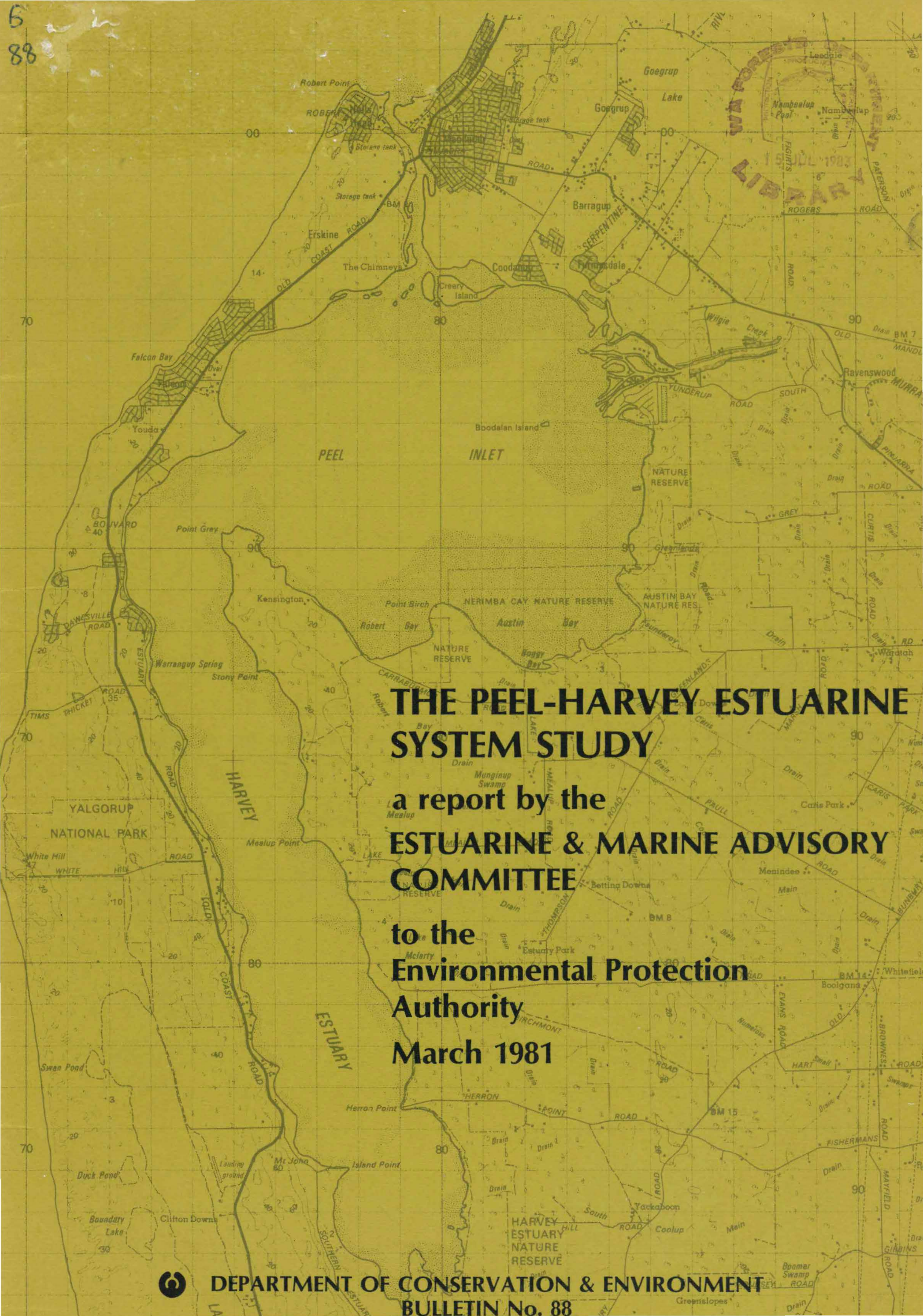

THE PEEL-HARVEY ESTUARINE SYSTEM STUDY

a report by the ESTUARINE & MARINE ADVISORY COMMITTEE

to the Environmental Protection Authority

March 1981

DEPARTMENT OF CONSERVATION & ENVIRONMENT
BULLETIN No. 88

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CHAIRMAN
ENVIRONMENTAL PROTECTION AUTHORITY

The Estuarine and Marine Advisory Committee has pleasure in submitting to the Environmental Protection Authority a report on the study of the Peel-Harvey Estuarine System. The report sets out our findings with regard to the cause of excessive growth and accumulation of algae in Peel Inlet and makes recommendations with respect to control. The study has also added greatly to understanding Western Australian estuarine ecosystems generally and to our ability to advise on environmental problems relating to them.

