EUTROPHICATION OF THE PEEL INLET AND HARVEY ESTUARY

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ABSTRACT

Two large, shallow (2 m), coastal lagoons of south western Australia have become eutrophic during the last 20 years. This is evidenced principally by massive growths of macroscopic algae in one lagoon (Peel Inlet) and by dense phytoplankton blooms in the other (Harvey Estuary). Initially a benthic green alga, *Cladophora* sp., was dominant and it accumulated and decomposed on the shores, but with further deterioration other filamentous algae became abundant.

The eutrophy is caused by a great increase in the input of plant nutrients, especially phosphorus, which comes mainly in two rivers that drain the coastal plain part of the catchment. The soils are naturally deficient in phosphorus, but phosphate fertilisers are applied at rates of 15 to 30 kg P per hectare. Most of the nitrogen comes in the third river which has its catchment on the plateau.

Tidal range is small and exchange between estuary and ocean is restricted; significant river flow is confined to only about two winter months (July-August), evaporation is high and salinity varies seasonally from 5 to 50 ppt. It is only during and immediately following river flow that nutrient concentrations are high in lagoon water and this is a time of low temperature and low light conditions which are unfavourable for growth of benthic algae. However, nutrients are held in the system by winter diatom blooms and are recycled in detrital sediment and are available for benthic algae and the blue-green *Nodularia*.

At present, input of phosphorus exceeds export from it so that, without remedial action, the lagoon system will continue to deteriorate.

THE PROBLEM

- EXCESSIVE GROWTH OF ALGAE ESPECIALLY *CLADOPHORA*
- ACCUMULATION AND DECOMPOSITION OF ALGAE FOULING BEACHES

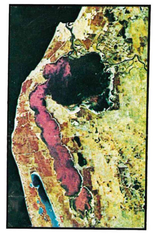
THIS HEAP OF ALGAE — ONE OF MANY — ESTIMATED TO CONTAIN: 75t dry wt. OF ALGAE 2000 kg OF N 200 kg OF P

- DESTRUCTION OF MARGINAL VEGETATION BY:

ACCUMULATING ALGAE

DAMAGE BY TRACTORS REMOVING ALGAE

- DENSE PHYTOPLANKTON BLOOMS — ESPECIALLY OF THE NITROGEN-FIXING BLUE-GREEN *NODULARIA*



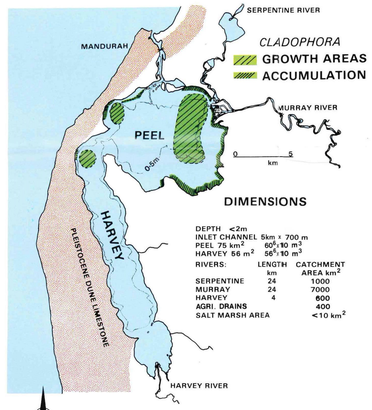
NODULARIA BLOOM DEC. 1980

- CONSEQUENT DEOXYGENATION, FISH DEATHS, DAMAGE TO FISHERY AND TOURIST INDUSTRY

HISTORY THE PROBLEMS ARE RECENT. EARLY 1960s FISHERMEN'S NETS FOULED BY GREEN ALGAE.
LATE 1960s MASSES OF ALGAE COLLECT AND ROT IN SHALLOWS AND ON BEACHES.
SPORADIC BLOOMS OF *NODULARIA*. THE WORST IN SUMMER 1980-81.
THIS FOLLOWED BY GREAT INCREASE IN ALGAE — PRINCIPALLY *CHAETOMORPHA*.

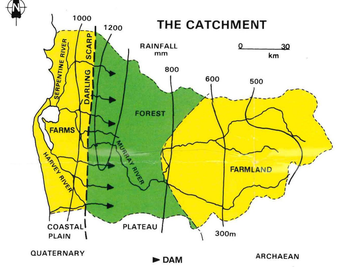
PEEL — HARVEY IS THE LARGEST ESTUARY IN WESTERN AUSTRALIA, IT SUPPORTS THE LARGEST INLAND FISHERY — PROFESSIONAL AND AMATEUR — IT IS A POPULAR TOURIST RESORT AND THE AREA IS ONE OF RAPID RESIDENTIAL GROWTH.

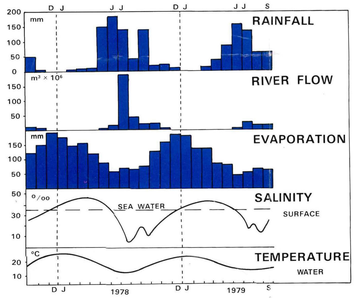
ENVIRONMENT

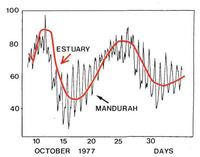


DIMENSIONS

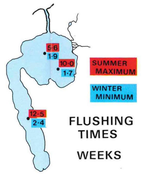
DEPTH <2m		
INLET CHANNEL	5km × 700 m	
PEEL 75 km²	60⁶ × 10 m³	
HARVEY 86 m²	56⁶ × 10 m³	
RIVERS:	LENGTH km	CATCHMENT AREA km²
SERPENTINE	24	1000
MURRAY	24	7000
HARVEY	4	600
AGRI. DRAINS		400
SALT MARSH AREA		<10 km²







