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REGIONAL SEAS

Regional co-operation on environmental protection of the marine and coastal areas of the Pacific basin

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Preface

The Regional Seas programme of UNEP commenced in 1974 and since that time considerable advances have been made in the development of regional action plans and conventions for the protection of the marine and coastal areas of some eleven regions world-wide. Following these developments UNEP has encouraged inter-regional co-operation in addressing various issues of environmental concern through the organisation of international meetings and inter-regional symposia. This volume contains the record of one such symposium, held in Vina del Mar, Chile in association with the VI Inter-Congress of the Pacific Science Association.

This symposium is the third in a series going back to the Pacific Science Congresses in Dunedin in 1983 (UNEP, 1985) and in Seoul in 1987 (UNEP, 1988). Together they document the progress that has been made in inter-regional co-operation in the Pacific over the last six years.

The themes of the present symposium reflect developments in the field of environmental pollution monitoring and control in the Pacific Basin, together with the growing concern of UNEP and the regional agencies concerning the economic and legal aspects of environmental management for sustainable development and the possible consequences of global climatic change and sea level rise in the achievement of sustainable development.

The present volume contains technical and scientific papers presented to the symposium, together with a record of the discussions and recommendations resulting from closing session during which representatives of agencies and organisations involved in the regional seas programmes of the South-east Asian, South Pacific and South-east Pacific Regional Seas Action Plan areas participated.

This publication was edited by John C. Pernetta, Chairman of the Association of South Pacific Environmental Institutions (ASPEI) who also acted as convenor for the symposium with the assistance of Jairo J. Escobar of the Comision Permanante de Pacifico Sur (CPPS) and Edgardo Gomez Chairman of the Association of South East Asian Marine Scientists (ASEAMS).

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OPENING ADDRESS TO THE UNEP SYMPOSIUM ON THE OCCASION OF THE VI PACIFIC SCIENCE INTERCONGRESS.

Chilean National Focal Point, for the South-east Pacific Action Plan

Chile is extremely proud to host the sixth intercongress of the Pacific Science Association, organised by the Institute for International Studies of the University of Chile and sponsored by the Council of Rectors of the Chilean Universities.

As the representative of the Chilean National Focal Point for the Southeast Pacific Action Plan, I have the great honour and pleasure of greeting and welcoming this select group of people, representing different disciplines and areas of the Pacific, present here today in this institute for higher learning

The Central theme of the sixth intercongress, "The Pacific: Bridge or Barrier" calls for us to reflect on the geography of Chile, seventy percent of which is oceanic and only thirty percent is formed of a narrow strip of land, which is itself divided into three major regions.

The first of these form the desert territories to the North which are themselves a virtual island, isolated from the rest of Chile and connected with the country's central region by a single highway and partially by railroad. Both of these means of communication, by virtue of their length and isolation are extremely vulnerable to climatological and other natural episodic events.

The second region, the central zone, is backed by the Andes and faced by the Pacific, more than 75% of the total Chilean population is presently settled in this area which contains most of Chile's industrial, agricultural and commercial centres.

The third region lies to the south and is a region characterised by its dissected coast; by more than 5,000 islands of different size; and, by its isolation. There, the recently completed southern highway provides the single land-link with the central zone and this regions high degree of isolation, both internally and from the rest of the country means that considerable reliance on maritime ferry boats is dictated by the insular nature of this section of our country.

These geographic features of our country give Chile an indisputable maritime flavour; the sea forms the essential link between the different regions of the country; provides the means and mechanisms for trade with other states; whilst at the same time forming a part of that complex ocean ecosystem in the Pacific Basin. Our marine areas also provide a wide range of renewable natural resources, providing the sources of food to support our people, hungry for protein.

Recognising the social and economic importance of the Southeast Pacific ocean areas the Governments of Chile, Ecuador and Peru promulgated on August 18th, 1952 the "Declaration of Maritime Zones" thereby establishing for the first time, the exclusive sovereignty and jurisdiction of coastal states in an economic zone adjacent to the coast. Thirty years later the United Nations Conference on the Law of the Sea added to the body of International Law the concept of an Exclusive Economic Zone based on the declaration of these three farseeing Governments whose objective was to "Guarantee their people the necessary conditions for subsistence as well as to provide them with the means for their economic development".

Against this background it is important to stress that protection of the marine environment is a task for everyone of us. Our government is very much concerned about the problems of marine protection and our constitution recognises the right of chilean people to live in an environment free from pollution. This is why our institutions co-operate as fully as possible in programmes such as "Research, monitoring and control of pollution in the Southeast Pacific by petroleum hydrocarbons and their effects on marine communities in ecologically sensitive areas", a programme central to the work of the CPPS.

As far as accidents involving marine pollution are concerned, our country has experienced one such event, when in 1973 the tanker "Metula" ran aground in the Straits of Magellan losing some 53,000 tonnes of oil. This was the second biggest spillage of oil world-wide after the "Torrey Canyon" disaster. Such an experience resulted in our country becoming determined to establish a capability for handling oil pollution, including the training of personnel, acquisition of equipment, the formulation of contingency plans and accession to the relevant International Conventions and agreements.

The search for remedies to marine pollution continues and has been expanded through the formulation of flexible and up-to-date regulations to control activities potentially causing pollution. Our current navigation act was passed in 1978 and now regulations to control aquatic pollution are under consideration by the legislature. When finalised these will form a valuable tool for providing protection to the marine environment.

Chile is interested in developing a dynamic and realistic policy for the inclusion of environmental considerations in the development process, and therefore we are happy to support initiatives which will strengthen international co-operation in this area. We are therefore pleased to welcome experts from many different countries today who will examine the links and barriers which characterise scientific co-operation across and within the Pacific Basin.

In conclusion I should like to thank the organisers, and the national and international organisations sponsoring this symposium for providing us with the opportunity of sharing these moments. I should like also to offer all of you, professionals from friendly states a cordial welcome to Chile, where I am certain, you will receive a warm and friendly welcome such that you will feel at home. We hope that this reception will facilitate your discussions and enable you to meet the objectives of this important symposium.

REGIONAL AND INTER-REGIONAL CO-OPERATION FOR THE PROTECTION OF THE MARINE AND COASTAL ENVIRONMENT OF THE PACIFIC BASIN.

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INTRODUCTION

This symposium is the third in a series going back to the Pacific Science Congresses in Dunedin in 1983 (UNEP, 1985) and in Seoul in 1987 (UNEP, 1988). Together they document the progress that has been made in inter-regional co-operation in the Pacific over the last six years.

It might be helpful to place these efforts in their global context, to review the strategy that UNEP has followed and to examine future directions.

The Stockholm Conference and subsequent developments

Global, co-operative efforts in the environmental sector commenced with the United Nations Conference on the Human Environment in Stockholm in 1972 that lead to the establishment of the United Nations Environment Programme (UNEP). The conference theme was "only one earth" and it became clear to the representatives of countries present that it was necessary to learn to live within the limits of the global and regional environments. The oceans were identified as one area where the global management of a shared resource was considered necessary.

Since the Stockholm Conference, the need to respect the environment has become elaborated into the concept of sustainable development, so clearly laid out in the report of the World Commission on Environment and Development, often referred to as the Brundtland Commission after its Chairwoman, the Prime Minister of Norway. The importance of the Oceans in the inter-linked, global ocean-atmosphere system has now become increasingly apparent, as evidenced by events such as El Nino.

The Regional Seas Programme of UNEP

Also since Stockholm UNEP has taken a regional approach to the problems of the ocean environment, building up step-by-step a series of regional seas programmes around the world. The basic philosophy of the Regional Seas Programme has been to strengthen each countries ability to assess, monitor and manage its own environmental problems, thus forming a basis for co-operation with other countries to resolve regional level problems. It may seem slow to train new, local specialists instead of simply bringing in experts from outside, but it is more effective in the long-term for countries to be advised by their own experts. It is also essential to effective regional co-operation for each participating country to draw on its own resources.

Each Regional Seas Programme has its own individual history and specificity. The South Pacific Regional Environment Programme grew out of regional activities begun in 1974 by the South Pacific Commission, before being adopted in 1980 as a Regional Seas Programme of UNEP. As an activity of island countries, it has involved consideration of environmental problems as a whole in both the marine and terrestrial environments. The South East Pacific Action Plan was developed in co-operation with UNEP at the request of, and under the direct supervision of the Permanent Commission for the South Pacific (CPPS). It has focussed more specifically on marine pollution. Both programmes are run by secretariats based in regional, intergovernmental organisations. In the East Asian Seas the initiative came directly from UNEP and UNEP serves as the secretariat for the Action Plan. The North-west Pacific is a new area where governments are

just beginning to consider the possibility of regional co-operation as a basis for protecting and managing their vulnerable marine environment.

All the programmes have started by defining local and regional environmental problems and by identifying the land-based sources of pollution. This formed the basis for deciding on control measures for coastal pollution, and from this developing sound management of coastal zones and their resources. There has been a slow but steady development of inter-regional exchanges, particularly in training and in sharing experience through meetings such as this.

Global Challenges

Today the regional programmes and the world as a whole, face a series of growing global challenges that will require co-operation around the Pacific Basin and beyond.

The increasing evidence for global climate change and sea level rise require a concerted response from all countries whose essential interests, particularly in coastal areas, are threatened. Countries in all regions should participate in the Intergovernmental Panel on Climate Change which is preparing the background for a global convention on the atmosphere and climate. The regional programmes should be considering how to plan for the impacts on coastal zones which will require much more precise coastal mapping to identify areas, vulnerable to sea level rise. The effects on critical coastal ecosystems such as coral reefs and mangroves also need to be considered.

It will be necessary to build up the regional marine pollution programmes into a global marine pollution monitoring system. The extensive use of an increasing number of toxic and persistent chemicals is bound to have effects on sensitive ocean systems. The oceans are like an organic soup in which chemical signals are an important form of communication: there is no telling what unexpected effects may be caused by man's increasing intervention in marine systems. The next event, equivalent to the discovery of the hole in the ozone layer, may well be in the sea.

There are already growing signs of larger-scale biological effects in the marine environment. The increasing occurrence of red tides and other algal blooms; the population explosions of *Acanthaster* on Indo-Pacific reefs; the die-off of *Diadema* in the Caribbean; widespread coral bleaching; and, the seal virus epidemic in the North Sea, all suggest that man's impacts are having widespread effects in upsetting the balance of large scale biological systems about which we know very little.

The accelerating loss of species around the world is threatening one of the most fundamental resources of the planet. Global action will be needed to preserve this biodiversity, and a convention end is now being drafted to address this problem.

Many significant marine species are under threat. Among the marine mammals for instance the latest figures from the International Whaling Commission suggest that the populations of the great whales in the southern ocean are an order of magnitude less, than the most pessimistic previous estimates. Some species such as the Blue Whale are obviously on the brink of extinction. The situation of marine turtles in many areas is of major concern, and other marine species may soon be under threat.

The tendency in many fisheries to push exploitation to unsustainable levels is also worrying. The rapid spread of drift net fishing in the North and South Pacific appears to be leading to over-harvesting of many important species, not to mention the unacceptably high incidental catch of marine mammals, turtles and other species of great conservation interest.

A recent review of the many nuclear-powered vessels and nuclear cargoes now crossing the oceans suggests that the risks of nuclear accidents in the seas are unacceptably high. The recent series of accidents involving Russian nuclear submarines off the coast of Norway has highlighted the vulnerability of many such systems. The expert consensus is, that a significant accident is

inevitable, yet how many regions have considered possible response strategies in the event of a nuclear accident in their waters? While this issue may not warrant the highest priority, some thought should be given to the laboratories able to undertake radioactive pollution measurements at short notice.

The potential industrial development of the seas through such activities as seabed mining or ocean thermal energy conversion will inevitably have major impacts that will need to be anticipated and mitigated.

In all these areas there is a major potential and indeed a requirement for inter-regional co-operation. Governments are increasingly recognising that not everything can be solved on the basis of national sovereignty. New, regional and eventually global structures must be built in order to manage the environment at the appropriate scales.

At the global level, UNEP is being given increased responsibilities, together with pledges of major increases in the budget. Plans are being made for a major world conference on environment and development in 1992, to examine the progress made in the twenty years since Stockholm and to chart a course for the future. Some preparatory sessions related to that theme will be organised at the next Pacific Science Congress in 1991. All of this will reinforce the tendency for the regional seas programmes to become integrated into a global network able to respond to the demands and expectations of governments for the sound protection and management of their shared regional and local environments.

MARINE POLLUTION SOURCES IN THE SOUTH-EAST PACIFIC: POLLUTION CONTROL ALTERNATIVES

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ABSTRACT

The area covered by the South-East Pacific Regional Seas Action Plan includes approximately 10,550 km of continental coastline and covers a stretch of land bordered on the east by the Andean mountains. The coastline stretches from latitude 9°S in Panama to 57°S at the southernmost point of Chile, and encompasses five states bordering the Pacific Ocean: Colombia, Chile, Ecuador, Panama, and Peru. Each coastal area in the region suffers from different levels of pollution originating from one or more sources which are reviewed in this paper.

It is suggested that currently the most extensively polluted geographical areas are the Bay and Gulf of Panama, in Panama; Buenaventura Bay and Tumaco Cove in Colombia; the Gulf of Guayaquil in Ecuador; coastal areas of metropolitan Lima and Callao in Peru; and Valparaiso and Concepcion Bays in Chile.

The majority of municipal and industrial wastes that reach the sea are untreated and appear to be the sources of variable concentrations of different pollutants. Pollution from petroleum hydrocarbons is mainly concentrated in areas where oil extraction, processing and transhipment activities are carried out.

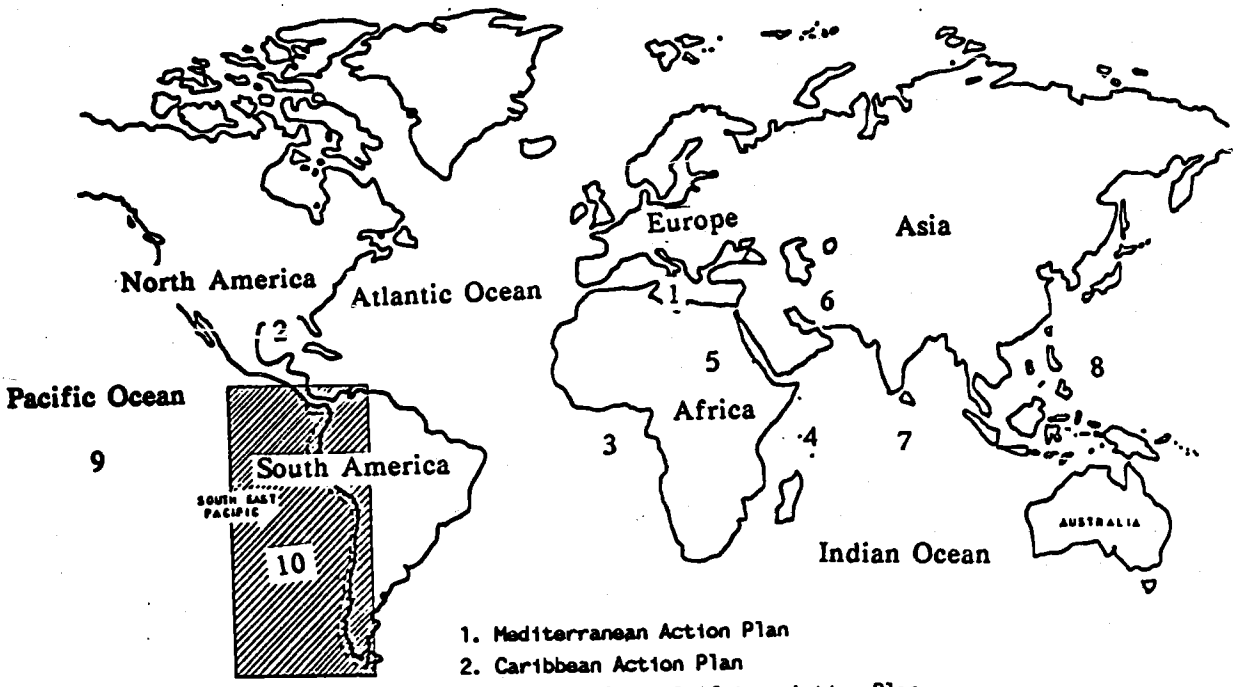
This paper proposes some pollution control alternatives as mechanisms to address current regional problems.

INTRODUCTION

In 1972 the United Nations Conference on the Human Environment, held in Stockholm, adopted the Action Plan for the Human Environment which included general principles for the assessment and control of marine pollution. As a follow up to the Stockholm Conference, the United Nations General Assembly established the United Nations Environment Programme, UNEP.

The Regional Seas Programme was initiated by UNEP's Governing Council in 1974, since which time it has repeatedly endorsed regional approaches to the control of marine pollution and the management of marine and coastal resources. Through its Regional Seas Programme UNEP has assisted in the development of a number of regional action plans and this programme currently includes over 120 participating coastal states. The programme is also technically supported by a number of United Nations agencies, intergovernmental and non-governmental organizations.

In Lima, in 1981, the Plenipotentiaries of Colombia, Chile, Ecuador, Panama and Peru, in the Permanent Commission for the South Pacific, (*Comission Permanente del Pacifico Sur*, CPPS), signed the Convention and Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific. Technical support in the preparation, formulation, implementation and development stages of the Plan was provided by UNEP and the south-east Pacific region was the tenth regional plan covered by the Regional Seas Programme of UNEP (Figure 1.)



1. Mediterranean Action Plan
2. Caribbean Action Plan
3. West and Central African Action Plan
4. Eastern African Action Plan
5. Red Sea and Gulf of Aden Action Plan
6. Kuwait Action Plan
7. South Asian Seas Action Plan
8. East Asian Seas Action Plan
9. South Pacific Action Plan
10. South-East Pacific Action Plan

Figure 1. Marine Environment Regions covered by the UNEP Regional Seas Programme.

Like other regional Action Plans, that for the south-east Pacific is designed to link assessment of the quality and causes of deterioration of the marine environment with activities for rational management and sustainable development of such areas. In addition, the Action Plan aims to promote the parallel development of regional legal agreements and of action oriented programme activities.

REGIONAL CHARACTERISTICS

The South-East Pacific Regional Action Plan covers some 10,550 kilometres of coastline between 9°S in Panama and 57°S in Southernmost Chile. The Continental shelf is mostly narrow and the outline of the coast to the north is moderately straight with only two major semi-enclosed marine areas, the Gulf of Panama and the Gulf of Guayaquil. Below 42°S, the coastal morphology features substantial numbers of fiords, archipelagos, and islands. As a consequence of

its wide latitudinal range the region displays a variety of climates, from warm tropical, to cold and humid.

The five countries of the region (Panama, Colombia, Ecuador, Peru and Chile) have around 70 million inhabitants aggregated into a number of urban areas on the coast and inland. For the purposes of this review only the marine environmental problems resulting from the coastal cities are considered (Table 1)

Table 1. Major urban centres of the Pacific coast of South America.

Coastal Cities	Population (thousands)	Coastal Cities	Population (thousands)
Panama (1986)		Peru (1984)	
Panama City	750.0	Tumbes	104.0
		Piura	1,126.0
Columbia (1985)		Lambayique	674.0
		La Libertad	963.0
Buenaventura	193.2	Aucash	818.0
Tumaco	93.4	Lima	4,746.0
		Callao	443.0
Ecuador (1988)		Ica	434.0
		Arequipa	707.0
Esmeraldas	206.1	Moquequa	102.0
Eloy Alfaro	30.5	Tacna	143.0
San Lorenzo	13.2		
Portoviejo	244.4	Chile (1987)	
Jipijapa	101.1		
Manta	145.7	Arica	172.3
Montecristi	43.0	Iquique	135.2
Rovafuerte	77.1	Autofagasta	206.0
Bahia de Caraquez	110.4	Tocopilla	22.2
Guayaguil	2,370.6	Chanaral	12.8
Naranjal	49.7	La Serena	107.6
Manglaralto	36.9	Coquimbo	106.6
Salinas	87.8	Valparaiso	279.7
La Libertad	90.7	Vina del Mar	300.5
Santa Elena	29.7	Quintero	16.2
Playas	41.3	San Antonio	73.9
Machala	180.2	Constitucion	36.8
Puerto Bolivar	36.0	Talcahuano	233.2
Arenillas	32.2	Tome	48.8
Santa Rosa	60.9	Penco	34.9
		Lota	47.5
		Coronel	74.9
		Puerto Mont	114.2
		Castro	29.9
		Ancud	32.1
		Puerto Natales	17.1
		Punta Arenas	113.5

POLLUTANTS FROM LAND BASED SOURCES IN THE SOUTH EAST PACIFIC REGION

All major sources of waste were identified and the nature and as far as possible, the magnitude of each was determined for this review (CPPS/UNEP/IOC, 1988). Sources were considered either individually or collectively on the basis of their location. The mode of identification and quantification of contaminant sources varied according to the nature of the source, but included consideration of factors such as the numbers of inhabitants and production figures in relation to land area.

In the coastal areas of the south-east Pacific a certain overlap of waste source categories is inevitable, since in this area, both domestic and industrial waste discharges enter coastal waters, as direct and indirect discharges carried by rivers. The majority of municipal discharges flowing into the south-east Pacific are untreated, and in addition industrial effluents are usually discharged without prior treatment.

Domestic Sewage

Table 2 presents data on the municipal discharge by country, in terms of volume and associated organic loads while Figure 2 shows the geographic location of the major domestic discharge points into the south-east Pacific. The areas most affected by domestic wastes are: the Bay of Panama, Panama (D'Croz, 1987; Delgado & Manelia, 1987); Buenaventura and Tumaco, Colombia (Astralaga & Pulido, 1986; Angel *et al.*, 1986); Gulf of Guayaquil, Ecuador (Campana, 1986); the coast off Lima and Callao, Peru (Conupoma *et al.*, 1986; Soldi *et al.*, 1987); and the Bays of Valparaiso and Concepcion, Chile (Bore *et al.*, 1986).

In Panama approximately 72 million m^3yr^{-1} with an associated 14,000 ton yr^{-1} of five day biochemical oxygen demand (BOD_5) are discharged into the Pacific Ocean through direct or indirect discharges via three small rivers. The domestic waste discharges into Panama Bay from the city of Panama account for 92 % of the country's total organic discharges into Pacific Ocean.

Table 2. Major municipal discharges in the south-east Pacific region.(Estimated 5 day Biological Oxygen Demand (BOD_5) -coefficient based on WHO, 1982.)

Country	Volume of discharge 10^6 m^3yr^{-1}	BOD_5 10^3 ton yr^{-1}
Panama	72	14
Colombia	6.1	3.4
Ecuador	108	28.6
Peru	605	185.9
Chile	709	140.1

In Colombia, pollution due to domestic wastes in largely associated with municipal discharges originating in the towns of Buenaventura and Tumaco. These discharges amount to approximately 6 million m^3yr^{-1} with an organic load estimated at 3,400 ton yr^{-1} BOD_5.

The Principal area of Ecuador affected by such pollution is the Gulf of Guayaquil. The largest volume discharged, 78.5 million m^3yr^{-1} with a BOD_5 of 17,400 ton yr^{-1} comes from the city of Guayaquil. This represents 60 % of the total annual organic load (28,600 ton yr^{-1} BOD_5) associated with domestic discharges from Ecuadorian coastal cities.

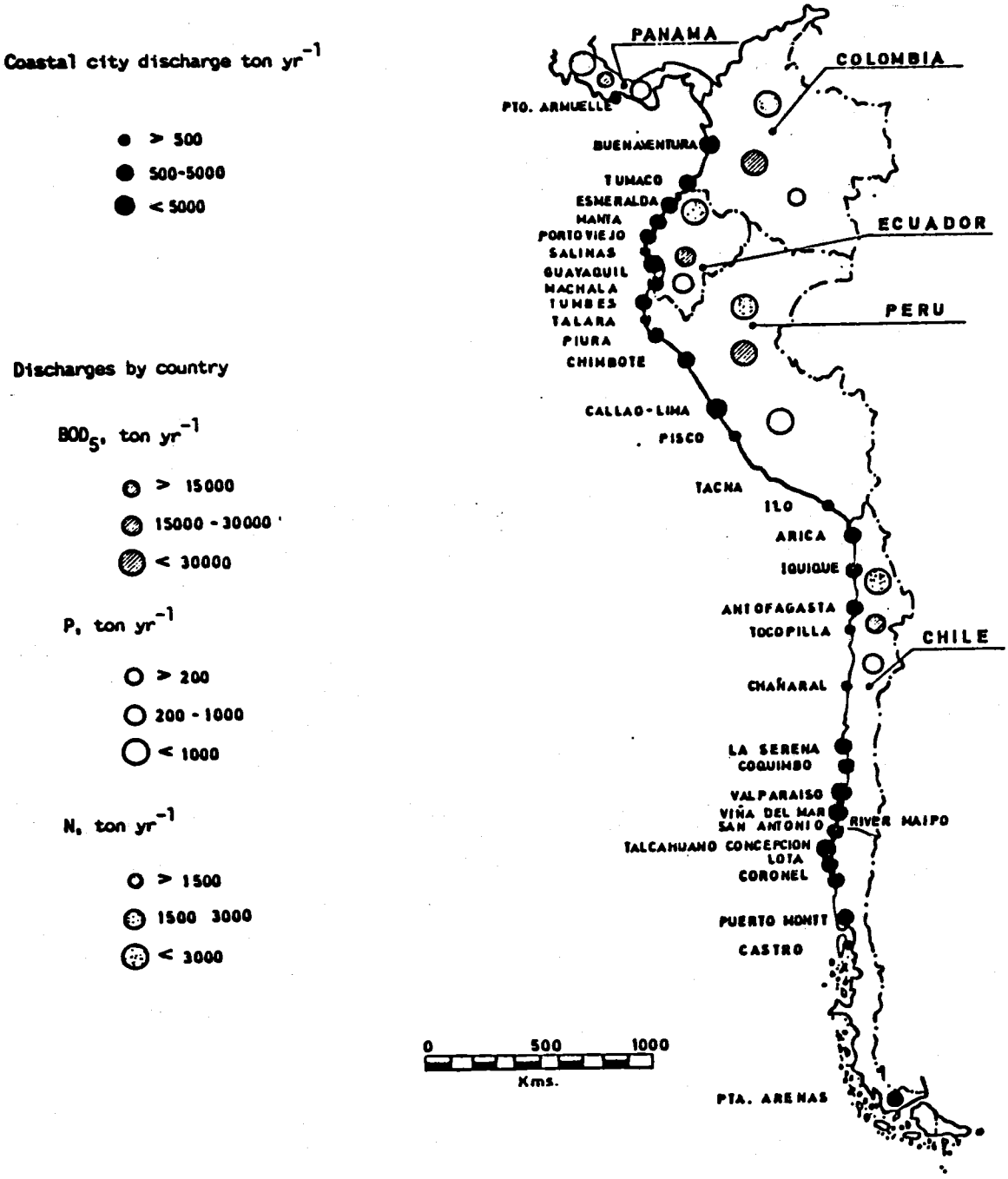


Figure 2. Location of major domestic waste discharges in the south-east Pacific and associated BOD_5 resulting from nitrogen and phosphorus.

In Peru, the coastal area of the metropolitan section of Lima receives effluents totalling 278.3 million m^3yr^{-1} . The organic load associated with direct discharges has been estimated at 85,500 ton yr^{-1} BOD_5. The total Peruvian municipal waste discharges reach approximately 605 million m^3yr^{-1} with a BOD_5 equivalent to 185,900 ton yr^{-1}.

In Valparaiso Bay in Chile, the Maipo River discharges all domestic wastes from the city of Santiago, and this Bay together with Concepcion Bay are the most heavily polluted areas in the country. The total discharges of the whole country reach 709 million m^3yr^{-1} and the organic load associated with these discharges is estimated at a BOD_5 equivalent of 140,100 ton yr^{-1}.

Industrial Waste Water

Table 3 indicates the level of industrial discharges by country, their volume and associated organic load while Figure 3 shows the distribution and location of industrial activities which result in direct and indirect discharges into the south-east Pacific. Figure 4 shows the geographic location of the major mine tailings discharge points, areas of mining activity and potential sources of metal pollution in the region.

In Panama, industrial activity is almost exclusively concerned with the processing and production of foodstuffs, and most of this activity is located in and around the city of Panama. Approximately 6 million m^3yr^{-1}, of industrial wastes with an estimated organic load of 7,000 ton yr^{-1} BOD_5 are discharged into the Bay of Panama.

Table 3. Industrial discharges in the south-east Pacific region.(Estimated BOD_5 -coefficient based on WHO, 1981.)

Country	Volume of discharge 10^6	BOD_5 10^3 ton yr^{-1}
Panama	6	7
Columbia	0.3	43
Ecuador	26.4	5.5
Peru	47.2	14.3
Chile	244.4	67

The principal industrial discharges in Colombia, originate near Buenaventura and Tumaco and coastal waters receive an annual volume of effluents equivalent to 300,000 m^3yr^{-1} with an organic load estimated at 43,000 ton yr^{-1} BOD_5 from these sources.

In Ecuador the volume of industrial effluents discharged to coastal waters totals 26.4 million m^3yr^{-1} with a BOD_5 of 5,500 ton yr^{-1}.

Industries are more widely distributed along the coast of Peru but even here, 65% of the total discharges of 47.0 million m^3yr^{-1} (14,400 ton yr^{-1} BOD_5) are concentrated in the metropolitan area of Lima.

Pollution of the marine environment in Chile from industrial sources largely results from copper mining, cellulose and paper factories, fishmeal and fish oil production industries and oil refineries. The two most polluted areas of Chile, Valparaiso and Concepcion bay receive an annual volume of industrial effluents equivalent to 244.4 million m^3yr^{-1} with an associated BOD_5 of 67,000 ton yr^{-1}.

Mining pollution from tailings and residue discharge to the coastal marine environment is a problem largely confined to certain coastal areas of Peru and Chile (Figure 4).

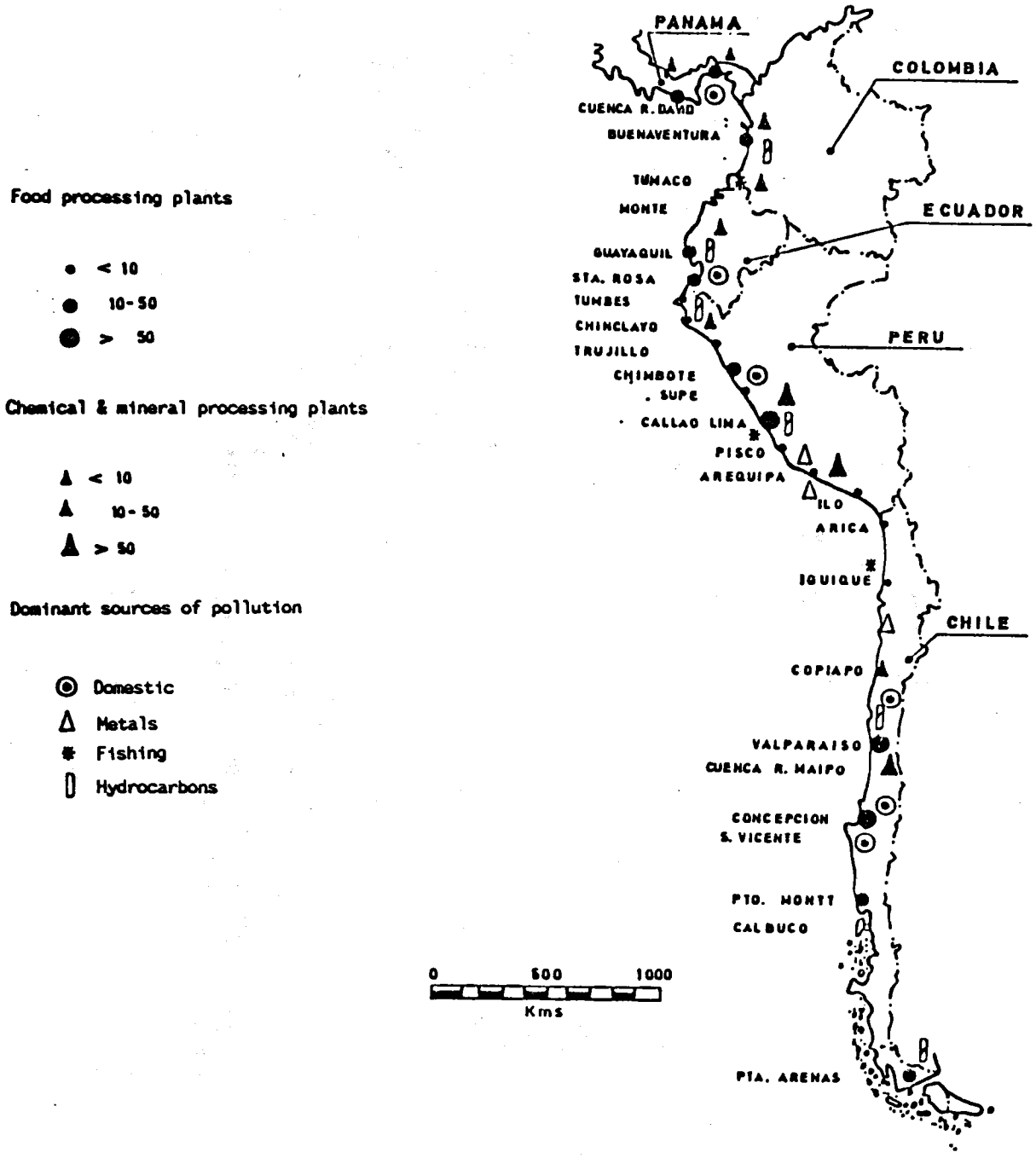


Figure 3 Distribution and location of industrial activities which result in direct and indirect discharges into the south-east Pacific.

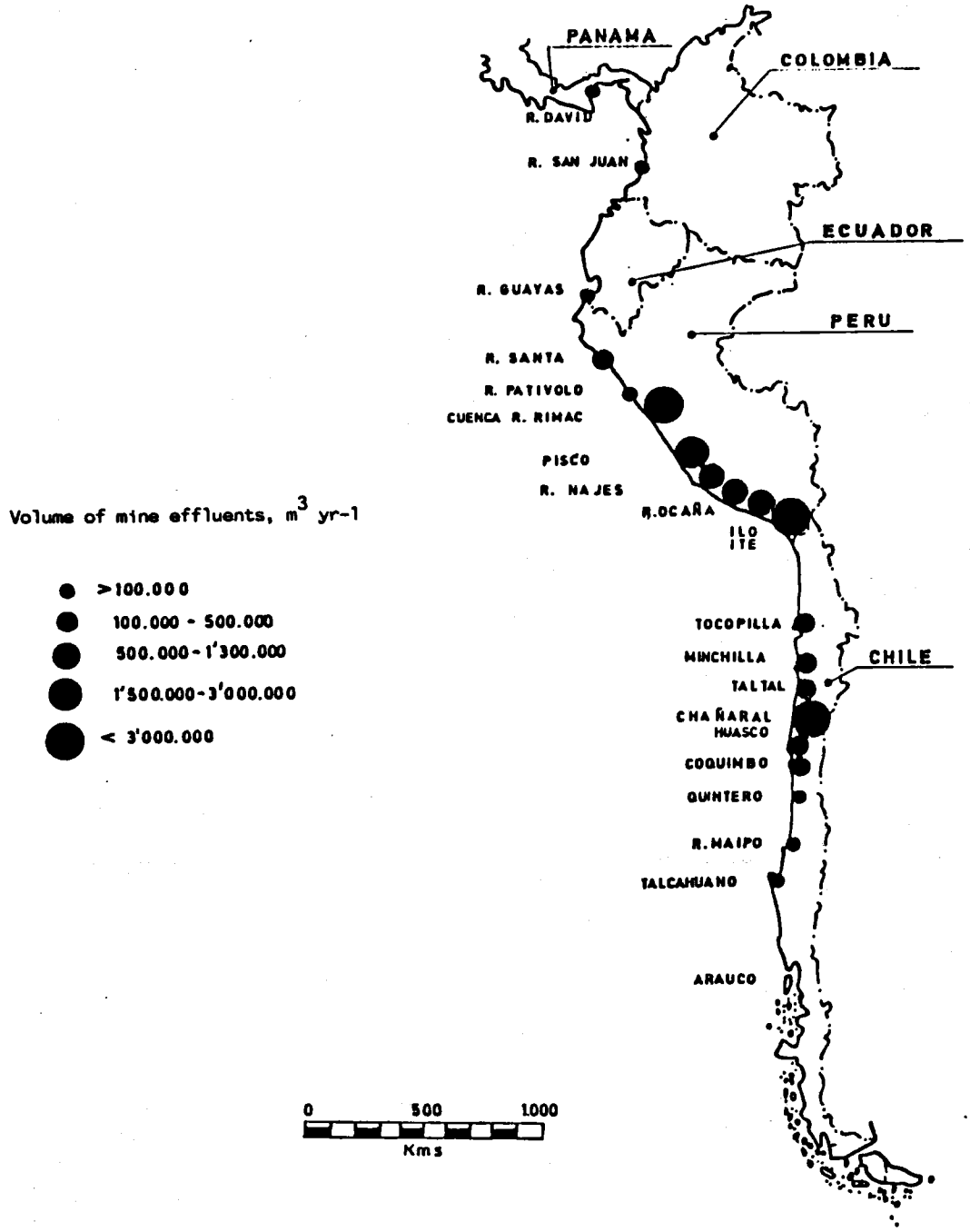


Figure 4. Main mining and tailings disposal areas, potential sources of metal pollution in the south-east Pacific.

Oil transport

The patterns of oil transport in the south-east Pacific depend on foreign trade and internal coastal trade requirements. Ecuador, Peru and Colombia are the principal oil producing countries of the region producing more than 90 % of the total. Nearly two thirds of all regional production is traded, and exports account for almost twice the import figure. The transport of oil and oil by-products is operated through seventeen oil terminals and nine coastal refineries established throughout the region. Figure 5 shows the main oil maritime traffic routes in the south-east Pacific and Figure 6 summarizes the current status of the coastal environments of the region illustrating the main polluted areas of the south-east Pacific.

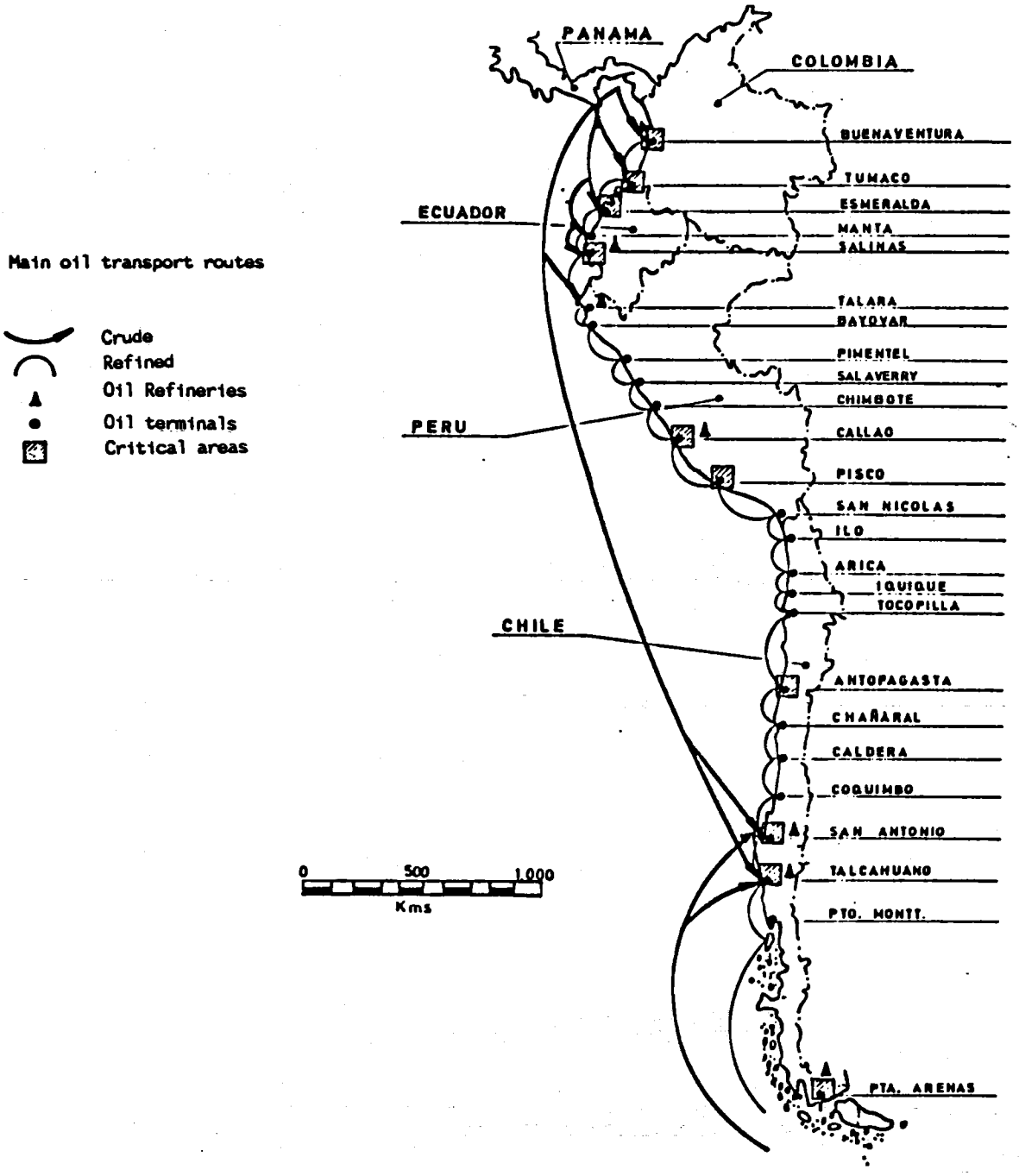


Figure 5. Main marine traffic routes for oil transportation in the south-east Pacific.

