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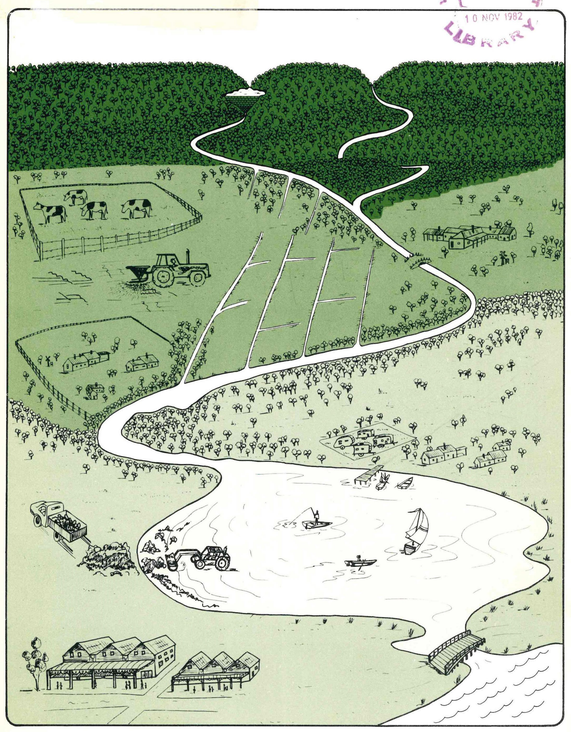
THE PEEL-HARVEY ESTUARY 1982



Department of Conservation and Environment Western Australia Bulletin 118

PHASE 1: NATURE AND CAUSE OF THE ALGAL PROBLEMS

Findings of the study

Phase I of the Peel-Harvey Estuarine System Study finished in mid-1980 and the research report (DCE Report No. 9) was published in December 1980. The Estuarine and Marine Advisory Committee (EMAC) submitted its report (DCE Bulletin No. 88) to the EPA in March 1981. The EMAC recommendations were accepted by Government in August 1981 with some minor reservations with respect to deep sewerage and further restriction of flow from hills catchments.

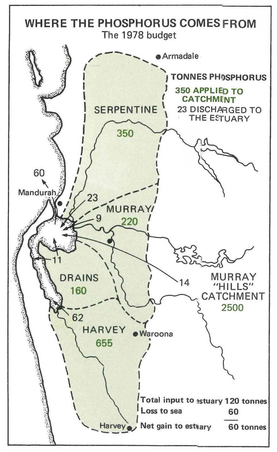
The study was directed primarily to determining the cause of the 'algal problem' in Peel Inlet – the excessive growth and accumulation of green algae. The principal algae were *Cladophora* ('goat weed'), which grows on the bottom as small balls that float to the surface and drift with the wind, and *Chaetomorpha* ('rope weed') which forms tangles of long filaments through the water. These algae accumulate on the beaches where they decompose and release hydrogen sulphide and other noxious odours. The decomposing algae are collected and carted away by the Peel Inlet Management Authority (PIMA) at considerable expense.

The reports identified the main cause of the algal problem to be the abundance of plant nutrients entering the estuary from agricultural drainage on the coastal plain. Phosphorus especially had increased greatly in the previous 25 years. It was also estimated that of the 120 tonnes of phosphorus that entered in 1978 half remained in the estuary, mainly in the surface sediment.

The reports stressed that management measures must be directed principally towards reducing the availability of phosphorus to algae in the estuary by reducing the input from drainage, increasing the loss by flushing, reducing the sediment store, or by some combination of these.

The EMAC Recommendations for Management were of three kinds:

- For administrative decisions to ensure that future developments did nothing to add to the nutrient input to the estuary.
- For measures to ameliorate the deleterious effects of the algal problem until there was an effective reduction in nutrients.
- For further research to determine how best to reduce the amount of phosphorus available to algae in the estuary, and in particular how the input of phosphorus to the estuary could be substantially reduced.



