

# MANGROVE DIE-BACK IN BOTANY BAY

W. G. ALLAWAY

School of Biological Sciences  
University of Sydney  
NSW 2006

This paper reports observations on the effects of oil pollution on mangroves in Botany Bay. Observations of the short-term effects (large-scale seedling kill and defoliation of all oiled leaves on bushes; death of some pneumatophores) of one oil contamination incident are reported first. Secondly, it is suggested that the correlation between oil contamination and die-back of mature mangrove trees indicates a long-term effect of oil pollution which has not previously been reported in Australia. If mangroves are to be retained in the Towra Point/Quibray Bay area they must be protected from contamination by oil. Prevention of oil spills, and measures for the collection and containment when they do occur, need much improvement.

## SHORT-TERM OIL SPILL EFFECTS

On 10th September 1979 the ship 'World Encouragement' ran over its own anchor as it was mooring at the deep-water terminal in Botany Bay, punching a hole in the hull and releasing about 100 tonnes of Arabian crude oil into the bay. This oil quickly spread into a large slick and, despite attempts to contain, collect or disperse it, much of the oil finally ended up in the mangrove swamps of Towra Point and Quibray Bay (see Figure 1). The oil contaminated all parts of the plants up to about 1 metre above the mud surface at the front of the swamp, and to lesser heights above the mud surface as it progressed further landward. In places where oiling was severe, small seedlings were totally oiled, pneumatophores and the mud surface were completely covered, and the lower leaves of bush mangroves were heavily oiled. While oil that had come ashore on sand beaches was relatively easily collected with front-end loaders or rakes and shovels, and disposed of by burying above the high-tide mark or by carrying it away to a dump, oil in the mangroves proved very difficult to remove. Attempts were made — largely unsuccessfully — to soak it up in straw for removal; in one small area to the south of Quibray Bay some success was had in washing the oil out of the swamp with high-pressure hoses (although this method is much too laborious for large-scale use). We recorded the progress of the oil slick and the clean-up operations, and we made monthly visits to contaminated and 'control' areas afterwards to assess the effects of the spills: some of the results are summarised in Table 1.

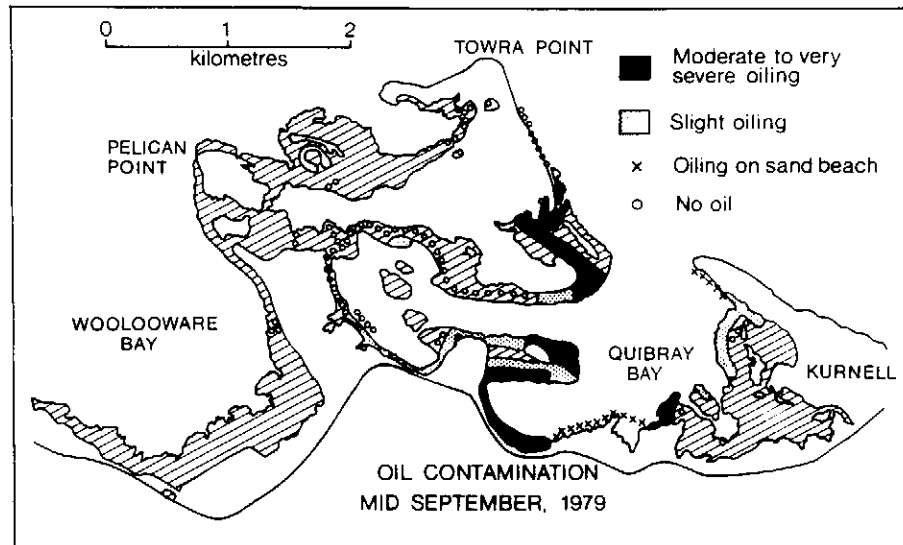


Figure 1. Oil contamination of beaches and mangrove areas of the southern shore of Botany Bay surveyed 11-18 September 1979, from the 'World Encouragement' spill. Mangrove area is shown diagonally hatched. All areas visited in the survey are shown by symbols "O", "X", dotted or black: other areas were not surveyed at this time.

