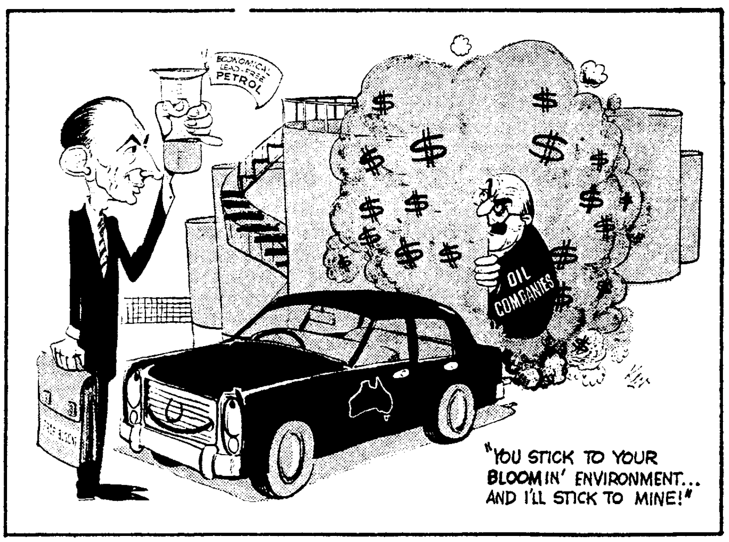
They remember Harry Bloom as an instigator of environmental awareness. He identified the need to evaluate the environmental status of the Derwent estuary and was a driving force behind the establishment of Tasmania's Department of Environment, which, with Bloom's encouragement, located its laboratory in the University of Tasmania Chemistry Department.

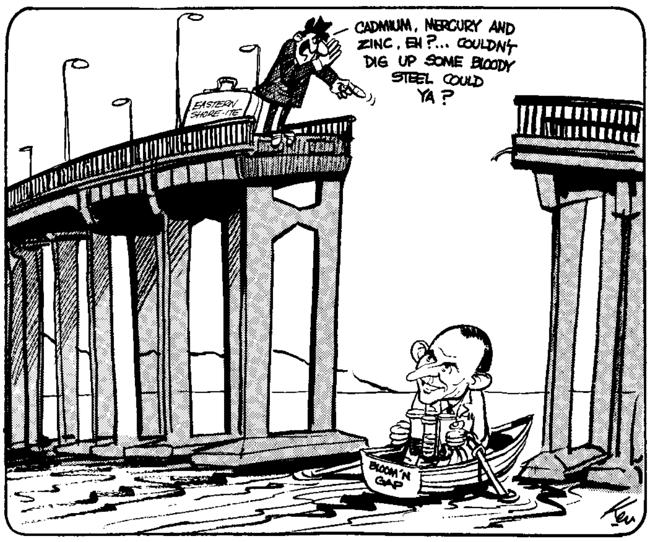
Noller says it was probably the first university in Australia to have a program on environmental chemistry. He says the collaboration fostered important studies of metals in Tasmanian waters, sediments, fish and shellfish, lead in petrol, lead poisoning in humans, and the effects of heavy metals in children's diets.

'They were interesting times,' Dineen says. 'Harry was very encouraging and most of our analytical work was at the forefront of environmental chemistry. Many of his students went on to become environmental managers in industry.'

Bloom's research featured regularly in the local media. In August 1972, his picture adorned a front-page story in the Hobart *Mercury* about the use of an atomic absorption spectrophotometer in a pioneering study of metal poisoning in humans. Also reported were his persistent efforts to demonstrate the feasibility of lead-free petrol. The stories chronicled Bloom's refusal to be deterred by government and public apathy, or industry opposition.

'In those days industries would rubbish people such as Harry Bloom because they had a vested interest in defending their polluting practices,' Richardson says. 'They really didn't want to know about the





The Pasminco zinc refinery has undergone a series of processing upgrades since the early 1970s to reduce its impact on the Derwent estuary. An environmental services group set up by the company has been biomonitoring for heavy metals in the estuary for more than 20 years.

environmental impacts of their operations. There was also widespread ignorance among the community.

'But Bloom was not a man to be put off by other people's opinions. Once he had formed an idea, he would follow it through to the end. He had a great tenacity for getting to the bottom of why things happened.'

In 1975 the University of Tasmania published Bloom's report on the extent of heavy metal pollution in the Derwent estuary. Noller says the findings were not welcomed at the time by Electrolytic Zinc, 'but it had credibility and could not be ignored'.