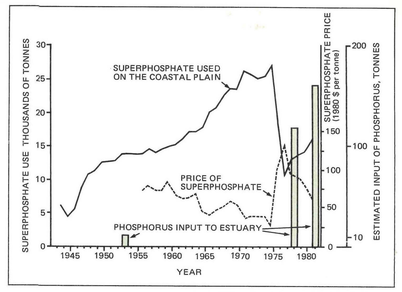
Subsequent events

Until 1980 the algal nuisance affected mainly Peel Inlet; the weed accumulations were unpleasant and were costly to remove. However, the massive blooms of the blue-green alga *Nodularia* in the summers of 1980-81 and 81-82 are a new dimension in the condition of the estuary. These affect Harvey Estuary especially and its condition has deteriorated dramatically, although the consequences of this may only be obvious to the general public over two or three months in summer.

During the *Nodularia* blooms the oxygen in the water was depleted, fish left affected areas and in 1980-81 fish and crabs died. *Nodularia* and green algae were washed up on the western beaches of Peel Inlet and decomposed rapidly with the release of sulphurous gases (hydrogen sulphide and mercaptans). These gases are nauseating and are toxic in concentrations which were experienced in residential areas.

Nutrients from the dead *Nodularia* augmented the sediment store and were immediately available to green algae. A tremendous growth of *Chaetomorpha* and *Cladophora* followed and in 1980-81 about 4800 cubic metres of alga (550 truck loads) were carted away from the Coodanup and Falcon shores.

The input of phosphorus to the estuary has increased since 1978, probably mainly because more superphosphate has been applied to the catchment and because of the greater rainfall and runoff in 1980 and 1981. The study period (1976-79) was one of unusually low rainfall and river flow. Even the wettest year (1978) had below average rainfall.



The future of the estuary

It is not possible to predict the future of the estuary with any certainty, there are too many unknowns: the variability of rainfall, the use of agricultural fertilizers, and the ability of coastal plain soils to store and release phosphorus. However, it will be clear from the foregoing that its condition is not likely to improve until the amount of phosphorus available to plant life in the estuary is reduced.

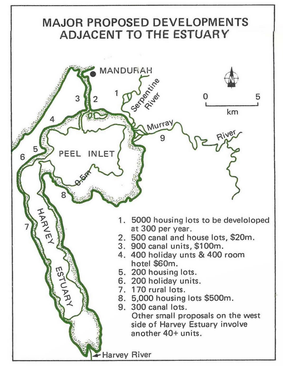
The *Nodularia* blooms will probably become more extensive and more prolonged and they will in turn fertilize greater quantities of green algae. *Nodularia* could be replaced by other blue-green algae, some of which are known to be toxic to fish, but at present there is no indication that this will occur. The blooms exhaust the oxygen of the water to levels which may be fatal to fish. Fortunately, however, our windy climate and the shallow depth of the water make it likely that such oxygen lack will not last for long in Peel and Harvey.

If the blooms get worse there will be a further decline in fish populations and in professional and amateur catches. The decrease in crab numbers over the last two summers cannot be attributed to the *Nodularia* blooms with certainty, because of the great natural variability in crab populations. However, it is likely that the blooms do create unfavourable conditions for crabs.

In recent years the population of Mandurah and settlements near the estuary has increased rapidly and there are likely to be even greater demands for development in the future. In accepting the EMAC recommendations Cabinet decided that:

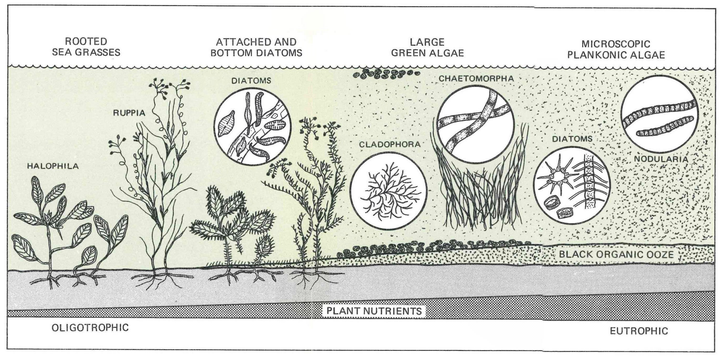
Measures be introduced to ensure that there is no significant increase of nutrients in the estuary from urban sources by requiring that all developments within 2 km include appropriate sewage disposal systems – with a minor modification to take account of small-scale approved urban developments.

