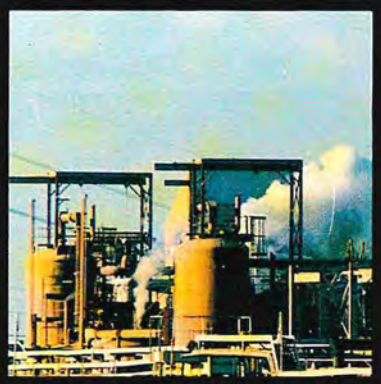
A STUDY FOR SOUND MANAGEMENT

A SUMMARY OF THE FINDINGS OF THE COCKBURN SOUND ENVIRONMENTAL STUDY










DEPARTMENT OF CONSERVATION AND ENVIRONMENT

BULLETIN NO. 73
DECEMBER 1979

INTRODUCTION

Cockburn Sound's protected waters, being adjacent to metropolitan Perth, have a unique value for the people as a resource: for recreational pursuits, for fishing, for heavy industry and as a harbour.

Aware that undesirable changes in water quality had begun to take place and concerned to maintain the Sound's suitability for multipurpose use, the State Government set aside $500 000 in 1976 to permit a three-year environmental study to be undertaken. The study's primary aim has been to assess the total impact of the various activities affecting the Sound, particularly to examine the effects of natural and man-made pressures on the aquatic environment. These man-made pressures have arisen from the continued rapid expansion of the Perth Metropolitan Area.

The Study is now complete and a comprehensive report has been prepared. It is a large document which has drawn on several scientific and detailed technical reports.

This brochure summarises the work of the Study and its conclusions.

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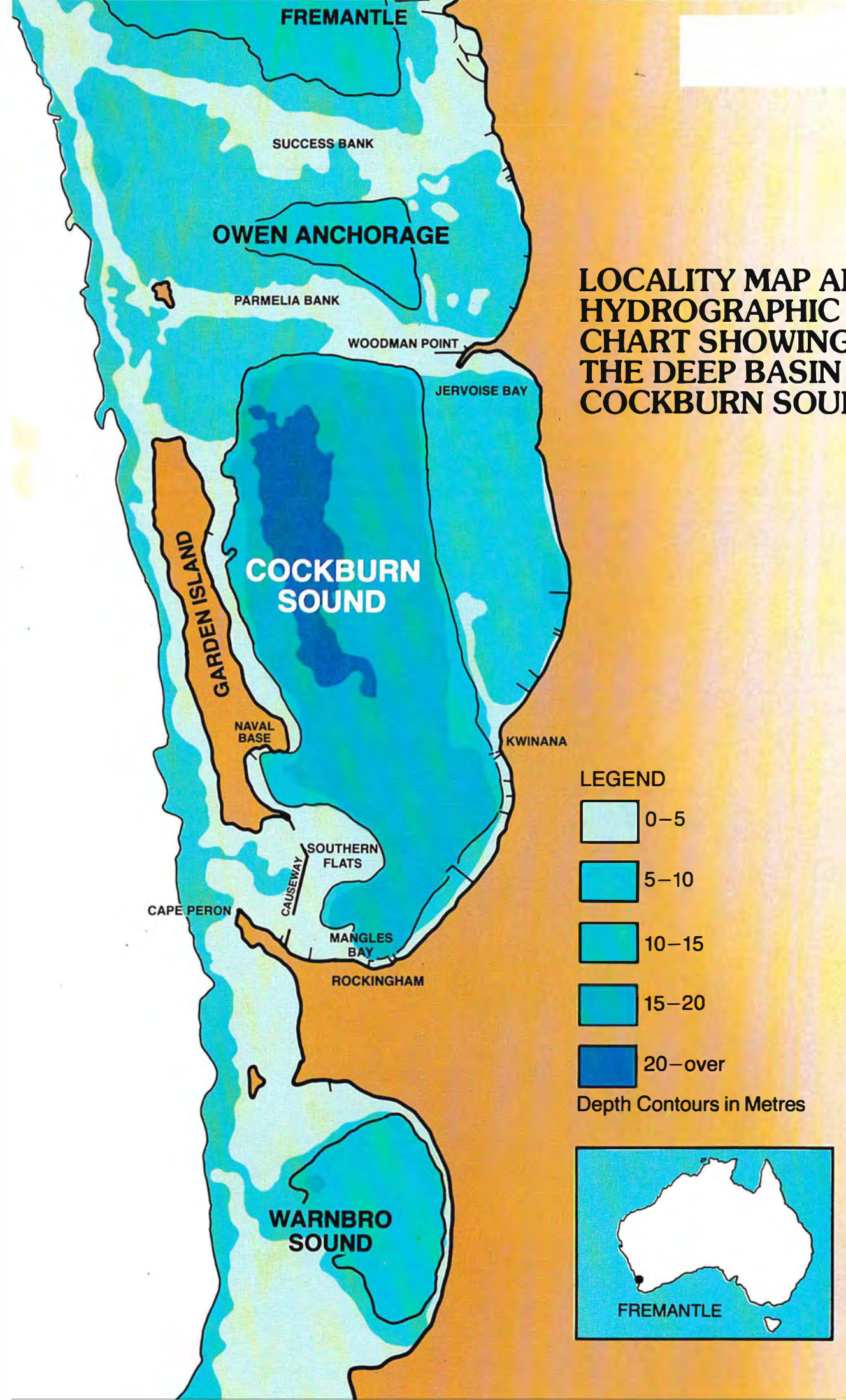


LOCALITY MAP AND HYDROGRAPHIC CHART SHOWING THE DEEP BASIN OF COCKBURN SOUND

HISTORY OF ENVIRONMENTAL CHANGE

To understand the changes that have taken place we must trace the history of Cockburn Sound to the early 1950s before significant industrial development began. Cockburn Sound encompasses a relatively small 'ecosystem' supporting a community of plants and animals which are dependent on one another. Certain animals and plants rely on movement into and out of the Sound as part of their life cycle, and that part of the cycle which is spent in the Sound is affected by the physical and chemical environment of this ecosystem. The environment is governed to a considerable extent by external influences of meteorological and oceanographical conditions and to a lesser extent by adjacent landforms.

Such an ecosystem must be able to respond to changes in physical, chemical and biological pressures, and these occur naturally, either daily or seasonally. Sometimes they fluctuate less predictably, for example through cyclonic storms; they may also take the form of long-term weather cycles.

Because of these processes, the environment of Cockburn Sound and the marine community within it does not remain static, even without the additional pressures superimposed by man.

European settlement has accelerated the environmental change of Cockburn Sound. The potential of the deep water basin as a natural harbour soon became apparent. With plans, later to be shelved, for establishing a naval base in the Sound, the Commonwealth Government began dredging a channel through Success and Parmelia Banks in 1919.

The channel was dredged periodically until in 1967 it reached its present size and depth. The access afforded by this channel to deeper draught steamships has had an important effect on the industrial development of the Sound, and on the establishment of a naval base on Garden Island.

Development of Cockburn Sound as the outer harbour for the Perth-Fremantle area really began in the 1950s and gained momentum during the ensuing 25 years.

Fishing

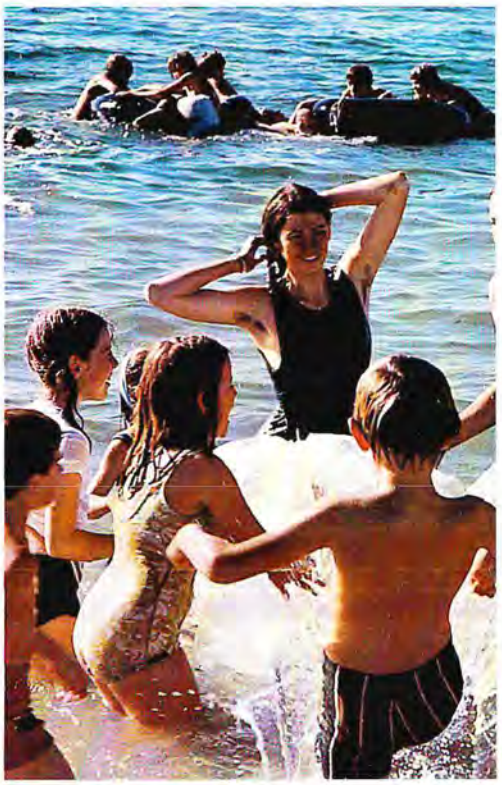
Recreation

The first major unit of an industrial complex which built up on the eastern margin of the Sound was an oil refinery which opened in 1955. Development brought environmental changes such as the clearing of the dunes and coastal vegetation, the building of wharves and groynes and the excavation of channels for shipping access.