'Areas of the River Derwent have higher percentages of mercury, zinc, lead and cadmium than ore bodies at Broken Hill,' the *Mercury* reported in July 1975. In the story Bloom branded the Derwent the 'worst polluted river in the world' and said it would take hundreds of years, if pollution were stopped completely, for the river to clean itself through natural tidal action. 'To clean up the river quickly will take considerable study and many millions of dollars,' Bloom said.

Dr Ed Butler of CSIRO Marine Research calls it a 'pivotal point in Australia's environmental history'. 'Bloom put his career on the line, and completed research that still stands up today,' Butler says. 'He had the courage to say something serious was wrong. It was a brave move at the time as there was a lot of negative feedback. Today there's a different philosophy.'

Des Richardson agrees. 'Industries today have a much better understanding of their environmental impacts,' he says. 'They're no longer acting from a position of ignorance. We (Fletcher Challenge Paper) can now talk seriously and openly about environmental issues and share our knowledge. It's a totally different situation to 25 years ago.'

But the real test of the new philosophy is how it translates into action. Have 'many millions of dollars' been committed to research and restoration? Or is the Derwent still waiting for its troubles to trickle out with the tide? The answer probably lies somewhere in between.

Changes won

The environmental status of the Derwent estuary was reviewed in 1997 as part of the three-year Riverworks Tasmania program managed by the DPIWE and funded by the Natural Heritage Trust. The review was led by Christine Coughanowr, manager of the Derwent Estuary Program, a joint Federal, state and local government initiative to restore and protect the Derwent estuary. Her report, *State of the Derwent Estuary*, carried both good news and bad.

Much of the good news surrounded reductions in end-of-pipe emissions from sewage treatment plants and industries. These had yielded some improvements in water and sediment quality, including a reduction in sludge-affected areas downstream of Fletcher Challenge Paper, and a decrease in some extreme heavy metal concentrations off Pasminco.

This was a significant step forward. Some 10 years ago, most of Hobart's sewage received only primary treatment or secondary treatment without disinfection and all of it was discharged to the river or estuary. High concentrations of bacteria compounded the Derwent's pollution problems, particularly near the estuary's sewage outfalls.

According to DPIWE senior environmental officer, Greg Dowson, the past 10–15 years has seen a major commitment by councils up and down the Derwent to improve sewage treatment levels and reduce pollutant discharge. All the larger plants have moved to secondary treatment with disinfection, with two installing nutrient removal facilities in the past three years. A major advance has been the move from raw sewage discharge at the Sandy Bay sewage outfall to full tertiary treatment of the sewage at the Selfs Point Treatment Plant.

Dowson says the ultimate goal in Tasmania is full effluent reuse where feasible. This is being achieved by the Brighton Council, some 40 km up the Derwent, which is in the process of diverting its entire treated wastewater to water crops such as poppies, fodder and tree plantations. The council's approach to environmental management was rewarded in June 1999 with the inaugural Tasmanian Environment Minister's Sustainable Development Award.

Another award winner was Pasminco, which was praised by Tasmanian Environment Minister, David Llewellyn, for adopting new smelting technology. Since 1973, the company had used the jarosite process to recover zinc from waste iron residues. Dust from the residue stockpile was a source of heavy metal pollution. Until 1997, the waste jarosite, which contains zinc, cadmium and other trace metals, was dumped at sea under Federal Government licence. The historical jarosite residue is now being sealed and the by-product of the new process, paragoethite will be sent to Port Pirie in South Australia for further treatment.

The move heads a long list of processing upgrades by Pasminco spanning almost three decades. Other steps taken to reduce its environmental impact have included recycling of previously discharged surface, ground and process waters; effluent treatment to reduce trace metal discharges to river outfalls; and installation of an acid plant to improve mercury removal. The effort is continuing with upgrades to the plant's drainage system and development of a wetland for stormwater retention. An environmental services group set up by Pasminco has been biomonitoring for heavy metals in the estuary for more than 20 years.

The major processing improvement made by Fletcher Challenge Paper has been its installation in 1990 of a primary effluent treatment plant. But the company has delayed plans for a $30 million secondary treatment facility – originally scheduled for commissioning in 1998 – pending results of a major two-year ecological risk assessment. Des Richardson says this will show whether effluent from the mill is causing environmental harm and target what further effluent treatment is needed.

