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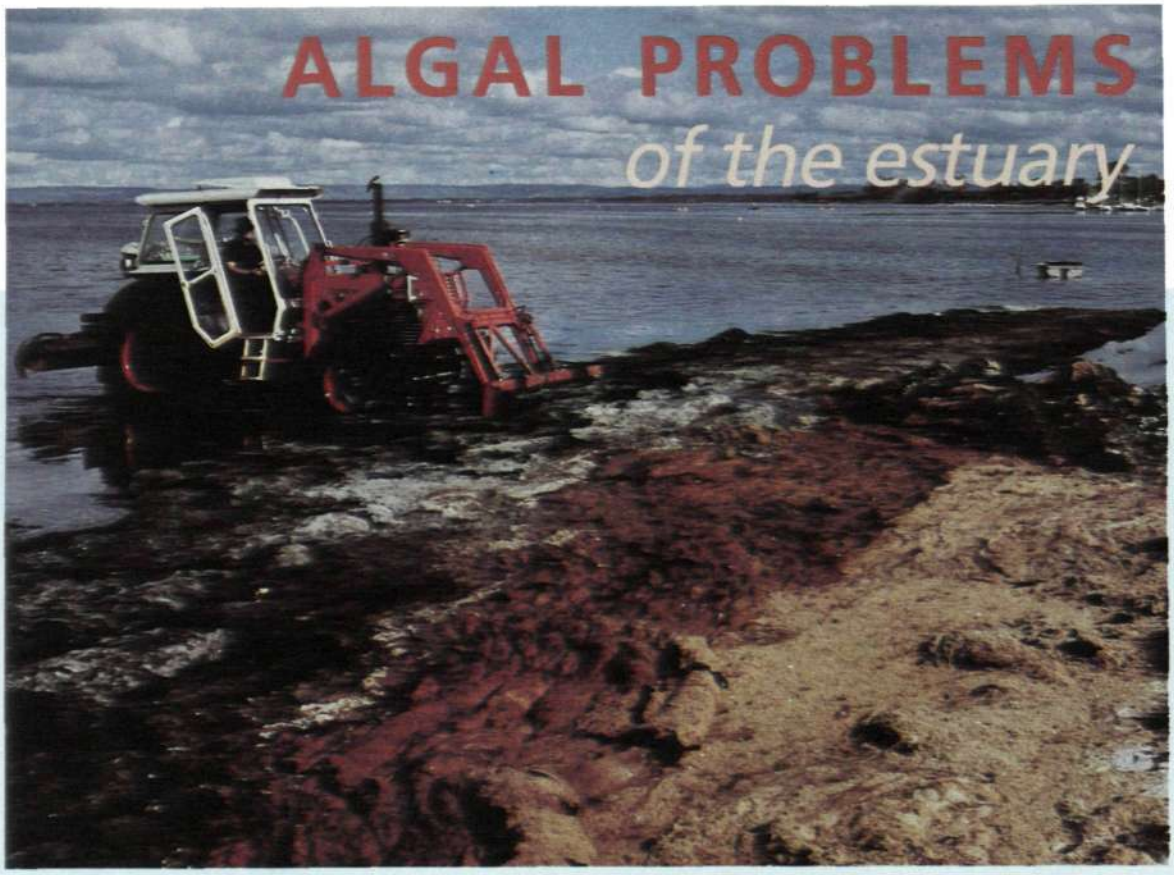
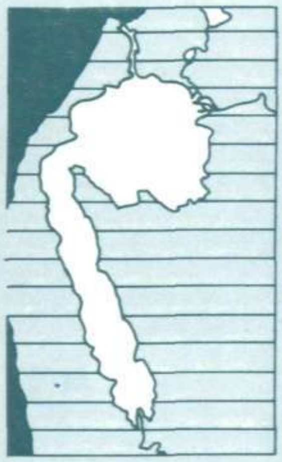


■ Bulldozing to clear algae at Falcon Beach.



PEEL-HARVEY *Estuarine System*

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The Peel-Harvey estuarine system study began in 1976 because people living near Peel Inlet complained about the accumulation of water weeds and algae on the shores and the smell of hydrogen sulphide (rotten egg gas) that resulted from their decomposition. From 1974 efforts had been made to control this 'algal problem' by raking up the weed with tractors and carting it away. This 'cosmetic' activity had little impact on the problem.

The immediate cause was obvious: a carpet of green algae covering about 20 square kilometres of the bottom of Peel Inlet. From time to time this 'goat weed' floated to the surface and was driven ashore by the wind. There it collected in huge piles that decomposed to an evil-smelling, black sludge that fouled the previously clean beaches.

During the past ten years the extent of the problem has varied with the seasons and its nature has changed according to the different kinds of algae present. With more and better equipment the Peel Inlet Management Authority has successfully kept the shores clean near inhabited areas, but the problem remains. Weed accumulations are as great as ever along the uninhabited south-eastern shores.

Until 1978 the Harvey Estuary appears to have been largely free of algal problems; at least there were no complaints. However, in November of that year a massive bloom of the microscopic blue-green alga *Nodularia* turned the whole of Harvey Estuary bright green. This 'pea soup' spread into Peel Inlet and flowed out to sea past Mandurah.

Every year from 1980 there have been similar blooms, usually starting in October and dying out in January. When there is no wind to stir the tiny *Nodularia* filaments into the water they float to the surface and form a thick scum. This also drifts to the shore and decomposes, and its peculiar nauseating smell is added to that of the hydrogen sulphide from the rotting goat-weed and other large algae. The *Nodularia* blooms are preceded by blooms of diatoms (microscopic algae) in the water but these are not a nuisance.