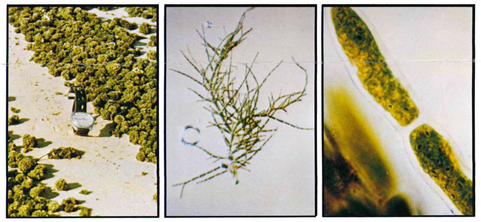
TIDE RECORDS



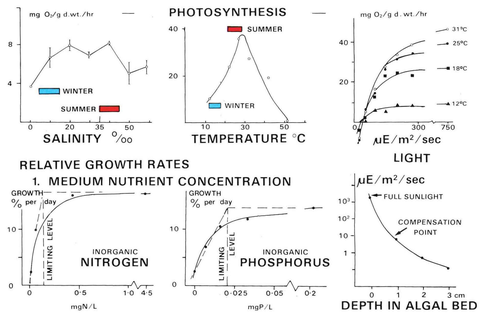
FLUSHING TIMES WEEKS

THE ALGAE AND THE NUTRIENTS

CLADOPHORA AFF. ALBIDA (CHLOROPHYTA, CLADOPHORALES) IS THE PRINCIPAL NUISANCE SPECIES — IT IS BENTHIC, GROWS AS UNATTACHED BALLS WHICH FLOAT TO THE SURFACE AND DRIFT WITH THE WIND.

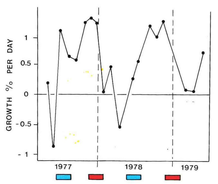


EXPERIMENTAL DATA

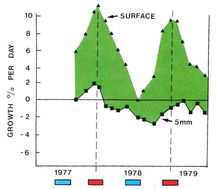


CLADOPHORA GROWTH

IMPRISONED FIELD POPULATIONS



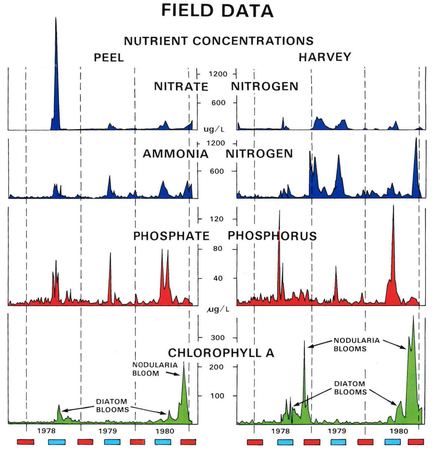
SIMULATED POPULATIONS AT TWO DEPTHS IN ALGAL BED



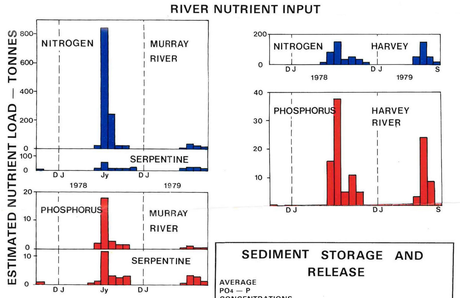
SOURCES FOR ALGAL GROWTH IN SUMMER:

1. STORED TISSUE NUTRIENTS FROM UPTAKE IN WINTER
2. AMBIENT WATER (ONLY 10μgP/L)
3. DETRITAL SEDIMENT

FIELD DATA



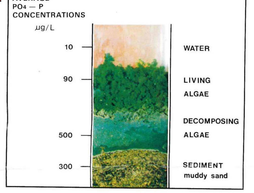
RIVER NUTRIENT INPUT



PHOSPHATE FLUX RATES SEDIMENT TO *CLADOPHORA*

MEASURED RATES USING ^{32}P
STILL CONDITIONS: 0.1 - 0.4 mg P/m²/day
STIRRED CONDITIONS: 1 - 4 mg P/m²/day
THIS WOULD SUPPORT GROWTH OF 0.2 - 8g DW/m²/day
MAX OBSERVED FIELD GROWTH 8g DW/m²/day
SIMULATED MAXIMUM ~13 g DW/m²/day
P SUPPLY MAY THEREFORE LIMIT GROWTH AT TIMES IN SUMMER

