Bibliography on marine pollution in South Africa

D A Darracott and C E Cloete

A Report of the Marine Pollution Section
National Programme for Environmental Sciences

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PREFACE

This bibliography was compiled at the request of the Marine Pollution Section of the National Programme for Environmental Sciences.

The following persons are thanked for their assistance: Mr N D Geldenhuys (Department of Planning and the Environment), Dr L V Shannon (Sea Fisheries Branch), Prof A C Brown (Zoology Department, UCT), Dr J H Wallace (Port Elizabeth Museum), Mr F P Anderson (NRIO), Mr A F Pearce (NRIO), Dr G A Eagle (NRIO), Dr P F Berry (Oceanographic Research Institute), Dr T F W Harris (Oceanography Department, UCT), Dr J R Grindley (School of Environmental Studies, UCT), Mr P Coombs (National Institute for Water Research, Pretoria), Mrs S D Wall (NIWR, Congella), Prof T Erasmus (Zoology Department, University of Port Elizabeth), Mr G de F Retief (Fisheries Development Corporation), Drs C R Houba and R J Nachenius (Fishing Industry Research Institute) and Mrs E Auret (NSPU, CSIR).

Mis A M Nolte of the CSIR library in Pretoria and Miss J Joubert and staff of the Department of Planning and the Environment's library are thanked for their assistance in obtaining references. The typing was done by Mrs L A Myburgh (NSPU, CSIR).

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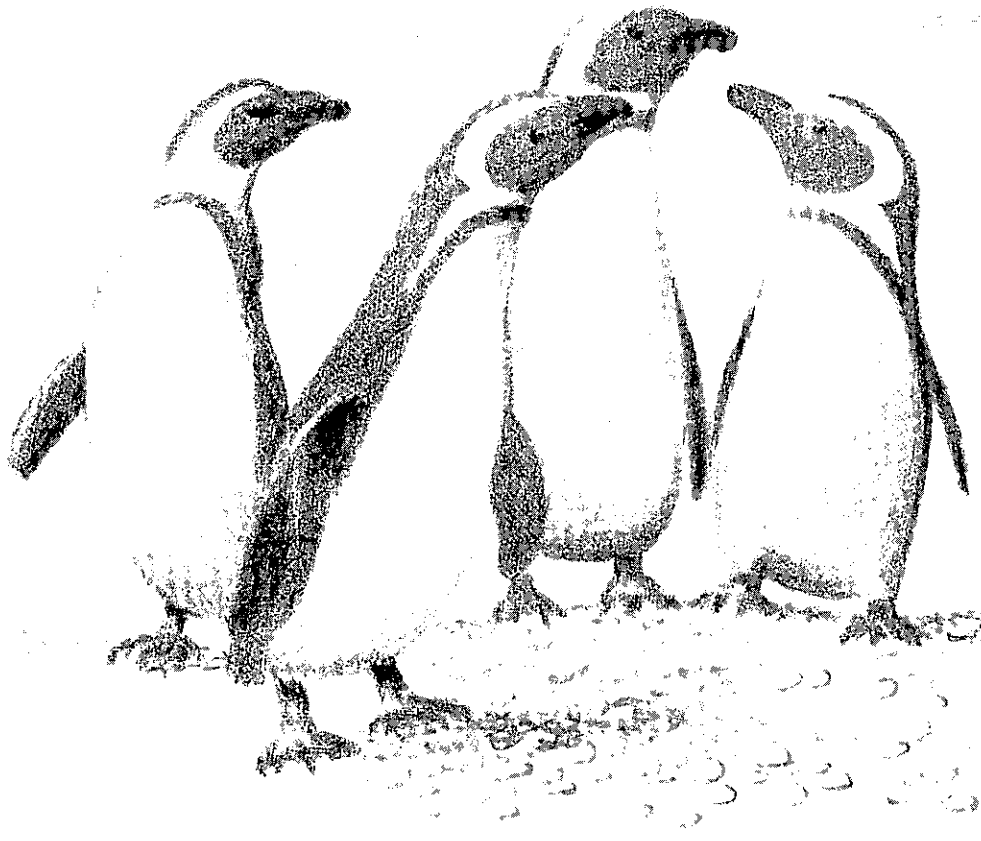

A. REYNOLDS

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Opposite - *Jackass penguins on the Cape Sea Route*, drawn by Mr A Reynolds (Department of Planning and the Environment)

CURRENT TITLES IN THIS SERIES

1. A description of the Savanna Ecosystem Project, Nylsvley, South Africa. December 1975. 24 pp.

2. Sensitivity analysis of a simple linear model of a savanna ecosystem at Nylsvley. W M Getz and A M Starfield. December 1975. 18pp.

3. Savanna Ecosystem Project - Progress Report 1975/1975. S M Hirst. December 1975. 27 pp.

4. Solid wastes research in South Africa - A report by the Committee for Solid Wastes. R G Noble. June 1976. 13 pp.

5. Bibliography on marine pollution in South Africa. D A Darracott and C E Cloete. June 1976. 131 pp.

INTRODUCTION

The bibliography was compiled by Mrs D A Darracott (Department of Planning and the Environment) and Dr C E Cloete (National Programme for Environmental Sciences, CSIR), assisted by Miss E Ferreira and Miss W Taljaard (Department of Planning and the Environment).

Abstracts of papers were composed by D A Darracott (DAD) and C E Cloete (CEC) when an author abstract was not available. No abstracts were composed for the Fishing Industry Research Institute reports as these were short reports adequately described by key words. In cases where the document was unobtainable no abstract has been included.

The bibliography contains references (listed alphabetically), abstracts and a keyword index. It covers the following subjects :-

- field studies of chemical pollutants introduced by man into the South African marine environment
- marine pollution related techniques and methods
- the prevention and combating of marine pollution
- 'natural' pollution from 'red tides'
- coastal currents and fresk hydrographic conditions
- a very limited number of papers on sediment transport, marine biology and ecology.

An effort has been made to include all relevant papers up to and including May 1976. It is realised that omissions may have occurred, especially in the earlier papers. Future updating of this publication will attempt to improve the coverage.

The sources used in this compilation were :-

- The Repertorium of South African magazines
- CSIR Publications Index
- Current Literature on Water (CLOW)
- Termatrex Oceanography Bank, Department of Planning and the Environment
- Contact with institutes and university departments working in this field

Other bibliographies concerning the marine environment in South Africa include :

- Lutjeharms J R S 1972. A guide to research done concerning ocean currents and water masses in the South West Indian Ocean. *Oceanography Department, University of Cape Town* 577 pp.

- Pearce A F 1974. Bibliography on Natal coastal currents up to 1973. Unpublished report, *NRIO Internal General Report IG 74/1*. 33pp.

The South African Committee in Oceanographic Research (SANCOR) has been requested to compile a comprehensive bibliography on marine biology in South Africa. It is hoped that it will appear in 1977. SANCOR has made funds available on its 1976 budget for the production of a collective reference work on South African estuaries, under the editorship of Professor J H Day, University of Cape Town. The South African entry in the FAO International Directory of Marine Scientists has recently been updated and will also be published in 1976 as a separate booklet.

1. Alexander P A. Recirculation of flume water. *Fishing Industry Research Institute. Annual report No 20*, 47.

No abstract available

FISH FACTORY EFFLUENTS

2. Anderson F P 1961. The use of drift-cards to deduce currents along the Natal coast. *CSIR Symposium S2 Marine studies off the Natal Coast*, 40-45.

A series of drift-card releases were made during September and October 1960 in the vicinity of Durban. By making allowances for the effect of the wind, the residual currents adjacent to the coast were deduced. These currents compared favourably with measured currents, in both direction and magnitude.

METHODS COASTAL CURRENTS EAST COAST

3. Anderson F P and T F W Harris 1964. Some technical notes on the general problem of the disposal of wastes to sea. *Institute of Municipal Engineers* 1 (2), 97-111.

No abstract available

DISPOSAL OF EFFLUENTS

4. Anderson F P and C C Stavropoulus 1964. A system for the rapid direct measurement of current profiles. In Oceanographic Research Group 1964, 15-22.

A system devised for the measuring of currents is described. The system was proved over a period of nine months of operation at sea. Comparisons of currents measured with this system and measurements obtained by tracking floats show reasonable agreement. (CEC)

EAST COAST COASTAL CURRENTS METHODS

5. Anon 1960. Should radioactive wastes be dumped in the sea? *Industr Rev Africa* 12 (1), 76-78.

No abstract available

RADIOACTIVITY

6. Anon 1964. Sea-bottom pipeline for Umkomaas effluent. *Power Plant* 5 (9), 11-13.

The structure of a marine pipeline, to be sited at Umkomaas, and its method of installation are described. (DAD)

DISPOSAL OF EFFLUENTS EAST COAST

7. Anon 1966a. Harbour population committee, Walvis Bay. Preliminary report on activities. *Fishing Industry Research Institute Report (M152).*

No abstract available

FISH FACTORY EFFLUENTS

8. Anon 1966b. Sewage treatment of coastal resorts. *Municipal Affairs* 31 (366), 13-15.

No abstract available

DISPOSAL OF EFFLUENTS

9. Anon 1968. Submarine pipeline off the Durban coast. *The Civil Engineering Contractor* 2 (12), 32-37.

The structure and method of installation of the two mile submarine pipeline off the Bluff coast at Durban, is described. (DAD)

DISPOSAL OF EFFLUENTS EAST COAST

10. Anon 1974. Waste not, pollute not. *South African Shipping News and Fishing Industry Review* April, 40-45.

Plant for clarifying effluent from fish factories is described. It is reported that FIRI recommends the following design features for a full-size plant:

The skimming and scraping devices should rotate at the lowest practical speed to reduce turbulence to a minimum. The effluent should enter through a suitably designed diffuser to reduce its velocity gradually so as to reduce turbulence. No air bubbles should enter the tank with the effluent. The clarified liquid should be discharged over a continuous circumferential weir and not via goosenecks as fitted to the pilot plant.

Although encouraging results were obtained with the type of tangential screen fitted to the pilot plant, further tests are required to determine the optimum wedgewire size and spacing, the screen angle, feed system, etc. that will ensure maximum recovery of suspended solids in as dry a condition as possible. (DAD)

FISH FACTORY EFFLUENTS PREVENTION AND COMBATING

11. Anon 1975a. Dry offloading - boon or burden. *South African Shipping News and Fishing Industry Review* 30, 50-61.

The merits and demerits of the dry offloading system and related economic factors are discussed. Dry discharge equipment and how it is used is described. (DAD)

FISH FACTORY EFFLUENTS PREVENTION AND COMBATING

12. Anon 1975b. 1100-ton oil burn at Agulhas wreck. *South African Shipping News and Fishing Industry Review* 30 (6), 17.

Oil was burnt off from the wreck of the Oriental Pioneer using a virtually standard marine burner. It comprised a boiler, heat exchanger, 35KW fan and combustion chamber. Oil was pumped to the ships' 60 ton capacity swimming pool as a reservoir, through the heat exchanger to raise its temperature and pressure fed into the combustion chamber. A smoke free flame was maintained by regulating the flow of air to the combustion chamber by the forced draught fan. Initially ignition was by electric spark but later ignition was manual (at the end of a long pole). (DAD)

OIL PREVENTION AND COMBATING METHODS

13. Anon 1975c. Monitoring marine pollution. *Public Health, Johannesburg* 75 (2), 47, 49.

The research activities, in relation to marine pollution, of the National Programme for Environmental Sciences are briefly described. (DAD)

MONITORING

14. Atkinson A. Purification of sea water with excess lime or chlorine dioxide. *Fishing Industry Research Institute, Annual report No 25*, 51.

No abstract available

FISH FACTORY EFFLUENTS

15. Atkins G R 1970a. Thermal structure and salinity of False Bay. *Transactions of the Royal Society of South Africa* 39, 117-128.

Date on temperature and salinity obtained during twenty-six cruises from 1963 to 1966, each covering twenty-eight hydrographic stations are presented. The data are grouped into four zones - the three coastal zones, and one central zone, and the mean temperature and salinity of each zone are tabulated for each season. Surface isotherms and isohalines and four vertical temperature sections for each season are shown. The results are discussed and possible explanations for variations are suggested.

COASTAL CURRENTS WEST COAST

16. Atkins G R 1970b. Winds and current patterns in False Bay. *Transactions of the Royal Society of South Africa* 39, 139-148.

Wind records from six reporting stations in the vicinity of False Bay have been analysed, and the mean directional frequency and velocity combined to give relative 'wind run' for each station and season are shown in the form of wind roses.

Methods of current measurements are briefly discussed, and the 'dye-bomb' technique using aircraft chosen to obtain a nearly snyoptic pattern over a wide area. The results of thirteen such operations at eleven selected stations have indicated that four main patterns have evolved, the predominant type being a clockwise rotation. Fifteen further operations close to the west, north and north-east shores were later carried out and the results are shown in current roses for each station for winter and summer conditions.

COASTAL CURRENTS WEST COAST METHODS

17. Atmore M G 1965. Schemes for reducing discolouration of the sea at Umgababa. *South African Mining Engineering Journal* 76 (1), 1051-1052.

To utilize the heavy mineral deposits, calculations showed that up to 1 600 tons of fine material per day would be fed to the plant so that removal and storage of 97% of the fines would be necessary. The following schemes were investigated: complete land disposal of all tailings; disposal of all tailings by undersea pipeline; cycloning with land or undersea disposal of the separated fines; coagulation of the fines into larger non-discolouring flocs. All schemes were unsuitable due to prohibitive cost and/or inefficient operation in practise. (DAD)

EAST COAST TRACE METALS POLLUTION SOURCES SEDIMENTS PREVENTION AND COMBATING

18. Aucamp P J, J L Henry and G H Stander 1971. Pesticide residues in South African marine animals. *Marine Pollution Bulletin* 2 (12), 190-191.

Analyses of organochlorine pesticides in South African marine animals living far from any obvious source of contamination reveal surprisingly high values.

PESTICIDES ORGANISMS FISH

19. Bain C A R 1972. Radioisotopes in the determination of dispersion coefficients in estuaries for pollution control studies. *National Conference on the Technological Application of Nuclear Techniques*, Pelindaba, 12-13 October 1972, P11. 5 pp.

A short review of some nuclear techniques used in differing river and estuary flow problems which may be linked to pollution control studies is given. This is followed by the discussion of radioactive tracer techniques developed locally for the determination of longitudinal dispersion coefficients in estuaries. The choice of tracer, injection of tracer, procedures in field collection of data and data analysis are discussed.

RADIOACTIVITY ESTUARIES METHODS

20. Bain C A R 1975. Coastal water movement study. *Progress report No 1 to the Atomic Energy Board, for the period ending June 1975.* 30pp. Available: Oceanography Department, University of Cape Town.

As a consequence of the technique testing experiments and the examination of the literature, certain tentative ideas about the nature of the circulation regime in Duynefontein Bay have emerged. These are: (a) the Bay is not subject to the continuing influence of the Benguela Current, but further work may show it to have indirect and intermittent influences such as those indicated by previous ART data where colder water has moved through the embayment. There is as yet no evidence of any sustained baroclinic driving force; (b) the near surface currents immediately offshore of the Bay are mainly a consequence of local wind stress with little time delay; (c) in the absence of local winds the currents within the Bay seem to be primarily wave driven. There is evidence from aerial photographs that the circulations at the north and south ends of the Bay may differ; (d) beach slopes are gentle and surf widths are relatively wide. Wave orthogonals are usually directed nearly normally to the shoreline. In the absence of wind these conditions result in a symmetrical cellular nearshore circulation, important features of which are large rip currents. These rip currents can under high wave conditions extend seaward 1 to 3 km (this is more than twice as far as anything experienced on the Natal coast). (e) Normally in the absence of wind, the nearshore circulation appears from surface observations to be confined within the Bay and there may be little exchange with offshore waters. Nevertheless float tracks within the Bay have shown a high degree of current shear in the vertical. The possibility of a vertical circulation therefore exists. This considerably complicates the problem and must be investigated.

WEST COAST COASTAL CURRENTS METHODS

21. Bain C A R and T F W Harris 1976a. Coastal Water Movement Study. (July 1975 to January 1976) *Progress Report No 2 to the Atomic Energy Board* 88pp. Available: Oceanography Department, University of Cape Town.

For abstract see following reference.

WEST COAST COASTAL CURRENTS METHODS

22. Bain C A R and T F W Harris 1976b. Coastal water movement studies at a nuclear power station site. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

The research work reported aims to establish the dominant features and underlying mechanisms of the water circulation in the near-

shore and coastal region, in order that predictions can be made of the dispersion and dilution of radioactive wastes and nuclear power station coolants, discharged over the shallow sloping beaches in embayments of the Cape coast. The bounds of the present study extend along 15km of coastline and several kilometres offshore at the site of South Africa's first nuclear power station, some 25 kilometres north of Cape Town. The paper describes various techniques developed to investigate the water movements. such as radar tracking of floats, aerial photogrammetry of floats, airborne radiation thermometry (ART) and tracers. Results of the continuing project are reported together with tentative conclusions on the parameters responsible for the observed water movements.

RADIOACTIVITY METHODS COASTAL CURRENTS WEST COAST

23. Bain C A R, W R McMurray, G de F Retief, A P M Vonk and D van As 1970. Radioisotopes as a tracer for studies of sediment transport in the sea - a preliminary report. In collected contributions of the *Symposium on Oceanography in South Africa*, CSIR Durban. Paper C2, 1-11.

After a brief review of the use of tracers in sediment transport studies, the factors underlying the use of radioisotopes are outlined. This is followed by a description of a field test at a site in False Bay.

The techniques for radioisotope tracing which have been developed for this investigation are shown to be perfectly practicable. The field test has yielded information which was not previously obtainable by means of fluorescent tracers. Further developments are mentioned.

SEDIMENTS METHODS RADIOACTIVITY WEST COAST

24. Bain C A R, W R McMurray, D van As and D de F Retief 1972. The use of radioisotope tracers in coastal sediment dispersion studies. *National Conference on the Technological Application of Nuclear Techniques*. Pelindaba, October 1972.

The use of surface-labelled and volume-labelled radioisotope sand tracers in coastal sediment dispersion studies is described. Data are collected in situ with a scintillation detector and recorded on magnetic tape. Results of field tests for various sites along the South African coast are given in the form of isoactivity contour maps.

SEDIMENTS RADIOACTIVITY METHODS

25. Ballard J A and W D Oliff 1969. A rapid method for measuring the acute toxicity of dissolved materials to marine fishes. *Water Research* 3, 313-333.

A rapid residual oxygen method for measuring the acute toxicity of dissolved poisons to fish is described and evaluated in comparison with the routine 24 or 48 hr test. The effects of varying

the densities per unit volume of test fishes, the temperature, and the size of the fish are examined.

It is concluded that the residual oxygen method is a quick and reliable method for routine monitoring work.

METHODS FISH

26. Bang D G 1971. Pollution survey of the Black River complex. Unpublished student project, Zoology Department, University of Cape Town.

No abstract available

WEST COAST

27. Bang N 1976. On estimating the oceanic mass flux budget of lateral and cross circulation of the southern Benguela upwelling system. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

Recent papers have thrown some new light on northward (lateral) transport in the eastern boundary region of the South Atlantic Ocean, and on the rate and annual flux of upwelling in the Cape upwell cell. However no attempt has hitherto been made to produce a cohesive picture of the ralationship between north/south transports, east/west transports and vertical movements, or to apportion, for example, the onshore replacement flow at depth between bottom Ekman layer transport, diffuse mid-water inflow and bottom movement along the axes of canyon-like geomorphological features. In making such an attempt this presentation aims to put some rough numbers on the various components of the overall budget; to provide a conceptual sketch for further discussion and comparison with other upwell systems; and to point to measurement and modelling priorities in future experiments.

WEST COAST SOUTH COAST COASTAL CURRENTS

28. Banks D J 1975. The effects of zinc on behaviour and respiration in *Bullia digitalis* (Prosobrachiata). Unpublished student project in the library of the Zoology Department, University of Cape Town.

Individuals of the sandy-beach whelk *Bullia digitalis* were exposed to a range of concentrations of zinc chloride in natural sea water and observed for a period of 21 days. Zinc concentrations were monitored by means of atomic absorption spectrophotometry. Animals exposed to concentration of zinc greater than 1,3 ppm showed the same stress symptoms as those previously found for exposure to cadmium, crude oil, ammonium nitrate and hydrogen sulphide. Stress symptoms gave way to a general paralysis and eventual death; at 1,3 ppm Zn 50% of the animals were dead by the fifth day. A concentration of 3,9 ppm Zn significantly lowered the oxygen uptake of the animals.

TRACE METALS ORGANISMS MOLLUSCS

29. Basson J K 1976. Thermal pollution and radioactivity in the marine environment. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976. 22pp.

The ever-increasing demand for electricity makes power stations the dominant source of waste heat transmitted to the ocean. Because the generation of electricity is such an inefficient process, most of the heat produced is wasted. The impact of the heated cooling water is not directly felt by man, but may lead to changes in marine ecology. Its beneficial use is limited by the low temperature to possible biological applications such as aquaculture.

Radioactive effluent from nuclear power stations should make only a fractional contribution to the natural marine radioactivity.

With the radiation dose to man as the most restrictive limit, the capacity of the marine environment to receive radioactive effluent safely, can be determined. This depends on various local factors such as dispersion conditions, the ecology, the habits of the local population and the accumulation by critical organisms of the pertinent radionuclides.

In South Africa the existing coastal industries have a minor thermal impact on the marine environment, and are responsible for negligible radioactive effluent, but the lack of inland water resources is leading to the establishment of large nuclear power stations on the coast. These factors are reviewed with specific reference to the coastal site, Duynefontein, 28 km north of Cape Town, where ESCOM will be erecting South Africa's first nuclear power station, Koeberg.

THERMAL POLLUTION RADIOACTIVITY WEST COAST ORGANISMS COASTAL CURRENTS

30. Basson J K and D van As 1972. Investigation of safe releases of radioactive effluent to the sea. *South African Journal of Science* 68 (5), 139-142.

It is considered that simple exposure of the public to radioactive sea water i e by drinking or bathing, will not be critical. It is evident that physical or biological concentration processes (e g absorption by sediment or uptake in seafood) may lead to much more limiting pathways.

However, physico-chemical contamination of sand is unlikely to be the limiting mode of exposure. It is clear that biological concentration of various elements in sea water by marine organisms leads to much more limiting values. It was decided to predict the reconcentration of radionuclides by analyses of the stable elements in seawater and critical seafoods. Concentrations factors were found to be of the order of 10^3 -10^5 for Zn, Fe and Mn compared with 10^2 - 10^3 for Cr and Co. Assuming a maximum intake for

each seafood, the permissible concentration for a specific radionuclide in the particular seafood can be calculated on the basis of the ICRP value. Coupled with the concentration factor determined, the working limit for each radionuclide in the local seawater may be derived. In the case of nuclear power stations, pollutant dilution is usually effected by mixing with the very large volumes of cooling water. The recipient capacity can then be calculated on the basis of (i) a fixed volume of seawater into which the effluent is discharged, with only radio-active decay providing removal of the activity, and/or (ii) complete removal of the effluent by tidal movement and/or a longshore current. Experience has shown that calculations utilizing simple concepts such as the volume of the average tidal excursion and typical rates of exchange (say 10% per day), can provide order of magnitude estimates which are sufficient to meet the requirements of initial planning. If the recipient volume is known with any degree of accuracy, the safe release rate can then be calculated. However, if the recipient volume is uncertain, it may be assumed that the radioactive waste will be dissolved in the cooling water and that the resulting concentrations in the discharge itself will be the limiting values. The discharge rate is thus limited by its concentration in seafood postulated to be growing at the point of release. (DAD)

RADIOACTIVITY ORGANISMS THERMAL POLLUTION
COASTAL CURRENTS

31. Basson J K and D van As 1973. The preoperational determination of safe releases of radioactive effluent from nuclear installations to the ocean. *South African National Oceanographic Symposium Abstracts*, Cape Town, 17.

When nuclear power is eventually introduced to South Africa it is expected that units of 1 000 megawatt and larger will be clustered at suitable locations on the coast, using sea water as a secondary coolant and disposing of liquid radioactive effluent into the local coastal waters. Among other factors that determine the suitability of a particular site for the erection of such a nuclear installation is the recipient capacity of the environment for radioactive wastes. This capacity is determined by factors such as dispersion and dilution, physical concentration, biological accumulation and the extent to which the particular ocean and beach area is used as a source of food and recreation.

The effluent normally consists of a mixture of fission and radioactive corrosion products, which is only a very small fraction of the total radioactive inventory of such an installation. As the exact quantities and nature of the effluent is unknown during the planning stages, an evaluation is made of all possible nuclides, pathways and food products that may lead to hazardous situations for human beings. Normally it is found that there are one or possibly a few exposure pathways which are much more hazardous than others; these are termed critical pathways and the critical nuclides and groups can be identified. These critical groups determine the

safe levels for the disposal of effluent. In practice it is only necessary to control the levels of these critical nuclides to ensure that hazardous situations do not arise.

The application of this approach to the control of radioactive pollution is discussed in the light of preoperational studies conducted at a site along the Cape west coast.

RADIOACTIVITY WEST COAST

32. Basson J K and D van As 1975. Pre-operational investigation of safe radioactive releases from the nuclear power station site, Duynefontein. *European Nuclear Conference*, Paris, April 1975, 1-12.

The capacity of an environment to accept radioactive effluent safely depends on various local factors such as dispersion conditions, the ecology, the habits of the local population and the accumulation by critical organisms of pertinent radionuclides.

These factors have been investigated at the coastal site, Duynefontein, 28km north of Cape Town where the Electricity Supply Commission intends erecting South Africa's first nuclear power station, Koeberg A.

Surveys as well as analysis to determine concentration factors for various stable elements in edible marine organisms, have led to a determination of the recipient capacity of the marine environment. Full details are presented of the concentration factors and seawater DWL's for 19 radionuclides, as well as the resultant safe release rates.

The effects of atmospheric releases have been investigated by conventional mesometeorological measurements, as well as by newly developed techniques for the actual measurement of dispersion with nuclear tracers and by radar tracking of balloons.

RADIOACTIVITY WEST COAST ORGANISMS COASTAL CURRENTS

33. Bergstedt R P 1970. The use of ion exchange on ammonium molibdo-phosphate for the assessment of caesium and thallium in sea water. *M Sc thesis, University College of the West Cape/University of South Africa*. 71 pp. In Afrikaans.

A method was developed whereby caesium can be concentrated and separated from large volumes of sea water (350 litres in this case) in 1½ hours by batch adsorption onto microcrystalline ammonium molibdo-phosphate after an equilibration period of 15 minutes. Gooch asbestos fibre was used as a filtering aid. The AMP/asbestos mixture was separated from the sea water by filtration with suction with the aid of a 'filter stick' technique. This method is simple and quick (the collection of one sample takes approximately 1 to 1½ hours) and is very useful on board ship

even in rought weather conditions. The following variables and factors were investigated: (i) The solubility of AMP in sea water (ii) the adsorption of caesium onto AMP from acidified sea water by means of a batch process; with or without the addition of a caesium carrier. (iii) recovery of caesium from AMP/asbestos-cake. The minimum solubility of the AMP was found at a pH of approximately 2,25. It was found that adsorption equilibrium was reached after approximately 15 minutes when (in laboratory experiments on a small scape) nearly 96% of the caesium was adsorbed onto the AMP. The addition of 0,06mg caesium carrier per 2 litres of sea water had no influence on the adsorption of caesium. After the conditions had been determined in the laboratory, the method was tested on a large scale at Gordons Bay. Samples for the determination of radioactive and inactive caesium were taken from the surface waters of Table Bay on two voyages of the T B Davie, the research ship of the University of Cape Town. The method of sampling was briefly as follows: 350 litres of sea water was acidified up to pH 1, 44g AMP and 20g asbestos were mixed with it for 15 minutes, and the AMP/asbestos mixture was separated from the sea water by filtration with suction by means of a 'filter stick' technique.

This AMP/asbestos mixture was processed later in the laboratory. The AMP was in each case dissolved in natrium hydroxide solution, the asbestos filtered off, and the latter washed well with a 2N HNO_3/1N KNO_3 solution. The combined filtrate and washing agent was heated to drive off ammonia and acidified to pH 3. One gram of AMP was added to this acidified AMP solution, it was mixed for 15 minutes, and the AMP was then filtered off and washed with 1N natrium nitrate solution. The AMP was redissolved, the solution heated, acidified, and passed through a small column of specially prepared coarse AMP. After the column was washed, the AMP was put into a counting tray, the liquid was evaporated and the beta-activity measured in a low background counter. The gamma spectrum of the combined samples was determined and it was shown that foreign sources of gamma radiation were present. The inactive caesium was determined spectrophotometrically with dipicrylamine. The average value of 0,350 $\pm$ 0,022 ug/litre compares well with the latest value of 0,35 $\pm$ 0,01 in the literature. Due to the fact that thallium is strongly adsorbed onto asbestos, efforts to retrieve it were unsuccessful and the determination of the concentration of thallium in sea water was not possible. On the basis of experimental work, a modified method is proposed were use is made of the addition of a caesium carrier. Samples are taken as previously described, except that 100mg of caesium carrier is added to the sea water samples. The AMP is dissolved in 30% natrium hydroxide solution and the asbestos filtered off. The asbestos is then washed first in water and then in 2N nitric acid. The AMP solution is then heated until all the ammonia is driven off. The caesium is precipitated onto it by an excess of dipicrylamine reagent, filtered, and the precipitate washed first with ice-cold water and then with cold ethyl ether. The precipitate was plated out and the beta activity measured. Lastly the percentage yield was determined by dissolving the precipitate, diluting it to a known volume, and determing the caesium, flame

photometrically. The caesium activity is then corrected to 100% yield. This method is fairly short and ought to be very suitable for the determination of caesium activity by gamma measurement.

RADIOACTIVITY METHOD

34. Berry P F, L F Jackson and M J Smale 1975. Observations on stranded oil on the sandy beaches of Natal and Zululand with particular reference to its effect on sand crabs *(Ocypodidae)* and mole crabs *(Hippidae)*. Council for the Habitat, *Proceedings of Coastal Areas Conference*, Durban 3-4 April 1975, 1-6.

Stranded oil on the Natal and Zululand coasts is described with observations on an apparent recycling process associated with beach erosion. The species of sand and mole crabs are enumerated and the frequency of oil contamination and its possible effects on them is discussed.

OIL ORGANISMS EAST COAST

35. Bester M H C. Anaerobic digestion of fish factory effluent. *Fishing Industry Research Institute, Annual report No 27*, 72.

No abstract available

FISH FACTORY EFFLUENTS

36. Birch G F, J M Bremner and J Rogers 1976. Sedimentation controls off the west coast of southern Africa. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

The Benguela Current System, the Orange River and the Kunene River are the chief sedimentation controls along the west coast of southern Africa. The upwelling waters of the Benguela are the most productive in the world and are underlain by organic- and metal-rich diatomaceous muds in the Walvis Bay region. Carbonate sediments composed of the skeletons of planktonic foraminifera and coccolithophorids underlie oceanic waters along the westward boundary of the upwelling zone.

Cooling and condensation of moisture-bearing sea air over the cold, upwelled water restricts precipitation and the development of an effective drainage network in the Namib Desert. Terrigenous input is chiefly restricted to the perennial and allochthonous Orange and Kunene Rivers, which derive their water and sediment from the interior of the subcontinent. Terrigenous sand is dispersed swiftly northwards within the littoral zone, which is exposed to powerful swells from the stormy Southern Ocean. Continual gales in the Sperrgebiet blow sand from the beaches into the desert, particularly near Lüderitz and the Kunene. Terrigenous mud is transported southwards by inshore countercurrents, particularly south of the wave-dominated submarine delta of the Orange River.

Potentially economic deposits of phosphorite rock and sand, and of potash-rich glauconite sand are found along the entire outer shelf. Detailed microprobe investigations into the genesis of both apatite and glauconite are relevant in a world faced with a growing shortage of fertilizers.

WEST COAST SEDIMENTS

37. Branch G M 1973. The biology of *Patella cochlear* with reference to oil pollution. *South African National Oceanographic Symposium* Cape Town: 18.

Our knowledge of the effects of crude oil on South African marine life is limited, and based predominantly on short-term observations. Day *et al* (1971) recorded the effects of spillage from the tanker *Wafra*. The limpet *Patella cochlear* was among the species which were particularly susceptible. Observations at Hangklip, and more recently in False Bay, verify this. In the case of the *Wafra* large numbers of *P. cochlear* died and their scars were left empty as testimony. In the False Bay incident an unidentified and relatively light oiling occurred. The *P. cochlear* were not in direct contact with the oil, but were nevertheless weakened, and whelks *Burnupena delalandii* were seen feeding on them.

Normal population densities of *P. cochlear* range from 100 to over 2 000 per square metre. At densities below $400/m^2$ biomass increases in proportion to density. Above this, a plateau of about 125 g/m^2 is reached and further increase in density does not increase the standing crop. Increase in density is associated with a decrease in mean length.

More important is the effect of density on gonad output, which rises to a maximum at a density of $400/m^2$ and then progressively decreases. This is a natural population control mechanism. Growth rates and survival rates are also lower in higher-density populations.

All of these factors have been experimentally measured, and can be explained in terms of intraspecific competition, which is clearly density dependent.

Similar observations on population dynamics are applicable to the effects of oil spills, as Crapp (1971) has recorded in Britain. In *P. cochlear* the immediate effect of oiling is a heavy mortality (Day *et al* 1971), but total eradication has not been observed. Almost immediately the surviving juveniles invade the empty scars, thus spreading the remaining population uniformly. This low-density population then has the capacity for rapid growth of the individuals, greater mean size, higher gonad output and a higher subsequent survival.