This is the second major study undertaken by the Committee into problems related to estuarine and marine environments and, in the manner of the Blackwood Estuary Study, the present investigation has been undertaken by a team of scientists drawn both from government departments and from a number of tertiary institutions. The Committee wishes to place on record its appreciation of the willing cooperation and unstinting efforts of all members of the team of scientists who participated in this interdisciplinary research project.

B. K. Bowen (Chairman)

W. S. Andrew

D. A. Hancock

B. W. Logan

R. A. Field (Secretary)

CONTENTS

INTRODUCTION

Peel Inlet and Harvey Estuary, with their associated estuarine waterways, are developing at an accelerating rate as a major aquatic resource, second only to the Swan River as a centre for recreational activities and for waterside residential development. Their shallow waters support the largest inland fishery in Western Australia, as well as a variety of aquatic sports. Large numbers of resident and migrant waterbirds use the estuary and its saltmarshes, and Nature Reserves include parts of the estuary itself.

Early in 1976 the Environmental Protection Authority (EPA) of Western Australia asked its Estuarine & Marine Advisory Committee (EMAC) to undertake an investigation of Peel Inlet. The reasons for this study were:

(a) In recent years large quantities of green algae had accumulated and decayed on the shores causing a nuisance to residents. The continuing 'cosmetic' action required to ameliorate the effects of this was thought to be costly and offered no permanent solution. It was desirable to identify the cause or causes of this 'algal problem' and, if possible, propose long term solutions.

(b) The Metropolitan Water Board was investigating the possibility of damming the Murray River in order to supply water to the metropolitan area. Reduced freshwater input to Peel Inlet could greatly alter the aquatic environment and it was desirable to identify the nature of likely changes.

(c) Residential and recreational use of the area was increasing rapidly and the effect on the estuary had to be understood in order to formulate management policies that would minimise adverse environmental change.

The study began in 1976 and ended in 1980, and this report to the EPA summarises the results and makes recommendations on management of the estuary. The principal conclusion is that the estuary is eutrophic and that proper management of it can only be achieved by reducing the present input of nutrients from agricultural drainage, by preventing any increase of nutrients from other sources, and by not restricting flushing of nutrients to the sea.

STUDY OBJECTIVES

The study requested by the Environmental Protection Authority had two objectives:

(a) Specific: To determine the causes of the excessive growth and accumulation of green algae in Peel Inlet and if possible to propose methods for its control.

(b) General : To gain an understanding of the working of this estuarine ecosystem so that environmental problems can be foreseen and decisions made about its management on the basis of sound knowledge.

STUDY APPROACH

EMAC was responsible for defining the structure of the study and was fortunate to have the services of Dr. Ernest Hodgkin as the study Research Co-ordinator. He undertook the task of bringing together research personnel from tertiary institutions and government departments to undertake research into a number of aspects of the Peel-Harvey estuarine system. Each research worker was responsible to EMAC through the Research Co-ordinator for his or her own programme, but all those who participated benefited from the opportunity for interdisciplinary research. Through the Department of Conservation and Environment (DCE), EMAC was also able to provide financial support for a number of the research programmes.

Each research worker participating in the study was required to present to the Research Co-ordinator a technical report on the work undertaken (Page 16). At the conclusion of the study period, the Research Co-ordinator, assisted by researchers Dr. Birch, Mr. Black and Dr. Humphries, produced a synthesis report* drawing together the principal elements of the findings of the research team.

* The Peel-Harvey Estuarine System Study, 1976-1980. Report to the Estuarine & Marine Advisory Committee of the Environmental Protection Authority. E.P. Hodgkin, P.B. Birch, R.E. Black & R.B. Humphries. Report No. 9 Department of Conservation and Environment, 1981.

EMAC has studied the synthesis report, which is submitted as an Annexe to this report, and has had discussions with the principal research workers. EMAC now has pleasure in presenting below the main conclusions of the study and the management options available. Understanding of the working of the ecosystem is still incomplete, but the study has reached a stage where recommendations can be made for management of the estuary and in particular for control of the algal problem. The recommendations are in three parts relating specifically to management, further research, and monitoring.

CONCLUSIONS

1. The Peel-Harvey estuarine system is eutrophic (nutrient enriched) in that there is an excess of the nutrient elements (phosphorus and nitrogen) available for plant growth.

   In Peel Inlet this eutrophic condition is manifested principally by an abundance of bottom-living green algae. In consequence, algae accumulate to nuisance levels which has necessitated remedial action since 1974.