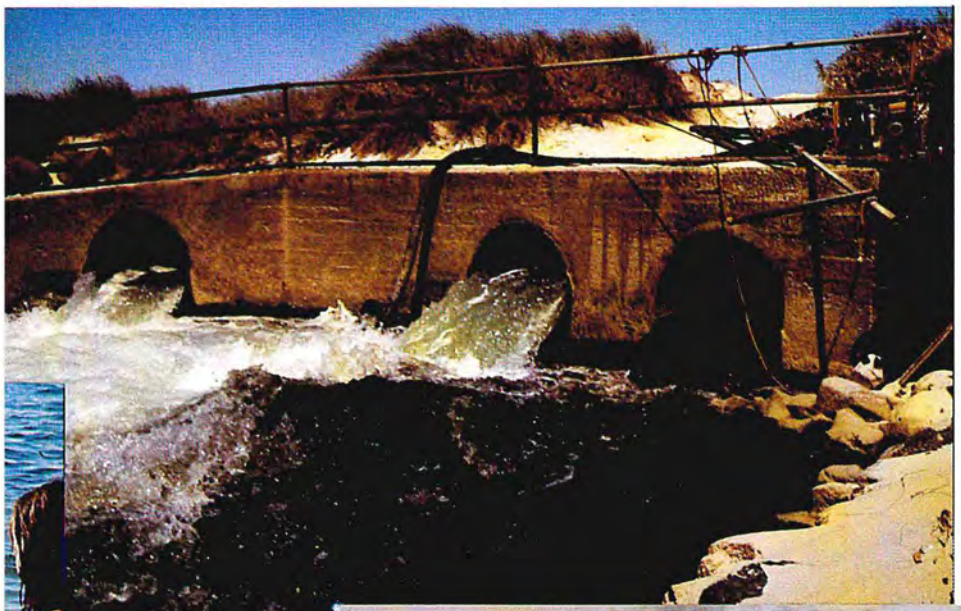
In 1969 the Commonwealth Government announced plans to build a naval establishment on Garden Island. A solid fill causeway with two open bridge sections was begun in January 1971 and completed in April 1973. Another significant environmental change was heralded in 1971 when the Western Australian Government ratified an agreement allowing a cement manufacturing company to dredge lime sands from Success and Parmelia Banks for the next 40 years.

This period of industrial development around Cockburn Sound has been accompanied by a steady growth of urban population. In 1976 the total population in the hinterland of the Sound from Fremantle to Rockingham was 144 709 and this is expected to reach approximately 200 000 by 1990.

SOME USES OF COCKBURN SOUND TODAY



Cooling water and discharge of effluents



Harbour for shipping

EVENTS LEADING TO THE PRESENT STUDY

The signs of stress

With the expansion of the industrial complex and the discharge of effluents to the Sound visible changes began to occur. These were heralded by death of seagrass, at first in patches along the shallow banks of the eastern shores of the Sound followed by widespread dieback along the total length of these shores. Heavy metals such as cadmium were found in a mound of gypsum, a substance being discharged into the Sound by the CSBP fertiliser works. There was evidence of dune erosion in some areas and a build-up of sand in others, and occasionally dead marine life was washed ashore. In some areas public access was restricted and beaches, once quiet and secluded, became dominated by heavy industry. Perhaps the most obvious change was that of the water quality; bathers complained of the water having a greasy feel and the water lost its clarity. At times the waters off the Rockingham beaches were too unpleasant to swim in. This deterioration of the water quality arose largely as a result of algal blooms.

Following the announcement in 1969 of the building of a causeway from the mainland to Garden Island a range of environmental studies was financed by the Commonwealth Department of Works, now the Commonwealth Department of Housing and Construction, and the Fremantle Port Authority. In this awakening phase of environmental awareness a number of baseline studies of the general ecology of Cockburn Sound were undertaken. These included investigations of some industrial and urban wastes, although attention was mainly focused on water circulation and exchange with the open sea in the area of the causeway.

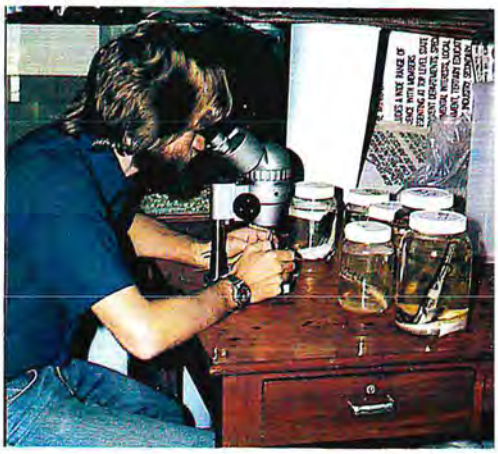
The call for a study

In those early days the over-riding planning objective was to utilise the area for industrial growth. But as the local urban population grew, more space was needed for recreation and the fish resources came under increasing pressure from amateur as well as professional fishermen.

There was a pressing need for an integrated management plan for the Sound. Effluents were being discharged into the outer harbour by government instrumentalities as well as by a number of major industries that were discharging under earlier agreements ratified by Acts of Parliament. The Fremantle Port Authority was concerned at the deterioration of the environment but had only limited powers to act. It sought active participation from the Environmental Protection Authority (EPA), which was also concerned that the Sound's capacity to absorb wastes was probably being exceeded.

The EPA commissioned consultants to review all relevant data available to the end of 1975, and as a result of this review and of the EPA's recommendations to the Western Australian Government, the Study was undertaken.

Fish ecologist identifying juvenile fish for the study on fish production.



Study Group diver collecting a core of sediment for heavy metal analysis.

Marine chemist analysing crab flesh on an atomic absorption spectrophotometer for the study on the distribution of contaminants.

PURPOSE OF THE STUDY

The objective has been to gather the information necessary to manage the Sound for multi-purpose use, accommodating **recreational** and **fishing activities** as well as use for **port** and **industry.** The present levels and potential of each of these types of activity were analysed, and the impact of each activity on the environment of the area was assessed. Finally, options for future management were considered, with the aim of maintaining as wide a range of activities as possible.
It was evident that attention had to be focused on existing problems. The alternative approach, a base-line study designed to give a thorough understanding of all elements of the system, was considered inappropriate as a means of resolving the pressing issues.

Study Group scientists filtering seawater samples for the study into nutrient enrichment and eutrophication.

COMPONENTS OF THE STUDY

The major lines of investigation pursued by the Study followed the principal objectives set by the Cabinet Minute authorising the Study:

i) **monitoring of industrial discharges;**
ii) **assessment of the causes of the death of seagrass;**
iii) **assessment of the causes and possible cures for the algal blooms which can and do degrade the Rockingham swimming domains;**
iv) **analysis of the social and recreational uses of the Sound and its tourist and recreational value;**
v) **assessment of the fisheries potential and productivity for professional and amateur fishermen;**
vi) **appraisal of water movements to reassess flushing of effluents and to provide alternative options to treatment on land by discharge of effluents into well-flushed areas;**
vii) **beach movement studies to assess the role of seagrass naturally or the need for artificial devices to control beach erosion.**

Information on these aspects was obtained by controlled scientific work, the collation and analysis of existing information and, where appropriate, canvassing the opinions of members of the public. In addition, closely related aspects were investigated by other departments and institutions. These ancillary studies were carried out at little additional cost and enhanced the overall value of the project.

THE STUDY BEGINS....

Operations began in November 1976 with the appointment of a project leader, followed in the next few months by the recruitment of staff (a core group of ten people), acquisition of equipment and appointment of consultants.
The length of each segment of study varied depending on the nature of the problem to be solved. However, integration of approach and exchange of information was encouraged so that the total effect of the various pressures on the ecosystem could be assessed.

Study Group divers measure the growth of tagged seagrass leaves.

Beach scene, Cockburn Sound; the numbers of beach users and boat owners were assessed during the survey on recreation.

FINDINGS

USE OF COCKBURN SOUND FOR RECREATION

Opportunities do exist for a wide variety of recreational pursuits in the Cockburn Sound area provided water quality is improved and the siting of any further industrial or port developments is carefully planned, particularly in the Rockingham/Mangles Bay area. Of the 30 km mainland foreshore about 13.5 km are available for intensive recreation at present.

A census undertaken on a typical hot summer's day revealed over 7000 people, mainly in family groups, on the beaches; over half of this number was concentrated on the Rockingham beaches, where there is natural protection from the strong south-westerly sea breeze. Nearly all of those at the Rockingham beaches actually lived in areas outside the Shire of Rockingham, whereas the visitors to other beaches came from nearby locations. On peak days more than 600 boats containing about 2200 people, whose main activity was fishing, could be expected on the waters of the Sound.

Taking into account arrivals and departures, it is reasonable to conclude that the recreational facilities of the Sound attract over 10 000 people on peak summer days, which represents greater recreational activity than on the lower reaches of the Swan and Canning Rivers.