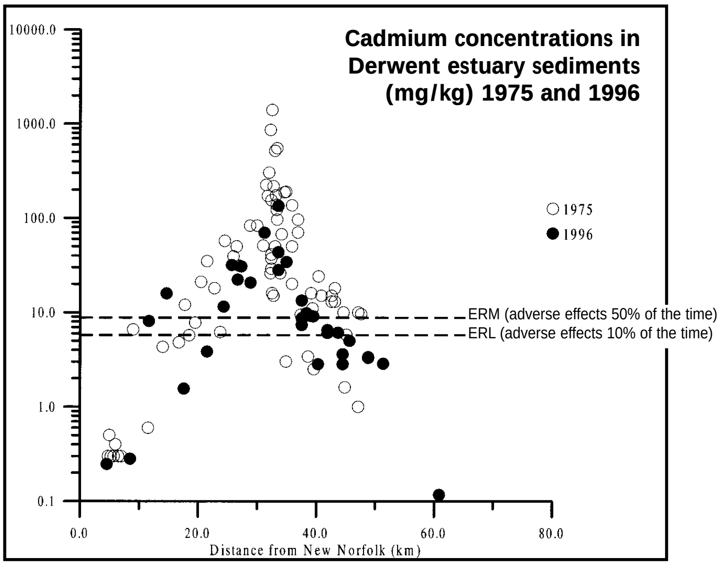
According to *State of the Derwent Estuary*, the effects of suspended solids and organic matter discharged to the upper estuary include sludge accumulation, depressed dissolved oxygen levels and impoverished benthic communities. Resin acids, organic compounds released by pines during pulp production, also affect the upper estuary. These are toxic to fish at less than one milligram per litre.

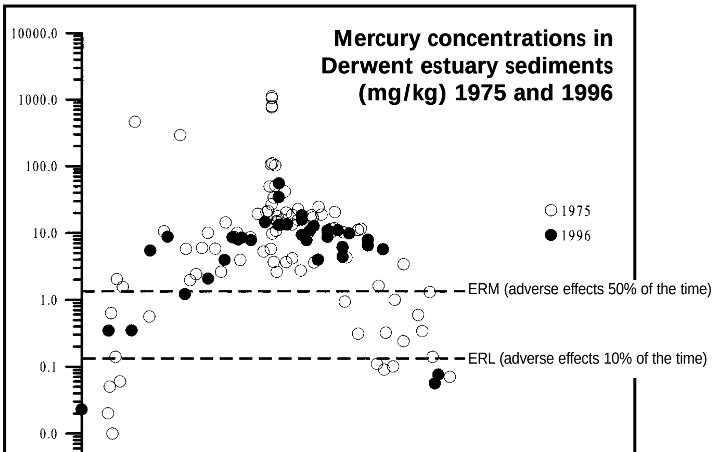
Sedimentary secrets

Two years before his death in 1992, Harry Bloom asked the Department Environment and Land Management to re-monitor the estuary using the same sampling sites as in

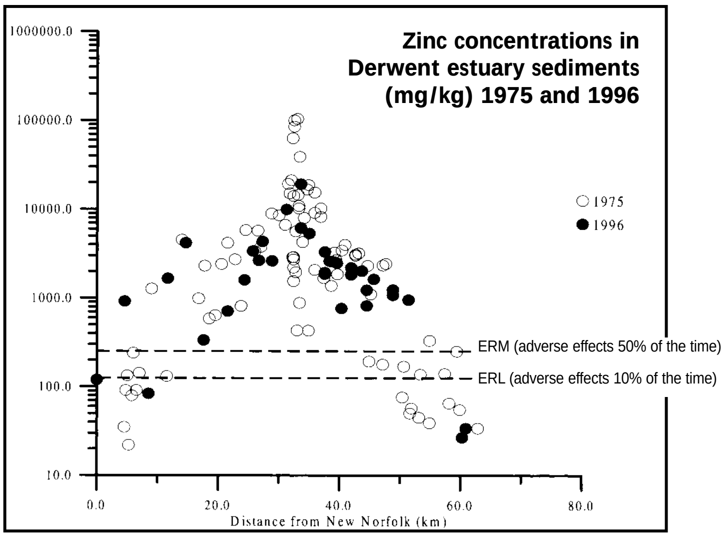
Below: A 1996 study of the Derwent estuary sediments by Helga Pirzl found there had been little reduction in heavy metal levels since the first surveys conducted by Professor Harry Bloom in 1975.