TABLE 1

Survival of oil spill by *Avicennia marina* at Towra Point

|   | Oiled Site      |              |             | Control Site    |              |             |
|---|-----------------|--------------|-------------|-----------------|--------------|-------------|
|   | Number alive on |              |             | Number alive on |              |             |
|   | 13 Sept 1979    | 8 April 1980 |             | 13 Sept 1979    | 8 April 1980 |             |
| Previously labelled seedlings                             | 8               | 3            |             | 5               | 5            |             |
| Newly labelled seedlings                                  | 6               | 1            |             | 6               | 6            |             |
| Seedlings sprayed with seawater                           | -               | -            |             | 6               | 6            |             |
| Seedlings sprayed with BPAB                               | 6               | 0*           |             | 6               | 0*           |             |
| Seedlings sprayed with Corexit + water                    | 6               | 2            |             | 6               | 3            |             |
|   | 13 Sept 1979    | 11 Feb 1980  |             | 13 Sept 1979    | 11 Feb 1980  |             |
| High level shoots or bushes                               | 6               | 6            |             | 6               | 6            |             |
| Low-level shoots on bushes                                | 6               | 1            |             | 6               | 6            |             |
|   | 13 Sept 1979    | 10 Jan 1980  |             | 13 Sept 1979    | 10 Jan 1980  |             |
| Leafy shoots on trees                                     | 20              | 20           |             | 20              | 20           |             |
|   | 13 Sept 1979    | 8 Oct 1979   | 10 Jan 1980 | 13 Sept 1979    | 8 Oct 1979   | 10 Jan 1980 |
| Pneumatophores under trees - percentage found to be alive | 93.3 ± 2.3      | 80.5 ± 1.7   | 74.1 ± 1.9  | 97.5 ± 0.7      | 97.5 ± 0.7   | 90.6 ± 3.6  |

Seedlings and leafy shoots were labelled with tags either before or at the time of contamination by the spilled oil. Similar ones were labelled at a non-contaminated site (control). Oil severely contaminated seedlings, pneumatophores and low-level shoots at the oiled site: high-level shoots and shoots on trees were above the level of oil contamination. Pneumatophores were counted in 0.25m<sup>2</sup> quadrats randomly located under mature trees at both sites: means of 6 quadrats ± standard error are shown.

\*The two rows in the Table showing seedlings sprayed with BPAB and Corexit refer to attempts to clean up seedlings by spraying them until completely covered with the dispersants BPAB (undiluted — about 20 ml per plant) and Corexit 9527 (diluted 1 + 9 with seawater — about 40 ml per plant): both dispersants were as toxic as oil or more so — in the case of BPAB the seedlings were all dead after 2 months.

Most of the small seedling mangroves that had been heavily oiled died, as did most of the severely oiled lower leaves of bush mangroves ('low-level' shoots in Table 1). This resulted in an appearance resembling the 'browse-line' left by sheep or cattle grazing in wooded country. The only short-term effect we observed on mature mangrove trees was a statistically significant increase in the proportion of dead pneumatophores in the oiled site over a 4 month period: there were no apparent ill effects on leaves of the tree mangroves at this time. Besides the results shown in the Table, we recorded by 11th February, 1980 the sudden appearance of 'die-back' in 53 mangrove bushes at the severely oiled site at Towra Point: 51 of these bushes showed all their leaves dried up and brown (although still attached to the twigs) and in the other two the leaves were still green, but limp and wilted. The appearance was very much like that of a *Phytophthora*-induced die-back (see Pegg and Foresberg 1981) and at the time there seemed to be no particular reason to connect this occurrence with the oil spill 5 months before. By the end of May, 1980, when regular recording was terminated, these 53 bushes were dead sticks, but no further spread of the disorder had been noted.

I was away from Sydney for about a year, and next visited the southern shores of Botany Bay in August 1981. In the intervening period there had been another major oil spill affecting the mangroves of Towra Point and Quibray Bay: this was a spill in early 1981 from the Matraville refinery which entered the bay via a storm-water channel. Precise information as to the areas contaminated has been hard to find, but from talks with oyster fishermen and others it seems clear that the areas contaminated were broadly similar to those of the 'World Encouragement' spill. The frequency with which oil spills severe enough to contaminate the mangroves occur, regrettable though it is, was not a surprise to us: in fact we had already been monitoring the effects of a smaller spill in January 1979, hence the 'previously labelled' seedlings in Table 1. It seems on the basis of the past three years' experience that an average of about one serious mangrove oil-contamination occurrence is to be expected each year.