Measurements made at Hangklip after an oil spill demonstrated the achievement of greater size and gonad output, although relative growth and survival rates could not be assessed.

P. cochlear thus has a high capacity for long-term recovery after an oil spill (or treatment with emulsifiers), provided the food source is not destroyed.

OIL MOLLUSCS WEST COAST ORGANISMS

38. Breyer-Menke C J 1975. Bacteriological survey of Saldanha Bay. *Environment RSA* 2 (9), 3 and 6.

Results of bacteriological sampling in various points in Saldanha Bay, including sampling near a fish factory outfall are given. Results indicate that no extensive or lasting pollution was apparent on the day the sampling was conducted. (DAD)

BACTERIA WEST COAST ESTUARIES

39. Brown A C 1964. Effect of hydrogen sulphide on *Bullia* (Gastropoda). *Nature* 203, 205-206.

Bullia laevissima and *B. digitalis* disappeared from beaches in Hout Bay coincidentally with increasing organic pollution from the outlet of a fish meal factory. On the northern beaches of the bay there is some evidence of hydrogen sulphide gas in the substratum. Exposure of *Bullia* to hydrogen sulphide gas bubbled through seawater resulted in all animals exposed for 0,5 hour or more dying. Animals removed after 0,25 hour all recovered. Of the animals removed at intermediate stages, some recovered and some did not. It was found that exposure to hydrogen sulphide in the absence of air resulted in lack of movement within 0,5 hour but those removed within 1 hour and 10 min recovered completely. Animals removed after 1,5 hours and 2 hours were mostly dead. It is concluded that hydrogen sulphide is lethal to *Bullia* quite apart from oxygen lack. Experiments indicated that hydrogen sulphide does not appear to interfere permanently with the oxygen-carrying ability of *Bullia* haemocyanin. *Bullia* can detect small quantities of hydrogen sulphide and tends to avoid such pollution. If such avoidance is not possible the snails refuse to burrow and eventually turn on their backs and spread their feet, a position which, in the field, encourages transport by waves and water currents. Such behaviour might well account for the absence of *Bullia* on Hout Bay beaches. (DAD)

FISH FACTORY EFFLUENTS MOLLUSCS WEST COAST ORGANISMS

40. Brown A C 1967. The elimination of foreign particles injected into the coelom of the holothurian, *Cucumaria stephensoni* D. John. *Zoologica Africana* 3, 3-8.

The elimination of thorium dioxide particles introduced into the coelom of *Cucumaria stephensoni* was investigated by means of radiographs, sections and the examination of coelomic fluid samples. Phagocytes laden with the particles migrate through

the respiratory trees and gut, and also via the anterior water-vascular system. The elimination is remarkably efficient, being rapid and virtually complete. The numbers of homogeneous ameobocytes are affected by the introduction of Thorotrast and it is tentatively suggested that these cells give rise to the phagocytes as well as to other coelomocyte types.

RADIOACTIVITY ORGANISMS

41. Brown A C 1974a. Observations on the effects of ammonium nitrate solution on some common marine animals from Table Bay. *Transactions of the Royal Society of South Africa* 41, 217-223

The toxicity of ammonium nitrate in natural sea water has been studied with respect to a number of sandy-beach animals, to the rock lobster, *Jasus lalandii*, and to the isolated heart of *Ciona intestinalis*. Results are integrated with previous findings on other species.

AMMONIUM NITRATE ORGANISMS POLLUTION SOURCES
WEST COAST

42. Brown A C 1974b. Report on the effects of the effluent discharged into Table Bay by Fedmis (Pty) Ltd. Unpublished Report on work undertaken for Fedmis (Pty) Ltd, available in the library of the Zoology Department, University of Cape Town. 82pp.

Field studies were undertaken on the dispersion of the Fedmis effluent, consisting mainly of a solution of ammonium nitrate, and its contribution to the nitrogen enrichment of Table Bay. Dilution was shown to be rapid and the level of nitrogen enrichment could not be measured 200 to 300 meters from the mouth of the effluent pipe. The benthic fauna closer to the mouth was found to be protected by the rise of the effluent directly to the surface of the sea. Quantitative sampling of the benthos around the mouth of the pipe and of the sandy-beach community at the effluent site failed to show biological damage as a result of the effluent. Toxicity studies showed that the invertebrate fauna of Table Bay has a very wide range of tolerances to ammonium nitrate pollution and demonstrate that developing larvae are very much more sensitive than are adults. The lowest concentration shown to cause biological damage was 0,5 ppm ammonium nitrate, though it was felt that still lower concentrations may be harmful where pollution is continuous. It is recommended that the rate of release of this substance into Table Bay be not increased. (Information released by kind permission of Fedmis (Pty) Ltd).

POLLUTION SOURCES AMMONIUM NITRATE WEST COAST ORGANISMS

43. Brown A C and R J Brown 1965. The fate of thorium dioxide injected into the pedal sinus of *Bullia* (Gastropoda : Prosobrachiata). *Journal of Experimental Biology* 42, (3), 509-519.

1. The removal and ultimate disposal of foreign particles injected into the haemolymph of the sandy-beach snail, *Bullia*, has been studied by using the radio-opaque dye Thorotrast.

2. Particles are removed by phagocytic haemocytes which migrate by various routes to the outside of the body. The main pathway is through the heart wall into the pericardial cavity and via the renopericardial canal into the lumen of the kidney, from which the cells escape into the mantle cavity.

3. The injection of foreign particles stimulates a marked increase in the haemocyte population and also in the mitotic index.

4. The final discussion integrates the available evidence and a comparison is made between *Bullia* and other molluscs. The origin of the macrophages is discussed.

RADIOACTIVITY MOLLUSCS ORGANISMS

44. Brown A C and R Winterbottom 1969. The fate of thorium dioxide injected into the coelom of the sipunculid *Golfingia capensis*. *Journal of Invertebrate Pathology* 13, 229-234.

The elimination of thorium dioxide, in the form of Thorotrast, from the coelomic fluid of a sipunculid *(Golfingia capensis)* has been studied by means of radiographs, sections, and coelomic fluid samples. The rate of elimination is slower than that in any other animal so far subjected to the same technique. All the coelomocyte types phagocytose thorium dioxide particles. Routes of elimination include the nephridia and gut, and possibly the tentacles.

RADIOACTIVITY ORGANISMS

45. Brown A C and A B Davies 1971. The fate of thorium dioxide introduced into the body cavity of *Ciona intestinalis* (Tunicata). *Journal of Inverterbrate Pathology* 18, 276-279.

The elimination of thorium dioxide from the body fluids of *Ciona* has been studied by means of radiographs, sections, and samples of body fluid.

The particles are phagocytosed by granular amoebocytes, green cells, and nephrocytes and are then eliminated via the intestine and the vas deferens. Some particles appear to become lodged in the test. Elimination from the body fluids is complete some 9 days after injection.

RADIOACTIVITY ORGANISMS

46. Brown A C and A B Currie 1973. Tolerance of *Bullia digitalis* (Prosobranchiata) to solutions of ammonium nitrate in natural sea water. *South African Journal of Science* 69, 219-220.

The prosobranch gastropod, *Bullia digitalis* was exposed to a series of concentrations (25 ppm to 1 500 ppm) of ammonium nitrate freshly made up in sea water. It was found that the threshold disablement concentration lies in the region of 300 ppm under the conditions tested though stress was observed at lower concentrations. The disablement takes the form of paralysis. It was found that exposure to concentrations of ammonium nitrate between 100 and 1 000 ppm produced no measureable effect on the respiratory rate of *Bullia* specimens. Also measurement of oxygen consumption of animals which had been kept in 1 000 ppm ammonium nitrate for 48 hours gave results lying between 1,00 and 1,32 mg O_2 (gm dry weight) $^{-1}h^{-1}$, a range well within that displayed by normal animals, despite the total paralysis from which they were suffering. It is concluded that the physiological effects of ammonia poisoning on animals remains unknown. At any rate the respiratory pathways in *Bullia* are not effected and thus changes in respiratory rate cannot be used to monitor this type of pollution. (DAD)

AMMONIUM NITRATE MOLLUSCS POLLUTION SOURCES ORGANISMS

47. Brown A C , P de B Baissac and B Leon 1974. Observations on the effects of crude oil pollution on the sandy-beach snail, *Bullia* (Gastropoda : Prosobranchrata). *Transactions of the Royal Society of South Africa* 41, 19-24.

The effect of crude oil on *Bullia* has been observed in the field, following an oil spill, and in the laboratory, using a light Arabian oil. Well-defined stress symptoms appear at sub-lethal concentrations; at higher doses these give way to paralysis before death ensues. Very low concentrations are fatal if there is contact between the animals and the oil, even if the oil has been weathered. If there is no direct contact much higher concentrations of fresh oil can be tolerated and weathering greatly reduces toxic effects. Mass mortality is unlikely to occur through eating oil-contaminated food.

OIL MOLLUSCS ORGANISMS

48. Burton A J 1961. A quantitative assessment of the effect of factory effluent upon littoral and estuarine faunas at Umkomaas, Natal. CSIR Symposium No S2 Marine Studies off the Natal Coast : *South African Journal of Science* 56, 163-166 (1960).

A quantitative assessment of the effect of factory effluent upon the littoral and estuarine faunas of Umkomaas, Natal, has been made by comparing population counts estimated before, and three years after, the commencement of the effluent flow.

It has been concluded that no significant change in the rock-dwelling fauna, that could be said to be exclusively due to the

effect of the factory effluent, has occurred at the stations examined during the investigation.

POLLUTION SOURCES EAST COAST ORGANISMS ESTUARIES

49. Burton A J, S R Rogers and M P S Berry 1970. A reassessment of the effect of effluent on the littoral fauna at Umkomaas, Natal. *South African Journal of Science 66*, 141-142.

A re-assessment of the possible effect of factory effluent upon the littoral fauna in the region of Umkomaas was carried out in 1968 and the population densities of the major species were compared with those of a previous survey (1955 - 1958).

A marked reduction in the population density of all but one of these species was observed.

The significance of short-term ecological surveys in establishing the effect of pollution is discussed and criticised.

POLLUTION SOURCES ORGANISMS EAST COAST

50. Butler L R P and R J Watling 1975. The development of analytical methods for chemical elements in the environment. *Annual Report to the National Committee for Environmental Sciences for the period 1 April, 1974 to 31st March 1975*. 19pp.

This report outlines the work carried out at the National Physical Research Laboratory, CSIR, during the period 1 April 1974 to 31 March 1975 on the development of analytical methods for chemical elements in environmental samples, a project which is supported by the Department of Planning and the Environment through the National Committee for Environmental Sciences.

During the period work has been concentrated on the development of methods for sample preparation and trace metal analysis of biological and aqueous samples. Foremost among these elements were mercury and arsenic. A considerable effort has also been made to survey the analysis of several matrices for seventeen different elements in order to determine in which area analytical problems lie.

Seawater, freshwater and biological materials have been distributed for inter-laboratory calibration purposes.

METHODS TRACE METALS

51. Cherry R D 1964a. Alpha-radioactivity of plankton. *Nature* 203, 139-143.

Data on total alpha activity and the percentage due to thorium series is presented from samples of zooplankton and phytoplankton. Total alpha activity of fresh zooplankton contains in general upwards of 4pc/g dried sample. For zooplankton some of the initial activity is often of 'short lived' (less than 2 years) duration and this short-lived activity can contribute an activity considerably in excess of the 'basic' 4pc/g. In one sample such activity was attributed to polonium-210. No such short-lived activity has been observed in phytoplankton samples though some do show very high values. The figure of 4pc/g in dry zooplankton is higher than the reported alpha activities of foodstuffs. If it is assumed that about half the 'basic' 4pc/g is due to polonium-210 then a typical value would be of the order of 125 x 10^{-3} pc/g 'wet' plankton, which is considerably larger than human tissue levels. The concentration factor for polonium in plankton appears to be more than 2 500. Thorium series will contribute, typically, upward of 0,4pc/g dried plankton to the alpha activity (equivalent to 0,025pc/g of wet plankton). The concentration factor for the thorium series in plankton appears to be about 1 250. It is presumed that 1-2pc/g of alpha activity is due to the uranium series (1,6pc/g dry plankton gives 0,1pc/g wet plankton). The concentration factor for uranium series appears to be about 50. (DAD)

PLANKTON RADIOACTIVITY ORGANISMS

52. Cherry R D 1964b. Low level alpha and gamma-radioactivity in some naturally occurring samples. *PhD thesis, University of Cape Town.*

This thesis discusses low-level alpha and gamma-detection techniques and their application to the determination of small quantities of radioactivity in some naturally-occurring samples. The main emphasis is placed on alpha-radioactivity, and the techniques of low-level alpha-particle detection and alpha-spectroscopy are reviewed. Certain aspects of gamma-spectroscopy are then discussed briefly.

The specific contributions of the candidate are listed separately in Appendices. They cover

(a) the principles of alpha-counting plus "thorium-pairs" detection as a means of determining thorium and uranium in geological samples which are in radioactive equilibrium, a simple technique for reducing photomultiplier noise, and the theory of alpha-emission from sources containing inhomogeneously distributed radioactivity

(b) the results of "total" alpha counting techniques applied to australites and to plankton

(c) the results of two alpha-spectroscopic methods applied to whole rock granites and to granite minerals respectively and, finally

(d) the results of uranium, thorium and potassium determinations in tektites using non-destructive gamma-spectrometry.

RADIOACTIVITY METHODS PLANKTON ORGANISMS

53. Cherry R D S W Fowler T M Beasley and M Heyraud 1975. Polonium-210: its vertical oceanic transport by zooplankton metabolic activity. *Marine Chemistry 3*, 105-110.

An earlier work based on atmospheric input of ^{210}Po to oceanic surface waters, *in situ* production from its radioactive precursors and its measured equilibrium concentration has shown that ^{210}Po is removed from the upper mixed layer at a rapid rate, expressible by a turnover (or mean residence) time of 0,6 years. Since ^{210}Po is known to be highly concentrated in numerous marine species, a method was devised to assess the importance of marine zooplankton in removing this radio-nuclide from the surface waters. Measurements of ^{210}Po losses from living zooplankton lead to a rapid turnover time of the order of 0,9 years due to zooplankton metabolic activity alone. It is shown experimentally that fecal pellet deposition constitutes a major mechanism in transporting the radionuclide from surface to deeper waters.

RADIOACTIVITY PLANKTON ORGANISMS

54. Cherry R D and L V Shannon 1970. Polonium 210 and lead 210 in marine organisms and sea water. *Symposium on biology and ecology of Polonium and Radiolead*, Sutton, May 1970. Abstract only : 1 pp.

The limited amount of published data on ^{210}Po and ^{210}Pb in the marine environment is summarised. A technique for measuring ^{210}Po and ^{210}Pb in sea water and marine plankton is described briefly, and the results of measurements on samples from Southern African oceanographic areas are discussed. The ^{210}Po content of sea water is found to be at the very low level of about 10 atoms/ml. Mean values for ^{210}Po in sea water and zooplankton are 20 x 10^{-3} pCi/l and 399 pCi/kg respectively and for ^{210}Pb the corresponding values are 38 x 10^{-3} pCi/l and 33 pCi/kg. Real variations in the concentrations of these nuclides are found, and certain interesting but tentative correlations that can be made with different water masses and current systems are indicated.

The biogeochemical balance of ^{210}Po and ^{210}Pb in the surface layer of the ocean is considered, and it is seen that the ^{210}Po to ^{210}Pb activity ratio increases steadily in the sequence rainwater - sea water - phytoplankton - zooplankton. Application of a very simple oceanographic model to our data results in removal times from the upper mixed layer of 5 years for ^{210}Pb and 0,6 years for ^{210}Po.

The fate of these nuclides higher up the marine food chain is of obvious interest, and measurements on fish "livers", bones, gills and flesh show that excess, unsupported ^{210}Po is present in the "livers" and gills at mean levels of 904 pCi/kg and 91 pCi/kg respectively. In the "livers" this excess ^{210}Po constitutes, on the average, almost 75% of the total alpha-radioactivity, and a preferential uptake mechanism for ^{210}Po into marine "livers" is suggested. In conclusion brief reference is made to (i) the radiation dose rate in marine organisms and (ii) the high position occupied by many marine tissues in a table of natural alpha-radioactivity in different species.

RADIOACTIVITY METHODS PLANKTON ORGANISMS FISH

55. Cherry R D and L V Shannon 1974. The alpha-radioactivity of marine organisms. *Atomic Energy Review 12*, 3-45.

The important role played by alpha-radioactive nuclides in the marine radiation environment is discussed, and the need for comprehensive and co-ordinated knowledge concerning the distribution of these nuclides in the oceans and in marine life is motivated. The core of the article contains detailed surveys of the alpha-emitting nuclides and their relevant nuclear properties, and of the present state of knowledge of the concentration and distribution of these nuclides in seawater, in marine organisms and in the organs thereof. The dominant contribution made by the natural fall-out nuclide ^{210}Po to the alpha radioactivity of most marine organisms is stressed. Brief comments are made on experimental techniques, the biogeochemical balance problem and radiation dosimetric considerations. The article concludes with the authors' suggestions for future lines of research.

RADIOACTIVITY ORGANISMS

56. Cherry R D, L V Shannon and I H Gericke 1969. Thorium-228 in marine plankton and sea water. *Earth and Planetary Science Letters 6*, 451-456.

Data are given for thorium-228 in zooplankton, phytoplankton and seawater from seven different oceanographical water masses in the South Atlantic and around the Southern African coast. The levels in plankton are easily detectable, being up to 27×10^{-18}g thorium-228 per g wet zooplankton and up to 65×10^{-18}g thorium-228 per g wet phytoplankton. What appear to be real variations from one water mass to another are observed, and the possible utility of thorium-228 as a natural oceanographic tracer is noted. The levels in seawater are in general at or below the sensitivity level of the technique used, but for one set of samples a particularly high thorium-228 content of $2,7 \times 10^{-15}$g thorium-228 per litre seawater is obtained. This set is from the Walvis Ridge area, and attention is drawn to the fact that this region is likely to be particularly interesting as far as thorium and certain other trace elements are concerned.

RADIOACTIVITY PLANKTON ORGANISMS

57. Cherry R D, I H Gericke and L V Shannon 1970. Alpha-radioactivity in the natural radiation environment. *South African Journal of Science 66*, 360-368.

The general subject of alpha-radioactivity in the natural environment is reviewed briefly. The essential features of data obtained in the UCT laboratories from South African samples are then discussed. Particular attention is paid to

(a) Natural alpha-radioactivity in the marine environment.
(b) Problems associated with thorium-series activity.
(c) The special position of the isotope polonium-210 environmental samples.

RADIOACTIVITY

58. Cherry R D, L V Shannon and M M Shay 1969. Natural radioactivity in the human body and other biological organisms. *Symposium on Cross-Disciplinary Sciences in Biomedical Research*, Johannesburg, South Africa, April 1969. 24pp.

The advent of nuclear energy and the possible dangers associated with an artifically increased nuclear radiation environment have highlighted the fact that our knowledge of the natural radioactivity of biological organisms is far from complete. In the present paper the nature and levels of the naturally occurring nuclear radiations to which man and other species are exposed are summarized briefly, and the important contribution made by the heavy alpha-radioactive elements is emphasized.

Relevant new information obtained in the UCT laboratories is discussed, and specific attention is paid to the following points:

(a) The inherent radioactive content of different species, and the attempts to answer the question "Is man a radioactive animal?" Our data indicate that man is quite clearly towards the lower end of the scale as far as natural alpha-radioactive content is concerned. Thus total alpha-radioactivity levels in human bone are of the order of 100 picocuries per kilogram; in bone from many herbivores the level is variable but usually an order of magnitude higher. Again, in human soft tissues total alpha-activity levels are typically about 10 picocuries per kilogram, while in marine plankton they average more than twenty times higher.

(b) The natural fall-out nuclide polonium-210 is known to be the major source of natural alpha-radioactivity in human tissues. Our data show that the preponderance of this nuclide is even more striking in samples from the marine environment, and that it is moreover present at much higher levels.

(c) We have recently investigated the sites of the alpha-emitting elements in various organisms. In humans, bone appears to be the most alpha-radioactive tissue, but this is not generally true for other species. In certain marine species and possibly in some herbivores the liver has a notably higher alpha-activity and here again it seems that polonium-210 is the likely major source.

In conclusion some important unanswered questions are posed, and the likely lines of progress for future research are outlined briefly.

RADIOACTIVITY PLANKTON ORGANISMS

59. Cherry R D, M M Shay and L V Shannon 1970. Natural alpha-radioactivity concentrations in bone and liver from various animal species. *Nature* 228, 1002-1003.

The natural alpha-activity (including the percentage due to excess polonium 210) of the livers of marine (rock lobsters, fish, seal) and terrestrial animals including man are compared. The total alpha-activity of marine livers was found to be higher. The high activity level in marine livers was attributed to the excess polonium 210 levels. It was considered that a specific metabolic mechanism existed in the marine 'livers' probably involving direct uptake of polonium 210. (DAD)

RADIOACTIVITY ORGANISMS FISH SEALS

60. Chew J A 1941. Disposal of sewage in a seaside town some problems with which East London has been faced. *South African Municipal Magazine.* 24 (288), 7, 9, 27.

Problems occur in the East London sewage system. The existing scheme includes two sea outfalls, the main outfall being constructed with a storage tank designed to discharge only on the ebb tide, the intention being to ensure that sewage is carried well out to sea. It has been found that this system is unsatisfactory as sewage stored for, say 8 hours, turns septic. Our object is to discharge sewage into the sea as soon as possible, so that reduction will take place by oxidation. Our proposals include a delta or multiple outfall so as to spread the load over as wide an area of sea as possible. Provision may also be made at a future date for pumping clear sea water into the inlet of the existing outfall tunnel and so diluting the sewage and delaying the septic action. It was found that to prevent odour formation a chlorine dose of probably 10 - 15 ppm would be necessary, this would prove most costly. Without any treatment whatsoever there is a reasonable prospect of carrying the sewage out to sea before septic action takes place provided the outfall is discharged continuously irrespective of tide or weather conditions. To prevent the deposition of faecal matter on the shore line it is intended to instal disintegrators or mincing apparatus.

Problems have been experienced with storm water resulting on occasion in flooded sewers. In our present designs it is proposed to provide flood relief tanks which will accommodate the peak flow during the period of heavy rain. Seepage into the sump has also caused problems varying from an explosion due to fumes from leaked petrol in the sump igniting, to silt brought in by storm water. Tree roots growing into the sewers e g wild fig and kaffir-boom, are the main cause of sewer chokage. The costs involved in supplying sub-economic services are described. £11 10s per dwelling covers the cost of one W C, one shower, one tap with washing area and the necessary supply of water and drainage fittings. A sewerage rate is levied based on the property valuation and the number of pans installed. (DAD)

DISPOSAL OF EFFLUENTS SOUTH COAST

61. Coetzee O J 1961a. Comments on sewage contamination of coastal bathing waters. *South African Medical Journal* 35, 261-263.

It would appear that the carrier rate of *S. typhi* in South Africa lies between 100 and 2 000 per 100 000 population compared to 2 per 100 000 in Great Britain. The chances of sea water in South Africa containing intact particules with viable salmonellae originating from such carriers would be about 50 times greater than in Great Britain. It is calculated that in South Africa the chances would be 1 in 28,5 for a daily swimmer to contract typhoid fever in a 30 day period. When compared with the typhoid rate the risk of contracting diarrhoea-enteritis is calculated as 1 in 1,42. The fact that no *Mycobacterium tuberculosis* or *Mycobacterium balnei* organisms were isolated in the sea water investigated in England and Wales, would not exclude the possibility of finding them in South African waters, due to the higher incidence of tuberculosis in South Africa, especially amongst the Bantu population. (DAD)

BACTERIA DISPOSAL OF EFFLUENTS ORGANISMS

62. Coetzee O J 1961b. The bacteriological problems of the discharge of waste water into the sea - a literature survey. *19th Annual Health Congress of the Institute of Public Health,* Margate, October 1961.8 pp.

The following factors affecting the survival of bacteria in sea water are reviewed: 1. Presence in sea water of toxic substances. 2. Presence of bacteriophage. 3. Adsorption or sedimentation. 4. Sunlight and temperature. 5. Aeration and food supply. 6. Antibiotics and animal predators. It is concluded that bathing in sewage polluted sea water does carry a certain amount of risk. (DAD)

BACTERIA DISPOSAL OF EFFLUENTS ORGANISMS

63. Coetzee O J 1962a. Shell fish - a potential threat to public health. *Public Health, Johannesburg,* August 1962. 2pp.

Regulations for coliform organisms in shellfish in the USA and UK are described. The lack of recorded cases of typhoid fever, gastro-entritis and dysentery as a result of shellfish consumption in South Africa would tend to create a false sense of security. It is apparent that we have to be much more careful about collecting grounds, marketing and handling of shellfish where it is meant for human consumption. It is proposed that a strict form of control be instituted as regards edible shellfish and shellfish beds in South Africa. (DAD)

MOLLUSCS BACTERIA ORGANISMS

64. Coetzee O J 1962b. The possible use of oysters as integrated bacteriological samples of a specific area to detect the presence of pathogens in sea water. *Public Health, Johannesburg,* August 1962. 2pp.

2 out of 5 oysters collected next to a swimming area were found to contain *S. typhi.* It is considered that this indicates that sewage or sewage effluents are reaching the bathing area. It is concluded that : (1) Oysters can be used as integrated samples of a specific area. (2) The samples are probably representative of the water that had passed over a certain area or a certain length of time. (3) The only limit to this method would be the time taken for the bacteria to remain viable in the oyster (it has been reported that *S. typhi* survive in shell oysters for at least two weeks and in some cases up to 60 days).

It is suggested that coastal authorities, in addition to their normal determinations for *E. coli* in their bathing waters, experiment in the possible use of oysters as integrated water samples of these bathing beaches. If a supply of clean oysters is kept, and every beach is supplied with a stationary wire cage into which is put a clean oyster every 10 days and the previous one from the cage sent for analyses for the presence of *S. typhi* it would give an indication as to the cleanliness of the bathing waters. (DAD)

MOLLUSCS BACTERIA MONITORING ORGANISMS

65. Coetzee O J 1963. The viability of *Salmonella typhi* in sea water. *Public Health, Johannesburg,* July 1963.

An experiment was carried out to determine the viability of *S. typhi* in sea water. The inoculum used was natural occurring *S. typhi* as obtained in the faeces of typhoid carriers. The bacteria was acclimatized by gradually adding sea water to the inoculum. Incidental to the actual experiment it was found that *S. paratyphi B* bacteria were more resistant to adverse conditions

than *S. typhi*. The die-off in the silt layer was retarded. The mortality in distilled water was of the same pattern and a working hypothesis on the role of the medium in die-off is postulated.

BACTERIA ORGANISMS

66. Coetzee O J 1964. Development of a technique using *Serratia marcescens* as a quantitative tracer in the sea. In Oceanographic Research Group 1964, 39-43.

The development of a quantitative technique is described. The use of *Serratia marcescens* as a qualitative tracer has very few advantages relative to fluorescein, but as a quantitative tracer it has the advantages of cheapness, ease in performing the test, and sensitivity. (CEC)

EAST COAST COASTAL CURRENTS WAVES METHODS

67. Connell A D, W D Turner, B D Gardner, T P McClurg, J E Carter and D J Livingstone 1974. National Programme for Marine Pollution Monitoring - East Coast Estuarine Surveys. Progress Report No. 1 - The Umzimkulu Estuary. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 22pp.

A survey of the Umzimkulu estuary was carried out. The following parameters were measured: physical and chemical parameters, bacteriology, benthic fauna and sediment quality, zooplankton, pesticide residues and trace metals. (CEC)

EAST COAST BACTERIA TRACE METALS PESTICIDES
SEDIMENTS METHODS PLANKTON ORGANISMS FISH
ESTUARIES MONITORING

68. Connell A D, W D Turner, B D Gardner, T P McClurg, D J Livingstone, J E Carter and W J N Gertenbach 1975. National Marine Pollution Monitoring Programme (East Coast Section) Progress Report No. 2. (March 1974 to March 1975). *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 118pp.

This report covers Impact Area Surveys, Coastal Reference Surveys and Oceanic Reference Transects on the East Coast region, in execution of the National Programme to Monitor Marine Pollution.

Attention has been given to Durban Bay, Richards Bay and the beaches south of Durban. Indicator accumulator species are proving useful in tracing local sources of pollution.

Coastal Reference Surveys continued at Fynnlands, south of Durban and Umbogintwini and confirmed local sources of pollution at those points. Recently, in February 1975, the

work was extended to Port Elizabeth and St Croix. The results of this latter work are not yet available.

Estuarine surveys have covered the following:

The Umzimkulu Estuary, which proved not to be an especially productive one, with some puzzling features of minor pollution; the southern area of Richards Bay, which proved to be unpolluted and rich in nutrients and estuarine life; the Ifafa lagoon proved to be a typical lagoon, rather poor in nutrients and productivity. The marina development in the area has been slow and has had no effect on the area yet.

Oceanic Reference Transects have been made on four occasions during the year and have provided useful background data. There has proved to be somewhat elevated levels of pesticides and some metals in the inshore water, probably originating from the Durban and South Coast industrial areas.

BACTERIA TRACE METALS PESTICIDES DISPOSAL OF EFFLUENTS POLLUTION SOURCES SEDIMENTS EAST COAST METHODS PLANKTON ORGANISMS MOLLUSCS FISH ESTUARIES MONITORING

69. Currie A B, Brown A C and G R Bennet 1974. The effect of ammonium nitrate solutions on some aspects of the biology of the black mussel, *Choromytilus meridionalis*. *Transactions of the Royal Society of South Africa*. 41, 209-215.

The effects of low concentrations of ammonium nitrate on the fertilization and early development of *Choromytilus meridionalis* have been studied in the laboratory at 14°C. Concentrations up to 10 ppm have no significant effect on fertilization, though concentrations as low as 0,5 ppm retard early development. Spontaneous recovery takes place unless the pollutant is repeatedly renewed. At 10 ppm a high proportion of the larvae achieving the veliger stage show abnormal shell growth. At 100 ppm ammonium nitrate there is complete failure to pass beyond the trochophore stage, development tending to terminate at gastrulation. These results contrast with the tolerance of the adults, solutions of 1 000 ppm having no significant effect on either the tendency to shell adduction or the ciliary beat of the gills.

POLLUTION SOURCES AMMONIUM NITRATE MOLLUSCS ORGANISMS

70. Currie B and P A Cook 1975. Report on biological investigation for the proposed ESCOM nuclear power station at Duynefontein. Report in Department of Zoology, University of Cape Town.

Biological investigations in connection with the proposed ESCOM nuclear power station which is to be built at Duynefontein, near Cape Town, have just been completed. Completion of the first phase of the power station, which will use sea water as a coolant, is scheduled for the mid 1980's. Once in operation, vast

quantities of sea water, heated to at least 6°C above ambient, will be pumped into the sea. The possible thermal pollution effects of this effluent have been investigated over the past three years and a base-line ecological study has been carried out in the area so that changes in the fauna and flora can be monitored once the station is in operation. The results are at present available only in the form of reports to ESCOM but will shortly be published in the scientific literature.

THERMAL POLLUTION RADIOACTIVITY ORGANISMS WEST COAST

71. Cuthbert K C 1975. Some effects of cadmium pollution on *Bullia digitalis* (Prosobranchiata). Unpublished student project in the library of the Zoology Department, University of Cape Town.

Individuals of *Bullia digitalis* were subjected to a range of concentrations of cadmium chloride in natural sea water, the cadmium levels being monitored by means of atomic absorption spectrophotometry. The same stress symptons as those reported for other pollutants were observed at cadmium levels of 0,5 ppm and more. The 60-hour LC_{50} was 4 ppm, that for 72 hours was 3,6 ppm, while the 96-hour LC_{50} was only 0,9 ppm cadmium. Chronically stressed animals did not recover when transferred to unpolluted sea water. Oxygen consumption appears to be elevated, at least initially, by low-grade cadmium pollution. Attempts to discover the rate of uptake of cadmium and its accumulation in the tissues failed because of the very high cadmium content of the untreated animals. Animals collected from Ou Skip beach had a whole-body cadmium concentration of 30 ppm cadmium (wet weight) or 125 ppm (by dry weight). The viscera had a cadmium content of approximately 7 times these values, among the highest ever recorded for marine animals anywhere in the world.

TRACE METALS ORGANISMS MOLLUSCS

72. Cuthbert K C, A C Brown and M J Orren 1976. Cadmium concentrations in the tissues of *Bullia digitalis* (Prosobranchiata) from the South African west coast. *South African Journal of Science* 72, 57.

Tissues of the prosobranch gastropod, *Bullia digitalis* collected from a relatively unpolluted beach well outside and to the north of Table Bay have been shown to contain unexpectedly high levels of cadmium (mean concentrations of 30,1 ppm wet weight and 125,3 ppm dry weight). Levels in the viscera were significantly higher than that of the whole body (including viscera). It is pointed out that during summer, water from Table Bay, polluted by a number of outfalls including industrial effluents, may be carried past the site but in winter the currents tend to flow in the opposite direction due to the prevailing north-westerly wind. (DAD)

TRACE METALS MOLLUSCS WEST COAST ORGANISMS

73. Cuthbert K C, A C Brown and M J Orren (In press). Toxicity of cadmium to *Bullia digitalis* (Prosobranchiata: Nassariidae). *Transactions of the Royal Society of South Africa.*

Following experiments to determine the degree of absorption of cadmium, large adult females of *Bullia digitalis* were subjected to a series of concentrations of cadmium chloride in sea water, and their responses observed. A concentration of 0,1 ppm cadmium inhibits attraction to food, while visible stress symptoms are apparent at 0,5 ppm after 4 days. The 60-hour LC_{50} was 4 ppm, that for 72 hours was 3,6 ppm, while the 96-hour LC_{50} was only 0,9 ppm cadmium. Chronically stressed animals did not recover when transferred to unpolluted sea water. The symptoms observed are not specific to cadmium poisoning but are similar to those encountered in *Bullia* for a number of other pollutants.