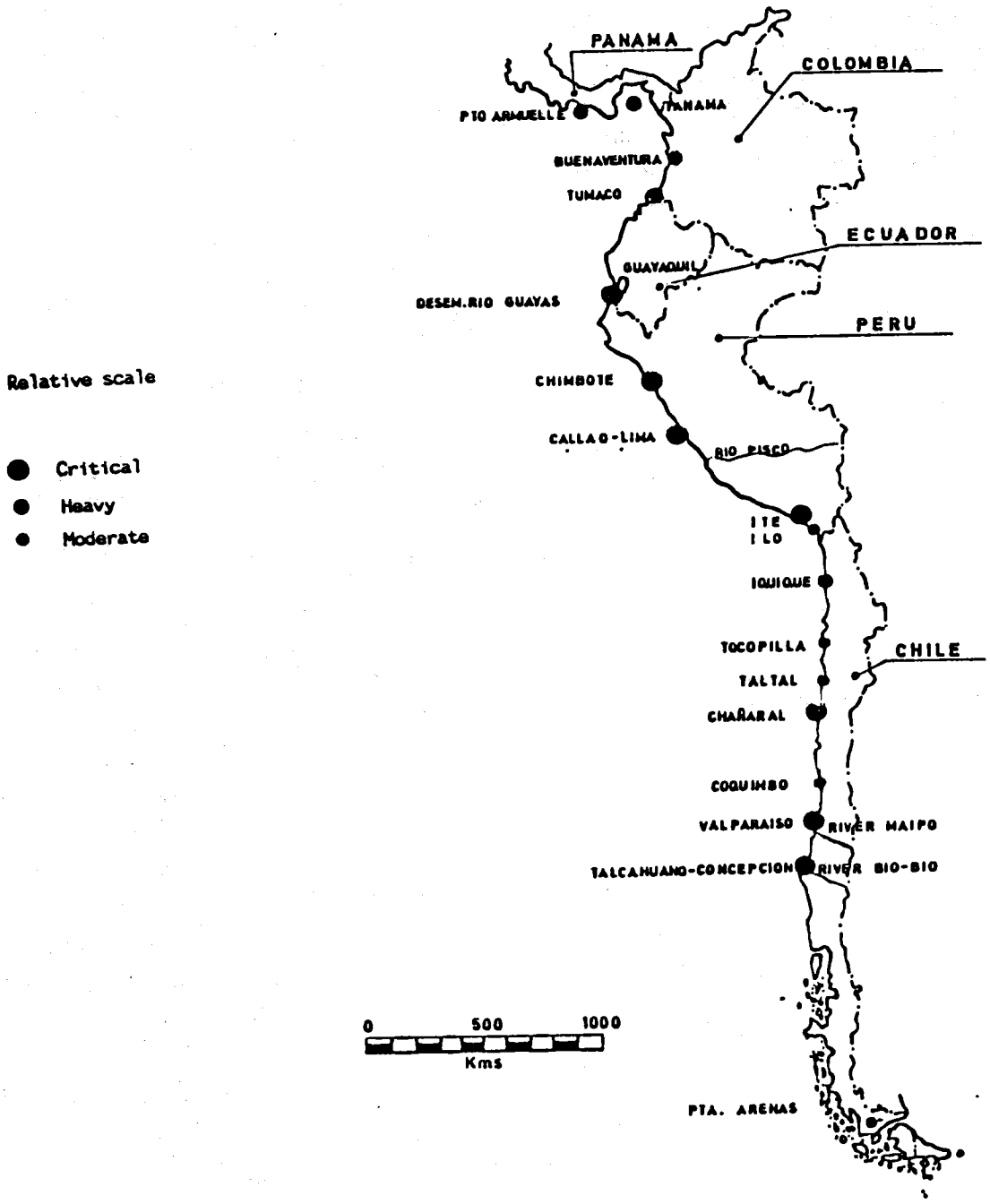


Figure 6. Areas of the south-east Pacific with major pollution problems.

PREVENTION AND CONTROL

Prevention of pollution should be stimulated by activities designed to study and apply pollution control methods to problems of coastal water pollution due to the discharge of untreated municipal sewage. In this regard, due consideration should by given to alternative treatment and disposal methods based on local geographic and climatic conditions including the provision of primary waste stabilization ponds.

An important alternative to the present marine waste discharge systems might include, submarine outfalls designed to utilize the total available waste assimilation capacity of the natural environment. Such an approach would keep costs to a minimum. It is important to emphasize, that there is an enormous difference between merely dumping or discharging raw waste into the ocean via rivers and in discharging wastes through well engineered and properly designed submarine out-fall and diffuser systems. Such systems should include adequate control of chemical pollutants and buoyant solid wastes which must be eliminated at source. Present deficiencies in the operation and maintenance of sewage handling facilities and in the training of operators should receive increased attention.

The application of economically sound treatment methods and processes for various industrial wastewaters should be promoted, and the best practicable technology applied. Such methods should aim to reduce pollution at the source and to provide for the conservation and possible reuse of substances which are particularly hazardous and/or consist of valuable material resources.

A legal framework for a strategy to prevent and control marine pollution in the south-east Pacific Region exists in the legal instruments which include a convention and its three complementary protocols. These were developed within the framework of the regional Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific and are currently being implemented by the Governments of Panama, Colombia, Ecuador, Peru, and Chile with the support of the United Nations Environment Programme, and other international agencies. The Action Plan is co-ordinated by the Permanent South Pacific Commission, the CPPS.

The internationally agreed legal instruments governing the prevention and control of marine pollution in the region are as follows:

1. Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific; Lima, Peru, November 1981.

2. Agreement for Regional Co-operation to Combat Pollution of the South-East Pacific due to oil Hydrocarbons and Other Noxious Substances in Cases of Emergency; Lima, Peru, November 1981.

3. Complementary Protocol to the Regional Co-operation Agreement to Combat Pollution of the South-East Pacific due to Oil Hydrocarbons and Other Noxious Substances in Cases of Emergency; Quito, Ecuador, July 1983.

4. Protocol for the Protection of the South-East Pacific against Pollution from Land Based Sources; Quito, Ecuador, July 1983.

These four legal instruments were ratified by subscribing Governments and entered into force, in 1987. They form the basis for future regional cooperation in addressing the issues of coastal and marine pollution in the south-east Pacific.

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OIL HYDROCARBONS IN THE SOUTH-EAST PACIFIC REGION

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ABSTRACT

Concentrations of dissolved/dispersed oil hydrocarbons in shallow waters, in marine animals and bottom sediments have been measured in samples collected from 18 critical areas along the Pacific Coast of Latin America from Panama to Concepcion in Chile. These data represent the results obtained through the development of the programme entitled "Research, monitoring and control of pollution by petroleum hydrocarbons, and their effects on marine communities in ecologically sensitive areas of the south-east Pacific", undertaken as part of the South-East Pacific Action Plan.

Data have been derived from reports submitted by countries to the regional coordinating unit (CPPS). More than 1,100 measurements have been obtained for petroleum hydrocarbon concentrations in coastal areas and information is provided on those areas having the highest concentrations between 1985 and 1988, of: dissolved/dispersed petroleum hydrocarbons; tar on beaches; hydrocarbons in beach sand, in benthic sediments and in marine organisms. In addition some general considerations concerning the study area are included, as well as details of the methods of analysis and the sources and input of petroleum hydrocarbons in the south-east Pacific region.

General Information

The zone referred to as the "South-East Pacific" covered under the "Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific", extends from 9^{o} north in Panama to 56^{o} south in Chile. This continental area, located between the Andes mountain range and the Pacific Ocean has an approximate length of 105,000 km and an average width of 300 km. The shoreline is generally rather straight except for the Gulfs of Panama and Guayaquil and other small bays. South of latitude forty two degrees a large number of fiords, archipelagos and islands are present, forming the so called "Channels of South Chile". Several rivers cross the region, short in course but quite torrential, carrying waters from the Andes to the Pacific and carrying with them a relatively large amount of sediment which is deposited on a narrow continental shelf of average width around 17 km in Panama, 24 km in Colombia, 28 km in Ecuador and which is reduced to a mere 6.5 km in Chile (Gallardo, 1984).

The climate of the region is variable; between Panama and part of Ecuador, temperatures fluctuate between 23 and $28^{o}C$ (Gallardo, 1984), while rainfall reaches 10,000 mm yr^{-1} in some areas (CPPS/PNUMA, 1988d). Between the southern part of Ecuador and northern Peru ($10^{o}S$) mean temperatures range from $20^{o}C$ to $25^{o}C$, while rainfall varies around 1,000 mm yr^{-1}. From $10^{o}S$ in Peru to $20^{o}S$ in northern Chile, temperatures range from 15 to $25^{o}C$ and rainfall does not go beyond 20 mm yr^{-1} some areas lack precipitation entirely. In Chile, between 20 and $30^{o}S$, desert climates predominate and rainfall reaches 160 mm yr^{-1} in the south of this region. Between 30 and $50^{o}S$ the climate is temperate, mean annual temperatures fall from $18^{o}C$ to $13^{o}C$ while rainfall increases reaching 3,000 mm yr^{-1}. From $50^{o}S$ the weather gets colder and wetter, with mean temperature and rainfall of $6^{o}C$ to $7^{o}C$ and 5,000 mm yr^{-1} respectively (Gallardo, 1984).

In the southern region of Chile (Figure 1) the Antarctic Circumpolar Current approaches from the west to the coast, reaching the continent between 40 and 45°S, it results in a very complex current system to the north, while the Coastal Cape Horn current is formed to the South. To the North the currents originating from the Circumpolar current divide into two components going northwards, one along the coast, the other towards the ocean, separated by an opposing current flow. The coastal branch of this northern Humboldt Current follows the coastal topography and is diverted to the West around 5°S when it meets the Equatorial Front; along its path several cyclonal and anti-cyclonal eddies are to be found (Gallardo 1984).

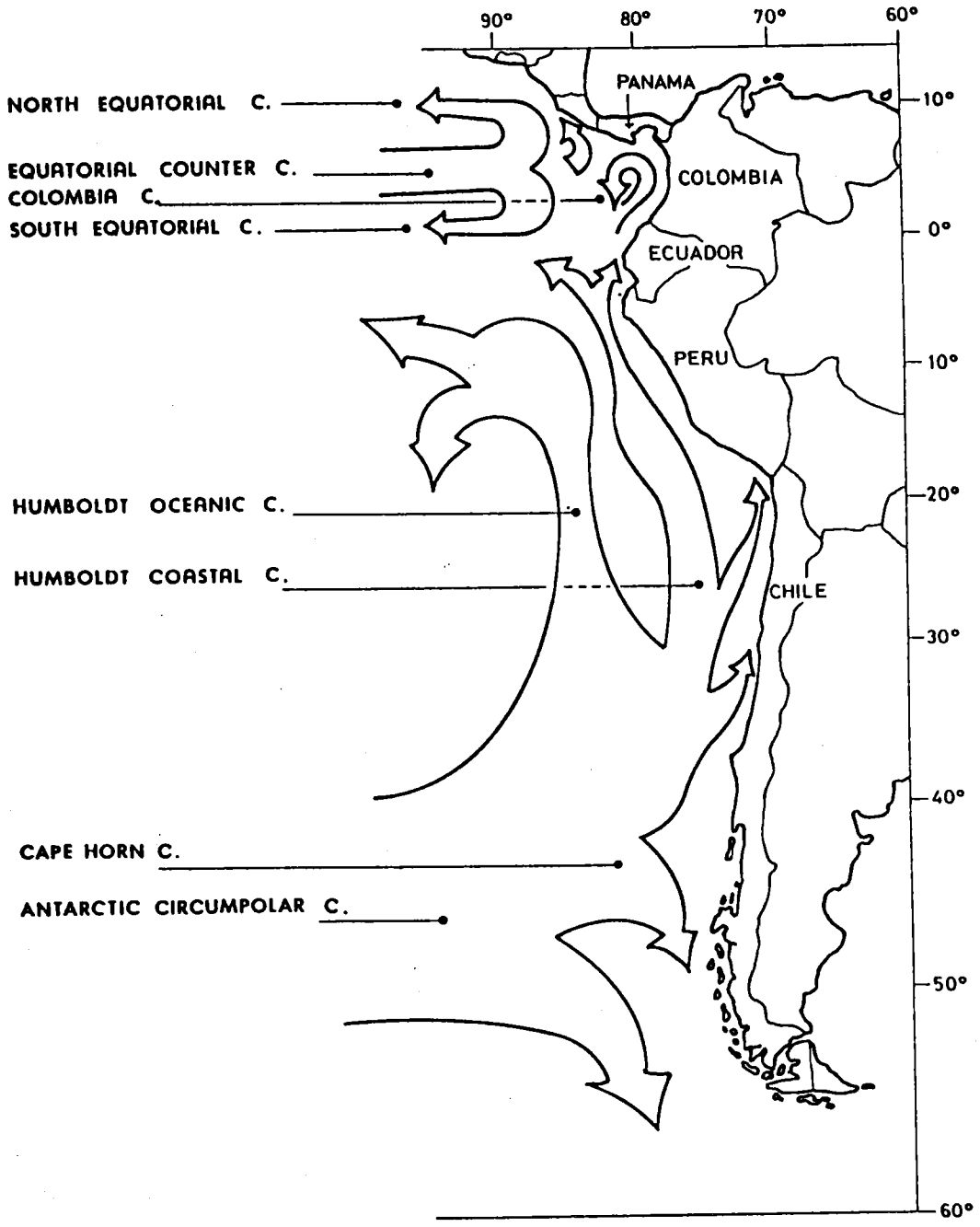

Figure 1. Major surface currents in the south-east Pacific region (based on: Report of the State of the Marine Environment in the South East Pacific region)

The coast of Ecuador is influenced by the eastern part of the Equatorial Front which moves from a northerly to southerly position during winter and summer. This front alters the northwards flow of the coastal branch of the Humboldt Current hence altering climate and circulation in this region (Salcedo, 1988).

The coastal surface circulation, in much of Panama and Colombia reflects the cyclonic circulation of the so-called Colombia current. At Panama Bay, it flows northwards along the coast at a rate of 0.5 knots (Kwiecinsky, 1981; 1986), and reaches a top flow of 1.5 knots during spring tides (D'Croz, 1988).

In the areas close to the shore and particularly in bays, the surface circulation is altered by a variety of local factors. In one of the latest reports produced under Ecuador's Action Plan (Salcedo, 1988), several flow rates are given in the vicinity of the shore. In Esmeraldas, velocities were measured between 0.57 and 1.31 knots moving northeastwards. Winds and discharges from Esmeraldas river contribute to the direction and strength of flow. At Manta Port, the direction of flow is similar to that at Esmeraldas, with values between 0.08 and 0.63 knots. On the inner part of Santa Elena Bay currents fluctuate between 0.54 and 1.19 knots in a nor'nor'easterly direction. In Bolivar Port circulation is determined by the tidal regime, flowing southwards on the rising tide and northwards on the falling tide. Maximum velocity reaches 1.26 knots during the rising tide.

Near-shore in the vicinity of Callao (Peru), prevailing surface currents flow from North to South (Sanchez de Benités & Soldi, 1988).

In Chile, at Valparaiso Bay, there are some areas with currents following the coast from North to South, and others flowing from South to North (Instituto Hidrografico de la Armada, 1984). The coastal zone at Concepcion is dominated by the northwards flow of the Humboldt Current, modified on a local scale by prevailing winds. In summer, winds from the southern quadrant generate surface currents which move northwards; in winter, prevailing winds from the north produce south moving surface currents. San Vicente Bay, near Concepción, has a West facing entrance, shallow depth and coastal relief which amplify wind action, generating turbulence and reducing the time needed for water recharge; hence preventing residue accumulation. Concepcion Bay is dominated by upwelling between September and April and by estuarine conditions from April till August under the influence of the Bio-Bio River.

Panama and Colombia have the only coral reef habitats in the South East Pacific, this habitat being reduced and discontinuous to the South as a result of the influence of the cold Humboldt Current. Mangrove ecosystems are located along the low-lying coastal areas of Panama, Colombia, Ecuador and northern Peru. To the South, there are coastal pelagic ecosystems of high primary productivity with values around 100 gC m^{-2} yr^{-1} which support a high production of anchovy, sardine, jurel and a dense population of guano producing seabirds. In southern Chile, ecosystems of the Channel Zone, are highly suitable for bivalve mollusc and salmonid aquaculture.

Sources and input of Petroleum Hydrocarbons in the south-east Pacific

According to Gallardo (1984), the annual discharge of hydrocarbons through domestic sources to the coastal waters of the region, is of the order of 6,000 tonnes. If this is compared to the "Metula" spill of 52,000 tonnes in the Strait of Magellan, or the "Cabo Tamar" spill in San Vicente Bay of 12.000 tonnes, then terrestrial contributions may be considered insignificant. From a global perspective it is interesting to note that, generally speaking, the rate of oil loading and unloading along the coast is relatively low, except for areas such as Panama, Esmeraldas, Callao and Magellan (Gallardo *op cit.*). According to Vergara and Pizarro (1981) transport of hydrocarbons in the south-east Pacific region during 1980 involved 60 millions m^3. Accidental spillage between 1965 and 1978 was almost 3 times greater in relation to the volume transported compared to other marine areas of the world. The occurrence of major spills, as in the case of the accidents along the Chilean coasts between 1973 and 1978, would however bias such statistics.

Regardless of the more general considerations, there are some areas along the south-east Pacific coast that may be considered as susceptible to hydrocarbon pollution (Figure 2) and a regional contingency plan has been developed (CPPS/PNUMA/OMI, 1986).

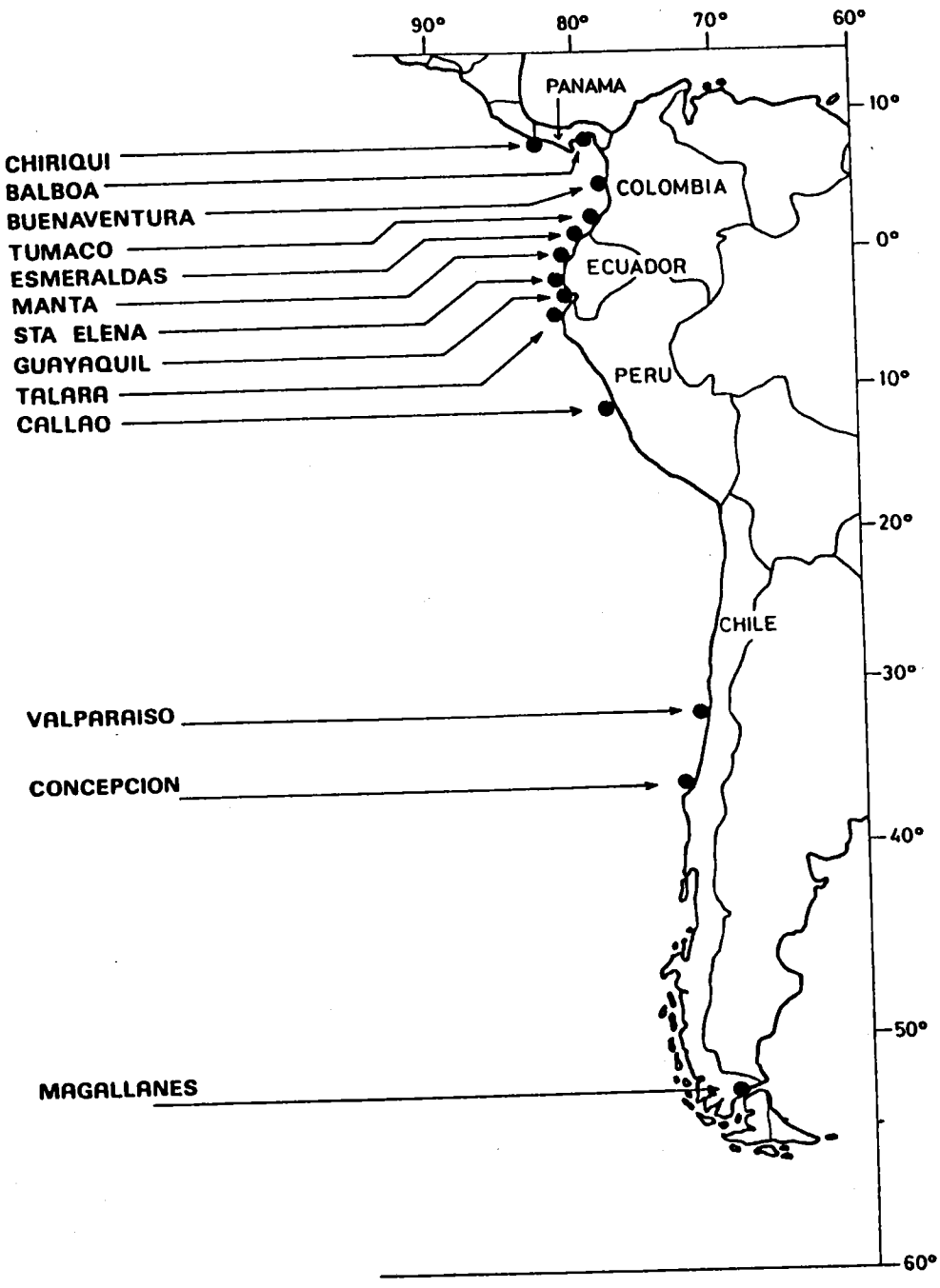

Figure 2. Areas susceptible to pollution by petroleum hydrocarbons in the south-east Pacific (Escobar, 1988a;1988b).

Panama is prone to pollution as a consequence of the high volume of shipping traffic passing through the Canal (Figure 3). It has a petroleum tanker fleet of approximately 8 million Gross Registered Tonnes (GRT). Records from 1973 to 1984 indicate that an average of 2.5 million ton yr^{-1} of oil are handled in the Pacific terminal of the Panama Canal for refueling approximately 1.900 ships yr^{-1}. The average oil spilled from these operations is 200 ton yr^{-1} (D'Croz, 1988). The fishing port of Vacamonte, located less than 20 km from Balboa, is reputed to have a spillage rate of 500 ton yr^{-1} (CPPS/PNUMA, 1988). The Pacific Terminal of the trans-isthmus oil pipeline is located in Charco Azul Bay, in the Gulf of Chiriqui, and between 1979 and 1981, 25 spills of between 1 and 800 m^3 were recorded (CPPS/UNEP/IOC, 1988).

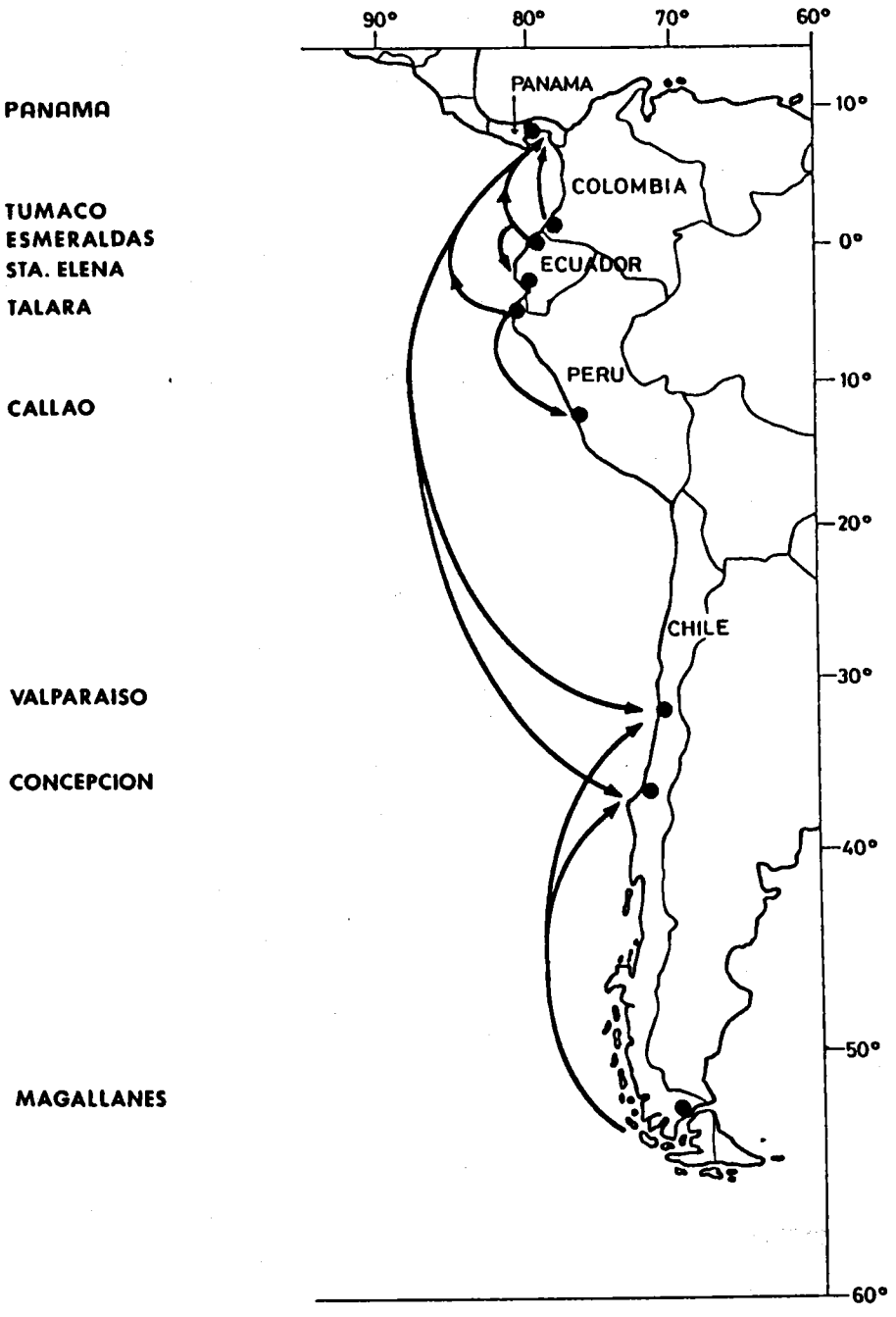

Figure 3. Major oil maritime traffic routes in the south-east Pacific

Panama Bay is an area of high biological productivity with good aquaculture potential, prawn and artisanal fisheries, tourist and recreational zones. Tidal range reaches 5 m in some areas and the Sensitivity Index of the coastal profile reaches 9.

As far as the Colombian Pacific coast is concerned, two critical areas have been identified, Buenaventura and Tumaco (Direccio General Maritima y Portuaria, 1985; Rodriguez, 1981). The pollution source of hydrocarbons in Buenaventura, is from shipping movements involving the loading and unloading of 2,356,862 tonnes of cargo (data for 1986, CPPS/PUMA, 1988b), but more importantly from fishing fleet discharges (135 ships) and possibly also from the oil unloading terminal. An oil terminal is located in Tumaco Bay, which receives and stores crude oils coming from a 305 km trans-Andes oil pipeline ending in two undersea lines 36 inches in diameter and 7.5 km long. The terminal also has 4 storage tanks with a total capacity of 145,000 m^3. In Colombia, an oil spill accident occurred involving the tanker "Saint Peter", which spilled between 3000 and 15000 tonnes of oil in 1976, off Tumaco; it covered an area of 120 km^2 and moved 450 km from the accident site. The coast between Buenaventura and Tumaco is low, liable to flooding and covered by mangrove swamps. Tidal range varies around 4 m and the Sensitivity Index of the coastal profile is between 5 and 9 (CPPS/PNUMA, 1988b). Prawn fishing is one of the main resource uses in the area which also has a high potential for aquaculture. (CPPS/UNEP/IOC 1988).

In Ecuador, the areas most prone to pollution by oil hydrocarbons include, Esmeraldas, Manta Port, Santa Elena Bay and the Gulf of Guayaquil, including the estuary and ports of Guayaquil and Bolivar. Oil produced in Ecuador is carried across the Andes via an oil pipeline terminating at Esmeraldas. The annual production in 1986 was about 17 million m^3, 70 % of which is exported (Solorzano, 1988). There are two coastal refineries in Ecuador: Esmeraldas, with a processing capacity of between 6.500 and 8.000 m^3 day^{-1}, which is connected by an under water oil pipeline to a terminal at Balao; and, La Libertad refinery (Santa Elena Bay) also with an underwater oil pipeline. Oil spills calculated for Ecuadorian coastal waters total approximately 1600 m^3 yr^{-1} (Solorzano, 1988). The coastal sensitivity index reaches 10, in several sectors (CPPS/PNUMA, 1988b). Northern areas of Esmeraldas and Guayaquil are fringed with mangrove swamps and the whole area is biologically highly productive. Near the mangrove swamp area, prawn aquaculture has been developed, and this is now one of the main economic activities. In Guayaquil there are about 90,000 ha (90 km^2) devoted to prawn production (CPPS/UNEP/IOC, 1988).

In Peru, pollution by oil is mainly the result of emissions in the exploration and drilling areas on the continental shelf (CPPS/UNEP/IOC, 1988). Between Paita and Punta Aguja, in northern Peru, there are 84 marine oil platforms and the oil is refined at three coastal establishments: Talara, located in the north of the country, produces 500.000 m^3 yr^{-1} and is supplied with 2 underwater oil pipelines 2 km long; la Pampilla, located northwest of Callao, produces 700.000 m^3 yr^{-1}, has three sub-marine lines 4 to 7 km in length; and, Conchan, located to the south of Callao, produces 107.000 m^3 and has two pipe-lines 1 km in length (Sanchez de Benites and Soldi, 1988). In 1978, the underwater oil pipeline at Talara was broken, spilling 400 m^3 of crude oil which reached the beaches of Miraflores. Oil residues covering areas of 100 to 1,000 m^2 were found in the sand; some benthic organisms were affected 20 km away from the site of the accident (Sanchez de Benites and Soldi, 1988). In Bayovar, South of Paita, there are facilities for storing 15.000 m^3 of oil coming from fields in the inland Peruvian jungle.

The main oil pollution sources in Chile are from shipping traffic and oil exploration and extraction. In 1987 shipping traffic in along the coast involved 7.800 vessels calling at around 40 ports. In addition the fishing fleet must be included since fishing is one of the most important activities in the country, with a total harvest in 1988 of 5,374,722 tonnes (SERNAP, 1988). Oil production in Chile is based on 23 drilling platforms in the Straits of Magellan, and production in 1984 was 2,237,000 m^3. The total spillage in Chile between 1973 and 1986, was approximately 100,000 tonnes, including the "Metula" disaster in the Strait of Magellan in 1974 with a loss of 52,000 tonnes; the "Napier" accident near Chilloe, in 1973, with losses of 30.000 tonnes; and, the "Cabo Tamar" spill in Concepcion in 1978 with losses of 12.000 tonnes. In 1987, spills detected

totalled around 5,800 tonnes, the most important of which was one in the Straits of Magellan involving losses of 5,500 tonnes.

Three critical areas have been identified along the Chilean coast from the perspective of pollution by hydrocarbons: Valparaiso, Concepcion and the Straits of Magellan. In Valparaiso, 1,500 craft used the bay in 1987 and the Conconsepcion refinery with a capacity of 3,700,00 m^3 is also located in the city. In 1975, to the North of Valparaiso, the "Northern Breeze" spilled 440 tonnes of which, 200 tonnes affected 46 km of rocky and sandy beaches, where 6% of the intertidal zone was effectively contaminated (Castilla *et al.*, 1977). The coast of Valparaiso has a mixture of sandy beaches, steep and exposed rocky and some sheltered rocky shores. Tidal range is 1.80 m and the coasts have been assigned a sensitivity index rating of between 1 and 3. The presence of a high volume of maritime traffic, refineries, terminals and storage tanks for hydrocarbons, and the presence of important tourist centres, all contribute to the designation of this as a critical area.

In 1987, Concepcion handled shipping traffic totalling 820 vessels with a cargo of 11,174,000 tonnes corresponding to 30 % of the country's total shipping cargo. The fishing fleet unloads about 1,934,000 ton yr^{-1}, and the San Vicente oil-refinery has (near Concepcion) a capacity of 4,200,000 m^3 yr^{-1}. In addition discharge from the Bio-Bio River of around 206,000,000 l day^{-1} of liquid residues pass into this Bay (Bore *et al.*, 1986). There is one terminal for crude oil products and two terminals for refined products. Population density is high, with almost one million inhabitants and the city is the most industrialized in the country. Concepcion has beaches with fine sand, together with steep and exposed rocky shores, and the tidal range is approximately 1.9 m; the sensitivity index rating is 3.

During 1988, around 1,200 ships of large tonnage operated in the Straits of Magellan in the far South of Chile, together with intense traffic between the Pacific and Atlantic oceans. In these waters there are 23 oil platforms which produced in 1984, 2,237,000 m^3 of crude oil (Vio, 1983; Bore *et al.*, 1986). There are also 2 refineries and 4 terminals for hydrocarbons (CPPS/PNUMA, 1988b). In some places tidal range in the Straits of Magellan reaches 10 m. The coast is a mixture of sandy and rocky shores, and in some places sand, pebble and estuarine areas. The sensitivity index is rated between 6 and 7. Currents fluctuate according to tides and wind and velocities 3 m sec^{-1} have been measured. Wind speeds are around 20 m sec^{-1} gusting to 50 m sec^{-1} with rapid shifts in direction.

Methodology

The programme entitled "Research, Monitoring and control of Pollution by Petroleum Hydrocarbons, and their effects on Marine Communities in Ecologically Sensitive Areas of the South East Pacific", (CPPS/PNUMA, 1983;1984) was initiated using the recommended methods contained in "Compilación de los Metodos de Muestreo y Tecnicas Analiticas" produced by and distributed by the CPPS to participating laboratories. This compilation is a supplement to the Guide to Operational Procedures for the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring, and the document "The Determination of Petroleum Hydrocarbons in Sediments", (CPPS/PNUMA/COI 1987). The above "Compilation" contains some methods and procedural aspects which are not definitive and which are currently under revision.

Oil hydrocarbons were analysed using spectrofluorometric techniques, with Crisene as the reference material and extraction with hexane. It is important to note that the lack of personnel qualified in sampling and analytical procedures combined with a lack of materials did not permit collection of sufficient data to allow statistical analysis and determination of the level of significance of the results.

When the programme commenced, these problems were addressed by the Action Plan through provision of regional courses on analytical techniques and intercalibration exercises agreed during the second session of the Expert Group held in Ecuador, in 1985. Having obtained results from one intercalibration exercise, an IOC expert visited different laboratories of the

region and made several recommendations on methods, for implementation by participating institutions during the programme continuation.

Experts from regional countries have attended two courses carried out with the help of CPPS, UNEP, IOC and IOCARIBE for training in analytical techniques used in hydrocarbon determination. Available records, and the data collected provide assurance that the quality of results has been considerably improved during the course of this programme.

Concentrations of Petroleum Hydrocarbons (Tables 1-6)

Values presented in Tables 1 to 6 are derived from country reports sent to the Regional Coordinating Unit (CPPS), between the start of the programme in 1985 and 1989. From these results it can be seen that:

The highest mean concentration of dissolved/dispersed hydrocarbons in water at Balboa Port, Panama, were found in 1985, with an average of 12.9 ug l^{-1} and a maximum of 70 ug l^{-1}. In Colombia (Tumaco), concentrations were considerably lower than in Panama, and the average for 1985-1987 was 4.5 ug l^{-1}, while the maximum value reached was 10.6 ug l^{-1}. In 1985, Ecuador showed the highest average value for the region in the Port of Bolivar, 202.7 ug l^{-1}; the average, minimum concentration in Ecuadorian waters was only 2.1 ug l^{-1} in the area of Santa Elena Bay.

The lowest concentrations in the region were measured in Peru with an average of only 0.2 ug l^{-1} and a maximum of 0.6 ug l^{-1} in the area of Callao. In Chile, during 1985, mean concentration was 19.3 ug l^{-1} with a maximum of 66.0 ug l^{-1} in Valparaiso Bay; in the same area, concentration was reduced to 8.7 ug l^{-1} in 1988 while the minimum concentration of 7.1 ug l^{-1}, is the highest in the region. All data analyzed between 1985 and 1988 are found to be within these values and, in general, it can be said there is a reduction in dissolved and/or dispersed hydrocarbon concentrations in sea-water, from 1985 to 1988.

Data for tar on beaches show that the highest values have been measured in Panama Bay, 91,160 mg m^{-2}. In decreasing order are: Valparaiso (Chile), 2,600 mg m^{-2}; the area between Ancon and Posorja (Peru), 578.0 mg m^{-2}; and the lowest values are found on the beaches of Santa Elena Bay (Ecuador), 0.7 mg m^{-2}.

Table 1. The concentrations (ug l^{-1}) of dissolved/dispersed petroleum hydrocarbons in shallow waters of the south-east Pacific region in 1985 (Tumaco values taken over the period 1985-1987; n = number of samples).

Area	Mean	Max.	Min.	n	References
Panama Balboa Port 9° N.	12.9	70.0	0.5	24	Com. Nac. Med. Amb. 1988 (F.5)
Colombia Tumaco 1°50' N.	4.5	10.6	0.3	47	CPPS/PNUMA, 1988
Ecuador Bolivar Port 3°30' S.	202.7	1,310.0	0.2	28	CPPS/PNUMA, 1988
Peru Callao 12° S.	0.2	0.6	0.1	26	CPPS/PNUMA, 1988
Chile Valparaiso 33° S.	19.3	66.0	2.0	36	Instituto Oceanologia, 1985

Table 2. The highest concentration (ug l^{-1}) of dissolved/dispersed petroleum hydrocarbons in shallow waters of the South East Pacific region in 1988 (Values for Tumaco 1983-1987; n = number of samples).

Area	Mean	Max.	Min.	n	References
Panama					
Balboa Port 9°N.	12.4	54.3	0.2	6	Com. Nac. Med. Amb., 1988.
Colombia					
Tumaco 1° 50'N.	4.5	10.6	0.3	47	CPPS/PNUMA, 1988.
Ecuador					
Santa Elena Bay 2°N.	2.1	3.2	0.8	12	INOCAR, 1988.
Chile					
Valparaiso 33°S.	8.7	10.4	7.1	8	Alcazar *et al.* 1989.

Table 3. Tar on Beaches (mg m^{-2}) in some areas of the South East Pacific, 1985-1988. (+ = Beaches with tar; - = beaches without tar; * sampled following an earthquake in 1985).

Area	Max	Min	+	-	References
Panama					
Panama Bay 9° N.	91,160	5,300.0	6	5	CPPS/PNUMA 1988.
Ecuador					
Santa Elena Bay 2° N.	82.0	0.7	6	14	DIGMER.,1985, 1987. CPPS/PNUMA, 1988. Salcedo, 1988.
Ancon-Posorja 2° 30'S.	578.0	0.7	16	15	as above
Peru					
Callao 12° S.	181.0	10.0	11	31	CPPS/PNUMA 1988.
Chile					
Valparaiso 32°35'-33° S	2,600.0	10.0	11	6	Instituto Oceanologia, 1985.
*abundant			1		

Table 4. Petroleum hydrocarbons (ug g^{-1}) in sand of some Chilean beaches in 1988.

Area	Mean	Max.	Min.	n	References
Iquique - Antogafasta 20° - 23°30' S.	0.77	7.95	0.01	14	Alcazar *et al.* 1989.
Michilla 22°45' S.	-	230.00	3.75	1	Alcazar *et al.* 1989.
Caldera-Coquimbo 27° - 30° S.	0.08	0.31	0.01	7	Alcazar *et al.* 1989.
Valparaiso 32°35'-33°S.	0.10	0.36	0.03	12	Leighton & Lopez, 1988.
Concepcion 36°40' S.	0.11	0.38	0.01	5	Alcazar *et al.* 1986.

Table 5. Petroleum Hydrocarbons (ug g^{-1}) in benthic sediments of the south-east Pacific in 1985-1988.