   Harvey Estuary is also eutrophic, often with even higher nutrient concentrations. However, it has a greater quantity of suspended matter in the water, which reduces light to a level unfavourable to growth of bottom-living plants. In consequence, the eutrophic condition is manifested by an abundance of phytoplankton (microscopic plants in the water body), especially by blooms of blue-green 'algae' (cyanobacteria) in summer.

2. The algal problem in Peel Inlet is caused mainly by a species of *Cladophora*, locally known as goat weed. The growth characteristics of this green alga and its unattached habit, favour both its use of the available nutrients and its accumulation in the shallows. Other species of bottom-living algae are seasonally abundant and also contribute to algal accumulations. No detailed study has been made of them.

3. The algal problem is of recent origin. It began in the 1960's and was only recognised as a nuisance at the end of that decade. Its development was coincident with a great increase in agricultural fertiliser run-off in drainage to the system. Eutrophic conditions and the algal problem are here attributed to the consequent increase in available nutrients, especially phosphorus, within the system.

   The status of phosphorus in the estuary and its catchment is summarised in Figure 1. This is a very simplified statement of a highly complex picture and rates and stocks shown can only be regarded as estimates.

4. The increased input of phosphorus results from application of superphosphate to phosphorus-deficient soils in the coastal plain segment of the catchment during the last 30-40 years. Tonnages of superphosphate applied increased rapidly to 1973-74, since when usage has decreased greatly as the result of higher prices (Figure 2). Nevertheless the input to the estuary in 1978 was at least 10 times that of 1953, a year with very similar rainfall and river flow.

   The increase in nitrogen input is much smaller; it is probably attributable to planting with pasture legumes on agricultural land throughout the catchment, and also to increased use of nitrogenous fertilisers over the same period.

5. During the last 30 years, there have been changes in the sources of river flow to the estuary and in river nutrient loadings, although the volume of freshwater flow is thought not to have changed greatly. Dams on hills catchments have reduced the input of water poor in nutrients, while clearing, cultivation, and drainage on the coastal plain have increased the input of nutrient rich water. Flow from the undammed plateau catchment of the Murray River is relatively rich in nitrogen, but poor in phosphorus, even though superphosphate application rates to farmland are similar to those on non-irrigated land on the coastal plain.

6. River flow and the consequent nutrient input to the system is strongly seasonal. For example, in 1978 85 per cent of both nitrogen and phosphorus input to Peel Inlet occurred in a period of 10 weeks (July-August).

7. Nutrient concentrations in estuarine waters are high during the annual periods of high river flow, but with reduced flow they decline to the relatively low levels common during the greater part of the year. Phytoplankton blooms (chiefly diatom species) develop at all times of high nitrogen and phosphorus concentration in estuary water.

8. While much of the nutrient input is lost directly to the sea at the time of river flow, a considerable proportion is retained in the estuary in phytoplankton, and by flocculation, from which it is transferred to the sediments as a potentially recycleable nutrient store that is most concentrated in the top few centimetres of sediment. This store of nutrients is augmented by massive blooms of blue-green 'algae', such as *Nodularia,* which fix atmospheric nitrogen. This occurrence is particularly common in Harvey Estuary.

   A precise estimate of the nutrient contribution from these sources must await completion of the sediment-nutrient studies in the coming year.

9. There is little growth of *Cladophora* in winter and during river flow even though nutrient concentrations in the water are at their highest at this time. This is because of low water temperature and low bottom light intensity. Even so *Cladophora* is able to take up nutrients and store them in its tissue, and this tissue store alone is sufficient to enable the algal biomass to double in spring-summer when light is again adequate for photosynthesis and growth. Nutrients are also supplemented to *Cladophora* during this growth phase from the store in decaying algae and surface sediment.

10. During the greater part of the year, the supply of both nitrogen and phosphorus in estuary water is inadequate for *Cladophora* and other algae to achieve their maximum growth potential. However, it is phosphorus that is in shortest supply in Peel Inlet and in consequence it is lack of phosphorus rather than of nitrogen that limits growth. The ratio of nitrogen to phosphorus in the water is greater than 17:1 (the ratio in algal tissue) most of the time. Moreover any deficiency of nitrogen is likely to be supplemented by nitrogen-fixing blue-green 'algae', when temperatures are above about 18°C.

11. The eutrophic condition of the estuary may be manifested in other ways. Other large algae contribute to the nuisance from time to time, but it is not clear whether, in the absence of *Cladophora,* they will cause similar problems of accumulation and decomposition on shore. The massive blooms of blue-green 'algae' in summer may cause deoxygenation of the water and consequent localised fish and crab mortality.