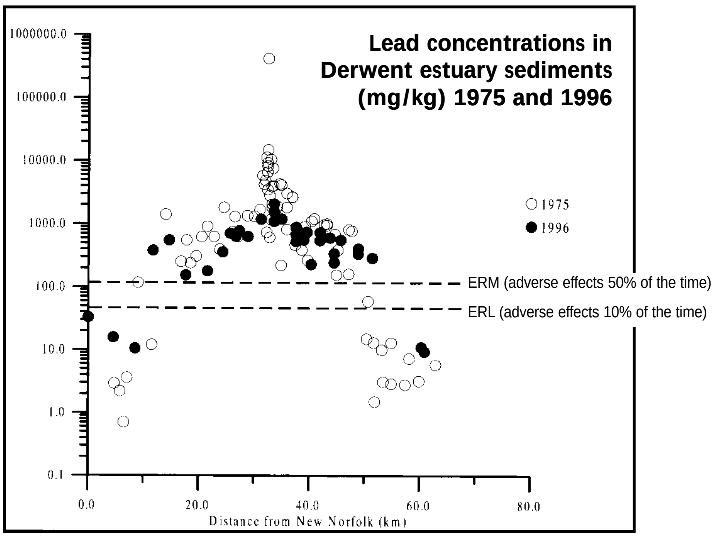
Right: Pirzl collected sediment cores from 36 of the 100 sites surveyed by Bloom.