TRACE METALS MOLLUSCS ORGANISMS

74. Darbyshire M 1963a. Long waves on the coast of the Cape Peninsula. *Deutsche Hydrographische Zeitung* 16 (4), 167-185.

A study is made of long waves recorded on the west coast of the Cape Peninsula and in Table Bay harbour. Two types are found to exist. The shorter ones of period 30 seconds to 6 minutes are surf beats associated with the arrival of sea waves and swell at the shore. The longer ones of period 15 minutes upwards are an oscillation of the water mass overlying the continental shelf and appear to be generated by fluctuations of similar period in the atmosphere. A number of examples of both kinds of long wave activity are cited and the frequency spectra of some of these are presented and discussed. The problem of range action in harbours is a particularly interesting application of this long wave study.

WEST COAST WAVES

75. Darbyshire M 1963b. Computed surface currents off the Cape of Good Hope. *Deep-Sea Res* 10, 623-632.

Data from six surveys of the region off the Cape of Good Hope and one in the Benguela Current have been used to calculate dynamic height anomalies and surface currents. The temperature and salinity distributions and the nature of the water masses are also discussed. Current velocities up to 70 cm/sec were found. The pattern of surface currents varied with each survey but a predominant feature in all was the large scale anticyclonic eddies off the Cape.

WEST COAST COASTAL CURRENTS

76. Darbyshire M and E Pritchard 1966. Sea waves near the coasts of South Africa. *Deutsche Hydrographische Zeitung* 19 (5), 218-225.

A statistical study is made of waves recorded in South African

waters over a period of four years. Distribution diagrams have been prepared for the wave parameters of height, period, spectral band and direction and for wind speed and direction.

WAVES WEST COAST SOUTH COAST

77. Darracott D A 1974a. International marine pollution control. *Environment RSA, October 1974*, 6-7.

Regulations embodied in the Convention for the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (1972) and the Convention for the Prevention of Pollution from Ships (1973), are briefly described. Prevention of pollution from the exploration and exploitation of the sea bed will be dealt with by the United Nations Law of the Sea Conference.

PREVENTION AND COMBATING

78. Darracott D A 1974b. International research into marine pollution. *Environment RSA, November 1974*, 4-5.

Existing international research programmes by non-governmental (e g SCOPE) and governmental (e g IOC) organisations are briefly reviewed. The South African national programme on marine pollution is described.

MONITORING

79. Darracott D A 1974c. Water pollution - summary of marine pollution legislation in South Africa. *Environment RSA, December 1974*, 4-5.

The following South African Laws for marine pollution control, are briefly described in terms of area of responsibility and penalty together with a note of which Department/Provincial Administration has jurisdiction.

; Sea Fisheries Act No. 58 of 1973
; Prevention and Combating of Pollution of the Sea by Oil Act No 67 of 1971
; Public Health Act No. 36 of 1919
; Water Act No 54 of 1956
; Sea and Seashore Act No 21 of 1935
; Natal Ordinances No 19 of 1958 and No 21 of 1942
; Cape Ordinance No 19 of 1951

PREVENTION AND COMBATING

80. Darracott D A 1975a. Water pollution - summary of related laws. *Environment RSA* 2 (2), 4-5.

The following South African Laws relating to marine pollution control are briefly described in terms of area of responsibility and penalties together with a note of which Department/Provincial Administration has jurisdiction -

; Hazardous Substances Act No 15 of 1973
; Merchant Shipping Act No. 57 of 1951
; Foodstuffs, Cosmetics and Disinfectants Act No 54 of 1972
; Mines and Works Act No 27 of 1956
; Fertilisers, Farm Feeds, Agricultural Remedies and Stock Remedies Act No 36 of 1947.

PREVENTION AND COMBATING

81. Darracott D A 1975b. Pesticides in the marine environment. 1. Chemical characteristics and route of entry. *Environment RSA* 2 (5), 4-5.

The chemical characteristics and route of entry into the marine environment of the following pesticides (and similar compounds) are summarised: organochlorines, polychlorinated biphenyls, organophosphorous compounds, carbamates, herbicides, mercurial compounds, metal and organo-metal compounds.

PESTICIDES

82. Darracott D A 1975c. Pesticides in the marine environment. 2. Accumulation in and effect on man and marine life. *Environment RSA* 2 (6), 4-5.

The accumulation in and effect on man and marine life, of the following pesticides (and similar compounds) is summarised; organochlorines, polychlorinated biphenyls, organophosphorous compounds, carbamates, herbicides, mercurial compounds, metal and organo-metal compounds.

PESTICIDES

83. Darracott D A 1975d. Pesticides in the marine environment. 3. Pollution sources, research, legislation and other control methods in South Africa. *Environment RSA* 2 (12), 3-5.

Pesticide pollution sources in South Africa are briefly described together with details of pesticide control measures. A ban on DDT, except for use in malaria control, will come into effect on April 1976. National and international research programmes and legislation are reviewed. Alternatives to the use of pesticides are given quoting South African examples.

PESTICIDES PREVENTION AND COMBATING POLLUTION SOURCES

84. Darracott D A 1976. The Law of the Sea Conference - its implications for South African marine research. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in South Africa*, Port Elizabeth, July 1976. 36pp.

A new Law of the Sea Convention will include provision for a 12 nautical mile territorial sea and a 200 nautical mile economic zone, to be controlled by the coastal state. The living (spiny lobsters, demersal fish, pelagic fish and migratory stocks) and non-living resources (manganese nodules, phosphorite, potential oil/gas areas) of a possible South African economic zone are briefly described together with details of current pollution problems in the zone. The present and possible future situation, with respect to control of these resources and marine pollution, is discussed. It is considered that research can play a role in the effective management of the economic zone particularly in resource assessment and in providing information necessary for formulating regulations. The probable control by the coastal state over all research carried out in the zone should increase the flow of information into South Africa. In terms of the most recent draft convention, the major gains to South Africa will be greater control over demersal fish stocks, marine pollution and marine research. The main loss, in comparison with rights in existing legislation, will be decreased control over mineral resources e g oil, outside the 200 nautical mile zone.

PREVENTION AND COMBATING

85. Darracott D A and H R Watling 1975. The use of molluscs to monitor cadmium levels in estuaries and coastal marine environments. *Transactions of the Royal Society of South Africa* 41, 325-338.

Molluscs are known to accumulate cadmium, an element toxic to man, to levels in excess of those commonly found in marine waters. It is shown that molluscs can be used to monitor cadmium levels in estuarine and other marine environments. The reliability of this type of monitoring is compared with data obtained from standard sediment and water sampling surveys, using as an example studies in two estuaries in the United Kingdom. Cadmium concentrations in the Pacific oyster *Crassostrea gigas* from these estuaries are quoted, together with concentrations in molluscs from other polluted and unpolluted environments. Suggestions are made as to which of the variety of molluscs occurring around the South African coast might be most useful as monitoring organisms.

TRACE METALS MOLLUSCS MONITORING ESTUARIES ORGANISMS

86. Day J H 1972. Oil pollution in South African seas. *South African Journal of Science* 68, 130-131.

The effect of oil pollution from the *Wafra* on marine life is briefly described. It was found that animals which could close up their shells e g mussels, were more tolerant of oil. Soft bodied forms e g octopus and echinoderms were mainly killed. Future plans for monitoring were outlined as follows: (1) The programme must start with tests of susceptibility of common shore animals and plants on Natal, South Coast and West Coast shores. Commercially important species (e g *Jasus* and *Donax*) must be included. (2) The tests must include different ages of oil since its toxicity decreases as volatile fractions evaporate. (3) Modern surfactants are far less toxic than those originally provided. The least toxic must be identified. Overseas studies suggest that among these are Correxit; Dispersol, BP 1100. (4) Areas for Monitoring: Sheltered areas are most severely affected and the South African marine biota changes from Natal to South West Africa. Again the susceptibility varies from species to species. These points must be borne in mind in selecting monitoring points.

In order to ascertain the severity of an oil spill one must know the density in numbers per m^2 of the test species. This study must be done early to provide a yardstick of pollution. (DAD)

OIL ORGANISMS MONITORING

87. Day J H, P A Cook, P Zoutendyk and R Simons 1971. The effect of oil pollution from the tanker *Wafra* on the marine fauna of the Cape Agulhas area. *Zoologica Africana* 6, 209-219.

The detailed effects of oil pollution on the flora and fauna of the intertidal zone on a rocky shore are described, together with a brief note of the effect of oil on sandy beaches and on offshore fishes. On rocky shores the most severe pollution was seen in coves and isolated pools where wave action was reduced. The effect of pollution on the flora and fauna at different tidal levels did not obviously correspond with the intensity of oiling at the same level. This difference in sensitivity to oil pollution is not a simple distinction between browsers such as limpets and periwinkles on the one hand and filter feeders such as tubicolous polychaetes, mussels or barnacles on the other. The literature on oil pollution suggests that some taxonomic groups such as the echinoderms are more sensitive to oil than are others, such as molluscs and certainly the sea-urchin *Parechinus* suffered a high mortality. On the other hand, the molluscs varied greatly in their susceptibility. Octopi died very quickly even though they are always submerged. This may be because they lack a protective shell. But the species of shelled molluscs varied in sensitivity even within a single genus. *Patella variegata* and *P. longicosta* tolerated the oil while *P. cochlear* and *P. oculus* died or were adversely affected. *Oxystele* variegata and *O. sinensis* were severely affected but *O. tigrina* was not.

We would suggest that at higher tidal levels the more tolerant species are *Patella granularis* and *Tetraclita serrata* while *Oxystele variegata* and *Cyclograpsus punctatus* are the more sensitive.

At low tide *Octomeris angulosa, Patella longicosta* and *Perna perna* are the more tolerant while *Octopus granulatus, Patella cochlear* and *Parechinus angulosus* are more sensitive. The commercially important species *Jasus lalandii* and *Haliotis midae* both appear to be unusually sensitive. (DAD)

OIL ORGANISMS MOLLUSCS SOUTH COAST

88. Department of Transport 1973. Prevention and combating of pollution of the sea and beaches by oil. 28pp plus 3 annexures (English and Afrikaans).

The planning of control and clean-up operations, re oil pollution, is described including the responsibilities of local authorities. Environmental factors affecting spilled oil are (1) sea conditions (2) wind direction and velocity (3) surface currents (4) water temperature (5) general atmospheric conditions in the vicinity of the spill. The use of absorbent materials and dispersants is discussed. Recommendations are made on the protection of a threatened shoreline and clean-up of the shore. (DAD)

OIL PREVENTION AND COMBATING

89. Department of Transport 1974. The role of the Department of Transport in the prevention and combating of pollution of the sea by oil - Law 67 of 1971. *Environment RSA* June 1974: 13. In Afrikaans.

A brief account of the distribution of patrol vessels and tugs with details of the quantity of dispersant to be carried is given. (DAD)

OIL PREVENTION AND COMBATING

90. Department of Water Affairs 1962. Regional Standards for Industrial Effluents. *Government Printer No R* 553. 5pp.

Details in terms of a general standard and a special standard, prescribed maximum limits in effluents for the following parameters: Colour/odour/taste, pH, dissolved oxygen, typical (faecal) coli, temperature, chemical oxygen demand, oxygen absorbed, total dissolved solids, suspended solids, sodium content, soap/oil/grease, and other constituents (residual chlorine, free and saline ammonia, nitrates, arsenic, boron, total chromium, copper, phenolic compounds, lead, phosphates, iron, manganese, cyanides and related compounds, sulphides, fluoride, zinc). A list of river areas where the special standard is applicable, is given. (DAD)

PREVENTION AND COMBATING STANDARDS

91. De Waal M T 1975. The effect of mining and industrial development on the environment of coastal areas. Council for the Habitat, *Proceedings of Coastal Areas Conference*, Durban, 3-4 April 1975. 9pp.

The development of industry in South Africa has increased rapidly since the Second World War, with its attendant pollution problems. A rapid increase in mineral refining in South Africa occurred in the 70's. Since 1965 an advanced stage in industrial development, with accompanying increased potential for air and water pollution, was reached. At this point the Water and Air Pollution Acts were already in force and technology was available for pollution control planning. There are many mineral resources along the coastline, for example, diamonds north of the Olifants river mouth, heavy mineral sands at various points along the coast, phosphate/kaolin/clays/gypsum on the West Coast.

The mining, pollution sources and pollution control of these resources is described. The estimated tonnages to be won from the heavy mineral sands on the north coast of Natal are given. The deposits in the dune sands of Richards Bay represent the largest proven reserves of heavy minerals of this type in the world. The method of mining will be in accordance with a new technique perfected in Australia, viz that of using dredgers. At Umgababa, this method would not have worked because of the clay/limestone present in ore sands. It was this clayish effluent which caused the distinct colouring of the surface water in the Umgababa region. In the case of Richards Bay, it is proposed to build a series of dams in the dunes, 30 metres above sea level. Two dredgers will pump the sand from the front of the dam to a concentration plant (also floating in the dam) where the heavy minerals will be extracted in the wet and the remaining sand (approximately 90% of the original quantity) pumped to the rear of the dam. In such a way the dam will be eaten away from one side and filled on the other side, thus forming a continuous operation in the dune area without any discharge to the sea or adjoining water courses. After the area has been re-filled, the natural shrub, *Acacia karroo* will be re-established.

Possible pollution from certain industries (existing and to be established) on the South Coast and the corresponding control measures are described. The industries include oil refining, petrochemicals, chemical and fertilisers, pulp and paper, cement manufacture, aluminium smelting, chrome chemicals, soda ash production, metal industries and heavy minerals processing. (DAD)

POLLUTION SOURCES PREVENTION AND COMBATING TRACE METALS

92. Doesburg J J and D A Reid. Recovery of oil from fish factory effluents. *Fishing Industry Research Institute. Annual report no 22*, 48.

No abstract available

FISH FACTORY EFFLUENTS

93. Dreosti G M 1959a. Abatement of pollution of air and water by fish meal plants. *Fishing Industry Research Institute Report (M95).*

No abstract available

FISH FACTORY EFFLUENTS

94. Dreosti G M 1959b. Pollution of sea water by fish meal factories. *Fishing Industry Research Institute Report (M97).*

No abstract available

FISH FACTORY EFFLUENTS

95. Dreosti G M 1965. Background of natural pollution of Walvis Bay. *Fishing Industry Research Institute Report (M141).*

No abstract available

FISH FACTORY EFFLUENTS

96. Dreosti G M 1966. Harbour Pollution Committee, Walvis Bay - Preliminary report on activities. *Fishing Industry Research Institute Report (M152).*

No abstract available

FISH FACTORY EFFLUENTS

97. Dreosti G M 1967. Clarification of effluent at Walvis Bay. *Fishing Industry Research Institute Report (M160).*

No abstract available

FISH FACTORY EFFLUENTS

98. Dreosti G M 1968a. Clarification of Walvis Bay effluent. *Fishing Industry Research Institute Report (M173).*

No abstract available

FISH FACTORY EFFLUENTS

99. Dreosti G M 1968b. Effluent clarification : Walvis Bay. *Fishing Industry Research Institute Report (M172).*

No abstract available

FISH FACTORY EFFLUENTS

100. Dreosti G M 1968c. Problems connected with effluent clarification. *Fishing Industry Research Institute Report (M174).*

No abstract available

FISH FACTORY EFFLUENTS

101. Dreosti G M. Recirculation of flume water. *Fishing Industry Research Institute. Annual report No 12,* 22.

No abstract available

FISH FACTORY EFFLUENTS

102. Dreosti G M and C K Simmonds. Re-use of flume water. *Fishing Industry Research Institute. Annual report No 24,* 39.

No abstract available

FISH FACTORY EFFLUENTS

103. Dreosti G M, S G Wiechers and R J Nachenius. Clarification of off-loading water. *Fishing Industry Research Institute. Annual report No 15,* 42.

No abstract available

FISH FACTORY EFFLUENTS

104. Dreosti G M and W Williams. Recovery of flume water solids by flocculation. *Fishing Industry Research Institute. Annual report No 12,* 24.

No abstract available

FISH FACTORY EFFLUENTS

105. Dreosti G M, *et al.* Clarification of polluted water. *Fishing Industry Research Institute. Annual report No 21,* 48.

No abstract available

FISH FACTORY EFFLUENTS

106. Dreosti G M, *et al.* Clarification of sea water. *Fishing Industry Research Institute. Annual report No 17,* 50.

No abstract available

FISH FACTORY EFFLUENTS

107. Dreosti G M, *et al.* Clarification of Walvis Bay effluents. *Fishing Industry Research Institute. Annual report No 21,* 46.

No abstract available

FISH FACTORY EFFLUENTS

108. Dreosti G M, *et al.* Disposal of effluent by evaporation. *Fishing Industry Research Institute. Annual report No 24,* 38.

No abstract available

FISH FACTORY EFFLUENTS

109. Dreosti G M *et al.* Filtration of flocculated solids from artificial anchovy effluent. *Fishing Industry Research Institute. Annual report No 21,* 55.

No abstract available

FISH FACTORY EFFLUENTS

110. Duncan C P and J H Nell 1969. Surface currents off the Cape coast. *Division of Sea Fisheries Investigational Report No. 76,* 1-19.

A definite seasonal variation in the movement of surface water off the west and south-west coasts of South Africa has been established by the use of drift bottles and drift cards. During summer (December, January, February) there is normally a southward flowing current inshore on the west coast, and a northward flowing current offshore, while a westward drift from Cape Agulhas often rounds Cape Point. During winter (June, July, August) there is either a general southerly trend both inshore and offshore on the west coast, or the summer pattern may prevail, but the flow around Cape Point is consistently eastwards. Monthly charts of drift card movements for the Cape coastal area are given, and show the probable current flow patterns and their alternatives. The influence of these currents on the distribution of the larvae of three local marine species is discussed.

WEST COAST COASTAL CURRENTS PLANKTON ORGANISMS

111. Dye A H 1976. Studies on the ecology of estuarine meiofauna in South Africa. Department of Zoology, University of Port Elizabeth. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

Research into the ecology of estuarine meiofauna was initiated by the Zoology Department of the University of Port Elizabeth in April 1975. This initial phase of the work has been concerned with the effects of abiotic factors on the distribution and seasonal fluctuation of the meiofauna. Two stations on the Swartkops estuary were chosen for study and monthly measurements of animal density, temperature, oxygen and salinity as well as nitrogen and chlorophyll a were made.

Station A was 200m upstream from the mouth of the estuary on the South bank of the river and lay on the boundary between the mouth and lower reaches. Station B was 11km upstream from the mouth on the North bank and lay between the middle and upper reaches. Apart from a few patches of *Arthrocnemum* sp at high water station A was devoid of vegetation. Station B, however, had a dense bed of *Arthrocnemum* sp at high water and supported a large population of the sand prawn *Callianassa krausii*.

Work has shown that the substrate composition is the main factor governing the gross distribution of the meiofauna. The median particle size at station A is 185 um and this can be described

as find sand. The median particle size at station B is 135 um and is classed as very find sand. The percentage subsieves at A is 0,96% and at B is 2,75%. As a consequence the dry weight biomass of meiofauna at station A is 1,5g/m^2 as opposed to 0,26g /m^2 at station B.

Temperature was found to be the most important factor governing seasonal fluctuations in numbers. Statistical analyses of temperature vs numbers of meiofauna showed significant correlations for both stations.

Oxygen was found to correlate strongly with both seasonal fluctuations and vertical distribution.

Mean nitrogen values, expressed as percent protein, were low at both stations viz 1,0%. There appears to be no correlation between animal numbers and this parameter. Similarly, measurement of chlorophyll a showed no significant correlation with animal numbers. The concentrations found were 1,0mg/l at station A and 0,5mg/l at station B.

Although no detailed taxonomic work has been done on the meiofauna the community may be divided into groups on the basis of biomass dominance. Nematodes account for 83% of the total biomass at station A and 95% at station B. Harpacticoid copepods occur at station A (not at B) and, along with an insignificant number of polychaete and prawn larvae, account for the remainder. It was frequently found that at station B the nematodes accounted for 100% of the biomass.

More detailed studies, including community as well as individual respiration, are planned for the future. Emphasis will be placed on quantitative data so that the role of meiofauna may be described in terms of ecosystem energetics.

ESTUARIES ORGANISMS SOUTH COAST

112. Eagle G A, A H Fricke, P J Greenwood and M J Orren 1976. Chemical and bio-assay experiments in the detection of marine pollution in certain Cape areas. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976. 16pp.

An initial pollution study of a number of Cape beaches, two West Coast estuaries as well as some near shore areas has been made. Water and sediment samples have been collected and tested for various forms of pollution. Measurements include oxygen absorbed from alkaline permanganate, trace metals, oxygen, salinity, nutrients, pH, temperature and sediment particle size. Concomitant with this work, quantitative samples of macro- and meiofauna have been taken at the exact sites of the water and sediment collections. The biological material has been identified as far as possible. Figures for the relative abundance and biomass will be given. Base line levels for deep sea and

'unpolluted' beaches as reference will be presented and compared with those obtained at other sites. The results show considerable pollution at some of these.

Experiments testing the susceptibility of certain sea urchin larvae and limpits to marine pollution have been conducted with a view to producing sensitive fast field tests for evidence of such environmental degradation.

TRACE METALS WEST COAST MONITORING ORGANISMS ESTUARIES

113. Eagle G A and A H Fricke 1976. National Programme for Marine Pollution Monitoring - Cape Group. Report (January 1975 to December 1975). *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 42pp.

The report covers Impact Areas Surveys, Estuarine Surveys and Oceanic Transects. (1) Impact Area Surveys: Five sites (Salt River Mouth, Camps Bay, Dido Valley Beach, Zandvlei and Strandfontein) were investigated. At all areas samples of water and sediment, both from the surface and from 1 m below the surface, were taken at the half-tide mark for temperature, salinity, oxygen, nutrients, trace metals and OA. Samples for macrofaunal analysis were also taken at the exact sites of water and sediment collections. Results of bacteriological measurements, sediment analysis and trace metals analyses at Saldanha are also reported. (2) Estuarine Surveys: The Berg River Estuary was investigated. Chemical and biological measurements showed marked seasonal variation. (3) Oceanic Transects: During 1975 four cruises were carried out, sampling both the West and South Coast Transects. At all stations water samples for temperature, oxygen, salinity, nutrient and trace metals were collected, as well as tar balls and sediment samples where possible.

The report includes a 3 page appendix by Prof A C Brown on marine pollution studies undertaken by the Zoology Department, University of Cape Town. (CEC)

SOUTH COAST WEST COAST BACTERIA TRACE METALS OIL SEDIMENTS METHODS ORGANISMS LAGOONS MONITORING

114. Erasmus T 1975. St Croix Island. *Environment RSA* 2 (4), 1-2.

It is pointed out that St Croix island is the only important breeding site of Jackass penguins *Spheniscus demersus* along the whole East coast of Africa. Other birds are also there in abundance. Mans activities based on the island in the past includes whaling and the collection of penguin eggs and guano.

From data on the number of birds on the island and what they are expected to eat per day it is obvious that they play a very important role in the marine environment of Algoa Bay.

The possible effects of future developments on the island, especially the proposed ore-loading berth are not at present known. Research to establish basic biological data is being undertaken. (DAD)

SOUTH COAST BIRDS

115. Fahrbach D O E. Core samples from Walvis Bay. *Fishing Industry Research Institute. Annual report No 19,* 56.

No abstract available

FISH FACTORY EFFLUENTS

116. Fahrbach D O E. Digestion of fish material in sea water. *Fishing Industry Research Institute. Annual report No 19,* 56.

No abstract available

FISH FACTORY EFFLUENTS

117. Fahrbach D O E. Digestion of fish solids in sea water. *Fishing Industry Research Institute. Annual report No 18,* 63.

No abstract available
FISH FACTORY EFFLUENTS

118. Fahrbach D O E. Percolation of off-loading water into sand. *Fishing Industry Research Institute. Annual report No 18,* 63.

No abstract available

FISH FACTORY EFFLUENTS

119. Flemming B W 1976. Large scale sediment transport by the Mocambique/Agulhas current system along the east coast of Southern Africa. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

In January 1975 a 900km continuous side-scan sonar profile was run between 34°S (Port Elizabeth) and 38°S (Cape Vidal) on a more or less coincidental course. The sonograph records reveal extensive occurrences of large underwater dune fields indicative of near-bottom current velocities in excess of 50cm/sec. Individual dunes reach heights up to 8m and wavelengths over 100m. All occurrences were recorded on the outer shelf in water depths between 50 and 90 metre. Between East London and Port Edward where the cruise track was close inshore with waters shallower than 50m no large bedforms

were observed, but here too dunes can be expected on the outer shelf. In most cases sediment is transported in a southerly direction suggesting that a strong component of the Mocambique/ Agulhas Current system is geologically active on the outer shelf. Between the Mkomazi River and Durban a northerly bound dune field was observed which reflects the activity of a strong counter current reported in the literature.

Most dune fields display smaller superimposed bedforms, e g climbing megaripples, indicating the fluctuating nature of the flow system. In some places, e g off Port Edward, the seaward boundary of the dune fields are sharply defined exposing gravels conspicuously depleted of any sands. Here extremely high current velocities can be expected (over 1 m/sec). Very large dunes, over 10m high, have also geen observed off Beira (Mocambique) probably fed by the Zambezi River.

Whereas sediment transport on this scale is a common feature in all areas dominated by strong tidal currents, e g the English Channel, it had hitherto been uncertain whether ocean currents could generate sediment transport on a comparable scale. The morphologic structure of the continental margin of this area suggests that we are not dealing with a single continuous feature but rather with several independent units each with its own sediment sources and separate areas of final deposition. It is almost certain that terrigenous sediments are being fed 'en route' to the deep ocean basins via submarine canyons lining the continental margin, thus giving rise to an additional model of sediment dispersal on continental shelves and the provenance of sediments in deep sea fan deposits. A more complete study of the whole phenomenon is currently in progress.

EAST COAST SEDIMENTS

120. Foster R W, *et al.* Ultraviolet sterilisation of contaminated water. *Fishing Industry Research Institute. Annual report No 24,* 38.

No abstract available

FISH FACTORY EFFLUENTS

121. Fourie H O 1975. Preliminary report on the present trace element concentrations in Saldanha Bay and the Langebaan Lagoon. *Progress report to Marine Pollution Section of the National Programme for Environmental Sciences* (In Afrikaans). 17pp.

The use of accumulator organisms and the determination of trace element concentrations in the organisms and sea water are discussed. Preliminary analysis of the results indicate that Saldanha Bay and the Langebaan Lagoon are relatively unpolluted, and concentration levels compare favourably with existing data for the West Coast of South Africa. (CEC)

WEST COAST TRACE METALS MOLLUSCS

122. Fourie H O 1976. Metals in marine organisms from Saldanha Bay and Langebaan lagoon, prior to industrialisation. *South African Journal of Science*. In press. Also presented at *Symposium on Research in the Natural Sciences at Saldanha*, February 1976.

Heavy and transition metals are relatively toxic and are concentrated by marine animals from water or other organisms. These metals may enter the marine environment through industrial effluent, mining operations and aerial pollution. To establish existing background levels of metals in marine organisms and to monitor any possible future metal pollution by means of indicator species, monitoring points for the sampling of the organisms *C. gigas*, *C. margaritacea*, *Choromytilus meridionalis*, *Mactra glabrata*, *Haliotis midae*, *Pyura stolonifera*, *Ulva* sp. and *Jasus lalandii* were established. The chemical treatment of biological material for the analysis of metallic elements at very low concentrations, and their determination by atomic absorption spectrophotometry, are described.

Results indicate that the levels of metals in marine organisms from Saldanha Bay and Langebaan Lagoon, prior to harbour development and industrialisation, are consistent with an unpolluted environment. *C. gigas*, *C.margaritacea* and *Choromytilus meridionalis* proved to be most suitable for use as indicator species and accordingly will be used as such to monitor metal pollution during the development of the Bay.

MOLLUSCS TRACE METALS WEST COAST ESTUARIES MONITORING ORGANISMS

123. Fourie J M 1959. Recovery of blood and fish body solids from blood-water by a system of heat coagulation. *Food Industries of South Africa* 11 (11), 26-29.

A system for precipitating the bulk of organic material present in blood-water is described. It is concluded that the recovery of blood solids from blood-water should be of economic interest to the fishing industry. On the basis of the results obtained in these tests, it would appear that the average fish processing factory at Walvis Bay, handling a quantity of 40 000 tons of pilchards per annum, is allowing 200 tons of recoverable blood solids to run into the sea. (DAD)

FISH FACTORY EFFLUENTS PREVENTION AND COMBATING

124. Fromme G A W 1970. The movement of suspended river sediments along the Natal coast. *Collected Contributions of the Symposium on Oceanography in South Africa*, Durban. Paper E1: 1-16, 6 Figs.

The objective of this investigation carried out on a SANCOR grant during 1968-69 was to determine the distribution and deposition of river sediments in suspension (silt) in the sea. Since the

movement of sediments in the sea reflects the long term response to the hydrodynamic factors of waves and currents, the current system prevailing in a certain sea area can be investigated from the distribution of the sediments.

The Umgeni River near Durban and the sea area opposite its mouth was chosen for a reconnaissance survey on suspended solids discharged to sea by a river in spate. Water-silt samples have been collected in different water depths from the surf out to sea until reaching "blue water", and the amount of silt was analysed gravimetrically using a special accurate and rapid filtering device. At the same time bottom-sand samples were taken during the second part of this study for the determination of the littoral sand drift using "diagnostic minerals" carried by rivers coming from catchments of different petrographic composition.

It was found that the heavily discoloured flood waters from the river, spreading out seawards 1 to 2 km offshore and up to 5 km parallel to the shore (following the current systems), form a thin layer approximately 1 metre thick on the surface, whereas the deeper water was found to be relatively clear. Towards the bottom again higher silt concentrations were measured, similar to those at the surface. In a number of figures the dispersion and the deposition of suspended solids off the Umgeni River are shown. Exchanges in temperature and density between the warmer river and the cooler sea water are the initiators for these processes. Check samples with low concentrations obtained from the bottom during the dry season but during rough seas indicate that the high bottom concentrations as measured during the wet season are mainly a result of the deposition of river flood sediments, rather than of wave action.

SEDIMENTS EAST COAST

125. Georgala D L. Examination of harbour water for pathogens. *Fishing Industry Research Institute. Annual report No 11,* 12.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

126. Georgala D L. Bacteriology of harbour water. *Fishing Industry Research Institute. Annual report No 13,* 9.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

127. Georgala D L. Effect of sea water on the growth of fish bacteria. *Fishing Industry Research Institute. Annual report No 13,* 9.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

128. Gericke I H 1967. Measurements of alpha-radioactive elements in South African sea waters. *M Sc Thesis, University of Cape Town.*

170 samples of sea water from 7 different oceanographic regions in the vicinity of Southern Africa have been analysed for alpha radioactivity. Samples were freeze dried prior to alpha counting, and the relative thorium and non-thorium series activities were determined by the "thorium pairs" method.

The technique used measures total activities and not merely the activity due to isotopes in solution. For the truly "oceanic" regions non-thorium series activities obtained are in good agreement with the uranium series activities quoted in the published literature, while thorium series activity is not detectable. On the other hand, results from coastal regions indicate thorium series activity corresponding to a level of 10^{-5} to 10^{-6} gm Th-232/ℓ, i e two orders of magnitude above the published values. The non-thorium series activity in these regions corresponds to 2-4 times the oceanic level. The results from the various regions are discussed on an oceanographic basis. The high activities observed are considered due to

(i) the association of thorium isotopes with the particulate phase;
(ii) high productivity, upwelling and localized oceanographic effects on the west coast of Southern Africa.

In conclusion, preliminary experiments to investigate particulate matter in sea water, using dialysis and a large area ion chamber are reported briefly.

RADIOACTIVITY COASTAL CURRENTS

129. Gill A E and E H Schumann 1974. The generation of long shelf waves by the wind. *Journal of Physical Oceanography 4,* 83-90.

Currents [$O(0,1$ m sec^{-1})] and sea-level variations [$O(0,1$ m)] on the continental shelf can be produced when atmospheric disturbances pass by. Since the atmospheric systems have length scales large compared with the width of the shelf, a boundary-layer approximation can be made to the equations governing the local response to these forcing systems. The low-frequency response can be expressed as a sum of modes (continental shelf waves) and the amplitude of each mode is found to satisfy a first-order wave equation which can readily be solved. In a case where some details are worked out, the second mode's contribution to sea-level changes is only 25% of the first mode's and the third mode's contribution only 8%. Thus, given appropriate meteorological information, sea level changes can easily be calculated, and a prediction system is theoretically possible.

WAVES

130. Greenwood P J and A C Brown 1974. The effect of ammonium nitrate solutions on fertilization and development of the sea urchin *Parechinus angulosus*. *Zoologica Africana* 9, 205-209.

Eggs and sperm of *Parechinus* have been placed in sea water containing 1, 10 and 100 ppm ammonium nitrate and the percentage fertilization as well as the subsequent development of the embryos compared with controls. At 10 and 100 ppm there is a marked reduction in fertilization. Abnormal forms are common at 100 ppm and some 95% of the population fail to reach the gastrula stage.