#### MANGROVE DIE-BACK

By August 1981 large areas of mature mangrove trees had died in the Quibray Bay/Towra Point area (e.g. Fig. 2). On casual inspection the areas affected seemed strongly correlated with those contaminated by oil in the 'World Encouragement'

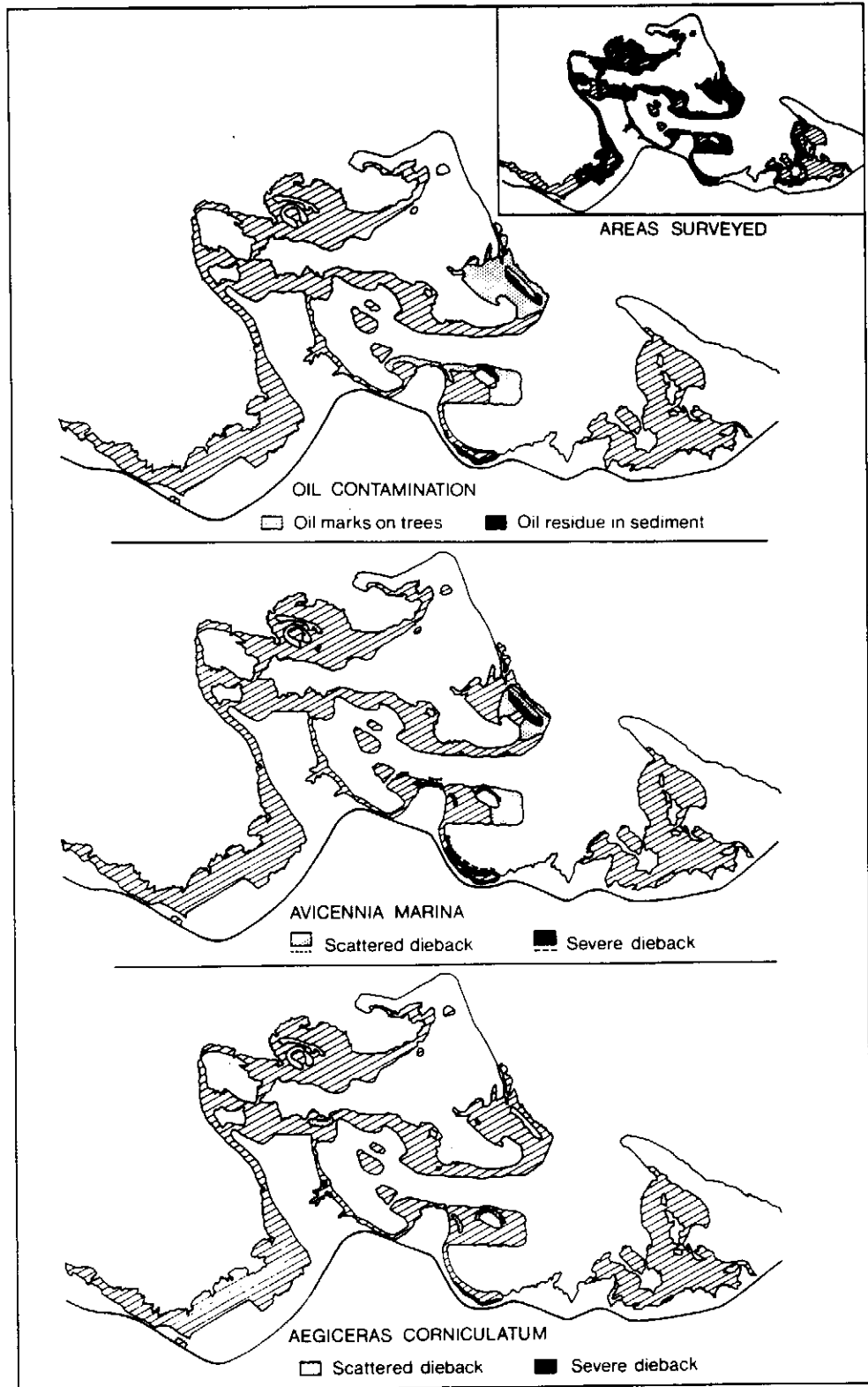


Figure 3. Survey of southern Botany, 12 August – 10 September 1981. Inset map shows in black all the areas visited in the survey.