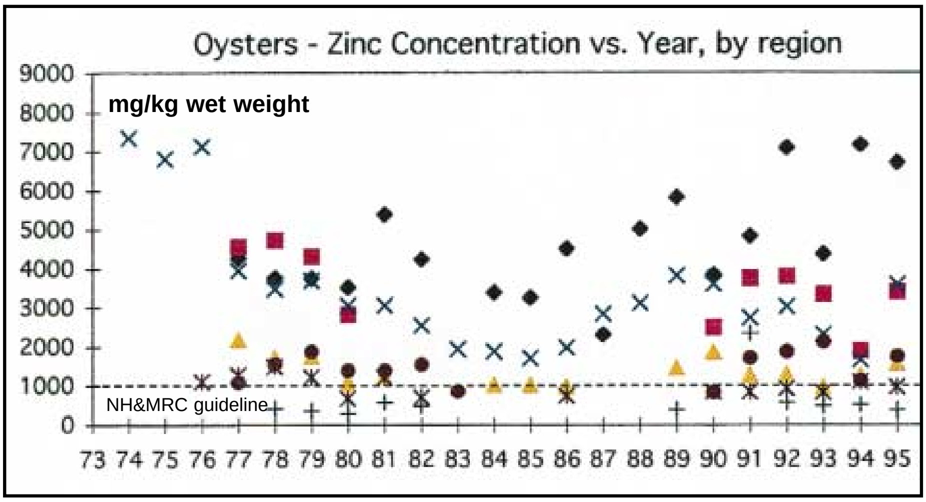


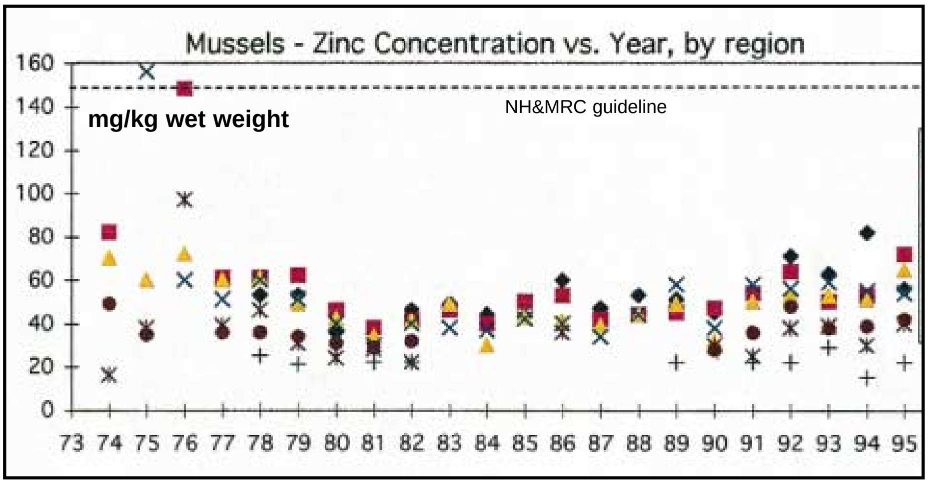


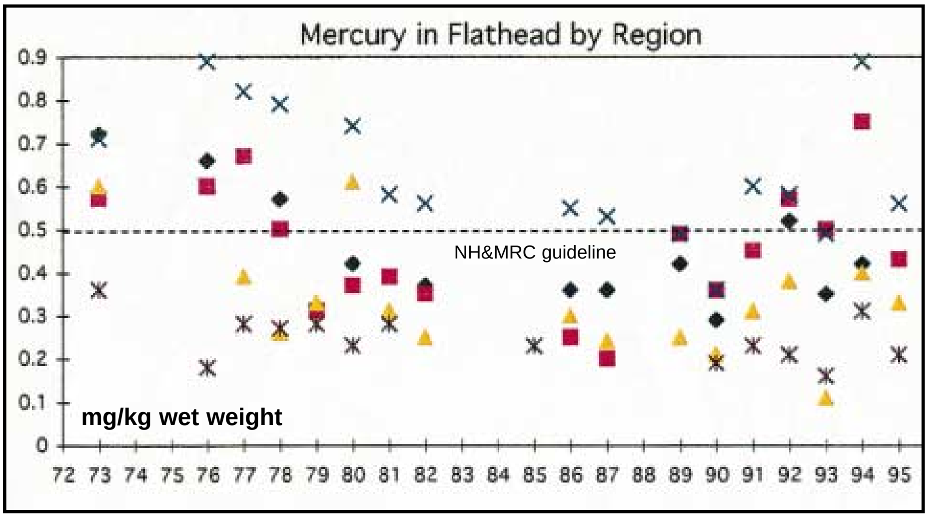
Source of graphs: *State of the Derwent Estuary*, 1997











Source: *State of the Derwent Estuary*, 1997 (after PMEZ 1996 EMP)

Key to regions

- ◆ Above Tasman Bridge
- ■ Eastern shore
- ▲ Western shore
- ✕ Ralph's Bay
- ✱ D'Entrecasteaux Channel (outside estuary)
- ● Fred Hardy Bay (outside estuary)
- + Background

A 25-year record of annual fish and shellfish monitoring data has been compiled by Pasminco. The record suggests there has been no significant decrease in heavy metal levels in monitored species since the mid 1980s. This is thought to be due to a saturation of heavy metals in the river sediments.

1975. The resulting study, completed by Barry Noller and Rob Dineen, found a reduction of cadmium, copper, mercury and lead concentrations in fish and shellfish. But zinc levels still exceeded National Health and Medical Research Council guidelines.

Unfortunately, it appears that 1989 was a particularly 'clean' year for Derwent estuary biota. Since then, the full 25-year record of annual fish and shellfish monitoring data has been compiled by Pasminco. The record suggests there has been no significant decrease in heavy metal levels in monitored species since the mid 1980s.

Noller says zinc levels in the water relative to background remain high because years of discharge from the refinery has caused a saturation of zinc on the river sediments.

'This zinc continues to be released from the sediments to the water column, even though discharges from Pasminco have been reduced,' he says. 'Shellfish take up zinc released to the water column from the sediments. It is possible that further treatment of sewage prior to discharge has removed components such as fine solids which previously complexed the zinc and other heavy metals, now making more metal available to shellfish.'

In 1996, University of Tasmania honours student Helga Pirzl collected water samples and sediment cores from 36 of the 100 sites visited by Harry Bloom. Her aim was to plot the change in distribution, concentrations and range of heavy metals from New Norfolk to the estuary mouth. The analysis confirmed that although the water quality had improved, there had been disturbingly little reduction in heavy metal levels in the Derwent sediments.

Pirzl's findings, and Pasminco's long-term monitoring records, came as an unwelcome surprise, even to the people who had been working in estuary monitoring and management. 'There was a perception that things were getting better,' Christine Coughanowr says. 'But there hadn't been nearly as much improvement as everyone had hoped and thought.'

Strong attack, or poor defence?

Coughanowr's report identified another formidable danger in the Derwent's murky depths. The northern Pacific seastar has colonised large areas of the estuary during the past 10–15 years, and is likely to have dramatically reduced the numbers and species of other benthic (bottom dwelling) organisms

Bruce Miller

Asterias has also become established in Melbourne's Port Phillip Bay and appears likely to spread to South Australia and New South Wales. Its alarming advance has prompted a search for biological and genetic controls, but current research indicates that improved management of coastal waters might be a simpler, more cost-effective means of reducing the seastar's impacts.