AMMONIUM NITRATE ORGANISMS POLLUTION SOURCES

131. Grindley J R 1970. The role of fresh water in the conservation of South African estuaries. Republic of South Africa Water Year 1970. Convention: *Water for the Future*, 1-5.

Recent studies in South Africa have revealed the vital role played by fresh water in South African estuaries. Estuaries are that part of a river system where fresh water and sea water mix. Water entering an estuary is often thought of as running to waste, and its vital importance is frequently not considered. Estuaries are important parts of the environment because : (1) They are vital for many marine organisms which migrate into estuaries for part of their life cycles, (2) They are very productive areas and the only part of the marine environment that can be cultivated (3) They are the most sensitive part of the marine environment, most liable to be affected by mans activities, and (4) They are important areas for human recreation. Fresh water is necessary for the estuarine environment: (1) to maintain the salinity gradient, (2) for its flushing action, and (3) as a source of nutrients. Estuaries may be harmed by : (1) insufficient fresh water resulting in the development of hypersaline conditions, (2) Too much fresh water resulting in flood damage, (3) Polluted fresh water killing estuarine fauna and flora, and (4) Silt-laden fresh water depositing its silt load and smothering the estuarine environment. In future thinking the water needs of the environment must be considered as well as mans direct needs for water for agriculture and industry. Fresh water plays a vital role in estuaries and they are an important part of mans environment.

SEDIMENTS ESTUARIES

132. Grindley J R 1972a. Ecological challenges for designers of engineering works affecting estuaries. *ECOR Symposium on the Ocean's challenge to South African Engineers*, Stellenbosch. S71, 10 pp.

Ecologically one might speak of "The Engineers' challenge to the ocean". Engineering works are liable to cause ecological changes in the sea and particularly in estuaries. Estuaries are the most sensitive part of the marine environment most liable to be affected by the actions of man. There is a vital ecological inter-relationship between life in estuaries and in coastal waters. Various ecological hazards form a challenge

to engineers. Designers need to be aware of these dangers in order to avoid them effectively.

Deoxygenation in marina canals can be a problem but can be avoided by adequate tidal exchange. Reduced tidal exchange caused by bridge embankments is undesirable and avoidable by the use of additional spans. The design of dams in river catchments must make allowance for the fresh water requirements of estuaries to avoid hypersalinity problems. Allowance must be made for siltation problems following erosion in the catchment or the destruction of filtering marshes. Engineers must be aware of the widespread ecological harm which can follow the reclamation of tidal marshlands. The ecological implications of modified tidal exchange caused by the dredging of harbours must be considered. Thermal pollution may have exaggerated ecological effects in the limited waters of estuaries. Salt evaporation pans should be constructed away from estuaries and water pumped to them for evaporation. South African examples are illustrated by slides.

Environmental disturbances can be limited by environmental surveys (such as that of the Swartkops estuary now being carried out) before major development. In future, ecologists should be employed in all major planning in the same way that consulting engineers are.

SEDIMENTS ESTUARIES POLLUTION SOURCES

133. Grindley J R 1972b. Pollution of the sea. *South African Journal of Science 68*, 162-170.

While the sea once appeared to be an infinite medium, unaffected by human actions, there is much evidence today of various adverse effects of pollution of the sea. Marine pollution is considered here in the broad sense to include any unfavourable alteration of the marine environment as a result of the actions of man. It is stressed that the marine environment includes estuaries and lagoons. Types of pollution considered include oil pollution, industrial effluents, radio active wastes, explosives and poison gas, thermal pollution, sewage pollution, pesticides, siltation, hypersalinity, exotic species, engineering works, disturbance of natural balance, over-exploitation and litter and jetsam. Various measures to limit and control pollution of the sea are discussed.

POLLUTION SOURCES PREVENTION AND COMBATING

134. Grindley J R 1976. The plankton of the Swartkop Estuary. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

As part of the SANCOR programme on the plankton and productivity of South African estuaries the plankton of the Swartkops estuary has been sampled monthly for 8 years.

Sampling was carried out initially at a series of 13 stations through the estuary and later only at stations No. 4 and No. 10 which were found to be representative of the lower and upper reaches of the estuary respectively. Monitoring of environmental conditions has included observations of thermal stratification and thermal pollution, salinity fluctuations resulting from heavy rains and evaporation in dry periods, etc.

A relationship between zooplankton species diversity and salinity was evident with highest diversities near 35 o/oo. Highest biomasses of plankton were found in the upper reaches of the estuary where the plankton was dominated by the copepods *Pseudodiaptomus hessei, Acartiella natalensis, Oithona brevicornis* and the mysids *Gastrosaccus brevifissura* and *Mesopodopsis slabberi*. This longterm study has allowed observations of not only seasonal variations but also of changes in the plankton from year to year in relation to environmental fluctuations. Sub-sampling of *Pseudodiaptomus hessei* and *Gastrosaccus brevifissura* populations has allowed the documentation of breeding cycles. Work has been concentrated on the zooplankton but studies by collaborating colleagues have covered water chemistry, marine bacteria, nannoplankton, phytoplankton and some studies of the role of these various organisms in food chains in the estuary.

THERMAL POLLUTION SOUTH COAST PLANKTON ESTUARIES

135. Grindley J R and Erasmus T 1971. The problem of oil pollution of the sea. *Focus UPE 1* (1), 8-9, 15.

The effects of oil pollution on marine life from the *Wafra* incident are described. A mass mortality of the Pear Limpet was reported. It is pointed out that the use of detergent on beaches causes more damage to marine life than the oil. At Cape Agulhas straw was used as an absorbant. Spraying with dispersants was carried out at sea but was not allowed near the seashore to avoid harming the sea shore fauna. It is considered that there is a need for greater public awareness of the danger of pollution and for planning on a national and international scale. (DAD)

OIL MOLLUSCS ORGANISMS

136. Grindley J R and H Masson 1974. Red water off the Eastern Cape coast in December 1973. *Eastern Cape Naturalist 51*, 16-18.

Red water occurred off the Eastern Cape in December 1973. Prior to the bloom, calm, hot weather prevailed and sea temperatures reached unusually high levels. Several readings of 20°C and above were recorded by the Department of Transport. Strong winds earlier in the month caused wind-induced upwelling of cold nutrient water and blooms of diatoms co-existed with the red water. The

cause of the red water was found to be the dinoflagellate *Noctiluca miliaris*. Various other species of dinoflagellate were associated with the *Noctiluca* in small numbers and a variety of diatoms co-existed with it. Other occurrences of red water caused by *Prorocentrum micans*, *Cyclotrichium meunieri* and *Gonyaulax catenella* have occurred in the past on different parts of the South African coastline. (DAD)

RED TIDES PLANKTON SOUTH COAST ORGANISMS

137. Grindley J R and N Sapeika 1969. The cause of mussel poisoning in South Africa. *South African Medical Journal* 43, 275-279.

The occurrence of mussel poisoning in South Africa and the causes of mussel poisoning elsewhere are reviewed. Recent investigations of mussel poisoning on the west coast of South Africa are described. It is shown that the cause of mussel poisoning in this area is the planktonic dinoflagellate *Gonyaulax catenella*. This is confirmed by extraction of the toxin directly from the phytoplankton.

It is demonstrated that the toxicity of *Gonyaulax catenella* cells off the west coast of South Africa is similar to that determined off California (30 mouse units/mg., 45% Gonyaulax). The toxicity of black mussels at Elands Bay on 8 December 1968 was 42 000 mouse units/100 G (estimated lethal dose for man 36 500 mouse units). In 1967 mussels at Elands Bay remained toxic for 4 months. The nature and action of the toxin and the significance of mussel poisoning in South Africa are discussed.

RED TIDES PLANKTON WEST COAST ORGANISMS

138. Grindley J R and F J R Taylor 1964. Red water and marine fauna mortality near Cape Town. *Transactions of the Royal Society of South Africa* 37, 111-130.

Red water caused primarily by a very high concentration of the dinoflagellate *Gonyaulax polygramma* Stein, associated with another dinoflagellate *Prorocentrum micans* Ehrb., in smaller numbers appeared in False Bay near Cape Town during March and the early part of April 1962. This bloom resulted in a mass mortality of fish and invertebrates when the *Gonyaulax* died in large numbers. The cause of the fauna mortality could not be determined with certainty, but observations indicated that it was due primarily to the depletion of oxygen in the water by the decaying plankton, aggravated by the products of their putrefaction. It was shown that no toxins of the 'mussel poison' type were present, but there remains the possibility that a toxin of a type affecting only marine fauna was released. Details of the pattern of mortality are given and the hydrological and meteorological conditions associated with this phenomenon are described. It is suggested on the basis of published reports

that mussel poisoning and mass mortalities of marine fauna are distinct phenomena caused by different species of dinoflagellates.

RED TIDES ORGANISMS PLANKTON WEST COAST

139. Grundlingh M L 1974. A description of inshore current reversals off Richards Bay based on airborne radiation thermometry. *Deep-sea Research 21*, 47-55.

The infra-red radiation thermometry done over the coastal waters off Richards Bay is described. A model concerning the local current behaviour is derived from these results as well as measurements from a research vessel. It is postulated that the atmospheric forcing of the Agulhas Current at nodal points along the South African East Coast has direct bearing on the creation of inshore turbulence and reversals regularly experienced along this coast.

COASTAL CURRENTS EAST COAST

140. Gründlingh M L 1976. Agulhas current circulation concepts derived from Nimbus VI satellite-tracked buoys. *Proceedings of the First Inter-disciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

During 1975 the National Research Institute for Oceanology deployed 3 satellite-tracked spar buoys in the South Western Indian Ocean. The buoys were successfully tracked over thousands of kilometers, and their quasi-lagrangian drift tracks have provided a new insight into existing circulation concepts. Some of the main features of the results are :

a) Analoguous to the Gulf Streat "rings", evidence of cyclonic eddies have been found in the Mocambique Basin. It is argued that they originate south of 35°S from the Agulhas Return Current and have "life times" of the order of months. Indications exist to believe that they are eventually entrained into the zonal flow of the East Madagascar Current.

b) Large scale phenomena, resembling moving, anticyclonic gyres have been detected between the South African Coast and the Mocambique Ridge. This confirms opinions raised during the past decade that the meridional arrangement of anticyclonic eddies off the South African Coast is unstable.

c) The core speed of the Agulhas Current derived from the buoy tracks was 228 - 260 cm s^{-1}, during a season of generally weak flow.

d) Several mesoscale semi-permanent eddies as well as Rossby waves have emerged from the buoy drift track south of 35°S and in the Subtropical convergence.

EAST COAST COASTAL CURRENTS

141. Gunn B 1975. Dynamics of Cape Coastal Waters. Progress Report No. 1 (May 1975 to September 1975). *Report to the Marine Pollution Section of the National Committee for Environmental Sciences.* 5pp.

An outline of the progress in the study of the circulation in Matroos Bay is given. Preliminary results indicate that the circulation pattern is depth dependent. (CEC)

WEST COAST COASTAL CURRENTS

142. Gunn B W 1976. Dynamics of a Cape Coastal Embayment. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

Several experiments involving the measurement of current velocity and water temperature and salinity have been performed in Matroos Bay, approximately 30km north of Cape Town. The results show that the circulation within the Bay is often dominated by large rip currents, on occasions reaching more than a kilometre offshore. The position of the dominant rip was found to vary and possible reasons for the variation of position are being investigated.

Contours of surface (1 m) temperatures and salinities show patterns that sometimes conflict and sometimes agree with the current patterns. In general, however, the temperature patterns appear to be more consistent with the current patterns than do the salinity patterns. The temperature range recorded was typically about two degrees Calcius whilst the salinity range was typically .01%. In addition the salinity range was found to differ considerably between morning and afternoon samples on several occasions and for these reasons temperature was considered to be the more useful parameter for tracing the movement of water in the area.

WEST COAST COASTAL CURRENTS

143. Hanekom F and I G Bothma 1971. Oil tanker traffic and oil pollution on the Cape Sea Route. *Codicillus* 12 (1), 13-16. In Afrikaans.

After the closure of the Suez Canal, the number of ships visiting South African ports rose from 8 111 in 1967 to 12 400 in 1968. The transport of crude oil, as a percentage of total cargo carried, has increased from 50% in 1961 to 63% in 1969 despite a threefold increase in total carriage. The size of tankers is also increasing. The larger tankers would have to round the Cape whether the Suez Canal was open or not. In 1969, 7,6 oil tankers per day left the Persian Gulf to round the Cape compared to 8,3 tankers per day in 1970. It has been estimated that 490 000 tons of oil per day are carried round the Cape. Due to limited docking facilities not all tankers enter South African ports. These ships are serviced via helicopters

and small boats. The difficulties in navigating along the coast from the Kunene to St Helena Bay (north of Cape Town) are described. On the east coast ships going from west to east stay inshore (where a south to north counter current is located) whilst ships going in the opposite direction stay further offshore to obtain the maximum help from the Agulhas Current. Recent IMCO recommendations for a 'keep right' traffic lane system would in this case involve ignoring local oceanographic conditions.

It is suggested that IMCO should be contacted. South Africa has not signed the 1954 Oil Pollution Convention. If this was done ships would be prevented from deballasting within 160km of the coast. A committee should draw up a plan to regulate the movement of oil tankers. Ships would be required to move a certain distance from the coast and to keep between certain lanes. Ships carrying a full cargo should be forced to stay out of dangerous coastal waters especially in the region of Cape Agulhas which is a busy area. The plan should also consider local conditions. (DAD/WT)

OIL PREVENTION AND COMBATING

144. Hardy E 1945. Sewage disposal in tidal rivers doesn't increase mud-banks. *Municipal Affairs 10* (123), 5.

It has been alleged that sew
It has been alleged that sewage disposal in tidal rivers increases the formation of mud banks. It is mostly untreated sewage that would have to be tipped into rivers and estuaries as an emergency wartime measure. To assess the effect of this discharge information on the total volume of the estuary in gallons of sea water/day and the rate of flow of tidal current is needed. Sewage can increase the mud deposition of a river bed if in a certain condition and the quickest way to detect the type of bank, stable or unstable, is to take a census of its marine life - the worms, shell-fish and other small life of each bank. If it has plenty of these it is a stable bank; if only sparsely inhabited, it is unstable. It has been found that the concentration of organic matter in the mud of polluted estuaries is the same as that of the open sea mud-beds and those of unpolluted estuaries. It is concluded that sewage does not affect the rate of sedimentation of mud unless the natural suspension (from erosion of upper riverbanks) is in fine particles; the resistance of mud to erosion in a sewage-polluted estuary is the same as that in an unpolluted estuary and it is not affected by any previous sedimentation of mud by water containing sewage. (DAD)

DISPOSAL OF EFFLUENTS SEDIMENTS ESTUARIES

145. Harris T F W 1961. The nearshore circulation of water. *CSIR Symposium S2 Marine studies off the Natal Coast*, 18-30.

The factors affecting the circulation of water within about 1 mile of the coast are discussed. Circulation patterns observed during investigations off the Natal Coast are de-

scribed. Some observations on the inshore currents off the South Coast of Natal are recorded.

COASTAL CURRENTS EAST COAST

146. Harris T F W 1964a. A qualitative study of the nearshore circulation off a Natal beach with a submerged longshore sand bar. Document 11-025-0019. *MSc thesis, Department of Physics, University of Natal, Durban.*

No abstract available

EAST COAST COASTAL CURRENTS

147. Harris T F W 1964b. The use of dyes in nearshore circulation studies. In Oceanographic Research Group 1964, 25-26.

The use of sodium fluorescein dye and its photographical recording is described. It provides a cheap method of tracking the circulation of water near the shore (CEC)

EAST COAST COASTAL CURRENTS WAVES METHODS

148. Harris T F W 1964c. Notes on Natal Coastal Waters. *South African Journal of Science 60*, 237-241.

An analysis of coastal currents between Cape St Lucia and South Sand Bluff as measured by ships' drifts is reported.

COASTAL CURRENTS EAST COAST

149. Harris T F W 1967. Field and model studies of the nearshore circulation (characteristics and underlying mechanism of the two main types of circulation near the shore - a cellular system resulting from waves propagated nearly normally to the shore and an essentially alongshore flow system associated with oblique waves) Document 11-025-0020. *D Phil thesis, Department of Physics, University of Natal.*

No abstract available

COASTAL CURRENTS EAST COAST WAVES

150. Harris T F W and B Gunn 1975. Dynamics of Cape Coastal Waters. Progress Report No. 2. (September 1975 to November 1975). *Report to the Marine Pollution Section of the National Programme for Environmental Sciences.* 15pp.

The location and bathymetry of Matroos Bay, the field methods employed, the general circulation (offshore, onshore and north-west winds), the residence times and the wind and wave influences are discussed, as well as the requirements for a numerical model of the circulation within Matroos Bay. (CEC)

WEST COAST COASTAL CURRENTS WAVES

151. Harris T F W, J M Jordaan, W R McMurray, C J Verwey and F P Anderson 1962. Mixing in the Surf Zone. *International Conference on Water Pollution Research*, London, September 1962. Paper from Section 3, No. 34, 177-198.

The nearshore circulation along the Natal coast was investigated by the use of tracers released in the surf and their movements noted. It was found that a normal breaker approach resulted in divergent longshore currents whilst an oblique breaker approach resulted in unidirectional longshore currents. Variables e g breaker height, wind, bottom topography, which affect the breaker approach, are described.

It was found that the dispersion of a foreign liquid discharged into the surf at the water's edge takes place by eddy diffusion and translation. When breakers approach normally to the coast translation along the shore is minimal and there are periods when dispersion is only achieved by eddy diffusion. Under calm conditions when breaker approach is normal, the coefficients of eddy diffusion are not expected to be less than about 150 ft^2/min. When breaker approach is oblique, longshore translation is the dominant dispersing mechanism.

By considering normal and oblique breaker approaches it is possible to produce a graph which gives some notion of how the minimum dilution along the shore varies with distance from the source. The graph shows the least dilution which may be conservatively expected when a miscible foreign liquid is discharged into the surf at the rate of 1 gal/min. (DAD)

WAVES COASTAL CURRENTS EAST COAST DISPOSAL OF EFFLUENTS

152. Harris T F W and C C Stavropoulos 1967. Some experience with a radiation thermometer over the Agulhas current. *South African Journal of Science 63*, 132-136.

Using an infra-red radiation thermometer mounted in an aircraft flying at about 500 ft measurements were made of the radiation from the sea surface off the Natal Coast. These measurements showed spatial differences well within the sensitivity of the instrument. Sharp discontinuities (possibly associated with the seaward boundary of the warm Agulhas current) occurred at a distance of 50 - 60 miles out from Durban.

It is concluded that this technique may be used to obtain a quasisynoptic picture of the distribution of water masses of differing temperature over a wide area in this region of the sea and serve as a useful adjunct to hydrographic surveys by ship.

METHODS EAST COAST COASTAL CURRENTS.

153. Harris T F W and W G van Lienden 1964. Moored buoy system for measuring near surface currents. In Oceanographic Research Group 1964, 11-14.

A moored buoy system was developed to obtain a time series of current measurements near Durban. The accuracy and limitations of the system is described. (CEC)

EAST COAST COASTAL CURRENTS METHODS

154. Harvey R A. Beach Pollution. *Fishing Industry Research Institute. Annual report No 15*, 46.

No abstract available.

FISH FACTORY EFFLUENTS

155. Henry J L 1974. Pesticide residues in some South African marine fish species. *Proceedings of the Third International Congress of Pesticide Chemistry* (IUPAC), Helsinki, Finland, July 1974. Published in F Coulston and F Korte (Eds), *Environmental Quality and Safety*. Supplement Volume 3, Georg Thieme Publishers, Stuttgart, 1975, 196-198.

The total pelagic fish catch of the fishing industries of South Africa and South West Africa for 1972, the year which most of the samples referred to here were taken, was 0,96 million metric tons and the trawler fishery caught a further 114 thousand metric tons in 1971, the last year for which figures are available. Of this amount, some 60% was exported to world markets in the form of canned fish, fish oil, or fish meal.

References in the literature to pesticide residue concentrations in marine fish of the South Atlantic are sparse and there is only one previous report on samples taken from Southern African waters.

PESTICIDES FISH ORGANISMS

156. Henry J L 1975. The Cape Fur Seal, an indicator of marine pollution. *Progress report to Marine Pollution Section of the National Programme for Environmental Sciences*. 4pp.

The Cape Fur Seal *Arctocephalus pusillus* is being used as an indicator species in an investigation of organochlorine pesticide contamination of ocean waters around the coast of South Africa. The 'total DDT' and PCB levels found in South African Seals are similar to those found in Arctic Canada and Arctic Norway but very much lower than the levels in the North Sea, Baltic Sea and from the North American coastline. (CEC)

PESTICIDES SEALS MONITORING WEST COAST
SOUTH COAST

157. Henry J L 1976. Pesticide residues in the Cape Fur Seal. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976. 18pp.

Analyses of seal blubber from the south western Cape and South West Africa showed the presence of chlorinated hydrocarbons. The concentrations in the Cape samples were : pp DDE 2,33 ug/g, pp TDE 0,34 ug/g, pp DDT 1,44 ug/g and PCB (polychlorinated biphenyls) 3,08 ug/g. The concentrations in the South West Africa samples were lower, pp DDE 1,14 ug/g, pp TDE 0,09 ug/g, pp DDT 0,25 ug/g, PCB 0,44 ug/g. The reasons for this regional difference are discussed in terms of possible global and local sources of residue supply. It is concluded that the higher Cape concentrations are produced by a local source of residues.

PESTICIDES SEALS WEST COAST ORGANISMS

158. Heydorn A E F 1972. Notes on environmental monitoring applicable to South African and possibly Antarctic Waters, with emphasis on biological aspects. *South African Journal of Science 68*, 132-135.

Progress in marine research in South Africa is reviewed and the present need to evaluate man-induced environmental changes and their effect on the marine ecosystem is stressed. In order to obtain an understanding of the environment as it is now, to recognise changes which have already taken place as a result of man's activities and to forecast changes which may be expected in future, it is proposed that a monitoring programme should be set up in South Africa along the lines proposed in Monitoring Commission of SCOPE (Scientific Committee on Problems of the Environment). Possible monitoring sites are suggested.

MONITORING

159. Heydorn A E F 1974. Comments on the biological implications of the SBM, (Single Buoy Mooring) Durban, South Africa. In P J Smit, comp. *Barologia, Proceedings of the Third South African Symposium for Underwater Sciences*, Pretoria 2 - 4 December 1974, 12-23.

Since September 1970 the SBM (Single Buoy Mooring) system has been used for the discharge of oil from tankers off Durban. Spillage of oil occurred repeatedly during offloading and this has led to public criticism. Biological observations were undertaken to assess damage to marine life by the oil and the dispersants used to clean it up. In the light of these observations the merits of offloading oil via the SBM system or by conventional methods in Durban Harbour are discussed.

OIL EAST COAST ORGANISMS

160. Heydorn A E F (editor). 1976. The ecology of the Agulhas current region - an assessment of biological responses to environmental parameters in the South-West Indian Ocean. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

During the past five years, increasing emphasis in biological research in the Agulhas Current region and more specifically in Natal, has been placed on the response of marine organisms to various factors characterising their environment. This approach has become necessary in view of the increasing urgency with which biological opinion is sought on the effects of man's manipulation of the marine environment, e g the utilization of estuarine systems for harbour or marina development, the disposal of effluents in the sea, or the utilization of components of the foodweb for recreational or commercial fishing. The approach is also basic to an assessment of the inter-dependence of living organisms within communities.

In this paper an attempt is made to relate the response of those marine and estuarine organisms which have been subjected to detailed study to the climatic-, physical- and geological characteristics of the South African East Coast. The organisms used are calanoid copepods and chaetognaths (indicator communities), spiny lobsters, teleost marine- and estuarine fishes, sharks and marine turtles. Their occurrence, reproductive cycles and distribution of larvae and juveniles are related to environmental processes such as large-scale circulation patterns of the S W Indian Ocean, Agulhas Current structure, and inshore current reversals. The ecological implications of seasonal fluctuations in freshwater and sediment runoff into the sea are discussed as well as that of longshore movement of sediment, its abrasive action and the natural processes of covering and uncovering of reefs.

This multi-author paper is a first attempt to present in cohesive fashion the practical implications of research results of physical-, geological- and biological oceanographers.

EAST COAST SEDIMENTS COASTAL CURRENTS ORGANISMS MOLLUSCS FISH

161. Heynicke J J C 1976. Some aspects of water and effluent management in the iron and steel industry. *Proceedings of a Conference of the Institute for Water Pollution Control*, Durban, 7-11 June, 1976. 10 pp.

The water requirements of an iron and steel plant in South Africa are described. Modern methods for conserving water and preventing pollution are detailed. It is pointed out

that pollution problems generated by the coke oven and by products plant have still not been completely solved. A summary of what treatment is carried out on these waters is given. (DAD)

TRACE METALS POLLUTION SOURCES PREVENTION AND COMBATING

162. Jordaan J M 1961. Basic model studies of nearshore wave action. *CSIR Symposium S2 Marine studies off the Natal Coast*, 118-134.

The influence of wind on the conditions of the sea close to the shore is described and it is shown how storm waves, currents and wind drift may be studied by means of scale models. Wave approach and refraction, breaker angularity and energy dissipation yield theoretical and experimental bases for predicting the strength of longshore currents. Longshore and rip currents, combined with turbulence generated by breakers, causes sand transport leading to the formation of characteristic types of bars and shoals, which may also be studied readily by means of scale models. The distinctive underwater topography which develops, may give rise to complex circulation patterns, which, again, may best be studied in model scale.

WAVES COASTAL CURRENTS METHODS SEDIMENT

163. Jordaan J M 1964. The contribution of scale-model studies to the determination of mixing and dispersion characteristics of the surf zone. In Oceanographic Research Group, 1964, 27-38.

The nature of mixing and dispersing in the surf zone was assessed by scale model studies. Two-dimensional model studies were designed and a special statistical and analytical approach, which allowed the number of tests to be kept to a minimum, is outlined and illustrated.

Subsequent use of a three-dimensional model permitted a study of both horizontal and vertical circulation and included certain of the interdependent variables, such as longshore currents. The model also simulated rip currents and showed the effects of oblique breaker approach and features, such as headlands and sand-bars, on longshore currents and convection. (CEC)

EAST COAST COASTAL CURRENTS DISPOSAL OF EFFLUENTS
WAVES

164. King J 1974. Oil pollution and the beach-hopper, *Talorchestia*. Hons. project, in the Library of the Zoology Department, University of Cape Town.

No abstract available

OIL ORGANISMS WEST COAST

165. Kinmont A 1966. The sewage disposal problem in Durban. *Journal and Proceedings of the Institute for Sewage Purification*, 235-238.

A brief history of sewage disposal in Durban is given. Topographically, Durban divides naturally into three main drainage areas, with the Umgeni and Umbilo Rivers acting as the dividing lines. These are the Central, Southern and Northern drainage areas. The probable needs in terms of sewage disposal for each area is discussed with details of the proposed sewage systems to be installed. The possibility of having a centralised system for sewage and sludge treatment was found to have little merit. An economic appraisal of three possibilities: treatment works with crude sewage discharge, full treatment on land and partial treatment with a sea outfall, showed that the latter would be the most economical. (DAD)

DISPOSAL OF EFFLUENTS EAST COAST PREVENTION AND COMBATING

166. Knock G G and M K Rowan 1955. Sea water for fish canneries. *Fishing Industry Research Institute Report (M55)*.

No abstract available

FISH FACTORY EFFLUENTS

167. Lamprecht E. Treatment of contaminated sea water with disinfectants. *Fishing Industry Research Institute. Annual report No 17*, 52.

No abstract available

FISH FACTORY EFFLUENTS

168. Lamprecht E and M Elliott. Survival of *Escherichia coli*, and *Salmonella* in sea water. *Fishing Industry Research Institute. Annual report No 22*, 55.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

169. Lewis A M 1954. Water supply and effluent disposal problem of fish processing. factories. *Fishing Industry Recearch Institute Report (M43)*.

No abstract available

FISH FACTORY EFFLUENTS

170. Lewis A M and C W Ehmke. Chlorination of sea water. *Fishing Industry Research Institute. Annual report No 7*, 30.

No abstract available

FISH FACTORY EFFLUENTS

171. Livingstone D J 1969. An appraisal of sewage pollution along a section of the Natal Coast. *Journal of Hygiene 67*, 209-223.

A bacteriological survey was made on the distribution and occurrence of coliforms and pathogenic indicators of pollution within the surf-zone and near-shore waters along a section of the Natal Coast, prior to the use of submarine outfalls. The distance covered measured approximately 47 miles. The waters sampled and assessed ranged from 'clean' beaches to heavily polluted areas; a single short run off an Eastern Cape coastal region was included for comparative purposes. In all cases, the bacteriological picture was related to sanitary features on the shore. The method is based on *Escherichia coli I* counts, parasite units, staphylococci, salmonellae and salinity, and provides an objective approach to the assessment of any future changes in water quality consequent on development.

DISPOSAL OF EFFLUENTS BACTERIA EAST COAST STANDARDS ORGANISMS

172. Livingstone D J, J W Degoede and B A Warren-Hansen 1968. The distribution and occurrence of coliforms and pathogenic indicators of pollution within the surf zone and near-shore water along a section of the Natal Coast. CSIR Research Report 278.

A report is presented on the distribution and occurrence of coliforms and pathogenic indicators of pollution within the surf-zone and near-shore waters along a 47-mile section of the Natal Coast, prior to the use of submarine outfalls. The area surveyed is described, as are methods of collecting and assessing samples from a wide spectrum of waters ranging from 'clean' beaches to heavily polluted areas. A single short run off an Eastern Cape coastal region has been included for purposes of comparison as have the results of an examination of a typical Natal coastal river. In every case examined, the bacteriological picture has been found to be related to sanitary features on the shore. The method of determining the degree of pollution is based on *Escherichia coli* 1 levels, parasite units, staphylococci, salmonellae and salinity, and provides an objective approach to the assessment of any further changes in water quality consequent on development.

BACTERIA EAST COAST METHODS DISPOSAL OF EFFLUENTS ORGANISMS

173. MacKenzie C R and D J Livingstone 1968. Salmonellae in fish and food. *South African Medical Journal* 42, 999-1003.

The epidemiology of salmonellae particularly in freshwater and sea fish is examined, including the wastage of tilapia fish used in sewage stabilization ponds. The question of contamination of precooked meats is considered and a tentative salmonella standard is proposed, together with observations on the need for hygienic principles to be practised rigidly by manufacturers in the public and their own interests.

BACTERIA FISH STANDARDS ORGANISMS

174. Macleod D C 1972. Durban's submarine outfalls with special reference to measures taken to prevent pollution. *ECOR Symposium on the Ocean's Challenge to South African Engineers*, S71 Stellenbosch, South Africa. 22pp.

This paper records the bases on which two major sea outfalls were designed for the discharge into the sea off Durban's Bluff of settled sewage and industrial wastes so as not to have a deleterious effect upon the environment and marine life. Field studies, both to establish data on which to decide the feasibility of the proposals together with design criteria and to determine the performance of the completed pipelines, are described.

PREVENTION AND COMBATING DISPOSAL OF EFFLUENTS
MONITORING

175. Mallory J K. Quarterly progress reports 1-10 prepared by Department of Oceanography, University of Cape Town for ESCOM on the Oceanographic Investigations for the proposed ESCOM Nuclear Power Station at Duynefontein. (Available: Oceanography Department, University of Cape Town).

This is an on-going contractual research programme to determine the currents, temperatures, wind, waves, etc. in the close inshore waters in the vicinity of the site for the proposed nuclear power station commenced in 1969. Progress Reports are circulated to the Coordination Committee responsible for the site studies relative to the cooling water system.

COASTAL CURRENTS WEST COAST THERMAL POLLUTION

176. Mallory J K 1961. Bathymetric and hydrographic aspects of marine studies off the Natal coast. *CSIR Symposium S2 Marine studies off the Natal Coast*, 31-39.

The paper covers the topography of the sea bed in the area to the south east of South Africa, and of the continental shelf bordering the coast from Cape St Lucia to Cape Agulhas. The cause and effect of the currents flowing along the South African seaboard are discussed and after an explanation of

the prevailing winds in the area, the counter current and its causes and duration are theorized upon. Possible causes of upwelling in the west and south east coasts are discussed and the paper ends with remarks on a suitable research programme to establish whether the theories contained in it are in fact true or false.

COASTAL CURRENTS EAST COAST SOUTH COAST WEST COAST

177. Mallory J K 1972. Measurement of physical factors affecting disposal of effluents. *ECOR Symposium on the Ocean's Challenge to South African Engineers*, S71 Stellenbosch, South Africa. 8pp.

Effluents are of different characteristics and hence require different measurements and techniques in order to assess the effects of the disposal of any particular effluent into the marine environment.

Those which float will require measurements of the wind and waves and the resulting current motion, in order to determine the direction in which it will travel. Biological aspects of the effluent need to be taken into account and the diffusion and dispersal rate has to be calculated. Soluble wastes are soon stirred up in a turbulent sea surface and the depth to which such turbulence extends has to be determined.

The transportion of effluents on the bottom and of the sediments which may become polluted has to be investigated.

All these measurements need to be made over an extended period of time for seasonal comparisons and a statistical analysis thereof to be made.

The methods of obtaining the data are discussed.

DISPOSAL OF EFFLUENTS COASTAL CURRENTS METHODS

178. Mallory J K 1974. Abnormal waves on the South East Coast of South Africa. *Oceanography Department, University of Cape Town*, 18pp. plus appendices.