Facilities provided at the five main Cockburn Sound beaches other than Rockingham were generally found to be adequate for present peaks in demand. The main activity of those launching boats from the three main public ramps was fishing; most boating activity was on Southern Flats, off Garden Island and in Jervoise and Mangles Bays.

WHAT THE PUBLIC THINKS

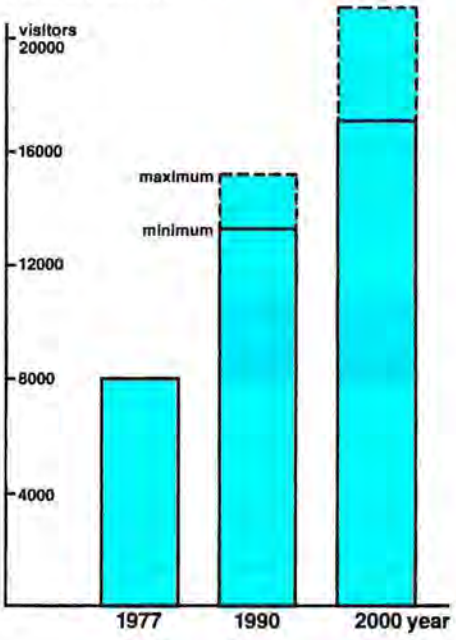
Local community groups indicated concern over additional port and industrial developments. Although they recognised the economic need for industry they felt that the recreational potential of the Sound had been disregarded in the past. Most groups preferred that industry should be set back from the foreshore, its growth restricted and more control exercised over the discharge of its effluents.

Although beach users were relatively more tolerant of non-recreational uses of the Sound, they expressed concern about a variety of matters ranging from the provision of adequate facilities, to the presence of industry and government installations on the foreshore. Boat users were more concerned with the availability of ramps and associated facilities than with the effects of industry on their activities.

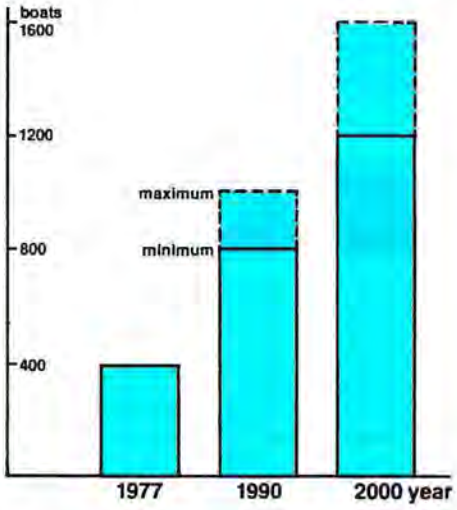
THE FUTURE DEMAND

Beach space is likely to be sufficient to cater for this demand provided that the relatively protected beach north of Woodman Point, previously used as a quarantine station and explosives depot, is developed for recreation. However an additional four to eight lanes of public boat launching ramps will be needed in the near future.

VISITORS TO BEACHES IN COCKBURN SOUND AND OWEN ANCHORAGE ON A PEAK DAY.



POWER BOATS – NUMBERS LIKELY TO BE LAUNCHED AT RAMPS ON A PEAK DAY.



Based on:

Population projections and assuming present proportion of users from various population units

These figures will increase with:

- **Increased leisure time.**
- **Improvement in water quality with resulting changes in attitudes.**
- **Provision of additional facilities.**

FISH RESOURCES

The Sound is an important area for fish production and the numbers and value of fish caught by professional and amateur fishermen are substantial. Because the Sound is a protected embayment it provides shelter and sustenance for many marine species at some time during their life cycles.

In the 1977-78 financial year, the total catch by professional fishermen of fish, crustacea (mainly crabs) and molluscs (mainly mussels) was approximately 760 tons as measured on a live weight basis and valued at about $500 000. Over 60 per cent of these were bait fish and **the five most important species of the catch out of a total of 29 species were scaly mackerel, mussels, pilchards, Perth herring and blue manna crabs.**

A creel survey carried out in 1978 indicated that amateur fishermen took more than 2.5 million fish and shellfish from the Sound in that year, of which 885 000 were blue manna crabs. The professional fishermen's crab catch during the same period totalled only about 1.5 per cent of the weight of this catch.

The main species of scale fish taken by amateurs were the Australian herring, whiting, skipjack, garfish and yellowtail scad.

It is clear, therefore, that professional and amateur fishermen tend not to catch the same species of fish, thereby minimising conflict and competition between them.

The Department of Fisheries and Wildlife currently is investigating the future potential of several species which are not yet being fished or are being lightly exploited. The most promising of these is the edible mussel. However, the potential for culture of this species is presently threatened by bacterial contamination of mussels collected from structures along the shores of Woodman Point and Owen Anchorage. Moreover, mussels taken from Cockburn Sound, particularly along the eastern shores adjacent to the Kwinana industrial area, contain relatively high concentrations of heavy metals, particularly cadmium. Scallops and prawns also are being considered for increased production. It would appear that improvements in water quality, particularly reduction of constituents such as heavy metals, petroleum-derived hydrocarbons (oil) and bacteria, need to be made before specific action can be taken to increase production of these species.

The Study Group used trawl, beach seine and set nets to catch fish and shellfish so that an inventory of marine faunal resources could be made and the Sound's role as a breeding and nursery area could be assessed. About 200 000 individuals representing 144 different species were counted and identified. Of these, 81 species were of commercial and recreational value. Some species were found to use the Sound as a permanent breeding and nursery habitat, some as a nursery habitat for juveniles, whereas for others it is only an occasional feeding area for maturing and mature adults.

The Effects of Changing Habitats

In the past no detailed study had been made to document fish species characteristic of certain habitats within Cockburn Sound. It is, therefore, difficult to draw conclusions concerning the effects of habitat changes on fish species composition. Loss of seagrass meadows, dredging and filling, the building of jetties, shipping berths and the causeway, as well as the discharge of effluents are likely to have changed habitats. However, a comparison of species found in seagrass and sandy substrate habitats showed that the species which prefer the seagrass habitat are of limited direct benefit to commercial and recreational fishing interests. Only in the long term will the effects on fish of the seagrass dieback be seen.

School of yellowtail in Cockburn Sound a species caught by amateur fishermen.

The blue manna crab, the species caught in greatest numbers by amateur fishermen in Cockburn Sound.

INDUSTRIAL ACTIVITIES AND THE DISCHARGE OF EFFLUENT.

The waters of Cockburn Sound provide process cooling water for many industries along its shore. The total volume of about 1600 megalitres per day of salt water used for cooling and fresh water used in plant processes is discharged into the Sound. The major industries and other wastewater producing installations on the shores of Cockburn Sound are shown below:

NAME	ABBREVIATION	PRINCIPAL ACTIVITY
KWINANA INDUSTRIAL AREA		
Alcoa of Australia (W.A.) Ltd.	Alcoa	Alumina refining
Broken Hill Pty. Ltd.	BHP	) Steel rolling and
Australian Iron and Steel Pty. Ltd.	AIS	) blast furnace
BP Refinery Pty. Ltd.	BP	Oil refining and related activities
Kwinana Nitrogen Company Pty. Ltd.	KNC	Nitrogenous fertiliser manufacturing
CSBP & Farmers Ltd.	CSBP	Superphosphate manufacturing
Western Mining Corporation Ltd.	WMC	Nickel, metal refining and ammonium sulphate production
WASTEWATER TREATMENT PLANT		
Woodman Point	WPTP	Wastewater treatment
Cape Peron	CPTP	Wastewater treatment
POWER STATION		
Kwinana	SEC	Electric power generation

LOCATION OF COCKBURN ROAD AND KWINANA INDUSTRIAL AREAS.

Cockburn Road Special Industrial Area.

Industries in this area discharge into Owen Anchorage wastewaters having a total volume of 4.0 megalitres per day. The Western Australian Meat Commission (WAMC) abattoir is the principal discharger in terms of volume (2.2 megalitres per day). The effluent has a very high biological oxygen demand and a substantial load of suspended solids, grease and oil. The group of hide processing plants situated in this area accounts for inputs in excess of 11.4 kg per day of chromium.

The effluents discharged by the WAMC abattoir, Anchorage Butchers abattoir and other meat processors are sources of enteric bacteria, including Salmonella bacteria. These, with the Woodman Point sewage effluent, have been found to contaminate the waters and mussels in Owen Anchorage and around Woodman Point. The discharge of blood and grease from these industries also lowers the water quality for bathing in this area, particularly at Coogee Beach, from time to time.

Groundwater Contaminants can also enter the Sound via indirect discharges into land soaks and into pits which ultimately drain into the groundwater. The Study has identified localised contamination of the groundwater beneath a number of industries by ammonium sulphate, free ammonia, hydrocarbons, phenols, herbicides, metals and bacteria. Nevertheless pollution of the Sound by contaminated groundwater is not large compared with direct discharge.