Head of Zoology at the University of Tasmania, Professor Craig Johnson, says it has long been assumed that *Asterias* can displace native species assemblages in its own right. With an estimated 30 million of them in the Derwent, and 12 million in Port Phillip Bay, it's easy to see how the theory emerged.

But in the early 1990s, scientists began noticing that *Asterias* was not becoming established outside the Derwent. Recent studies by PhD students Alice Morris and Jeff Ross, working with Johnson, and supported by CSIRO's Centre for Research on Introduced Marine Pests, have been investigating new theories about the seastar's invasive potential.

'Part of the reason for its high numbers is that *Asterias* is extremely fecund,' Johnson says. 'Each female in Tasmania produces, on average, about two million eggs annually, fertilisation takes place in the water and the resulting larvae float in the current for three to four months until they are competent to metamorphose. They then settle to the bottom where metamorphosis is triggered by chemical cues, and the larvae transforms into a juvenile starfish the size of a pinhead.'

Given their high reproductive potential, the distribution *Asterias* is intriguing, Johnson says. 'We estimate that a fair few of the larvae are advected out of the river, and certainly lots of juvenile seastars have appeared over the years at different places on the east coast, such as at marine farms between the estuary and Maria Island,' he says. 'Despite this, until recently *Asterias* hasn't established itself in large numbers outside the Derwent.'

Experiments by Jeff Ross have shed light on this apparent mystery by showing that juvenile starfish are susceptible to native predators. 'Jeff's preliminary results suggest that larvae are getting out (of the Derwent), metamorphosing, and being eaten in short order,' Johnson says. 'If that's what's happening, *Asterias* is not driving the dynamic of the ecosystem. It may be tracking other processes such as ecosystem disturbance.

'When there are pristine conditions and lots of predators there is no evidence of damage by *Asterias*. It doesn't mean they can't invade, but it appears they are less likely to. Of course, once the starfish reaches some threshold density, they may switch from 'trackers' of disturbance to 'driving' the ecosystem dynamic, as has occurred in the Derwent.'

Should this theory be proven, it will have important implications for the seastar's management: if *Asterias* can't displace native species, but has to track disturbance, then the management of disturbance can help to control *Asterias*.

Top: Laboratory experiments by PhD student Alice Morris have given clues to how the behaviour of *Asterias* larvae influence their dispersal throughout the Derwent estuary and beyond.

Above: *Asterias* indulge in a feast of mussels on the river bed. Management practices that reduce such plentiful food supplies may help to control seastar numbers.

Further studies will help pinpoint how and where such management might be targetted. For example *Asterias* adults are known to aggregate in places where humans kindly provide a plentiful supply of food. These include areas around wharves, bridges and yacht clubs where mussels are washed off boats or shaken into the water from pylons by passing traffic.

Seastars respond to such plenitude by producing more eggs and sperm. When combined with their aggregation, this greatly enhances the seastar's reproductive success. In response to starvation, however, the reverse occurs. So the simple removal of a food supply might reduce the seastar's fecundity, and cause them to disperse in search of food, lessening the chances of fertilisation.

Complementary research by Alice Morris aims to determine how *Asterias* larvae move through and out of the estuary, and which populations contribute to successful fertilisation and recruitment.

In experiments at laboratories of the Tasmanian Aquaculture and Fisheries Institute, she has observed the behaviour of larvae in experimental water columns under varying light conditions and salinity gradients. The experiments offered clues to the effects of larval behaviour on their dispersion through the estuary where fresh water from the river 'floats' above saltier water from the ocean. Their results are being incorporated in a hydrodynamic model of the estuary developed during CSIRO's Coastal Zone Program (See *Ecos* 83.)

'We think that larval behaviour may play an important role in their dispersal,' Morris says. 'They can't swim against the current to change horizontal position, but they can move vertically to place themselves in water of favourable salinity, and this may alter their horizontal dispersal.'

Morris is also working on a separate model of dispersion and fertilisation of seastar gametes with the aim of predicting fertilisation success of different populations in the Derwent. It is hoped the modelling exercises will aid environmental management of the seastars by identifying their major breeding grounds.

'The situation may be less disastrous than was first thought,' Johnson says. 'Sensible environmental management, such as not dumping mussels or other food into the water, reducing nutrient loadings, and maintaining healthy and diverse ecosystems might offer a simpler, and cheaper, solution than measures such as biological or genetic controls which are costly and take years to develop. It's a whole lot easier to stop force feeding the little buggers and maintain a suite of natural predators, and there are so many other benefits too.'