Abnormal waves have been experienced along the eastern seaboard of South Africa from Durnford Point to Port Elizabeth, mainly within 2 to 3 miles of the edge of the continental shelf. This region is described in terms of bathymetry, meteorology, and hydrography. Incidents involving freak waves are discussed. Briefly, it seems that south westerly winds generate large waves which, when they come up against the southward flowing current, are slowed down but their heights are increased as a result. The superimposing of two or more of these waves of different wave lengths creates an abnormally high wave up to 60 feet (18 m) high, with a correspondingly deep trough on the north east side of the wave. As this wave is travelling in the opposite direction to the fast flowing current, the northern face of the wave becomes extremely steep. Suggestions are made as to how these waves can be avoided by shipping. (DAD)

WAVES EAST COAST

179. Mallory J K 1976. The aquisition of physical oceanographic data in the nearshore waters on the open South Western Cape Coast. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

The paper opens with a description of the research site in an area north of Melkbos Strand on the S W Cape Coast exposed to the Westerly gales and rough seas where a Nuclear Power Station is soon to be constructed for ESCOM.

Then follows the purpose of the research work which was to obtain physical oceanographic data needed for the supply of information to the designers of the cooling water system for the power station, where it was estimated that 50 cubic metres per second would be required.

The problem was initially to determine the most advantageous method of drawing this large quantity of water into the cooling system. The ultimate decision to build a harbour to protect the intake ducts, lead to the additional requirements to investigate the movement of the waters in the surf zone and seasonal changes in beach levels. Wave directions were also of prime importance in the design of the harbour.

A description of the equipment required to obtain the data in the various parameters such as wind, temperature, currents, wave heights and direction, etc and the methods used to keep the recording instruments in operation, leads into a description of the sea tower, situated 1 200 metres from the high water mark, in which much of the equipment was installed, and the problems encountered in maintaining regular visits to the tower to obtain the records, especially in winter.

The paper will include an explanation of the work carried out by the research assistant domiciled at Melkbos who made regular daily visits to the site to record, amongst the many observations, such phenomena as rip currents and the amount of flotsam and jetsom that arrived on the beach in a specified area, and the maintenance of a radar equipment recording photographically the wave direction.

The paper will conclude with a list of highlights which were revealed during the course of the research programme and the many lessons that were learnt, some through the course of bitter experience.

WEST COAST COASTAL CURRENTS WAVES

180. Mallory J K and P Cook 1974. Nuclear power and the sea. *The South African Shipping News and Fishing Industry Review* 29 (8), 52, 53, 55, 57.

The survey work for siting the hot water effluent from the Koeberg nuclear power plant is described. The ambient water tem-

perature was found to fluctuate between 10°C to 15°C at a depth of 5m due mainly to wind direction changes, whilst currents measured in the near shore area were also found to be subject to meteorological conditions. In the summer months (November - March/April) when the wind is mainly from the south east the current flows to the north west parallel to the coast. If the wind changes (blows from the north west and west) the current reverses but has a weaker flow. Closer inshore in or near the surf zone the wave induced circulation results in a longshore current flowing to the north west when south of the proposed basin but is often to the south east on the northern side, the direction of the waves in this area being most frequently normal to the coastline. This means that the position in which the warmed water is discharged could be a critical decision to ensure that no prolonged recycling takes place. Biological surveys in the area are described. Results indicate that the sandy beach fauna in this area is not particularly rich. The fauna and flora on the rocky shores is much richer. The densities of commercially important rock lobster, perlemoen and red bait are reported. Aquarium tests on the effect of warm water on marine test animals have not demonstrated any noticeable adverse effects. It is noted that these experiments have not run long enough to establish effects on growth rate and reproductive capacity. It is thought likely that the overall effect of the heated effluent may be to create in the vicinity of the outlet pipe a small area in which the fauna and flora will resemble that found in Table Bay where the average summer temperature is a few degrees higher than in the Duynefontein area. (DAD)

RADIOACTIVITY COASTAL CURRENTS ORGANISMS THERMAL POLLUTION WEST COAST WAVES

181. Mallory J K, G H Stander and W D Oliff 1968. The pollution of the sea by oil. *Interim report of the Ad Hoc Committee for Oil Pollution to the Minister of Economic Affairs and tabled in the House of Assembly.* (Available: Oceanography Department, University of Cape Town).

From this report stemmed all subsequent anti-pollution measures.

OIL

182. Marine Effluent Research Unit, University of Cape Town 1970. Green Point outfall investigation. Final Report, in the library of the Zoology Department, University of Cape Town.

No abstract available

WEST COAST DISPOSAL OF EFFLUENTS

183. McClurg T P and W D Turner 1974. National Programme for Marine Pollution Monitoring - East Coast Coastal Reference Surveys. Progress Report No. 1. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 10 pp.

Beach transects were conducted in the vicinity of the Umbogintwini discharge and Fynnlands outfall (located between Durban Bay and Isipingo). Results of sediments, faunal, interstitial water samples and animal tissue mercury analyses are given and discussed. (CEC)

EAST COAST MONITORING SEDIMENTS TRACE METALS
ORGANISMS AMMONIUM NITRATE MOLLUSCS METHODS

184. McClurg T P, W D Turner, B D Gardner, A D Connell, R C Stanton, J E Carter and W Gertenbach 1974. National Programme for Marine Pollution Monitoring - East Coast Ocean Reference Transect. Progress Report No. 2. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*, 34pp.

The first sampling run of the East Coast Ocean Reference Transect (ECOR 1) was undertaken by the R V Meiring Naudé between the 11th and 13th March 1974 and the second sampling run (ECOR 2) on the 3rd and 4th June 1974. Methods, results and discussion of the following parameters are given : basic physical and chemical data, sediment chemistry, benthic fauna, pesticide residues, zooplankton, trace metals and alkali metals. (CEC)

EAST COAST TRACE METALS PESTICIDES SEDIMENTS
COASTAL CURRENTS METHODS PLANKTON ORGANISMS
MONITORING

185. McLachlan A 1976. Studies on marine meiofauna in Algoa Bay. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

A brief review will be given of the category of benthos known as meiofauna, emphasising work that has been done in the Northern Hemisphere as there are no published papers concerning ecological studies on meiofauna in Southern Africa or the Southern Hemisphere. An outline will be given of the work done on meiofauna in Algoa Bay and this will be followed by a detailed discussion of the meiofauna of two beaches.

The beaches studied were Kings Beach and Sundays River beach, which represented sheltered and exposed conditions respectively. The sheltered beach had finer sands, greater porosity and more available food, but, owing to the smaller sizes of the interstices, it had lower permeability and

oxygen levels in the interstitial water and shallower water tables than the exposed beach.

A rich and diverse meiofauna occured on both beaches, the highest numbers recorded being 2250/10cm^2. The intertidal distribution of the meiofauna on the sheltered beach was limited mainly by the amounts of available oxygen and numbers were highest near the high water mark. On the exposed beach meiofauna numbers were limited mainly by available food and were highest around the mid tide level. Nematodes dominated the meiofauna of the sheltered beach while crustaceans were more numerous on the exposed beach.

Seasonal variations were monitored and meiofauna ash-free dry biomasses were estimated and compared with those of the macrofauna. The meiofauna dominated the total biomass on the sheltered beach where their maximum biomass was approximately 4g/m^2. The macrofauna dominated the total biomass on the exposed beach, but on the basis of production estimates the meiofauna dominated both beaches.

The meiofauna at higher tide levels was found to undergo vertical migrations correlated to the alternate drying and wetting of the sand during the tidal cycle. Further, a community analysis was carried out based on the nematode and crustacean communities and the beaches were divided into three areas of similar meiofauna communities and diversities.

In conclusion it will be speculated on the ecological role of the meiofauna on sandy beaches with special reference to their trophic relationships.

SOUTH COAST ORGANISMS

186. McMurray W R 1964. Analysis of the longshore current system. In Oceanographic Research Group 1964, 51-59.

A mathematical expression to describe the mixing of effluent discharged into the longshore current was developed and evaluated in field tests. The work presented has been outlined in Harris *et al* 1962, which covers the full scope of the investigation of mixing in the surf zone. (CEC)

EAST COAST COASTAL CURRENTS DISPOSAL OF EFFLUENTS

187. Moldan A and Christie N D 1976. The effects of organic pollution caused by fish-factory effluent on the benthic macrofauna of Saldanha Bay. *Symposium on Research in the Natural Sciences at Saldanha*, February 1976. *Transactions of the Royal society of South Africa* (in press).

A survey was conducted adjacent to a pelagic fish canning factory in Saldanha Bay to determine the effects of effluent on the benthic macrofauna. Pairs of samples were taken using SCUBA diving techniques at each of five stations situated at increasing distances from the factory. The benthic macrofauna was analysed for species richness, density of individuals, length of selected species and ash-free biomass. The fauna nearest the factory was impoverished with several species having only small individuals, but with increasing distance from the factory, species richness, density of individuals and ash-free biomass improved. Computer analysis of the macrofauna from the five stations divides these into three distinct groups. Although conditions adversely affected some of the macrofauna at the five stations the situation has undoubtedly improved since June 1972. Newman and Pollock (1973) then noted a huge benthic mortality caused by very low sea water oxygen values as a result of large amounts of raw effluent being dumped in this area. The method of offloading was changed from a wet to a dry system since then, which causes less damage to the fauna in the receiving waters.

FISH FACTORY EFFLUENTS ORGANISMS WEST COAST ESTUARIES

188. Nachenius R J. Factory effluent clarification. *Fishing Industry Research Institute. Annual report No 19*, 56.

No abstract available

FISH FACTORY EFFLUENTS

189. Nachenius R J. Variations in nitrogen content of Walvis Bay harbour water. *Fishing Industry Research Institute. Annual report No 25*, 59.

No abstract available

FISH FACTORY EFFLUENTS

190. Nachenius R J 1972. Effluent clarification. *Fishing Industry Research Institute Report (M207).*

No abstract available

FISH FACTORY EFFLUENTS

191. Nachenius R J 1974. Effluent clarification in perspective. *Fishing Industry Research Institute Report (M218).*

No abstract available

FISH FACTORY EFFLUENTS

192. Nachenius R J 1975. Technology of fish processing water clarification. *Fishing Industry Research Institute Report (M228).*

No abstract available

FISH FACTORY EFFLUENTS

193. Nachenius R J and M H C Bester. Free and saline ammonia and albuminoid nitrogen contents of inshore waters at Walvis Bay and Saldanha Bay. *Fishing Industry Research Institute. Annual report No 26,* 61.

No abstract available.

FISH FACTORY EFFLUENTS

194. Nachenius R J and M H C Bester. Effluent clarification. *Fishing Industry Research Institute. Annual report No 27,* 64.

No abstract available

FISH FACTORY EFFLUENTS

195. Nachenius R J and M H C Bester. Effluent clarification. *Fishing Industry Research Institute. Annual report No 27,* 72.

No abstract available

FISH FACTORY EFFLUENTS

196. Nachenius R J and M H C Bester 1973. Treatment of fish factory effluent. *Fishing Industry Research Institute Report (M215).*

No abstract available

FISH FACTORY EFFLUENTS

197. Nachenius R J and G M Dreosti. Economy of oil recovery from offloading water. *Fishing Industry Research Institute. Annual report No 15,* 43.

No abstract available

FISH FACTORY EFFLUENTS

198. Nachenius R J and D O E Fahrbach. Clarification of sea water: factory tests. *Fishing Industry Research Institute. Annual report No 17,* 52.

No abstract available

FISH FACTORY EFFLUENTS

199. Nachenius R J and A N Rowan 1972. Standards for fish factory effluent. *Fishing Industry Research Institute Report (M219).* 4 pp.

No abstract available

FISH FACTORY EFFLUENTS STANDARDS

200. Nachenius R J *et al.* Treatment of South African fish factory effluent. *Fishing Industry Research Institute. Annual report No 22,* 47.

No abstract available

FISH FACTORY EFFLUENTS

201. Nachenius R J *et al.* Tentative recommendations for the treatment of sea water used by fish canneries and rock lobster factories. *Fishing Industry Research Institute. M206.*

No abstract available

FISH FACTORY EFFLUENTS

202. Natal Town and Regional Planning Commission 1969. The disposal of effluents into the sea off the Natal Coast. In W D Oliff (ed), *Natal Town and Regional Planning Commission Report 14,* 139pp.

This document on the disposal of waste into the sea concerns the coast of Natal, where urban and industrial development is giving rise to quantities of varied wastes and effluents. Although Natal has many rivers running into the sea, they cannot justifiably be used to absorb wastes and the sea is the better choice for this purpose. While the sea is capable of absorbing large quantities of waste, these must be introduced so that the environment is not materially polluted. Public health, and aesthetic, wild-life and recreational factors must all be considered.

Control of pollution is a statutory obligation and the government departments concerned have laid down standards for waste discharge. Waste should first be treated so that as many constituents as possible - especially water - can be reclaimed; only the remainder should be discharged into the sea. This can sometimes be deposited in the surf zone, or dumped at sea from barges, but it is usually run into the sea through long offshore pipelines. Whatever the means of disposal, the nature of the waste must be studied to determine its possible effects on the environment, and the local characteristics of that environment must also be considered. Wind, waves and curents may dilute and disperse the waste satisfactorily, or may deposit it back on shore or in fishing areas where it is not wanted.

When a marine disposal system is planned, pollution standards applicable at the shore must be determined and also the dilution factor likely to be attained for the amount of waste to be dispersed. This will necessitate surveys of sea-bottom topography, sea currents and wind, so that appropriate pipelines and diffusers can be designed. Details of mechanical and hydraulic design are given, and also practical recommendations for the construction, laying and operation of the system.

COASTAL CURRENTS DISPOSAL OF EFFLUENTS EAST COAST
PREVENTION AND COMBATING STANDARDS

203. Newman G G and D E Pollock 1973. Organic pollution of the marine environment by pelagic fish factories in the Western Cape. *South African Journal of Science 69,* 27-29.

Incidents of mass mortalities of rock lobster, (*Jasus lalandii*), and bivalves (*Mactra glabrata, Choromytilus meridionalis* and *Tellina* species) were reported for the Western Cape. The mortalities were

attributed to pollution from fish factories in the area. Via the wet offloading system considerable amounts of organic water enter the water (particularly from catches of anchovy which deteriorate rapidly). Bacterial decomposition of this organic material caused low oxygen levels and this was thought to have caused the mortalities. (DAD)

ORGANISMS MOLLUSCS FISH FACTORY EFFLUENTS WEST COAST

204. Norval E and L R P Butler 1974. Trace metals in man's environment and their determination by atomic absorption spectroscopy. *South African Medical Journal* 48, 2617-2626.

The role of trace metals in pollution and occupational diseases is discussed. The occurrence of these metals, their effects, and their detection by the method of atomic absorption spectroscopy are reviewed. A large number of references enables the reader to obtain a wide insight into the literature of this increasingly important field of medical science.

In Part I, three metals which are the chief sources of dangerous and worldwide environmental pollution are discussed with regard to their physiological significance and determination methods. The metals causing occupational diseases are discussed in Part II.

TRACE METALS

205. Notice to Mariners 1973a. South Africa - East Coast No 67. *Caution regarding freak waves* H.14/2: 1p.

It has been found that off the east coast between East London and Richards Bay, freak waves of 20 metres or more in height preceded by a very deep trough occasionally occur in the area on the seaward edge of the continental shelf. These waves can occur when an area of low pressure moving to the east-north-eastward produces a strong southwesterly wind blowing against the flow of the Agulhas Current. The crests of waves produced by this wind may coincide with the crests of waves emanating from storm centres further south to produce a freak wave. Mariners are warned that caution should be exercised when steaming on the seaward edge of the continental shelf against a strong south-westerly wind with a low barometer. (DAD)

EAST COAST WAVES PREVENTION AND COMBATING

206. Notice to Mariners 1973b. South Africa No 58. *Traffic separation schemes abolished* H. 5/2 (V): 1p.

Traffic separation schemes are abolished and new regulations for laden tankers will come into effect on 1st July 1973. (DAD)

PREVENTION AND COMBATING OIL

207. Notice to Mariners 1973c. South Africa No 57 (P). *Traffic separation schemes*. H.5/2 (V): 2pp.

All traffic separation schemes are abolished. Laden tankers carrying cargo oil in excess of one half percent of their deadweight tonnage should maintain a distance of not less than 12 miles from a line drawn between the following points on the South African coast. South Sand Bluff, Mbashe Point, Hood Point, Great Fish Point, Cape Recife, Seal Point, Cape Agulhas - Quoin Point, Cape Point, Slangkop Point. Tankers may approach closer than 12 miles to avoid the Alphard Banks. Between Slangkop and Cape Agulhas these vessels should navigate near the boundary of the southern limits of the summer load line zone. Laden tankers may proceed closer inshore to replenish stores but when doing so shall cross the main flow of traffic, so far as is practicable at right angles (DAD)

OIL PREVENTION AND COMBATING

208. Oceanographic Research Group 1964. Some techniques in coastal oceanography (being an outline of methods developed mainly in the course of ocean-outfall studies off the Natal coast). *CSIR Research Report 222*. 59 pp.

For abstracts see Anderson and Stavropoulos 1964; Coetzee 1964; Harris 1964; Harris and van Lienden 1964; Jordaan 1964; McMurray 1964; Oliff and Varney 1964; Stavropoulos 1964a, 1964b; Verwey and McMurray 1964.

EAST COAST DISPOSAL OF EFFLUENTS METHODS WAVES COASTAL CURRENTS RADIOACTIVITY

209. Oliff W D 1972. Priorities in studies of pollution in the coastal zone and open ocean along the East Coast of South Africa. *South African Journal of Science 68*, (5),127-129.

An outline of research findings in relation to the effluent discharge on the Natal coast is presented. Current systems were studied within 1 mile of the shore and estimates made of the frequency with which they reached the shore. For different lengths of pipeline expected effluent concentrations were estimated. General principles were established which could be used to determine for any given set of circumstances the depth and length of pipeline needed in order to prevent pollutant levels from exceeding prescribed levels. Criteria from biological and chemical surveys of beaches and submarine sediments were also established e g OA value >0,06 mg O_2/ℓ and a faunal count >300 organisms /m^2 are indicative either of organic pollution or of some similar trophic disturbance. It was noted that development around estuaries results in increased inflow of nutrients which accumulate and lead to eutrophication e g nitrates or phosphates from a sewage treatment plant built to service a marina. The

following priorities for future research are outlined: (1) as a first priority, surveys must be carried out of the present state and the extent of normal variabilities established. (2) Secondly, the wastes and pollutants to be monitored must be identified. Methods must be developed for their analysis and these must be intercalibrated internationally. (3) A toxic level for each pollutant for the most important organisms in the food chain must be established. Attention should be given to food chains both leading and not leading to man. (4) Long-term trends and changes must be monitored. (5) The findings of monitoring should be used for the effective control of pollution sources. Both local authorities and industries should be encouraged to recover and to treat their wastes. (6) The information derived from monitoring should be disseminated both locally to the authorities and polluters concerned and internationally to the global monitoring network. (DAD)

EAST COAST DISPOSAL OF EFFLUENTS COASTAL CURRENTS
STANDARDS MONITORING

210. Oliff W D 1975. Coastal areas as affected by marine pollution. Council for the Habitat, *Proceedings of Coastal Areas Conference*, Durban, 3 - 4 April 1975, 6pp.

The measurement of pollution can be achieved by the monitoring of certain parameters. Deviations from normal have been found to be a reliable index of pollution. These parameters are described as are the effects of pollutants and their possible sources. It is pointed out that the physical regime of the coastal area affects the actual impact of effluents and pollutants. A large, shallow estuary may have a shorter retention time than a deep one. In the coastal and nearshore zone the important factors are: the degree of exposure to waves and currents; the supply of sediment and runoff to the coast; the topography of the continental shelf and the adjacent coast; the tidal range and intensity of the current and the coastal climate. The circulation over the shelf is also important. In our area the inner shelf water has a pattern of currents running parallel to the shore and reversing direction between NE and SW every 2 - 5 days.

This system, supposedly of eddies, can allow the slow increase of waste concentration over a period of time before a change in the outer shelf system i e in the Agulhas current sweeps the whole body of inner water out to sea.

The prevention of pollution is discussed in terms of the identification of pollution sources and the treatment and adequate disposal of wastes. Structures, such as jetties, can interrupt the longshore transport of sand and can affect the processes of accretion and erosion, resulting in coastal changes which can in turn affect the disposal of wastes in the nearshore environment. (DAD)

MONITORING EAST COAST COASTAL CURRENTS SEDIMENTS
POLLUTION SOURCES DISPOSAL OF EFFLUENTS

211. Oliff W D 1976. The Sea and Pollution. *Proceedings of the First Inter-disciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976 10 pp.

Various types of pollution of the sea are briefly described in this address. Pollution of beaches with faecal material near urban areas is considered and the measurement of relevant parameters is discussed. Some consideration is given to practical standards of quality. Pollution with industrial wastes is also considered.

The dangers arising from human consumption of shell-fish in polluted waters is discussed. The particular vulnerability of estuaries to pollution is mentioned. Particular effects of pollution of concern to the public are effects on appearance, effects of toxic substances on sea life, effects of enrichment.

Pollution can be minimised with proper consideration of the waste, conditions in the sea and the physical realities of dilution processes.

Legal control of pollution is vested in the Water Act 1956, the Sea Fisheries Act of 1973 and the Sea-Shores Act of 1935. Monitoring responsibilities reside in the relevant statutory bodies. However, the CSIR established a National Programme for Environmental Sciences in 1972 which includes an Advisory Committee for Marine Pollution. This Committee attempts to correlate nationwide work on establishing present conditions along the shores and in the estuaries of the land, and to control the effects of pollution.

Such control presupposes knowledge of the toxicity of material and the levels which are safe. This requires laboratory investigations in many cases to establish acceptable levels for toxicants.

Finally, a brief resume of some interesting findings of the present survey is presented.

STANDARDS MONITORING PREVENTION AND COMBATING
ORGANISMS DISPOSAL OF EFFLUENTS POLLUTION SOURCES

212. Oliff W D, C D Berrisford, W D Turner, J A Ballard and D C McWilliam 1967a. The ecology and chemistry of sandy beaches and nearshore submarine sediments of Natal. Part 1: Pollution criteria for sandy beaches in Natal. *Water Research 1,* 115-129.

Measurements have been made of some chemical and faunal parameters on Natal beaches. Comparisons between polluted and unpolluted localities have yielded evidence of consistent

differences associated with enrichment or impoverishment of the environment resulting from pollution. Criteria are suggested for assessing the state of beaches.

EAST COAST STANDARDS DISPOSAL OF EFFLUENTS ORGANISMS

213. Oliff W D, C D Berrisford, W D Turner, J A Ballard and D C McWilliam 1967b. The ecology and chemistry of sandy beaches and nearshore submarine sediments of Natal. Part II: Pollution criteria for nearshore sediments of the Natal Coast. *Water Research 1*, 131-146.

Measurements have been made of some chemical and faunal parameters in nearshore submarine sediments off the Natal coast. Some variations depending on the type of sediment, the depth of water, and the season were detected. Comparisons between polluted and unpolluted areas showed that considerably increased levels of chemical parameters and high faunal densities were associated with organic pollution. The species *Capitella capitata* was specifically associated with organic pollution. Monitoring control levels are suggested which if exceeded, will indicate the existence of pollution with organic material in the area.

ORGANISMS EAST COAST STANDARDS DISPOSAL OF EFFLUENTS MONITORING

214. Oliff W D, B D Gardner, W D Turner and J B Sharp 1970. The chemistry of the interstitial water as a measure of conditions in a sandy beach. *Water Research 4*, 179-188.

Interstitial water in polluted and unpolluted beaches was analysed. It was found that : (1) The quantity of oxygen absorbed was correlated with the Kjeldahl nitrogen concentration in the sand. (2) The quantity of oxygen absorbed was correlated with the number of species of invertebrates in the sand. (3) The pH value of the water was correlated with the amount of dissolved oxygen, the salinity, the phosphorus content of the water and the particle size of the sand. It was inversely related to the Kjeldahl nitrogen content of the sand, and the number of invertebrates in the sand. (4) The number of animals were inversely related to the small variations of pH level and the phosphorus content of the interstitial water. (5) The number of species was positively correlated with the oxygen absorbed in the water and the number of animals, and inversely related to the ammonia and phosphorus content.

From examination of these data, it appears that the interrelationships of the parameters are such that knowledge of the dissolved oxygen concentration, the pH and NH_3 content, and the oxygen absorbed gives a good indication of conditions, and it seems that this information generally might suffice to monitor beaches.

Even at the most polluted point, though the average parameters were raised in level five to tenfold, the beach remained aerobic and

relatively pleasant and healthy. In this connection the local physical conditions on the beaches examined are important i e porosity of beach sand, slope, wave/tidal action. As a result of oscillation of the sea there is a constant flooding of the swash zone of the beaches by waves, and a relatively rapid circulation of water from the surface at the top of the beach to the deeper layers further down the shore. The beaches thus filter the sea water on their margin, (planktonic animals are found trapped in the interstitial water) and the beach sands appear to be acting as active self-purifying units.

It is necessary to remember that the beaches can be overlooked with organic material, with subsequent breakdown of aerobic processes, and the onset of anaerobic conditions with gas production and associated unaesthetic conditions; the supply of oxygen is the limiting condition. Poisons can also destroy the efficiency of the beach self-purifying system by killing the organisms in the sediment. The beach sediments in fact are a valuable self-purifying and self-regulating mechanism on the shores.

The ultimate quality criterion at a popular beach is likely to remain aesthetic acceptibility and considerations of public health. However, at places other than popular resorts it seems logical to relax such standards within reason, and allow the self-purifying power of the beaches and the sea to dissipate the load, particularly as this process can be controlled successfully by monitoring the parameters which have been considered. (DAD)

STANDARDS MONITORING ORGANISMS DISPOSAL OF EFFLUENTS

215. Oliff W D, D J Livingstone and V C Stone 1969. Factors determining dilution in the marine environment and affecting the return of effluent to shore. *Water Pollution Control 68*, 560-568.

It is stressed that the dilution of an effluent is dependent upon the volume of the receiving water and on the effectiveness of mixing. Criteria have been determined for establishing acceptable degrees of dilution for various beach uses. Given such criteria, it is possible to calculate whether a beach discharge or some particular length of submarine pipeline will provide sufficient dilution.

Experience in Natal has indicated that a parameter based on the sum of a number of important factors, namely the numbers of *E.coli I* organisms, the presence of *Salmonella typhi*, Salmonellae organisms, Shigellae, coagulase +, mannitol +, Staphylococci and parasitic ova, and salinity, can be a useful and reliable indication of conditions in the sea water, and may be used to arrive at a working standard.

To arrive at a provisional safety standard it is suggested that the water in question should be aesthetically pleasing, that the

salinity should be not less than 34 o/oo, and no Salmonellae should be recoverable from 250-ml samples. Gross pollution with sewage, indicated by say 10 000 presumptive coliform organisms (or about 2 000 *E. coli I* organisms) per 100 ml or more, with the presence of Salmonellae and parasite eggs in 250 ml of sea water, should be unacceptable. To achieve such levels, normal crude sewage needs to be diluted at least 1 000 times in sea water.

If it is accepted that crude sewage diluted 1 000 times is a maximum concentration level, then the level of chemical parameters is fixed and would be about PV 0,1 mg/1, BOD 0,5 mg/1, amm.N 0,05 mg/1, org.N. 0,02 mg/1 and SS 0,75 mg/1.

A tentative level of between 5 and 10 mg/1 BOD or PV is suggested as a reasonable upper limit for degradable organic matter in a bathing water, subject to the turbidity being less than 5 mg/1 silica scale and no noticeable colour being present.

In Natal, the general current system usually runs parallel to the shore and frequently reverses direction, wind-driven currents are most powerful at the surface and their velocity falls below the surface (water moves downwind, and to some degree to the left of the wind), wave action effects mass transport in the direction of propagation, and in the surf zone there is the mass transport of water onshore and a longshore littoral drift.

Tidal current do not seem to be important. Methods for measuring currents are described and the results of test results on dispersion discussed. (DAD)

MONITORING STANDARDS BACTERIA DISPOSAL OF EFFLUENTS
EAST COAST COASTAL CURRENTS ORGANISMS

216. Oliff W D and P A Varney 1964. Simple aerial photography in coastal oceanography. In Oceanographic Research Group 1964, 1-4.

Use was made of aerial photography during investigations into current regimes and dispersal patterns in the near-shore water off the Natal coast. The use, advantages and disadvantages of aerial photography is discussed. (CEC)

EAST COAST COASTAL CURRENTS WAVES METHODS

217. Orren M J 1965. The determination of trace metals in sea water. *M Sc thesis, University of Cape Town.*

In this thesis, some methods which have been used for the determination of traces of copper, iron and manganese were critically discussed. Special emphasis was laid on spectrophotometric procedures. Techniques were improved or modified where necessary. Sea water samples, collected in the South East Atlantic Ocean up to 600 miles offshore,

were analysed for copper, and further samples from a sea area within 100-150 miles of the coast were analysed for copper, iron and manganese. An attempt was also made to improve the sampling technique by the use of cation exchange resin.

Samples of sea water were collected by a special technique which minimised contamination of samples by traces of metals. The samples were then stored frozen in polythene containers until ready for analysis. On storage of sea water in polythene at room temperature, marked losses of trace metals occurred. The processes which might remove metals from solution were discussed. Special cleaning procedures were devised to remove all traces of metals from the apparatus used.

Copper in sea water samples was determined by complexing the cupric ions present with diethyldithiocarbanate ions. The complex was then extracted into xylene and determined spectrophotometrically.

Iron in sea water samples was first reduced to the divalent state and then complexed with bathophenanthroline. The complex was extracted into isoamyl alcohol and determined spectrophotometrically.

A method was devised for the determination of manganese in sea water samples. This involved coprecipitation of hydrated manganese dioxide with a carrier of magnesium hydroxide. The precipitate was taken up into sulphuric acid, and, after removal of halide ions, manganese ions were oxidized to permanganate ions, which were determined spectrophotometrically. A special procedure was developed in order to estimate the reagent blank.

The general factors controlling the concentration of trace metals in the ocean were discussed as were the most likely forms of the metals present in sea water. It was necessary to carry out a detailed analysis of the oceanographic conditions in the area studied in order to relate the distribution of copper to water masses and ocean currents. The seasonal variation of copper in coastal waters was discussed and was related to upwelling of deeper water to the surface layers. Samples taken from the surf zone showed low concentrations of copper, iron and manganese. The concentrations of iron and manganese increased after much rain, but copper concentrations remained fairly constant.

The concentration of iron in coastal water was fairly high, but decreased as the distance from the shore increased. The concentration of manganese was fairly constant in the few samples obtained.

Due to the absence of large rivers in the area, metal concentrations in the area studied were almost exclusively controlled by oceanographic factors such as currents and upwelling.

A procedure involving the sorption of traces of copper, iron and manganese on cation exchange resin was developed and investigated. This procedure also determined metals present in a particulate form. Experimental techniques were developed for analysis of particulate metals. Copper in sea water could be successfully determined with the ion exchange technique. Manganese was not sorbed strongly by the resin. Iron, present mainly as colloidal hydrated ferric oxide, was not successfully determined by the method.

TRACE METALS METHODS

218. Orren M J 1967. Trace elements (copper, iron and manganese) off the coast of South Africa. *Investigational Report of the Division of Sea Fisheries, South Africa* 59, 40pp.

This report discusses some methods used for the determination of traces of copper, iron and manganese in sea water. Special emphasis has been laid on spectrophotometric procedures. Sea water samples, collected in the South-East Atlantic Ocean up to 600 miles off shore, were analysed for copper, and other samples from a sea area within 100 - 150 miles of the coast were analysed for copper, iron and manganese. An attempt was also made to improve the sampling technique by using cation exchange resin.

TRACE METALS METHODS

219. Orren M J 1969. The abundance and distribution of some elements in the ocean. *PhD thesis, University of Cape Town.*

Simple, rapid atomic absorption methods have been developed for the determination of soluble Cu, Fe and Mn in sea water. Existing methods for the determination of K. Rb and Li were adapted and improved. Particulate Cu, Fe, Mn, Rb and Li were determined by modification of a standard wet-ashing technique after Millipore filtration and determined by atomic absorption. Organic complexed Cu, Fe and Mn were investigated and simple atomic absorption methods were developed for their determination. An attempt was made to identify the ligands responsible for complexing, and it appears that none of the commonly present organic constituents of sea water contributes markedly to the complexing.

Serious Zn contamination was found in samples collected at sea and this was traced to Zn present in the polythene bottles used to store samples. Efforts to remove Zn were unsuccessful.

Water samples were taken from a large area including the South Atlantic, South Indian and Southern Oceans to establish concentration levels, and a specially detailed survey was made of the upwelling areas along the west coast of South Africa from 20°S to Cape Point.

The data for K, Rb, Li, Cu, Fe and Mn established levels of these elements in the ocean areas mentioned, in which very few samples

had previously been collected. Values found agreed with generally accepted world average figures except that lower concentrations of K, Rb and Li were found in upwelling zones. This was attributed to biological transport of these elements, a feature believed to have been undetected previously, using evidence from analysis of plankton and the results of the detailed distribution of the alkalis in the upwelling areas. Apart from the above biological effects the Cu/Mn ratio in particular appeared to be stabilized at values of about 2 in upwelling water by biological uptake and regeneration.