Most fish—and the fishermen—seem to avoid the *Nodularia* blooms. In January 1981 many fish and crabs died where *Nodularia* had accumulated and rotted. However, the green algae appear to have benefited the fishery, and annual catches in the 1970s were double those of the previous decades.

Causes of algal growth

The cause of this abundant algal growth is the rich supply of nutrients: the estuary is highly eutrophic. More than enough nitrogen and phosphorus now enters it from the Serpentine, Murray and Harvey Rivers to account for all the algal growth.

Most of the nitrogen comes in Murray River water, much less from Swan coastal plain drainage in the Serpentine and Harvey Rivers. A substantial amount also comes from the atmosphere because *Nodularia* can fix atmospheric nitrogen. So there is seldom any shortage of nitrogen.

It is phosphorus that is in shortest supply and it is mainly the amount of phosphorus entering the estuary which determines the size of the crops of green algae, *Nodularia* and diatoms. So far, the size of the *Nodularia* blooms has been roughly in proportion to the amount of phosphorus coming into the estuary in river water each winter (Figure 1). In 1981, a year of near average rainfall, more than three times as much phosphorus entered the estuary as in the dry year 1979. In 1981 there was a big *Nodularia* bloom; there was none in 1979.

Nearly 90 per cent of the phosphorus enters the estuary in drainage water from the soils of the coastal plain (Table 1). Most of it is from the highly leaching sandy soils from which up to 30 per cent of phosphorus applied as superphosphate each year is lost to drainage.

About 60 per cent of the phosphorus entering the estuary comes from the Harvey River and Mayfield Drain at the southern end. Just why so much more phosphorus comes from the Harvey River catchment than from the Serpentine River catchment is not certain, but the main reason is probably the bigger number of drainage channels and greater river flow in the Harvey catchment. The amount of phosphorus carried by both is high, with concentrations in the water more than ten times that in most rivers of the south-west of Western Australia.

Almost all the phosphorus brought into the estuary in Harvey River water is used by the diatoms and other microscopic plants in Harvey Estuary. Very little flows on into Peel Inlet or is flushed out to sea. This means that most of the phosphorus remains in the estuary and, after decomposition of the diatoms by bacteria, it is available again to re-fertilise a *Nodularia* bloom.

Although a lot of the phosphorus which enters Peel Inlet from the Serpentine and Murray Rivers is lost to the sea, much of it is still trapped in the same way by the diatoms and other microscopic plants and fertilises both *Nodularia* and green weed growth

Big increase in phosphorus input

The big increase in the amount of phosphorus coming into the estuary from the rivers during the past 30 years is the principal reason for the increasingly eutrophic condition of the estuary. Much more phosphorus now enters the estuary each year than is flushed out to sea, either in river flow or by tidal exchange.

Phosphorus must then be accumulating in the sediments of the estuary. This is worrying because, like a farmer's 'super bank' in the soil, this phosphorus could fertilise future crops of weed.

Although the annual crops of *Nodularia* and green weed get their phosphorus from the surface sediment, most of it comes from the breakdown of diatoms which bloomed earlier in the season. A 'super bank' seems to be building up in the estuary, but the rate at which phosphorus is released from the bank is probably too slow to support massive blooms of either green weed or *Nodularia* without the continued input from the rivers.

If the algal problems are to be reduced to acceptable levels, much more phosphorus must leave the estuary than comes into it. This can be achieved either by reducing input from the rivers or by increasing the loss to the sea, or by both methods.

Figure 1. River and drain flow to Harvey Estuary and phosphorus input, 1976 to 1983. The dark green shading shows the years of *Nodularia* blooms.

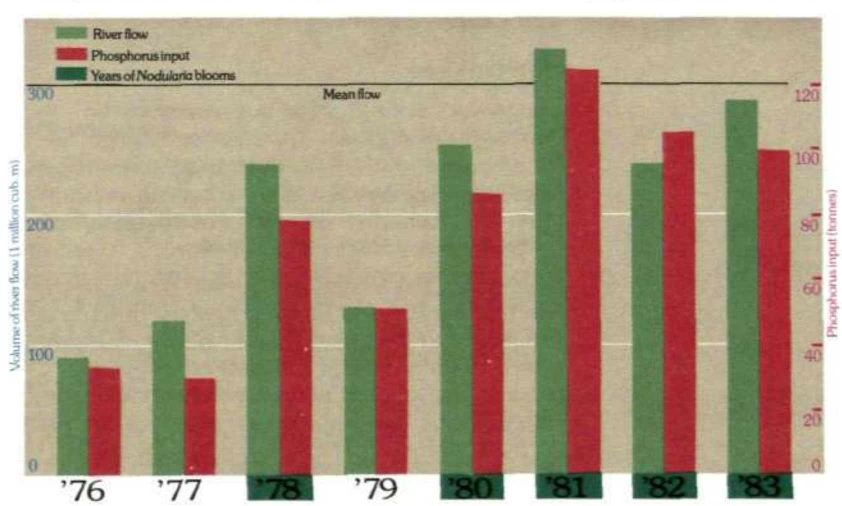

Table 1. Phosphorus loss from the catchments of the Harvey River and Mayfield Drain into the Harvey Estuary in 1982. These figures are approximate and vary from year to year.

Soil type	Catchment area		Fertiliser applied**	Phosphorus loss to drainage	
	sq. km	%	kg/ha	tonnes	% of total
Deep grey sands	144	21	15	20	31
Sand over clay*	227	33	13	29	46
Clays and loams	158	23	16	11	17
Foothills	158	23		4	6
		100			100

*Includes brown and yellow sands. **Per fertilised hectare.