Air Emissions. Another indirect source of possible pollution to the Sound's water is that from air emissions by industries. These have been studied separately by the Kwinana Air Modelling Study but are believed to be of minor significance.

SUMMARY OF WASTEWATER VOLUMES AND LOADINGS TO COCKBURN SOUND

Samples and analyses of individual effluent streams in Cockburn Sound showed that they contained the following major contaminants:

	WPTP	SEC Kwinana	BHP	AIS	BP Total	KNC	CSBP (Includes KNC)	CPTP	TOTAL
Total Volume megalitres per day	30	1000	0.5	175	332	65	81	1.1	1620
Load, Kg/day									
Biological oxygen demand	8900							25	8925
Suspended solids	4000		4	1225	261			20	5510
Grease solids	1230								
Detergents	320				4.3			0.33	325
Phenolics					514[b]				514
Petroleum hydrocarbons (oils)					1000				1000
Total nitrogen	1422	110	0.9	49	322[b]	2725	3075	6.8	4986
Total phosphorus	261	220	<0.1	2	7.9	47.2	3275	9.7	3776
Sulphides	300 (annual average				592[b]				892
Metals									
Cadmium	<0.1		<0.1			<0.1	4.3	<0.1	4.3
Chromium	2.6		<0.1	0.2	0.6	<0.1	2.5	<0.1	5.9
Cobalt	0.2		<0.1			<0.1	0.4		0.6
Copper	2.6	2.0	<0.1		3.1	0.3	1.5	<0.1	9.2
Iron	10.0	80	1.0	200	85.0	14.2	140		516
Lead	1.6		<0.1	0.5	1.3	<0.1	0.35	<0.1	3.8
Mercury	0.1		<0.1	0.1	<0.1	<0.1	0.1	<0.1	0.3
Molybdenum	<0.1		<0.1		0.3				0.3
Nickel	0.4	3.0	<0.1		0.7	0.2	0.6		4.9
Vanadium	<0.1		<0.1		1.8				1.8
Zinc	3.5	3.0	<0.1	2.0	4.9	2.6	7.8	0.1	21.3
Arsenic	0.3		<0.1	0.4	1.2	<0.1	0.1		2.0
Fluoride (soluble)	24.0						6050		6074

Footnotes

Blanks in the table mean that the concentration of the constituent was not determined.

Dashes in the table mean that the concentration of the constituent was determined to be the same as in waters of the Sound and, therefore, there was no input of that constituent.

Most loads have been adjusted to reflect operating or production levels and are believed generally representative of conditions during the period March 1977 to May 1979.

[a] Approximately 350 000 kg/day of gypsum in slurry form is discharged by CSBP in addition to values listed.

[b] Modifications by the BP Refinery, since the completion of the field work, have reduced these loads.

< Indicates less than.

Slick emanating from an industrial outfall.

EFFLUENT CONSTITUENTS OF PRIMARY IMPORTANCE

Heavy Metals.

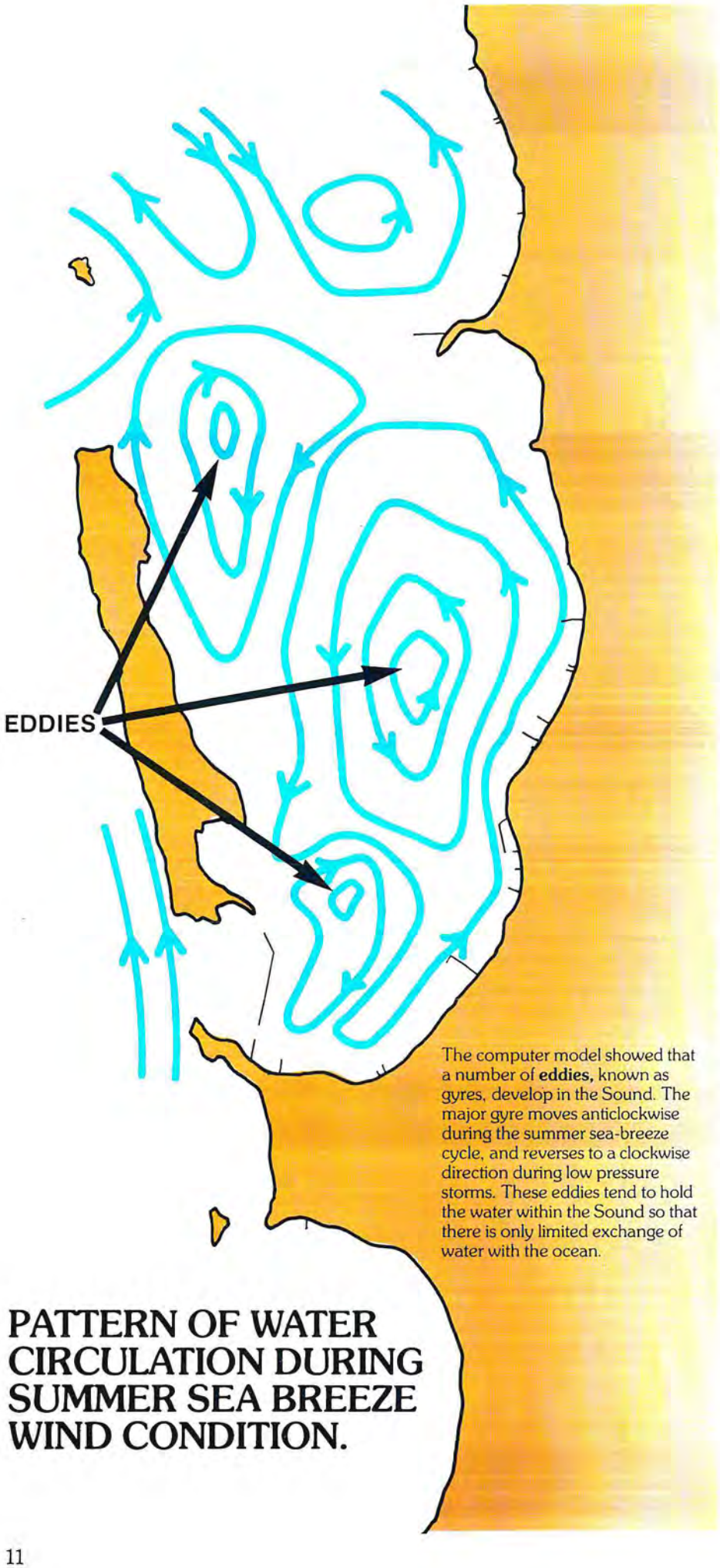
The constituents in the effluents which are of concern include some of the heavy metals, particularly cadmium. This is discharged by CSBP in the gypsum slurry. However, the company has plans to divert its gypsum to a land disposal site so that the cadmium and other heavy metals in the gypsum will be diverted away from the Sound. Other major contributors to the heavy metal load include the BP Refinery and the Woodman Point Wastewater Treatment Plant.

Nitrogen and Phosphorus.

Of the 5000 kg of nitrogen compounds discharged to the Sound each day the highest proportion is discharged by the Kwinana Nitrogen Company. The Company is, however, considering improvements to its plant which will reduce the input considerably. The Woodman Point Wastewater Treatment Plant would then be the major contributor of nitrogen as the volume of sewage discharged will continue to increase. The principal source of phosphorus is the gypsum waste which may ultimately be disposed of on land, again leaving the Treatment Plant as the main source.

Other Chemical Substances.

The input of soluble fluoride from CSBP are of unknown but potential environmental concern as are the petroleum hydrocarbons from the BP Refinery.



The computer model showed that a number of **eddies,** known as gyres, develop in the Sound. The major gyre moves anticlockwise during the summer sea-breeze cycle, and reverses to a clockwise direction during low pressure storms. These eddies tend to hold the water within the Sound so that there is only limited exchange of water with the ocean.

PATTERN OF WATER CIRCULATION DURING SUMMER SEA BREEZE WIND CONDITION.

WHAT HAPPENS TO EFFLUENT

In order to determine what happens to discharged effluents and where they will be carried and dispersed, the fine structure of water circulation within the Sound under various meteorological and oceanographical conditions had to be understood. Thus a computer driven model of circulation was developed using direct measurements of water currents and a full range of weather data, which were fed into the computer for analysis. The movement of water is mainly wind driven with tides exerting only a minor effect in this region and offshore currents being negligible close inshore.

Contrary to earlier beliefs **the Sound is not well flushed and much of the time it behaves as a "lake." Even during storm conditions the rates of exchange are not sufficiently high nor of sufficient duration to flush the Sound's water completely. Its ability to cope with pollutants, especially those that are not degradeable, is therefore limited.**

To determine where the pollutants are being carried and accumulated within the Sound and in parts of Owen Anchorage the seawater, sediments, plants and animals were sampled and analysed and the results compared with areas where contamination was likely to be negligible, e.g. Warnbro Sound and west of Garden Island. Groundwater was also analysed along the eastern margin of the Sound, where several industries discharged a portion of their wastewater on land and where accidental spillages on industrial sites have occurred over the years.