Organically bound Cu was found to be widespread and was apparently a stable constituent in the waters studied, and did not appear to be taken up or excreted by plankton. Organically bound Fe was only detected in the extremely productive area off South West Africa, and it is considered that organic compounds from plankton may bind Fe. No organically bound Mn was found, and the distribution of organically bound metals is discussed.

Emphasis was placed on the link between water masses and their movements, determined by standard physical oceanographic techniques, and the element distribution established simultaneously. Soluble Cu, Fe and Mn levels were low in Agulhas Current water, and Fe and Mn were lower in the Indian Ocean area generally. K/Rb, K/Li and Li/Rb ratios did not vary significantly in the area.

The seasonal flow of the Agulhas Current was found to influence metal content off Port Elizabeth. Upwelling zones over the Walvis Ridge were associated with anomalous element distribution, and upwelling was demonstrated, using evidence from element distribution and BT data, to occur on the Vema seamount, a fact previously undetected.

K and Li were low in the Subantarctic Water, in contrast, moderate levels of Cu, Fe Mn and Rb were found. All the elements, except K and Rb, were found to be concentrated in the eddy zone north of the Subtropical Convergence, where sinking of Central Water occurs. The "Cape Canyon" a submarine canyon north of Cape Town, was found to be associated with upwelling, confirming suggestions of other workers. The river run-off did not appear to influence the concentration of elements in the coastal sea water, and even two miles from the largest river mouth little effect was noted in the flood period. Distribution was apparently completely controlled by sea water movements and biological uptake and transport.

A model of an upwelling system, proposed by Schutz and Turekian, was expanded to embrace the complex upwelling system found, and the process was found to be intermittent and to lead to various layers of regeneration. The element distribution is closely approximated by the expanded model and its features are discussed.

TRACE METALS METHODS COASTAL CURRENTS

220. Orren M J 1970a. Trace elements off the West Coast of South Africa. *Collected Contributions of the Symposium on Oceanography in South Africa*, CSIR, Durban: 13pp.

Atomic absorption methods were developed for the determination of copper, iron and manganese in sea water and applied in a detailed study of the upwelling areas off the South-West Cape coast. Water movements were deduced using standard oceanographic techniques. The observed trace element distribution correlated closely with water movements and could be approximated with a model based on biological transport and regeneration processes.

TRACE METALS WEST COAST COASTAL CURRENTS

221. Orren M J 1970b. The distribution of trace elements in upwelling areas off the South West Coast of Africa. *International Symposium on Hydrogeochemistry and Biogeochemistry*, Tokyo, Japan. Abstract only: 1 pp.

Simple, rapid atomic absorption techniques for the determination of particulate and soluble Cu, Fe, Mn, Li and Rb were developed and applied to many sea water samples collected at closely spaced depths inshore along the West Coast of Africa between 32°S and 34°S. A further less detailed survey was also made of the area between 20°S and 25°S. Simultaneous serial observations of temperature and salinity were made to establish a physical oceanographic background.

The detailed trace element distribution was complex and appeared to be related to upwelling of subsurface water and biological activity. An early model of an upwelling zone, due to Schutz and Turekian, was expanded to include the different layers of regeneration present and the apparent cycling of elements through biological processes. This expanded model closely approximates the observed distribution and will be discussed.

TRACE METALS WEST COAST COASTAL CURRENTS

222. Orren M J 1971a. The determination of copper, zinc, iron, manganese, potassium, lithium and rubidium in sea water by atomic absorption spectrophotometry. *Journal of the South African Chemical Institute* 24, 96-102.

Simple, rapid atomic absorption methods have been developed for the determination of both the soluble and insoluble forms of copper, zinc, iron, manganese, potassium, lithium and rubidium in sea water. The alkalis are determined directly, while solvent extraction pre-concentration steps are used for the other metals. Particulate matter was determined by dissolving the membrane filters used to filter sea water and determining the metals in the resulting solution.

TRACE METALS METHODS

223. Orren M J 1971b. The distribution of Cu, Fe, Mn, Li, Rb in the offshore areas surrounding South Africa. *Proceedings of the Joint Oceanographic Assembly, The Ocean World,* Tokyo, 187-189.

Soluble Cu, Fe, Mn, Li and Rb were analysed in seawater samples from an area within 1 200 miles radius of Cape Town. It appears that compared to the Atlantic ocean, the Agulhas current is markedly depleted in soluble Cu, Fe and Mn. Indian Ocean waters were apparently enriched in soluble Li and Rb compared to Atlantic Ocean water. The concentrations of soluble Cu, Fe and Mn, in Subantarctic water were not appreciably different from those in waters to the north, and soluble Li and Rb values were not exceptional. However, soluble Cu, Fe and Li were markedly concentrated (values of 8,9:6,7 and 201 ppb respectively) in the eddy zone just to the north of the Convergence. It appears that low Fe/Cu (soluble) ratios (less than 2) are largely confined to Indian Ocean waters and this may be a useful indicator of Indian Ocean water. Samples from the offshore Indian Ocean were analysed for organic and particulate metals. Organic Cu was present whilst in the particulate phase copper was uniformly low and occasionally not detected, but Fe and Mn were detected in all samples. The distribution reflects the greater tendency for Fe and Mn to remain in a particulate phase when compared to Cu. Particulate Li and Rb were not detected. Data from deep stations (600-3 500m) in the South Atlantic showed peaks of soluble and particulate Cu and Fe. The large near bottom increases occur in the presence of Antarctic Bottom Water, and the upper layers of maximum concentration of soluble metals lay just below the core of the Antarctic Intermediate water. Similar, but less definite features were observed in the 0-1 000m layers of the Agulhas current. (DAD)

TRACE METALS

224. Orren M J 1973. Trace elements off the Western and Southern coasts of South Africa. *South African National Oceanographic Symposium Abstracts,* Cape Town, August 1973, 30.

During January and July 1971, trace-element samples were collected from surface and deeper waters in the area between Duiker Point and Skipskop and up to 90 miles off shore. The samples were analysed for soluble Cu, Fe, Mn, Li, Rb and K, using atomic absorption methods. Simultaneously, samples were taken for temperature, salinity and dissolved oxygen. A comparison of these data with previous findings along the west coast north of Cape Town are presented.

TRACE METALS WEST COAST SOUTH COAST

225. Orren M J 1974. Marine Pollution Monitoring - Cape Group Report (November 1973 - June 1974). *Report to the Marine Pollution Section of the National Programme for Environmental Sciences.* 7pp.

Details are given of (a) the administration of the Cape Group of the National Marine Pollution Monitoring Programme, (b) participation in the IGOSS Pilot Project for reporting visual oil and other floating pollutants, (c) participation in IAEA and IAGC intercalibration analyses of water samples, (d) ocean reference cruises carried out during the period under review and (c) the distribution of Hg, Cd and Pb based on data from the June and July 1973 cruises. (CEC).

TRACE METALS SOUTH COAST WEST COAST COASTAL CURRENTS MONITORING BIRDS

226. Orren M J 1975. National Marine Pollution Monitoring Programme (Cape Group). *Environment RSA* 2 (4), 6-8.

The South African coastline is, as yet, in the main underdeveloped and marine pollution problems have arisen only in a few industrialised area. In an effort to minimise any adverse effects of pollution stemming from the rapidly developing growth points along the coast, as well as that from established industries a Marine Pollution Monitoring Programme has been established. The scope of this programme is briefly described with particular reference to the programme of the Cape Group. Some preliminary findings in relation to oil pollution, trace metals, bacteria and effects of ammonium nitrate are given. (DAD)

WEST COAST MONITORING OIL TRACE METALS BACTERIA AMMONIUM NITRATE

227. Pearce A F 1967. Offshore disposal of effluents via submarine outfalls. *CSIR Report Meg 601*. 34 pp.

This report forms part of a monograph on the marine disposal of effluents in Natal coastal waters. The monograph, which is a review of co-ordinated research carried out during the past few years by the National Institute for Water Research, the National Physical Research Laboratory and the National Mechanical Engineering Research Institute, under the sponsorship of the Natal Regional and Town Planning Commission, deals with a general discussion of the problems relating to the marine disposal of effluents, a description of oceanographic conditions on the Natal coast and the design of marine disposal systems.

This report concerns the estimation of dilution values for various outfall systems and the hydraulic design of the pipe and the diffuser. Formulae for the dilution and hydraulic calculations, as well as some original experimental results, are included in the report.

EAST COAST DISPOSAL OF EFFLUENTS COASTAL CURRENTS

228. Pearce A F 1968. Eddy diffusion processes in the sea. *CSIR NMERI Hydraulics Research Unit Report*. 61 pp.

The diffusion of patches of dye or effluent released as a "slug" into the sea has been extensively investigated, partly in an attempt to understand the mechanism of turbulent diffusion and partly to devise means for its practical application to the disposal of effluents. Based on various assumptions concerning mathematical models representing a diffusion process, a number of solutions to the fundamental diffusion equations have been derived. These describe the concentration distribution in a patch of effluent in terms of space, time, and a diffusion parameter which must be determined experimentally. In this report the most promising of the available series are reviewed and they are compared with experimental results, for which local measurements of the diffusion of dye patches are used, in order to provide a guide as to the formulae considered to be most applicable to the Natal coastal waters.

DISPOSAL OF EFFLUENTS EAST COAST COASTAL CURRENTS WAVES

229. Pearce A F 1974. Bibliography on Natal coastal currents up to 1973. *Unpublished NRIO Internal General Report IG 74/1*. 33pp.

The bibliography contains a list in chronological order of all available reports and publications relating to current measurements along the Natal coast up to the end of 1973. Brief "abstracts" have been prepared with a bias towards inshore currents and a system of keywords is used. In the appendix reports are listed alphabetically under authors. (DAD)

COASTAL CURRENTS EAST COAST

230. Pearce A F 1976a. Seasonal variations in the inshore currents along the east coast. *Unpublished NRIO Internal General Report SEA IR 7604*, 17 pp.

The inshore currents on the continental shelf of the east coast of the Republic are characterised by periodic reversals from southerly to northerly flow and back again at intervals of a few days. In order to determine whether any seasonal variation exists, the available data was examined to see if any clear seasonal pattern emerges. It appears that the counter current may occur most frequently in winter/spring, but the net drift is greatest in the northerly direction in spring/summer. However, the variations are neither pronounced nor consistent, and bearing in mind the scatter in the results for individual seasons, it is considered that there is no marked seasonal cycle, such as a strong counter current occurring only in the winter season. Also the data are not of sufficient quantity or quality to show up relatively small seasonal variations (if they exist) in the inshore current system. (DAD)

COASTAL CURRENTS EAST COAST

231. Pearce A F 1976b. The gross features of the east coast shelf circulation. *Unpublished NRIO Internal General Report SEA IR 7605*, 18 pp.

It has long been known that a sporadic counter current is often found flowing northwards along certain sections of the Natal coast. Previously it has been postulated that the countercurrent is driven by westerly winds over the Agulhas Bank area in winter, with some local effects due to topography, and its cool nature is due to the intrusion of South Atlantic Ocean water and upwelled water. To test this hypothesis two basic issues are examined: the longshore characteristics of the counter current (i e whether it is a pulsating flow driven primarily from the Agulhas Bank area) and whether there is a strong seasonal variation. The results show that the 'counter-current' is not a continuous flow along major portions of the east coast, but is largely regional in character. Eddy-like local circulations tend to occur in preferred regions of the coastline on a variety of scales. These eddies are not permanent and the mechanism of their generation is unknown although it is probably the interaction between atmospheric disturbances (pressure and/or wind), the Agulhas Current and coastal and bottom topography. There are no major seasonal variations in the counter-current systems. The apparent tongue of cool water penetrating northwards in winter is due more to the normal annual cycle of temperature than to wind-driven advection from the south. On this basis, it would appear that the seasonal migration of marine fauna (e g the sardines) is largely due to the favourable temperature range in winter rather than to direct advection occuring solely in that season. (DAD)

COASTAL CURRENTS EAST COAST

232. Pearce A F 1976c. The Surface Structure of the Agulhas Current off Durban. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

A series of 48 sections across the Agulhas Current out to 100 km off Durban has shown up the major surface features of the Current. The distributions of temperature, salinity and current velocity with distance offshore show that four regions may be defined:

a) inshore region - relatively cool, relatively low salinity, and with periodically reversing currents; the local weather has an important influence in this region.
b) western boundary of the Current - strong surface temperature gradient and strong horizontal shear; there is no consistent salinity change across this front.
c) core region - the highest temperatures and current speeds are found; salinity increases gradually with distance offshore.
d) outer boundary region - in this poorly-defined region, temperature and current speed decrease, while salinity con-

tinues increasing, with distance offshore.

The four regions are all subject to short-term (e g daily) variations, resulting in (or from!) changes in the shapes of the temperature, salinity and velocity profiles, lateral meandering of the Current, and longshore fluctuations.

The subsurface (down to 500m) velocity structure is closely related to that at the surface, but there are some significant variations in the subsurface temperature and salinity fields.

EAST COAST COASTAL CURRENTS

233. Pearce A and E Schumann 1976. Shelf dynamics project-background, motivation and proposed research programme. *Unpublished NRIO Internal General Report SEA IR 7601*, 12 pp.

The Shelf Dynamics Project involves a detailed study of the circulation and hydrography on the continental shelf, inshore of the Agulhas Current. This report summarises the development of oceanographic research by the CSIR along the Natal coast from 1960 to early 1975, with special reference to the inshore current system; provides a formal motivation for the new project, in terms of practical benefits; reaffirms the aims of our coastal studies on the basis of the present state of knowledge of the circulation patterns; proposes an overall research programme for the period 1975 to 1980. The emphasis on the Shelf Dynamics project is on physical oceanography, namely currents, temperature, salinity and sea level, as well as the important meteorological forcing mechanisms of atmospheric pressure and wind stress. Biological and chemical data will be used where necessary to assist in the interpretation of the circulation and hydrographic structure. (DAD)

COASTAL CURRENTS EAST COAST

234. Pienaar A G and R A Harvey. Flume water treatment. *Fishing Industry Research Institute. Annual report No 15*, 43.

No abstract available

FISH FACTORY EFFLUENTS

235. Prout E G 1969. The dispersal of oil slicks. *Transactions of the Royal Society of South Africa 38*, 399-403.

Emulsions (oil in water O/W and water in oil W/O) are described in terms of their chemical nature, the mechanism of the dispersion process and their stabilisation. If an O/W emulsion forms it will be readily miscible in sea water and disperse quite rapidly in the volume of the ocean. However, if a W/O emulsion

forms as a result of emulsification by various resinous and asphaltic materials which occur in crudes then the most pernicious type of emulsion is produced. If one considers the problem of dispersing an oil slick on water by the process of emulsification one is faced with two problems, namely, the mechanical disruption of the oil into droplets, and the absorption of an emulsifier. The first could be solved by wave and wind action and the second by the addition of a detergent or by the presence in the oil itself of suitable emulsifiers. Man's attempts at oil dispersal have taken two forms, namely, emulsification by spraying the oil with a detergent; and the use of solid precipitants. If the first of these is practised it is desirable to form an O/W emulsion which disperses easily and presents no problem. Thus, the emulsifier should be water soluble. This presents problems when one is spraying detergent *on to* the *oil* from above - - ideally the emulsifier should be added at the oil/water interface by pumping from below the oil surface. If an oil-soluble detergent is sprayed on to the oil, then the most undesirable form of emulsion will be produced. In conclusion, it appears that we are faced with two immediate problems: firstly, the production of an effective, non-poisonous emulsifier and, secondly, a satisfactory means of applying the emulsifier in order to form an O/W emulsion at the site of the oil spillage. (DAD)

OIL PREVENTION AND COMBATING METHODS

236. Rand R W 1952. Oil contamination - a sea bird menance. *Bokmakierie* 4, 63.

No abstract available

OIL ORGANISMS BIRDS

237. Rossouw J 1976. The dynamics of estuary mouths. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

Many of the estuaries along the South African coast are unstable, i e have a tendency to close periodically. The improvement of the stability of estuary mouths present a major challenge to coastal engineers. The dynamics of an estuary mouth, espeically with respect to sediment movements, is not well understood at present. This is especially true of small estuaries in areas with strong longshore sediment movements. In the paper a review is given of a few typical estuary dynamics problems and approaches that have been used to study the stability of estuary mouths. These include empirical relationships established from prototype observations, fixed bed and movable bed physical models and mathematical models. A short description of further

research required for a better understanding of estuary mouth dynamics and stability is also given.

ESTUARIES SEDIMENTS

238. Rowan A N. Viability of coliform organisms in sea water. *Fishing Industry Research Institute. Annual report No 7,* 29.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

239. Rowan A N and S J F M Aalderink. Purification of dock water. *Fishing Industry Research Institute. Annual report No 7,* 30.

No abstract available

FISH FACTORY EFFLUENTS

240. Rowan M K 1969. Oiling of marine birds in South Africa. *Proceedings of the International Conference on Oil Pollution,* 1968, Wykeham Press, Winchester.

No abstract available

OIL ORGANISMS BIRDS

241. Rowan M K and C E B Cooper. Sterilisation by ultraviolet light. *Fishing Industry Research Industry. Annual report No 8,* 20.

No abstract available

FISH FACTORY EFFLUENTS

242. Rowan M K and A D Dichmont. Survival of coliform organisms in sea water. *Fishing Industry Research Institute. Annual report No 8,* 19.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

243. Russell K S 1976. Monitoring of nearshore sediment movement during the construction of Richards Bay harbour. *Proceedings of the First Inter-disciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July 1976.

Since 1967, the coastal area at Richards Bay has been the subject of an intensive programme of field measurements in connection with the harbour construction.

The coastline consists mainly of sandy beaches with an average grain size of 350 micron, while local outcrops of mudstone occur on the beaches north of the estuary.

The comparison of regular beach and nearshore surveys from 1967 until 1973 indicate the 'long term' stability prior to the commencement of harbour breakwater construction.

Initially the southward movement of the estuary mouth was thought indicative of a net southbound littoral drift. However detailed theoretical studies based on wave refraction, gave a net northerly littoral drift of approximately ½ M m^3/year. The direction of the theoretical littoral drift was confirmed by fluorescent and radioactive tracer tests and later by the pattern of sand build up around the breaker during construction. The movement of the estuary mouth against the dominant longshore sand movement is thought to be due mainly to the normal meander effect of the tidal flow.

Regular surveys adjacent to the south breakwater during construction showed considerable accretion in the form of a sand 'tongue' along the constructed section of the breakwater. The growth and development of this 'tongue' necessitated close monitoring to avoid encroachment into the construction area.

This accretion was considered to be aggravated due to considerable spoil pumping of dredger trailings discharged onto the beach some 1,5 km south of the breakwater (20 M m^3 were discharged from October 1973 to July 1975).

A mineralogical analysis of samples showed the spoil material to have a high magnetite content and could consequently act as a natural tracer. Samples from the breakwater vacinity indicated that the spoil material did in fact flow northwards from the discharge area and deposited around the head of the south breakwater.

A sand trap was subsequently dredged by SAR and H to prevent accretion into the area in advance of breakwater construction.

EAST COAST ESTUARIES SEDIMENTS

244. S A B S 1974. Oil-spill dispersant for marine pollution. *SABS Bulletin* 4, 68-72.

The specifications for oil spill dispersants and the methods used in dealing with offshore oil slicks and oil on beaches are briefly described. (DAD)

OIL PREVENTION AND COMBATING

245. S A B S 1975. Standard specification for oil-spill dispersant (liquid-solvent type) (metric units) *Council of the South African Bureau of Standards, SABS 1025-1975,* 12pp.

This specification covers a liquid-solvent dispersant for use in dispersing crude and fuel oil floating on seawater in harbours and on high seas and for beach cleaning. The specification includes sections on : (a) requirements e g toxicity level (b) packing and marking (c) sampling and compliance with the specification (d) inspections and methods of test. (DAD)

STANDARDS OIL PREVENTION AND COMBATING

246. Sandler L. Electrolytic precipitation of proteins in effluent water. *Fishing Industry Research Institute. Annual report No 21,* 50.

No abstract available

FISH FACTORY EFFLUENTS

247. Sandler L. Distribution of aluminium in effluent clarification. *Fishing Industry Research Institute. Annual report No 21,* 54.

No abstract available

FISH FACTORY EFFLUENTS

248. Sandler L. Reduction of aluminium content of proteinaceous floc. *Fishing Industry Research Institute. Annual report No 21,* 54.

No abstract available

FISH FACTORY EFFLUENTS

249. Sandler L. Effect of lime and formalin on texture of floc. *Fishing Industry Research Institute. Annual report no 22,* 50.

No abstract available

FISH FACTORY EFFLUENTS

250. Sandler L. Chemical treatment of Walvis Bay effluent. *Fishing Industry Research Institute. Annual Report No 22,* 51.

No abstract available

FISH FACTORY EFFLUENTS WEST COAST

251. Sandler L. Centrifugal separation of floc in effluent. *Fishing Industry Research Institute. Annual report No 22,* 53.

No abstract available

FISH FACTORY EFFLUENTS

252. Sandler L. Effect of ethoxyquin on floc during drying. *Fishing Industry Research Institute. Annual report No 22*, 54.

No abstract available

FISH FACTORY EFFLUENTS

253. Schoonbee H J 1962. An account of the hydrobiology of the Umgeni estuary and Zeekoe river with special reference to pollution. *MSc thesis, Zoology Department University of Potchefstroom*, 83pp.

A detailed faunal, bacteriological and physicochemical investigation was made of the Umgeni river estuary (Durban) and of the Zeekoe (Piesang) river which enters the Umgeni river at the head of the estuary, both of which were badly polluted by sewage and industrial wastes. Sampling sites were selected to cover the major effluents as well as those sections of the rivers into which they discharged. The results showed that the Zeekoe river, although badly polluted and contaminated with bacteria of faecal origin by a village drain and effluents from a sugar mill factory at Mount Edgecombe, made a good recovery whilst flowing through a vlei before it joins the main river and did not contribute much to the pollution of the estuary. The heavy loads of faecal bacteria and thick deposits of fibrous material found in the estuary, could largely be traced back to a combined effluent from a board mill and steam laundry. In addition, numerous storm water drains and other smaller effluents from industries also contributed to the cumulative bacterial contamination and pollution of the Umgeni estuary.

The faunal associations found in the various habitats at the different sampling stations clearly depicted the state of the river water and the picture obtained thus closely agreed with the findings of the bacterial and chemical surveys.

EAST COAST ESTUARIES BACTERIA ORGANISMS
POLLUTION SOURCES

254 . Schoonbee H J 1963. Pollution studies in the Umgeni Basin (Natal). Part 1. The Lower Umgeni at Durban - a report on estuarine pollution. *CSIR National Institute for Water Research Natal Regional Unit Special Report* No W23, 42pp.

A detailed faunal, bacteriological and chemical investigation was made of the lower 3 - 4 miles of the Umgeni river during August - October 1960. Sampling sites were selected to cover the major effluents as well as that part of the estuary into which they discharged. The results showed that the Umgeni river was unpolluted at the head of the estuary. Extensive faecal bacterial contamination and thick deposits of fibrous matter

found in the estuary itself could be traced back to a combined effluent from a Board Mill factory and Steam Laundry. In addition, numerous storm water drains and other effluents also contributed to the bacterial contamination and pollution of the estuary.

EAST COAST BACTERIA POLLUTION SOURCES ORGANISMS ESTUARIES

255. Schroeder B W and R D Cherry 1962. Caesium-137 in the seas off the Cape of Good Hope. *Nature* 194 (4829), 669.

Caesium-137 content of water around Cape Town just prior to the 1961 nuclear tests was calculated to be 90 ± 47 uuc/kl. If this is compared with levels from USA and Japanese waters, the level of contamination in the ocean would appear to be lower in the southern than the northern hemisphere. (DAD)

RADIOACTIVITY WEST COAST

256. Schumann E H 1975. High waves in the Agulhas Current. *South African Shipping News and Fishing Industry Review* 30 (3), 25-27.

Regarding the abnormal waves encountered off the east coast, it is pointed out that the change in wave height that occurs when a wave group moves into a strong opposing current is quite spectacular. Waves of different periods are amplified to different extents, the height of a short period wave increasing proportionately more than the height of a wave with a longer period. Also as the height of the wave increases or the length decreases, so the steepness increases. The changes that can be expected in wave steepness in a varying current region and relative to a moving ship are described. It is considered that for ships travelling in a south-westerly direction down the east coast, it is not necessarily the best policy to try to find the peak of the Agulhas Current in order to gain a 'free' 2m/s or so. If south-westerly winds have generated large waves over the previous days, these will be amplified in the current to such an extent that the captain will have to slow the ship down by an amount greater than that gained from the current. Under the circumstances, it would probably have been better to have stayed out of the main current stream, from the point of view of speed, comfort and safety. (DAD)

WAVES EAST COAST

257. Serfontein J 1975. The influence of human activities on coastal areas: agriculture. Council for the Habitat, *Proceedings of Coastal Areas Conference*, Durban 3 - 4 April 1975, 6pp.

Pollution due to suspended soil sediment, pesticides, fertilisers and intensive feeding lots is discussed.

Ground erosion is still an important form of pollution in coastal areas. This is caused partly by bad agricultural practises. The measures taken against this has not had sufficiently positive results. Little research information on ground erosion in South Africa is available. Control measures on pesticides and other poisons has reduced possible pollution of rivers and therefore the coastal area to a large extent. The loss of phosphate fertilisers is another reason for having preventative measures taken in relation to land erosion. Steps must be taken to ensure that cattle feeding lots are correctly located and controlled to reduce possible pollution. An impending food shortage in the world exists. Losses of land and fertilisers through bad farming practises is something the Republic cannot afford. As our country can have an important role in producing food for the rest of Africa we cannot afford to destroy a resource, which contributes to our food stocks, by allowing it to form pollution. (DAD)

SEDIMENTS PESTICIDES

258. Shannon L V 1965. Radioactivity related to oceanography. *South African Shipping News and Fishing Industry Review* 20 (8), 97-99.

The alpha, beta and gamma emitters found in the marine environment are briefly described. It is noted that carbon 14 and HTO (a combination of tritium, hydrogen and oxygen) have increased notably in surface oceanic water, since the advent of nuclear testing. Fission products such as strontium 90 and cesium 137 are also produced by nuclear bombs or reactors. Typical values for strontium 90 range from 0,5 - 3c/litre while values for cesium 137 are slightly higher. Various radionuclides are accumulated by marine organisms though different species accumulate different nuclides. Radio-isotopes of Fe, Co, Mn and Zn account for most of the artifically produced activity in marine animals, practically none of the above are found in marine algae. The possible use of natural tracers e g carbon 14, oxygen 18, deuterium and tritium, in measuring physical processes in the sea is discussed. It is pointed out that the probable future increase in the peaceful uses of atomic energy will pose problems of disposal of nuclear fuel waste and other radioactive effluent. Plankton, fish and other marine organisms tend to accumulate certain radionuclides. Plankton is especially susceptible and therefore a sound background as to the radioactivity of plankton should be established. (DAD)

RADIOACTIVITY ORGANISMS PLANKTON

259. Shannon L V 1969. The alpha-activity of marine plankton. *Investigational Report of the Division of Sea Fisheries, South Africa* 68, 38pp.

Using the thick-source alpha-particle detection technique, 141 samples of marine plankton, collected mainly during 1965 and

1966, were analysed for total alpha-activity. The relative contrabution of the uranium and thorium series elements was determined by the "thorium pairs" method.

Possible disequilibria in the radioactive series are discussed.

Results indicated that most of the total alpha-activity in marine zooplankton and phytoplankton was due to the presence of a nuclide with a half-life of about 140 days, almost certainly unsupported polonium-210. Thorium series elements accounted for much of the remaining activity during 1966 (typically 2 pc/g dry plankton) but only a small part during 1965. The contribution of uranium series elements other than Po-210 during both 1965 and 1966 were *circa* 0,6 pc/g dry zooplankton and 1,8 pc/g dry phytoplankton.

The dependence of alpha-activity on plankton species and oceanographic conditions is discussed in the light of the results obtained. The mean total alpha-activity of different groups of species was approximately constant when expressed on a fresh (wet) plankton basis. Four samples of pelagic fish exhibited similar alpha-activities to those of the plankton.

RADIOACTIVITY PLANKTON FISH ORGANISMS

260. Shannon L V 1970. Studies of alpha-radioactivity in the marine environment *PhD thesis, University of Cape Town.*

This dissertation deals with the alpha-radioactivity in the marine environment around South Africa, and the published literature relating to alpha-emitting nuclides in sea water and in marine organisms is surveyed in Chapter 1.

As a first step in the investigation, the total alpha-activity of some 400 samples of marine life was determined using the thick-source alpha-particle detection technique. The relative contributions of the thorium series nuclides and "excess" unsupported polonium-210 were determined by using the "thorium pairs" technique and by studying the variation of the total alpha count-rate with time. This is considered in Chapter 2.

The second phase of the investigation was to investigate the alpha-spectrum of marine life. This was done for several plankton samples using a large capacity ion-chamber. As expected several disequilibria were found to exist and the findings are discussed in Chapter 3. Unsupported polonium-210 accounted for the major proportion of the total alpha-activity in several marine groups, while radium-226 and daughters accounted for most of the long-lived radioactivity. Thorium series elements were also present. Using the ion-chamber data together with total alpha-counting data, an estimate of the radium-226 content of plankton was made.

After the ion-chamber experiments more detailed investigations, involving chemical extraction of polonium-210 and lead-210 and of thorium-232 and thorium-228, were made.

Chapter 4 deals with the polonium measurements in sea water and in marine organisms. A method is outlined for the determination of lead-210 and polonium-210 in sea water by solvent extraction, followed by electrodeposition and alpha-counting. Data are given for the lead-210 and polonium-210 content of twenty nine samples collected at a depth of 20 m in the sea around the Cape of Good Hope during March 1969. The mean activities of lead-210 and polonium-210 in these sea water samples were 38 x 10^{-15} c/l and 20 x 10^{-15} c/l respectively. Real variations in the concentrations of these nuclides were found to exist, and these could in part be ascribed to different water masses and current systems. The levels of unsupported polonium-210 in marine organisms were determined by repeated total alpha-counting. In addition to these measurements, the lead-210 and polonium-210 contents of 13 zooplankton and 4 phytoplankton samples collected during March 1969 were determined by chemical extraction, electrodeposition and alpha-counting. The mean values for lead-210 and polonium-210 in these zooplankton samples were 31 pc/kg wet material and 380 pc/kg wet material respectively. A correlation between these nuclides in zooplankton was found to exist, the lead-210 activity being on the average one twelfth of the polonium-210 activity.

The contribution of the thorium series elements to the alpha-activity of marine life is dealt with in Chapter 5. A thorium extraction technique was used, and a disequilibrium between thorium-232 and thorium-228 was found to exist in plankton, the thorium-228/thorium 232 activity ratio being on the average about 15. The level of thorium-228 in marine organisms was typically about 20 x 10^{-18} g/g wet material.

Attempts were made to calculate the biogeochemical balance of several of the alpha-emitters in the marine environment. Using the data presented, and making certain stated assumptions, the removal times of these nuclides from the upper mixed layer were calculated. These times were found to be about 8 years for radium-226, thorium-228 and thorium-232, 5 years for lead-210 and 0,6 year for polonium-210.

Finally, the dependence of alpha-activity on species and oceanographic locality is discussed in Chapter 6. In the light of the results obtained it appears that polonium-210 and thorium-228 may prove valuable in tracing oceanographic processes occurring on a time scale of months to a few years. The main conclusions are summarized in Chapter 7.

This dissertation is presented in two volumes. All the main results and discussion are included in the first volume. The second volume is in the form of an appendix and contains details of the equipment used, tables of data, sample calculations and a description of the oceanographic environment.

RADIOACTIVITY PLANKTON ORGANISMS METHODS

261. Shannon L V 1971. Radioactivity in the marine environment of South Africa. *South African Shipping News and Fishing Industry Review* 26 (4), 58-59.

Alpha activity in sea water is mainly due to natural uranium and thorium series, which includes uranium-238, radium-226, polonium-210 and thorium-232 and -228. Research has shown that the natural fallout nuclide polonium-210 accounts for a large fraction of the gross alpha-radioactivity in marine organisms. Polonium-210 in the seas around South Africa was found to be one part in 10^{20} or 10^{21}. Polonium-210 is accumulated by marine organisms from sea water and calculations indicate that plankton remove polonium from the surface layer on a time scale of about 6 months. Also accumulated by plankton is radium-226. It is present in phytoplankton at a level of about 1×10^{-12} g/g dry material (west coast and oceanic regions) while plankton from the Agulhas current is 8 times higher than the average. Thorium 228 and daughters are also accumulated. Variation in thorium series actively follows a similar trend to total alpha-activity and the polonium-210 concentration. Most of the natural beta-activity in seawater is due to potassium-40, rubidium-87 and carbon-14. From plankton analysis it would seem that the gross beta activity is lower than gross alpha activity. Seasonal variation in temperature, salinity, total alpha activity, excess polonium-210 activity and thorium series activity at Cape Columbine is described. It is pointed out that marine organisms have a higher radioactivity than terrestrial forms of life. (DAD)

RADIOACTIVITY PLANKTON WEST COAST ORGANISMS

262. Shannon L V 1972a. Marine alpha-activity off southern Africa 1. Gross alpha-activity, radiation dose, alpha-spectrum and variations in alpha-activity of marine life. *Investigational Report of the Division of Sea Fisheries, South Africa* 98, 80pp.

The total alpha-activity of some 400 samples of marine life was determined using the thick-source alpha-particle detection technique.