12. During the study there has been a decrease in the abundance of *Cladaphora* which may have resulted from a reduced nutrient input to the estuary because of low river flow and reduced usage of superphosphate. Also it is probable that repeated phytoplankton blooms, such as the 1978 and 1980 *Nodularia* blooms, or other natural factors limiting light penetration, may have contributed to the reduction in *Cladophora.*

13. The recreational fishery is of great and increasing value to the community. The fish study has found no evidence that either the abundance of *Cladophora* or the occurrence of phytoplankton blooms has had long term consequences for the abundance of fish or crabs. There is at present no measure of the amateur fish catch although it is believed to be at least as great as the professional catch. Amateurs and professionals are in competition and it is important for management purposes to know how the catch is shared between the two, even though fishermen probably have little impact on stocks of most species, except perhaps estuarine breeders such as black bream. Habitats of some species (e.g. river prawn) are specialised and are subject to damage by proposed developments.

14. Finally, in presenting these conclusions of the study, it is relevant to note that they are based on data from observations made over only two to four years. This period, 1976-79, was one of unusually low rainfall and river flow. It was also one during which the *Cladophora* problem has declined, following a peak in 1974-75.

MANAGEMENT CONSIDERATIONS

The Peel-Harvey Estuarine System Study has confirmed evidence that the aquatic environment has deteriorated, as manifested by accumulations of decomposing algae, massive blooms of phytoplankton, and by the localised death of fish and crabs, with associated nuisance and aesthetic consequences to the public and to responsible authorities. The study has established that the main cause of the deterioration is man-induced eutrophication, resulting from the progressive increase of plant nutrients entering the estuary and remaining in it. Remedial and preventive measures must therefore be directed mainly towards control and substantial reduction of all sources of nutrients available to plants in the estuarine system.

While reduction of the eutrophic condition of the estuary is the principal problem with which this report is concerned, increasing human use of the estuarine system must also be recognised as posing problems. In particular the suitability of the estuary for recreation and as a site for development, must be weighed against its value as a fishing ground, prized by amateurs and professionals alike.

The study has shown that it is the amount of phosphorus available in estuary water that controls growth of algae and management measures must first be directed towards reducing the availability of this plant nutrient. There does not appear to be any practical method by which the availability of nitrogen can be significantly reduced and in any case it is not clear that this will benefit the system unless phosphorus is also reduced at the same time.

The rationale for phosphorus management can be deduced from Figure 1. This clearly defines the principal external source of phosphorus as agricultural fertiliser applied to the coastal plain catchment of the estuary. Other external sources are the plateau catchment of the Murray River, urban drainage, and the sea. Internal sources of phosphorus are the sediments and decay products of algae (planktonic and bottom-living). Loss from the system is mainly to the sea, with smaller losses to the sediments and in the algae carted away.

The amount of phosphorus available in estuary water can be reduced in a number of different ways. It was not within the scope of this study to determine which of them would be practicable and in what combination; economic and social considerations were not included in the terms of reference.

The methods which could be adopted are outlined below:

1. **Reduce the input of phosphorus to the estuary from external sources.** It can be seen from Figure 1 that the present input of phosphorus to the estuary must be at least halved if the net loss to the sea is to balance gains from drainage, and the system brought into depletion. Input can be reduced by any of the following methods:

   (a) **By reducing the quantity of phosphatic fertiliser applied to the coastal plain catchment.** Present application rates are known to be excessive in many cases, so that this method offers an acceptable and economic long term solution to the eutrophic condition of the estuary. However, it is not yet clear how best this reduction can be achieved, nor how rapidly a decrease in tonnages applied can be expected to effectively reduce input to the estuary. The routes by which phosphorus reaches drainage water are not clearly identified, nor are the roles of different soil types in the storage and release of phosphorus to drainage; in particular, in soils of the irrigation areas. Further study is required in order to clarify these points.

(See Management Recommendation 1)

(b) **By diverting coastal plain drainage away from the estuary.** Various possible methods for achieving this can be envisaged; for example, by diverting the major coastal plain drainage direct to the sea; establishing wetland vegetation on the coastal plain as a 'biological filter' to retain excess phosphorus; using low-lying and irrigation areas for more intensive plant production or forestry activities.

(See Management Recommendation 2)

(c) **By limiting input from urban sources.** These sources can and should be prevented from contributing to the eutrophic condition of the estuary. Although the present input of phosphorus from urban sources is small relative to that from agricultural land drainage, it is clearly desirable that this should not be allowed to increase as a result of the present rapid urbanisation in the vicinity of the estuary.

(See Management Recommendation 3)

2. **Increase the amount of phosphorus lost by flushing of the estuarine system to the sea.** However, it has been shown that even by doubling the flushing rate the expected increased loss of phosphorus would only be about 15 per cent. Moreover, increased flow may result in undesirable side effects such as bank erosion or danger to navigation.