Area	Mean	Max	Min	n	References
Colombia					
Buenaventura 4° N.	0.20	0.36	0.11	27	CPPS/PNUMA, 1988
Tumaco 1°50' N.	0.64	1.42	0.04	29	CPPS/PNUMA, 1988
Ecuador					
Guayaquil Estuary 2°30' S.	0.57	2.06	0.17	8	Sonnenholzner, 1988
Chile					
Concepcion Bay 36°40' S.	2.52	5.06	0.14	10	Alcazar *et al.* 1986

Table 6. Petroleum hydrocarbons ug g^{-1} in marine biota (bivalves) of the South East Pacific, 1985-1988.

Area	Mean	Max.	Min,	n	References
Colombia					
Buenaventura 4° N.	3.12	5.29	1.61	12	CPPS/PNUMA, 1988
Tumaco 1°50' N.	4.31	10.73	0.53	16	CPPS/PNUMA, 1988
Chile					
Iquique - Antofagasta 20°-23°30' S.	3.71	10.10	0.49	15	Alcazar *et al.* 1989
Valparaiso 32°45' S.	2.20	3.58	0.40	7	Andrade, 1986
Concepcion 36°40' S.	1.66	2.07	1.25	5	Alcazar *et al.* 1986

Concentrations of hydrocarbons in sand on some Chilean beaches have also been determined. The highest values were measured for a beach at Michilla (22°S) of 3.75 to 230.0 ug g^{-1}. Mean values for four other areas of beaches, in the north and central regions of the country, were between 0.10 and 0.77 ug g^{-1}.

Mean values of petroleum hydrocarbons in benthic sediments in shallow waters of the south-east Pacific region are between 0.20 and 2.52 ug g^{-1}, the last value being found in Concepcion Bay (Chile). Lower average values are found in Buenaventura (Colombia) and the estuary of Guayaquil Gulf (Ecuador) being 0.20 and 0.57 ug g^{-1} respectively.

In marine biota, the highest average value was found at Tumaco (Colombia), 4.31 ug g^{-1} which also had a maximum value of 10.73 ug g^{-1}. Between Iquique (20°S) and Coquimbo (30°S), in the north of Chile, average values were between 3.71 and 3.89 ug g^{-1}. This area is not considered to have high concentrations of hydrocarbons in the water 0.66 to 5.0 ug l^{-1}, with averages no higher than 2.5 ug l^{-1}).

It is necessary to point out that in the south-east Pacific region, petroleum hydrocarbon measurements in the marine environment have been carried out only from the start of the operative phase of the Action Plan. Since that time, more than 1,100 measurements have been made of hydrocarbons, in water, benthic sediments, marine organisms (bivalves), beach sand, and tar on beaches.

It is to be hoped that, in future, the continuation of activities under the Action Plan will permit the collection of sufficient data both qualitative and quantitative to provide a broad perspective on hydrocarbon pollution in the south-east Pacific region. the present state of knowledge is summarised in Figure 4.

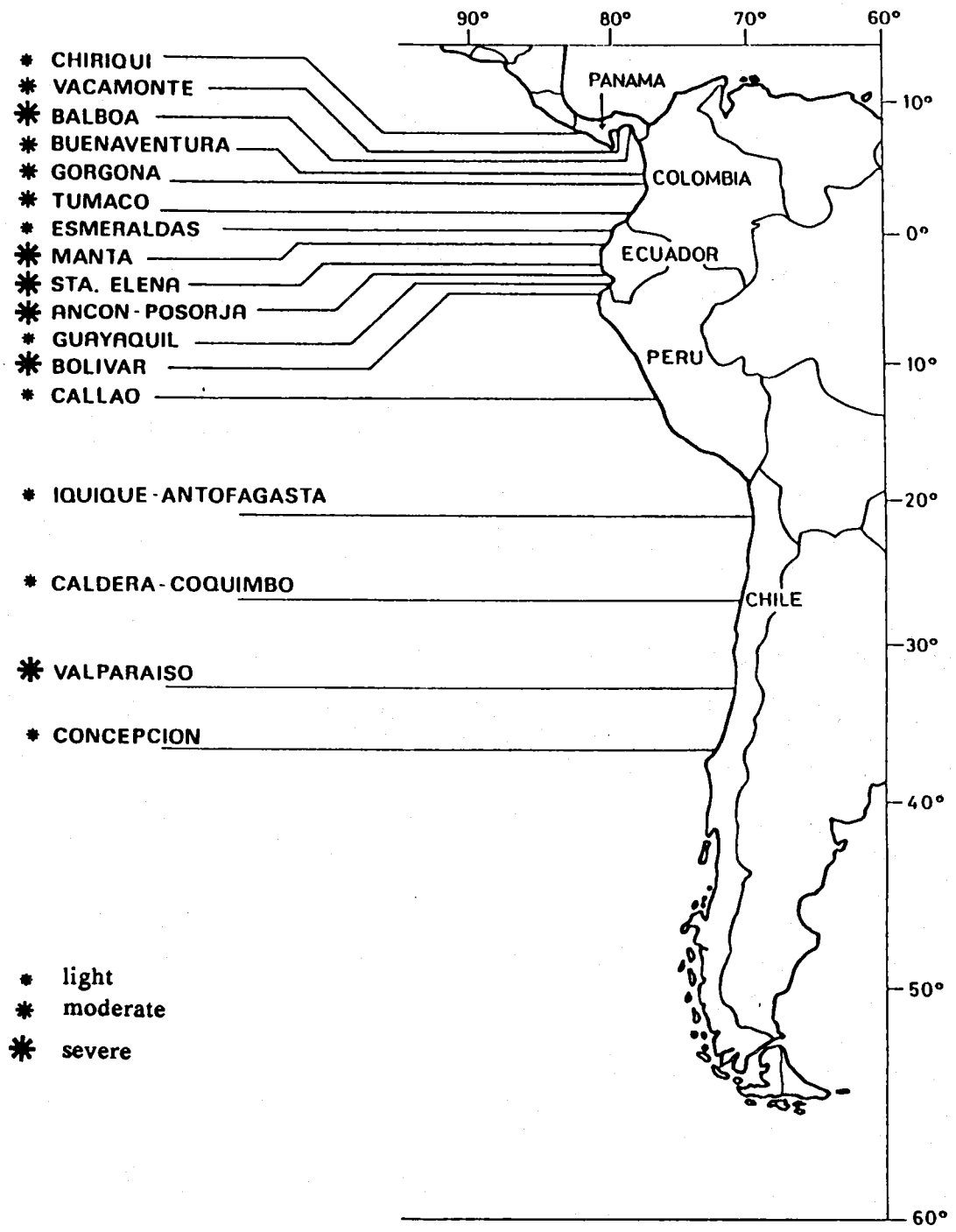

Figure 4. Levels of hydrocarbon pollution along the coast of the south-east Pacific between 1985 and 1988.

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NUTRIENT FLUXES IN ECUADORIAN PACIFIC WATERS

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ABSTRACT

The surface concentration of nutrients in the Pacific waters along the Ecuadorian coast varies seasonally and inter-annually. The main fluxes of nutrients involve oceanic waters with differing characteristics and freshwater runoff from the continental land mass.

The transport northwards of Peruvian coastal water and the southern displacement of surface tropical waters originating from the Panama Bight, the equatorial front have important biological repercussions in terms of the productivity of the area.

Available chemical data show that the surface tropical waters have total phosphate and nitrate ranges between 0.29-0.81 ug l^{-1} and 0.1-1.0 ug l^{-1} respectively, while the Peruvian coastal waters have ranges between 0.74-0.79 ug l^{-1} and 7.9-11.7 ug l^{-1}, respectively.

The influence of coastal drainage is more evident in the Gulf of Guayaquil than in other ares of the coastal waters. During severe El Nino events, changes in nutrient concentrations are observed outside the Gulf of Guayaquil while during moderate events its influence only passes near the 81°W meridian.

INTRODUCTION

The nutrient concentrations in Ecuadorian waters are dependent upon the hydrographic features related to changes in the surface and subsurface current patterns. The formation of the equatorial front and its seasonal displacement define the limits of the two water masses which have differing nutrient concentrations. During the southern summer of normal years the front disappears, or is displaced south of the equator and the area is dominated by warm and nutrient poor water from the Panama Bight which encompasses the northern and western sections of ecuadorian waters. At the end of the southern winter the Peruvian current is well developed and a tongue of cold, nutrient rich water is transported northwards. During El Nino events there is abnormal southward displacement of the equatorial front, and incursion of warm water is seen in front of the Ecuadorian coast.

NUTRIENT BUDGET OF THE WATERS

The concentration of nutrients in the Pacific waters off the coast of Ecuador are mainly influenced by the incursion of oceanic waters of different origins together with freshwater draining from the continent (Figure 1). Precipitation and runoff form important nutrient sources during the rainy season, in addition migration of marine organisms, sediment inputs and the decomposition of organic materials and their subsequent uptake in the food chain affect the concentration of dissolved nutrients in these coastal waters.

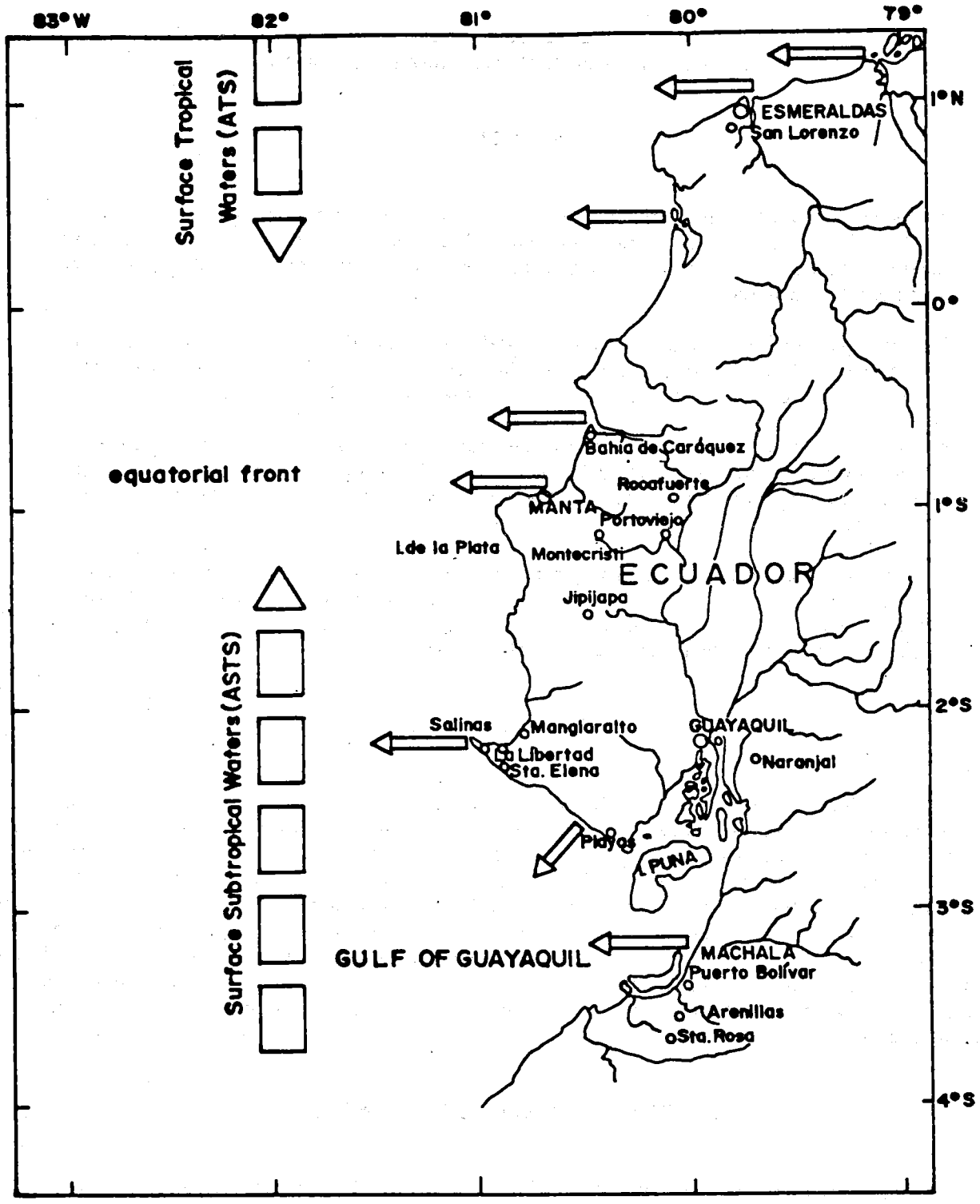

Figure 1. Nutrient sources in the coastal waters of Ecuador.

OCEANIC WATERS

According to Enfield (1976) the water masses influencing this region include the surface subtropical water; the coastal Peruvian water; and, the surface tropical waters. The front between the last two water masses is referred to as the equatorial front. Okuda, *et al.*,1983, based on chemical data collected during several cruises and on the descriptions provided by Wyrtki (1965), Zuta & Guillen (1970) and Enfield (1976) distinguished six watermasses with the following characteristics:

1. Surface tropical Water with temperatures above 25°C, salinity below 33.8°/$_{oo}$; phosphate from 0.29-0.35 ug l^{-1} and nitrate from 0.1-0.6 ug l^{-1}.

2. Surface equatorial waters with temperatures between 19 and 25°C, salinity below 33.8-35.1°/$_{oo}$; phosphate from 0.33-0.62 ug l^{-1} and nitrate from 3.1-6.8 ug l^{-1}.

3. Subtropical surface waters with temperatures above 19°C, salinities over 35.1°/$_{oo}$; phosphate from 0.14-0.75 ug l^{-1} and nitrate from 7.9-8.9 ug l^{-1}.

4. Coastal Peruvian waters with temperatures between 15 and 19°C, salinities 34.8-35.1°/$_{oo}$; phosphate from 0.96-1.20 ug l^{-1} and nitrate from 10.7-16.1 ug l^{-1}.

5. Equatorial Subsurface waters with temperatures between 13-15°C, salinities 34.9-35.1°/$_{oo}$; phosphate from 1.41-1.60 ug l^{-1} and nitrate from 19.7-21.7 ug l^{-1}.

6. Deep Equatorial Waters with temperatures between 7-13°C, salinities 34.6-34.9°/$_{oo}$; phosphate from 1.84-2.14 ug l^{-1} and nitrate from 24.6-29.2 ug l^{-1}.

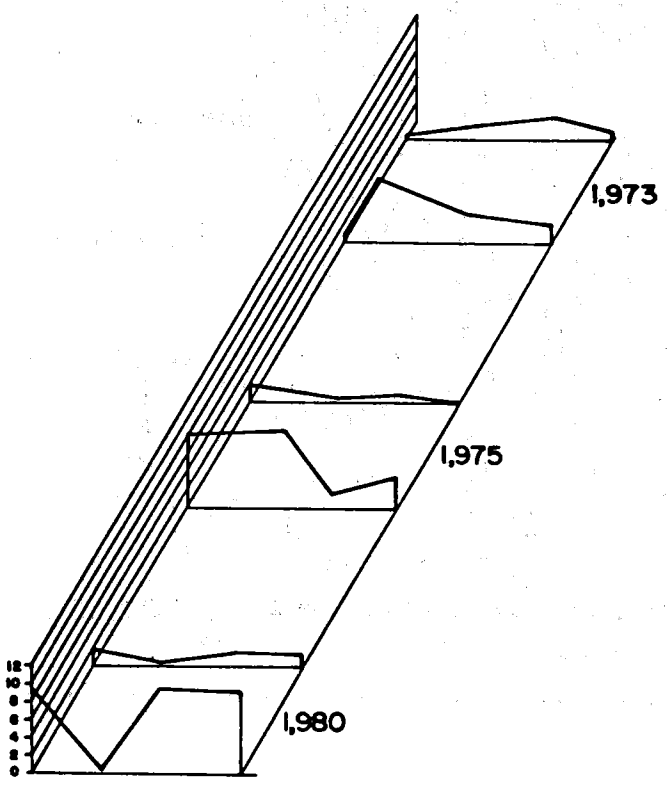

Figure 2. Nitrate and Phosphate concentration in the equatorial front region during 1973, 1975 and 1980.

These authors further reported that all six water masses were only distinguishable during the 1976 cruise and that at other times only four or five of the water masses could be distinguished.

Transport to the north of the high salinity and nutrient rich waters of the Peruvian coastal water mass fertilises the coastal waters of Ecuador and when this water masse meets the low salinity, nutrient impoverished waters of the Surface Tropical water mass the equatorial front is formed. The displacement of this front has important biological implications for the area since the nutrient concentrations of these two water masses are quite different. The ratio of nitrate to phosphorus is highest (9.9) in the Peruvian water mass and lowest in the tropical waters (2.5) (Figure 2). Levels of ammonia in coastal waters increase from north to south with the highest values (3.0-5.0 ug l^{-1}) being found in front of the Gulf of Guayaquil in association with the Peruvian coastal current (Figure 3).

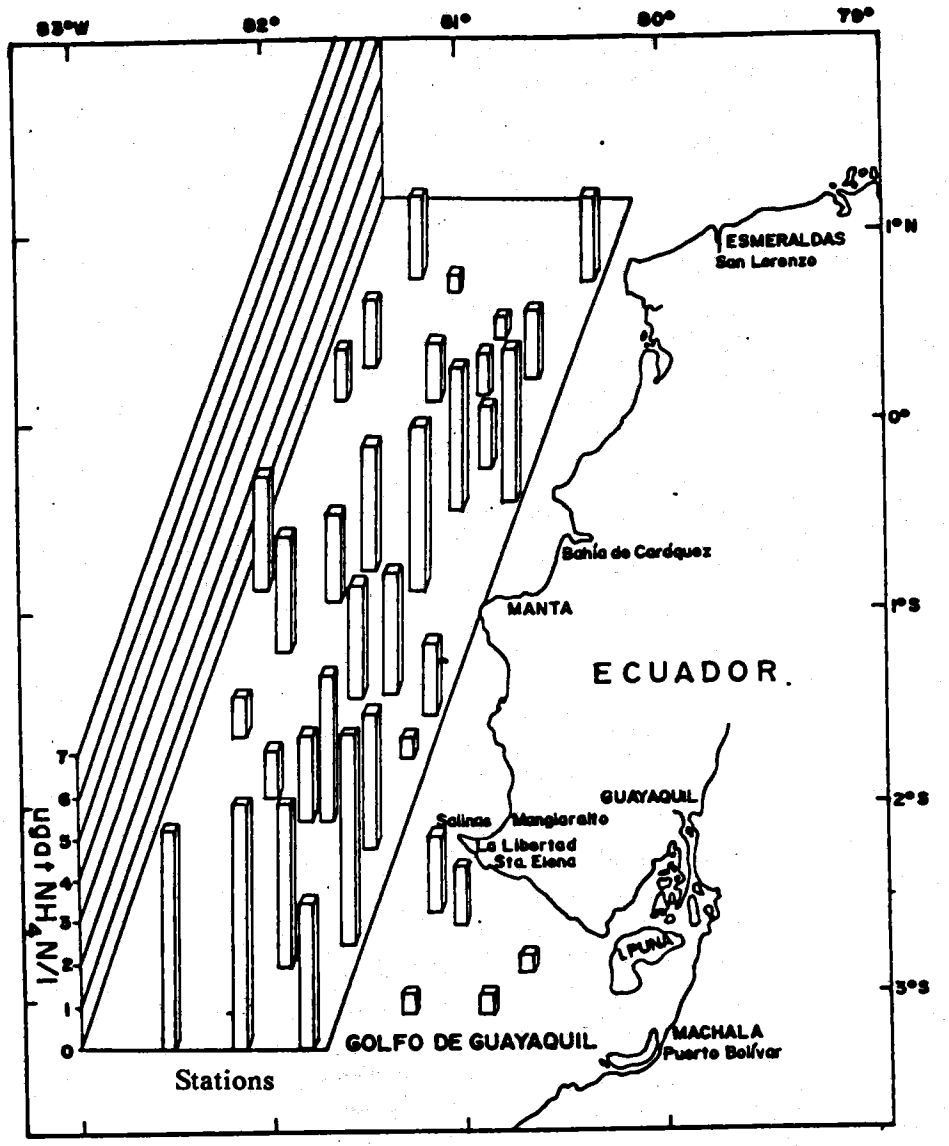

Figure 3. Ammonium concentrations in surface waters measured during the cruise T/1/81 February to March 1981.

CONTINENTAL WATERS

To the north of the Ecuadorian coastal region the Esmeraldas river receives residual waters from a petroleum factory and the domestic wastes of the City. The concentration of phosphate, nitrate and ammonia lie between 0.33-7.45 ug l^{-1}; 0.3-29.33 ug l^{-1}; 0.8-117.4 ug l^{-1}; respectively (Rendon, *et al.*, 1983), the lowest values being found near the mouth of the river where dilution with marine waters takes place (Figure 4).

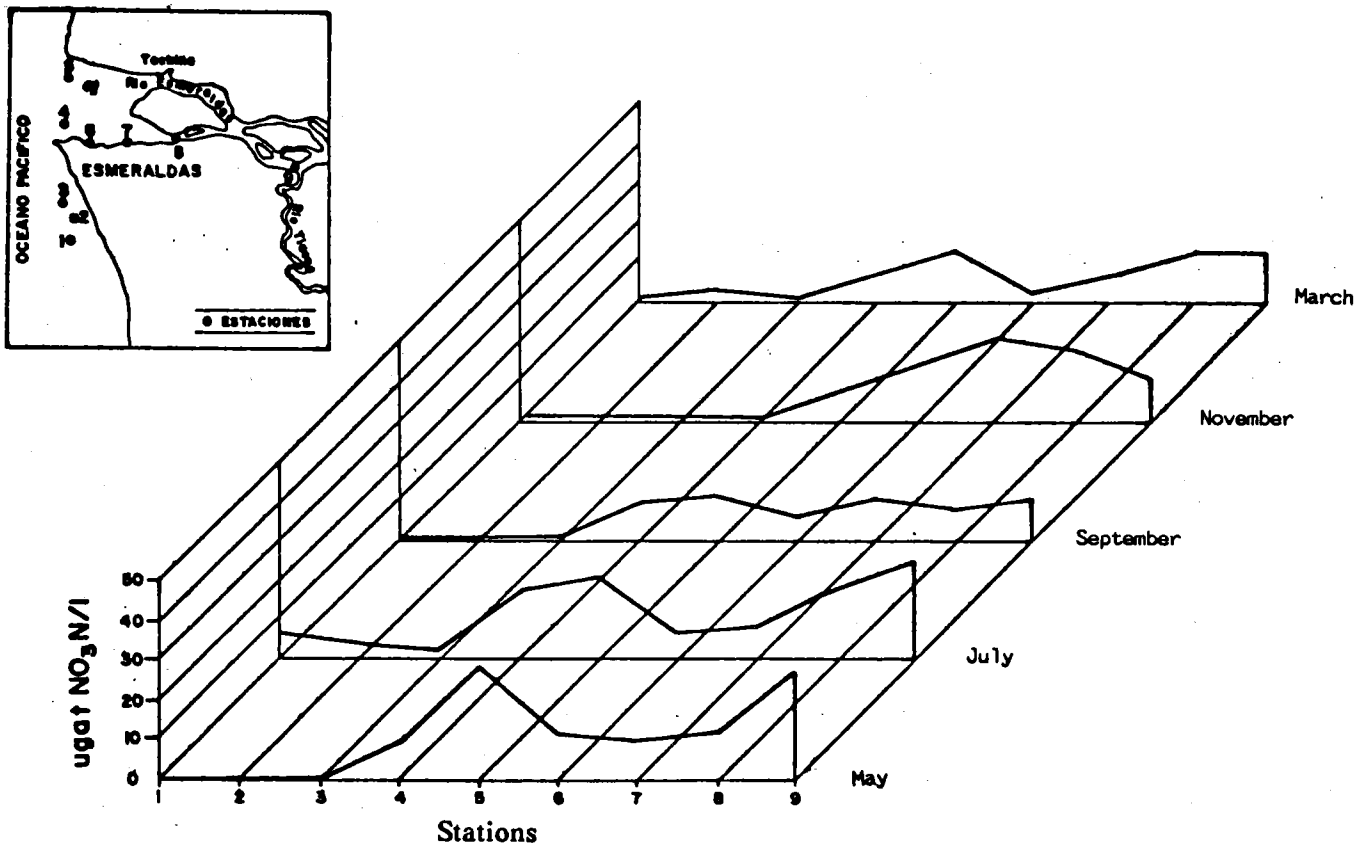

Figure 4. Nitrate concentrations in surface waters of the Esmeraldas River during 1981 and 1982.

In the south the Gulf of Guayaquil receives freshwater inputs from the Guayas River. The seasonal changes in flow of this river have a considerable impact on the chemistry and biology of this Gulf. Guayaquil the largest city in the country discharges around 143,275 m^3 day^{-1} of domestic sewage and wastes causing considerable alteration to the nutrient balance of the Gulf area (Planeamiento Urbano, 1986). Surface phosphate and nitrate concentrations vary between 2.0-5.0 ug l^{-1} and 15-40 ug l^{-1} respectively (Pesantes, 1987). Adjacent to the southern and western boundaries of the city is the estero Salado, a branch of the inner estuarine portion of the Gulf of Guayaquil where part of the industrial and domestic waste discharge takes place. Shrimp ponds built in this area are an additional source of nutrients and levels of phosphate, nitrate and ammonia in this section of the channel range from 1.56-2.28 ug l^{-1}; 8.4-17.2 ug l^{-1}; and 0.88-2.14 ug l^{-1} respectively. The lowest values are found in the Morro Channel suggesting some dilution

with incoming seawater. The run-off from towns such as Posorja, Playas, Ballemta, La Libertad and others (Figure 5) do not result in significant increases in nutrients in coastal areas. During moderate El Nino events continental drainage influences nutrient concentrations only as far west as 81° (Figure 6)

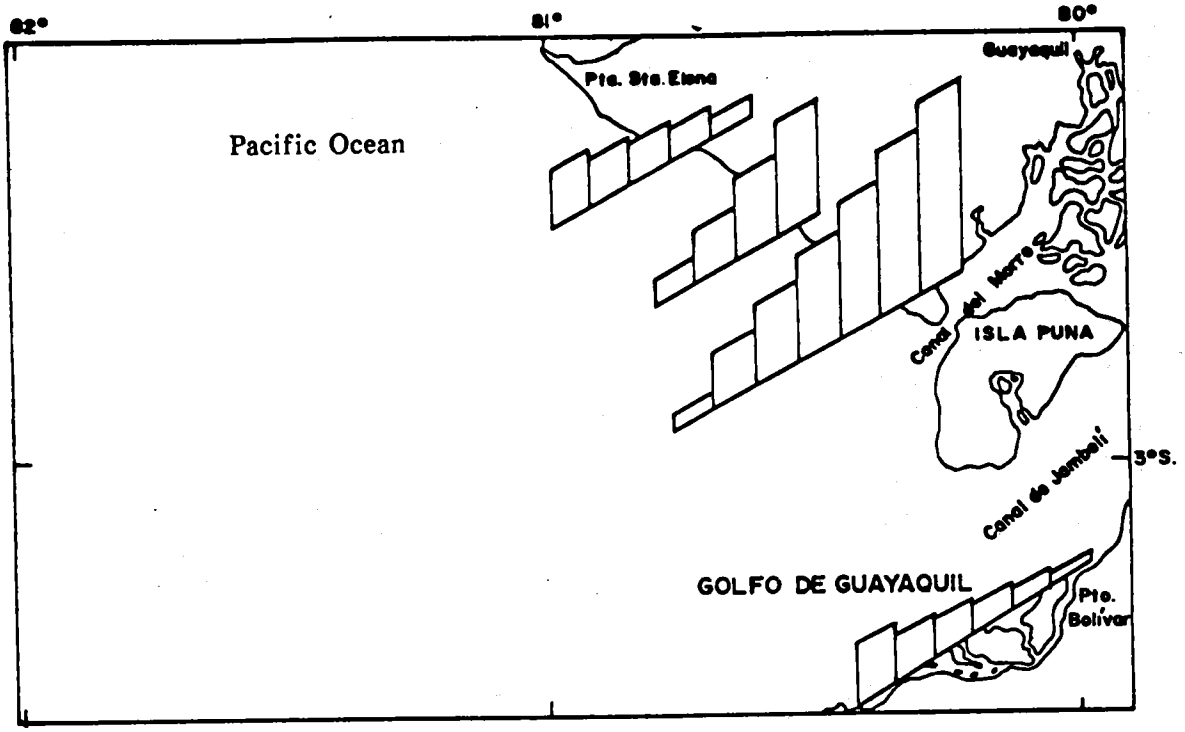

Figure 5. Influence of small town waste discharge on surface water nitrate concentrations.

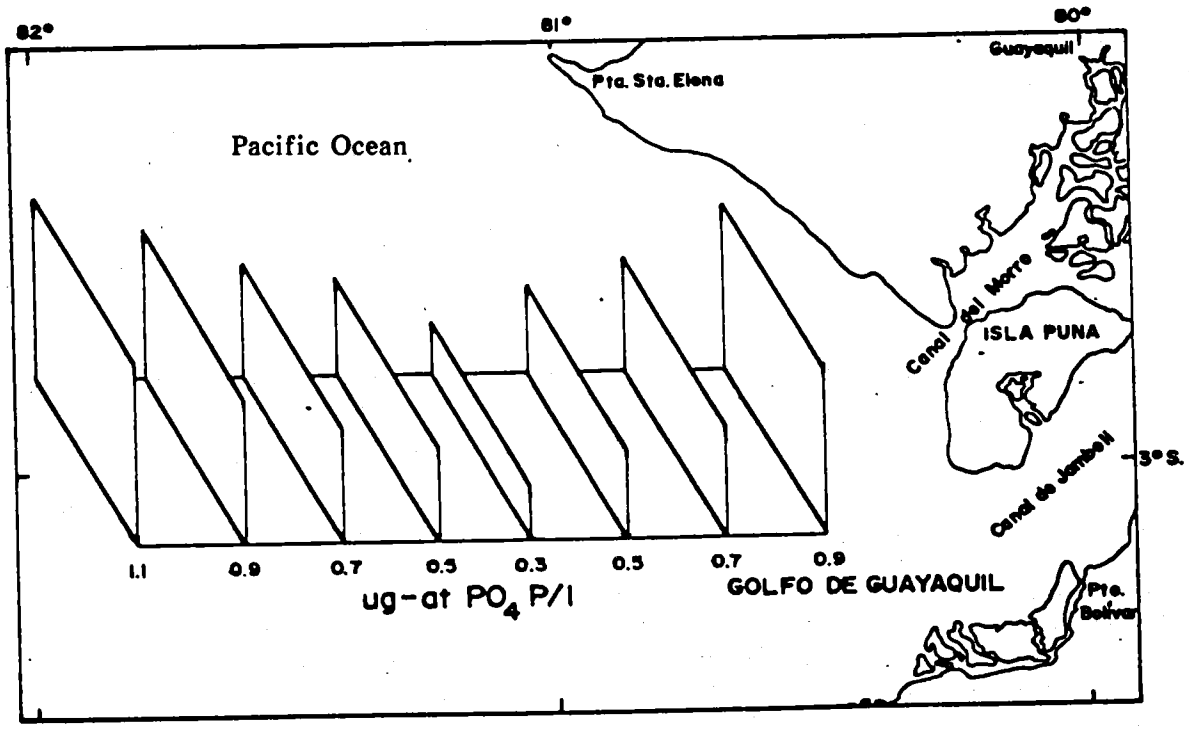

Figure 6. Phosphate concentrations in the Gulf of Guayaquil and ocean waters druing April 1976.

DISCUSSION AND CONCLUSIONS

The concentrations of nutrients in Pacific waters along the coast of Ecuador, are mainly influenced by the incursion of oceanic waters of different origins with some influence from riverine inputs. Run-off is more important during the rainy season.

The transport of high salinity, nutrient rich water from the Peruvian current fertilises Ecuadorian waters, increasing the biological productivity of the area, which is correspondingly lowered when lower salinity, nutrient poor waters from the Bight of Panama. However the invasion of this fresher water lowers the water densities on the shelf allowing the intrusion of nutrient rich subsurface water via upwelling.

The changes in position of the equatorial front (Wyrtki 1965; Wooster, 1969; Stevenson & Taft, 1970) throughout the year, result in a seasonal component to the nutrient flux which is clearly connected to temperature and salinity variations.

The contrasting values for nitrate/phosphate ratios present in Peruvian and Panama waters demonstrate the different nutrient fluxes in waters from north and south of Ecuador, however in both cases nitrate appears to set the limit for phytoplankton productivity (Rhee, 1973).

The presence of appreciable amounts of ammonia in Ecuadorian waters may favour increased primary productivity since it is preferentially taken up by some species of phytoplankton and is released by zooplankton according to species (Jawed, 1973), size (Smith & Whitledge, 1977), sex, temperature and food availability (Butler *et al.*, 1970; Conover & Corner, 1968; Corner *et al.*, 1965). Phytoplankton production in Ecuadorian waters, particularly to the north of the equatorial front may rely extensively on this regenerated nitrogen fraction.

Almost all cities are located on the coast-line and in the vicinity of rivers and no effluent treatment is undertaken (Solorzano, 1981). Although there are similarities in the biochemical composition of the wastes, the volume and some particular characteristics differ from town to town, with the volume of waste water varying according to water supply and industrial development, increasing as these increase. Waste water from Guayaquil the largest city in Ecuador has a strong influence on adjacent waters through the high concentrations of nitrate, phosphate and ammonia which vary in other cities according to the nature of the discharges and the volume of the receiving coastal water body.

The nutrient inputs via the Esmeraldas river affects only locations near the coast, in contrast nutrients carried by the Guayas river and the estero Salado influence nutrient concentrations of the Gulf as far west as the 81^{o} meridian particularly during moderate El Nino years. A marked difference in the ammonium levels is noted between the Gulf and incoming southern waters demonstrating the beneficial influence of this input (Perez, in press). During the unusually strong El Nino event of 1982-83 Pesantes and Perez (in press) detected the effects from River runoff and precipitation in terms of high nitrate/phosphate ratios outside the Gulf of Guayaquil.

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RESEARCH AND MONITORING OF MARINE POLLUTION IN PERU 1984-1988

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ABSTRACT

This paper summarises studies of marine pollution along the Peruvian coast undertaken within the framework of the UNEP/CPPS Action Plan, between 1986 and 1988. It is reported that the main source of the marine pollution in Chimbote comes from the industrial and domestic sources; discharges from the metal industries and from the 30 fish processing plants located in the Ferroles Bay total 8,600 x 10^3 m^3. In the case of Lima, the report details the characteristics of the domestic and industrial effluents having discharge volumes of 309 018 m^3 yr^{-1}; a BOD_5 of 94,796 ton yr^{-1}; COD 199,683 ton yr^{-1}; and, suspended solids of 114,881 ton yr^{-1}. Total and faecal coliform concentrations in Ancon and Pisco Bays were found to be 2,400 per litre for total coliforms in water in both locations and 2,400 and 1,100 per litre for faecal coliforms, respectively. Trace metal determinations were made for bioindicator species, which showed high values in areas where industrial discharges were present, but nearly always within the permissible limits.

Oil pollution data from the Callao area are reported with the values ranging ranging from 0.05 to 1.88 ug l^{-1} and 0.5 to 8.54 ug l^{-1} of dissolved/suspended hydrocarbons in the vicinity of the "La Pampilla" refinery. At Talara, which is the major centre of oil related activities on the Peruvian coast, having a refinery; an oil pier and platforms for oil drilling and extraction values as high as 26.5 ug l^{-1} of dissolved hydrocarbons were found. In Ilo with a mooring berth for fuel unloading, values were between 1.41 and 5.70 ug l^{-1}.

INTRODUCTION

The member states of the South Pacific Permanent Commission (CPPS), (Chile, Peru, Ecuador, Colombia and Panama), with the support of the United Nations Environmental Programme (UNEP), adopted the Action Plan for the Protection of the Marine Environment and Coastal Areas of the South Pacific. The purpose of this Action Plan is to preserve the marine and coastal resources and to protect the area from different kinds of pollution which might damage the marine environment and affect the coastal ecology in general,

Since 1984, the institutions in Peru which form the national network, have carried out studies within three major programmes:

(a) "Characterization and monitoring of marine pollution from oil hydrocarbons";
(b) "Characterization and monitoring of marine pollution from domestic wastes, agricultural, industrial and mining sources in ecological sensitives areas"; and,
(c) "Monitoring of marine pollution from heavy metals, commencing with the determination of mercury levels in bivalve molluscs from the regions of Pisco, Callao and Ilo and Ite".

Programmes (a) and (b) were developed under the direction of the Marine Institute of Peru, Hydrography and Navigation Division of the Peruvian Navy, while programme (c) was developed by the Oceanographic and Fishery Programme of the National University, Federico Villarreal.

During the course of the work the research activities have increased with complementary work being undertaken with the collaboration of a number of institutions under the guidance of the National Focal Point.

Oceanographic and climatic conditions on the Peruvian coast between 1984 and 1988

1984 was characterised by the appearance of cold waters in the Peruvian coastal zone with negative anomalies in the sea surface temperature being found from 6° to 15°S. Conditions returned to normal during 1985, although waters were still slightly cooler than normal in some zones, principally from 12°S northwards (Cucalon *et al.*, 1986).

Late in 1986 and at the beginning of 1987 along the north coast of Peru an El Nino event of median intensity and short life (Carrera *et al.*, 1989) occurred. The anomalous sea surface temperatures in the coastal zone were of greater intensity than those registered during the El Nino of 1976 but somewhat less than those observed during the El Nino of 1982-1983.

During 1988 the sea surface temperature did not display any greater anomalies than normal from autumn onwards although there were low temperatures, qualifying it as a cold year (Carrera *et al.*, 1989).

THE MARINE POLLUTION PROGRAMME IN COASTAL PERU

Industrial, domestic and mining pollution occur in Chimbote, Callao-Lima, Pisco and Ilo. In Chimbote the pollution comes from the iron and steel industries and from the fishery industry (Table 1). The fish processing and canning industry is centred in 30 fisheries plants which discharge their waste waters directly to the sea. Waste waters originate from the unloading of fish, and from fish processing industrial wastes resulting from the production of fish oils, fishmeal and canned fish. These discharges have a high organic content with a high biochemical oxygen demand, resulting in anoxic conditions in shallow waters.

Table 1. Total volume of effluent discharge and its pollution contribution to Ferroles Bay, Chimbote (1987) ([1] = fishing industry wastes; [2] preliminary results from metal processing industry).

Discharge quantities	Source				Total
	Domestic	%	Industrial	%	
Volume x 10^3 (m^3 yr^{-1})	15790	64.78	8585.1	35.22	24,375.0
BOD_5 (ton yr^{-1})	4720	86.15	758.9	13.85	5,478.9
COD (ton yr^{-1})	10569	96.38	396.5	3.62	10,965.5
SS (ton yr^{-1})	5628	81.10	1311.2	18.90	6,939.2
SDT (ton yr^{-1})	7556	99.68	24.1	0.32	7,580.1
OIL (ton yr^{-1})	-	-	550.92	100	550.93
N (ton yr^{-1})	683	97.81	15.3[1]	2.19	698.3
[2]Phenols (ton yr^{-1})	-	-	170.7	100	170.7
S^{2-} (ton yr^{-1})	-	-	156	100	15.6
CN^- (ton yr^{-1})	-	-	36	100	39.0

The iron and steel industry causes extensive air pollution and resulted in waste discharges to the Bay of the Ferroles of 8,600,000 m^3 yr^{-1} in 1987 (Ministerio de Marina, 1989), with a high metal content (Table 1). Table 1 also indicates that industrial sources account for a high proportion of total waste discharge into this bay.

In the case of the coastal areas of metropolitan Lima, serious impacts have resulted from the expansion of this large modern city, in which are concentrated 28% of the population and 65% of the country's industrial activity. There are 14,000 registered industries of which 1,500 constitute serious sources of environmental pollution, (Ministerio de Marino, 1989), in violation of the General Water Laws and Regulations. A large number of industrial effluents have been identified which exceed the allowable limits and which drain via domestic discharges into the marine environment at the rate of 18 m^3 day^{-1}.

Lima has approximately 500,000 vehicles or 65 % of the national total which add to the industrial pollution of the atmosphere. Table 2, presents data on industrial and domestic effluent discharge for metropolitan Lima.

Table 2. Wastes discharge and marine pollution from domestic and industrial activities in Metropolitan Lima (1987) (Data from Ministerio de Marina, 1989)

Discharge characteristics	Domestic	%	Industrial	%	Total
Volume (m^3 yr^{-1})	278327	90.07	30691	9.93	309018
DBO_5 (ton yr^{-1})	85448	90.14	9348	9.86	94796
COD (ton yr^{-1})	192084	96.19	7599	3.81	199683
SS (ton yr^{-1})	105612	91.13	9269	8.07	114881
SDT (ton yr^{-1})	208050	64.17	116181	35.83	324231
Oil/fat (ton yr^{-1})	--	--	2862	100.0	2862
ST (ton yr^{-1})	--	--	14974	100.0	14974
Alkali (ton yr^{-1})	--	--	2006	100.0	2006
Ammonia (ton yr^{-1})	--	--	16	100.0	16
Sulphur (ton yr^{-1})	--	--	5298	100.0	5298
Nitrate (ton yr^{-1})	18810	100.00	--	--	18810
Phosphate (ton yr^{-1})	2280	100.00	--	--	2280
Other (ton yr^{-1})	--	--	4800	100.0	4800

In the case of domestic pollution in the province of Lima, sea-side resort of Ancon, located 40 kilometres to the north of Lima was chosen for study. Ancon has a population of approximately 20,000 during the winter, increasing by 50 % or more during the summer. This bay was chosen for a study of the extent of faecal pollution, the distribution of faecal coliforms in sea water, sediments, benthic organisms and the effects on marine organisms during the summer months. Results are presented in Table 3.