Activities varied from 200 pc/kg wet material in the flesh of demersal fish to 15 000 pc/kg wet material in the digestive gland of rock lobsters, while the typical levels in plankton and pelagic fish ranged from 500 to 1 500 pc/kg wet material. The alpha-activity in marine life accounts for most of the natural radiation dose received by these organisms and places them high on the scale of natural radioactivity.

The relative contributions of the thorium-series nuclides and "excess" unsupported polonium-210 were established by using the "thorium pairs" technique and by studying the variation of the total alpha count-rate with time.

The alpha-spectrum of marine life was investigated for several plankton samples without prior chemical concentration, using a large-capacity ion chamber. As expected, several disequilibria were found. Unsupported polonium-210 accounted for the major proportion of the total alpha-activity in several marine groups, while radium-226 and daughters accounted for most of the long-lived radio-activity. Thorium-series elements were also present.

Finally, the alpha-activity of plankton was investigated on a taxonomic basis. Variations in the alpha-activity of zooplankton appeared to be related to the salinity of sea-water.

RADIOACTIVITY ORGANISMS FISH PLANKTON

263. Shannon L V 1972b. Marine alpha-radioactivity off southern Africa. 2. Thorium in marine life. *Investigational Report of the Division of Sea Fisheries, South Africa 99*, 20pp.

The thorium-228/thorium-232 activity ratio in plankton was determined by chemical extraction followed by semi-conductor alpha-spectroscopy to be about 15, i.e. similar to published ratios for sea-water.

The concentrations of the thorium series in 387 samples of marine life are presented. Thorium-228 levels in most marine groups were about 20×10^{-18} g/g wet material. Measured by the "alpha-pairs" technique the thorium series contributed 5-20% of the total alpha-activity of marine organisms.

Phyto- and zooplankton concentrate thorium from sea-water by factors of 2 000 and 800 respectively. The biological removal time for thorium from the upper 100 m mixed layer was calculated to be about eight years.

Highest values of thorium-228 were found in plankton from the Agulhas Current and in zooplankton from the Walvis Ridge region (no phytoplankton from the latter area was measured) whereas values were low in plankton from the Subtropical Convergence and the Benguela Current. The possible utility of thorium-228 as a natural oceanographic tracer is discussed.

RADIOACTIVITY ORGANISMS PLANKTON

264. Shannon L V 1973. Marine alpha-radioactivity off southern Africa. 3. Polonium-210 and Lead-210. *Investigational Report of the Division of Sea Fisheries, South Africa 100*, 34pp.

A method is outlined for the determination of lead-210 and polonium-210 in sea-water by solvent extraction followed by electrodeposition and alpha-counting. The mean activities of lead-210 and polonium-210 in sea-water samples collected at

a depth of 20 m in the sea around the Cape of Good Hope during March 1969, were 38 x 10^{-15} c/l and 20 x 10^{-15} c/l respectively. Variations in the concentrations of these nuclides could in part be ascribed to different water masses and current systems.

Unsupported polonium-210 in 387 samples of marine organisms, collected from 1967 to 1969 within 1 000 miles of Southern Africa was determined by repeated total alpha-counting. In addition, lead-210 and polonium-210 in 13 zooplankton, four phytoplankton and six pelagic fish samples collected during 1969 were determined by chemical extraction, electrodeposition and alpha-counting. The mean values for lead-210 and polonium-210 and polonium-210 in the zooplankton samples were 31 pc/kg wet material and 380 pc/kg wet material respectively. In zooplankton the lead-210 activity was on the average one-twelfth of the polonium-210 activity. The concentration of polonium-210 in marine life was found to increase along the food chain.

Polonium-210 in sea-water and plankton appears to be closely related to the distribution of salinity and the possible utility of polonium-210 as a natural oceanographic tracer is discussed.

RADIOACTIVITY METHODS ORGANISMS PLANKTON FISH

265. Shannon L V. 1975a. Preliminary discussion of some physical and chemical characteristics of the water in Saldanha Bay. (April 1974 to March 1975). *Report to Marine Pollution Section of the National Programme for Environmental Sciences*. 20 pp.

The physical (temperature, current speed) and chemical (Salinity, dissolved oxygen, pH, nutrients, chlorophyll, COD, OA) characteristics of Saldanha Bay/Langebaan lagoon are described. There does not appear to be a great deal of interchange taking place between the bay and the open sea through the mouth of the bay, but rather a 'slopping backwards and forwards' tidal motion. Three systems at present exist in Saldanha/Langebaan, viz, the Benguela current forming the western boundary, the Langebaan lagoon system and the Bay system. It is thought that the completion of the breakwater and jetty will change the circulation in the Bay and the three systems will become four. The changed circulation will probably influence temperature distribution and even without the discharge of any cooling water into the harbour area, the summer water temperature in the harbour will likely increase by a few degrees Celsuis. With the prevailing winds and currents it is likely that the beach near the residential area of Saldanha will be polluted from time to time once the harbour comes into operation. (DAD)

WEST COAST COASTAL CURRENTS ESTUARIES

266. Shannon L V 1975b. Pollution of the sea by fish factories. *Environment RSA* 2 (8), 6-8.

The role of the Sea Fisheries Branch in combating pollution of the sea by pelagic fish factories is described. It is concluded that water quality in the vicinity of such factories in the Republic has shown a dramatic improvement in 1974/75. This is attributed to the changeover from wet offloading to dry offloading (vacuum removal), improved housekeeping by the factories and a changed quota system which avoids overloading of processing plants. It is pointed out that pollution in Walvis Bay is serious and is unlikely to improve for a year at least because of costs involved. (DAD)

FISH FACTORY EFFLUENTS PREVENTION AND COMBATING

267. Shannon L V 1976. Report on activities of the Sea Fisheries Branch for the period April 1974 to December 1975. *Report to the Marine Pollution Section of the National programme for Environmental Sciences.* 3pp.

A brief review is given of the marine pollution activities of the Sea Fisheries Branch, covering the water quality in the vicinity of fishing harbours, the physical and chemical characteristics of the water of Saldanha Bay and Langebaan Lagoon, the circulation pattern in Saldanha Bay, trace metals in the Saldanha region and accumulator organisms (the Cape Fur Seal for pesticides and oysters for trace metals). (CEC)

WEST COAST TRACE METALS PESTICIDES FISH FACTORY EFFLUENTS COASTAL CURRENTS LAGOONS MONITORING MOLLUSCS SEALS

268. Shannon L V and R D Cherry 1967. Polonium-210 in marine plankton. *Nature* 216, 352-353.

Research was carried out to establish the general level of polonium-210 in marine plankton. Levels of unsupported polonium-210 showed a modal value of about 3 pc/g of dry plankton. From this a wet plankton concentration of 200 pc/kg was calculated. This is an order of magnitude greater than that reported for human soft tissues. Unsupported polonium-210 in pelagic fish was found to be in the range of 0,7-3,3 pc/g dry weight with a mean of 2,0 pc/g. This, calculated on a wet weight basis, gives a concentration of about three times the plankton figure. In addition levels of time dependant alpha-activity were also reported for plankton, showing a mean value of 2,3 pc/g of dry plankton. This was principally due to uranium, radium and daughters and in some cases thorium series. The contribution of unsupported polonium-210 to this mean is probably not more than 0,2 pc/g. It is concluded that the bulk of polonium-210 in the marine plankton is unsupported by its parent lead-210 and that the enrichment factor from seawater to plankton must be larger for polonium-210 than for lead-210.

Mean unsupported polonium-210 activity in zooplankton samples was 4,7 pc/g dry weight and in phytoplankton samples 2,8 pc/g dry weight. Plankton results indicate that there is a tendency for offshore samples to contain higher unsupported polonium-210 activity. A possible explanation could lie in the fact that much of the inshore surface water off the west coast of the Cape is upwelled water. Such water has, in general, less time in contact with the atmosphere than water further offshore; because the polonium-210 is presumably derived chiefly from atmospheric fallout a lower content in inshore waters seems reasonable.

The possible use of polonium-210 as a natural oceanographic tracer is suggested. (DAD)

PLANKTON RADIOACTIVITY ORGANISMS

269. Shannon L V and R D Cherry 1970a. Polonium-210 and lead-210 in the hydrosphere. *International Symposium on Hydrogeochemistry and Biogeochemistry,* Tokyo, September 1970. Abstract only : 1 pp.

Polonium-210 and lead-210 have been measured in sea water and marine plankton samples collected from the seas around the Cape of Good Hope. The mean levels found for polonium-210 in sea water and zooplankton are 20 x 10^{-3} pCi/l and 399 pCi/kg wet weight respectively. The figure quoted for sea water corresponds to the very low level of about 10 atoms/ml. For lead-210 the levels are at 38 x 10^{-3} pCi/l and 33 pCi/kg wet weight respectively. Evidence which suggests an association between the variation of the concentrations of these nuclides and the relevant oceanic water masses is discussed.

The polonium-210 to lead-210 activity ratio is found to increase steadily in the sequence rainwater - sea water - phytoplankton - zooplankton, the actual values for this ratio in this sequence being 0,1 - 0,5 - 3,1 - 12. Approximate removal times for polonium-210 and lead-210 from the upper mixed layer are estimated, on the basis of a simple model, to be 0,6 years and 5 years respectively. The fate of polonium-210 up the marine food chain is considered briefly, and evidence for a preferential uptake of polonium-210 into various marine "livers" is presented.

RADIOACTIVITY PLANKTON WEST COAST ORGANISMS

270. Shannon L V and R D Cherry 1970b. Natural radioactivity in the oceans around South Africa. *Collected Contributions of the Symposium on Oceanography in South Africa,* CSIR Durban, paper C1, 13pp.

Data are presented for the levels of natural radioactivity in marine organisms collected around South Africa. As alpha-activity accounts for most of the internal radiation dose in marine life, the main alpha-emitters viz. radium-226, polonium-210 and thorium-228 are considered in some detail. Analytical methods for determ-

ining polonium-210 and lead-210 in seawater and the thorium isotopic ratios in plankton are outlined. The biological removal times of polonium-210, lead-210 and radium-226 have been calculated and indicate that biological uptake is an important factor in the removal of radio-nuclides from the surface layer of the sea.

RADIOACTIVITY ORGANISMS METHODS PLANKTON

271. Shannon L V and R D Cherry 1971. Ra-226 in marine plankton. *Earth and Planetary Science Letters* 11, 339-343.

Data are given for radium-226 in marine phytoplankton collected in the surface waters around South Africa. Phytoplankton associated with the Agulhas Current System contain radium-226 at an average level of 7,7 x 10^{-12} g/g dry material, while the average concentration in phytoplankton from other regions is lower at about 1 x 10^{-12} g/g dry material. On the basis of a simple model requiring certain stated assumptions, a biological removal time of radium from the surface waters of the Agulhas Current of about one year is indicated. For the west coast and oceanic regions longer removal times (about eight years) result. These values may be atypically short, but it is nonetheless clear that biological uptake of radium-226 is a significant process and that Szabo's previously published estimate of the radium residence time in surface sea water is in need of drastic downward revision.

RADIOACTIVITY PLANKTON ORGANISMS

272. Shannon L V, R D Cherry and M J Orren 1970. Polonium-210 and lead-210 in the marine environment. *Geochimica et Cosmochimica Acta* 34, 701-711.

A method is outlined for the determination of lead-210 and polonium-210 in sea water by solvent extraction, followed by electrodeposition and alpha counting.

Data are given for the lead-210 and polonium-210 content of twenty nine samples collected at a depth of 20 m in the sea around the Cape of Good Hope during March 1969. The mean activities of lead-210 and polonium-210 in these sea water samples were 38 x 10^{-15} c/l and 20 x 10^{-15} c/l respectively. Real variations in the concentrations of these nuclides were found to exist, and these could in part be ascribed to different water masses and current systems.

The lead-210 and polonium-210 contents of eleven zooplankton and three phytoplankton samples collected during the same period were also determined. Mean values for lead-210 and polonium-210 in zooplankton were 33 pc/kg wet weight and 399 pc/kg wet weight respectively. A correlation between these nuclides in zooplankton was found to exist, the lead-210 activity being on the average one twelfth of the polonium-210 activity.

An attempt has been made to evaluate the biogeochemical balance of lead-210 and polonium-210 in the marine environment. Using the data presented, and making certain stated assumptions, the removal times of these nuclides from the upper mixed layer have been calculated. These times were found to be about 5 yr for lead-210 and 0,6 yr for polonium-210.

RADIOACTIVITY METHODS PLANKTON ORGANISMS WEST COAST

273. Shannon L V and M J Orren 1970. A rapid method for the determination of polonium-210 and lead-210 in sea water. *Analytica Chimica Acta* 52, 166-169.

Polonium-210 and lead-210 in the natural environment have been the subject of much attention in recent years. Radon-222 escapes from the surface of the land into the atmosphere, where it decays via short-lived daughters to lead-210 and its daughters. Data for polonium-210 and lead-210 in the atmosphere and rains have been given by several authors. Other authors have reported these nuclides in biological materials including foodstuffs, tobacco, blood, human and animal tissues and marine life.

Little work has been done on either polonium-210 or lead-210 in sea water. Lead-210 was first detected in sea water by Rama *et al* and subsequently these findings were considered in more detail by Goldberg. These observations were made on a small number of large sea water samples collected in the Eastern Pacific and the method employed involved coprecipitation of the lead followed by anion exchange and β -counting. The lead-210 content ranged from about 0,10 disintegrations min^{-1} l^{-1} in the upper water layers to 0,28 disintegrations min^{-1} l^{-1} at a depth of 2 000m. No values for the polonium-210 level in sea water seem to have appeared in scientific journals, although some data are given in two institutional reports. Folsom used iron (III) hydroxide as a scavenger on large sea water samples followed by α-counting and reported a mean polonium-210 value of 0,037 pCi l^{-1} (or 0,08 disintegrations min^{-1} l^{-1}) for samples collected from Scripps Pier.

Flynn found that polonium is strongly absorbed on to glass and, as it was evident from theoretical considerations that the polonium-210 content of sea water would be very small (i.e. at a level of 1 part in 10^{20} or 10^{21}), a cautious sampling and storage procedure was adopted.

METHODS RADIOACTIVITY

274. Shannon L V and G H Stander 1976. The physical and chemical characteristics of the water in Saldanha Bay. *Symposium on Research in the Natural Sciences at Saldanha, February 1976. Transactions of the Royal Society of South Africa.* (in press).

In 1974 the Sea Fisheries Branch commenced a detailed survey of the physical and chemical characteristics of the water in

Saldanha Bay and Langebaan Lagoon in order to establish base-line conditions in the region prior to the development of the Bay as a major port and industrial centre.

The thermohaline characteristics of the water resemble those of the Benguela current, although in summer surface heating and evaporation tend to raise the temperature and salinity of the system somewhat. This is most marked in the Langebaan Lagoon where surface temperatures and salinities in excess of 24°C and 37°/oo have been recorded during the latter part of summer. A variety of chemical parameters have been measured. These include a number of heavy and transition elements, dissolved oxygen, nitrate/nitrite, Kjeldahl nitrogen, inorganic phosphorous, reactive silica, pH, chlorophylls, chemical oxygen demand and oxygen absorbed. Data on some of these are tabulated, and indicate that the Bay is at present relatively unpolluted. Prior to 1974 organic pollution from the fish factories in Hoedjies Bay was serious, but the situation has shown a marked improvement since the installation of the dry fish off-loading systems.

The circulation pattern in Saldanha Bay is complex. The Bay and Lagoon are tidal and currents in the upper 5m are highly dependent on wind speed and direction. Surface currents in the region have a magnitude typically in the range 10-20cm/sec. Currents in the mouth of the Bay are tidal and are not appreciably influenced by wind. Tidal currents of up to 1m/sec have been recorded at the entrance to Langebaan Lagoon. The construction of the jetty and breakwater are altering the circulation pattern.

The physical and chemical data indicate the existence of three systems viz. Bay System, Lagoon System and Benguela System. The interchange between these systems is small and on the basis of a simple model the removal time of pollutants from the Bay has been calculated as 20 days. The available data indicates that the discharge of noxious and toxic effluents into the Bay should be discouraged. The beach near the residential area of Saldanha Bay and the Donkergat Peninsula will probably be polluted on occasions once the harbour comes into operation, and it is not impossible that the Langebaan Lagoon will also become polluted.

COASTAL CURRENTS WEST COAST ESTUARIES LAGOONS

275. Shillington F A 1976. Surface waves near Cape Town : Measurement and statistics. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July 1976.

Surface ocean gravity waves have been recorded near Melkbosstrand with a Wemelsfelder float type wave recorder, on a sea tower situated in water 13 m deep and one kilometre off shore. The half-hour records, taken twice daily between July 1972 and August 1974 have been analysed for maximum

wave height, upper one-tenth wave height and zero crossing periods. This data is then presented in the format suggested by Draper (1966). Measurements have been made from the wave records to check the value of statistical ratios of Longuet-Higgins (1952). Ratios of maximum wave height to root mean square height are lower than the theoretical values and reasons for this are discussed. Ratios of maximum height to average upper one-tenth wave height and average upper one-third wave height agree closely with the theoretical values.

WEST COAST WAVES

276. Simmonds C K 1968. Analysis of figures from the report by Aminodan on effluent clarification at Walvis Bay. *Fishing Industry Research Institute Report (M175).*

No abstract available

FISH FACTORY EFFLUENTS

277. Simmonds C K. Harbour pollution by factory effluents. *Fishing Industry Research Institute. Annual report no 18,* 62.

No abstract available

FISH FACTORY EFFLUENTS

278. Simmonds C K. Factors influencing precipitation of protein from effluent by acidification. *Fishing Industry Research Institute. Annual report No 21,* 52.

No abstract available

FISH FACTORY EFFLUENTS

279. Simmonds C K and G de V Fowler. Laboratory tests with Walvis Bay effluent. *Fishing Industry Research Institute. Annual report No 21,* 46.

No abstract available

FISH FACTORY EFFLUENTS

280. Simmonds C K and J de A Rodriques. Recirculation of flume water. *Fishing Industry Research Institute. Annual report No 25,* 49.

No abstract available

FISH FACTORY EFFLUENTS

281. Simmonds C K *et al.* Microbiological digestion of effluent. *Fishing Industry Research Institute. Annual report No 27,* 72.

No abstract available

FISH FACTORY EFFLUENTS BACTERIA

282. Spark A A. Purification of sea water at Walvis Bay canneries. *Fishing Industry Research Institute. Annual Report No. 25,* 52.

No abstract available

FISH FACTORY EFFLUENTS

283. Spark A A. Disinfection of sea water by ultraviolet irradiation. *Fishing Industry Research Institute. Annual report No. 25,* 55.

No abstract available

FISH FACTORY EFFLUENTS

284. Spark A A. Effect of iron on UV disinfection of sea water. *Fishing Industry Research Institute. Annual report no 25,* 59.

No abstract available

FISH FACTORY EFFLUENTS

285. Spark A A *et al.* Ultraviolet reflectance of aluminium paint. *Fishing Industry Research Institute. Annual report no 27,* 76.

No abstract available

FISH FACTORY EFFLUENTS

286. Stander G H 1968a. The "Esso Essen" incident. *South African Shipping News and Fishing Industry Review* August 1968, 41, 43, 45.

Methods used to deal with the oil spill from the "Esso Essen" incident which occurred in the Cape area are described. Air reconnaisance was used to chart the position of the oil slicks. Light aircraft were used to spray dispersant from the beach to 3 miles offshore. On the beaches sand hoppers *(Talorchestia sp)* were killed in large numbers but there were no signs of a mass mortality of other marine organisms. Isopods, limpets, periwinkles and anemones were alive though covered in oil. It is possible that appreciable mortality of periwinkles, limpets and diving birds did occur in certain localities. Rock lobsters, abalone and seaweeds collected in an underwater survey in the Olifantsbos area appeared normal. Phytoplankton sampled appeared normal. Zooplankton showed fair to high mortality rates but this was attributed to the influence on cold water species of warm water entering the area. The results of toxicity tests using Corexit on rock fish, periwinkles, whelks, limpets, starfish, abalone and rock lobster are described. It is concluded that there is no evidence to suggest that the stranding of oil had a major impact on marine life. (DAD)

OIL ORGANISMS PLANKTON PREVENTION AND COMBATING MOLLUSCS WEST COAST

287. Stander G H 1968b. Oil pollution off the South African coast - the "World Glory" disaster. *South African Shipping News and Fishing Industry Review* November 1968, 47-51.

The methods used to deal with the "World Glory" oil spills are described. Aircraft were used to survey the slick at regular intervals. Boats and cropspraying aircraft were used to spray dispersants on the slick. Limitations on the usefulness of aircraft for spraying include limited payload, inadequate agitation of the oil/dispersant mixture, loss of solvent before the detergent reaches the sea. They were thought useful in spraying behind the breaker zone where ships could not operate. Apart from isolated instances of dead marine birds and a case of small number of dead fish (which was probably not due to oil or spraying operations) there was no evidence of damage to marine life. Air reconnaissance proved important in planning operations but problems occurred in locating oil from the air. (DAD)

OIL PREVENTION AND COMBATING ORGANISMS

288. Stander G J, W D Oliff and D J Livingstone 1967. Problems in using the sea as part of a waste disposal system. *Institute of Water Pollution Control. Annual Conference*, Torquay 20-23 June 1967. Conference paper no 3, 3-11.

The factors to be investigated in order to design a waste disposal system are described. These include quantity and quality of waste; aesthetic effects of addition of waste to sea water; situation of discharge area i e is it close to holiday resorts etc; physical characteristics of sea and beaches, including the topography of the seabed and the depth of water of the proposed submarine pipe. For shore discharge pipelines information on waves, longshore currents and eddy diffusion is required. Some effects of pollution are described such as enrichment. Certain parameters are useful for measuring enrichment of the environment by discharged waste. For beach sands the following levels are normal : PV up to 0,06mg/g dry weight of sand; Kjeldal nitrogen up to 100 micro g/g; density of interstitial fauna of up to 300 animals/unit of 0,67 ft^3. Normal levels of parameters in submarine sediments are considered to be: PV up to 1 mg/g dry weight of sediment; dehydrogenase activity up to 1,0 micro g/g; humic acids up to 1,0 mg/g, faunal density up to 2 000 animals/litre of wet sediment. Levels greater than this are regarded as indicative of enrichment from unnatural sources. Concerning the bacterial quality of sea water a group of parameters are used.

A tentative monitoring standard is suggested which includes : not > 10 000 coliforms/100 ml, not > 500 *E.coli I*/100 ml, absence of *S.typhi* and the Salmonellae and Shigellae bacilli in 250 ml of water, not > 4 parasite units (viable ova)/litre, absence of coagulase-positive, mannitol positive staphylococci/ 50 ml. Once all the information has been obtained on the use made of disposal area, the type and quantity of effluent, the wind and current regimes in the sea, and the levels of parameters to be accepted in the area, then it becomes possible to

design a waste outfall to attain acceptable standards. Predictions of the probable dilutions at the shore for various lengths of submarine pipeline are made and the relative risks at the shore are determined. A suitable position and length of pipeline can then be determined. If this length of pipeline is an uneconomical proposition, then pretreatment of effluent is required to attain the degree of dilution possible with the selected economic length of pipeline. As a guide, under conditions along the Natal coast, a submarine pipeline a mile long out to sea from the shore ending in a depth of 100 ft of water, with a 1 000 ft in-line diffuser, will give a physical dilution of a buoyant effluent of about 100 times at the surface over the pipe-end, and an overall physical dilution of 500 to 1 000 times at the shore in the vicinity. The diluted material is likely to reach the shore in the area, a mile north or south of the pipeline, on about 5 to 15 percent of the days of the year in most places. In bad localities, such as within bays, the frequency of onshore components may increase to as much as 30 percent. There are serious limitations to discharge into the surf zone, due to longshore drift which occurs on approximately 50% of occasions increasing the chances of beach contamination, severe churning which can cause foaming by foaming agents and limited exchange between the surf zone and the water beyond. (DAD)

STANDARDS DISPOSAL OF EFFLUENTS MONITORING
COASTAL CURRENTS EAST COAST

289. Stander G H and J A V Venter 1968. Oil pollution in South Africa. *International Conference on Oil Pollution of the Sea,* Rome 7-9 October 1968, paper no 16B, 251-259.

The handling of various oil pollution incidents in South Africa is described as are effects on marine life due to crude oil from the 'Esso Essen' incident. In this survey intertidal and subtidal studies were undertaken. It was observed that millions of sand hoppers *(Talorchestia)* were killed in the intertidal zone. It was concluded that spraying detergents from ships suitably equipped remains the most effective, if not least expensive, method of treating large oil slicks. It was noted that on some untreated beaches, the action of natural cleansing agents cleaned the beaches within about 2 months. Toxicity tests using dispersants showed approximately the same order of toxicity for all products tested, with the exception of an aqueous-based dispersant containing about 30% surfactant. The work of the Ad Hoc Committee on Oil Pollution is described. Difficulties in drafting suitable legislation for dealing with the oil pollution menace are outlined e g existing provisions in international law such as the right of innocent passage through territorial waters and the inability to prescribe compulsory routes outside such waters. A further difficulty relates to the financial and legal responsibility of the party causing oil pollution. It is suggested that some scheme at an international level should be evolved whereby each owner, charterer or sub-charterer, of an oil tanker is required to insure such a tanker or establish a fund from which claims for oil

pollution clean-up costs can be paid. It is pointed out that apart from the fact that Governments will derive the benefit of financial compensation in respect of damage suffered or costs incurred in removing oil pollution, a scheme such as this will most probably bring about higher structural standards, the probable elimination and putting out of business of tankers not of the required standard and stricter controls and safeguards ensuring safer oil tanker traffic. It is considered that research could be centred on the prediction of the movement of oil slicks, methods of the estimating the thickness of the oil layer and the improvement of spraying equipment and vessel design. It is thought that the ultimate answer to oil pollution cleanup lies in the physical removal of spilt oil from the sea. (DAD)

OIL ORGANISMS PREVENTION AND COMBATING

290. Straszacker R L 1972. Siting and design aspects of power stations to limit thermal and radioactive pollution of the ocean. *ECOR Symposium on the Ocean's Challenge to South African Engineers*, S71 Stellenbosch, South Africa. 13pp. In English and Afrikaans.

Heat loss from power stations is related to the efficiency of the plant which for fossil-fuelled plants is a maximum of 64% and an average of 36% whilst the corresponding figures for a nuclear plant are 48% and 30%. As an example, for a net output of 500 MW electricity in each case, about 50% more heat is discharged heated water on the marine environment are described. The effect of thermal pollution on marine life is to reduce the number and type of organisms which can exist. Changes in temperature also affect the life cycles of various organisms e g reproduction may be prevented. In general, marine water temperatures do not change as rapidly or range as widely as those of fresh water. Marine and estuarine fish and other organisms are thus less tolerant of temperature variations. Thermal pollution which produces temperature fluctuations is therefore likely to be more harmful to marine life than the same temperature rise maintained continuously. Some uses of heated water e g in aquaculture, are described. For power stations at or near the coast, direct, once-through, seawater cooling is generally the most economical system in South Africa. The site and design characteristics of the Koeberg nuclear power station are described. Oceanographic work to help design the cooling water system has been undertaken. A survey of marine life has predicted that in this cold water area the warm water will encourage a 'pocket' of types of marine life typical of those found in Table Bay. Possible future development in the energy field is discussed.

Extensive studies are being undertaken to ensure that radioactive releases from the power station will be kept to an absolute minimum. Spent fuel from the nuclear reactor will be sent overseas for re-processing as it is at present not economically feasible to erect

such a reprocessing plant in South Africa. Small amounts of radioactive wastes will also appear in the effluent as a result of leakages. All such active and potentially active effluent will be collected, monitored, treated and again monitored, before being released into the sea. The volume and active concentration of this effluent will be extremely low (below internationally accepted limits) and additional dilution will occur in the sea. However, because of the accumulating effect of radioactive nuclides in the marine environment, steps will have to be taken to ensure that people will not be exposed to this radiation source. Work in this regard is presently being undertaken by the Atomic Energy Board, the Sea Fisheries Branch, and the University of Cape Town. (DAD/NG)

THERMAL POLLUTION RADIOACTIVITY ORGANISMS FISH

291. Stavropoulus C C 1964a. Some methods of constructing, launching and tracking current-measuring drogues. In Oceanographic Research Group 1964, 5-10.

The use of drogues for measuring sub-surface sea currents is described. Three methods were used

1) Drogues were launched from a ship and tracked by means of aerial photography.
2) The drogues were launched from an aircraft and tracked by means of aerial photography
3) The drogues were launched from an aircraft and tracked by means of optical range-finders on shore.

The third method has proved most effective in making measurements up to three miles offshore in silt-laden waters and for distances up to 30 miles from the airfield. (CEC)

EAST COAST COASTAL CURRENTS METHODS

292. Stavropoulos C C 1964b. Large instantaneous dye-solution discharges. In Oceanographic Research Group 1964, 23-24.

By pumping 150 gallons of dye mixture into a 200 gram size meteorological balloon and bursting the balloon while it floated in the water, the dye was discharged in a controlled manner and the dye patch maintained its circular shape until its diameter had increased to at least 100 ft. (CEC)

EAST COAST METHODS COASTAL CURRENTS

293. Taljaard W 1975a. Thermal pollution in the marine environment. I. *Environment RSA* 2 (8), 4-5.

This article is a compilation of information on thermal pollution. The sources of waste heat in the ocean are

pollution clean-up costs can be paid. It is pointed out that apart from the fact that Governments will derive the benefit of financial compensation in respect of damage suffered or costs incurred in removing oil pollution, a scheme such as this will most probably bring about higher structural standards, the probable elimination and putting out of business of tankers not of the required standard and stricter controls and safeguards ensuring safer oil tanker traffic. It is considered that research could be centred on the prediction of the movement of oil slicks, methods of the estimating the thickness of the oil layer and the improvement of spraying equipment and vessel design. It is thought that the ultimate answer to oil pollution cleanup lies in the physical removal of spilt oil from the sea. (DAD)

OIL ORGANISMS PREVENTION AND COMBATING

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such a reprocessing plant in South Africa. Small amounts of radioactive wastes will also appear in the effluent as a result of leakages. All such active and potentially active effluent will be collected, monitored, treated and again monitored, before being released into the sea. The volume and active concentration of this effluent will be extremely low (below internationally accepted limits) and additional dilution will occur in the sea. However, because of the accumulating effect of radioactive nuclides in the marine environment, steps will have to be taken to ensure that people will not be exposed to this radiation source. Work in this regard is presently being undertaken by the Atomic Energy Board, the Sea Fisheries Branch, and the University of Cape Town. (DAD/NG)

THERMAL POLLUTION RADIOACTIVITY ORGANISMS FISH

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The third method has proved most effective in making measurements up to three miles offshore in silt-laden waters and for distances up to 30 miles from the airfield. (CEC)

EAST COAST COASTAL CURRENTS METHODS

292. Stavropoulos C C 1964b. Large instantaneous dye-solution discharges. In Oceanographic Research Group 1964, 23-24.

By pumping 150 gallons of dye mixture into a 200 gram size meteorological balloon and bursting the balloon while it floated in the water, the dye was discharged in a controlled manner and the dye patch maintained its circular shape until its diameter had increased to at least 100 ft. (CEC)

EAST COAST METHODS COASTAL CURRENTS

293. Taljaard W 1975a. Thermal pollution in the marine environment. I. *Environment RSA* 2 (8), 4-5.

This article is a compilation of information on thermal pollution. The sources of waste heat in the ocean are

discussed as well as its effect on seawater, marine life, and man. Where possible, reference is made to South African conditions.

THERMAL POLLUTION POLLUTION SOURCES ORGANISMS

294. Taljaard W 1975b. Thermal pollution in the marine environment. II. *Environment RSA* 2 (9), 4-5.

Research and regulations regarding prevention of pollution and other means of prevention of pollution are described as found in South Africa and elsewhere.

THERMAL POLLUTION PREVENTION AND COMBATING

295. Taljaard W 1975c. Thermal pollution in the marine environment III. *Environment RSA* 2 (10) 4-5.

A table comparing the capacity, load factor, average heat input to the sea, source of intake water, rate of intake, temperature of return water and the method of marine growth control of the fossil fuel-fired power stations in South Africa, using seawater for cooling purposes, is presented. The proposed Koeberg nuclear power plant is also discussed.

WEST COAST THERMAL POLLUTION EAST COAST SOUTH COAST

296. Taljaard W 1976a. Radioactivity in the marine environment. I. *Environment RSA* 3 (1), 4-5.

This article is a compilation of information on radioactivity in the marine environment,

Radioactivity is discussed in general, describing what it is, its physical characteristics, possible sources and methods of entry into the marine environment, and location of areas along the South African coast so affected, e g the future Koeberg nuclear power plant at Duynefontein.

RADIOACTIVITY POLLUTION SOURCES

297. Taljaard W 1976B. Radioactivity in the marine environment. II. *Environment RSA* 3 (2), 4-5.

The accumulation of radionuclides in marine life and man is described with its possible effects on both.

ORGANISMS RADIOACTIVITY

298. Taljaard W 1976cc. Radioactivity in the marine environment. III. *Environment RSA* 3 (3), 4-5.

International and South African research on radioactive waste disposal into the sea and uptake of radionuclides by marine plants and animals is briefly described. Regulations regarding prevention of pollution in South Africa and elsewhere, together with means of preventing pollution are summarised.