SEDIMENT STORAGE AND RELEASE



OTHER ALGAE

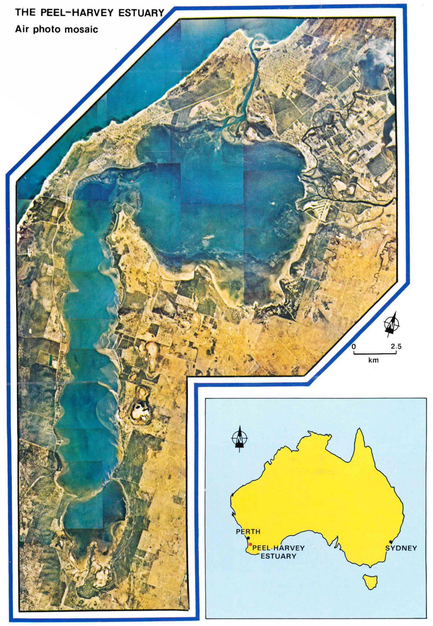
CHAETOMORPHA 2 spp.
CHLOROPHYTA, CLADOPHORALES FILAMENTOUS, BENTHIC BUT FLOAT TO SURFACE. GREAT INCREASE 1980-81

ENTEROMORPHA spp.
COMMON IN SHALLOWS ONLY

NODULARIA SPUMIGENA
BLUE-GREEN CYANOBACTERIA FIXES NITROGEN. SPRING-SUMMER BLOOMS FAVOURED BY: LOW N:P RATIO, TEMP. >18 °C SALINITY OPTIMUM 5 — 10 o/oo

DIATOMS MAIN BLOOMS DURING WINTER RIVER FLOW

THE PEEL-HARVEY ESTUARY
Air photo mosaic



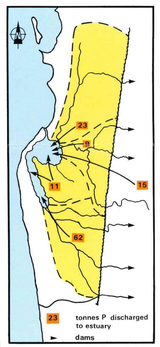
CONCLUSIONS

1. THE ESTUARY IS NUTRIENT ENRICHED — ALTHOUGH NUTRIENT CONCENTRATIONS ARE ONLY HIGH BRIEFLY IN WINTER.
2. THE ALGAL PROBLEM IS CAUSED BY A GREAT INCREASE IN NUTRIENT INPUT SINCE THE 1950's, ESPECIALLY OF PHOSPHORUS.
3. PHOSPHORUS IS THE LIMITING NUTRIENT MOST OF THE TIME
4. FERTILIZER APPLIED TO COASTAL PLAIN SOILS DEFICIENT IN PHOSPHORUS IS THE PRINCIPAL SOURCE OF PHOSPHORUS
5. THE WINTER INPUT OF NUTRIENTS IS RETAINED IN THE ESTUARY BY PLANKTON AND FLOCCULATION
6. SUMMER GROWTH OF *CLADOPHORA* AND OTHER ALGAE IS DEPENDENT ON RELEASE OF NUTRIENTS FROM DETRITAL SEDIMENT STORES AND FROM CELLULAR RESERVES
7. ANNUAL INPUT OF PHOSPHORUS FROM AGRICULTURAL SOURCES IS NOW ABOUT 120 TONNES — ONLY HALF OF THIS IS LOST TO THE SEA

MANAGEMENT PRINCIPLES

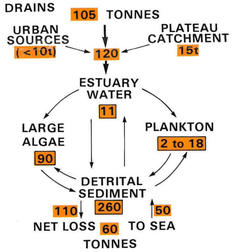
REDUCE INPUT OF PHOSPHORUS
— MODIFY AGRICULTURAL PRACTICES
— DIVERT RIVER FLOW TO SEA
— INTERCEPT NUTRIENTS
INCREASE LOSS TO SEA
DEPLETE ESTUARY NUTRIENT STORE
— HARVEST ALGAE
— REMOVE DETRITAL SEDIMENT

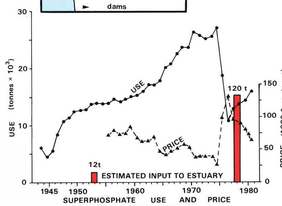
PHOSPHORUS BUDGET (1978)



PHOSPHATE FERTILIZER APPLIED TO COASTAL PLAIN CATCHMENTS 1400 TONNES P

PHOSPHORUS ENTERING ESTUARY FROM RIVERS AND AGRICULTURAL DRAINS 105 TONNES



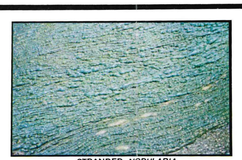


PHOSPHORUS — TONNES

	1977-78	1978-79
MARINE INPUT	50	50
RIVER & RAIN INPUT	120	90
	170	140
FLUSHED	110	110
SYSTEM GAIN	60	30
SYSTEM IN NET RETENTION		

FLOATING *CLADOPHORA*

FLOATING *CHAETOMORPHA*



STRANDED *NODULARIA*

DEPARTMENT OF CONSERVATION AND ENVIRONMENT BULLETIN 117

WATERWAYS COMMISSION
PEEL INLET MANAGEMENT AUTHORITY

Further information and details of the Study reports are available from the Department of Conservation and Environment, 1 Mount Street, Perth telephone (09) 322 2477 and the Peel Inlet Management Authority, 15 Pinjarra Road, Mandurah, telephone (095) 35 3760.

This poster was presented at the International Symposium on Coastal Lagoons/UNESCO 81, Bordeaux, France. September 1981