The values for total and faecal coliforms slightly exceed the permissible limits under the General Water Law Regulation for molluscs sediments and recreational waters tested near the Ancon Bay shore, (Flores *et al.*, 1988).

Another area characteristically polluted by domestic wastes is Pisco Bay. Results of analyses of samples taken from in front of discharge of the Pisco River and in the small San Andres bay, are again slightly over the permissible levels. Results of analyses of samples from Paracas Bay are much lower as may be appreciated from Table 3.

Table 3. Total and faecal coliforms in sea water (Data from Flores *et al.*, 1988)

Locality	Total Coliforms per 100 ml		Faecal Coliforms per 100 ml	
	Water	Sediment	Water	Sediment
Ancon Bay	2,400	2,400	2,400	2,400
Pisco Bay	2 400	2,400	1,100	1,100
San Andres	1 100	2,400	1,100	2,400
Paracas Bay	240	4	93	4

Pollution due to mining activity in the Rimac river basin (11° 21' S 76° 05' W and 12° 10' S 77° 10' W), is very high due to discharges 11 mineral concentration plants which produce an average of 352 metric tons of concentrate and use an average of 21,300 m^3 day^{-1} of water. The principal mineral ores which are treated are sulphur compounds such as glena, chalcopyrite, blende, barium sulphate, and silver sulphate. The concentrator plants are a source of river water pollution due to the water washing from the mine, drainage from the fines collection and from the erosion of the older tailings dumps. Table 4 provides data on trace metal concentrations in the Rimac River, during September 1986 (Ministerio de Salud, 1987).

Table 4. Heavy metal concentration in Rimac River waters, September 1986. (Data from Ministerio de Salud, 1986)

Distance inland	Cu mg/l	Cd mg/l	Pb mg/l	Zn mg/l	Fe mg/l	Mn mg/l	pH
Km 99	0.65	0.02	0.1	0.31	0.12	0.12	8.5
Km 90	-	-	-	-	-	-	-
Km 75	0.07	0.02	0.07	0.25	3.30	0.48	8.7
Km 40	0.05	0.02	0.01	0.44	0.20	0.04	7.9
Km 20	0.04	0.04	0.10	0.31	0.92	0.06	7.9

Monitoring of bivalve molluscs for heavy metals

Marine organism are known to bioaccumulate metal elements which they concentrate from the environment in which they live. Peru has an important and diverse mining industry, the most important mineral being copper the production of which has consistently increased over the decade since 1980. Along the Peruvian coast different areas receive, via river discharge the effluents and wastes derived from the mining activity located in the highlands, these wastes contain various heavy metal element.

For this reason monitoring of heavy metal levels in bivalves from the Chimbote, Callao, Pisco and Tacna areas has been undertaken periodically, with support from the UNEP/CPPS Programme (Echegaray *et al.*, 1988). In Chimbote the mussel, *Aulocomya ater*; the clam, *Gari solida*; and, the Peruvian calico scallop, *Argopecten purpuratus* were found to have levels of mercury of 12 to 104 ng g^{-1}, 14 to 112 ng g^{-1} and 8 to 118 ng g^{-1} respectively which are generally considered to be low values.

In view of the tailings discharge from copper concentration plants in the region of Tacna analyses of the copper and cadmium concentrations present in bivalves from Pisco and Tacna were undertaken. The copper levels in mussels from Pisco and Tacna were of the order of 0.7 to 1.8 ug g^{-1} and 7.0 to 22.0 ug g^{-1} respectively. Cadmium levels for clams and mussels from the

same localities were low: 0.6 to 1.7 ug g^{-1} and 0.7 to 1.8 ug g^{-1} respectively. Levels of cadmium at Pisco, were however over the permissible limit of 2 ug g^{-1} wet weight (Nicless, *et al.*, 1972) displaying values of 2.7 to 5.4 ug g^{-1}. In the region of Chimbote, the mussel and clam presented high values for cadmium of 2.9 to 6.8 and 1.9 to 2.1 ug g^{-1} respectively. This could be due to the pollution of Ferroles Bay, by industrial discharges as discussed above. Table 5 presents values for copper and cadmium concentrations in the Peruvian purple mussel, *Mytilus purpuratus* a bivalve which lives in rocky inter-tidal areas and which also displays high levels of cadmium in the Chimbote area.

Table 5. Copper and Cadmium levels in the Peruvian purple mussel, *Mytilus Purpuratus* (from Echegaray *et al.*, 1988)

Locality	Cu (ug/g) Mean	Cu (ug/g) Range	Cd (ug/g) Mean	Cd (ug/g) Range
Chimbote (9^{o}S)	4.15	0.34 - 6.42 3.88	3.05 - 5.20	
Pisco (13^{o}S)	2.89	2.55 - 3.24 1.55	1.48 - 1.62	
Tacna (18^{o}S)	12.47	2.44 - 27.34	1.14	0.31 - 3.39

Oil pollution in Talara, Callao and Ilo

Oil hydrocarbons are one of the most important toxic pollutants in the marine environment which have a great ecological impact over long distances, affecting juveniles of many species. The Programme examined the levels of the dissolved and dispersed hydrocarbons in water, in sediments and various organisms from selected areas, in addition to quantifying tar on beaches.

Initial research was undertaken in the Port of Callao (12^{o}S) where possible sources of pollution include the Pampilla refinery; Callao dock with its pier for unloading oil products; Callao Dry Dock; and Callao Bay which is used as an anchorage for ships of the merchant, fishing, and naval fleets.

During 1985 and 1986 values within the ranges of 0.10 to 0.63 ug l^{-1} and 0.05 to 1.47 ug l^{-1} of dissolve hydrocarbons respectively were found. During 1987 and 1988 the range was from 0.05 to 1.88 ug l^{-1} and 0.05 to 8.54 ug l^{-1} of dissolved hydrocarbons respectively. Greatest concentrations were found in the areas next to the Pampilla refinery and to the maritime terminal of Callao. Similar trends were detected in the analysis of tars on beaches with 0.189 g m^{-2} occurring in this area.

Talara Bay (4^{o} 29' and 4^{o} 34' 15" S) is an area where the Talara refinery; the oil pier; and 92 oil rig platforms with their oil discharge lines to land, and the mooring berths of Punta Arenas and Negritos are all concentrated. In this area during 1987-1988 concentrations of up to 26.5 ug l^{-1} of dissolved hydrocarbons were found together with the highest values for beach tar 0.30 g m^{-2} in the country.

Finally in Ilo Bay (17^{o} 27' S) in addition to the national port is a second commercial port, and a mooring berth for fuel discharging used by the smelters and refineries located in this area. The analyses demonstrated dissolved/dispersed hydrocarbon concentrations between 1.41 to 5.70 ug l^{-1}, but tar on the beaches was not analysed (Jacinto *et al.*, 1988).

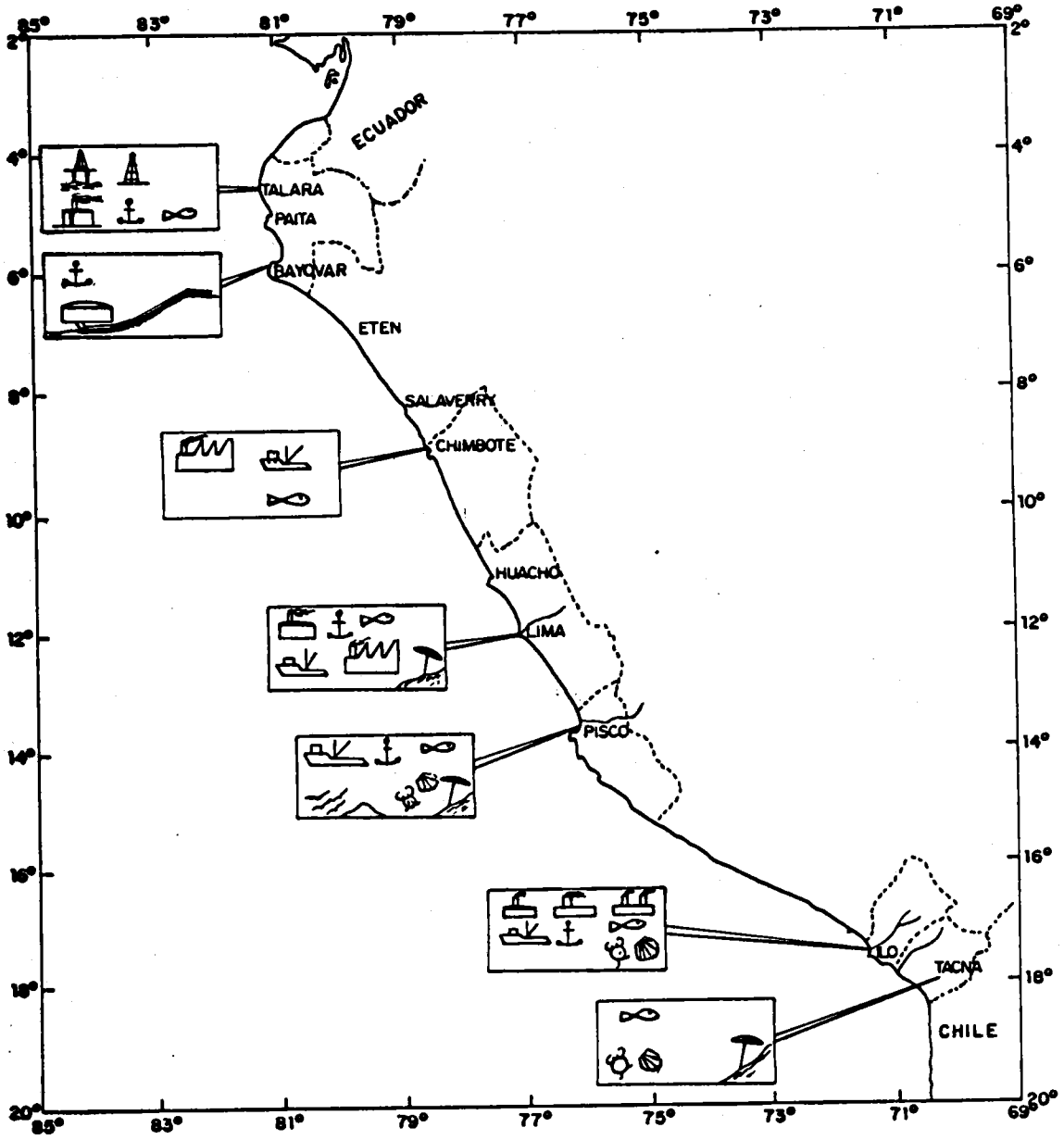

Figure 1. Pollution characteristics in the coastal marine environment of Peru.

CONCLUSIONS

Marine pollution along the coast of Peru, reflects the different activities which are developed in the cities and along the coast (Figure 1). Hence monitoring of pollution levels in the coastal areas demonstrates that, Talara with its high concentration of oil related activities also demonstrates the highest levels of pollution from dissolved hydrocarbons and tar. In Chimbote and Lima, marine pollution is largely due to industrial and domestic effluents discharged into the sea, with little or no pretreatment. In Pisco marine pollution is due to the fisheries and cosmetic industries; and, in Ilo there is extensive pollution due to mining activity and slight pollution resulting from fisheries activities.

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REGIONAL COOPERATION IN THE ENVIRONMENTAL PROTECTION OF GUAM AND MICRONESIAN COASTAL WATERS: THE UNIVERSITY OF GUAM EXPERIENCE.

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ABSTRACT

The term "regional cooperation" when applied to the environmental protection of coastal areas surrounding Guam and Micronesian Islands has been used in various ways. In the early 1970s in conjunction with the establishment of the University of Guam Marine Laboratory, regional cooperation was the justification provided by Guam biologists to extend their research efforts into Micronesian waters. Monitoring the crown-of-thorns starfish, *Acanthaster planci*, throughout the Micronesian region was a high priority during the period 1969 to 1971. Selection of sewer outfall sites and the monitoring of pollution from thermal, and domestic sewer effluent served as the major source of funding throughout the 1970s. These studies, however, could never be really construed as regional cooperation since the extent of the studies was limited to the expertise of the Guam-based biologists.

True regional cooperation began in the early 1980s with the University of Guam's participation in SPREP where contact with other environmental specialists from the South Pacific led to regional collaboration on specific environmental projects. Workshops and seminars brought together scientists to address common topics of coastal environmental protection in the tropical Pacific region. Numerous recommendations for specific studies have been elicited from these workshops and seminars. The recommendations of one such seminar held in 1980 in Papua New Guinea are examined and the progress of their implementation nearly a decade later is summarized relative to advancement of environmental protection in Guam and Micronesian coastal waters.

INTRODUCTION

The University of Guam's expected leadership role, as the only baccalaureate and masters' degree-granting U.S. institution in the western Pacific, mandates regional cooperation in terms of providing higher education programs for the people of Guam and the Western Pacific island communities. The issue of regional cooperation, which encompasses environmental protection, is addressed through research and community service programs at the University as detailed in its Mission Statement (University of Guam, 1980).

> *"Research and graduate programs that are responsive to the specific needs of Guam and other Western Pacific island communities and contribute to their economic growth and stability; and,*
>
> *Community service programs that promote intercultural interaction, societal development, and personal improvement."*

As the chief academic officer of a public, land-grant, post-secondary institution, the implementation of the University of Guam's academic plans has been and will continue to be the major responsibility of the Office of the Academic Vice-President. Its implementation is similar to the implementation of a region's environmental protection plan. In the case of an institution's academic plans, cooperation of the faculty and administrators of the various colleges and departments, representing a wide array of disciplines and philosophies, is mandatory. Likewise,

comparable cooperative efforts are necessary between scientists and governmental managers within the various political entities within the SPREP region, if they are to preserve and conserve their region's common coastal environment.

This communication will differ considerably from those presentations by other participants here, in that, it does not focus on any one specific scientific aspect of the environmental protection of coastal waters nor does it summarize the results of a specific research project conducted in Guam or Micronesian coastal waters. It is, instead, a summary of the University's emergence from a state of isolation in the realm of environmental studies to that of a full contributing partner among the multinational efforts of collaborating scientists to protect our coastal waters. The progress towards implementation of the recommendations posed at one regional seminar nearly a decade ago is reviewed as an example to demonstrate how true regional cooperation has advanced the environmental protection of Guam and Micronesian coastal waters.

FROM ISOLATION TO FULL REGIONAL PARTNER

The tropical island setting and coastal environment of western Pacific islands are conducive to marine-oriented research. This attraction was evident to the marine biologists who arrived at the University in the late 1960s and early 1970s and who had three factors in their favour - youth (i.e., an eagerness to undertake any project), diverse specialty interest, and the then, dearth of published information on Guam coastal waters.

Since University research funding was almost non-existent, external funding was the only means whereby sufficient supplies and equipment could be obtained to initiate serious marine studies. The infant Guam Environmental Protection Agency (GEPA), with funding support from the U.S. Environmental Protection Agency (U.S. EPA), appeared to be the most ideal source of potential funding. In addition, the GEPA's environmental laboratory was physically housed in the University's Science Building and, later, at the University's Marine Laboratory. Based on the appeal of inter-agency cooperation, two projects applicable to the monitoring of coastal effluent were funded. The first project addressed the impact of the primary treated sewage effluent discharged from a recently constructed ocean outfall at a depth of 28 meters located about 100 meters perpendicular off the reef front (Jones & Randall, 1971). The second project was a study on the effect of thermal effluent released from a newly constructed power plant on the surrounding reef flat (Jones et al., 1976).

During the same period, the damage to live corals by the crown-of-thorns starfish, *Acanthaster planci*, in Guam and Micronesian coastal waters prompted a large-scale survey, funded by the U.S. Department of Interior, aimed at assessing the status of coral reefs in the region (Chesher, 1969). The funding provided boats, compressors and scuba gear in Saipan, Palau, Truk, and Ponape (i.e., district centres of the Trust Territory of the Pacific Islands, TTPI) to be used by the control team members whose task was to eliminate all *Acanthaster* from the island reefs.

In 1970, verbal agreement was forged between the Marine Resources Division of the TTPI and the University, whereby Guam-based marine biologists would continue the monitoring of coral reefs in Micronesian waters, in exchange for airfare, *per diem* and logistic support. Similar arrangements were made in 1974 with the Environmental Protection Board of TTPI for University biologists to provide environmental assessments relative to the construction of sewage outfalls in Micronesia.

The studies conducted on Micronesian Islands are reflected in 27 of the 89 technical reports issued by the University of Guam Marine Laboratory (University of Guam Marine Laboratory, 1989). The studies and reports, however, could never be really construed as truly regional cooperation since the majority of studies were carried out solely by Guam-based biologists. Only two of the reports carry the names of non-University of Guam personnel as co-authors.

True regional cooperation applicable to environmental protection began in the early 1980s with the University of Guam's participation in the South Pacific Regional Environment Programme (SPREP) where contact with environmental specialists from the South Pacific's research institutions led to regional collaboration on specific environmental projects through international funding, as well as in-kind funding from home institutions, i.e., University of the South Pacific, University of Papua New Guinea and Papua New Guinea University of Technology. A listing of major projects undertaken by SPREP is available (Reti, 1988).

An important aspect of this contact with Guam's southern neighbours is the fact that all shared similar environmental problems relative to their coastal areas, and that the status reports provided by the participating institutions clearly indicated that cooperative efforts on specific targeted projects would not only enhance the studies, but would result in shorter time needed to answer pertinent questions. An example of regional cooperation was the consultancy on Applied Atoll Research for Development which was held in the Republic of Kiribati in 1988 (Thaman, 1989).

It is appropriate at this time to clarify any mistaken notion that the University of Guam was operating in a vacuum during the 1970s. Faculty members were participating in national and international meetings within their own disciplines and were sharing the results of their research with others. Bilateral cooperative research projects with Taiwan (NSF) and Indonesia (USAID) were on-going or being initiated. The University was, in fact, very much involved from 1975 onwards with the Pacific Science Association's Standing committee on Coral Reefs. It should be noted in this context that, the primary function of each of the 18 Standing Scientific Committees of the Pacific Science Association is the fostering of cooperation among Pacific Basin scientists both within and among the disciplines.

As a demonstration of how regional cooperation has advanced the knowledge of environmental management of Guam and Micronesian coastal waters, the progress made on recommendations posed nearly a decade ago at a Unesco sponsored seminar on "Marine and coastal Processes in the Pacific: Ecological Aspects of Coastal Zone Management" held at Motupore Island Research Station, University of Papua New Guinea on 14-17 July 1980 (Unesco, 1981) is summarised. The reason for singling out this one seminar from the multitude that have occurred in the region is that the recommendations elicited from the panel of experts at Motupore touched all aspects applicable to environmental protection of coastal waters.

THE MOTUPORE ISLAND SEMINAR

The focus of the meeting as expounded by Dr. John L. Munro who served as the local organizer, was to collect ".... information on the status of and changes in coral reefs and other coastal resources without waiting for the development of scientific manpower or the development of costly research facilities." The topics considered were habitat degradation, coral reef fisheries use and removal, and tourism and indirect impacts related to coastal zone management.

Eighteen recommendations were formulated under five subject headings relative to (1) population, development and environmental education, (2) coastal zone research and management, (3) traditional knowledge and management, (4) resource investigation, and (5) extension, research and training.

Population, Development and Environmental Education

The 18 papers assembled by Salvat (1987) on human impacts on coral reefs address the need for describing the various forms of coastal zone and marine resource impacts occurring or likely to occur in Guam and Micronesia. Similarly the review entitled, *"Integrated renewable resource Management for U.S. Insular Areas"* by the U.S. Congress' Office of Technology Assessment (1987) answer information needs concerning the intrinsic biological resources of Guam and

Micronesian islands, and their coastal ecosystems in relation to current and prospective population size and sustainable life styles. The appropriate dissemination of environmental information to the island people seems to be currently addressed by the moderate sophistication of the mass media including newspapers and radio stations.

Coastal Zone Research and Management

The research projects recommended at the Seminar concerned, basic population studies of marine organisms, studies of environmental changes at selected sites, and the effects of large-scale natural or artificial environmental catastrophes. All are inherently long-range studies which can be more effectively and economically carried out by scientists in their home environment rather than by visitors to the region. An example of one such study, relating to recovery following environmental catastrophes was conducted by Colgan (1982) who examined reef recovery after *Acanthaster* damage.

The call for the development of simple techniques for resource assessment, monitoring and management of coral reefs was met by Dahl (1982) who produced a *Coral Reef Monitoring Handbook*. Further information, however, is needed to evaluate the comparability of results obtained by different users, applying these techniques.

Traditional Knowledge and Management

Documentation of traditional knowledge and management of marine resources in Palau and Guam has been undertaken by Johannes (1981) and Amesbury *et al.* (1986). This topic also formed the basis of a Unesco-Rostsea Regional Seminar in Indonesia in December 1983 where numerous papers were presented and later published (Ruddle & Johannes, 1985). Further work needs to be undertaken to record such knowledge, before the information is lost forever.

Resource Investigation

The charting of potential fishing grounds with the use of high-quality areal photography and satellite images has yet to be undertaken in the Micronesian region. The standardization of survey methods for the assessment of exploitable marine resources although logical may be a long way from finalization. Biologists from the University of Guam and the University of the South Pacific have held workshops in Pohnpei, Fiji and Papua New Guinea to develop sampling methods, and to develop standardised methods for investigating fisheries and mangroves.

Further information on the basic biology of selected reef food organisms is still needed and the potential benefits of mariculture have renewed the impetus to obtain appropriate information on such organisms, as giant clams, sea cucumbers, and rabbitfish, in Guam and Micronesia. Likewise, the description of fish communities in Guam and Saipan waters are now available (Amesbury, 1978; Amesbury et al., 1979; Molina, 1983), and these studies can serve as the basis for future comparative studies in other sites within Micronesia.

The recent completed survey of Ngerukewid Islands Wildlife Preserve in the Republic of Palau (Birkeland & Manner, 1989) demonstrates the value of cooperation and team work in resource assessment between members of various units on Guam and from the South Pacific Commission.

Extension, Research and Training

Training workshops have always been available to coastal resource managers in the Pacific and one such workshop (SPREP, 1987) was held in Pohnpei and Tonga.

The publication of the *Coral Reef Management Handbook* (Kenchington & Hudson, 1984) targeted for middle- and upper-level managers, addresses the prior void in this area. The publication was strongly recommended in a resolution at a Unesco sponsored workshop in Manila in 1981 (Unesco, 1982). A guide (Salm & Clark, 1984) is also available for planners and managers of marine and coastal protected areas.

The limitation is not in the availability of training opportunities for appropriate officials, but the targeting and support of islanders who aspire to pursue baccalaureate and master's degrees in applicable environmental-related disciplines.

The existence of SPREP and ASPEI today implemented the Seminar's last recommendation that a network be established between various institutions in the tropical Pacific region with marine-oriented activities.

CONCLUSIONS

Based on my own experience at the University of Guam during the past 22 years, regional cooperation among environmental scientists has indeed become a means of standard operation in their quest to obtain the necessary funding levels over longer periods. The implementations of many of the tasks were not accomplished in direct response to the recommendations posed at the Motupore Seminar, but were completed by individuals who were aware of the needs in the region and who envisioned the completion of their product through regional cooperation as seen by the diverse authorships in the individual handbooks.

The resources, expertise and potential funding sources are available to improve our coastal island environment within the tropical Pacific, if we can resolve to do so. This situation will not come from individual or institutional territoriality in research endeavours, but only through genuine regional cooperation by all.

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INTEGRATED COASTAL RESOURCES MANAGEMENT PLAN: A FIRST FOR MALAYSIA

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ABSTRACT

The relatively recent and rapid development of Malaysia's national economy has taken place in the absence of adequate environmental safe-guards and has resulted in conflicting usage and severe degradation of the coastal resources.

This paper attempts to show how a unique experiment, using close collaboration, consultation and systematic research efforts combined with plan formulation, by a dedicated multi-disciplinary team of resource managers and scientists from local universities and State and Federal agencies, is resulting in the evolution of a promising and viable coastal resource management plan for South Johore, Malaysia. This management plan may be used as a model framework for developing solutions to Malaysia's problems of coastal resource use conflicts.

INTRODUCTION

South Johore, Malaysia which has an area of about 6,220 km^2 and a population of 650,000 is located on the southern most tip of Peninsular Malaysia, bounded by the Straits of Malacca to the west, Johore Straits to the south and the South China Sea on the east (Figure 1). The west coast has been largely developed for agriculture; the southern region for urban, port and industrial development; and the eastern coast and off-shore islands relatively slowly for tourism. (Universiti Kebangsaan Malaysia, 1988).

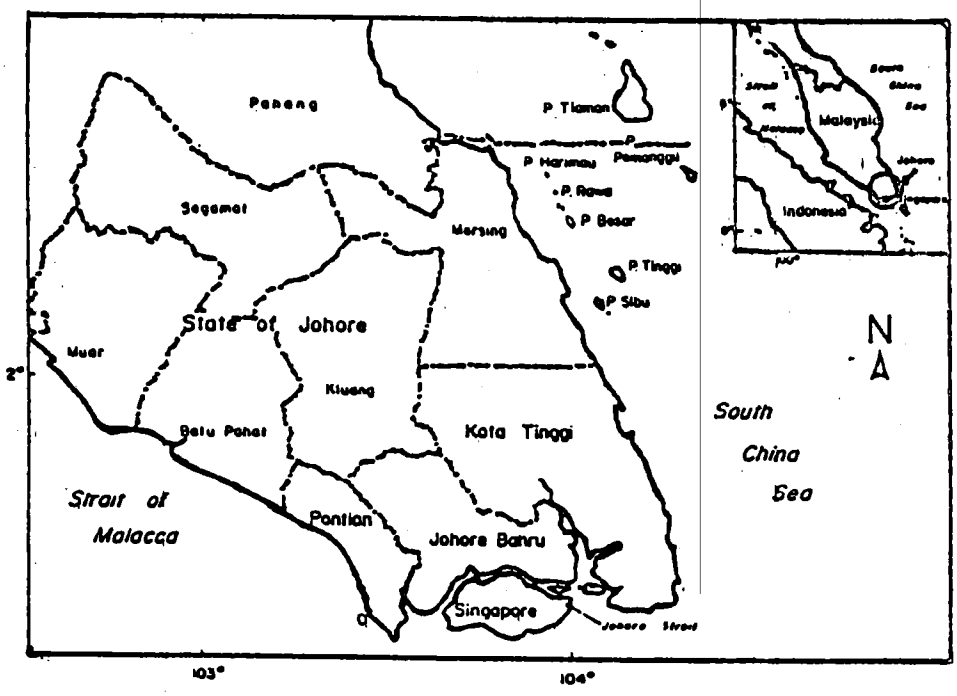

Figure 1. State of South Jahore, Malaysia.

There is as yet no policy or legislation which singles out the coastal zone as an area for integrated development in Malaysia. Nor is there a single body which has responsibility and comprehensive mechanisms for the effective co-ordination of all the various laws and legislative instruments pertaining to developments in the coastal zone. There are more than ten acts and several subsidiary legislative instruments relating to or having relevance for developments in the coastal zone (Ch'ng, 1987).

The regulation, control and planning of land use and building rest with the local authorities concerned with planning, which are subject to the guide-lines established by the State Planning Committee. Although the Federal Government may recommend national policies pertaining to development, it is still within the competence of the State Government concerning their local adoption (Ch'ng, 1987).

Planning and management of coastal resources in Malaysia and therefore also South Johore have been based on traditional economic sectors. This sectoral approach and the extensive and rapid economic development pressures faced by South Johore have resulted in a failure to develop effective solutions to the management problems of South Johore's fragile ecosystems. This coastal region contains varied and important resources including mangroves, coastal forest, fisheries, mudflats, sandy beaches, Nypa and peat swamps, estuaries, coral reefs and several off-shore islands.

Integrated coastal zone management is therefore a new approach in Johore and under an ASEAN-US initiative Malaysia is embarking on coastal resource management planning using South Johore as a pilot site. Under this project a unique experiment is being undertaken by a group of dedicated scientists, resource planners and managers from four local universities, and more than 25 state and Federal agencies in Malaysia (Table 1) designed to develop a coastal resource management plan for South Johore. This project is being undertaken under the auspices and initiative of an ASEAN-US Co-operative Programme on Marine Science over the period, 1987 to 1990 and is an attempt to formulate an appropriate model for Malaysia since no single coastal management model is likely to be appropriate for all countries (Lowry, 1988).

DEVELOPING A COASTAL RESOURCE MANAGEMENT PLAN FOR SOUTH JOHORE: PREMISES USED

The most important and crucial factor in the formulation of the plan is to ensure that not only is it acceptable but also that it is implementable (Chua, 1988). In the search for a formula to satisfy this criterion several premises were utilised to plan a working framework.

There is already an awareness of the coastal resource management issues faced by South Johore among the political leadership and top decision makers. The knowledge and technical expertise for the appropriate responses to these issues are mostly available locally. The ineffectiveness of present management policies, strategies and measures are due to a number of factors which are discussed below.

Political will

In the first instance decision making at the state level invariably lies with the political arm of the State Government. The political will to accept a coastal resource management plan is therefore a pre-requisite for successful implementation of any management plan. Many of Malaysia's top decision makers and politicians are not schooled in the field of environmental science and are therefore not familiar with the principles of sustainable management and development of coastal resources nor are they cognizant of the magnitude and seriousness of the issue involved. Under such circumstances it is important that they be shown convincingly the consequences of development decisions and of the environmental impacts involved and educated in the principles of sustainable environmental management and development.

Table 1. Agencies co-operating in the development of the coastal resource management plan for the State of South Jahore, Malaysia.

Federal Agencies
Coordinating and Implementing Unit (Prime Minister's Department)
Department of Town and Country Planning
Department of Hydrography (Ministry of Defence)
Department of Drainage and Irrigation
Department of Environment
Department of Survey and Mapping
Department of Geological Survey
Department of Agriculture
Department of Forestry
Fisheries Research Institute (Penang)
Forest Research Institute of Malaysia
Johore State Agencies
State Economic Planning Unit
Department of Forestry
Department of Land and Mines
Department of Drainage and Irrigation Department
Department of Agriculture
Department of Town and Country Planning
Department of Geological Survey
Department of Fisheries
Department of Mapping
Department of Environment
Marine Department
Universities
University of Science Malaysia
University of Malaya
University of Technology Malaysia
University of Agriculture Malaysia
National University of Malaysia

Economic evaluation of alternative uses

Secondly, in a fast developing state such as Johore, political decisions are often made solely on economic criteria. Therefore the present and future economic values and costs of the various competing uses of coastal resources should be clearly defined in order to enable decisions to be made between competing uses. Dixon and Hodgson (1988) and Aquero (1988) have demonstrated that "simple economic evaluation of the coastal resources can provide effective guidance to policy makers in assessing net benefits from alternative and conflicting uses".

A simple example would be the alternative use of mangroves as aquaculture, agricultural or industrial sites as opposed to their maintenance in support of marine capture fisheries. Generally mangroves are considered wasteland and therefore of low economic value. If the real long term economic value of mangroves in terms of various alternative uses can be demonstrated then politicians and decision makers have available the necessary information for making balanced decisions.

The need for a multi sectoral approach

A third premise, taken as a basis for developing the working framework was that the management of coastal resources needs to be undertaken from a multi-sectoral view point, since no coastal habitat exists independently of other habitats, but each is a component of a wider coastal system (Burbridge, 1988; Chua, 1988; Hodgson & Dixon, 1988). Therefore in the case of South Johore both the Federal and State Governments (at all levels) need to be closely involved in the evolution of the plan, and the active participation of both public and private sectors in its formulation is necessary for its success.

An important component of the envisaged team effort would be the involvement of Regional Development Authorities which have been shown by Ch'ng (1987) to have wide ranging planning powers and usually substantial resources to implement development programmes on a integrated regional scale. Moreover the success story of regional development authorities has been based on a tradition involving political leadership in each state in the initiation of development plans. Incorporating development authorities in the planning process would therefore win more support from the political arm of the Government.

In Malaysia where there is a strong tradition of competent government institutions, backed by strong legislative authorities, concerned with managing coastal resources or regions on a sectoral basis, it would be impractical if not impossible, to recommend institutional changes in order to secure more effective coastal resources management. What is practical however is the formulation of a framework for resource management with very clear, defined policies and strategies. A strong co-ordinating body backed by a strong mandate is necessary to ensure effective implementation of the plan once formulated. In order to obtain the consensus and support needed, maximum participation at all levels of all sectors, both government and private at every stage of plan formulation and implementation is imperative.

Specific techniques for development of a coastal resource management plan.

A premise adopted in the project for South Johore is that there needs to be a mix of various specific techniques including:

Specific site/resource management plans

Management of coastal resources would be more effective on a site or resource specific basis. This is particularly true in the case of Malaysia where plan implementation often takes place at provincial, district, and municipal levels. In the case of South Johore site and resource specific resource management plans could be established for mangroves, fisheries and the off-shore island resources.

Zoning designations

Zoning designations need to be made which clearly define and co-ordinate future uses to prevent user conflict.

Changing behaviour of people

Coastal resource management plans in South Johore would involve influencing, changing, and/or modifying the behaviour of politicians and decision makers; resource end-users; and, resource managers. Such an objective can only be achieved via educational programmes and incentives, such as tax exemption, rather than merely relying on legislation and regulations which in most cases have been found to be ineffective due to local, cultural practices and peculiarities.

WORKING FRAMEWORK FOR PLAN FORMULATION AND IMPLEMENTATION

Collection of secondary data and research: identification of issues

In order to harness and maximise the participation of all available national human resources and to enhance the learning process in the field of coastal resource management and planning, a total of 27 universities and institutions (government and private) are involved in a large number of research tasks and sub-tasks (Table I and Annex I). To date, research results have identified eleven management issues.

Plan formulation and implementation

In order for maximise participation in decision-making and co-ordination of plan formulation, two committees were established one at national and one at state level (Figure 2).

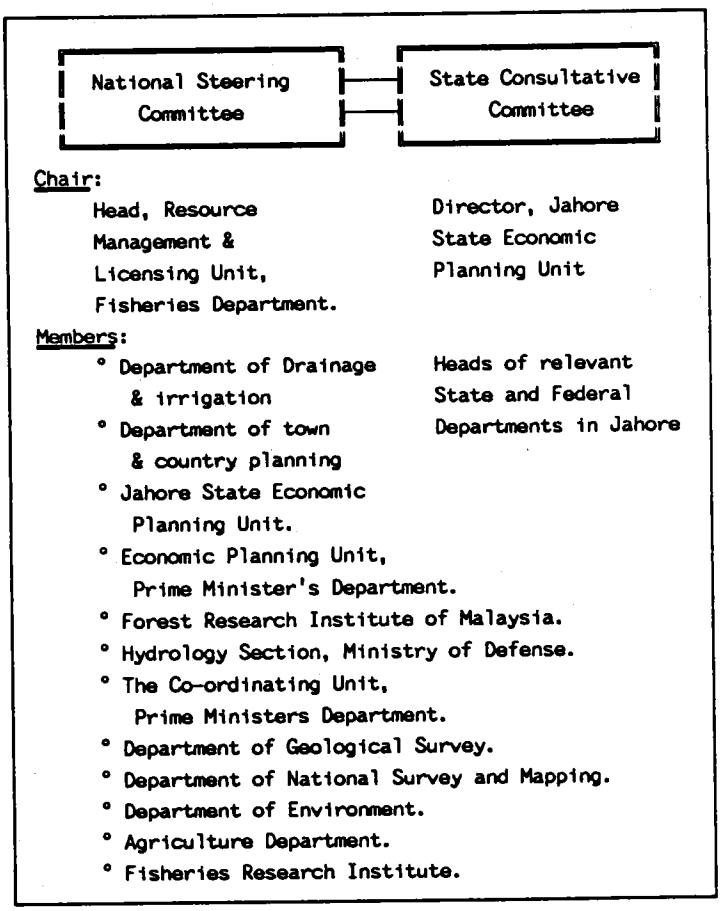

Figure 2. Committee structure for development of the Jahore Coastal Resource Management Plan.

The planning process (see Figure 3) places priority on the most important and crucial part of plan development, namely frequent interaction and discussion between researchers and the federal and state government officials through regular meetings, briefings and workshops.

Integration at various levels is ensured by the participation of both State, district and municipal personnel in the planning workshops (see Figure 4).

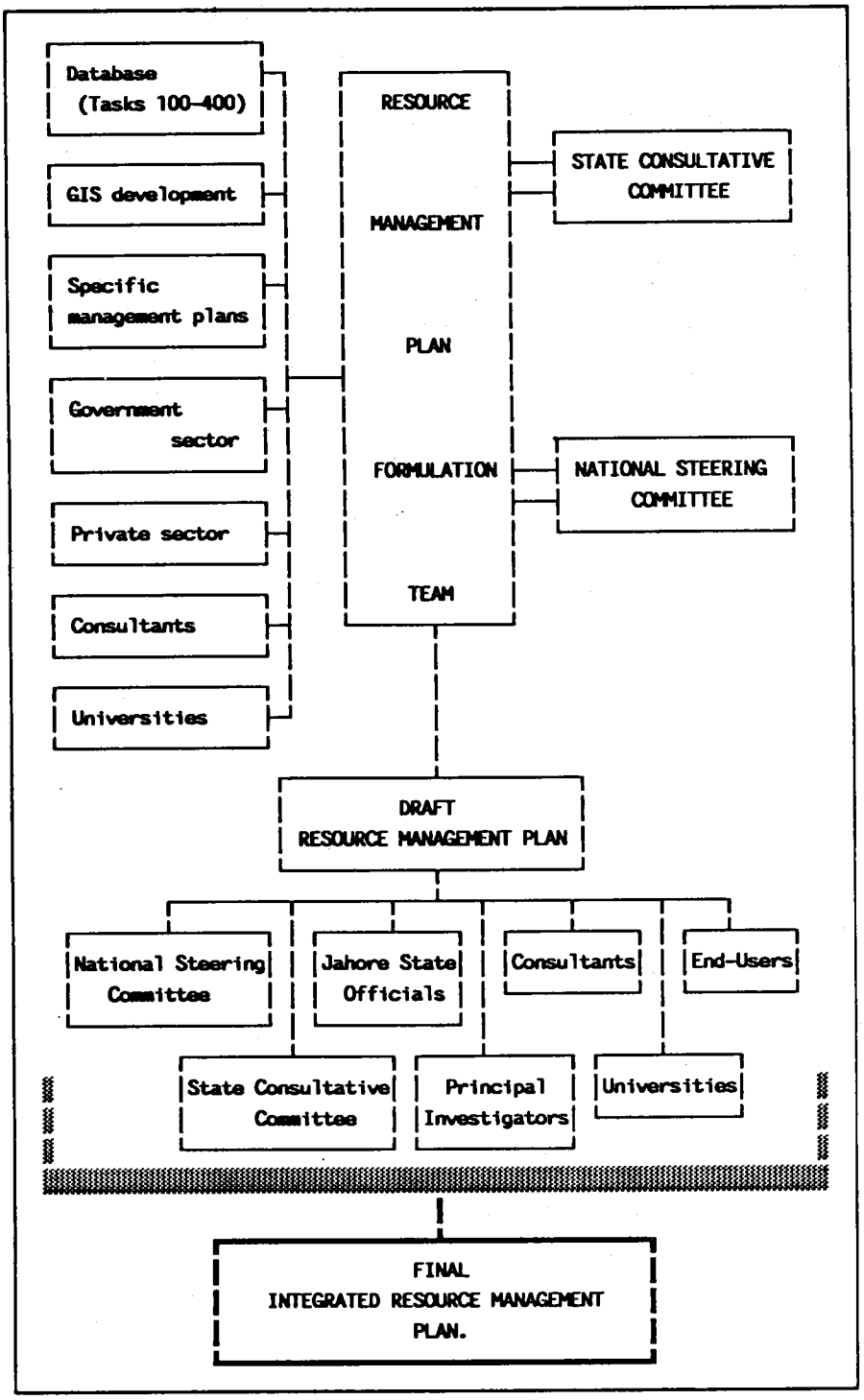

Figure 3. Resource management plan formulation.