There is no basis on which to predict nutrient retention in the estuary under extreme flood conditions. Nevertheless, the need to improve the biological condition of the estuary should be taken into consideration in the design of any channel works which may be undertaken to improve flood flow or facilitate navigation.

(See Management Recommendation 4)

It is equally important that nothing should be permitted which will reduce the present flushing of nutrient-rich water to the sea, either by restricting flow through the Mandurah channel or by decreasing the flow of nutrient-poor water to the estuary, especially from the Murray River.

(See Management Recommendation 5)

3. **Reduce the estuarine store of phosphorus present in algae and in the sediment.** This alone cannot result in long term improvement in the eutrophic condition. So long as input continues to exceed output the store of phosphorus will tend to accumulate and action for removal will be necessary. The nutrient store can be reduced in the following ways:

(a) **By removing the nutrient-enriched surface sediment of the estuary.** Surface sediment has a high phosphorus content which supplements other sources of this nutrient, although it is not yet known how much of the sediment phosphorus becomes available to algae in assimilable form. It is thought that removal of the top 10cm of sediment throughout the deeper parts of Peel Inlet could deplete available phosphorus to a level at which growth of algae may be greatly reduced for a period of 5-10 years, but this has still to be confirmed.

(See Management Recommendation 6)

(b) **By continuing and extending the cosmetic weed removal.** Pending effective reduction of the present high nutrient levels in the estuary, continued harvesting of algae from the shores is one practical measure by which to attack the algal problem. While primarily cosmetic, this will remove some part of the nutrient store, albeit a relatively small part. At the same time it may be expected to reduce the probability of events such as that at Falcon in January 1981 when massive accumulation of decomposing algae (*Cladophora* and *Nodularia*) resulted in deoxygenation of the water with consequent fish and crab deaths.

Until recently, weed removal has been confined to within 50m of the shore. Algae tend to accumulate in piles further offshore on the intertidal platforms, where they decompose slowly with release of nutrients, and are transported to shore by wave action. Removal of these accumulations will be a more effective way of reducing both the algal nuisance and the amount of nutrient returned to the water body and sediments.

(See Management Recommendation 7)

A more radical method of preventing excessive algal growth and accumulation would be to harvest algae from their major growth areas in deeper water. While this could be done in conjunction with sediment removal (3a above) it may be worthwhile investigating the possibility of removing algae free of sediment and disposing of it commercially. Of the dominant algae, *Cladophora, Chaetomorpha* and *Chondria* would be the species harvested in this way. *Enteromorpha* mainly grows in the shallows and would not be collected in quantity.

(See Management Recommendation 8)

Implementation of these management considerations and the recommendations arising from them must take into consideration other likely environmental consequences of management measures, such as damage to the fishery, and the social and economic factors involved. It is desirable that a social and economic cost-benefit analysis be made before management decisions are taken.

The synthesis report discusses other possible methods for controlling the algal problem; e.g. reducing benthic light, reducing the amount of available nitrogen, application of an algicide. They are not considered here because it is unlikely that they will reduce the eutrophic condition of the estuary.

RECOMMENDATIONS FOR MANAGEMENT

Recommendation 1

It is recommended that every effort be made to reduce the quantity of phosphorus discharged to the estuary from agricultural land. The Department of Agriculture and CSIRO Division of Land Resources Management should be asked to co-operate with the Department of Conservation and Environment in a study to determine methods by which release of phosphorus from coastal plain soils can be substantially reduced, whether by reduced application rates, modification of present application techniques, use of less soluble forms of phosphorus, or other methods. This study should be undertaken urgently.

Recommendation 2

It is recommended that every effort be made to reduce the input of phosphorus to the estuary; either by diverting the major sources of phosphorus-rich water away from the estuary, or by interposing a biological water quality improvement scheme into the drainage system. The practicability of these proposals should be investigated in the light of engineering, economic, social and ecological considerations.

Recommendation 3

It is recommended that every effort be made to reduce the amount of phosphorus entering the estuary from urban sources. Housing developments within at least 2km of the estuary should be serviced by deep sewerage, and any effluents from wastewater treatment plants should be diverted away from drainage to the estuary.

Recommendation 4

It is recommended that, where possible, all engineering works in the Mandurah channel be designed so as to increase flushing. Full support should be given to measures by which flushing of nutrient-rich water to the sea may be increased especially under flood conditions, even though they may make only a small improvement in the eutrophic condition of the estuary.

Recommendation 5

It is recommended that no action be permitted which may decrease the flushing of nutrients to the sea; either by restricting the dimensions of the Mandurah channel under both flood and normal flow conditions, or by reducing the volume of flow of nutrient-poor water from hills catchments.