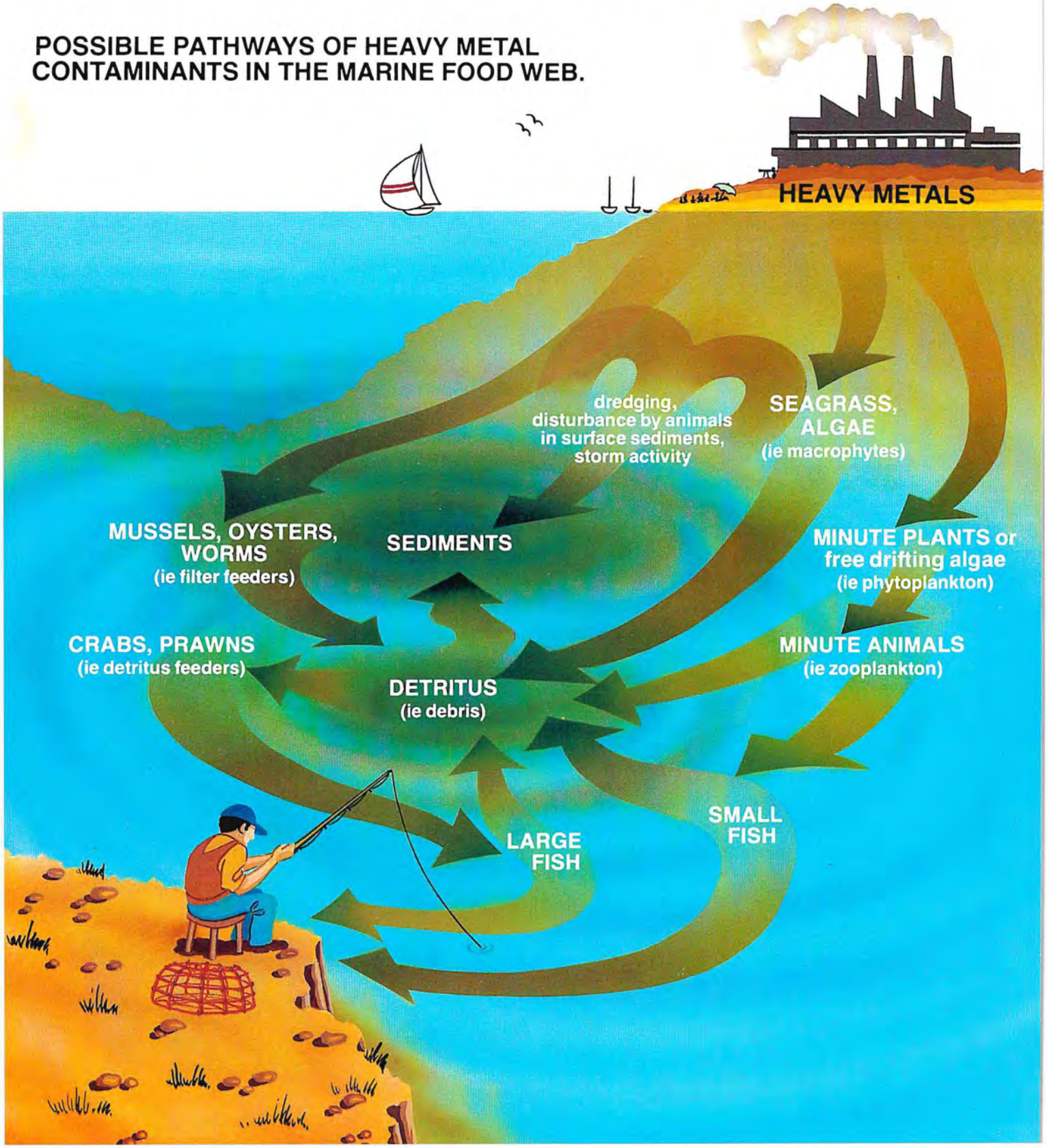
The main area of general contamination was found to be the eastern side of Cockburn Sound adjacent to the Kwinana and Owen Anchorage industrial areas. The **heavy metals** –cadmium, lead, chromium and zinc–were found to have exceeded Western Australian, and National Health and Medical Research Council recommended levels in certain edible shellfish species. In particular, the concentrations of cadmium in mussels were high.

However, heavy metals in fish flesh were not found to exceed official health standards. Several heavy metals have also accumulated in sediments. The main source of heavy metal contamination is the gypsum waste discharge from the CSBP outfall.

Petroleum-derived hydrocarbons (oils) were present in some plant and animal species, and fish tainted with the taste of oil have been caught from locations affected by the effluent from the BP oil refinery. This is the only significant continuous input of hydrocarbons to the Sound.

Mussels and water sampled from along the shores of Owen Anchorage and around Woodman Point were found to be contaminated with **enteric bacteria,** including **Salmonella bacteria.** These were found on occasions to be widespread in both seawater and mussels.

POSSIBLE PATHWAYS OF HEAVY METAL CONTAMINANTS IN THE MARINE FOOD WEB.



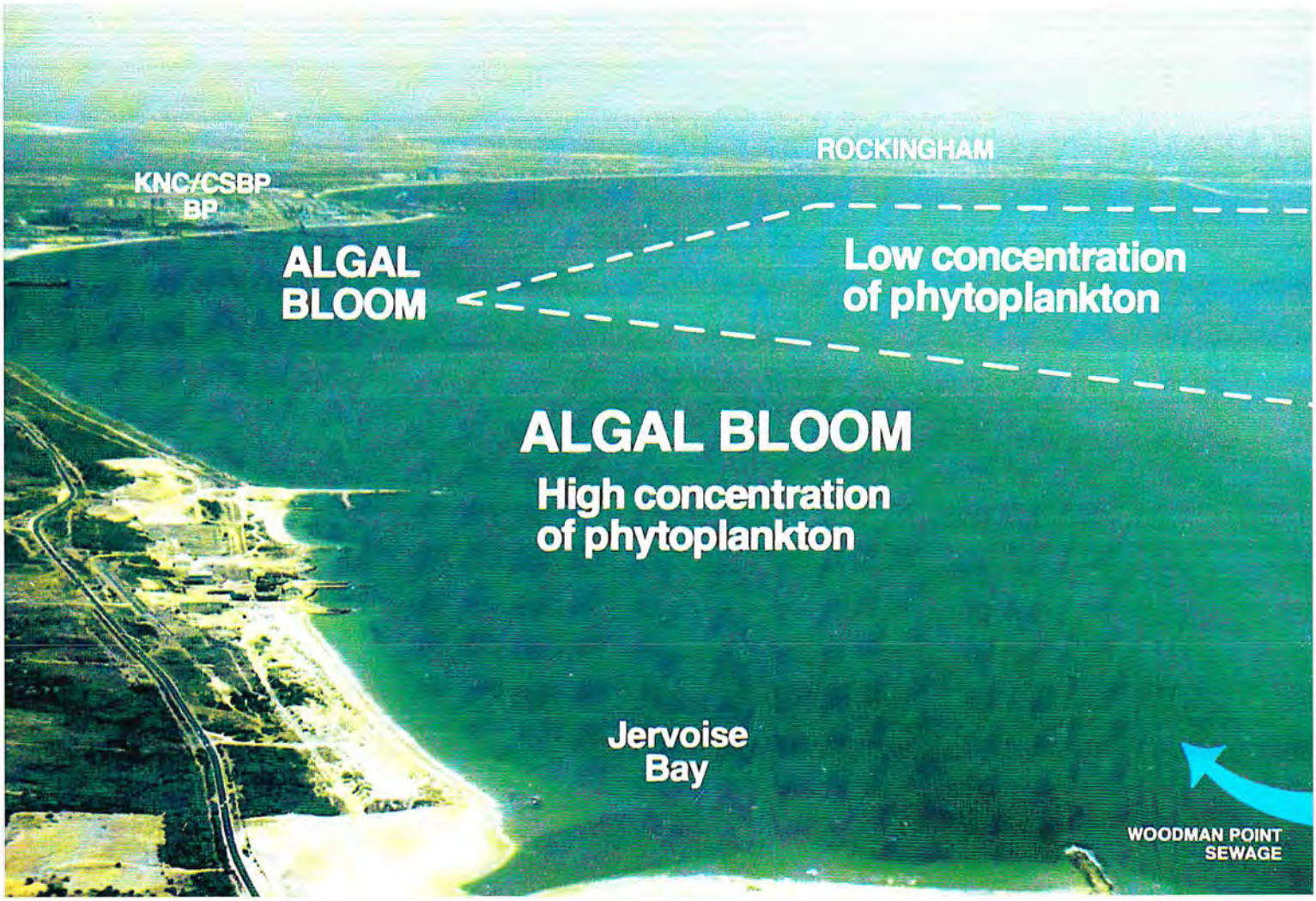
WHERE THE NUTRIENTS NITROGEN AND PHOSPHORUS GO

The impact of the nutrients nitrogen and phosphorus on the Sound's waters is the key to what is probably the major problem in Cockburn Sound, ALGAL BLOOMS.