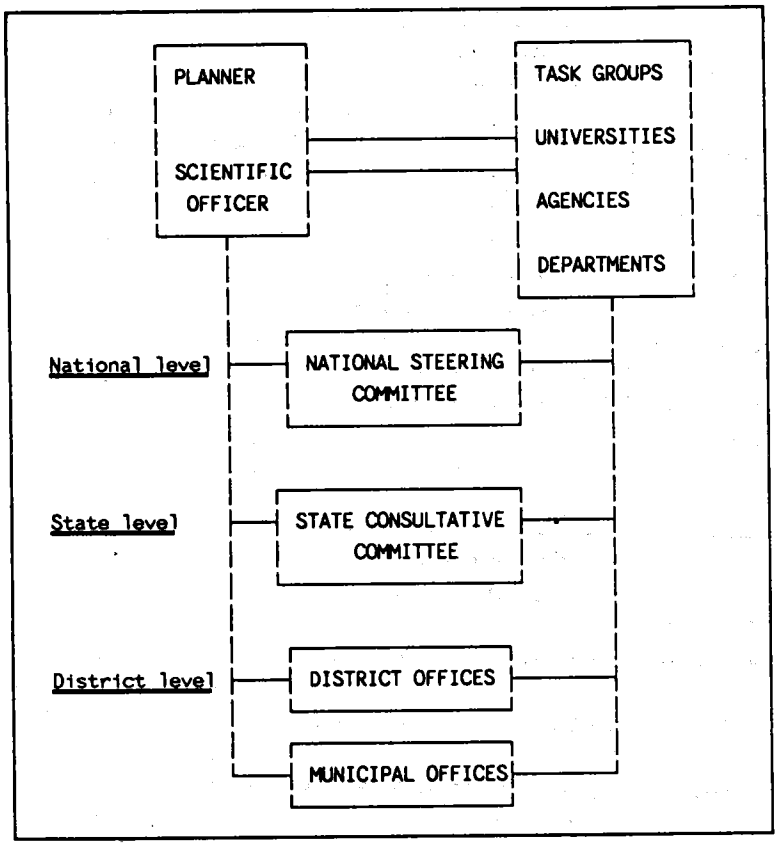

Figure 4. Integrated information flow at various levels.

To date three national workshops have been held involving all the personnel cited above and management plans are currently being formulated by resource management plan formulation teams. A full time planner and scientific officer have been employed to formulate resource and site specific plans through small working groups which include representatives from relevant federal and state government agencies, regional development authorities and researchers involved in relevant tasks (see Figure 5).

Resource and site specific management plans

The resource and site specific management plans which have been identified for formulation include:

Coastal forest/mangrove management plan;
Inshore fisheries management plan;
Water quality management plan;
Coastal erosion control management plan;
Sand mining management plan;
Aquaculture management plan; and
Tourism management plan.

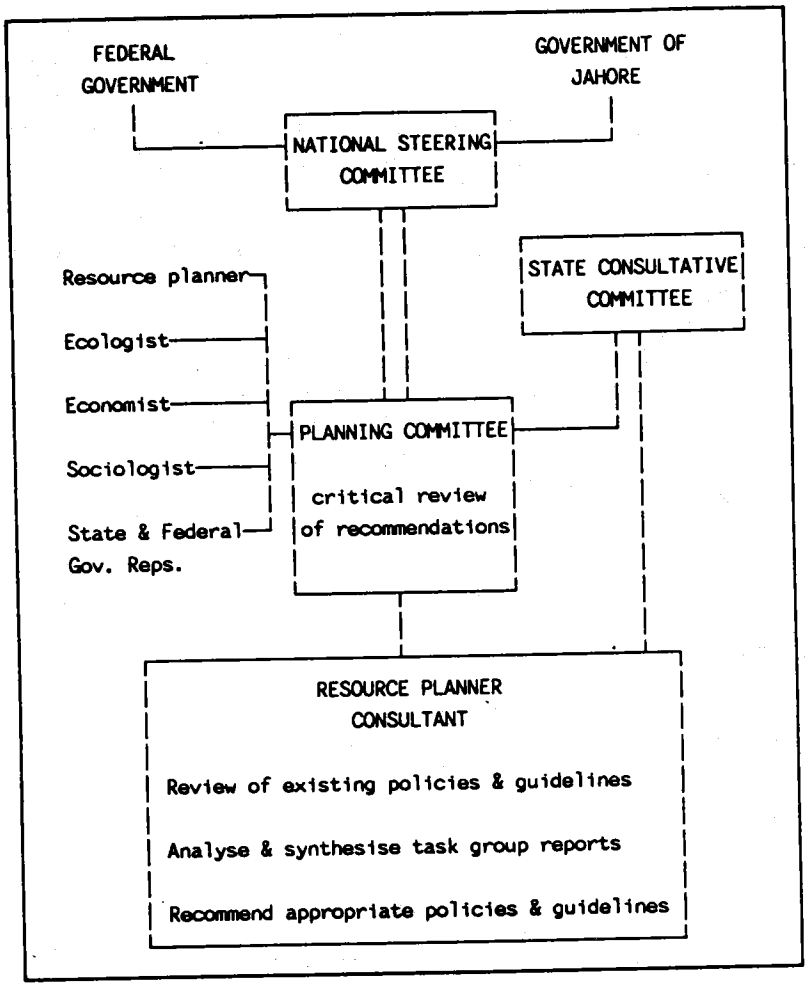

Figure 5. Decision making pathways in formulating policies and guidelines

In preparing these plans emphasis is placed on the integration of each sector; the resolution of existing resource use conflicts; and the allocation of future resources use through appropriate measuress and habitat enhancement procedures.

Geographical Information System (GIS) for plan integration

Plan formulation for South Johore involves using GIS (Kam & Leong, 1988; Wong, *et al.*, 1988) (Figure 6) to analyse the linkages between hinterland, river basin land use and the coastal zone, in particular the impact of the former upon the resources of the latter; and to establish a spatially related information base for the coastal zone.

Formulation of an Integrated coastal resource management plan for South Johore will result in the following:

* Flow charts showing linkages of all agencies and plans to accomplish integrated co-ordination of smaller area, issue-oriented and Marine and Estuarine Protected Area plans.

* Complete maps of Johore and all site specific management areas which are consistent in scale and complete with overlays to show important relationships and priorities of management.

* A document which spells out how the various plans will be co-ordinated and implemented.

* A working committee headed by the Economic Planning Unit of Johore (EPUJ) composed of dedicated persons representing appropriate agencies to co-ordinate plan refinement and review.

* A series of seminars to communicate the results of the planning process to various audiences.

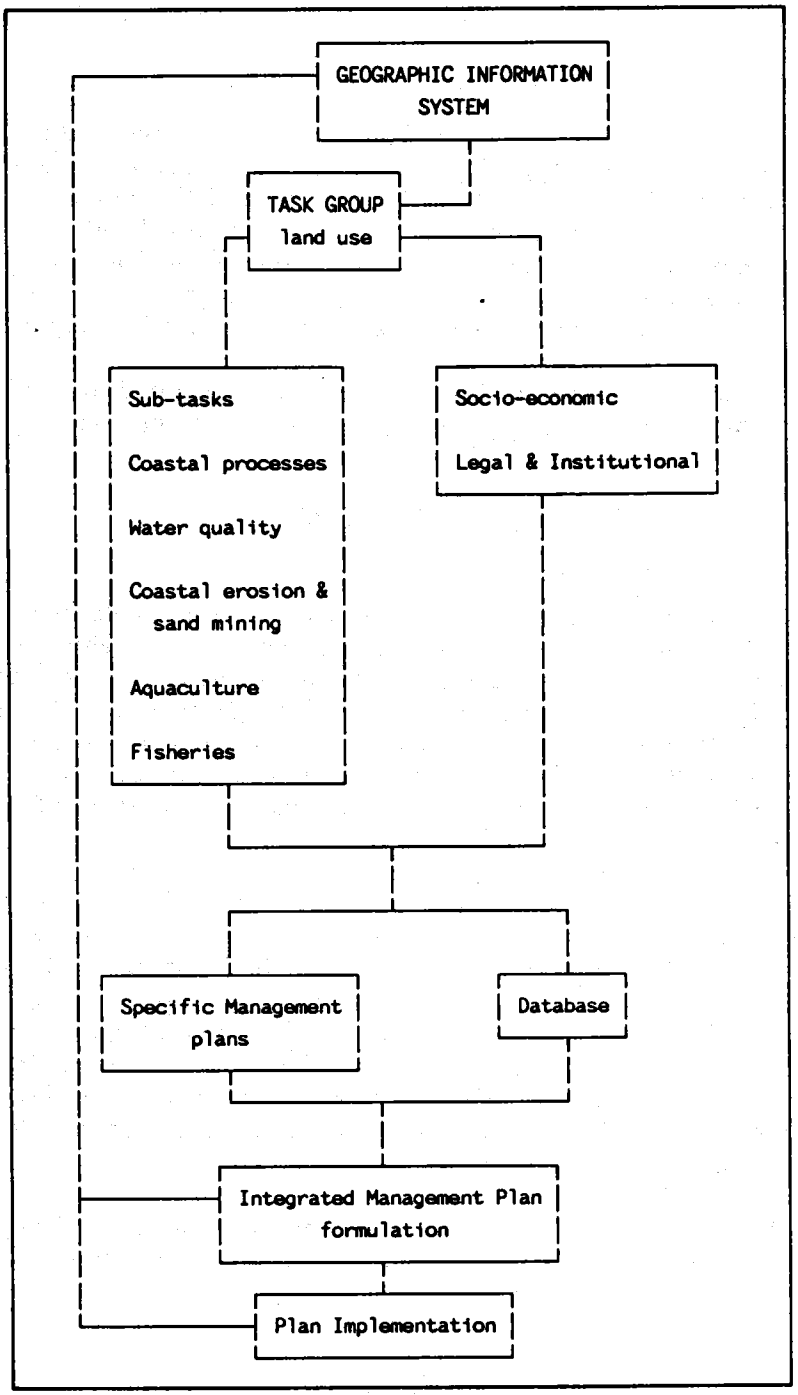

Figure 6. Information flow and use of Geographic Information System in the development of integrated coastal resource management plans.

Coordinating body for plan implementation

The Economic Planning Unit of the Johore State Government (EPUJ) has been identified as the body responsible for the co-ordination of the implementation of plan. This unit presently plays an active role in plan formulation and the planner referred to above is physically located in the executive office of the Economic Planning Unit. The Director of the Unit and his deputy both sit in the National and State Consultative Committees and also act as the secretariat for the Johore Government State Planning Committee. All development plan proposals submitted to the State Government are analysed and processed by the economic planning unit which is therefore the logical body to under-take the task of coordinating implementation of the plan.

Education and publicity

The South Johore project has also embarked on a planned, education and publicity programme to educate and convince both the end-users, resource managers and politicians, decision makers of the benefits of the plan and of the potentially serious implications should it not be adopted. The Director of the Economic Planning Unit, his deputy and other Federal and State officers and researchers have been sent to attend courses on: the principles of coastal zone management; policy workshops; training programmes on Geographic information systems; marine affairs; techniques for socio-economic evaluation and a variety of other important areas

Exhibitions and articles in national newspapers have featured the plan and widespread publicity through the mass media is given to every national workshop conducted.

CONCLUSION

The coastal resource management plan project in Malaysia is developing its management plan concurrently with on-going research. The planning process highlights the fact that the most important and crucial part in developing the plan is frequent and constant interaction and discussion between the researchers, and federal and state government officials. The successful development of the coastal resources management plan in South Johore and its implementation in the Sixth Malaysia Plan (1991 - 1995) is ensured by the active interest, support and participation of both the federal and state governments in particular the Chief Minister of Johore and the State Director of the Economic Planning Unit, Johore.

Action is also being taken to brief the state government at both the executive and political levels and to obtain their consent to the implementation of the plan. At the same time steps are being taken to sponsor officers both from the Economic Planning Unit of the Johore State Government and from relevant federal agencies for postgraduate programmes in marine sciences. This move is aimed at developing a trained cadre of officers with expertise in marine affairs at both state and federal levels. Officers from agencies represented in the Project Steering committee have also been sent for training on information systems. A series of coastal resource management and planning, technical workshops and policy seminars for decision makers and planners were conducted in 1987 and 1988.

It is envisaged that this first attempt at coastal resource management and planning in South Johore will, if proven successful, be extended to all other Malaysian states as part of the Regional Economic Planning Process.

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Annex 1. Project Structure, tasks, sub tasks and current status.

Division 100 - Baseline Information:	
Status:	Completed.
Task Code 110-M:	Preparation of an Environment Profile of Johore State, Malaysia.
Division 200 - Biogeographical Studies:	
Status:	Currently being accomplished.
Task Code 210-M:	Coastal Forest Management Scheme.
Task Code 220-M:	Water Quality Management Scheme.
Task Code 230-M:	Geographical Information System (GIS) for Coastal Resource Management.
Task Code 240-M:	Assessment of Coastal Erosion.
Subtask 241-M:	Data on Physiography.
Subtask 242-M:	Causes & Extent of Coastal Erosion and Remedial Measures.
Subtask 243-M:	Management Guide-lines for Sand Mining.
Subtask 244-M:	Movement of Dredging Residue and Dispersion of Pollutants.
Task Code 250-M:	Prawn Stock Assessment for Inshore Areas.
Task Code 260-M:	Present Status and Economics of Aquaculture Practices and Potential Areas for Development.
Subtask 261-M:	Present Status of Aquaculture Practices and Potential Areas.
Subtask 262-M:	An Economic Analysis of Coastal Aquaculture Practices.
Task Code 270-M:	Development of Management Plans for the Johore Causeway.
Task Code 280-M:	Development of Management Plans for the Off-shore Islands of Johore.
Division 300 - Socio-economic Studies:	
Status:	Currently being accomplished.
Task Code 310-M:	Socio-economic Survey.
Task Code 320-M:	Guide-lines for CR Management for Tourism.
Division 400 - Legal Institutional Studies:	
Status:	Currently being accomplished.
Task Code 410-M:	Legal and Institutional Studies.
Division 600 - Resource Management Plan Formulation:	
Status:	To be accomplished in 1989.
Task Code 610-M:	Resource Management Plan Formulation.
Subtask 611-M:	Guide-lines/Policies for CRM in Johore.
Subtask 612-M:	Formulation of Action Plans for Issue Areas and Important CR's.
Subtask 613-M:	Formulation of Management Plans for Marine and Estuarine Protected Areas (MEPA).
Subtask 614-M:	Formulation of an Integrated Coastal Area Management Scheme for Johore.
Subtask 615-M:	Coastal Resource Management System.
Division 700 - Implementation Division:	
Status:	To be accomplished from 1990 onwards.
Task Code 710-M:	Seminar/Meetings Decision Maker Level.

MARINE POLLUTION MONITORING IN THE SOUTH EAST PACIFIC: PAST AND FUTURE PROGRAMMES AND INTERNATIONAL CO-0PERATION.

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ABSTRACT

The development of Phase I of the Co-ordinated Programme on Marine Pollution Monitoring and Control in the South-East Pacific (CONPACSE) is reviewed. The range of pollutants monitored, institutions involved and constraints identified during this first phase of CONPACSE are detailed and the proposed structure and development of the second phase (CONPACSE Phase II) are outlined.

BACKGROUND

An International Workshop on Marine Pollution in the South East Pacific, held in Santiago (Chile), in November 1987 (IOC, 1989), examined the regional situation, and identified, amongst other problems, the following constraints in understanding the nature and extent of regional pollution problems:

- the inadequate and sometimes non-existent information concerning the main sources of pollution in the region, their extent and significance as well as the volumes, composition and impact of the pollutants; and

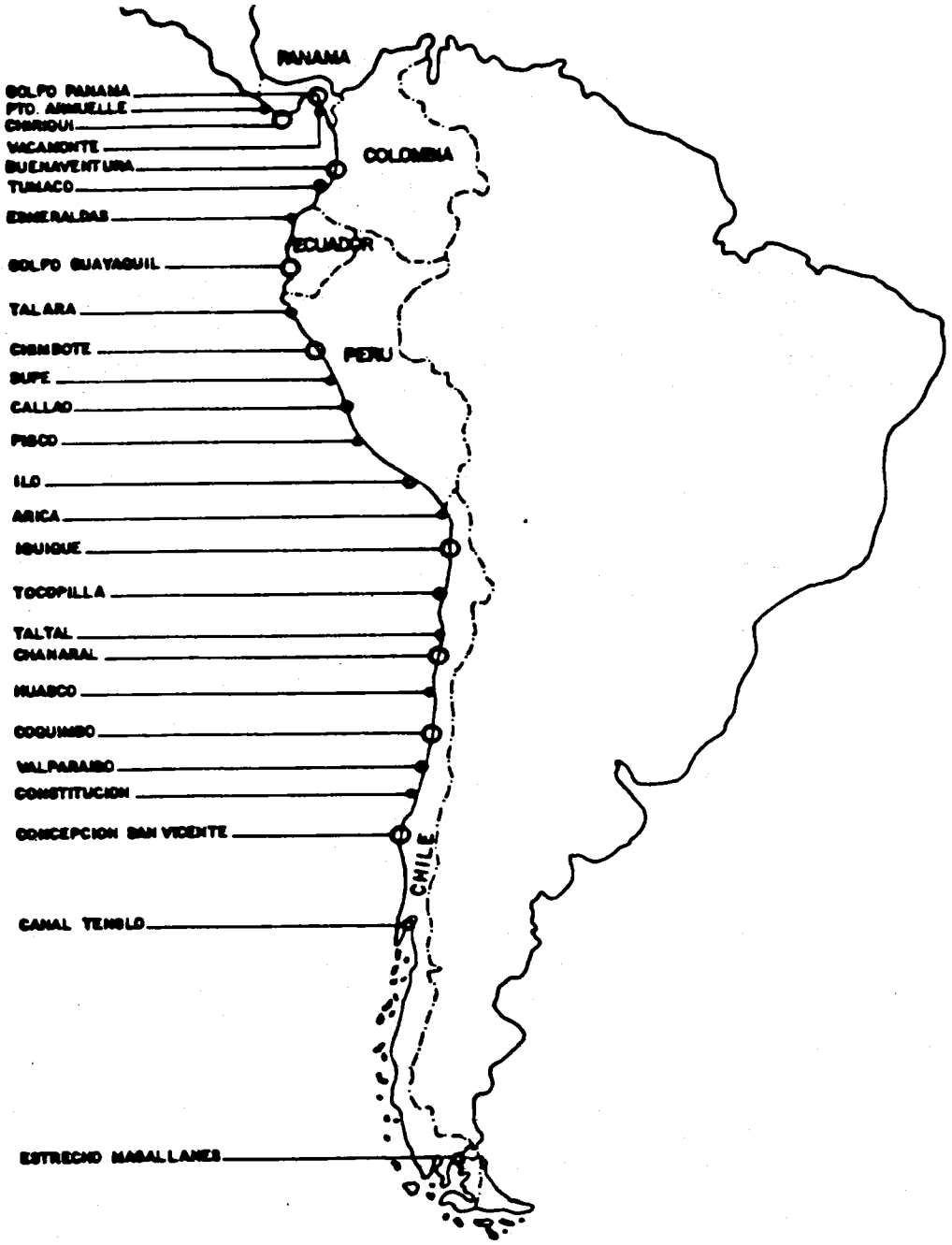
- the lack of up-to-date information on the pathways of the main pollutants involved in discharges, their distribution and final destination.

The Workshop stressed the limited scope of available information, its characteristics and the variety of methods employed in current studies. The Workshop recommended that further basic work should be carried out including the adoption of standardised methods and techniques as well as intercalibration exercises to ensure high comparability and quality of the data, and its wide dissemination and use in the region.

On the basis of the preliminary identification of pollution sources (Cabrera, 1979; Puga 1979; Valencia, 1979) in Chile, Peru and Ecuador, and a subsequent regional inventory of the sources, levels and impacts of pollution (including Colombia and Panama) based on an assessment of the scale and main sources of pollution in the South East Pacific, pollution sources were classified in order of importance as 'serious', 'moderate' and 'strong' (UNEP/CPPS 1981a). Figure 1 shows the location of sources of pollution and their relative importance in accordance with this arbitrary scale.

Based on this information, the First Intergovernmental Meeting of the Action Plan for the Protection of the Marine Environment and Coastal Areas of the South East Pacific, held in Quito in 1987, selected priority areas (Table 1) for the conduct of basic research on pollution through a Co-ordinated Programme on Research and Surveillance of Marine Pollution in the South East Pacific (CONPACSE II) (CPPS/UNEP, 1983), as follows:

Figure 2 illustrates CONPACSE Priority Areas in which various studies have been carried out during the period 1984 - 1989 together with the location of various research activities which will be pursued in compliance with the programme schedule.



Open circles: small = moderate pollution.
large = strong pollution.
Solid circles: = serious pollution.

Figure 1. Identified areas and sources of pollution in the CPPS Region (adapted from Gallardo, 1984).

Table 1. Geographic areas identified for priority action in during Phase II of CONPACSE.

Chile:	Valparaiso Bay, Concepcion Bay, Straits of Magallanes.
Colombia:	Buenaventura Bay, Tumaco Cove, Gorgona Island.
Ecuador:	Guayaquil Gulf, Lower reaches and estuarine areas of the Guayas, Daule and Babahoyos Rivers, La Libertad, Manta, Esmeraldas, Manabi, El Oro.
Panama:	Panama Gulf, Chiriqui Gulf, Vacamonte Port, Charzo Azul, Punto Caimito.
Peru:	Coastal Areas of Metropolitan Lima, Callao, Talara, Ilo, Ite, Tumbes, Chiclayo, Supe.

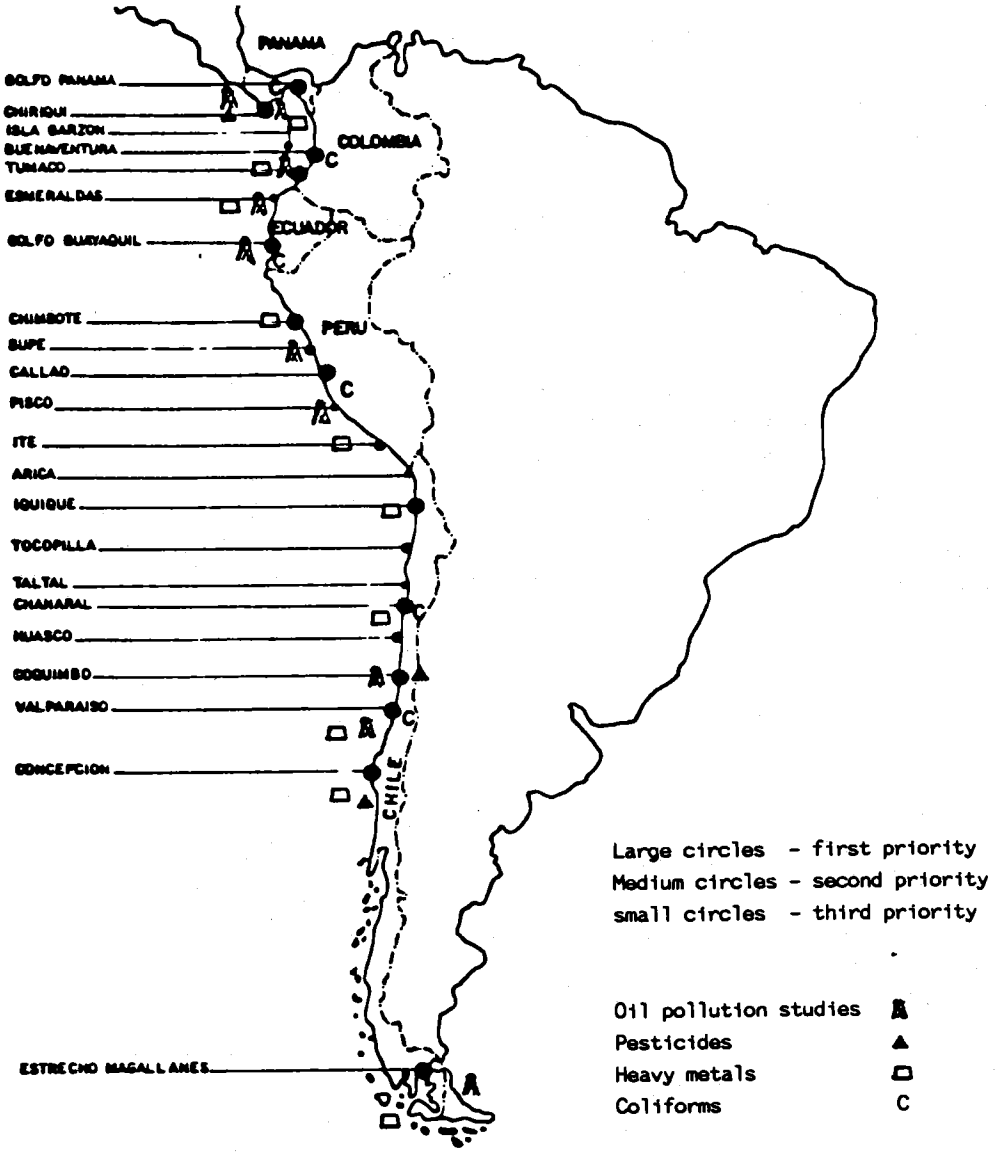


Figure 2. Priority areas for action in the field of pollution monitoring during Phase 2 of CONPACSE.

BASIC STUDIES

CONPACSE represents the merging of two basic regional programmes namely, the programme on the Characterization, Surveillance and Monitoring of Marine Pollution from Domestic, Agricultural, Industrial and Mining sources in Ecologically Sensitive Areas of the South East Pacific; and the Programme on Research and Surveillance of Marine Pollution of the South East Pacific due to Oil Hydrocarbons. Both programmes were brought together in the Working Document (UNEP/CPPS/IOC, 1984) which details a minimum workplan, using defined analytical and sampling techniques, provides guide-lines on data handling, and identifies training and education needs. Annex 1 shows the various techniques and methods adopted by CONPACSE in accordance with each specific activity, by geographic area and responsible institution.

Field and laboratory activities were initiated in late 1984 at which time an Institutional Network was established. Five years later, in 1989, the network had expanded to comprise forty-four institutions including state-run laboratories, universities, specialized centres, maritime authorities, and others. The adoption of common analytical techniques, and the running of intercomparison and intercalibration exercises and training courses has involved more than five hundred experts from the five member countries of the CPPS region.

RESULTS OF BASIC STUDIES

During the five-year period between 1984 and 1989, a total of 3,335 analyses were performed; 66 % (2,215) of these involved tests for heavy metal and pesticide residues in marine organisms, sea-water and shallow marine sediments; 1,120 (33 %) of the tests were for oil hydrocarbons dissolved or dispersed in sea-water, in marine organisms and in sediments; and the remainder involved the recording of tar on beaches and a few microbiological analyses of regional marine waters and beaches. Detailed results are described in various regional reports, (Escobar, 1987; Gallardo, 1984; UNEP/CPPS, 1981a;UNEP/CPPS, 1988a; UNEP/CPPS, 1988b; UNEP/CPPS, 1988c; UNEP/CPPS, 1988d) and a synopsis of results is provided in Table 2. Broadly speaking, the highest concentrations of pollutants coincide with those areas identified as priority areas in the initial surveys.

Problems identified during Phase 1 of CONPACSE.

On various occasions CONPACSE has been assessed both by Governments and/or intitutional agencies of the Action Plan or, by means of specific consultancy missions as recommended by meetings of experts. At the second and third Intergovernmental Meetings, held in the Galapagos Islands (August 1985) and in Bogota (April 1987), the CPPS provided information on the development of the Regional Action Plan, the results obtained and difficulties hindering further development of the Plan. For their part, Governments made decisions which ensured the smooth development of activities as scheduled. The various assessments of CONPACSE have identified the following problem areas:

i) routine maintenance programmes for analytical equipment are lacking;
ii) the programme faces difficulties in obtaining analytical standards, and reagents including difficulties in importing solvents in some countries;
iii) a variety of sampling techniques are currently being employed leading to non-comparability of the data;
iv) analytical capabilities are limited in terms of available equipment (Vasquez-Botello, 1986);
v) there is a further need to adopt comparable criteria for validation and comparison of analytical procedures;
vi) well defined programmes to ensure analytical and data quality are lacking;

vii) infrequent use of analytical standards and certified reference samples as a means to monitor accuracy, and precision and the need to reproduce reference methods and documents for wider dissemination and use (Cortez, 1989).

Table. 2 CONPACSE, Study areas, estimated pollutants and levels determined during Phase 1.

Locality	Pollutants		Values	Remarks
	Nutrients and suspended solids			
Columbia				
Tumaco/Buenaventura	Nutrients	NH_4	31 ug l^{-1}	Local, moderate
		NO_2	29 ug l^{-1}	
	Suspended solids		193.2-391.5 mg l^{-1}	
Ecuador				
Estuarine areas of	Nutrients	PO_4	33.4 ug l^{-1}	
the Daule, Guayas		NO_2	34.6 - 35.0 ug l^{-1}	Local, strong
and Babahoyos Rivers		NH_4	114.0 ug l^{-1}	
	Bacterial pollutants			
Panama				
Panama Bay	Coliforms		Not Measured	Local, moderate.
Columbia				
Tumaco/Buenaventura	Coliforms		1,000 ml^{-100}	Local, serious.
Chile				
Coastal Areas	Coliforms		95,000 ml^{-100}	Local, serious.
Valparaiso & Antonio	(Total and Faecal)			
Ecuador				
Coastal Areas	Coliforms	Total	24.5 - 3,375 ml^{-100}	Local, serious.
Guayaquil Gulf,		Faecal	120 - 4,002 ml^{-100}	
Panama				
Panama Bay	Total Coliforms		100,000 ml^{-100}	Local, serious.
Matasnillo River				
Peru,				
Rimac River Basin	Coliforms	Total	2400 ml^{-100}	Local, serious.
Metropolitan Lima,		Faecal	1-100 ml^{-100}	
Paracas, Pisco and Aton				
	Pesticides			
Chile	Pesticides in Waters			
Tome, Andalien,		Aldrin	0.163-0.100 ppb	
I de Reyes, Coliumo,		DDT	0.004-0.25 ppb	Exceeds EPA Limit.
Lirquen, Burca	Pesticides in Sediments			
		Aldrin	0.004 - 0.174 ppb	
		Lindane	0.021 - 2.151 ppb	
		DDT	0.009-0.68 ppb	Higher than average.
		DDE	0.749-2.12 ppb	
Panama				
Panama Bay	Pesticides in Sediments			
		Endrin	0.160 ug g^{-1}	
		Lindane	0.09 ug g^{-1}	Higher than normal.

Table 2. continued

Locality	Pollutants	Values	Remarks
		Heavy Metals	
Ecuador			
Lower river & estuarine areas of Guayaquil Gulf	Cu in Water	10.0 ug l^{-1}	Exceeds Threshold for Marine species.
Guayas	Cd in Water	10.44 ug l^{-1}	Concentrations above
Daule		14.78 ug l^{-1}	toxicity levels as
Babhoyos		7.47 ug l^{-1}	defined by several
Guayaquil Gulf	Hg in Sediments	0.89 - 5.44 ppm	authors, Serious.
Peru			
Chimbote, Callao, Pisco Tacna	Hg in Sediments	0.4 ppm	Concentration exceeds threshold values
Metropolitan Lima	Hg, Cd, Fe, Zn in Water	Not Measured	Pb & Fe Concentrations above national limits.
Columbia			
Buenaventura	Hg in Sediments	1.89-6.57 ppm	High values.
Tumaco/Buenaventura	Cd in Molluscs	0.05 - 01 ppm	Values above threshold limits.
Buenaventura	Hg in organisms	0.01 ppm	High conc. in 5% of samples.
Chile			
Coliumo,	Hg in Organisms	0.5 ppm	Above national av. 0.05ppm.
Burca and Lirquen)	Hg in Water	0.5 - 1.65 ppb	Exceeds risk threshold limits.
Caldera Organisms	Cu, Fe, Hg, As in	other areas in the country.	High values as compared to
San Vincente Bay, Concepcion, Arauco Gulf and Lenga Estuary	Pb in water	0.03 ppb	Exceeds normal concentration in Sea-water.
San Vicente	Hg in water	0.010 ppb	Exceeds normal concentration.
Valparaiso	Cd in water	0.18-0.24 ug l^{-1}	Values above Toxicity Level
	Cd in sediment	3.4-8.8 ppm	defined by several authors.
	Hg in sediment	0.61-6.30 ppm	Values above acceptable limit.
	Cu in water	7.99-20.58 ug l^{-1}	
	Pb in water	3.44-5.72 ug l^{-1}	
	Zn in water	8.66-55.61 ug l^{-1}	
Tome, Andalien, Roncuant	Cd in Sediments	0.23-2.91 ppm	High concentrations.
Iquique Calderas and Coquimbo	Hg in Sediments	1.05-5.55 ppm	High concentrations.

DRAFT PROGRAMME OF RESEARCH AND SURVEILLANCE OF MARINE POLLUTION IN THE SOUTH EAST PACIFIC

The Third Intergovernmental Meeting on the Action Plan, held in Bogota in April 1987, adopted Resolution eight granting approval to the formulation and design of Phase II of CONPACSE entitled Co-ordinated Programmes of Research, Surveillance and Monitoring of Pollution of the South East Pacific (UNEP/CPPS, 1988e).

The Following are the main components of the approved programme:

- Surveillance of Pollution of the South East Pacific (Plan to Monitor Main Critical Areas in Accordance with CONPACSE I results).

- Monitoring of Pollution, Issuance of Legal and Technical Provisions to Combat Regional Pollution

° Provisions for training, and the establishment of Environmental Management Plans.

On the basis of assessments of CONPASCE I and as part of CONPACSE II, the proposed Programme of Surveillance and Monitoring of Regional Marine Pollution will address the following issues with a view to improving identified drawbacks and problems related to the analytical capacity of institutions, enhancing resources and combining results.

Geographical scope

The following areas have been identified by the Governments concerned for incorporation into the Programme of Surveillance and Monitoring of Marine Pollution of the South East Pacific:

° Colombia:	Tumaco Cove and Buenaventura Bay.
° Chile:	Valparaiso Bay, Concepcion Bay and Straits of Magallanes.
° Ecuador:	Coastal Areas of the following Sea Front Provinces: Esmeraldas, Manabi, Guayas, el Oro, Puerto Bolivar, Gulf of Guayaquil and Low River-beds of the Daule, Guayas and Babahoyos Rivers.
° Panama:	Panama Bay and Chiriqui Gulf.
° Peru:	Chimbote, Callao, Ite, Ilo, Talara and coastal Areas of Metropolitan Lima.

Additional areas subject to local pollution problems will also be taken into account in future surveillance activities.

Institutional participation

National institutions and laboratories taking part in the Programme will include those currently participating in CONPASCE's Regional Institutional Network which will be responsible for all aspects of the Programme. Laboratories will be selected by the National Focal Points upon the request of the Regional Co-ordinating Unit, bearing in mind their geographic coverage which should be, at least, adequate to the Programme's goals. Those laboratories which have been particularly active during the development of CONPACSE I, and have demonstrated technical capabilities (both from the professional and instrumental point of view) will be preferentially selected. The responsible institutions already identified are given in Table 3 and their capabilities and geographic areas of responsibility are further detailed in Annex 1.

Pollutants to be monitored

Those pollutants listed in Annexes I and II of the Protocol for the Protection of the South East Pacific Against Pollution from Land-Based Sources, are included in the future monitoring programme which emphasises those pollutants of particular concern to the region namely, Cadmium, Copper, Mercury, Oil Hydrocarbons, and Biocides (UNEP/CPPS, 1983).

In addition those substances referred to in Paragraphs 10-13 of Annex II of the Protocol, and in Article IV of the Complementary Protocol to the Regional Co-operative Agreement on Combating Oil Pollution in the South East Pacific (UNEP/CPPS, 1981b) are also included as is any other substances not listed in Annex I and II to Protocol for the Protection of the South East Pacific which could significantly add to the world-wide concentration of pollutants in the marine environment.

Table 3. Identified institutions participating in the second phase of CONPACSE.

Country Institution	Type of Pollutant and mode of analysis Heavy metals	Oil & hydrocarbons Fluorescence	 Chromatography	Pesticides
Colombia:				
Centro de Investigaciones Pesqueras del, Instituto de los Resursos Naturales, INDERENA.	+		+	+
Centro de Investigaciones Oceanograficas, e Hidrograficas del la Armada de Colombia, CIOH.	+	+		
Centro de Investigaciones Oceanograficas, CPPS Tumaco			+	
Chile:				
Universidad de Valparaiso, Escuela de Quimica y Farmacia	+	+	+	
Instituto de Oceanologia		+		
Universidad del Norte, Instituto de Fomento Pesquero	+			
Universidad de Concepcion, Laboratorio de Quimica,	+	+		
Deptartamento de Resursos Naturales	+			
Departamento de Oceanologia		+	+	+
Universidad de Magallanes, Instituto de la Patagonia.	+	+	+	
Ecuador:				
Escuela Politecnica del Litoral, ESPOL	+			
Instituto Nacional de Pesca	+	+	+	
Universidad de Guayaquil, Facultad de Ciencias Naturales	+			
Instituto Oceanografico de la Armada, INOCAR		+		
Panama:				
Instituto Especializado de Analisis, IEA	+	+	+	+
Universidad de Panama,	+	+		
Instituto Nacional de Recursos Hidraulicos y Electrificacion	+	+		
Peru:				
Instituto Nacional de Desarrollo Agroindustrial, INDA	+		+	
Universidad Nacional Federico Villarreal	+			
Instituto del Mar del Peru, IMARPE	+	+		

Intercalibration exercises will be designed and carried out as part of the programme to ensure comparability and high quality of analytical results and data. Intra and intercalibration Exercises will be designed to obtain information on the reliability of analytical results and to identify those elements included in the analytical methodology which may require further work in order to achieve acceptable data quality. The goals of these exercises will be to:

- to assess the accuracy of methods in normal use in CONPACSE member laboratories.
- to assess the accuracy and precision of results obtained by CONPACE laboratories.
- to identify methodological gaps.

Figure 3 illustrates follow-up procedures relevant to the intercalibration exercises which should be carried out under the CONPACSE II surveillance programme as recommended by an expert consultant (Cortez, 1989). Similarly, it has been suggested that laboratories participating in CONPACSE II should become active in so-called "co-operative programmes". These programmes seek to take advantage of new analytical methods through the use of aliquotes of a particular sample which have been carefully prepared and homogenized to assess different new and current methods in terms of their accuracy, precision and reproducibility. The IAEA as well as other international organizations supporting UNEP activities use this system whenever a new Reference Method is being prepared.

The intercalibration exercises referred to above will allow continuous follow-up on the analytical efficiency of the instruments used and participating laboratories. This will result in identification of methodological gaps, training needs and equipment replacement requirements. Certified reference materials produced by the IAEA will be used to carry out these exercises.

Analytical methods

The adoption of common methods allowing for comparison of results is one of the most significant goals of the Co-ordinated Programme of Research and Surveillance of Marine Pollution in the South East Pacific. Reference Methods (as suggested to implement CONPACSE I) have been recommended by outside consultants for CONPACSE II and include analytical methodologies for marine pollution studies developed by UNEP with the support of IAEA and IOC.

Those reference methods recommended for adoption during the implementation in CONPACSE II (Cortez, 1989) are listed in Table 4 and generally encompass several basic features including the fact that: they are easy to apply and produce fairly accurate, precise and reproducible data; they can be applied to regional intra and intercomparison exercises; they should be jointly used with a quality control programme employing certified reference materials.

Analytical information quality

The Programme seeks to ensure and improve the information available both in terms of analytical and data quality and to ensure accuracy, precision and reproducibility of information originating from CONPACSE II. According to Cortez (1989) collection and handling of high quality data depends on the following:

° a strictly planned and truly representative sampling programme;

° a clearly defined procedure for sampling, storage and treatment prior to analysis;

° a planned programme to ensure accurate and reproducible analytical measurements.

Implementing phase II of CONPACSE

To implement these aspects of the programme, the following needs have been identified and taken into account in the CONPACSE II Working document (Cortez, 1989):

° the need for skilled and experienced staff, using proven, written analytical methods, working in adequate laboratory facilities.

° the need for active participation in intra and intercalibration exercises and the acquisition of certified reference samples to control accuracy and reproducibility.

° the need for control of statistical quality through the use of control sheets and use of appropriate computer statistical programmes.

° the need to acquire high quality analytical standards for equipment calibration;

° the need to use high quality equipment which is well maintained.

° adoption of appropriate sampling, preservation and sample storage procedures detailing: sampling strategies, sampling methods, storage, preservation and identification of samples.

° the adoption of agreed reporting format and procedures and use of reference materials.

Table 4. Reference methods recommended for adoption during the implementation of CONPACSE Phase II.