Recommendation 6

It is recommended that the practicability of a dredging operation which can remove the top 10cm of enriched sediment from the estuary be investigated.

Recommendation 7

It is recommended that the present cosmetic weed removal be continued and extended further offshore so as to remove algae where they first accumulate in the shallows and decompose, with release of nutrients. The equipment now being used is not designed for this purpose and it is recommended that more suitable equipment be obtained.

Recommendation 8

It is recommended that the practicability of developing equipment to harvest *Cladophora* and other algae where they grow, mainly in water of greater than 0.5m depth, be investigated.

RECOMMENDATIONS FOR FURTHER RESEARCH

Our understanding of how the estuarine ecosystem works is still far from complete; limitations of time and study content, and the unusually low rainfall and river flow during the study period have left many questions unanswered. Study of the uptake of nitrogen and phosphorus by phytoplankton and their transfer to and release from the sediments is continuing. This is essential to our knowledge of the role played by sediments in nutrient supply to algae.

Other problems recommended for further study are outlined below and it is considered important that they be undertaken in order to give confidence to conclusions and recommendations, some of which have necessarily been made on inadequate data.

1. **Opportunistic flood study.** There is no firm basis for predicting the behaviour of nutrients under extreme flood conditions, either their release to drainage or their retention within the estuary. It is recommended that sampling be undertaken opportunistically in relation to flood flow in the rivers. It is suggested that this be done by DCE in co-operation with PWD Water Resources Section and the Waterways Commission.

2. **The role of nitrogen in facilitating retention of phosphorus.** It is generally phosphorus rather than nitrogen that is in shortest supply to algae in estuary water, nevertheless there are times when the reverse is true. At summer temperatures a low N : P ratio is associated with initiation of blooms of nitrogen-fixing blue-green 'algae' that make full use of available phosphorus. In winter, when temperatures are too low for blue-greens, a low N : P ratio may restrict growth of diatoms, and other phytoplankton, and consequently the retention of phosphorus. It is known that nitrogen input to the estuary depends greatly on volume of flow in the Murray River. However the source of the nitrogen is not well defined and the mechanism of its release to drainage is poorly understood. It is recommended that these be investigated, with special reference to Murray River flow. This could be undertaken on an opportunistic basis and it is suggested that DCE seek the co-operation of PWD water monitoring groups.

3. **Survey of the amateur fishery.** This fishery, for fish, crabs and prawns, is increasing and it is desirable that its value to the community be assessed. The amateur fishery is also potentially in conflict with the long-established professional fishery. It is recommended that the status of the amateur fishery be assessed and its development then monitored on a continuing basis in order to predict the likely effects of proposed development and management measures on this resource. It is suggested that the W.A. Department of Fisheries and Wildlife be asked to initiate such a study.

4. **Data analysis and storage.** Despite the limited duration of the study a

comprehensive data set has been accumulated relating to weekly samples for many water quality parameters, algal biomass, etc. as listed in Appendix 1 of the synthesis report. This valuable data set is easily accessible, much of it stored on computer tape, and should be used for further scientific analysis and progressive analysis of data collected by the proposed monitoring programme in relation to existing data.

RECOMMENDATIONS FOR ONGOING MONITORING

It has not been possible to predict with any certainty how rapidly the management procedures recommended will reduce the eutrophic status of the estuary to a condition where there will be no excess of large algae or massive phytoplankton blooms. To achieve effective management it will be essential that the condition of the estuary be monitored, as recommended below. The results should be reviewed annually by a scientific management group such as EMAC, with DCE being responsible for data storage.

1. **Benthic algae.** Benthic algae must be sampled regularly for biomass and species composition. It is preferable that this be undertaken four times a year at about 20 stations (a one day exercise on each occasion). It is recommended that this be undertaken by DCE in co-operation with the Department of Botany, University of W.A.

2. **Nutrients, chlorophyll, salinity.** It is recommended that water samples be taken for these constituents at 3 stations each in Peel and Harvey, monthly except during high river flow and then weekly. Samples should also be taken in the Serpentine, Murray and Harvey Rivers weekly during periods of river flow. It is recommended that this be the responsibility of the Waterways Commission with analyses and data processing being undertaken at the University of W.A., Department of Botany's analytical laboratory.