The nutrients are used by free drifting algae (phytoplankton) which grow rapidly in numbers to form dense concentrations or algal blooms. In Cockburn Sound these have on occasion affected the quality and clarity of the water to the extent that they have interfered with recreational activities, particularly in the Mangles Bay area.

Work carried out in the waters of the Sound has shown that although phytoplankton require both phosphorus and nitrogen for their growth during the summer months, nitrogen is in shorter supply and is therefore more important if measures are to be taken to reduce the growth of phytoplankton. Light and temperature may limit growth in winter. There is a build-up of nutrients in the sediments, especially around the major input sites. During storm conditions some of these are recycled and made available for growth of more phytoplankton.

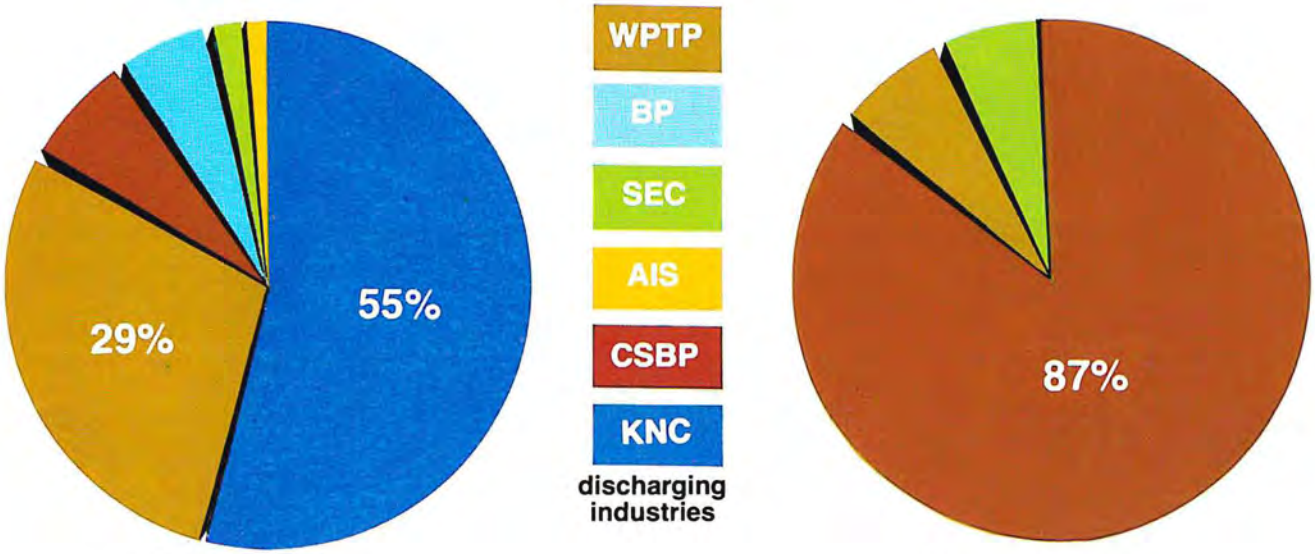
Nutrient enrichment of the waters has also led to very rapid growth of filamentous epiphytic algae, plants which attach themselves to the surfaces of other plants. In Cockburn Sound heavy growths of epiphytes have been observed on seagrass plants.



ALGAL BLOOMS

are caused by overenrichment of water by the nutrients, NITROGEN and PHOSPHORUS.

This phenomenon of overenrichment is known as EUTROPHICATION.



are discharged into Cockburn Sound

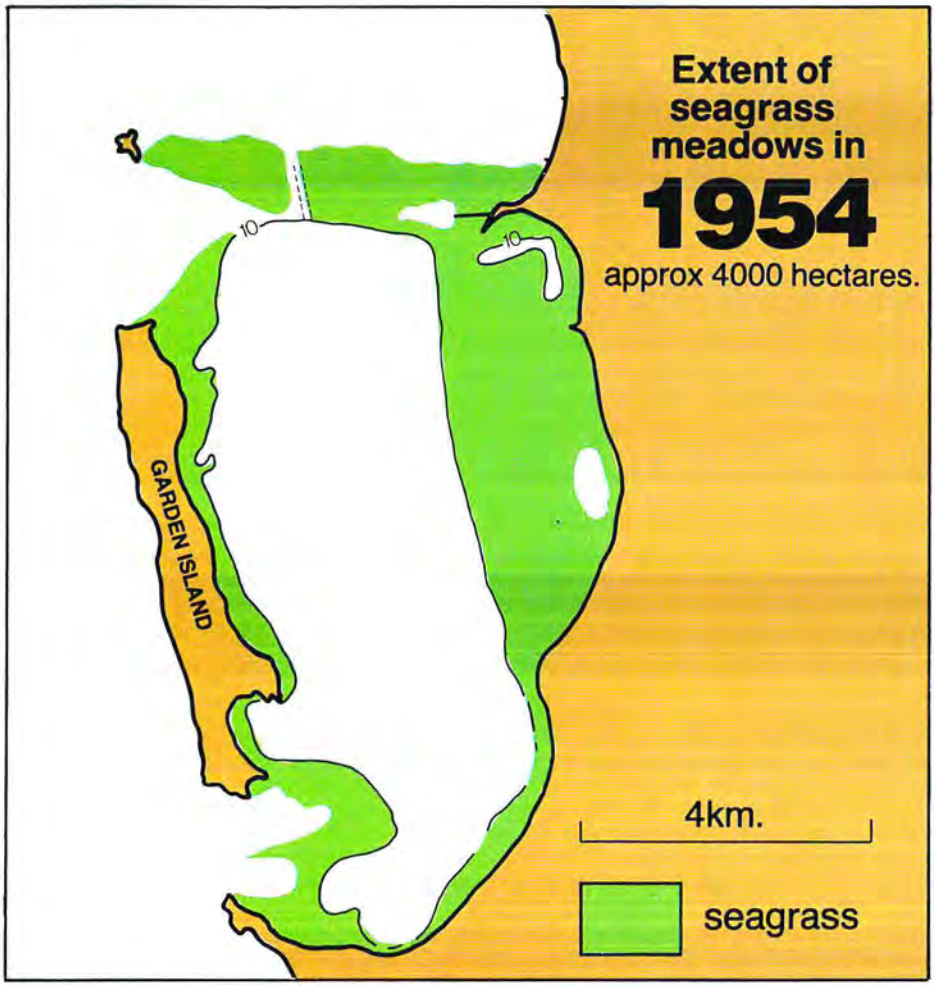
and used by PHYTOPLANKTON
(microscopic algae)
which grow rapidly in numbers

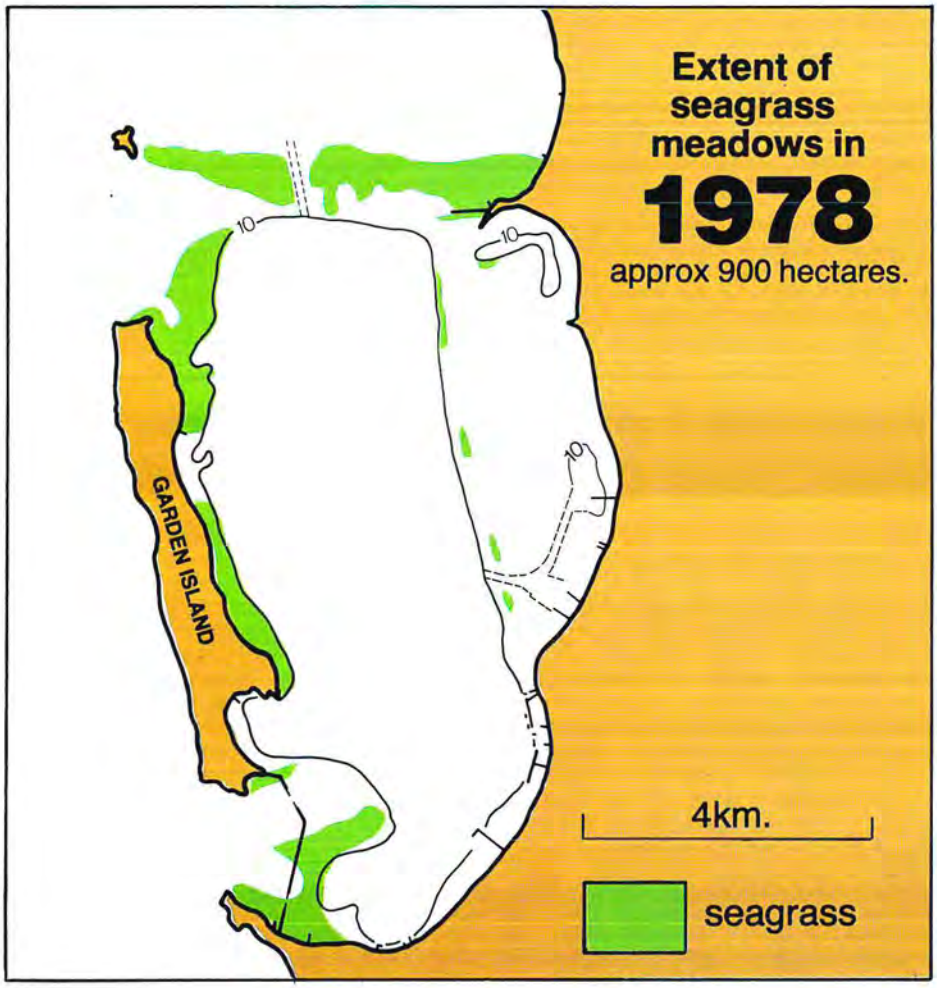
to form dense concentrations in the water known as algal blooms.