Vision splendid

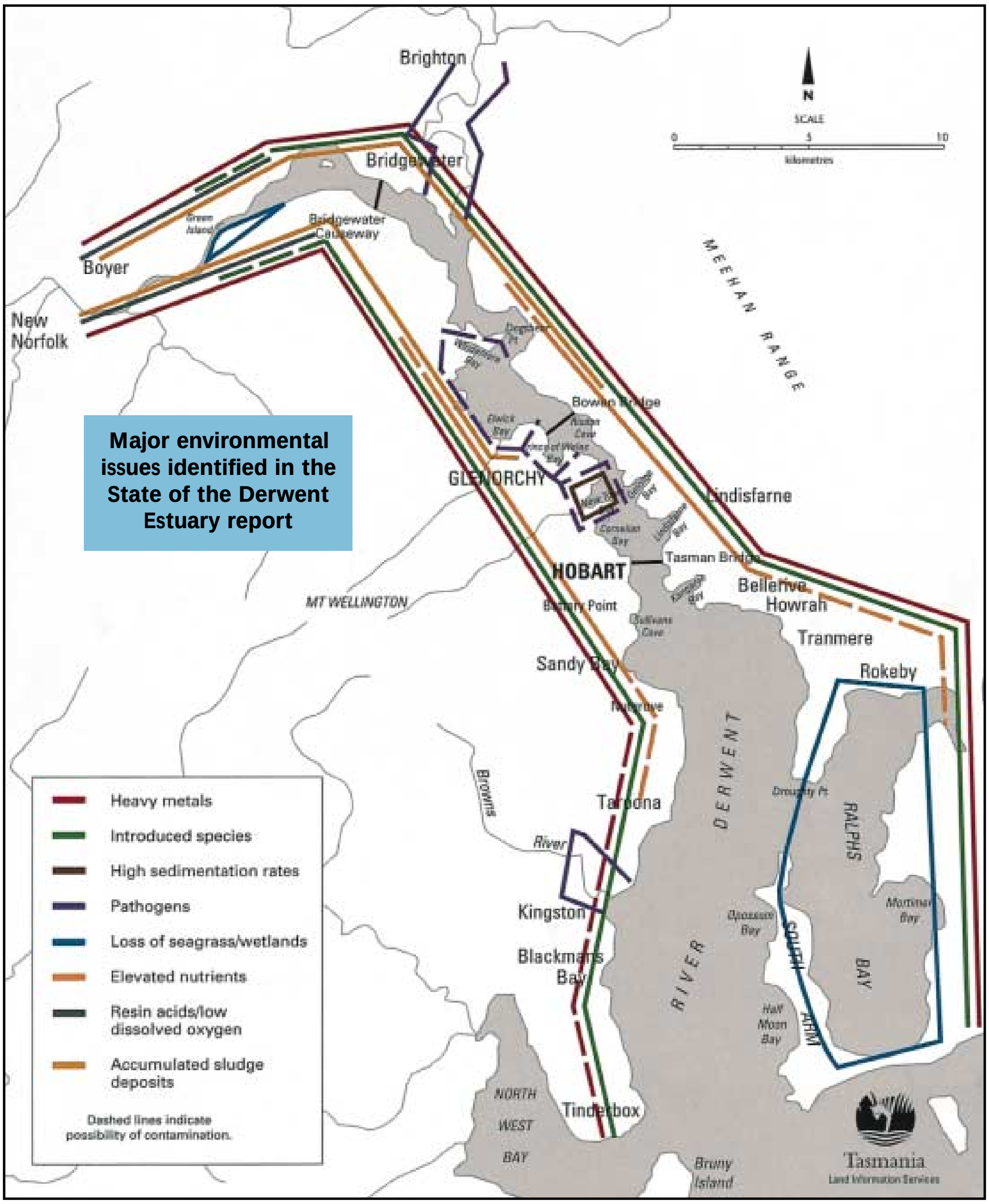
Hopes of addressing the environmental problems that plague the Derwent estuary now rest with the Derwent Estuary Program. The program, which kicked off last year, provides a framework under which the Tasmanian Government and six local councils are developing a shared vision for the estuary, as well as a strategic management plan to help achieve it.

'There has been interest in developing such a plan for years,' Coughanowr says. 'A $175 000 Natural Heritage Trust coastal planning grant has been the catalyst to get it off the ground.'