There should not therefore be any substantial increase in the relatively small nutrient contribution from urban development (less than 10 tonnes phosphorus in 1978).



The State Government has expended very substantial sums on research and possible solutions and remains firmly committed to reversing the deteriorating condition of the Peel-Harvey estuary. As Minister for Conservation and the Environment I am very concerned that ways should be found to decrease the present level of input of plant nutrients to the estuary. This publication explains the nature of the estuarine problems and summarises the research which is being undertaken to determine how best to correct them. I commend it to all those interested in the future of this fine waterway.

Ian Laurance
MINISTER FOR CONSERVATION AND THE ENVIRONMENT



Changes in the plant life of the estuary
The estuary is now eutrophic – rich in plant nutrients – but 30 to 40 years ago estuary water held only a small supply of nutrients and the principal plants were rooted sea grasses. Green algae obtain their nutrients from the water and, with the increase in nutrients, they became abundant. With even more nutrients, there have been dense summer blooms of the planktonic blue-green alga *Nodularia*.

The prospects of management

There is no doubt that a radical cure of the eutrophic condition can be achieved, but how soon and at what cost have still to be determined. Too much phosphorus has been poured into the estuary for the last 20 to 30 years, and is still pouring into it, for any simple and immediately available measures to be effective.

The hills dams of the Harvey catchment do not hold enough water to exert a significant flushing effect on Harvey Estuary even if the water could be released (average flow in Harvey River 220 x $10^6 m^3$, volume of dams when full 70 x $10^6 m^3$, volume of Harvey Estuary 55 x $10^6 m^3$). Enlarging the Mandurah channel would increase the loss of nutrients to the sea, but it would have to be greatly enlarged, at enormous cost, to have much effect on nutrient retention.

Such drastic short-term management measures as the use of algicides do not tackle the cause of the problem and may have unforeseen ecological side effects. However, because of the urgency for action to ameliorate the effects of the blooms, certain possible short-term control measures are being studied. Meanwhile PIMA is doing all it can to alleviate problems associated with the abundance of algae. It collects algae from the shores near residential areas with bulldozers equipped with rakes and carts it away. PIMA is investigating the practicability of acquiring machinery to harvest algae where they accumulate in piles 100 m or more offshore and also where they grow in the deeper water of the Inlet.

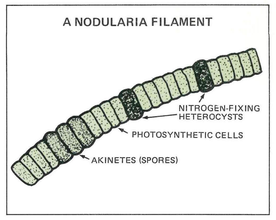
A radical cure to the eutrophic condition of the estuary can only be achieved by reducing the amount of phosphorus available to algae in the estuary. How this is to be achieved is the main focus of the Phase II research programme. This aims to determine how best to substantially reduce the input of phosphorus to the estuary – without at the same time reducing the productivity of agriculture on the coastal plain. Clearly it is in the interests both of farmers and of residents around the estuary to use fertilizer with the minimum loss to drainage water to fertilize the estuary.

The Biology of Nodularia

Nodularia is a microscopic blue-green alga (Cyanobacteria) that forms chains of cells less than one millimetre long that can float or sink in the water. Unlike green algae, *Nodularia* can use atmospheric nitrogen and so is independent of other sources of this nutrient and grows well in Harvey Estuary where it is nitrogen rather than phosphorus that is in short supply. *Nodularia* also forms resistant spores (akinetes) which sink to the bottom and stay dormant in the mud until conditions are again favourable for growth.

Research is continuing into the biology of *Nodularia* with the aim of understanding how environmental factors (salinity, temperature, nutrients etc.) control its growth. There is the possibility that blooms may be limited by modifying some such factor, other than the availability of phosphorus. For example, *Nodularia* requires iron and manganese in much greater quantities than do green algae and the practicability of limiting these elements merits further study.

Also in order to have a realistic target figure for management proposals which aim to reduce the input of phosphorus from drainage, it is most important to determine the level of phosphorus that is required to initiate and sustain blooms of *Nodularia*.