RADIOACRIVITY PREVENTION AND COMBATING ORGANISMS

299. Tayler C K 1970. Treating oil soaked sea birds. *Eastern Cape Naturalist* 41, 16-19.

Trials with various methods of treating oil-soaked penguins were undertaken. It was found that a well-soaked penguin had no chance of survival if it is de-oiled and forced to remain afloat in water for 12 hours immediately or even 3 weeks after treatment. Death in this case was due to exposure as the plumage as a protective and waterproof coating is broken down. Penguin deaths were generally found to be due to one of the following : (a) the toxicity of ingested volatile oil. (b) bacterial infection of the digestive system following the irritant effect of less volatile oil. (c) bacterial infection of the respiratory system following the admittance of oil or vapour. (d) exposure as a result of plumage "matting" following a period sufficient to permit most of the volatile components of the oil to evaporate leaving the plumage in the form of hard tufts. (e) exhaustion and stress in the cases closely following the moult phase, where the penguin is in a weakened condition. The most successful treatment was found to be crowding birds into a box filled with absorbant material and encouraging them to be active so as to hasten the absorbing process. Afterwards an antibiotic injection is given, and doses of cod liver oil and enteritis preparation. Birds can be sprayed lightly to encourage them to preen and remove the oil residue themselves. (DAD)

OIL ORGANISMS PREVENTION AND COMBATING BIRDS

300. Turner W D 1974a. Trace Metal Analysis in the Environment. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 25pp.

The report is divided into two parts :

1) Cation analysis of seawater : Sampling procedures and sample storage are discussed and methods and the results of determination of major (Ca, Mg, Na, K) and Minor (Cu, Pb, Cd, Fe, Zn) elements are given.
2) Trace metal analyses of particulate matter, biological

tissues and sediments: Procedures for the collection and processing of particulates, animal and plant tissues and bottom sediments and the determination of total mercury are given. (CEC)

TRACE METALS SEDIMENTS METHODS ORGANISMS

301. Turner W D 1974b. National Programme for Marine Pollution Monitoring - East Coast Impact Area Surveys. Progress Report No. 1. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 3pp.

Various drains, canals and outfalls in the vicinity of Durban have been examined. Results of the physical, chemical and trace metals analyses are given. (CEC)

EAST COAST TRACE METALS POLLUTION SOURCES MONITORING

302. Turner W D and D J Livingstone 1974c. National Programme for Marine Pollution Monitoring - East Coast Impact Area Surveys. Progress Report No 2. *Report to the Marine Pollution Section of the National Programme for Environmental Sciences*. 9pp.

Results (bacteriological and trace metal analyses) of a survey of Durban Bay influents are given. (CEC)

BACTERIA TRACE METALS EAST COAST MONITORING
FISH POLLUTION SOURCES

303. Tworeck W and R J Nachenius 1965. Estimated cost of pumping scheme for disposal of Walvis Bay factory effluents. *Fishing Industry Research Institute. M147*.

No abstract available

FISH FACTORY EFFLUENTS

304. Van As D 1972. Activable tracers in the control of pollution and the study of environmental transport processes. *National Conference on the Technological Applications of Nuclear Techniques*. Pelindaba, 12-13 October 1972.

Activable tracers are often more convenient to use than radioactive tracers, especially when studying large-scale environmental processes. These tracers can be either stable elements added to the particular medium which they then uniquely label, or they can be a single trace element or combination of trace elements which are naturally present in the medium. The presence and concentration of these elements can be determined at extremely low levels ($\sim 10^{-9}$g) by means of nuclear techniques such as neutron activation and X-ray fluorescence.

The application of activable tracers for the investigation of atmospheric dispersion ecological concentration processes and the characterization of aquifers and air masses in South Africa is briefly described.

METHODS RADIOACTIVITY

305. Van As D, H O Fourie and C M Vleggaar 1973a. Trace element concentrations in marine organisms from the Cape West Coast. *South African National Oceanographic Symposium Abstracts*, Cape Town. 48-49.

This study of trace-element concentrations in the marine environment formed part of an investigation of the recipient capacity of the sea for radioactive effluent. As activated isotopes of the corrosion elements are important constituents of the effluent from nuclear power stations, the concentrations of these elements in edible marine organisms are necessary parameters in the calculation of safe disposal rates.

The elements investigated, i e Cr, Fe, Zn, Co, Mn and Sb all have long half-life, neutron-induced isotopes. These elements are present in trace amounts in sea water and are known to be concentrated to high and variable levels in marine organisms.

It was assumed that the radionuclide will follow the same route as its stable isotope. This assumption is only valid if the chemical and physical forms of the two isotopes are similar, or if rapid equilibrium is established between the isotopes in the effluent and their stable counterparts in the ocean.

The marine organisms investigated included mixed zooplankton (mostly copepods), various algae e.g. *Ulva*, *Ecklonia*, *Porphyra* and *Shuria*, the molluscs *Choromytilus*, *Donax* and *Haliotis*, the crustacean *Jasus* and various species of line fish, white fish and pelagic fish. Analyses were only performed on the edible part of those species consumed by man.

Comparative analyses of the dissolved and particulate fractions of these elements in coastal and off-shore waters were made. The analytical techniques of atomic absorption and neutron activation were applied and the merits of these techniques for different sample materials are discussed.

Sample treatment is of the utmost importance when working at these concentration levels. To ensure that losses or contamination did not occur, particular attention was paid to the influence of container material on liquid samples and the effect of various methods of sample preparation, e g freeze drying and wet and dry ashing.

TRACE METALS ORGANISMS PLANKTON MOLLUSCS FISH

306. Van As D, H O Fourie and C M Vleggaar 1973b. Accumulation of certain trace elements in marine organisms from the sea around the Cape of Good Hope. *Radioactive Contamination of the Marine Environment*, IAEA, SM-158/39, 615-624.

An investigation of the recipient capacity of the sea for radioactive effluent from a site on the west coast of South Africa, 25km north of Cape Town, necessitated the determination of concentration factors for those nuclides which would probably be present in the effluent of the proposed nuclear installations. Stable element analyses were done for these corrosion elements which are known to have high accumulation factors and which have induced radioactive isotopes of long half-lives, e g Cr, Fe, Zn, Co, Mn and Sb, as well as for the stable counterparts of the fission products ^{90}Sr and ^{137}Cs. Various methods of sample preparation e g freeze drying, dry and wet ashing and of sample analyses e g atomic absorption and neutron activation, were used in parallel and the results compared. The marine organisms which are either regularly consumed or which may have future economic importance were investigated. These species included algae (*Poryphyra capensis, Ecklonia maxima, Ulva* spp., *Suhria vitatte*), molluscs (*Haliotis midae, Donax serra, Mytilus meridionalis*) and Crustacea (*Jasus lalandii*) as well as various line and pelagic fishes of commercial importance. Analyses were normally performed on the edible parts of the species only. With regard to coastal and off-shore waters, measurements of the soluble and particulate fractions of these elements were made and different techniques of sample storage and sample preparation, e g deep freezing and freeze-drying, were compared.

TRACE METALS WEST COAST ORGANISMS MOLLUSCS
RADIOACTIVITY FISH METHODS

307. Van As D, H O Fourie and C M Vleggaar 1975. Trace element concentrations in marine organisms from the Cape West Coast. *South African Journal of Science 71*, 151-154.

Average levels of elements in sea water, fish, benthos (mainly those of commercial importance e g mussels), seaweed and plankton in the Cape West Coast have been obtained prior to the construction in this area of a nuclear power station. Plankton is not consumed by man but is a primary link in the food chain and could be an important indicator of initial build-up of radioactive pollutants. The elements Cr, Fe, Zn, Co, Mn, Sb, Cs were analysed in all samples (with the exception of Cs in sea water). Average concentration factors for benthos, seaweed and fish are given. It was noted that the concentration levels of different elements in individual species of molluscs, crustacea and seaweeds were fairly constant. Certain plankton samples showed extremely high concentrations of trace elements. Stable trace element concen-

trati›ns in sea water from the surf zone at Duynefontein differed from that of the off-shore samples: in the former case the dissolved fractions generally had lower concentrations, while those of the particulate fractions were high and variable. It is not certain to what extent the particulate fraction is metabolised and concentrated in the edible parts of marine organisms; consequently the values for the dissolved fraction in seawater from the coastal zone was used in the calculation of concentration factors. In comparison with U K data, our values were higher for Cr and Fe and lower for Co, Mn and Cs; Sb and Zn showed comparable values. (DAD)

TRACE METALS ORGANISMS MOLLUSCS FISH PLANKTON WEST COAST

308. Van der Merwe R P. Flocculation of blood waters. *Fishing Industry Research Institute. Annual report No. 21,* 48.

No abstract available

FISH FACTORY EFFLUENTS

309. Van Ieperen M P 1971. Hydrology of Table Bay. An oceanographic investigation carried out from late 1966 until early 1971 as part of the National Oceanographic Programme of the Council for Scientific and Industrial Research as approved by SANCOR. *Report to SANCOR.* 192 pp.

Measurements of surface and subsurface currents, winds, temperature, salinities, oxygen concentrations and waves, made in Table Bay during the period 1966 to 1969 are reported.

COASTAL CURRENTS WEST COAST WAVES

310. Van Ieperen M P 1976. Characteristics of wave fields recorded along the West Coast. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July, 1976.

In this paper characteristics of wave fields recorded at the weathership F H Hughes and at several stations along the west coast are discussed. The study shows that the average energy density differs considerably from station to station; it is highest at the weathership and lowest at Walvis Bay. The peak frequencies of the spectra generally lie between 0,08 and 0,12 Hertz; it appears therefore that the bulk of the energy is normally generated by relatively local winds. The time lag between the arrival of wave fields at the weathership and the other stations is also discussed.

The spectral analysis shows that distinct differences exist between the calculated spectra and the Pierson-Moskowitz spectrum. The results of this paper emphasize some of the problems involved in developing a successful forecasting model for the west coast.

WEST COAST WAVES

311. Van Zinderen Bakker E M and A C Brown 1970. The fate of thorium dioxide injected into the coelom of the sedentary polychaete, *Sabellastarte longa*. (Kinberg) *Zoologica Africana*, 5, 339-340.

Small quantities of thorium dioxide were injected into posterior segments of the polychaete *Sabellastarte longa* and monitored. Radiographs showed little or no tendency for the foreign material to spread to segments other than those injected. It was found that protective cellular responses e g phagocystis by coelomocytes, was not greatly stimulated by thorium dioxide. Thorium dioxide was excreted slowly from the animals throughout the experiment. Sections through the segmental nephridia displayed lumina containing thorium dioxide throughout their length. It is concluded that the functional nature of segmental nephridia is proved. The completeness of the intersegmental septa is also established. It therefore seems that each pair of nephridia is concerned with the coelomic fluid of only that segment into which it opens, though the possibility of substances being transferred from one segment to another via the blood stream is real. (DAD)

RADIOACTIVITY ORGANISMS

312. Verwey C J and W R McMurray 1964. Tracers for the study of mixing in the surf. In Oceanographic Research Group 1964, 45-49.

Field tests were undertaken to compare the behaviour of the fluorescent tracer, sodium fluorescein, and the radioactive tracer, phosphorus-32, when released simultaneously into the surf zone under conditions of strong longshore currents movements. The two tracers behaved similarly and it is concluded that, in the surf zone over short periods of time, phosphorus-32 as NaH_2PO_4 is an acceptable tracer. The concentration method for phosphorus-32 is also described. (CEC)

EAST COAST COASTAL CURRENTS METHODS RADIOACTIVITY

313. Visser G A 1974. Report from the attendance at the International Conference for the Prevention of Pollution from Ships, London, October 1973. *Environment RSA* January 1974. 13-15. In Afrikaans.

A brief account is given of the work of the IMCO Conference resulting in the International Convention for the Prevention of Pollution from Ships 1973. Under the new convention the coastal state has the right to retain ships if they pollute that states territorial waters and also if the ship does not comply with certain design specifications. (DAD)

PREVENTION AND COMBATING

314. Vogel J C 1972. Radiocarbon in the surface waters of the Atlantic ocean. *Proceedings of the 8th International Conference on Radio Carbon Dating, Wellington, New Zealand, October 1972.* C44-C55.

Evidence is presented that too low values for the carbon-14 content of sea water are obtained from samples stored for two months in plastic containers without the addition of a preservative. It is, therefore, important that the inorganic carbon be extracted directly after sampling.

Samples collected in the eastern Atlantic Ocean between 1967 and 1970 show that the carbon-14 content of the surface waters is relatively homogeneous over wide areas, but that low values occur in areas of upwelling and that water masses with higher values exist in some regions. The limited number of samples suggests that the increase in radiocarbon content is not taking place at a steady rate and that a simple box model of the ocean does not apply on a timescale of one or two years.

Nevertheless, the slow decrease in the excess carbon-14 in the atmosphere of the southern hemisphere can be used to predict the rate of increase in the surface ocean water. Comparison with the existing data allows the residence time of water in the mixed layer of the South Atlantic to be estimated as longer than 10 years.

RADIOACTIVITY WEST COAST

315. Vogel J C and A S Talma 1976. Natural Isotopes in the Southwest Indian Ocean. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa,* Port Elizabeth, July, 1976.

A number of profile and surface samples up to 150 miles off the Natal and Transkei coasts have indicated the basic distribution of the natural and bomb produced isotopes of hydrogen, oxygen and carbon.

The concentration of radiocarbon (^{14}C) and tritium (^{3}H) has increased substantially in the atmosphere since 1954 due to nuclear weapon tests and provided tracers to study water and CO_2 exchange across the air/sea boundary

and internal mixing of the oceans. In line with a previous prediction the ^{14}C content of water in the mixed layer (top 50-150 meter) has reached a velue of 120% of base line level for an atmospheric concentration of 150% and has remained constant thus indicating that the stage has been reached where equal amounts of CO_2 are added from atmosphere and removed to deeper waters. Faster sinking of surface water closer to the Subtropical Convergence is suggested by differences in the depth of infiltration of ^{14}C at different localities and can be used to estimate the sinking rate.

Oxygen-18 variations in sea water are produced by evaporation, freezing and melt water contributions. Different water masses can therefore be characterised by an oxygen-18 concentration and oxygen-18-salinity plots can be used in an analogous manner to T-S plots. A few values of the water masses encountered in the profiles off Natal are given and compared with surface measurements elsewhere.

Isotope discrimination during photosynthesis and carbonate deposition from sea water enables the isotopic composition of the remaining bicarbonate to yield information on the relative extent of these processes. The two profiles measured show that the decrease in bicarbonate content of surface water is caused by equal amounts of photosynthesis and carbonate formation. Combination of these measurements with CO_2 exchange rates, determined by radioactive isotopes, has the potential of calculating average productivity over large areas.

EAST COAST RADIOACTIVITY

316. Watling H R 1975. The occurrence, determination and biological effects of Trace-Metallic Species in water. *CSIR Report*, November 1975.

Many methods for the determination of total trace-metal concentrations in water have been described. Less attention has been paid to the determination of metallic species in water although their occurrence and their effects on aquatic life are well documented.

Some of the techniques which have been applied to the determination of metallic species are reviewed, together with reported findings on the occurrence, behaviour and biological effects of ionic, chelated and complexed metals.

TRACE METALS METHODS

317. Watling H R and R J Watling 1975a. Note on the trace metal content of membrane filters. *Water SA 1* (1), 28-29.

Five brands (seven types) of commercially available membrane filters have been analysed for thirteen trace elements, in order to select that filter which might be expected to least contaminate water samples (soluble and particulate fraction). The results may be summarised as follows : (1) No one particular type of filter contains significantly low trace metal concentrations with respect to any other. (2) When a few selected elements are to be analysed it may be possible to select a filter containing low concentrations of these elements. (3) When a large number of elements are to be determined it is advisable to choose that filter with the least coefficient of variation (percent) in trace metal levels in order to determine a useful background level. (4) When determining the trace metal content of the particulate fraction in natural water, it is necessary also to determine a "filter blank" in replicate. (5) It is advisable to collect and prepare particulate samples in replicate for trace metal analysis.

METHODS TRACE METALS

318. Watling H R and R J Watling 1975b. Isotope Geophysical Profiles. Results of the first IGP cruise 10 - 12 June 1974, R V Meiring Naudé. *CSIR Report*, April 1975.

Trace metals were determined in a number of samples at depths from the Indian Ocean. Samples were filtered, and soluble trace metals were chelated using sodium diethyldithiocarbamate and extracted into chloroform. Trace metals were also determined for the particulate phase.

The ranges of the concentrations compare well with data reported from some recent surveys and there is no evidence of metal pollution in the surface samples. On the whole, good correlation is shown between soluble trace metal concentrations and other measurements made on the samples.

EAST COAST TRACE METALS METHODS

319. Watling H R and R J Watling 1975c. Statistical interpretation of the results obtained from trace metal analysis of environmental samples - Preliminary report. *CSIR Report*, June 1975.

Some statistical methods of analysis have been applied to the data obtained from a preliminary trace-metal survey of six molluscan species from an unpolluted area. The object of this study was to examine these methods as potential tools in the evaluation of trace-metal pollution in the South African coastal marine environment.

This preliminary study will be followed by a detailed examination and modification of those methods which appear to be most useful on a national scale, with the object of providing a single computer programme which can be used by any of the groups working in this field.

One important fact has emerged from the study. All the tests were affected to varying degrees by the relatively small numbers. The effect was further magnified by the variation in element concentrations determined for individuals of a natural population. To overcome this it is suggested that at least fifty individuals from a population should be analysed for the purpose of evaluating a particular method, although it may be possible to reduce the sample size or use a sample mean for monitoring on a routine basis.

Logarithmic regression analysis and the use of regression coefficients, a method which has been used to relate metabolic functions to growth in animals, looks particularly promising for use in measuring and comparing the degree of trace-metal pollution in different areas. Although initially large numbers of individuals of a given species would be required in order to establish the rate of trace-metal uptake in a specific population, as few as ten individuals could be used for the routine monitoring of the same population.

TRACE METALS MOLLUSCS METHODS

320. Watling H R and R J Watling 1975d. Preliminary preparation of molluscs for trace metal analysis. *FIS Special Report* 76, October 1975.

The results of a preliminary survey of the trace-metal content of molluscs from Saldanha Bay and Langebaan Lagoon indicated that the organisms had not been cleansed efficiently prior to analysis. In order to confirm this molluscs were collected from two sites, cleaned as described and analysed. At the same time a series of sediment samples was collected from sites in the vicinity of the mollusc populations and analysed for twelve trace elements. The results of the survey may be summarised as follows :

1) It is essential that molluscs be thoroughly purged if they are to serve as monitors of metal pollution. Only then will the trace-metal concentrations determined reflect the metal uptake of the organism over a given period of time.
2) It is recommended that the cleaning process consist of storage in clean sea water for a period of at least three days. If tanks are not available then large plastic containers may be used.

TRACE METALS MOLLUSCS SEDIMENTS METHODS

321. Watling H R and R J Watling 1976a. Trace metals in Oysters from Knysna Estuary. *Marine Pollution Bulletin* 7 45-48.

A preliminary survey of trace metals in three species of oyster from the Knysna estuary has been carried out. The results which were obtained indicate that this area is as yet unpolluted and provide baseline levels against which future trace-metal pollution can be measured. Two species of oyster are being grown at a number of sites as part of a long-term programme to monitor trace-metal levels in the estuary.

SOUTH COAST MOLLUSCS TRACE METALS ESTUARIES

322. Watling H R and R J Watling 1976b. Preconcentration and extraction techniques for the determination of trace elements in water. 1. Sodium diethyldithiocarbamate - Chloroform. *Council for Scientific and Industrial Research Special Report FIS 83*, 70pp.

A brief literature review has been prepared in which are outlined those factors which must be taken into account when choosing a suitable method for the determination of trace metals in water samples.

The problems of contamination and preservation of water samples have been studied and the procedures adopted for their collection and preliminary preparation for analysis are described.

The sodium diethyldithiocarbamate - chloroform system, one of the many methods available for the extraction of trace metals from fresh and sea water, has been evaluated for eight elements, zinc, cadmium, copper, lead, iron, manganese, nickel and cobalt and the problems which have arisen during the analytical procedure are discussed.

METHODS TRACE METALS

323. Watling H R and R J Watling 1976c. Trace metal studies in Knysna Estuary. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July, 1976. 29pp.

Knysna estuary is the most biologically productive estuary in South Africa and, as such, is listed as an area of primary importance in the national marine pollution monitoring programme. It is also a popular holiday resort. The further development of amenities in the area may prove harmful either directly or indirectly to the many plant and animal species found in the estuary.

This preliminary study will be followed by a detailed examination and modification of those methods which appear to be most useful on a national scale, with the object of providing a single computer programme which can be used by any of the groups working in this field.

One important fact has emerged from the study. All the tests were affected to varying degrees by the relatively small numbers. The effect was further magnified by the variation in element concentrations determined for individuals of a natural population. To overcome this it is suggested that at least fifty individuals from a population should be analysed for the purpose of evaluating a particular method, although it may be possible to reduce the sample size or use a sample mean for monitoring on a routine basis.

Logarithmic regression analysis and the use of regression coefficients, a method which has been used to relate metabolic functions to growth in animals, looks particularly promising for use in measuring and comparing the degree of trace-metal pollution in different areas. Although initially large numbers of individuals of a given species would be required in order to establish the rate of trace-metal uptake in a specific population, as few as ten individuals could be used for the routine monitoring of the same population.

TRACE METALS MOLLUSCS METHODS

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TRACE METALS MOLLUSCS SEDIMENTS METHODS

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SOUTH COAST MOLLUSCS TRACE METALS ESTUARIES

322. Watling H R and R J Watling 1976b. Preconcentration and extraction techniques for the determination of trace elements in water. 1. Sodium diethyldithiocarbamate - Chloroform. *Council for Scientific and Industrial Research Special Report FIS 83*, 70pp.

A brief literature review has been prepared in which are outlined those factors which must be taken into account when choosing a suitable method for the determination of trace metals in water samples.

The problems of contamination and preservation of water samples have been studied and the procedures adopted for their collection and preliminary preparation for analysis are described.

The sodium diethyldithiocarbamate - chloroform system, one of the many methods available for the extraction of trace metals from fresh and sea water, has been evaluated for eight elements, zinc, cadmium, copper, lead, iron, manganese, nickel and cobalt and the problems which have arisen during the analytical procedure are discussed.

METHODS TRACE METALS

323. Watling H R and R J Watling 1976c. Trace metal studies in Knysna Estuary. *Proceedings of the First Interdisciplinary Conference on Marine and Freshwater Research in Southern Africa*, Port Elizabeth, July, 1976. 29pp.

Knysna estuary is the most biologically productive estuary in South Africa and, as such, is listed as an area of primary importance in the national marine pollution monitoring programme. It is also a popular holiday resort. The further development of amenities in the area may prove harmful either directly or indirectly to the many plant and animal species found in the estuary.

In addition, if the estuary should become polluted, the coastal fishery may be adversely affected. For these reasons it is necessary to make a thorough study of the current tracemetal levels which occur in the estuary, to provide baseline data against which the effects of any future developments can be measured.

A large number of sediments and biological samples have been collected from Knysna estuary and their trace-element concentrations have been determined by atomic-absorption spectrometry.

The trace-element concentrations determined for the sediments are generally low indicating that, although point sources of metal pollution exist, the overall effect on the estuary thus far is negligible.

The trace-element concentrations which have been determined for the oysters *Crassostrea gigas* and *Ostrea edulis* grown at Knysna, when compared with values obtained for these species from locations outside South Africa, clearly indicate tht Knysna is an unpolluted estuary with respect to metals. It can therefore be assumed that the concentrations determined for the Cape oyster *Crassostrea margaritacea* also represent near-background levels.

Numbers of other molluscan species have been collected from several sites in the estuary and at the Heads. The trace-metal concentrations which have been determined for these species are assumed to represent near-background levels, and as such can be compared with similar data relating to the same species from other estuaries.

Data obtained from the continued monitoring of trace-metal levels in sediments and in these biological species can be used to evaluate the effects of all future development in Knysna estuary, so that when necessary, immediate steps may be taken to control any pollution.

MONITORING SOUTH COAST TRACE METALS MOLLUSCS ESTUARIES

324. Watling R J 1974. Detection of nanogram amounts of mercury in sea water and fresh water using an atomic absorption technique in conjunction with amalgamation procedures. *NPRL report, CSIR.*

Although detection limits using quartz amalgamation tube techniques are not substantially lower than those already obtained by various laboratories in South Africa, the advantage of the technique lies in the fact that the amalgamation tubes can be taken to the sampling site and prepared there. This removes the necessity of transport of large samples of water back to the laboratory. The risk

of contamination, sample-deterioration and loss of mercury from solution by storage are eliminated.

TRACE METALS METHODS

325. Watling R J 1975. The determination of mercury in picogram/litre levels in water using a microwave-induced argon plasma emission system. *Analytica Chemica Acta 75,* 281-288.

The need for accurate determination of mercury at sub-ng l^{-1} levels in sea water has led to the development of a microwave-excited argon plasma emission method. The system utilizes an amalgamation stage where mercury released from water samples by tin (II) chloride reduction is amalgamated onto silver wool. The wool is subsequently heated and the mercury thus released is flushed by argon into a plasma where it is excited. The emission signal thus produced results in a detection limit of $3x10^{-17}$ g and an analytical range of $1x10^{-14}$ - $1x10^{-7}$ g.

METHODS TRACE METALS

326. Watling R J and H R Watling 1974. Trace Metal Concentrations in selected molluscs and algae. *FIS Special Report 70,* November 1974.

In view of the proposed industrial and urban developments for the Saldanha Bay - Langebaan Lagoon area it is obvious that the concentration and distribution of trace metals in the waters, sediments, flora and fauna of this area will change. A preliminary survey of this relatively unpolluted area has been carried out to establish existing trace metal concentrations. Samples of six species of molluscs and two species of algae were collected during June and September 1974.

Samples were analysed for fifteen trace metals by atomic absorption spectrophotometry. The metal concentrations determined for these species have been compared with those of related species where data are available.

The following conclusions can be made :

1) Saldanha Bay and Langebaan Lagoon are as yet unpolluted with respect to metals, and represent an excellent area for studies on the effects of industrial pollution on marine flora and fauna.

2) The results indicate that the South African oyster *Crassostrea margaritacea* may prove useful as a monitoring organism for metal pollution in the same way as has been reported for the Pacific oyster *Crassostrea gigas*.

3) Other molluscan species from the area may indicate metal pollution, although little comparative data on their accumulation of metals is available.

4) A study of metal uptake in local species of algae could be undertaken to determine whether they may be useful as indicators of metal pollution.

WEST COAST TRACE METALS ORGANISMS MOLLUSCS LAGOON

327. Watling R J and H R Watling 1975a. Trace-metal studies in Knysna Estuary. *Environment RSA* 2 (10) 1975, 5-7.

Comparison of the trace-metal concentrations in three species of oysters grown at Knysna with those reported for many other locations immediately showed that there is no major trace-metal source in the estuary. It is particularly fortunate that so many other species of molluscs also grow in the estuary because it can be assumed that trace-metal concentrations in these will also represent background levels. These results will therefore be able to be compared with those obtained for the same species from other estuaries, many of which do not have naturally occurring oyster populations.

The fact that the estuary is unpolluted and that so many shellfish species grow there makes Knysna an excellent marine-pollution monitoring station for the southern coast of South Africa.

SOUTH COAST TRACE METALS MOLLUSCS ESTUARIES

328. Watling R J and H R Watling 1975b. The spectrometric determination of mercury (at 253,65 nm) in Natal waters - a brief literature survey. *Water South Africa*, 1, 133-117.

With the growing interest in environmental pollution, the problems encountered in the storage and determination of mercury, present in waters in ultra-trace concentrations, have received considerable attention. Atomic absorption, fluorescence and emission spectrometric methods of mercury analysis are reviewed, together with methods used to prevent mercury loss during sample storage. Reference is made to the use of an amalgamation technique as an alternative to solution storage.

TRACE METALS METHODS

329. Welsh G 1964. Measurements of currents on the Agulhas Bank with an Ekman current meter. *Deep Sea Research* 11, 43-52

During the period December 1960 to December 1961, currents were measured at three different depths on the Agulhas Bank, using an Ekman current meter.

The steady currents were found to be negligible and the observed currents were found to be of the rotating kind with tidal periods, the diurnal amplitude being greater

than the semi-diurnal. The currents were rotating *cum sole*. There was also some evidence of a 4½-day period current.

SOUTH COAST COASTAL CURRENTS

330. Welsh J G 1967. A new method of measuring coastal surface currents with markers and dyes dropped by aircraft. *Journal of Marine Research*, 25 (2),190-197.

This paper describes a new low-cost method of measuring coastal surface currents with markers dropped from light aircraft at each of a series of stations. Each marker consists of a cloth bag containing floats and a different dye. One marker, with anchor attached, remains stationary while a second marker, with drogue attached, moves with the current. The specific dye with each marker disperses slowly and continuously through the cloth into the water and aids in the subsequent location of each marker. Following a predetermined lapse of time, the distance and direction of the moving marker from the stationary marker can be determined from the aircraft.

METHODS COASTAL CURRENTS

331. Westphal A L and M K Rowan 1969. Some observations on the effects of oil pollution on the jackass penguin. *Ostrich* supplement, 8, 521,526.

Since the closure of the Suez vanal the traffic rounding the Cape has greatly increased. This traffic includes an average of 650 oil carriers per month. Accidents have occurred, notably the wrecking of the Esso Essen. Sea birds were badly affected, mainly cormorants *Phalacrocorax* sp, Cape Gannets *Sula capensis* and especially Jackass Penguins *Spheniscus demersus*. At least 500 gannets perished and at least 1 700 oiled penguins were found on the beaches. The survival of beached penguins which were freshly oiled, previously oiled or with no signs of oil are described. It was noted that all the beached penguins were well below the average weight of a healthy adult. Bacteriological examination indicated that pathogenic infections occurred in over 50% of penguins examined. It is pointed out that most of other penguins live in remote areas but the limited world range of the Jackass lies right in the path of busy shipping lanes. In proof of the species vulnerability, is the fact that the number of oiled penguins found after the Esso Essen disaster was more than 3 times the number of gannet or cormorants although the penguin population is much the smallest. The question of the declining penguin population is discussed in terms of the validity of censuses, and the effects of penguin egg collection and development of the inshore fishery, which utilises fish (pilchards and anchovies) on whith the Jackass penguins depends for food. (DAD)

OIL ORGANISMS BIRDS

332. Whillier A 1962. Ocean currents at East London. *Civil Engineering South Africa* 4 (1), 1-7.

Model studies and field investigations of the ocean currents in the immediate vicinity of the entrance to the harbour at East London are reported, and their engineering significance is discussed. It is shown that the northflowing counter current does not exist at this part of the coast. Between Nahoon Point and the main breakwater there is a slow clockwise rotation of water giving rise to a north-flowing current at the shore, but this northward flow of water does not extend past Nahoon Point. Arising out of this investigation there is a suggestion that the net movement of sand along the South African coast between Port St Johns and Port Alfred is from north to south, and not from south to north as is generally believed. This *net* sand movement is thus opposite to the northward littoral drift of sand that is known to exist along the east coast.

COASTAL CURRENTS SOUTH COAST SEDIMENTS

333. Wiechers S G *et al.* Conditioning of hake processing effluents. *Fishing Industry Research Institute. Annual report no 18*, 63.

No abstract available

FISH FACTORY EFFLUENTS

334. Wiechers S G and B D C le Roux. Chlorination of sea water at Walvis Bay. *Fishing Industry Research Institute. Annual report no 15*, 38.

No abstract available

FISH FACTORY EFFLUENTS

335. Wood A C N. Coagulation of bloodwater. *Fishing Industry Research Institute. Annual report No 22*, 53.

No abstract available

FISH FACTORY EFFLUENTS

336. Working Committee on Monitoring Marine Pollution 1974. South Africas' marine environment to be monitored. *Environment RSA*. July 1974. 4-7.

A description of the South African national marine pollution programme is given. Impact areas, coastal reference and oceanic reference surveys will be undertaken. Areas of importance are listed. (DAD)

MONITORING

337. Zoutendyk P 1973. Oil pollution of the Cape Infanta coastline. *Zoologica Africana* 7, 533-536.

Observations on oil pollution over the past 24 years have been made along the Cape Infanta coastline. Although no shipping disasters have occurred in the area, the oil cover of the rocks has increased markedly in places, with signs of affecting the intertidal fauna. It is concluded that the cumulative pollution by oil under present conditions may in time produce results similar to those encountered after large oil spills.

OIL SOUTH COAST ORGANISMS

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APPENDIX B:

ADDRESSES OF INSTITUTES AND ORGANIZATIONS

Atomic Energy Board (AEB)
Private Bag X256
PRETORIA
0001

Council for Scientific and Industrial Research (CSIR)
P O Box 395
PRETORIA
0001

Department of Planning and the Environment
Private Bag X213
PRETORIA
0001

Fishing Industry Research Institute (FIRI)
University of Cape Town
Private Bag
RONDEBOSCH
7700

National Physical Research Laboratory (NPRL)
CSIR
P O Box 395
PRETORIA
0001

National Programme for Environmental Sciences (NPES)
CSIR
P O Box 395
PRETORIA
0001

National Research Institute for Oceanology (NRIO)
P O Box 320
STELLENBOSCH
7600

National Institute for Water Research (NIWR)
National Regional Laboratory
P O Box 17001
CONGELLA
4013

Oceanographic Research Institute (ORI)
P O Box 736
DURBAN
4000

Port Elizabeth Museum
P O Box 13147
HUMEWOOD
6013

South African National Committee for Oceanographic Research (SANCOR)
CSIR
P O Box 395
PRETORIA
0001

Sea Fisheries Branch
Department of Industries
Private Bag
SEA POINT
8060

University of Cape Town
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RONDEBOSCH
7700

University of Natal
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University of Port Elizabeth
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