and later spills. Therefore we made a comprehensive survey of the mangroves from Kurnell to Woollooware Bay, both for areas of die-back and for visible oil contamination. The areas covered, and the results, are shown in Figure 3. Oil contamination was both heavy and widespread, with thick residues of oil just under the mud surface in places of severe contamination. These places corresponded to the places worst hit by the 'World Encouragement' spill and, according to reports, by the Matraville spill. The oil residue has remained; if we walked through these areas at high tide, small oil slicks bubbled up behind us in our footsteps (Fig. 4). On the tree-trunks the oil has 'weathered'; so that by now only a tarry residue is left, but in the mud the process of 'weathering' is much slower; the oil is still liquid and presumably retains many of the lower molecular weight fractions. These are likely to include the more toxic fractions.

Most of the areas of severe contamination correspond to areas of severe mangrove die-back (Fig. 3). Mature mangrove trees up to about 8 metres tall have died, and in the 'severe' patches every tree is dead (Fig. 5). Bush mangroves and seedlings were affected too, so that in mid-1981 these areas had no living mangrove in them. Seedlings from the late 1981 seed fall have established in many of these areas, however, and so far (January 1982) seem to be growing successfully. In less severely affected areas (Fig. 3) bush mangroves and occasional tree mangroves were wholly or partly killed at late 1981. There is such a strong correlation between the oil contamination remaining and the presence of die-back that a causal connection seems very probable. The area surveyed included mangroves of similar size, similar aspect, similar exposure and similar tidal levels in non-contaminated areas, and nowhere in the non-contaminated areas was there any sign of recent die-back. There were some tiny patches on Woollooware Bay (— Fig. 3) — but these all clearly are long-dead and pre-date the oil spills being considered. Similarly there are two large patches of mangroves which died back about 1975 near Kurnell village (shown as patches of non-mangrove area surrounded by mangroves on the maps) but no satisfactory explanation of these has yet been advanced. They certainly pre-date this study.

Mangrove die-back in Botany Bay has affected *Aegiceras corniculatum* as well as *Avicennia marina* (Fig. 6). Dead *Aegiceras* is also strongly correlated with severe oil contamination (Fig. 3). Areas of severe die-back, and of the worst oil residues in the swamps, are at the front of the mangroves and at the rear.

Oil pollution causing death of mature mangroves has been reported from the Americas, Saudi Arabia, Indonesia and elsewhere (e.g. Rützler and Sterrer, 1970; Spooner, 1970; Baker *et al.*, 1980) but as far as I know not previously from Australia. While it seems clear from the strong correlation between oil and dead mangroves that oil pollution is the primary cause of the die-back, the mechanism by which it kills the trees is not known. Possibilities include that repeated oil pollution occurrences, each killing a fraction of the pneumatophores, result finally in a sufficient reduction in root oxygen supply to kill the trees (severe effects of repeated oiling have been described by Baker (1971) in salt-marsh in Britain). Alternatively, prolonged exposure of roots to oil in the sediment may be resulting in physiological damage to the roots: or damage allowing *Phytophthora* to infect and become pathogenic (Pegg and Foresberg, 1981). Whatever the mechanism, the effect is continuing and prolonged: of the 8 trees marked for our physiological experiments on 24th September, 1981 as being alive but partially affected by die-back at Quibray Bay, six had died by 21st December, 1981. A similar pattern of increasing die-back is seen near Towra Point.

#### WHAT CAN BE DONE?

It is hard to escape the conclusion that unless oil is kept out of mangrove areas they are all likely to be killed. A combination of destruction of seedlings by oil, oil-induced die-back of mature trees, and the high frequency of oil spills contaminating the mangrove areas of Towra Point/Quibray Bay lead us to this view. It may be too late to save many areas now since the die-back is still spreading. If the killing of the remainder is to be prevented, the mangroves must be protected from further oil contamination. Prevention of oil spills should be the first priority; if oil is spilled then containment and collection come next in importance. Spilled oil must be kept out of mangrove areas; if an oil spill must come ashore it should be directed with booms on to sand beaches where (although public complaint is loud) it can be collected up with greatest efficiency. Dispersants may not be used in shallow waters because of risk to underwater life, and cannot be used to clean up contaminated mangroves since they are at least as toxic as oil on direct application (Table 1), and would enhance the penetration of oil into the sediment. The mangroves of the Towra Point/Quibray Bay area have been recognised as one of our important biological reserves (e.g. the Towra Point Report) but at present they are very much at risk.