Coughanowr admits it's a huge challenge. The logistics of organising community and stakeholder participation in the program are mind-boggling enough, let alone the technical complexity of managing such a hugely diverse ecosystem. Then there is the vital task of securing long-term commitments to funding and implementation.

In recognition of this need, the program has an inbuilt accountability mechanism: the council mayors and the Premier of Tasmania have pledged their support through a formal Memorandum of Understanding. Coughanowr wants to see this approach extended to the management plan.

Ultimately, our goal is to implement the management plan through a series of agreed projects, formalised via implementation agreements between the relevant parties,' she says. 'For example, an agreement to manage stormwater runoff by implementing specific



Major environmental issues identified in the State of the Derwent Estuary report

projects might be signed between councils, industries and the State Government.'

Such agreements will be needed to tackle the many diffuse pollution sources that affect the estuary, and their associated contaminants. In addition to urban run-off, these diffuse sources include, tips and contaminated sites, catchment inputs carried in the Jordan and Derwent rivers and atmospheric contributions.

Coughanowr believes that flexibility in the management process will be vital to the program's success. 'You have to tailor the approach to the situation and constantly re-evaluate,' she says. 'We will have to be realistic in our goals, and we may have to target projects that are economically and politically feasible. We walk a narrow line between priorities and resource availability.'

This is likely to be felt in the area of research, the pace of which has seriously waned since that flurry of activity in the 1970s. CSIRO Marine Research studied water flows and pollutant dispersal in the estuary as part of its Coastal Zone Program earlier this decade, but on the whole, knowledge of the Derwent ecosystem is embarrassingly thin.

The management plan will set new research priorities. Chief among them will be the need for a better understanding of the sediments. Nobody can say how big a store of heavy metals the sediments contain, what conditions might stimulate their absorption and release, or their wider effects on the Derwent ecosystem. Nor have they been mapped or quantified.

Further mysteries surround the rates of sedimentation. How long would it take for the contaminated sediments to be buried and what biological dilution processes are at play? What influence has the damming of rivers for hydro-electricity had on the downstream movement of sediments?

More information is needed on the distribution, abundance and status of the estuary's habitat types and species. Four hundred hectares of seagrass beds have disappeared from Ralph's Bay in the past 50 years, but few data exist on these ecosystems.

Another concern is the effects of heavy metal contamination and introduced marine pests on native species such as the endangered spotted handfish. Whether significant changes have occurred to the sedimentary habitats previously occupied by spotted handfish has not been investigated.

Without this information, the prospects of the Derwent's recovery are difficult to predict. It may depend on how successfully Coughanowr and her team can prick and keep pricking the public consciousness, just as Harry Bloom did back in the 1970s.

'Undoubtedly the pollution of the Derwent estuary has taken too long to address,' Coughanowr says. 'There's been a bit of complacency. People have become used to not being able to eat the shellfish. But the Derwent is a valuable asset that needs to be lobbied for.'

Rob Dineen says the program will finally pull together what Harry Bloom started all those years ago. 'Things are improving as a result of his original stirrings,' Dineen says. 'Where everyone was once off side and the issue was ignored, now councils and industry are saying "this is what we want to do".'

Ralph's Bay, the original site of shellfish contamination, remains the most polluted part of the Derwent estuary and has experienced severe habitat degradation.

More about the Derwent

Beckmann R (1986/87) Oysters and zinc – the Derwent revisited. *Ecos* 50.

Coughanowr C (1997) *State of the Derwent Estuary*. Supervising Scientist Report 129, Canberra.

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Toxic metals in Tasmanian rivers (1974) *Ecos* 1.

Abstract: Decades of uncontrolled industrial and sewage discharge into the Derwent estuary has depleted the health of its water and sediments. Particular problems are the trace elements zinc, cadmium, lead and mercury which shellfish from parts of the estuary contain in toxic high levels. The degradation of the estuary may have assisted the spread of the northern Pacific seastar which exists in the estuary in plague proportions. Considerable efforts have been made by the main historical polluter, Pasminco, and by local councils, to reduce their environmental impact, but the ecology of the estuary, and the processes of heavy metal fluxes in the sediments are poorly understood. Further research will be supported by a new, integrated management strategy coordinated by the Tasmanian Department of Primary Industries, Water and Environment.

Keywords: Derwent estuary, Tas., Derwent Estuary Program, northern Pacific seastar, *Asterias amurensis*, introduced species, heavy metals, zinc, marine species, effluent discharge.