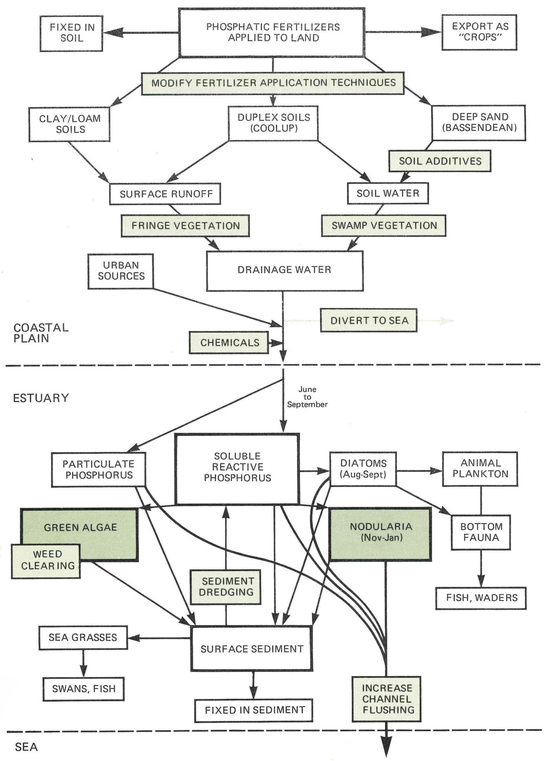


Fish and the fishery

Until the *Nodularia* bloom of 1980-81 drove fish out of Harvey Estuary, both Peel and Harvey were still in a healthy condition biologically. Professional fish catches increased throughout the 1970s, despite the inconvenience to fishermen caused by *Cladophora* clogging their nets. Weed-eating fish, such as the six-lined trumpeter, are abundant and catches of sea mullet, which are mud feeders, and yellow-eye mullet and certain other species that feed on worms, shrimp and other small invertebrates have increased considerably.

Any management measure will alter the ecosystem in ways which it is not easy to predict and it will be important to monitor the response of fish and other fauna to environmental changes which may occur over the next few years. The chemistry of the water and algal abundance will also continue to be monitored.

PHOSPHORUS FLOW PATHS IN THE COASTAL PLAIN/ESTUARY ECOSYSTEM



PHASE II: RESEARCH RELATED TO MANAGEMENT

Phase II studies aim to find out how the present level of eutrophy can be reduced, first to the point where there are no longer blooms of *Nodularia* and then to eliminate the harmful effects caused by filamentous green algae.

Most of the present studies have the strictly practical objective of determining how to reduce the eutrophic conditions. This can be done in a number of ways, as shown in the phosphorus flow diagram. However, before recommendations can be made for management it is necessary to know quantitatively, not merely subjectively, by how much the phosphorus input must be reduced, what is the potential of the various measures to reduce the phosphorus available to algae in the estuary, what they will cost, and how rapidly they can be expected to be effective. It is also necessary to determine what other ecological effects any management measures may have, particularly as they affect fish and the fishery, and also the popular crab fishery.

Biological filter

EMAC management recommendation 2 suggested investigating the practicability of "interposing a biological water quality improvement scheme into the drainage system". This could take various forms such as fringe vegetation along the margins of drains or swamp vegetation intercepting drainage water at some point. Such biological filters can greatly reduce the high levels of nutrients discharged in wastewater from sewerage or dairies and piggeries. It will require careful studies to determine whether they can be effective in reducing the relatively low level of phosphorus in the large volume of agricultural drainage water entering the esturary.

Engineering Measures

The EMAC report recommended investigation of the practicability of engineering measures for reducing the available phosphorus, particularly by diversion of drainage water away from the estuary and increasing flushing to the sea.

Undoubtedly the phosphorus could be reduced greatly in such ways and their potential should be investigated, but it is to be hoped that the same result can be achieved by less costly measures and with less risk of altering the character of the estuarine ecosystem.

The sediment store of phosphorus

Because the estuarine sediments play an important role in storing phosphorus and releasing it to algae, EMAC recommended that the practicability of removing the surface 10 cm of sediment by dredging should be investigated.