#### ACKNOWLEDGMENTS

This work was supported by the University of Sydney. Field work was done with the help of many colleagues and students in the School of Biological Sciences. I thank June Jeffery, Alan Lennon and Bert Lester for assistance with illustrations.

## REFERENCES

- Baker, J.M. (1971). Successive spillages. In "Ecological Effects of Oil Pollution" (E.B. Cowell ed.), Applied Science Publishers, London, pp. 21-32.
- Baker, J.M., Suryowinoto, I.M., Brooks, P. and Rowland, S. (1980). Tropical marine ecosystems and the oil industry; with a description of a post-oil spill survey in Indonesian mangroves. *Proceedings of 'Petromar 80' Conference (EUROCEAN)*, pp. 617-643.
- Pegg, K.G. and Foresberg, L.I. (1980). *Phytophthora* in Queensland mangroves. *Wetlands* 1, 2-3.
- Rützler, K. and Sterrer, W. (1970). Oil pollution damage observed in tropical communities along the Atlantic seaboard of Panama. *Bioscience*, 20, 222-224.
- Spooner, M. (1970). Oil Spill in Tarut Bay, Saudi Arabia. *Mar. Pollut. Bull.* 1, 166-167.
- Towra Point Report (1977). "An investigation of management options for Towra Point, Botany Bay". Australian Littoral Society (N.S.W. division).

Figure 2. Dead *Avicennia* bushes. All the photographs in this paper are from the southern shore of Qibray Bay, December 1981.



Figure 4.

Oil slick rising from footsteps in the contaminated mud, southern shore of Qibray Bay, December 1981. Note newly germinated seedlings in the contaminated area: all previously existing mangroves here are dead.



Figure 5.

Typical die-back of mature *Avicennia* trees in a severely affected area.

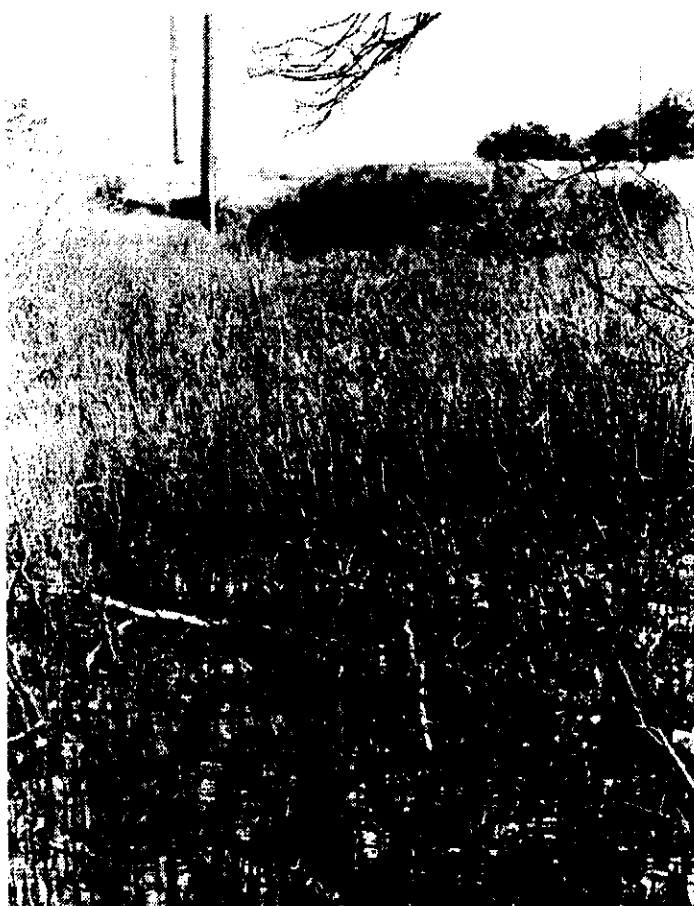


Figure 6.

*Aegiceras corniculatum* at the rear of the swamp in an area of severe oil contamination.