HEAVY METALS
UNEP/FAO/IOC/IAEA: Sampling of selected marine organisms and sample preparation for traces metal analysis. Reference Methods for Marine Pollution Studies No. 7 Rev. 2., UNEP, 1984.
UNEP/IAEA: Determination of total Cadmium in marine sediments by flameless atomic absorption Spectrophotometry. Reference Methods for Marine Pollution Studies No. 27 (Draft) UNEP, 1985.
UNEP/IAEA: Determination of total Copper in marine sediments by flameless atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 33 (Draft) UNEP, 1985.
UNEP: Determination of total Mercury in marine sediments and suspended solids by cold vapour atomic absorption spectrophotometry. Reference Methods for Marine Pollution Studies No. 26, UNEP, 1985.
UNEP/FAO/IOC/IAEA: Determination of total Mercury in selected marine organisms by CVAAS. Reference Methods for Pollution Studies No. 8, Rev. 1, UNEP, 1984.
HALOGENATED HYDROCARBONS
UNEP/FAO/IAEA: Sampling of selected marine organisms and sample preparation for the analysis of chlorinated hydrocarbons. Reference Methods for Pollution Studies No. 12, Rev. 1, UNEP, 1984.
UNEP/FAO/IOC/IAEA: Determination of DDTs and PCBs in selected marine organisms by packed column gas chromatography. Reference Methods for Pollution Studies No. 14, Rev. 1, UNEP, 1986.
UNEP/FAO/IAEA: Sampling of selected marine organisms and sample preparation for the analysis of chlorinated hydrocarbons. Reference Methods for Pollution Studies No. 12, Rev. 1, UNEP, 1984.
UNEP/FAO/IOC: Determination of DDTs and PCBs in selected marine organisms by capillary gas chromatography. Reference Methods for Pollution Studies No. 40, UNEP, 1987.
UNEP/IAEA: Determination of DDTs PCBs and other hydrocarbons in marine sediments by gas-liquid chromatography (Draft). Reference Methods for Pollution Studies No. 17, UNEP, 1982.
OIL HYDROCARBONS
IOC/UNESCO: Determination of Oil Hydrocarbons in Sediments, 1982. Manuals and Guide-lines No. 11.
IOC: Manual to Monitor Oil and Oil Hydrocarbons dissolved/dispersed in sea-water and beaches, IOC/UNESCO, Manuals and Guide-lines No. 13.

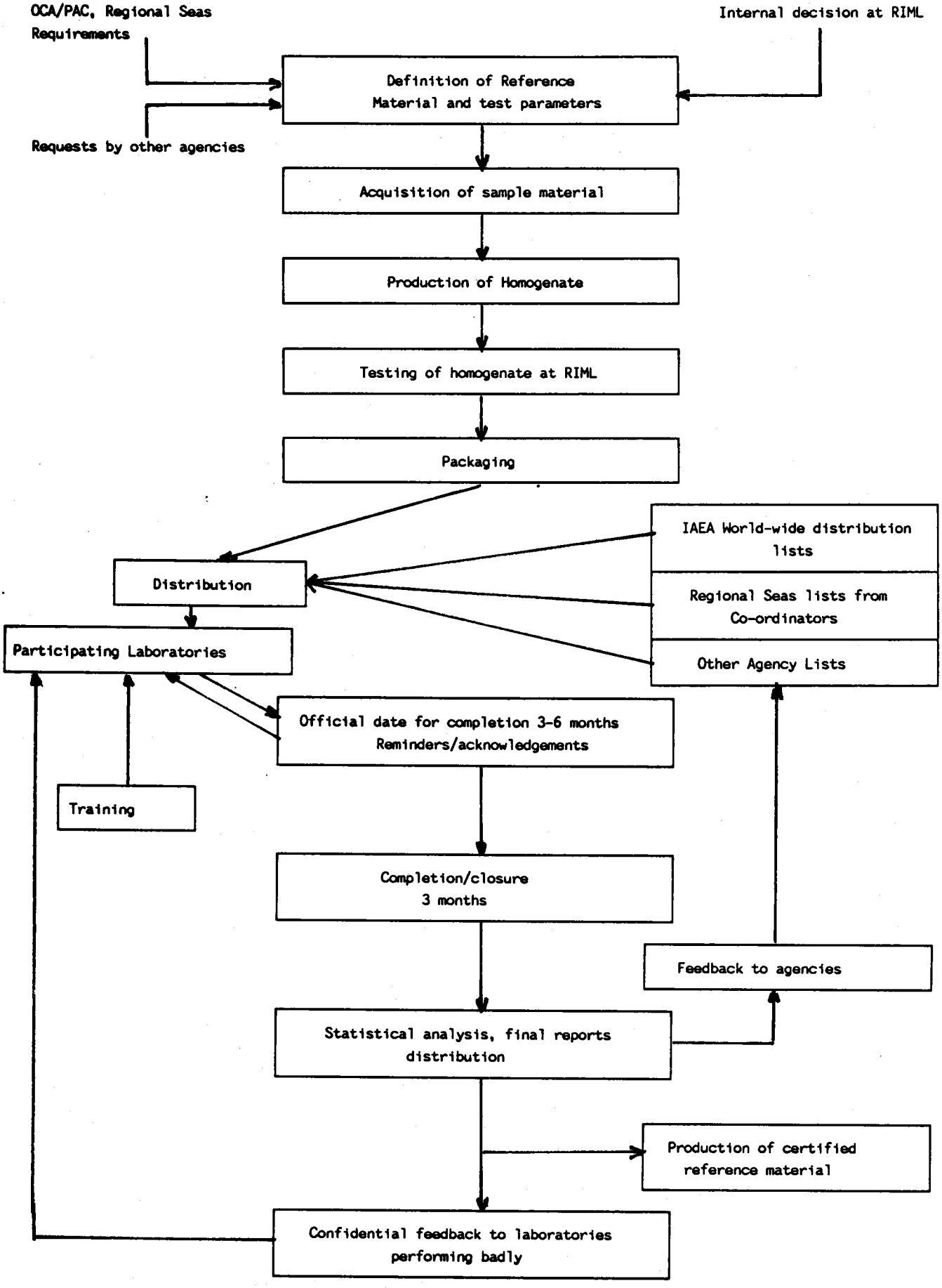


Figure 3. Steps in the execution of intercalibration exercises.

International co-operation

In accordance with previously agreed arrangements concerning communication, institutional and financial provisions as stipulated in the Action Plan for the Protection of the Marine Environment and Coastal Areas of the South East Pacific, CONPACSE I has the support of several international specialized United Nations organizations; in particular, the United Nations Environment Programme (UNEP), the Intergovernmental Oceanographic Commission (IOC), and the Oficina Panamericana de la Salud (OPS).

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Annex 1. Geographic coverage and analyses performed by Institutions Participating in CONPACSE I (1984-1989)

Country Institution	Activity	Geographical Area	Methods and Techniques.
Chile			
Universidad de Concepcion, Departamento de Oceanologia	Inventory of Pollution Sources	Concepcion Bay	Rapid Analysis Coeff. WHO(62), 1962
	Level and Distribution of Pesticides in Marine Organisms and Sediments	Gulf of San Vicente Rocuant, Tome, Andalien	Capillary Column Gas Chromatography Ref. Methods Nos: 12 (Rev.1);14 (Rev.1); 17;40.
Departamento de Oceanologia	Level and Distribution of Heavy Metals in Marine Organisms, Waters and Sediments	Concepcion Bay, Arauco Gulf, San Vicente, Marga-Marga	Flameless EAA, Ref. Methods Nos: 7 (Rev.1);8;9;11.
Universidad de Valparaiso Instituto de Oceanologia	Level and Distribution of Hydrocarbons dissolved/ dispersed in sea-water, organisms and sediments	Valparaiso Bay	Gas Chromatography, IOC Manuals and Guide-lines Nos. 11 & 13.
Universidad de Valparaiso Escuela de Quimica	Level and distribution of Heavy Metals in Organisms and Sediments	Valparaiso Bay V Region	Flameless EAA .Spectrophotometry Ref. Methods Nos: 7 (Rev.1); 8;9;11.
Instituto de Fomento Pesquero	Inventory of Pollution Sources	III Region	Rapid Analysis Coeff. WHO(62), 1962.
	Levels and Distribution of Heavy Metals in Organisms	III Region	Flameless EAA, Ref. Methods Nos: 7 (Rev.1);8,9,11.
Universidad de Magallanes Instituto de la Patagonia.	Levels and Distribution of Oil Hydrocarbons in Water	Straits of Magallanes	Ultraviolet Fluorescence Spectroscopy. IOC Manuals & Guide-lines Nos. 11 & 13.
Colombia			
INDERENA	Inventory of Pollution Sources	Tumaco Cove and Buenaventura Bay	Rapid Analysis Coeff. WHO(62), 1962
	Heavy Metals in Organisms, Water and Sediments	Tumaco Cove and Buenaventura Bay	Flameless EAA: Ref. Methods Nos: 7 (Rev.1);8;9;11.
	Total, Faecal Coliforms in Waters and Beaches	Tumaco Cove and Buenaventura Bay	Membrane Filtration and Multitubes, Ref. Methods Nos: 1;2;5 (Rev.1)
Centro Control Contaminacion del Pacifico	Levels and Distribution of Oil Hydrocarbons dissolved /dispersed, Floating Tar Balls, Tar on Beaches	Tumaco Cove, Buenaventura Bay and Gorgona Island	Gas Chromatography; Ultraviolet fluorescence Spectroscopy. IOC Manuals & Guide-lines 1, 13.
Centro Investigaciones Oceanograficas e Hydrograficas CIOH	Levels and Distribution of Oil Hydrocarbons in Marine Waters, Organisms and	Tumaco Cove, Buenaventura Bay and Gorgona Island	Gas Chromatography Ultraviolet Fluorescence Spectroscopy. IOC Manuals and Guide-lines 11, 13.
Comision Colombiana de Oceanografía	Definition of Critical Areas and Resources Vulnerable to Accidental Oil Pollution	Colombian Pacific Coastal Region	CPPS/UNEP Guide-lines

Annex 1. Continued

Ecuador			
Instituto Oceanografico de la Armada INOCAR	Level and Distribution of Oil Hydrocarbons in Water, Organisms and Sediments	Coastal Areas of all Provinces	Ultraviolet Fluorescence Spectroscopy. IOC Manuals & Guide-lines Nos. 11 & 13
Departamento de Contaminacion DIGMER	Levels and Distribution of Oil Hydrocarbons in Water, Organisms and Sediments	Coastal Areas of all Provinces	Ultraviolet Flurescence Spectroscopy, IOC Manuals & Guide-lines Nos. 11 & 13.
	Inventory of Pollution Sources	Coastal Cities	Rapid Analysis Coefficients WHO(62), 1962
Instituto Nacional de Pesca	Levels and Distribution of Heavy Metals in Waters, Sediments and Organisms	Guayaquil Gulf, Estuarine areas of Guayas, Daule and Babahoyos Rivers	Flameless EAA, Ref. Methods Nos. 7 (Rev.1);8;9;11. Colorimetry
	Levels and Distribution of Oil Hydrocarbons	Guayaquil Gulf	Gas Chromatography. IOC Manuals & Guide-lines Nos. 11, & 13
Empresa de Alcantarillado de Guayaquil EMAG	Inventory of Pollution Sources and Effluent Characterization	Coastal Cities Guayaquil Gulf Saline Estuarine areas	Rapid Analysis Coefficients WHO(62), 1962. Colorimetry
	Microbiological Pollution of Waters and Beaches	Guayaquil Gulf Manta, Manabi	EPA (1962) Membrane and Multitubes, Ref. Method Nos: 2 (Rev 1);5 (Rev.1).
Instituto Ecuatoriano de Obras Sanitarias	Microbiological Characterization of Waters & Beaches	Guayaquil Gulf, Salinas Manta, Manabi, Esmeraldas	EPA (1962), Membrane Filtration and Multitubes
Universidad de Guayaquil, Ciencias Naturales	Heavy Metals dissolved/ dispersed in Sea-water	Guayaquil Gulf	Flameless AA Spectrophotometry, Ref. Methods Nos: 7 (Rev.1); 8;9;11
Escuela Superior Politecnica del Litoral ESPOL	Oceanographic Supplementary Parameters (currents)	Guayaquil Gulf	Drifting Buoys, Oceanography.
Panama			
Universidad de Panama Laboratorio Especializado de Analisis	Heavy Metals in Organisms and Sediments	Panama Gulf, Chiriqui Gulf	Flameless AA Spectrophotometry
	Pesticides in Organisms and Sediments	Panama Bay, Chiriqui Gulf	Packed Column Gas Chromatography, Ref. Methods Nos: 12 (Rev.1); 14 (Rev.1);17;40.
Centro de Ciencias del Mar y Limnologia	Oil Hydrocarbons in Waters, Organisms and Sediments	Panama Bay, Chiriqui Gulf	Ultraviolet Spectrofluorometry, IOC Manuals & Guide-lines
	Microbiological Pollution	Panama Bay	Multitubes and Membrane Filtration
Depto. de Salud Ambiental - Ministerio de Salud	Inventory of Pollution Sources	Panama Bay	Rapid Analysis Coeff. WHO(62), 1962
Instituto de Recursos Hidraulicos y Electrificacion IRHE	Heavy Metals in Waters and organisms	Panama Bay	Flameless EAA, Colorimetry.
	Inventory of Pollution Sources	Panama Bay	Rapid Analysis Coeff. WHO (62), 1962

Annex 1. Continued

Peru			
Instituto del Mar del Peru	Levels & Distribution oil, dissolved/dispersed Hydrocarbons, tar on beaches, oil in organisms and sediments	Metropolitan Lima, Callao, Pisco	Ultraviolet Fluorescence Spectroscopy, IOC Manuals & Guide-lines 11 & 13
	Inventory of Pollution Sources	Lima, Callao, Pisco	Rapid Analysis Coeff. WHO (62), 1962
	Assessment of Pollution Impact on Marine Organisms	Lab Tests	Bioassays, FAO Manuals and Methods.
Universidad Na. F. Villarreal	Levels and Distribution of Heavy Metals in Organisms and Sediments	Pisco, Ilo, Ite, Supe, Chimbote, Tacna	Flameless EAA, Ref. Methods Nos: 7 (Rev.1);8;9;11.
Universidad Nal. Mayor de San Marcos	Microbiological Pollution of Beaches	Callao	Membrane Filtration and Multitubes
Direccion de Hidrografia y Navegacion del la Marina	Inventory of Sources of Industrial Pollution	Lima, Callao	Rapid Analysis Coeff. WHO (62), 1962
Direccion Tecnica de Saneamiento Ambiental	Heavy Metals in Water	Rimac Basin	Flameless EAA Colorimetry
DITESA	Microbiological Pollution of Beaches	Callao, Metropolitan Lima	Multitubes and Membrane Filtration

THE CONSERVATION OF AQUATIC ENVIRONMENTS AND RESOURCES IN CHILE

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ABSTRACT

Aquatic environments and resources, both marine and fresh water are particularly important for the country's present and future sustainable development, due to their extent and diversity. However, conservation actions are urgently needed in order to assure their continued maintenance in the face of increasing use.

In the absence of a national environmental policy, agencies are struggling to make use of environmental impact assessment (EIA) techniques developed abroad. In the international sphere the Permanent Commission of the South Pacific, of which Chile is a party, is presently drafting a protocol which would allow for the application of EIAs within the region. Nationally a regulation was established in 1987, which requires all users of coastal ecosystems to carry out a minimal program of environmental impact assessment. This national regulation, originally designed for the marine environment, appears applicable to users of freshwater ecosystems as well, particularly in cases where river-transported pollutants affect coastal marine ecosystems.

It is also proposed that the same regulations should be applied to intensive aquaculture activities, in particular salmon culture, activities which are exhibiting an explosive development in lakes, rivers and marine near-shore waters of southern Chile. To date such activities are initiated with inadequate basic knowledge of the ecosystems involved. It is suggested that overseas experience may be extremely useful in developing our understanding of both land-based and water-borne aquatic pollution.

INTRODUCTION

Coastal marine and fresh-water resources and environments are important assets for the development and well-being of Chile. Extending in a relatively straight line, for about 4.200 km from the border with Peru, at latitude 17°47'S to Cape Horn at latitude 55°59'S, Chile occupies more than half of the western coast of South America, and includes various types of marine and continental water environments.

From the perspective of terrestrial ecosystems the country can be divided into several geographical regions; in contrast from the point of view of the management of marine resources and environments (excluding the oceanic islands), it may be considered to form three main regions:

1. North of Puerto Montt, where the coast is mostly straight, is the coastal and oceanic region dominated by the Humboldt Current system;

2. South of Puerto Montt, where the coast is deeply incised and indented forms a region of extensive, sheltered marine and estuarine areas, which comprise about 50.000 km of coast-line; and,

3. Off-shore from the second region lies a coastal and oceanic region dominated by the southwardly directed branch of the Westward Drift.

Most of the inland fresh-water resources, which form the lake and river district of the country run from a few hundred kilometres north of Puerto Montt to the extreme south of the country.

Of the aquatic living resources, the marine resources are at present the most important to the country's economy providing a substantial fish, shell-fish and algal harvest which totalled 5,374,722 tons in 1988. Fresh-water living resources are at present of minor importance, although the system of intensive fish culture of Pacific and Atlantic salmon which combines freshwater and sea-water phases, is undergoing an explosive development with an estimated total production for 1989 of about 7,300 tons of mainly Pacific salmon.

The marine living resources and environments are threatened both by the impact of marine pollution from municipal and industrial wastes, and by deficient public management practices. In contrast aquaculture, both in freshwaters and marine coastal waters, is threatened by the negative impacts of its own actions currently undertaken with a total lack of conservation practices. This activity poses a threat to the resources and environment in which it is performed.

In this paper we examine the public sector efforts made to prevent and minimize pollution effects from domestic and industrial discharges in the coastal environment which, coupled with technological efforts by industry may contribute to amelioration of the present situation. The environmental problems in inland water systems and those posed by aquaculture, both in fresh-water and sheltered marine environments however, similar actions to those being applied in the coastal seas may be applicable to these systems.

ENVIRONMENTAL IMPACT ASSESSMENT IN THE COASTAL MARINE ECOSYSTEMs OF CHILE

A national environmental policy (NEP) is still lacking in Chile, and many of the environmental problems and conflicts presently identified in the country may stem from this fact. The inception in the U.S.A. of a national environmental policy in 1969 (U.S. Gov., 1970) gave rise to the concept of Environmental Impact Assessments (EIA), a process, and techniques, which were later introduced in many countries. Since that time such assessments have become one of the basic tools in the process of environmental management, having as its ultimate objective the aim of harmonizing economic development with environmental quality. (See for example: Ditton & Goodale, 1972; Goodale. 1972; Rosenberg & Resh, 1981; Szekely, 1986;US Gov., 1970;). In this country, despite the lack of a NEP the application of EIAs is being pursued through international and national channels.

Internationally the main activities in connection with this subject have occurred within the framework of CPPS (*Comision Permanente del Pacifico Sur*) activities, as part of the Regional Seas Program of the UNEP (United Nations Environmental Program), in particular in relation to the Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-east Pacific.

These efforts include for example:

(1) a Workshop on *Evaluacion de Impacto Ambiental en el Medio Marino y Areas Costeras en el Pacifico Studeste"*, carried out in Santiago, Chile in 1983 (CPPS/CEPAL, 1983);

(2) *Taller sobre Evaluacion del Impacto Ambiental de Sustancias Potencialmente Nocivas Provenientes de Fuentes Costeras en el Medio Marino: Estudio de un Caso en Chile"*, (CPPS/PNUMA/CEPAL, 1984) held Concepcion, Chile in 1984; and, ,

(3) various consultative activities, for example *Evaluacion de Impacto Ambiental - Nociones Bassicas: Informe de Consultoria - Plan de Accion del Pacifico Sudeste.* (UNEP/CPPS/CEPAL, 1986)

Present CPPS activities have concentrated on the drafting of a *"Protocolo sobre la Evaluacion del Impacto Ambiental en el Pacifico Sudeste,"* which suggests that the Contracting Parties to the regional Convention (Chile, Colombia, Ecuador, and Peru) should not embark on activities and development projects which could result in adverse effects in marine and coastal areas, without a prior environmental impact evaluation. (see Escobar, this volume)

Nationally, Resolution 12,600/550 dated August 28, 1987 originating from the *Direccion General de Territorio Maritimo y Marina Mercante (DGTM), Armade de Chile,* establishes the requirement of a *"Programa Minimo de Evaluacion de Impacto Ambiental en el Ecosistema Marino Costero, (PMEIA)",* should be mentioned as the most recent and practical action taken in Chile on the subject (see Annex 1). This Resolution requires users of the coastal sea (and by interpretation of the Law of Navigation, on which it is based) rivers and lakes for dumping to carrying out a minimal program of environmental impact evaluation.

The above Resolution is based on Article 142, Title 9th (On *Contaminacion*) of the Decree-Law N^{O} 2.222 of 1978, also called "*Ley de Navegacion*" (Law of Navigation), which forbids the dumping of wastes and other materials that may cause damage in the waters under the national jurisdiction, including harbours, rivers and lakes (DGTM, 1987).

Although, the Resolution does not strictly require an EIA in the modern sense, it comes close to the kinds of actions observed in the early stages of progressive development of EIA requirements in other countries, (Escobar, 1983) and undoubtedly constitutes an important move in the right direction. This resolution applies to any organisation, institution, enterprise or industry, whether public or private, which is considering future discharges, or installation of discharge systems, for liquid or mixed residues to the sea or any other body of water under the jurisdiction of the DGTM. For discharge systems already in operation the Resolution establishes a five-year period from the date of the publication of the Resolution within which the responsible body must comply with the terms of the resolution.

Briefly, the requirements of the Resolution can be divided into two groups. The first of these makes up what one might term the Preparatory Phase, and includes the description of the physical characteristics of the area to be affected, or already affected. The latter is explained by the fact that in most cases, dumping of wastes is done at the coast-line, with little or no pre-treatment. Under these circumstances, and although in many instances pollution is fairly obvious, in order to achieve some degree of change to this situation, damage to the waters under jurisdiction, according to Title 9th of the Navigation Law, must be proven and detailed.

The description and study of the uses of the sea, in fact, the coastal zone, in the impacted area is included under the first set of terms, together with the description of the chemical, physical and biological characteristics of the effluents. Although it is intended that one PMEIA is done by each of the users, in an area with many users, the activities carried out under this requirement, will presumably provide some indication of the relative importance of different sources of contamination, which in turn may end up in a division of the costs needed to comply with requirements under the resolution.

The second paragraph of the Resolution calls for the compilation of existing scientific data relating to the area under study. These data should include information on meteorology, oceanography and benthos, the later both from the economic and ecological points of view. A bibliography for the area should also be compiled.

The second set of components of the Resolution form the final phase of the PMEIA, which requires updated studies, in many ways determined or planned on the basis of results obtained in the previous phase, covering the oceanography of the area, (including Eulerian and Lagrangian measurements, continuously for at least two months in both the summer and winter), on the state of the water column (with reference to normal or original conditions), and on benthos. The latter should include maps of sediment type and grain size, and on benthos distribution (including species selected on the basis of their economic or ecological importance). The determination of

structural and functional indices of the benthic communities should be attempted. Benthic studies should also define a set of species to be studied in the ensuing monitoring program.

The monitoring program is to be applied in the case of a newly established unit, as well, presumably, as in the case of a unit which might have undergone some sort of change or modification since the previous PMEIA. It could be applied also in the case of the implementation *de novo* or *ex post facto* of a submarine outfall.

The Resolution in its final sections covers the design of submarine outfalls, their technical and dispersion characteristics (type of diffusor, type of tubing, anchoring system, etc).

As of this date the application of the Resolution (which must be performed by independent scientific laboratories) appears to have resulted in the installation of at least one submarine outfall (in Arica), where it is said that the condition of an extensive beach where municipal wastes were previously discharged, has improved to the extent that it has been now open for public use.

The application of the Resolution in some of the coastal areas most affected by pollution such as Concepcion and San Vicente Bays for example, has been rather slow. This is in part due to the co-ordination requirements in multi-user situations and the lack of experience in this field. The lack of well trained personnel and properly equipped laboratories could be another source of these delays.

The application of this Resolution to the inland freshwater environment (rivers and lakes), where the DGTM has jurisdiction, appears not only possible with some modifications, but necessary and indeed urgent. In this environment EIA-type actions have been recently implemented largely on the basis on the perceptions of industrial managers or as a requirement of international loan agencies (eg. various hydroelectrical developments). The industrial and municipal growth in the proximity of rivers and lakes necessitates a more formal arrangement in the future.

THE APPLICATION OF THE RESOLUTION IN AREAS OF INTENSIVE FISH FARMING

The rapid and environmentally unregulated development of aquaculture, mainly in southern Chile, introduces a new and urgent need for action in the area of environmental management. A list of environmental problems associated with the activities of fish-farms (Cobham Resource Consultants & Fisheries Development Ltd., 1987) includes the following:

1. Landscape effects
2. Recreational effects
3. Nature conservation effects.

Considering the latter, which may include less obvious impacts (Woodward, 1989), such as:

1. Increase of organic matter into the system.
2. Settling of solids to the bottom.
3. Nutritional enrichment of the water column.
4. Changes in the benthic fauna and flora.
5. Increased growth of microalgae and other plants.
6. Low dissolved oxygen concentrations in the water column.
7. Generation of unpleasant tastes and odours.
8. Presence of pathogenic bacteria and parasites.
9. Presence of chemicals and drugs in the water column.
10. Predator conflicts ((Cobham Resource Consultants & Fisheries Development Ltd., 1987)

Using indices derived from aquaculture activities in the UK and taking into account that the production of salmon in southern Chile was in 1988 of the order of 4,200 tons, this would mean that in terms of BOD_7 there exists the equivalent of a human population of about 1.4 million; in terms of ammonia, 0.8 million; in terms of nitrate 0.08 million; and in terms of suspended solids, 6.5 million people. Given the rate of increase of this industry there is at present cause for concern on the impacts, not only on the ecosystems involved but for the activity itself.

CONCLUSION

There is an urgent need to apply the Resolution to activities carried out in the coastal environment and inland waters and to evaluate its applicability to fish-farming and other intensive aquaculture activities in the country.

In this connection, the aim of presenting this paper is to draw the present situation to the attention of the international scientific community, with experience in this type of activity. This provides an opportunity for South-South co-operation across the Pacific Basin. Such relationships already exist and we would welcome the opportunity of contributing to the expansion of activities which might be already taking place in this field.

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MARINE POLLUTION PROBLEMS IN THE SOUTH PACIFIC AND THE ROLE OF SPREP-POL IN THEIR IDENTIFICATION AND MANAGEMENT

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ABSTRACT

Compared with other regions of the world, the South Pacific has been relatively free of major pollution problems. Small populations, limited industrial development and relative isolation from major shipping lanes have contributed to this situation. This position, however, is liable to change. Coastal ecosystems in the region are extremely fragile and rapid increases in population, industrial development and tourism present serious problems for marine pollution control.

The major marine pollution problems in the region are: the destruction of Coastal ecosystems; lowering of water quality, changing ocean processes and properties; and, climatic change and sea level rise. The primary causes of these problems are the disposal of domestic and non-domestic wastes, increased sedimentation, coastal development activities, over-exploitation of living marine resources and natural disasters. Secondary causes include inadequate waste management programmes, inadequate legislation, inadequate data and a lack of awareness (in some places) of the seriousness of the problem.

Some control measures do exist and some monitoring activities have been completed. An overall picture of the amounts of pollutants entering the South Pacific marine environment and of the major trends in pollutant concentrations is not, however, available. SPREP POL a regional, coordinated project for the monitoring, research and control of pollution in coastal and ocean waters (of the South Pacific Regional Environment Programme countries) has been developed to address these problems and to assist governments in dealing with them. This paper outlines the aims, activities, and anticipated outputs of SPREP POL and possible contributions to inter-regional cooperation in marine pollution control.

INTRODUCTION: THE SPREP REGION.

The South Pacific Regional Environment Programme includes a substantial proportion of the world's major ocean. It covers more than two and a half million square kilometers stretching from Palau in the west to French Polynesia in the east and from the Mariana Islands in the north to New Zealand in the south. Apart for the east coast of Australia, New Zealand and Papua New Guinea, the area is made up of a vast expanse of ocean over which are dotted thousands of small islands. Excluding Papua New Guinea, Australia and New Zealand, the land area of the Region is less than 100,000 km^2, of which approximately 75 % is made up of the large island groups of Fiji, New Caledonia, Solomon Islands and Vanuatu. The Region therefore consists basically of about 20 small countries or territories separated by substantial stretches of ocean.

This "isolation" has both advantages and disadvantages. The disadvantages include problems of transport and communications but the lack of major industrial centres and the associated infrastructure of ports, shipping traffic, factory complexes and waste disposal sites is seen by many concerned with the environment as a significant advantage. The small size of many of the islands is an environmental hazard, however, as it means that mistakes in management may be impossible to rectify, at least in the short term.

The South Pacific has an attractive image internationally, an image that has been exploited for tourist development. The picture of white sandy beaches, clear lagoon waters, and thriving coral reef communities is widely used to attract travellers from all over the world. This picture is valid in many places but in some there is already considerable environmental pressure. If care is not taken, the coastal resources that form the basis of this substantial foreign exchange earning capacity may cease to be attractive, and once the image is damaged it may be impossible to repair.

With the exception of Australia, New Zealand and Papua New Guinea, most Pacific islanders live on or near the coasts and are dependent on the coastal or open ocean environment for a substantial part of their food and income. The population of many of the small island territories is increasing (Table 1) at a rate above the world average and this represents a major problem in terms of environmental management. The expanding populations also want improved standards of living, including piped water and sewerage facilities, better housing, a wider range of foodstuffs and consumer goods. All of these social demands contribute to additional stress on the coastal environment as they lead to increased construction, increased waste disposal problems, deforestation and subsequent erosion and siltation. In several countries (Papua New Guinea, New Caledonia and Fiji) the exploitation of mineral deposits adds to the problems of coastal environmental damage.

TABLE 1. Population Size, Growth and Density in Countries in the South Pacific Region (Bakker, 1988)

Country	Population				
	Last census	Size	Growth Rate(%)	Density No $^{-km^2}$	Pop'n yr.2000
American Samoa	1980	32,297	1.7	164	46,000
Cook Islands	1981	17,754	-0.4	74	18,000
Fiji	1986	715,375	2.0	39	895,000
French Polynesia	1983	166,753	3.0	51	268,000
Federated States Micronesia	1988	101,155	3.4	144	145,000
Guam	1980	105,979	2.2	196	159,000
Kiribati	1985	63,496	2.0	89	81,000
Marshall Islands	1980	30,873	2.7	171	50,000
Nauru	1983	8,123	2.4	387	11,000
New Caledonia	1983	145,368	1.2	8	178,000
Niue	1981	3,281	-3.4	13	3,000
Northern Marianas	1980	16,780	1.7	35	27,000
Palau	1980	12,116	-1.6	24	15,000
Papua New Guinea	1980	2,978,057	2.3	7	4,700,000
Pitcairn	1980	50	-9.8	10	
Solomon Islands	1986	285,176	3.5	10	440,000
Tokelau	1986	1,690	1.4	169	2,000
Tonga	1986	94,535	-1.1	135	98,000
Tuvalu	1986	8,364	3.2	322	11,000
Vanuatu	1979	104,371	3.2	9	196,000
Wallis & Futuna	1983	12,408	4.4	49	22,000
Western Samoa	1986	158,940	0.3	54	177,000

MARINE POLLUTION PROBLEMS IN THE SOUTH PACIFIC

Over the last 10-11 years a number of reviews of environmental problems in the South Pacific have been produced (e.g. Dahl & Baumgart, 1983; Dahl, 1984; Brodie & Morrison, 1984; Brodie, *et al.* 1989). A meeting of scientists held in Sydney, Australia, in January 1989 considered these reviews and concluded that the priority marine pollution problems in the SPREP Region are:

1. Destruction of Coastal Ecosystems;

2. Lowering of Water Quality;

3. Changing Ocean Processes and Properties; and,

4. Climatic Change and Sea Level Rise

The first three problems can be addressed directly in a regional marine pollution project (see below) while the climatic change and sea level rise issue needs to be considered separately as it is not one which island governments can overcome (this is the subject of a separate SPREP Project).

Primary causes of the marine pollution problems:

(a) **Disposal of domestic waste (sewage and solid wastes)**

The extent of this problem varies from one country to another. It is particularly acute in the smallest countries, particularly atolls, where the disposal of sewage or solid wastes is extremely difficult. If marine disposal is not to cause major pollution (both chemical and microbiological) then expensive pre-treatment is required. Often this is economically, socially or politically unacceptable. Sewage disposal is a major environmental concern in most Pacific island countries. A recent study of water quality in a number of Pacific lagoons concluded that the chemical and microbiological contamination due to sewage was the principal marine pollution problem (Naidu *et al.*, 1989). The report also showed that nitrate and phosphate levels were often sufficiently high to have serious adverse effects on coral reefs (Table 2). Similar investigations of water quality in French Polynesia have led to the closing of several swimming areas because of bacteriological contamination (Service d'Hygiene et de Salubrite Publique, 1989)

(b) **Disposal and management of non-domestic waste**

These materials include solid waste, agricultural chemicals (both toxic and non-toxic), waste lubricating oils and mine tailings. Mowbray (1988) has reviewed in detail the problems associated with pesticide use in the SPREP region and has highlighted the difficulties of wrong material selection, disposal of surplus supplies, inappropriate application techniques and poor storage facilities, all of which may lead to marine pollution.

Mining activity is limited at present to only a few countries but extensive prospecting is occurring. In the smaller countries (and even in Papua New Guinea) mining must have a major impact on the marine environment as ocean disposal of tailing will occur. Unless pressure is exerted to ensure good tailings management major difficulties must ensue.

(c) **Increased sedimentation due to land use changes, mining and construction**

The land use changes referred to include logging which is often very poorly managed environmentally and the intensification of agriculture (particularly on steep slopes) in an attempt

to either produce crops for export (and earn foreign exchange) or for feeding the increasing populations. Increasing population in coastal areas which also require housing, and is associated with increased shipping and industrial activity have led to noticeably greater construction activity in the coastal zones. As mentioned above mining leads to increased sediment movement particularly as the majority of mining projects are in areas of high (>3000 mm/yr) and usually erosive rainfall.

TABLE 2. Nitrate and Phosphate Concentrations (umol l^{-1}) in Some Pacific Lagoons. Data from Naidu *et al.*, 1988. n.d. = no data.

Site		NO_3	PO_4
Laucala Bay, Suva, Fiji	av.	3.87	2.67
	SD	8.74	1.55
	Range	0.2 - 92	0.3 - 60
Suva Harbour Fiji	av.	3.95	1.84
	SD	4.94	1.64
	Range	0.2 - 45	0.3 - 10.6
Port Vila, Vanuatu	av.	7.31	0.55
	SD	13.2	0.45
	Range	0.7 - 62	0.2 - 2.34
Tarawa, Kiribati	av.	4.50	0.3
	SD	12.7	0.2
	Range	0 - 78	0 - 1.24
Tongatapu, Tonga	av.	1.92	1.24
	SD	0.87	0.50
	Range	1.0 - 3.6	1.0 - 2.5
Morovo, Solomon Islands	av.	n.d.	0.41
	SD	n.d.	0.32
	Range	n.d.	0.2 - 1.0

(d) **Coastal development activities**

These include sand and gravel extraction, dredge and fill activities, port development and the tourism-related activities of resort construction, airport enlargement and road upgrading. The blasting of reefs the preparation of artificial beaches and the establishment of attractive "natural" swimming areas have had major detrimental effect on the local environment, e.g., in Palau, Guam, Fiji, Cook Islands, Queensland (Australia).

(e) **Over-exploitation of living marine resources**

Apart from the region-wide concern over drift net fishing this is a particular problem near major population centres where reef-gleaning is a major source of food. Examples include the concerns over *Anadara* sp. (*'ta bun'*) exploitation in Tarawa where the local population is expanding rapidly (Thaman, 1989), the markedly increased exploitation of the reefs around Suva during the economic depression in 1987-8 (Veikila Vuki, personal communication) and the

extensive cutting of mangroves for fuel in several countries. As Johannes (1978) has pointed out, increased "westernisation" in the Pacific Islands has, in some places, led to the breakdown of traditional marine resource conservation practices such as closed seasons, catch size limitations and effective marine tenure systems.

(f) **Natural Disasters**

These include both episodic/local events such as cyclones and volcanic eruptions and cyclical/regional events such as the El Nino Southern Oscillation (ENSO). The impacts of the ENSO events on coastal fisheries and biological communities, although relatively well studied in the South Eastern Pacific have received little attention to date in the SPREP region

Secondary causes of marine pollution problems

Included in this category are inadequate waste management programmes; inadequate legislation or inefficient enforcement/application of existing legislation; inadequate data for preparation of appropriate standards, legislation and other mitigating action; and, a lack of awareness in some countries of the seriousness of the problem. In many countries the inadequacies result from financial difficulties. While most governments do pay reasonable attention to the quality of drinking water supplies, few resources are expended on the monitoring and control of coastal or ocean water quality.

At present, some control measures do exist including:

(i) Limited research and monitoring by governments, regional and international agencies, including universities in the region. Several countries e.g., Cook Islands, Niue, Tokelau, Tuvalu, simply do not have the facilities at present, to carry out any monitoring activities.

(ii) Localized waste treatment and disposal facilities and management plans for dealing with wastes. These are often outdated or overloaded and therefore unable to operate asoriginally planned. This is particularly true in the old United States Trust Territories, e.g. Marshall Islands and Federated States of Micronesia.

(iii) Environmental management planning, including land use planning, coastal zone management and environmental impact assessment requirements for new development projects. Experience indicates, that in at least some situations the plans when prepared, are ignored and the EIA recommendations are not adopted.

(iv) Developing environmental awareness through both formal and non-formal education. A major effort has been made through SPREP to have environmental issues discussed in formal education at all levels and a drive by NGO's to provide non-formal education in this area is continuing.

(v) Development/improvement of legislation and enforcement at all levels. This is a slow process but progress has occurred.

MONITORING, RESEARCH AND CONTROL OF POLLUTION IN COASTAL AND OCEAN WATERS OF THE SPREP REGION - SPREP POL.

Previous work in the field of marine pollution in the SPREP region.

Limited regional activities completed to date include monitoring marine pollution which have produced valuable data. SPREP funded projects in Papua New Guinea, Fiji, Vanuatu, Kiribati, French Polynesia and Tonga together with excellent national programmes in Australia,

Guam and New Zealand have contributed much of the available data. Oceanographic work by ORSTOM (operating from New Caledonia), NOAA (USA), CSIRO (Australia), DSIR (New Zealand) together with visiting Japanese, Russian and German vessels have also produced very significant information on currents, temperature and salinity profiles, oxygen level and phytoplankton production (e.g. Wauthy, 1986; Eldin, 1986). This information is, however, insufficient to provide an overall picture of the amounts of pollutants entering the South Pacific marine Environment or to determine the major trends in pollutant concentrations in likely problem areas. Without this information it will be difficult for governments to take timely and cost-effective action to correct pollution problems which may threaten human health or important resources, or to plan for sustainable development and management.

Proposed activities of the SPREP-POL programme.

The SPREP POL project will attempt to assess the extent of pollution and quantify trends by means of a series of monitoring and research activities (Table 3). The project will develop a data base for a more accurate assessment of the pollution situation in the South Pacific and will provide a basis for recommendations to control pollution, where appropriate, by legislative or other means. Activities will be carried out in some 15 countries in the South Pacific (American Samoa, Australia, Federated States of Micronesia, Fiji, French Polynesia, Guam, Kiribati, Marshall Islands, New Caledonia, New Zealand, Palau, Papua New Guinea, Solomon Islands, Tonga, Vanuatu).

TABLE 3. SPREP POL Monitoring and Research Activities

MONITORING ACTIVITIES
1. Ocean Processes and Properties: Of particular importance are variability in circulation patterns, thermal structure, salinity distributions, plankton productivity, nutrient fluxes, larval dispersion patterns.
2. Heavy Metals: Activities in this sector will concentrate on mercury, cadmium, lead and tin.
3. Pesticides: Particular emphasis will be placed on organochlorine pesticides.
4. Sewage related parameters: This sector will study the problems of increased nutrients and microbiological contamination.
5. Other pollutants: including hydrocarbons and detergents.
RESEARCH ACTIVITIES
1. Preparation of a regional status report on land-based pollutants entering the marine environment.
2. Study of the role of sedimentation in marine pollution including the transport of pollutants.
3. Development of circulation model for the main Southwest New Caledonia lagoons a potential model system (for other Pacific island coastal areas).
4. Review of the Guam EPA coastal water monitoring programme 1978-88 to assess the appropriateness of site selection parameters determined and sampling strategy in meeting the needs of coastal area management decision makers. Guam is the only small island territory with the long-term data to carry out such an exercise. The results of this review will be made available to other

governments planning monitoring programmes.