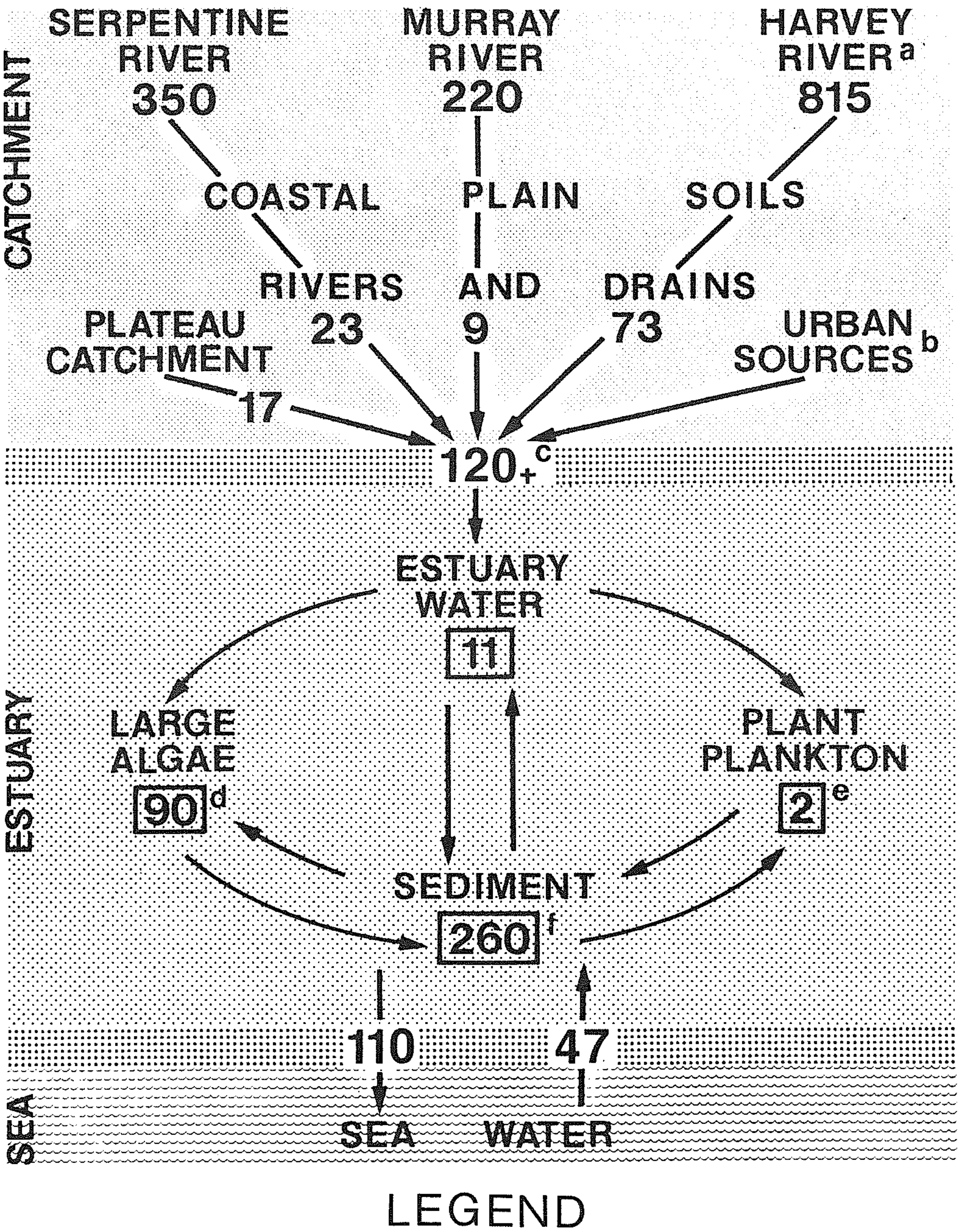
3. **River flow.** In order to meaningfully interpret nutrient data from the rivers it will be necessary to relate them to river flow. Flow in the Murray and Serpentine Rivers is gauged by PWD Water Resources Section, and their continued co-operation should be sought, but it will be necessary to re-establish a permanent water level recorder on the Harvey River. It is recommended that the PWD Water Resources Section or the WAIT School of Physics and Geoscience are appropriate bodies to be approached to undertake this.

4. **Urban sources of nutrients.** It is recommended that a programme be initiated to monitor the groundwater contribution to the system of nutrients and pathogenic organisms from urban sources. This is particularly important in older established permanent residential areas where septic tank waste disposal has been in operation for many years. Transects of a few bores should be drilled across the groundwater table of Quaternary sediments at Coodanup, Falcon and Dawesville. Bimonthly sampling would be adequate to detect changes in groundwater nutrient levels resulting from increasing urbanisation. The School of Physics and Geoscience at WAIT would be an appropriate body to approach to initiate such a programme.