Undoutedly the sediment acts as a short-term phosphorus store (weeks or months), but it is far from clear how long it will function as a store from which sufficient phosphorus can be released to support growth of algae, once the external source has been substantially reduced. We need to be able to budget the flow of phosphorus between water, sediment and the various forms of plant life much more accurately than is now possible, before investment in costly dredging machinery can be recommended.

PHOSPHORUS IN THE ESTUARY

	APPROXIMATE Concentration ug/L	APPROXIMATE Quantity Tonnes
WATER	10	50
LIVING ALGAE	90	100
DECOMPOSING ALGAE	500	500
MUDDY SAND	300	50

Chemical treatment of drainage water

Laboratory experiments have shown that phosphorus can be precipitated out of solution in Harvey River water by the addition of iron, aluminium, and calcium, in appropriate chemical form. All three are waste products of local industry: iron as ferrous sulphate, aluminium as red mud, calcium as gypsum.

The practicability of using these chemicals to reduce the phosphorus available to algae merits further study. We need to know: where and how to introduce them, in what chemical form, how to remove the precipitated metal-phosphorus floc that is formed and, most important, what side effects the treatment may have on the estuarine ecosystem.

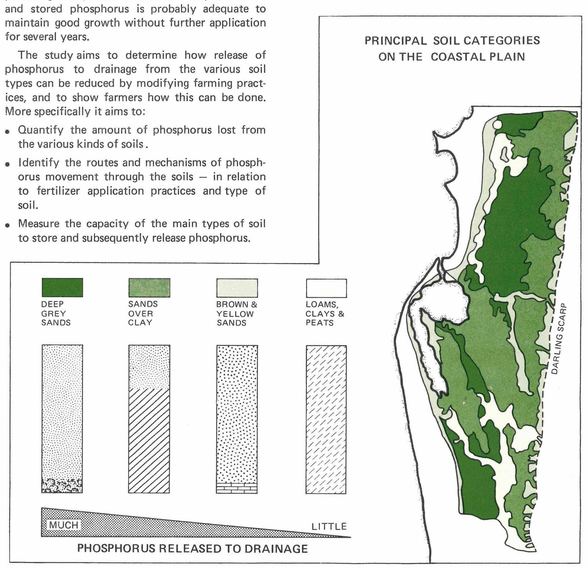
Phosphorus loss from the catchment

The soils of the coastal plain are naturally deficient in phosphorus, and superphosphate has been applied to agricultural land for the last 40 years. They vary greatly both in structure and in their capacity to retain and release phosphorus and other nutrients. Sandy soils release much more phosphorus and other nutrients. Sandy soils release much more phosphorus to drainage than heavy clay/loam soils, irrespective of the amount of super applied. Conversely, the heavy soils have a much greater capacity for retaining phosphorus than do sandy soils. So while sandy soils need repeated applications of phosphorus in order to maintain pasture growth, little is lost from clay/loam soils and stored phosphorus is probably adequate to maintain good growth without further application for several years.

The study aims to determine how release of phosphorus to drainage from the various soil types can be reduced by modifying farming practices, and to show farmers how this can be done. More specifically it aims to:

- Quantify the amount of phosphorus lost from the various kinds of soils.
- Identify the routes and mechanisms of phosphorus movement through the soils – in relation to fertilizer application practices and type of soil.
- Measure the capacity of the main types of soil to store and subsequently release phosphorus.
- Develop fertilizer application techniques, different types of fertilizer and soil additives, which will minimise phosphorus release to drainage, whilst providing adequate nutrients for plant growth.
- Demonstrate to farmers how the techniques can be applied in practice.

This study is being undertaken by DCE in close collaboration with other organisations and with local farmers. It will have to extend over two winters, 1982 and 1983, before final decisions can be made. However, it is hoped to be able to make recommendations for large scale trials on the basis of soil sample analyses on about 100 farms in the Harvey River Catchment in the 1983 season.



Further information and details of the Study Reports are available from the Department of Conservation and Environment, 1 Mount Street, Perth WA 6000. Tel: (09) 322 2477.