The long-term objectives of the project are:

(a) To provide the scientific and technical information needed by the governments of the Region for the control of marine pollution as envisaged by the SPREP Convention, its protocols and the SPREP Action Plan;

(b) To build up a consistent and comparable time-series of data relevant to the state of the marine environment, including the sources, amounts, pathways, levels and effects of pollutants in the SPREP Convention area;

(c) To contribute, through the Regional Seas Programme of UNEP to the Global Environment Monitoring Systems (GEMS) of UNEP;

(d) To analyse the causes of environmental degradation in the SPREP Convention area;

(e) To formulate recommendations for pollution control measures suitable for the socio-economic development of the SPREP region on a sustainable basis.

(f) To enhance the indigenous capability for monitoring and analysis of marine pollution and informed decision-making concerning the control of such pollution.

The project will be supported as a joint SPREP/UNEP sponsored activity; UNEP will support the project as the South Pacific part of its Regional Seas Programmes and its Global Environmental Monitoring System (GEMS). The regional and global comparability of data will be ensured by mandatory use of relevant Reference Methods for Marine Pollution Studies and by mandatory participation in the regional and global intercalibration and data quality control exercises organised in the framework of the Regional Seas Programme. Priority will be given to the training of nationals from the SPREP island states in order to ensure broad, stable and long-term institutional support for the project.

INTERACTION WITH OTHER REGIONS

Several SPREP-POL activities outlined above may be of considerable interest to other Regional Seas Programmes. With most of the activities occurring in small tropical islands a valuable data base of small island coastal area pollution and its management will be developed. This would be of considerable use to workers in the South East Asian Seas Programme. The work on lagoon modelling would, when completed, be valuable in other situations where coastal zones having limited water circulation are being investigated. The data produced on mining impacts particularly from Australia and Papua New Guinea will provide planners in other regions examining the potential impacts of such activities with a much clearer picture of what is likely to occur. The land-based pollutants survey which should be completed by the end of 1990 will provide much valuable information on the usefulness of rapid assessment techniques in a range of different environments. Sedimentation studies will also be an area where inter-regional cooperation could be extremely useful.

It is hoped that SPREP-POL collaborators will also benefit from work in other regions. Given the financial problems faced by many of the smaller island countries, work on developing cheaper but reliable analytical techniques for detecting pollution would be of considerable interest. Information on the economic effect of coastal and marine pollution would assist scientists and planners in convincing governments of the need for control of such pollution. Assessments of the health implications of pollution could be exchanged between workers in different regions.

CONCLUSIONS

Marine pollution problems in the South Pacific have not yet reached a crisis point. There is no room for complacency however, as the situation is changing for the worse in some areas. Rapidly expanding coastal area populations, increasing industrial development (including mining and the rapid escalation of tourism are all having major impacts on the marine environment in the Region. SPREP-POL has been established by regional governments to assist them in addressing these problems. Through its monitoring and research activities SPREP-POL will develop an overall picture of the amounts of pollutants entering the South Pacific marine environment and determine the major trends in pollution concentrations in likely problem areas. Using this information remedial measures (including legislation) will be recommended where appropriate. Considerable potential exists for cooperation with other Regional Seas marine pollution programmes.

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A STRATEGY FOR DEVELOPING COASTAL MANAGEMENT AND PLANNING PROGRAMMES IN THE PACIFIC BASIN

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ABSTRACT

This paper provides a broad overview of the current needs and activities in coastal zone management in the countries covered by the Action Plan for the South Pacific Regional Environment Programme (SPREP). Given the geography of the countries of this region coastal zone management programmes are perceived as being of high priority and aspects of the development of such programmes are discussed.

INTRODUCTION

The entire land area of many islands in the Pacific Basin can be considered to lie within the coastal zone. As a consequence the entire island influences, or is influenced by, processes and activities occurring in coastal ecosystems and waters. Economic development activities increasingly result in broad changes to land use patterns and individual development projects which have severe, adverse effects on the marine and coastal environments of small islands.

The waters and ecosystems surrounding small Pacific islands are important both for their subsistence and commercial resources and for their natural and scientific values. Much of the destruction, degradation or depletion of these resources and consequent loss of value can be avoided, reduced or mitigated through coastal management and planning; sometimes also referred to as coastal zone management, coastal resources management, or coastal area management.

Coastal management promotes a comprehensive, multi-sectoral, integrated approach to the planning and use of coastal resources. A fully functional coastal management programme may take many years of development to put in place and become effective. In building towards this ultimate goal, a strategy for controlling coastal problems including pollution, on small islands in the Pacific Basin through coastal management and planning could focus on three areas in the short and medium term:

1. Assessing Immediate Coastal Management and Planning Priorities by developing discrete components of a coastal programme to address those immediate concerns.

2. Developing Integrated Coastal Management and Planning by instituting mechanisms for the multi-sectoral integration of development planning and resource management on a scale appropriate to existing needs.

3. Developing the foundations for coastal management and planning through the build-up of appropriate information banks and manpower resources.

COASTAL ZONE MANAGEMENT AND PLANNING PRIORITIES

Development and implementation of coastal water quality monitoring programmes, analytical capabilities and control measures

Waters surrounding most Pacific island urban centres and industrial areas have been shown to be moderately to highly polluted by organic pollutants, pesticides and/or heavy metals (see Morrison, this volume). Although these waters are used for recreation by residents and tourists and may support locally important subsistence and commercial resources of fish and shellfish, few countries currently have sampling programmes and analytical capabilities which allow them to consistently monitor water quality and inform users of unhealthy or potentially dangerous conditions.

A top priority within coastal management in Pacific islands is therefore the establishment of water quality monitoring programmes in known problem areas. Once in place these programmes should be expanded to cover all major coastal water areas currently or potentially in use. To achieve this assistance in establishing sampling programmes and analytical laboratories, and in training field and laboratory technicians will be required. Merely identifying polluted areas and monitoring trends is not enough however. Pollution sources must be identified and control measures implemented at source. Long-term monitoring must be undertaken to ensure compliance with standards and effectiveness of the control measures.

Development and implementation of Environmental Impact Assessment (EIA) legislation, policy and capabilities

Environmental impact assessments are designed to evaluate the potential environmental impacts of a particular development activity and should include a thorough consideration of alternative modes and sites for the project or activity. If properly undertaken and implemented an EIA may go a long way towards avoiding and mitigating costly coastal pollution problems and resource degradation, by dealing with specific development activities as they are proposed. Development of EIA legislation, policy and capabilities should thus be of high priority for island states.

Conducting a superficial or post event assessment of the environmental impacts of a particular project or activity is not only ineffective from a coastal management perspective but may be actually counter-productive if it serves to provide a false legitimacy for development activities the environmental effects of which have not been properly incorporated in decision making. On the other hand, when included as part of a wider programme of coastal management and planning, EIA's can evaluate individual development projects within a framework of comprehensive, integrated planning. Such a management programme may have already designated areas and drawn-up guide-lines concerning control measures for various types of development.

Development of contingency plans for marine pollution emergencies

Most Pacific island states are neither oil producers nor are they located on major oil or chemical tanker routes. Nevertheless, traffic in hydrocarbon fuels and packaged chemicals within the Pacific, not to mention the bunker fuels carried by all ships for their own operation, pose a significant threat of marine pollution to sensitive coastal ecosystems and resources.

Training in the Pacific for oil spill response and contingency planning has been conducted every 2 years through SPREP by the International Maritime Organisation (IMO) and the Australian Department of Transport. As a result, more countries have and are developing national contingency plans for marine pollution emergencies. However, it is imperative that all Pacific

countries and territories develop, adopt and periodically test and update comprehensive marine pollution emergency response plans. These national plans should cover both oil and chemical pollution emergencies and include oil sensitivity maps.

In addition, IMO and SPREP have drafted a Pacific Regional Marine Pollution Emergency Response Plan outlining a network for mutual assistance in the Pacific region. The plan includes access to support from metropolitan country response teams in the event of a major, catastrophic marine pollution incident. Pacific Island States should participate fully in the final, adoption and periodic testing of the regional pollution emergency response plan.

DEVELOPMENT OF INTEGRATED COASTAL MANAGEMENT AND PLANNING

Multi-sectoral planning for priority coastal areas or topics

Many coastal areas in the Pacific where major development activities are occurring or are proposed already need coastal management in order to reduce existing environmental degradation and conflicts of resource use. Inter-agency task teams should be established to develop integrated management plans for areas such as industrial/port complexes, heavy tourist use areas or islands, and urban shore-lines for example. Integrated planning will have to consider the requirements and constraints of all involved sectors of the community including commercial and public interest groups.

Certain types of on-going coastal activity or resource use have major impacts which require management planning before cumulative impacts become too great. For example, a long-term reef dredging management plan for a particular island could aim to maximise the use of existing extraction sites and regulate the uncontrolled opening of new sites, thus containing the adverse environmental impacts. Similar activities include resort development and road construction which to date have largely been developed as individual projects or activities outside a wider framework. Results from specific efforts at multi-sectoral management and planning of particular areas or types of activities within the region would serve as pilot projects, indicating the usefulness of integrated coastal management and planning in the Pacific Island context.

Integration of sectoral planning and resource management

Sectoral and resource management agencies need to integrate planning and management in all areas of concern including those of determined priority. Sectoral bodies and agencies including commercial, tourism, transport, agriculture, public works-water, power, and waste disposal interests need to interact among themselves and with resource management agencies such as forestry, fisheries, and parks in order to integrate development planning and resource management activities at a policy level.

Methods to accomplish this include the development of inter-agency review committees or processes through which proposed private or public sector development activities or resource management agency plans are passed for review, comment and revision. The inclusion of opportunities for input by the public, by special interest groups and by concerned individuals will contribute to the success of this process.

Large scale planning

With an adequate information base, it is possible to broadly indicate appropriate use categories for coastal lands and waters. The categories might include:

1) areas dedicated predominantly to single sector, development oriented uses;

2) multiple-use areas, for sustainable use of resources which are compatible, but which often need some controls to avoid conflict;

3) areas for the conservation of natural resources, which may include subsistence resource use; and,

4) core areas for the preservation of unique natural systems and processes; where human intervention is minimised.

On land, the basic principles and methods of land use planning can be used to accomplish large scale planning. However this assumes a government ability to define and control to some degree, the conditions of non-government land use, an ability which does not necessarily exist in countries where the majority of land is held by customary or traditional land owners or groups of owners. Shore-line areas and waters, usually including sub-tidal or 'submerged' land such as mangrove forests and coral reefs, are more often subject to some control by governments. Large scale zoning may be more feasible in these areas, although many island communities have traditional reef or mangrove ownership and usufruct rights which must be incorporated into any modern management scenario.

DEVELOPING THE FOUNDATIONS FOR COASTAL MANAGEMENT AND PLANNING.

Assembling an information base

In many areas there is little or no information available to provide a systematic overview of:

1) the resources occurring on coastal lands and in neighbouring waters;

2) the existing and potential uses of these resources; and,

3) the current status and sources of degradation of these resources.

Ideally information should be available for entire countries in sufficient detail to assist coastal management and planning. Since it is costly and difficult to undertaken major field surveys, information gathering activities should target areas where resource depletion, degradation or conflicts in resource use already exist. These include the areas described above for which multi-sectoral planning is needed, such as islands with growing urban centres, and islands or coastal regions with large scale tourist developments.

An understanding of the distribution and abundance of resources and biological communities in the coastal environment is an essential information baseline. This should include major coastal ecosystems and habitats, physical features and biological communities, as well as cultural and social resources such as archaeological sites and recreational areas. Much of this can be accomplished by broad-brush, semi-quantitative field surveys, the results of which can be extrapolated through air photo interpretation. Satellite image analysis may be appropriate if facilities, expertise and imagery are readily available. In-depth biological inventories are usually not necessary at this stage, but may be required later to provide details on the distribution and abundance of rare or endangered species or habitats. Survey methods should also include interview surveys with resource users, such as older fishermen and natural historians who can provide information on long-term trends, seasonal variations, local natural processes and other aspects of the resource base which are impossible to collect by rapid one-off surveys.

Information gathering by interview techniques also forms the basis for identifying existing and potential coastal resource uses. Older, expert resource users are a valuable source of data on location, timing, methods, and trends of resource harvest or other use related activities in coastal areas. Government agencies with a mandate for developing, promoting, managing or conserving resources found in coastal areas need to make available details of their current and planned activities with regard to these resources. Information on the commercial enterprises operating in coastal areas or utilising coastal resources (e.g. hotels, sand mining companies, dive tour operators) should also be gathered.

Information on the sources and types of pollutants or activities which are depleting or degrading the coastal resource base is a third layer of essential information. Much of this can be determined in a qualitative way during interviews with resource users, and may be elaborated upon through a pollution sources survey.

To be of use in coastal management and planning, all of the above information must be as geographically specific as possible. In other words, determining the location of resources, their uses and pollution threats is a critical component of the information gathering process. The information can then be archived in computer based, geographic referenced data-banks and portrayed on maps, air photos, overlays or in atlases which are an essential tool for coastal management and planning.

Education and awareness raising programmes and materials

The long-term success of coastal management and planning depends upon the public and decision makers being informed and aware of the fragility and importance of coastal ecosystems, their resources, and their use, and the potential impacts of modern development activities. A programme to develop public awareness including production of materials, radio programmes, and awareness raising seminars for public officials is essential as is the development of appropriate educational materials and curricula for schools.

Regional Governments should take advantage of materials developed by international and regional agencies such as SPREP and should provide input into the development of these materials. They might suggest what is needed and appropriate and pursue the translation of these materials into vernacular languages for wider distribution in the region.

Awareness raising seminars and the mass media should be used to inform both the public and decision-makers of the need for and value of coastal management and planning. Seminars may be best used to primarily address specific components of a coastal management and planning programme, such as a particular EIA, but they should also stress the comprehensive, integrated aspect of coastal management and planning.

Development of legislative, policy, administrative and institutional arrangements for coastal management and planning

A variety of mechanisms exist for establishing coastal management and planning programmes. Some components of a coastal programme such as environmental impact assessment procedures can be developed separately through specific legislation and programme development. Other aspects can be implemented through specific actions; establishing a multi-sectoral management or planning task team for a particular problem or area. However, the overall concept and structure of a coastal management and planning programme needs to be promulgated through high level national policy decisions and national legislation if it is to be comprehensive and effective. In some countries it may be possible to achieve such a comprehensive approach by amending or revising existing legislation.

It is important that administrative arrangements and institutional responsibilities are clearly defined at the outset when designing a coastal management and planning programme. In

particular, an appropriate lead agency needs to be designated. The process whereby various agencies interact, how reviews are executed and the mobilities of private and public sector involvement all need to be thoroughly considered. The opportunity for public participation in the coastal management and planning process is critical to its success. The cultural and political context of many Pacific island countries will necessitate creative adaptation of the public participation processes common to many metropolitan countries to ensure the successful incorporation of this important input into future programmes.

Formal education and in-service training in coastal management procedures

Training in various aspects of coastal, planning and management should be made available for officials of appropriate government agencies, for planners, resource managers and scientists. In the Pacific, SPREP has and continues to provide, a two-week, in-country training course for mid-level officials in coastal zone management upon request by individual countries. In addition training in EIA has been undertaken and, in collaboration with IMO and Australia, training in oil spill response and contingency planning takes place on a biennial basis. Other regional and international organisations also provide relevant training opportunities. There are no long-term, formal educational opportunities in coastal management and planning in the region and few such opportunities world-wide; the M.Sc. and Diploma programme in Tropical Coastal Management at the University of Newcastle-upon-Tyne, United Kingdom being a notable exception. Individual post-graduate programmes at universities in and around the Pacific Basin can and are adapted to provide a multi-disciplinary, resource management outlook for individual or small groups of students. Such activities need to be strengthened and expanded within the region.

CONCLUSION

There is a tremendous variation in the cultural, political, economic development and environmental background within the small island states of the Pacific Basin. The development of any coastal management and planning programme to address the current and future problems of the coastal zone must be adapted to the context of the individual country or territory. This context will determine the priority and manner in which coastal pollution and resource degradation are addressed through comprehensive coastal management and planning. Additionally, coastal management and planning efforts must now be developed within the context of global climatic change and take into account changing conditions resulting from global warming and sea level rise.

THE EFFECT OF POLLUTION ON COASTAL FISHERIES IN THE SOUTHERN REGION OF PERU

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ABSTRACT

The present paper describes the types of pollution which occur along the south coast of Peru and their effects on fisheries production, in particular on the culture of molluscs. In Pisco and Ica moderate pollution of marine waters is due to organic matter from fisheries sources. In 1985, widespread mortality in the Peruvian calico scallop culture in this area was caused by the discharge of 8 metric tons of decomposed sardine which resulted in extensive pollution of Paracas Bay.

In Ilo and Ite and other small bays of the Tacna area pollution caused by mining activities, modifies the physical and geomorphological characteristics of the rocky coast changing its suitability for shellfish and consequently depressing fisheries production in this area. Tailings discharge to Ite Bay, amounts to an annual volume of 36.4 millions cubic meters, affecting the area which is the natural habitat of shellfish and consequently affecting fisheries production and other economically important activities.

INTRODUCTION

In the coastal localities of Pisco, Moquegua and Tacna (Fig. 1) Peru, economically important activities related to fisheries, mining and agriculture have all been developed. These activities result in different levels of pollution in the coastal marine environment. Previous research on pollution has shown (Sanchez & Jacinot, 1987)that environmental quality has been lowered in the Pisco and Paracas Bay areas, owing to the direct discharge of fisheries wastes to the sea from fish processing plants. In the Moquegua and Tacna areas mining activity has had a severe impact and a number of studies have examined the levels of metal pollution in water, sediments, organisms from Ilo and Ite bays, (Ancieta, 1960; Valcarcel *et al.*, 1974; Dames & Moore, 1976; 1986; Sanchez *et al*, in press). The coastal areas of Pisco were described as moderated polluted, and Ite as heavily polluted by Guillen, (1981).

The marine environment in front of Pisco, Ilo (Moquegua) and Ite (Tacna) is the base for the development of industrial and artisanal fisheries activities, with 66 % of the whole country's mollusc fishing vessels being registered in these ports. Although the shellfish resources in these areas are the most affected by pollution they are also the areas which are the most productive for natural shellfish populations. In addition to supplying shellfish to the domestic market (it is estimated that 80 % of the approximately 200 thousands tons harvested annually is internally consumed, (Zapata, 1987), the shellfish forms an important export product. In 1985, production of Peruvian calico scallop formed 67.7 % of the total frozen shellfish produced (Tables 1 & 2).

Table 1. Industrial and commercial fisheries exports from Pisco, Moquegua and Tacna; 1976 to 1987 (Figures do not include fish meal and fish oil).

	PISCO		MOQUEGUA		TACNA	
	Tonnes	US$ 000's	Tonnes	US$ 000's	Tonnes	US$ 000's
1976	210,161	58,227	67,395	18,086	44	67
1977	121,702	46,877	36,432	13,925	289	239
1978	4,500	1,629	98,160	39,691	414	342
1979	19,821	7,349	111,610	42,229	N.D	
1980	31,994	13,492	120,361	55,184	1,183	1,046
1981	14,037	5,626	159,346	70,585	155	162
1982	12,124	4,236	111,846	39,780	105	107
1983	8,955	4,646	13	13	49	95
1984	26,236	35,433	4,297	1,999	85	85
1985	82,231	22,871	73,763	25,407	145	132
1986	46,648	25,840	55,436	17,127	39	34
1987	109,393	34,049	36,671	12,044	199	175

Table 2. Weight and value of frozen fisheries exports from Peru 1985-1987. (Data from Ministry of Fishery Peru 1988).

	1985			1986			1987		
ITEM	Tonnes	%	US$ 000's	Tonnes	%	US$ 000's	Tonnes	%	US$ 000's
FINFISH									
Peruvian Hake	2,206	1.8	1,611	2,488	61.1	2,004	4,175	58.3	4,105
Pacific sardine	55,004	45.2	12,154	796	19.5	211	1,947	27.2	504
Southern jack mackerel	33,138	27.2	8,746	-	-	-	-	-	-
Chub mackerel	29,612	24.3	9,010	-	-	-	-	-	-
Others	1,839	1.5	1,987	788	19.4	1,357	1,040	14.5	1,824
TOTAL	121,799	100,0	33,508	4,072	100.0	3,572	7,162	100.0	6,343
SHELLFISH									
American Squid	559	6.2	181	-	-	-	47	2.1	64
Chocolate rock shell	218	2.4	689	391	10.7	1,372	374	16.4	1,252
Peruvian Calico Scallop	6,108	67.7	25,708	1,666	45.8	13,721	13	0.5	299
Shrimps	1,938	21.5	16,347	1,021	28.1	10,634	1,553	68.2	11,898
Others	195	2.2	1,245	562	15.4	3,373	291	12.8	1,662
TOTAL	9,018	100.0	44,170	3,640	100.0	29,100	2,278	100.0	15,175

These areas are extremely productive in particular Pisco, which is located in one of the areas of greatest coastal productivity world-wide, as a consequence of coastal upwelling (Zuta & Guillen, 1970). Thus the present study highlights the effects on artisanal fisheries of marine pollution resulting from organic waste discharge (mainly animal wastes) which has occurred in coastal bays or zones that are shellfish habitats and in an area which includes the only national reserve covering marine areas in Peru. Similar impacts result from the discharge of mine tailings which disturbs and modifies the marine environmental quality for the benthic biota that constitute the main fisheries resource.

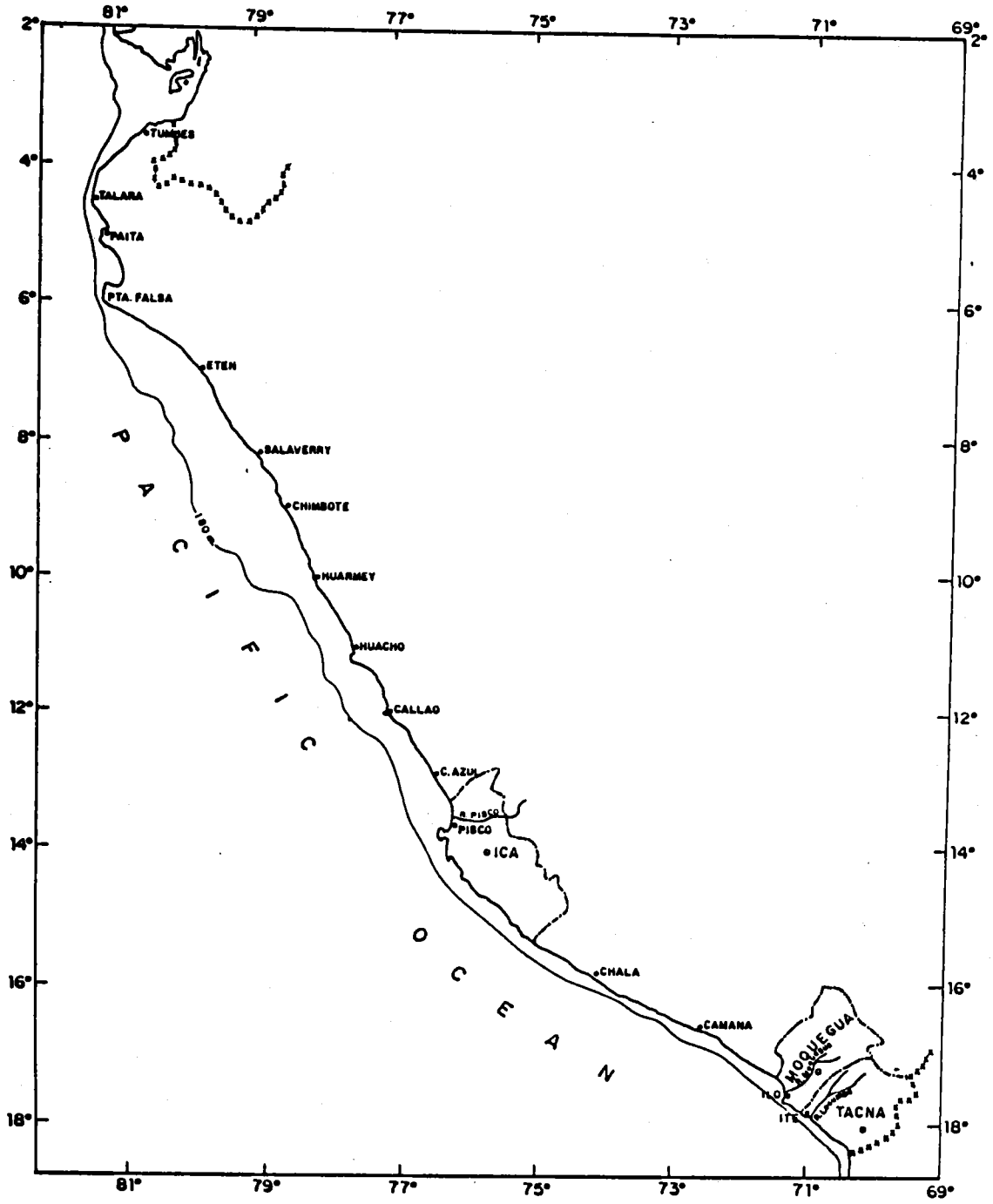

Figure 1. Coast of Peru showing the areas considered in this study.

PISCO, PARACAS BAYS AND PARACAS NATIONAL RESERVE

General Oceanographic and Fisheries characteristics

Pisco is situated on the southern coastal area of Peru (14°S) at the western limit of the large Pisco desert and 20 km South of the Valley and river of the same name. The coastal profile is straight down to Paracas Bay (13°51.5'S-76°17'W), which is a sheltered, semi-enclosed bay, with calm waters and a sandy-muddy bottom similar to a lagoon (Figure 2).

The temperature and salinity regime of the bay reflect the influence of the cold ocean water masses, with temperatures of 19°C and salinities of 35.1 % or less, resulting from the Peruvian Current and the nearby San Juan upwelling (Zuta & Guillen, 1970). Nutrient levels are high due to these same water masses. Paracas Bay is a tourist, recreation centre with several small piers used for yachts. Inside the bay and mainly in the west, shellfish breeding and fattening places were established in 1984; seed being brought from Independence Bay and other locations.

The other geographical feature is the Paracas Peninsula (13°52'S-76°23.3'W) backed by a sandy pampas area this runs for 5 km from the South of Paracas Bay up to Lagunillas inlet, facing the sea with cliffs. The total area of the peninsula is about 135 square kilometres. In bays such as the small San Andres bay there has developed an important artisanal fishery, which according to Pinedo (1988) includes 51 commercial species. Of these, the most important among the finfish are the Peruvian silverside, *Odontesthes regia regia* and the Palm ruff, *Seriolella violacea*, which together constituted 50.6 % of the total capture in 1987. Among the shellfish *Thais chocolata*, the chocolate rock shell formed 95 % of total landings in the same year.

The Paracas National Reserve is located in the Department of Ica, in Pisco and Ica provinces (Figure 2) and encompasses the Paracas Peninsula, and Independence Bay among other areas. This Reserve represents 117,406 hectares of land and 217,595 hectares of sea, giving a total area of 335,000 hectares lying between 13°46'-14°30'S and 76°00'-70°30'W.

The Paracas peninsula and the neighbouring land have an exceptional diversity of terrestrial and aquatic faunal resources. In this area the separation of the Peruvian and Humboldt Currents, occurs which facilitates the formation and development of a characteristic Peruvian biocenosis (Ministerio de Marina, 1987). The Paracas National Reserve covers the ecological regions of the Peruvian-Chilean oceanic domain and encompasses the coastal desert. It was established by Supreme Decree No 1281-75-AG on 25 September 1975, with the objective of preserving the marine shore ecosystems including the fish, birds and mammals occurring there and providing special protection for endangered species such as *the sea otter, Lutra felina*; the South American fur seal *Arctocephalus australis*; the South American Sea Lion, *Otaria flavescens* South American sea lion; the Peruvian condor, *Vultur gryphus*; and the penguin, *Spheniscus humboldti*, amongst others. In addition the area is designed to provide protection for cultural and historic sites, which include evidence of human occupation and agriculture dating back 9,000 years.

The National Reserve is visited in summer time by large numbers of people from Lima, Pisco and Ica, for swimming and water sports. Within the Paracas National Reserve activities are limited to fishing and tourism. The fisheries are artisanal and include line fishing, and bottom net fishing in the marine waters in front of the peninsula.

Independence Bay (14°15'S-76°7.5'W) is 13 miles long and 4 miles wide with a sandy and stony bottom, at depths of between 7 and 85 m. The oceanographic conditions of the bay were described by Moron *et al* (1988), who pointed out that mean temperatures ranged from 13.5°C in winter to 15.8°C in summer, salinities varied from 34.7 to 35.2°/$_{oo}$ on the surface, and nitrates were generally low (1 to 10 ug l^{-1} at the bottom and 3 ug l^{-1} at the surface). Prevailing winds are from the SE with velocities between 5 and 20 m s^{-1}. The circulation of the surface water currents which enter bay flow parallel to the coast while the sub-subsurface currents go in the opposite direction, with velocities of 5 and 40 cm s^{-1} at the surface and close to the bottom respectively.

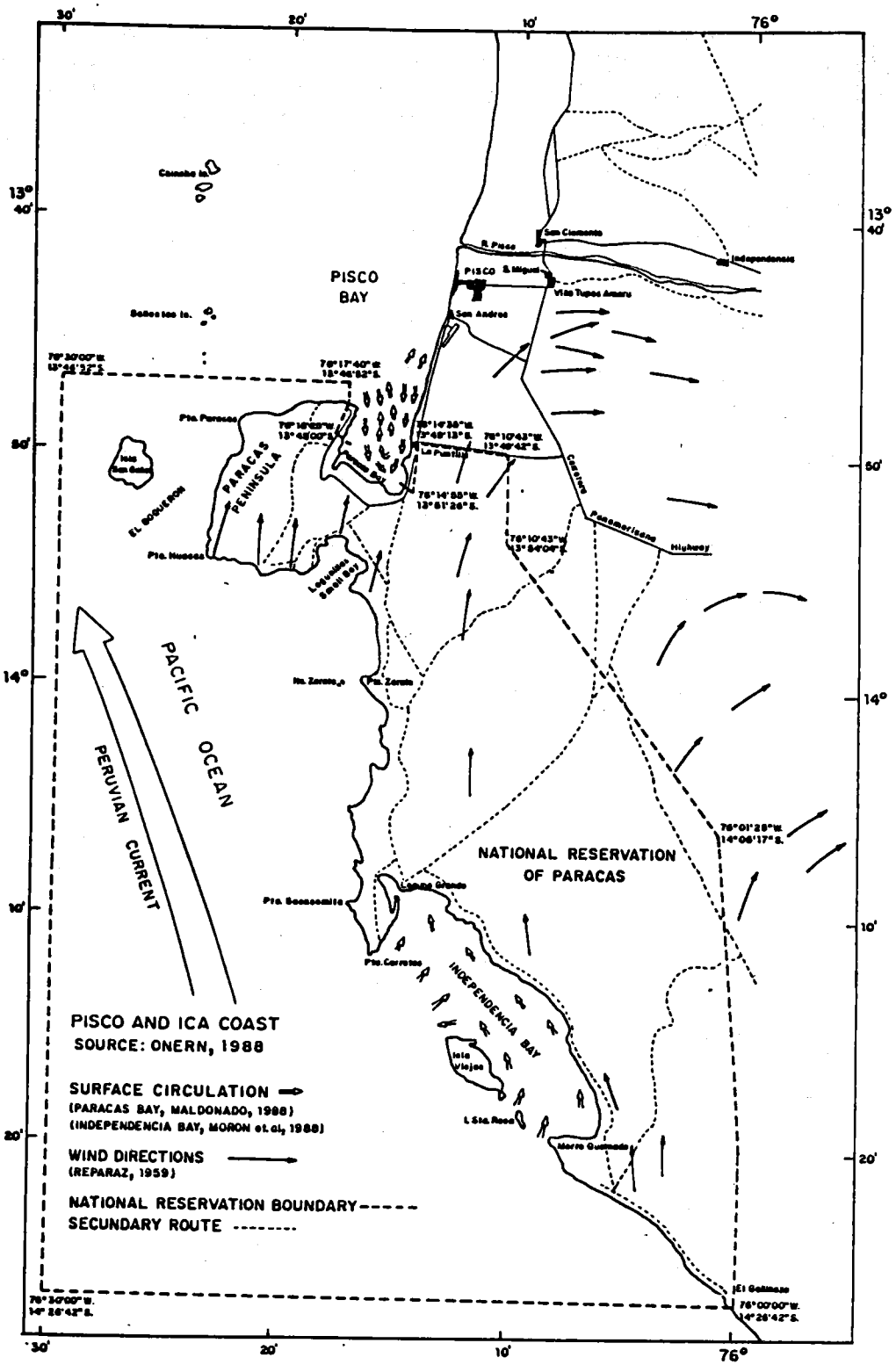

Figure 2. Location of the Paracas National Reserve and surface wind and current regimes.

This bay has eight extensive, sandy beaches, and at the southern boundary lies Independence (La Vieja) Isle. The 1982-83 El Nino phenomenon caused an marked increase in the Peruvian calico scallop population of Independence bay, and resulted in increased rates of capture of this shellfish and consequent exports. In 1984 2,908 metric tons of this bivalve were exported and its value was nearly 10 millon U.S. dollars; in 1985 this rose to 22 millon US$ (Ministry of Economic and Finance, 1985). Due to the over exploitation of this resource and the decrease of the population as a result of normalisation of the oceanographic conditions, there is an restriction on capture for the protection of this resource.

Shellfish mortality as a consequence of organic pollution

During February 1985, 8 thousand tons of putrefying sardine were discharged into Pisco Bay, as a result of a strike by workers at the Pesca-Peru fisheries plants. This polluted an extensive area of the coastal zone, particularly along the Paracas Peninsula, affecting the shellfish breeding areas, where there are normally high concentrations of individuals per square meter. Damage was estimated to be in excess of 5,384 million U.S.$. The breeding areas in Paracas Bay, occupy an area of 176 hectares (Benites, 1988), and the wind and current regimes (Rapaz, 1979); (Maldonado, 1988), result in a continuous a water from Pisco Bay which on this occasion was polluted by the discharges which occurred approximately 5 miles off-shore. As noted previously the Paracas National Reserve includes part of Paracas Bay, and its coastline provides important habitats for a number of species both resident and migrant that were also seen to be affected by changes in environmental quality resulting from pollution.

In 1985, Independence Bay, a natural habitat for the calico scallop was estimated to contain a biomass of 62,150 metric tons in May and 41,187 in October of the same year. During this year captures yielded a figure of 7,045 metric tons, much lower than would be suggested by the two previous estimates. According to IMARPE (1986), this may reflect the clandestine harvest of this resource during which the animal is extracted from the shell and the wastes are thrown into the Bay causing a high production of sulphur. The mud is carried by the currents to areas of shallow water where *A. purpuratus*, the Peruvian calico scallop lives, and the sulphur released in the substrate causes mortality of this species. This was observed to occur in January 1987 when Moron *et al* (1988) observed and increase in sulphur and a decrease in oxygen concentration, due to the discharge of organic wastes to waters of the Bay.

ILO AND ITE BAYS, AND THE SMALL BAYS OF MECA AND VILA-VILA

Oceanographic and Fisheries Characteristics

Ilo Bay is located at the southern extremity of Moquegua Department, 17°37'S-71°20.3'W and has a rocky coast which extends for 2 miles, The Ilo River, which meets the coast in the northern half of the bay has a low water flow to the sea since it is heavily used for agriculture in the narrow river valley. Currents inside the bay are significant (HIDRONAV, 1982). To the South of the city is the Punta Coles, which with its limited rocky elevation protects the port of Ilo and the other small bays and allows the mooring of commercial and fishery vessels without any major difficulty. The industrial and artisanal fishery which has developed in front of the coast at Ilo is very important for the socio-economic development of the region and supplies fish and shellfish to the populations of Ilo, Moquegua, Arequipa and Lima (Orozco, 1988). Table 3, details the marine biological landings over the last seventeen years. In the case of Ilo, this shows that the landings of fish although variable are always important, while shellfish landings increased during the 1980's.

Table 3. Landing of Commercial Marine Catch (metric tons) from Ilo (Moquegua Department) and Small Bays in Tacna Department, 1970-1987. Figures do not include finfish landings for fish meal and oil production. Sources include Annual Fishery Statistics 1970-1987 and unofficial data from the Tacna Fisheries Office.

YEAR	MOQUEGUA			TACNA						
	ILO				ITE		MECA		VILA VILA	
	TOTAL	Fish	Shell-fish	TOTAL	Fish	Shell-fish	Fish	Shell-fish	Fish	Shell-fish
1970	497,7	429.6	68.1	828.2	825.9	2.3	-	-	-	-
1971	1,020.7	1,003.2	17.5	N.D	N.D	N.D	N.D	N.D	N.D	N.D
1972	4,347.4	4,334.1	13.3	830.0	-	-	830.0	-	-	-
1973	4,478.3	4,410.0	68.3	788.0	-	-	552.0	-	236.0	-
1974	3,566.5	3,524.5	42.0	604.0	-	-	423.0	-	181.0	-
1975	3,711.0	3,650.0	61.0	1,450.0	-	-	162.0	-	618.0	670.0
1976	2,917.0	2,829.0	88.0	1,530.0	-	-	196.0	-	604.0	730.0
1977	7,735.0	7,564.0	171.0	1,706.4	-	-	284.0	-	536.0	884.4
1978	7,432.0	7,330.0	102.0	3,360.2	-	-	623.0	-	273.7	2,463.5
1979	9,457.0	9,168.0	294.0	2,111.0	-	-	245.0	-	444.9	1 420.9
1980	10,689.0	10,070.0	619.0	1,450.6	-	-	231.8	34.8	862.0	322.0
1981	13,882.0	6,175.0	707.0	1,852.3	-	-	209.0	14.1	1,141.0	487.4
1982	4,234.0	3,634.0	600.0	1,479.7	-	-	257.5	12.1	1,016.3	193.8
1983	5,177.0	4,768.0	409.0	677.0	-	-	14.0	-	598.0	65.4
1984	6,269.0	5,806.0	463.0	2,738.9	-	-	63.0	-	2,643.0	32.9
1985	4,461.0	3,217.0	1,244,0	1,396.3	-	-	-	-	1,366.0	30.3
1986	12,133.0	9,715.0	2,418.0	3,227.9	-	-	-	-	2,873.2	354.7
1987	12,558.0	10,275.0	2,283.0	2,098.8	-	-	-	-	1,096.0	192.4

This table does not include the landings for fishmeal and fish oil production, which are also high. In 1986 the fish processing plant produced 150,980.8 metric tons of fishmeal and 25,233 metric tons of oil fish, with a total discharges from the fishmeal plants of 623,893 cubic meters of waste water (Sanchez *et al.*, in press) without any pre-treatment. This caused problems of anoxia in the bay with oxygen values of between 0.89 to 2.27 ml l^{-1} and sulphur values of between 0.04 and 0.19 ml l^{-1} higher than the levels permitted by the General Water Law of Peru.

The Bay of Ite, on which is situated the city of Ite (Figure 3) is in Tacna Department (17°55'S-70°56.6'W), is delimited to the North by the rocky Alfarillo Point and includes Playa Inglesa, which was formerly a sandy, public swimming beach, with some cobblestones and shell fragments. These geomorphological and physical characteristics have now changed significantly as a result of the deposition of very fine silica particles derived from the tailings discharged by the Toquepala and Cuajone mines. This has resulted in the development of a new beach and seaward migration of the coastline of Playa Inglesa by nearly 1000 meters (Dames & Moore, 1986).

The oceanic temperatures of this region vary from 16.7°C to 19°C; during winter, the low temperatures are directly related to the oceanic upwelling. Temperatures higher than 22°C are related to the inflow of warmer oceanic waters between November and June, which occurs along nearly all the Peruvian coast (Zuta & Guillen, 1970). According to Dames & Moore (1976) winds at Ite, are dominated by southeasterly winds with mean velocities at 17:00 hours of 4.1 to 5.3 m s^{-1}, based on records from 1968 to 1975. Fisheries activity is based on an artisanal fishery and shellfish extraction from the rocky habitats between Punta Huaca Luna and Yarada, landings being made at the different small bays (Table 3).

The Port of Ite has ceased to be used for landing as a consequence of the ecological impact of the tailings in this area. During the decade between 1950 and 1960, Ite and Meca (17°56'S-70°54.6'W) were artisanal fisheries centres with enough activity, in 1965, to support 25 vessels

(Southern Regional Development Office, Tacna 1967) and provided employment for 40 families living in Meca, a small neighbouring village. Subsequent to 1984 fishing activity has ceased, due to pollution by the mine tailings, as seen from the fisheries statistics in Table 3. The small bay of Vila Vila (18°06.7'S-70°43.7'W), located in the Southern part of Meca, has increased the volume of artisanal finfish landings in the decade since 1980, although shellfish landings have remained unchanged.