FIGURE 1:

PHOSPHORUS IN THE PEEL-HARVEY ESTUARINE SYSTEM AND CATCHMENT (A BUDGET BASED ON 1978 DATA)

PHOSPHORUS APPLIED AS SUPERPHOSPHATE TO COASTAL PLAIN CATCHMENTS OF:



LEGEND

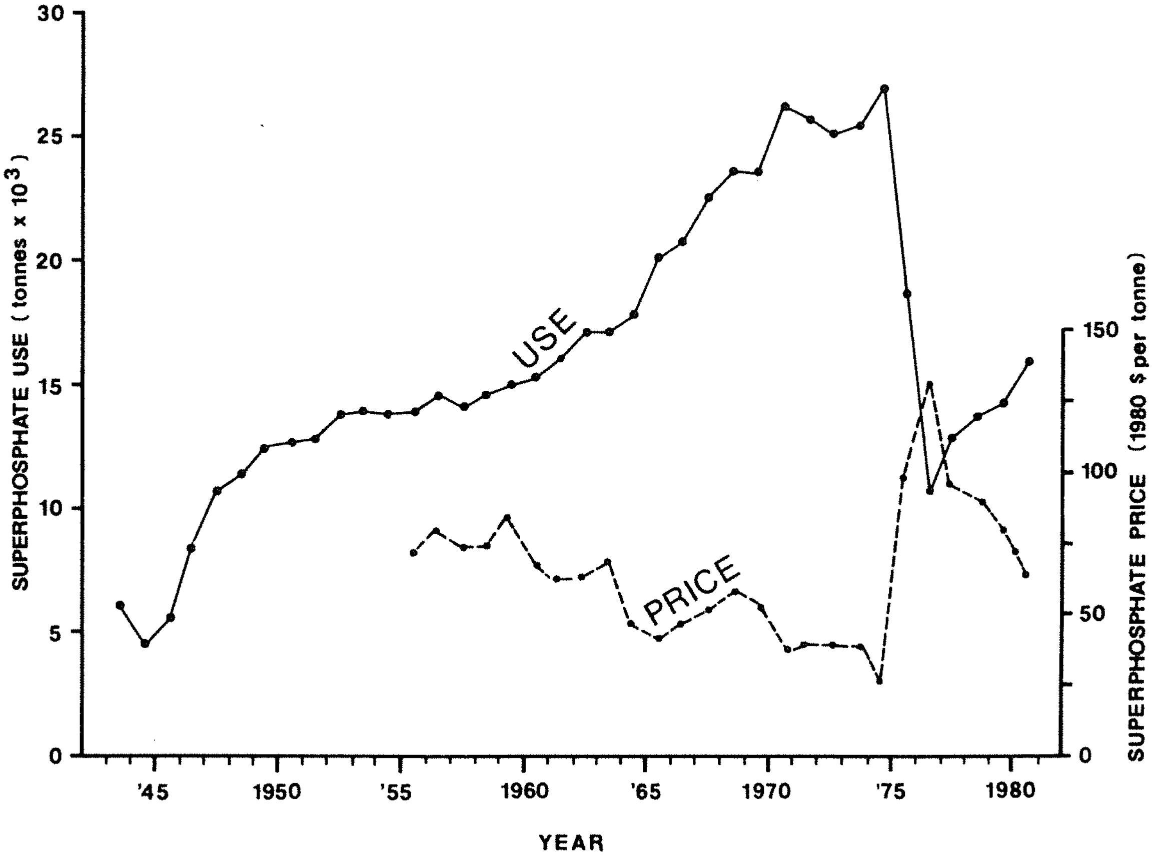
NOTES. **All figures are in tonnes and are approximate only. Arrows: rates per annum. Boxes: mean quantities present.**

a. includes Mayfields and other drains discharging direct to the estuary.
b. estimated to be less than 10 tonnes.
c. of this, 103 tonnes entered the estuary in July-August.
d. *Cladophora* 55 tonnes, other large algae 35 tonnes.
e. during blooms this figure may be as great as 30 tonnes.
f. top 2 cm of sediment only; includes organisms present.

FIGURE 2:

SUPERPHOSPHATE USE AND PRICE :

COASTAL PLAIN CATCHMENTS OF THE PEEL–HARVEY ESTUARINE SYSTEM.



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93 The Control of Phytoplankton Populations in the Peel-Harvey Estuarine System. R.J. Lukatelich and A.J. McComb. 1981.

94 Cyanobacteria and Nitrogen Fixation in the Peel-Harvey Estuarine System. A.L. Huber. October 1980.

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97 Aspects of the Biology of Molluscs in the Peel-Harvey Estuarine System, Western Australia. F.E. Wells, T.J. Threlfall and B.R. Wilson. June 1980.

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