Blooms cause discoloration of the water which may smell, becoming cloudy & greasy

Blooms reduce the amount of light reaching the seagrass.

On decomposition of the phytoplankton, the water may be depleted of oxygen killing fish.





THE DECLINE OF SEAGRASS

Since industry was established in 1954 on the shores of Cockburn Sound, about 80 per cent of the seagrass meadows have died and the remaining meadows continue to decline.

Experimental transplants of seedlings failed to show that seagrass could still survive on the eastern banks. **Studies into the causes of the general disappearance of seagrass point to the effects of heavy growths of thick mats of filamentous epiphytes growing on the seagrass itself.** These reduce the amount of light available for photosynthesis and also add mechanical stress to the plants.

Epiphytes are species of algae which attach themselves to structures and plants such as seagrass. Epiphytes grow rapidly in waters which are enriched with nitrogen and phosphorus.

Algal blooms have also had the effect of filtering light and may have contributed to the decline where the meadows grow in deep water. Localised loss of seagrass has occurred in a number of places and may be attributed to various causes. Aquarium trials showed that the BP Refinery effluent did inhibit the growth of seagrass, but only at concentrations considerably in excess of those likely to be found even a short distance from the outfall. Other factors which have caused localised loss of seagrass include the construction of groynes and breakwaters, dredging and the grazing by sea urchins.

6 WEEKS AFTER TRANSPLANTING TO WARNBRO AND COCKBURN SOUNDS

HEALTHY SEAGRASS
FROM WARNBRO SOUND
Plants have vigorous root growth and the leaves are free of heavy epiphytic growth.

SEAGRASS PLANTS

(Posidonia sinuosa)
Photographed under water

UNHEALTHY SEAGRASS
FROM COCKBURN SOUND NEAR INDUSTRIAL EFFLUENT DISCHARGE POINTS.
Plants have reduced root growth and leaves are covered with heavy epiphytic growth.

SAND STABILITY

The present seagrass cover on the barrier banks to Cockburn Sound and Owen Anchorage helps to stabilise the sediments and prevent large scale erosion. The survival of the seagrass meadows is crucial if the barrier banks are to continue to protect Cockburn Sound and Owen Anchorage from the effect of high energy wave systems caused by strong north-east winds.

During the past thirty years there have been some changes in beach line around the Sound, especially with a build-up on the northern side of groynes and water intakes, and with erosion to the south of these obstructions. In places the erosion has extended shoreward into the dune system. However, rates of sediment movement are generally low.

Erosion along the shoreline of Mangles Bay extending to the Garden Island causeway.

SOLUTIONS TO THE MAJOR ENVIRONMENTAL PROBLEMS

The major problems which have been defined by the Study are:

- nutrients in the water of the Sound
- bacterial contamination of shellfish on shoreline structures and shore waters;
- contamination of fish and shellfish by heavy metals.
- aesthetic quality of shore and nearshore waters, lowered by nutrients and abattoir wastes;
- groundwater contamination.

All these arise out of industrial activities either through the discharge of effluents or accidental spillages.

There are two broad options for dealing with contaminants in effluents: **ocean disposal** involves diverting the effluent outside the confines of the Cockburn Sound circulation system into deep ocean water, and **in-plant treatment** involves removal of undesirable pollutants by each industry so that a purified effluent is discharged. The feasibility and cost of treatment would vary widely from plant to plant.

The removal of nitrogen from sewage discharged from the Woodman Point Wastewater Treatment Plant would involve major capital treatment as well as substantial operating costs. The removal of bacteria from the sewage and abattoir wastes would require a high degree of disinfection and to achieve this on a consistent basis most of the suspended solids would first have to be removed. With diversion of the CSBP gypsum waste to a land disposal site the cadmium, other heavy metals and phosphorus in this waste would cease to be problems in the Sound. However, heavy metals from the other sources and the petroleum hydrocarbons from the BP Refinery would continue as real or potential contaminants to the ecosystem.

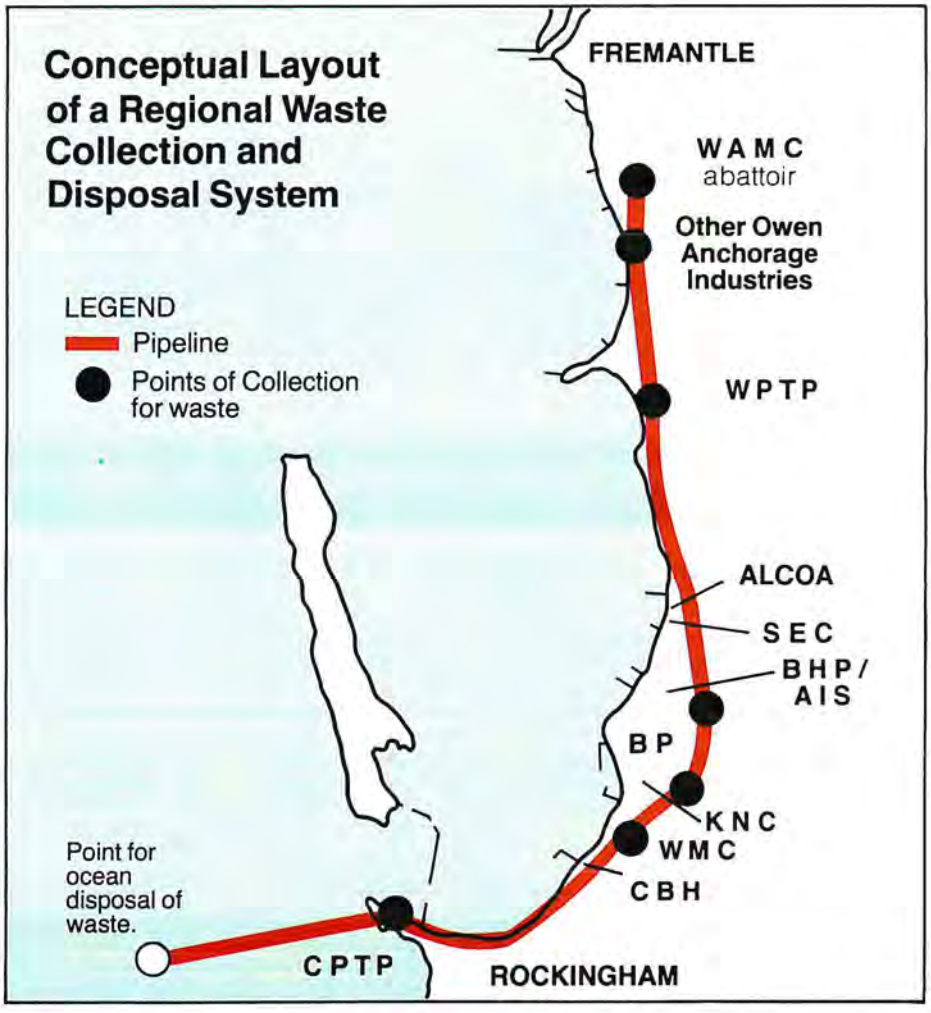
Disposal of wastewaters to the ocean represents a long-term regional solution. Effluents whose characteristics are associated with environmental problems in Cockburn Sound and Owen Anchorage would be removed from these areas where mixing and exchange with ocean water is restricted.

A number of alternative wastewater disposal locations and conceptual layouts of land and submarine pipelines for ocean disposal were considered. Indicative costs were prepared so that alternative solutions could be compared. In most cases, the effluent would require a much lower degree of in-plant or preliminary treatment prior to ocean discharge than for continued discharge at present disposal sites within the Sound and Owen Anchorage.

The most economical solution for ocean disposal approximately 6 kilometres offshore is shown here.

It should be noted that this study pointed out appropriate solutions and actions, but it was not intended to replace decision-making responsibilities of industries or governmental authorities.

The Study has also pointed to the need for the development of appropriate water quality criteria for Cockburn Sound so that industries and government have some guidelines on water quality to maintain the recognised beneficial uses such as recreation, fishing and boating. Initial steps have already been taken by the Environmental Protection Authority to establish water quality criteria.



THE NITROGEN PROBLEM

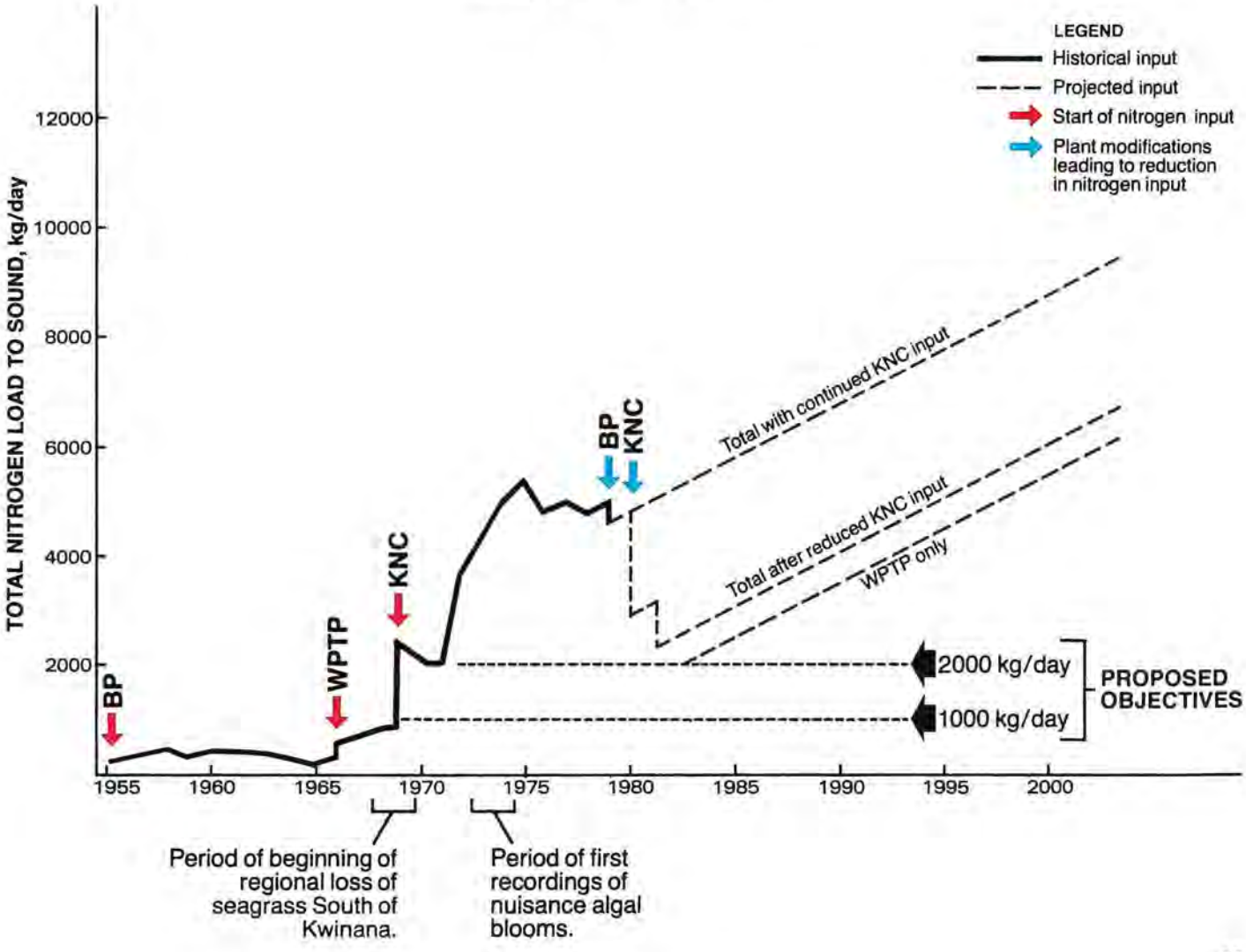
Field observations and laboratory work during the Study have shown that of the two nutrients, nitrogen and phosphorus, nitrogen is the growth limiting nutrient for phytoplankton. If excessive growth of phytoplankton, which causes algal blooms, is to be controlled a substantial reduction in nitrogen loads entering Cockburn Sound will have to be achieved.

Enrichment by nutrients of Cockburn Sound's waters has also lead to rapid growth of epiphytic algae on seagrass plants, which is likely to be the main cause of the widespread death of the seagrass meadows.

The diagram shows two possible objectives for nitrogen input levels that might be proposed in the future. These two levels represent the input from effluent discharge over the period (i) December 1967–October 1969 when regional loss of seagrass south of Kwinana began, i.e. approximately 1000 kg per day, and (ii) 1972 to 1974, when the first recordings were made of nuisance algal blooms, i.e. 2000 kg per day.

These levels could be achieved by reduction in input of nitrogen to Cockburn Sound by each of the main contributors or by diverting the effluents containing the nitrogen to an ocean disposal point outside the Cockburn Sound circulation system.

Historical and Projected Nitrogen loads to Cockburn Sound.



KEY CONCLUSIONS AND RECOMMENDATIONS

THE STUDY HAS SHOWN THE FOLLOWING:

- **that the Sound behaves as a tidal "lake" for much of the time and thus effluents do not move out of the Sound readily;**
- **that seagrass dieback is related to the increase in nutrient input to Cockburn Sound;**
- **that water quality has deteriorated through the occurrence of undesirable blooms of free drifting algae, also attributable to nutrient input;**
- **that some of the plants, animals, sediments and inshore waters are contaminated by heavy metals or bacteria;**
- **that nutrients, heavy metals and bacteria originate from industrial or sewage effluents.**

Towards an effective management programme:

The conclusions summarised above are based on the mass of data collected during the Study. From them flow the key recommendations which will provide the basis of a water quality management programme in Cockburn Sound.

1. Water quality objectives related to the various uses of the Sound and its flora and fauna should be established. Recommendations for these have already been made by a working party set up by the Environmental Protection Authority.
2. All waste dischargers should proceed with such process changes, in-plant treatment, or removal of specific wastewater discharges from Cockburn Sound as necessary to achieve collectively these water quality objectives.
3. For the Woodman Point Wastewater Treatment Plant, it would appear less costly in terms of capital and operation costs to develop a new deep-water outfall to the ocean rather than provide facilities to remove nutrients, particularly nitrogen compounds. Since the plant is, or will become, the principal source of wastewater and nitrogen compounds which can be collected in a regional system, the Metropolitan Water Supply, Sewerage and Drainage Board should obtain oceanographic and other information necessary to evaluate the merits of disposal to ocean waters, in contrast to nearshore waters having restricted circulation.
4. Industries in the Cockburn Road Special Industrial Area should pretreat wastewaters to a degree compatible with connection to a regional wastewater treatment and disposal scheme.
5. Monitoring of the effectiveness of in-plant and other control measures should be carried out by periodic sampling of effluents, nearshore waters, plants, animals and sediments in the vicinity of existing outlets. The Fremantle Port Authority in collaboration with the Environmental Protection Authority should organise and evaluate this monitoring.
6. Steps should be taken to prevent further pollution of groundwater, and recovery programmes in the more severely affected areas should be expanded as fully as possible.
7. Future plans for the mining of lime sands from Success and Parmelia Banks should be carefully examined to ensure that the banks maintain their protective function.
8. Recognising that competition between different users for the limited open foreshore remaining around the edges of the Sound must increase in the future, decisions regarding future use of foreshore should have regard to existing and other potential uses.

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* Reports on the major segments of the Study.

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Department of Youth, Sport and Recreation
Government Chemical Laboratories
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Metropolitan Water Supply, Sewerage and Drainage Board
Murdoch University
Department of Health and Medical Services
Soil Conservation Service: Department of Agriculture
Western Australian Institute of Technology
Western Australian Museum

Publisher: Department of Conservation and Environment, Western Australia.
Production Co-ordinator: Brian Stewart
Editor: Liz Moore

Design & Art Work: Le Page, Bevan & Jones, Design Partnership

Printer: Frank Daniels Pty. Ltd.

Photographs: Cockburn Sound Study Group, Roger Garwood, Richard Woldendorp, Charles Amery & Associates, Patrick Baker, Richard Curtis, Meagher & Le Provost, Klaus Schmechtig.