Effects of pollution from mining and metal processing on shellfish

As noted above the littoral zone of Ilo is dominated by rocky bottomed habitats which are the natural habitats for the shellfish which comprise the commercial fisheries catch for direct consumption and export as canned or frozen products. The coastal zone of Ilo Bay, receives discharges from mining and industrial ore processing plants such as the private enterprise copper smelter at Ilo and the state owned copper refinery, both of which are situated to the North of Ilo. In the areas of direct discharge to the sea is a rocky habitat where the false abalone, *Concholepas concholepas*; the giant keyhole limpet, *Fisurella maxima*; the keyhole limpet, *Fisurella latinmarginata*; and the chocolate rock shell, *Thais chocolata* all occur naturally.

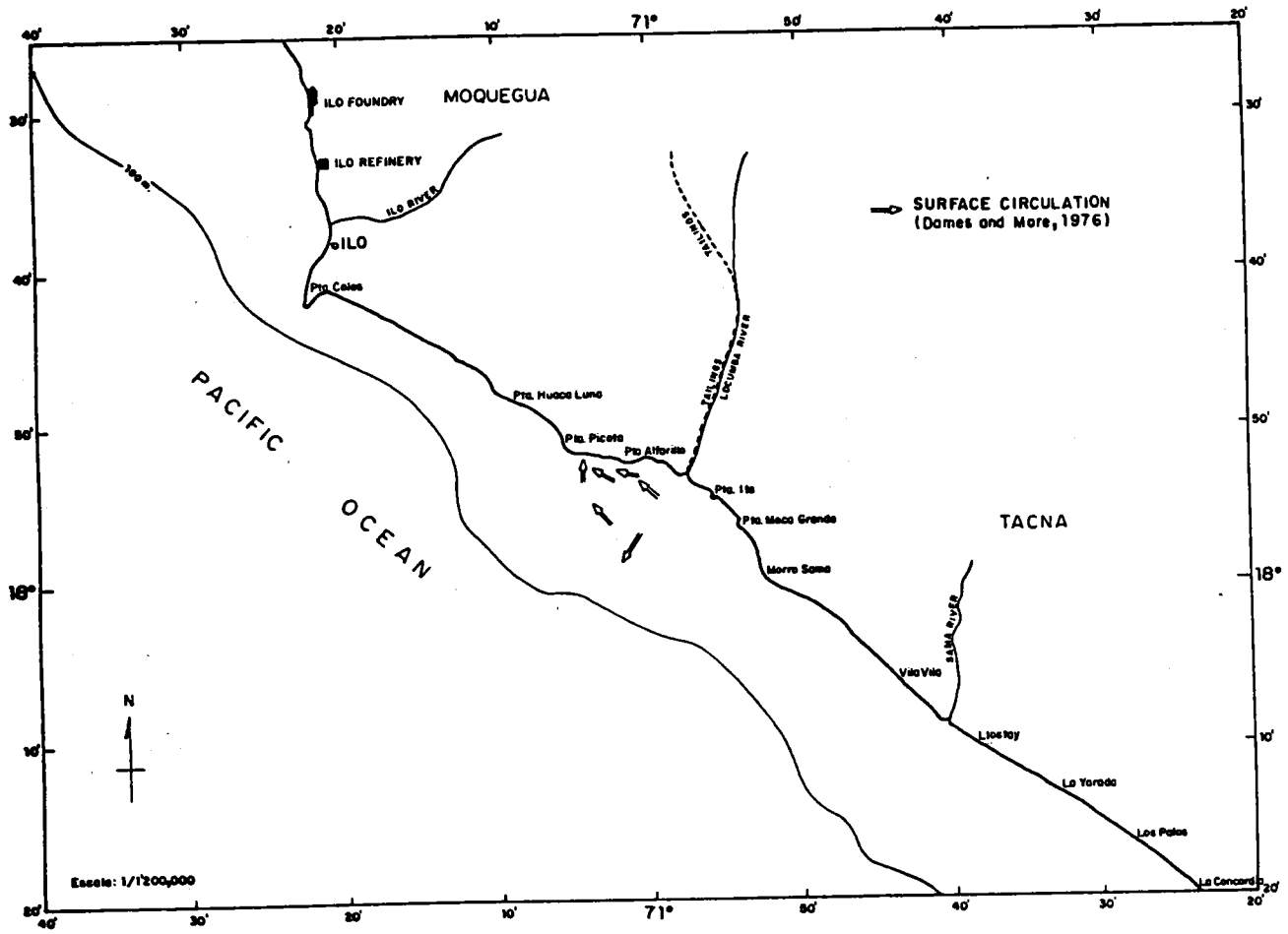

Figure 3. Southern coast of Peru, showing the location of Ilo, Ite, Meca and Vila Vila.

The waters in this area have copper concentrations of 0.059 to 0.163 ppm; zinc of 0.092 to 0.748 ppm; iron of 0.15 to 0.800 ppm; manganese of 0.050 to 0.075 ppm; lead of 0.21 to 0.32 ppm; and, cadmium of 0.037 to 0.106 ppm. The values for copper, zinc, lead and cadmium are over the permissible levels for sea water in areas where shellfish are collected for human consumption; for the conservation of aquatic fauna; and, for commercial or sport fishing according to the Water General Law of Peru (D.S. 007-83-SA). In practice the shellfish populations have disappeared (pers. comm. fisherman from Ilo), and their capture over the last few years has not yielded a great deal.

In Ite the pollution of the rocky shore, is due to the tailings discharge from the Toquepala and Cuajone mines which annually discharge a volume of 36.4 million cubic meters. These tailings have covered the rocky substrata where the shellfish normally live, and rocky shore fauna such as the mussel species *Perumytilus purpuratus* and *Semimytilus algosus* mussel are no longer found there. The trace metal levels in the Bay include cadmium of 0.029 to 0.049 ppm; zinc of 0.048 to 0.579 ppm; copper of 0.040 to 0.220 ppm; lead of 0.210 to 0.316 ppm; iron of 0.029 to 0.059 ppm; manganese of 0.029 to 0.118 ppm. As in the case of Ilo the values for copper, lead, cadmium and zinc exceed the permissible levels as detailed in the General Water Law of Peru. The marine waters in this area have a milky appearance due to the turbidity of the suspended sediment which extends for between one and three miles off-shore and reaches as far as the small Bay of Meca Grande. The ecological impacts in this area are severe and have resulted in depressed fishing activity for shellfish as is clearly seen from the figures for annual landings for human consumption; since 1984 there have been no commercial fish landings in Meca Grande. Nevertheless in the same bay of Ite and Meca, pelagic resources like the anchovy, sardine and other species continue to be landed in Ilo to supply the fishmeal and fish oil plants.

CONCLUSION

The artisanal fishery in Peru is based principally in the Pisco, Ilo and Ite areas on the capture of species, including important shellfish for direct human consumption, and for export as frozen or canned products.

Pollution of the Pisco coast is principally due to organic discharge from the fisheries plants which produce fishmeal, fish oil and canned or frozen shellfish. This discharge occurs in protected areas and causes shellfish mortality as was the case in 1985 following discharge of organic wastes in scallop breeding places and more recently in their natural habitats.

Along the coast near Ilo, Ite and Meca marine pollution results from tailings discharge from mines and waste discharge from metal processing plants causing extensive damage to shellfish habitats and economic impacts on the artisanal fisheries of these areas.

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THE ENVIRONMENTAL COSTS OF DEVELOPMENT IN PNG-THE CASE OF BOUGAINVILLE COPPER

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ABSTRACT

This paper examines some of the economic costs of environmental pollution in one of the most important development projects in Papua New Guinea. We examine the Bougainville Copper project and consider the costs associated with environmental pollution and the impact of this mining project upon society as a whole. It will be argued that proper development of environmentally sound mining projects has been constrained by a bureaucracy and political leadership that has emphasised the revenue benefits of such projects without appropriate consideration of the social costs. This difference of perspective lies at the very heart of the current military conflict on Bougainville.

What is made evident in this paper is that the PNG government has consistently failed to consider many of the wider social and environmental costs associated with the least cost, private solutions to environmental management in mining projects. In the case of both Bougainville Copper and the Ok Tedi mine there has been no attempt to undertake a formal cost benefit analysis of the available waste disposal options. This paper also argues that not only has the choice been based purely upon the private cost to the developer but it has been based upon information and assumptions about the future that are at best incomplete.

It is clear that in not undertaking formal, social cost-benefit analyses in any of the mining projects in the country the state has implicitly discounted the future social costs to a point where the recurrent revenues of the state are endangered. The process of treating social and environmental costs with disdain has not enhanced PNG's long term prospects for economic growth in the narrowest definition of the term.

INTRODUCTION

At the present time a state of low intensity guerilla warfare currently exists in the North Solomons Province resulting in the closure of the Bougainville mine by militant landowners. This has resulted directly from the social and environmental costs of mining activity. We can only conclude that past social and environmental decisions regarding mining projects are affecting current state revenues and are thus also affecting future economic growth.

At present a large number of mining and petroleum projects are being reconsidered directly as a result of the violent confrontation on Bougainville. Foreign investors are now taking a more cautious position *vis-a-vis* PNG until they are assured that the state can protect against para-military actions occurring at other mining and petroleum sites within the country.

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THE BOUGAINVILLE CRISIS

The greatest single source of revenue for the government of Papua New Guinea is the copper and gold mine at Panguna on Bougainville Island in the North Solomons Province. In 1988 Bougainville Copper provided the national government directly, with $US 175 million which constituted approximately 24 % of internal revenues. With indirect effects it probably accounts for over 30 % of government internal revenues [2].

In April 1988 a group of young landowners from the Panguna area, headed by a former employee of Bougainville Copper Limited (BCL), Mr Francis Ona, wrote to the government demanding, among other things some $US12 billion in compensation for the destruction of land, pollution of the environment and social dislocation[3]. The group also demanded the closure of the mine. Without doubt the primary cause of this demand was the destruction of the environment combined with a method of compensation for the loss that compensated only those who were the matrilineal titleholders to the land and not the land users. The demand for compensation came from a group that had, in the words of the late landowner leader, Perpetua Serero 'Received nothing from the mine except pollution' [4]. The demand for additional compensation over and above what had been agreed to in the 1980 compensation agreement between Bougainville Copper and the landowners was rejected by the company out of hand. This was not surprising given that the sum demanded was equivalent to five times the entire annual GDP of PNG.

In the absence of a positive response from both the government and the company, militant landowners stole dynamite from the company, began blowing up installations, shooting mine workers and effectively halted the operation of the mine from late May 1989. The reaction of the government to the violence was restrained at first, but after eight months of intermittent guerilla warfare and repeated attempts to negotiate, the government finally imposed a state of emergency on June 24th 1989 and sent some 2,000 troops into the Panguna area to arrest armed militants. It must be understood that the government of PNG was to a large degree supportive, in principle, of the demands of the landowners for increased compensation. Ironically it was this same government that had been the first to amend the Mining Act to make landowners equity partners in future mining projects.

In order to understand how this situation arose it is essential to examine the situation prior to the development of the BCL Copper mine, and to examine the choices made in the disposal of waste and mode of compensation adopted for landowners and users. It is then possible to determine the basis of the current crisis on Bougainville.

THE PRE-MINE ENVIRONMENT

Bougainville Island is located 6° South at the northern end of the Solomon Island chain (Applied Geology Associates Ltd., 1989). The actual mine is located at Panguna on the head-waters of the Kawerong River in the Crown Prince Range. The climate is typically tropical with two distinct seasons; a north west monsoon, and a period of south east trade winds. Rainfall and

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[2] The government of PNG received $US200 million in direct untied budgetary assistance from the Australian government for 1989. This accounts for 21 % of total government revenue.

[3] Francis Ona and much of the younger generation of militants are in fact not legally landowners as they are not part of the group of matrilineal title-holders that receive compensation from BCL. As a result they have not been direct financial beneficiaries from the mine and are to a large degree reliant upon gifts from titleholders.

[4] Interview with Ms Perpetua Serero, former head of the Panguna Landowners Association in June 1988.

temperatures are high, with rainfall occurring throughout the year leading to the development of dense tropical rainforest. Average, annual rainfall at Panguna is 4.3 metres per year. Due to the height and narrowness of the Crown Prince Ranges, river systems are steep with slow meandering sections only in the coastal plain and foothills, and the Jaba and Kawerong rivers are typical in this respect.

Prior to the development of the mine there was extensive subsistence agriculture in the upper reaches of the Kawerong. The fertility of the soil was such that only 0.1-0.2 hectares needed to be cultivated per person per annum. Staple crops included sweet potato, taro, sugar-cane, bananas, papaya and breadfruit. The Kawerong and Jaba Rivers were both used for fishing.

Land rights in the mine impact area are fairly well documented. The population of Central Bougainville is divided into a number of matrilineal clans, and the western concept of freehold ownership of land does not exist within the clan ownership structure. Usufruct rights normally accrue to the man who first cleared the forest and that land may be used to plant gardens, establish houses and plant tree crops. Transmission of land rights in central Bougainville is through men, though matrilineal kinship is important and land use decisions increasingly cannot occur without the agreement of the wife. However since marriage has traditionally occurred through cousins there has been no general transfer of land in the western sense of the word. Traditional methods of land transfer do exist inside the clan but there was no concept of land alienation. This is crucial to understanding the reaction of the population of Central Bougainville to the development of BCL.

There is no doubt that when CRA (Conzinc Rio Tinto, Australia) began exploration activities in 1964 the area around the current mine site was one of the least developed regions of the North Solomons. A 1964 patrol report described the Guava census division as "a fairly isolated area with very restricted communication and access and the people are among the least sophisticated in Bougainville" (Anon, 1965). In an earlier patrol report dating from 1961 it was reported that "Economically the Guava census division is very underdeveloped at the present time" (Anon, 1962).

Monetised economic activity was at that time little developed despite the attempts of the colonial administration to encourage such activity.

> "The majority of the income in the Guava villages was from plantation labour on the east coast land in East New Britain.....There was no access road to the villages and in 1964 coffee was being brought on foot to Kieta from such villages as Pakia and Guava. By 1964 Dapera had only 343 coffee trees, all of which were immature, although Pakia had 2660 mature and 178 immature trees.
>
> There were primary schools in the district although few students went on to secondary education. Nutrition and health, apart from gastroenteritis, appear to have been relatively good, partly because of the diversity of locally available food and high altitude" (Applied Geology Associate Ltd, 1989 p.25).

Thus what appears to have existed prior to the development of the mine was a traditional, Melanesian, subsistence society with a population of approximately 2,000 existing in relative harmony with an environment that apparently had little potential for development or economic growth. The reaction of the local people to the arrival of CRA and its exploration team in 1964 was almost university hostile and negative. In one of the Patrol Reports, the Kiap, or Patrol officer reported.

> "This is where I first found that the people along the ridges were against any interference by the Company. They told me they owned the land and thus the copper and didn't want the company to take it away and leave their children with nothing. They said they wanted to wait until their children had received an education to handle the company. The people refuse to accept the principle that all mining rights belong to the Government and any benefits as such go to the territory as a whole and not to various individuals in the mining area. When talking to the priest at Demori I found that his beliefs are the same as the people. Some of the priest's ideas are incorrect. He believes that the mining rights belong to the people and that the people have to receive payment for these rights" (Anon, 1966).

Throughout the entire exploration stage CRA met with often violent resistance from disgruntled landowners. In general landowners argued against the mine on the grounds that eventually there would be land shortages, there would be complete destruction of land and that there would be nothing left for them to mine once the company had finished mining in the area. While there were supporters of the mine, among whom were some of the most prominent landowners there was no possible way for the landowners to know in the 1960's what would eventually become of their land. Nevertheless it is still uncanny that the natural conservatism of those tied to the land had correctly grasped that the proposed project would devastate their land which was the basis for their own subsistence agriculture.

The antagonistic and at times violent response of the landowners to what was seen by many of their number as an illegal incursion onto their land meant that throughout the 1960's the CRA exploration teams had to be accompanied by armed police to assure their safety. By the time the company began operations in 1972 the situation *vis-a-vis* landowners had changed somewhat.

> "A few of the villagers near the mine site seem to have greeted events with pleasurable anticipation of the material rewards they would reap from it while a few others became and remained implacably hostile. Most of them appear to have become resigned more or less disconsolately to what they regard as another example of the white man's cupidity, deceit and irresistible power" (Oliver, 1973).

What is evident is that the time horizon of landowners, their land law and their fundamental mistrust for a project they could not understand was entirely at odds with the position of the Australian colonial administration and that of CRA. For CRA it was simply not possible to wait until the next generation of Bougainvillians became educated, and indeed because future revenues are heavily discounted in third world countries there is generally no way in which such a project could wait. For the territorial administration, the imperative was to develop a project (indeed any project) that could assist in the financing of a territory that was soon to become independent. There was also a clear conflict between British land law which vests mineral rights in the state and traditional Melanesian law which makes no distinction between the earth and its contents.

MINE DEVELOPMENT AND ENVIRONMENTAL DEGRADATION

By 1967 the territorial government had prepared special legislation for the development of the Panguna mine. Throughout the exploration stage, which continued until 1969 and the construction stage up until 1972, there appears to have been very little discussion and consultation with the local landowners. Land that was needed for the mine was acquired by special mining leases which were granted to Bougainville Copper Limited (BCL), subject to satisfactory compensation. Some of the compensation matters were settled in court. Land for public purposes was acquired by the state.

Despite the fact that villagers were publicly assured that they would be adequately compensated for the loss of land and that those forced to resettle would be given new land there was evidence of continued opposition to the project throughout the entire development stage. In 1969 and 1970 289 villagers from the Kawerong-Jaba valley were resettled in new villages. Despite opposition from many landowners there appears to have developed a group of Bougainville politicians as well as a group of very influential Panguna landowners who had become supporters of the project.

Without doubt the greatest error made by both the company and the colonial administration was a failure to consult fully with landowners.

> "It is apparent that the administration and to a lesser extent the company ignored or at least paid very little heed to the important Melanesian principle of clan decision making or Melanesian consensus. The Bougainvillean desire for self determination or at very least a contribution on decision making on the type and pace of development was also overlooked" (Applied Geology Associates Ltd. 1989 p 27).

The method employed by the administration and the company in preparing for the development of the mine resulted not only in some major conflicts with landowners but also fuelled the secessionist movement in the North Solomons Province. The acquisition of land by the administration came to international attention when landowners at Rorovona were forcibly evicted by police to make way for the Loloho port facility. The pictures of bare-breasted women being dragged from their land by territorial police helped focus attention on the matter of land alienation in Bougainville. Simultaneously these events focused Bougainvillean political demands for secession from the rest of PNG, demands which were resurrected by Francis Ona in the early months of 1989.

The deposit of copper, gold and silver at Panguna is extremely large by world standards but of very low grade. As it was originally defined in the feasibility study there were 950 million tonnes of ore grading 0.48 % copper, with 0.55 grams per tonne of gold and 3 grams per tonne silver. By the end of 1988 the company had mined some 610 million tonnes of ore with a further 530 million tonnes at 0.4 % copper and 0.46 grams of gold remaining. The mine is expected to continue operations until 2001 and will probably continue until 2007. It must be remembered that the mine is one of the least cost copper producing mines in the world, despite what thirty years ago were considered absurdly low grades of ore. The mine has been very profitable earning an average 21 % rate of return to the original investors.

In retrospect one of the most crucial decisions made by BCL concerned the disposal of waste rock and tailings from the mine. There were five options considered by the company and while it may appear to be a tedious history it is crucial to outline these as the decision that was made resulted in the destruction of some 3,000 hectares of land, which might not otherwise have been affected. Had BCL used an environmentally safe method of tailings disposal then the current conflict might not have occurred or might not have been as serious as it has become.

Tailings disposal options:

At the time of the original BCL agreement the consultants for BCL, Bechtel considered five possibilities (Brown, 1973).

1) Discharge of tailings into the Karewong-Jaba river system, relying on the river waters to carry the material to the marine environment. Bechtel estimated 60 % of the tailings would be deposited eventually in Princess Augusta Bay at the mouth of the Jaba river. It was estimated that the other 40 % would be deposited on the land. Due largely to water flow rate estimates it was felt that the vast majority of tailings would settle below contour

elevations of 4 metres. Because rainfall statistics had not been collected for long periods of time prior to the mine development the carrying capacity of the Karewong and Jaba were overestimated. Moreover the estimates were undertaken by Bechtel for a period of ten years only. At this stage it is impossible to know why Bougainville Copper's consultants only extrapolated ten years forward. However under the Disposal of Overburden and Tailings Agreement (DOTA) between the territorial administration and BCL the deposition of tailings would continue in such a manner for a period of ten years [5].

> "It is intended that from the 1st January 1980, the method of disposal shall be consistent with the objective of re-using any land affected by tailings disposal".

2) The second alternative considered by Bechtel was to dump tailings in the much shallower Mariropa river. It was felt that such an alternative was a viable second option in the event that disposal into the Jaba was unacceptable. Since the area around the Mariropa was uninhabited it was felt that even if the river broke its banks it would not cause serious impact to the local population.

3) The third alternative considered was to pump the tailings into the swamp between the Jaba and the Mariropa and slowly reclaim the swamp using the coarse tailings with the fines being slurried into the river system.

4) The most interesting alternative from an historical vantage point was the pumping of tailings directly to Princess Augusta Bay. Because of the distance involved it was estimated that it would have cost the company some $A100 million. This would have increased the project cost by 25 % above the SA400 million figure and would have been unacceptable at the time. This alternative, was later accepted by the company and at the time of mine closure in May 1989, BCL was in the process of establishing a pipeline to the coast. Clearly had BCL employed this alternative from the very outset it would have meant that there would have been no land loss along the Jaba and Karewong.

5) The last and most interesting alternative was the deposition of tailings in a series of tailings dams using an open flume to transport tailings to the dam. This alternative was rejected by Bechtel on the grounds that Bougainville was a seismically unstable area and that the heavy rainfall in the area would endanger any tailings dam. This argument has become the standard position of all mining companies in PNG.

It is now a matter of historical record that the company took the least cost solution to its problem of tailings disposal, which also created the maximum social disruption. Prior to the Bechtel report there was an earlier report which does not appear to have been in the public domain, in which BCL proposed the construction of a tailings dam and an open flume. The following lengthy explanation from the PNG Department of Minerals and Energy study indicates the sequence of events:

> "A number of consultants reports on tailings disposal and the effects of tailings and fine overburden discharge to the Kawerong-Jaba river system were prepared in 1969-70. Initially consultants advised against discharge of tailings to the river, predicting deposition and land degradation on the scale which has eventuated. The company proposed the construction of an open flume to carry tailings to the lowlands where they would be retained in a conventional tailings dam. Subsequently a further report (the Bechtel Report mentioned above) was prepared in which disposal to the river near the base of the dumps was identified as the least costly of the five options

[5] Correspondence between L.W. Johnson, Territorial Administrator and Mr F.F. Espie 27th April 1971. This letter is normally referred to as the Disposal of Overburden and Tailings Agreement (DOTA).

> considered. The cost estimates were based entirely on construction and maintenance costs of disposal pipelines and associated facilities. In the report, a review and reconsideration of the earlier predictions of tailings deposition was presented and new predictions were made. Without explanation or reasoned justification for the revisions of earlier predictions, these new predictions indicated that tailings would pass through the Kawerong and upper Jaba rivers to deposit at sea and the flood plain adjacent the coast. The portion reaching the sea was predicted to be removed by ocean currents" (Applied Geology Associates Ltd. 1989 p37). (Authors' underlining.)

What this indicates is the BCL did not simply make an error in predicting rainfall levels and water flow rates. It appears that BCL was fully aware of the environmental damage that it was about to cause and that even with fuller data the company would still have opted for a method of waste disposal that minimised its cost of production. What is perhaps even more interesting is that the two reports used by the government and the company as the basis for the tailings disposal agreement have disappeared:

> "There are two possibly different reports on this subject (effects of tailings disposal) referred to in the DOTA (Disposal of Overburden and Tailings Agreement) which neither the government nor the company can, now locate and it is accordingly now not possible to compare the accepted proposal for tailings disposal with operational results" (Applied Geology Associates Ltd., 1989, p 37).

What is evident is that BCL was acutely aware of the fact that its proposed tailings disposal system would have massive environmental impact. It is not clear whether the colonial administration was equally aware of what was about to be done since the original BCL study was an internal document. However it is difficult to imagine that Port Moresby was not aware at least unofficially and the colonial administrators were apparently sufficiently concerned to place a clear limit on the length of time that the company would be permitted to dispose of tailings into the river system. The ten year cut off period prescribed in the DOTA was allowed to continue by the independent state of PNG and tailings disposal into the Kawerong and Jaba only ceased in May of 1989 when fighting around Panguna forced the closure of the mine.

Environmental consequences of tailings disposal:

The tailings deposition in the Jaba river is such that the river now flows some 30m above its original height. In order to stop the river from flooding outside its tailing lease area the company has been forced to build high levees. However, as the head grades diminish at the mine it is necessary for the company to increase production so as to maintain profitability. It was estimated before mine closure that throughput would have to increase to some 142,000 tonnes per day by 1989 for the mine to remain profitable. This is up from some 80,000 tonnes per day in 1987. Needless to say this massive increase in the extraction of low head grade copper ore would have resulted in a substantial increase in tailings disposal in the Kawerong-Jaba. As a result of this increase, BCL announced in 1988 its intention to build a tailings pipeline to the coast. The $US80 million pipeline would be built by Bechtel and Mimenco which is a subsidiary of BCL's parent, CRA. The move was reported widely in the PNG press:

> "BCL Managing director Mr Bob Cornelius said the company decided to pipe the waste direct to the sea because deposits in the river were rising and could not be controlled in the company's boundary lease area.....

> Mr Cornelius said the waste would be 'well and truly nuetralised' and would not damage the marine life or disturb the people's life style. He explained that the copper concentrate was treated with lime during the floatation process, making the waste harmless. Before mining began, the company had wanted to build a pipeline to carry waste to the sea but suitable technology was not then available.
>
> Mr Cornellius said that when the pipeline was completed the heavily polluted Jaba River would 'substantially clear' within a short time" (Post Courier, 1989).

To say the least the public position of BCL falls far short of what is known; to suggest that tailings treated with lime are harmless either to the environment or to people is simply false. Moreover the Jaba River will not 'substantially clear' as a result of the development of the pipeline to the coast. The environmental report on the operations at Bougainville makes it quite clear that the impact of tailings disposal will be felt for many years to come and while scientists are not specific it is believed that:

> "The water and fish resources of the Kawerong River and the Jaba Rivers have been lost for several generations. The unstable flow of water, high sediment loads and unacceptable water chemistry deter fish from migrating to the upper Jaba system" (Applied Geology Associates Ltd., 1989 p 85).

It is evident that BCL management knew perfectly well that the river system will not clear for a long time to come (Applied Geology Associates Ltd. 1989, p 85). It was also known by the company that even when the pipeline is established they will continue to dump tailings into the river system since provision exists to allow the company to dump tailings in the river system, for up to 21 days per year while the pipeline is being serviced.

LAND ALIENATION AND COMPENSATION

BCL has some 22 leases with landowners on Bougainville; of these the special mining lease and the tailings lease areas have suffered virtually irretrievable land degradation. The special mining lease covers some 3,770 hectares of land and includes the mine and processing area as well as the township of Panguna. At present the actual mine pit covers some 400 hectares which is land that has been effectively destroyed. The size of the mine pit will grow to some 550 hectares in fifteen years, and at the end of the mine life BCL plans to convert this into a lake stocked with fish.

By far the largest area of land degradation is in the tailings lease area which covers some 9030 hectares, of this 3,000 hectares are currently occupied by tailings. A tailings delta covers a further 900 hectares in Princess Augusta Bay. BCL has undertaken a revegetation program on the tailings and while it is not possible to state categorically that the tailings area is of no economic value, there is certainly evidence that the Jaba river and surroundings are unlikely to be usable for agricultural production for several generations.

Thus to the extent that the current conflict between landowners, the state and the company is over land and its loss, then the conflict can be seen to result, to a very large degree from the method of tailings disposal into the Jaba and Kawerong rivers.

Landowners present demands:

The entire thrust of the present Landowners Association demands for massive compensation is based on the environmental costs and land loss associated with the mine. It could be argued that the military confrontation would have occurred even if a tailings dam had been constructed, since the proposed site would have resulted in extensive land loss in the area just North of the Jaba river. The direct impact upon agriculture might have had greater, immediate, social and economic impact on the dwellers and users of land in the vicinity of the Jaba valley.

While a tailings dam may not have been sufficient to deal with the vast bulk of environmental degradation a pipeline to the coast at the beginning of the project would certainly have ameliorated the situation considerably. Without doubt that the choice of the economically least cost solution to tailings disposal has exacerbated the current problems on Bougainville.

The claims of Ona's group for massive compensation have been based on land loss, environmental degradation and alleged health effects of mining. It must be pointed out that while the militants have demanded compensation they have also simultaneously demanded the closure of the mine. These are initial demands and while the demand to shut the mine has been made the militants have also demanded that the mine pay half of all future profits to the landowners. This apparent contradiction reflects what we suspect is a divergence of opinion within the landowner group themselves. While a substantial group of landowners are willing to live with the mine there is also a group that have never come to terms with BCL and hence the apparent contradiction in the demands.

There are numerous forms of compensation currently paid by the company to landowners. On average, landowners received approximately K1.5 million per year between 1980 and 1985. From 1969 to 1974 compensation was on average K0.4 million per year. These figures include the payments into the Road Mine Tailing Lease Trust.

It was estimated that in 1988 landowners received K539 *per capita*. On a per hectare basis, landowners were paid on average K50 per hectare. It has been estimated that on Bougainville one hectare of land under cocoa would generate K300 per year in family income. Thus it is evident that the level of compensation is quite low and that the demands of landowners are in some respects justifiable. It is hardly surprising that the present violent reaction to BCL should occur so late in the life of the mine. The intention of the company is to close in the year 2001 and landowners reason that the level of compensation received to date is insufficient for saving for the post mine era. Thus they will by the year 2001 be left with land that is virtually unusable and have generated no alternative renewable source of income. The company has destroyed the environment while not compensating landowners at a level and in a manner that will allow them to maintain a reasonable level of subsistence in the post-mine era. Thus a renewable flow of subsistence income has been replaced by a temporary but higher level of non-renewable income flows. It is this situation that has been the essential cause of the conflict at Panguna.

It must be pointed out that figures for compensation do not include royalty payments which accrue to the landowners in the mining lease area. Thus for some 511 landowners there has been extra flow of K2.25 million over the life of the mine. These payments are given to titleholders who do not necessarily represent all land users, and those who have rights to land use but are not titleholders have received no compensation. In theory the financial benefits from the mine should be distributed among all those in the area. In practice certain key landowners in the special mining lease area have become quite wealthy, with bankers in Arawa reporting that some have six figure interest bearing deposits. Thus while we have a system of compensation that has given small average payments there is also evidence that it has been distributed unevenly.

The distribution of compensation is complicated by the fact that since the signing of the original agreement there has been a substantial increase in population in the mine impact area. It has been estimated that the population has doubled in the seventeen years since the commencement of operations at the mine, and this has meant that payments of a fixed sum must be distributed between an ever increasing number of land users.

Partly in response to the system of compensation payments that created large, short-term income and large inequalities, a new system was devised in 1980 whereby compensation payments for social inconvenience were to be paid into a trust fund and earnings from that trust fund were to be distributed. The Road Mining Tailings Lease Trust (RMTL) rather belatedly recognised the need for a more rational method of calculation, distribution and investment of compensation. Unfortunately control of the RMTL has been the subject of much heated controversy in the last few years as the young generation of landowners represented by Francis Ona have alleged that the older generation which controlled the trust have also abused the funds. Indeed there has been evidence that funds have been loaned out to individual landowners and there was for some time little systematic attempt at bad debt recovery.

While in principle the RMTL is the way of the future for the landowners the very system itself has come under attack from landowners because it has done precisely what it was intended to do, namely to keep money out of the hands of landowners. Ona's group has persistently complained that the RMTL has kept money out of their hands just as the population of the area is increasing rapidly.

CONCLUSION

The declaration of a state of emergency on Bougainville; the dispatching of 2,000 troops by the national government to the area; and, the closure of the Panguna mine are without doubt the most momentous events in the post-independence history of PNG. What is certain to follow is a more intense period of civil unrest and guerilla warfare in the jungles around Panguna. The causes of the conflict are essentially environmental. The landowners want either a more adequate method and level of compensation for their losses or a complete shut-down of the mine [6]. These demands have been compounded by a new series of demands for secession of the North Solomons Province from the rest of Papua New Guinea.

We have argued that at least a good portion of the blame for the current conflict rests with BCL which at the very outset knowingly took the least cost option for the disposal of tailings while it was aware of the environmental consequences of its options. The choice made by the company was fairly simple given the relatively low cost of land compensation in the area. The level of land compensation at K50 per hectare is well below what could be considered to be the opportunity cost.

The company could have used the option of the construction of a tailings dam. While this certainly would have occupied land it would have been unlikely to have occupied as much land as the present scheme. Perhaps of equal importance is the fact that had the company opted for a tailings dam it is quite possible that technological changes and increasing copper prices may have made it possible at some future time to recycle the tailings as is currently the practice among copper companies in other countries where less environmentally destructive methods of waste disposal have been practiced.

The traditional position of the Department of Minerals and Energy in PNG towards the construction of tailings dams, especially in the case of the Bougainville, Porgera and Ok Tedi mines is that the country is too seismically active to construct a dam that will be stable over geological time. While there is no empirical evidence to suggest that they are incorrect there is every reason to believe that extraction technology will render it unnecessary to leave tailings in a dam over a geologically significant period of time. It is quite possible that the tailings will be recycled and returned to the environment. In the face of uncertainly and the high environmental and social costs such as those increased by the current military confrontation in Bougainville this

[6] At the time of going to press the mine remains closed and the likelihood of it ever re-opening is quite low, Editor.

would appear to be the most prudent future course of action. Prudence as it pertains to environmental matters has been at a premium in PNG.

While it may appear to be science fiction at this stage to think of extracting copper profitably from such a low grade tailings deposit it is not inconceivable that a situation will eventuate in the near future when this would be possible. In this regard it is worth pointing out that as a rule of thumb no copper mine would have been developed at the end of World War II unless the ore grades were approximately 10 %. Thus the Bougainville mine with its 0.48 % ore was itself science fiction, from the vantage point of 1945.

BCL is currently experimenting with the possibility of leaching its rock dump which is estimated to contain 800,000 tonnes. This is only possible because the rock dump is located in one small area and hence the spatial economics make it possible. The recycling of tailings from the Kawerong and Jaba valleys is virtually inconceivable given the very wide dispersion, which would not have occurred if they had been confined in a tailings dam.

The PNG Department of Minerals and Energy has throughout the entire post-colonial era consistently supported mine developers who have not wished to construct tailings retention dams. In effect PNG is creating a double problem; by pursuing such a policy it has not only created environmental degradation it has also flushed what may be valuable future foreign exchange down the nation's river systems. This policy results from undue emphasis being placed on maximising current earnings for the government, and yet it is this very emphasis on short-term revenue that has led to a state of warfare on Bougainville.

Whether in fact a tailings dam would have been the solution is debatable in the case of Bougainville but certainly if tailings had been piped to Princess Augusta Bay as is currently planned then the vast bulk of present environmental degradation would not have occurred. It would be fair to conclude that BCL had in fact costed the pipeline proposal in 1970 and rejected it not because the technology did not then exist but because it would have raised the cost of the project by $A100 million. Given the very low cost of land compensation the choice of the existing solution to its waste disposal problem was rational, at least from the perspective of BCL.

To suggest however that the Bougainville crisis is simply about tailings disposal would be misleading in the extreme. The conflict arises because of inadequate compensation for land loss. The state has undertaken a policy of giving landowners lump sum compensation for the loss of land. It was only in 1980 that for the first time it was recognised that the flow and distribution of compensation was inadequate given the mine life. The RTML Trust was a first step in attempting to compensate for a perpetual loss of income by creating a trust fund.

The national government of Prime Minister Rabbie Namaliu has offered landowners in the mine impact area a quadrupling of royalty payments which would be given not in cash but in expenditures on social development as well as the establishment of a fund which would pay compensation to future generations. The national government has also offered landowners a share of the national government's stake in the mine. The entire cost of these proposals has come from the national government's coffers. BCL has steadfastly maintained its position that this matter of royalty increase as well as equity participation is a matter for Papua New Guineans to settle from their own coffers. This view has been consistently supported by the PNG Departments of Minerals and Energy, and Finance and Planning which have attempted to maintain stability in the benefit mix, since independence.

What is particularly tragic about the events on Bougainville is that they coincide with the time that the government must make a decision on whether a tailings dam will be built at Ok Tedi, the nation's other copper mine in the Star mountains of Western Province. Since the signing of the Sixth Supplemental Agreement between the PNG Government and OTML in 1986 Ok Tedi has been disposing of copper tailings into the Ok Tedi and Fly River systems. For simple economic reasons the government allowed the company to delay the construction of a tailings dam so as to enable the company to earn a profit which it has not yet done. With the Bougainville copper mine closed resulting in a 40 % decrease in exports it is highly unlikely that any

government in PNG would be able to make a reasoned decision on such a matter because it would be impossible to risk the closure of the country's other main source of foreign exchange [7]. Thus the government of PNG is caught again in an economic quandry where it must decide whether to close the Ok Tedi mine and have the economy grind to an almost immediate halt or create another potentially disastrous environmental and social situation. In the light of previous experience and current economic pressures there seems little room for optimism concerning environmentally sound decision making.

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[7] In late 1989 the Government decided to permit continued disposal of tailings from the Ok Tedi mine into the Ok Tedi-Fly River system despite advice concerning the adverse environmental effects. They were forced into this position as a consequence of the continued closure of the BCL mine resulting in severe economic pressure as predicted by the author. Already there are indications of local disquiet in the area of the lower Fly where no revenue accrues from mine operation but where the population is dependent on the riverine fish resources both for subsistence purposes and for cash income. Editor.

THE ECONOMICS OF ENVIRONMENTAL PROTECTION

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ABSTRACT

Consideration of the economics of environmental management and protection involves a closer integration of the disciplines of economics and environmental science than currently exists. Such a closer relationship necessitates the development of databases and models which permit a realistic and appropriate analysis of the costs and benefits of different approaches to controlling and limiting environmental degradation. It is suggested that a regional databank and modelling capability should be developed as a basis for the development of standards and methodologies in the field of environmental management and protection, if the long-term objectives of sustainable development in the region are to be achieved.

INTRODUCTION

Any analysis of environmental phenomena depends on the perception of what is understood by the term environment and its use by at least two groups of people, natural scientists and social scientists. The first group is concerned with the physical and/or biological aspects of the environment including its degradation, while the second is concerned with the analysis of social and economic behaviour that could guide the future use of the environment and its resources.

From an economic point of view, the physical environment may be considered in one sense as a factor of production, a source of goods and services and in another as goods itself, generating services and satisfaction simply by being there. As a factor in production the environment is located both at the starting and end points of traditional economic processes such as production, distribution and consumption since it serves as a the basic source of resources while at the same time serving as the final recipient of the products derived from economic development activities.

Thus the mere process of human settlement and the development of communities requires the exploitation of natural resources by man, for the purpose of generating goods and services that meet the varied and increasing needs of population. Therefore development puts pressure on the environment through direct and indirect involvement of the environment in the process of development and resulting in differing degrees of effect, from a minimal level at which the capacity of the environment for replenishment is unaltered to the point where resources are exhausted and the surrounding environment is degraded.

In addition the processes of urbanisation and industrialisation involve the use of the environment as a waste reception facility, often at a level beyond its capacity to absorb and resist the influences of such foreign influences on its dynamic balance. Such discharging beyond the absorptive capacity and the natural process of assimilation can result in environmental degradation to the point that the environment is no longer able to function as a production factor, having arrived at or exceeded its limit of capacity.

Finally as "goods" itself the environment may be degraded through the impact of development projects which alter its natural state, producing negative effects such as altering the natural beauty of the landscape or reducing atmospheric protection from harmful radiation.

Within this context, each additional human activity that uses or affects the environment necessitates a re-evaluation of the state of the environment and it should be noted that the scale of human impacts increases daily resulting in the need for more radical and dramatic solutions to be found for environmental problems. The perception of the need for environmental protection emerges from a recognition of the fact that pressures on the environmental are in danger of rendering the environment non-sustainable and the implication the man's intervention are the main source of this degradation despite the existence of natural phenomena that affects its state and that constitute part of its dynamic nature.

The exhaustion and depletion of resources and increases in contamination and pollution of the environment serve as fundamental arguments in favour of environmental protection measures and policies of restraint or no increase in environmental degradation even though it is recognised that such policies can only mitigate against the impacts rather than solve the problem. Mitigation measures will not in fact directly address existing problems of pollution and resource depletion even though they may limit future pressure on the environment they will do nothing to diminish or to stop existing problems. On the other hand limiting the increase in existing rates of resource depletion and pollution involves high investment costs which may lead to unprofitability and low financial returns on existing investments in physical and human capital; eliminate or reduce the stimulus for technological change through invention and discovery of substitutes; and may in particular reduce opportunities for improving the well being of the community through restriction of the quality and quantity of available goods and services.

Since the use of resources cannot be avoided it is imperative that such use must be rational, and must ensure protection and conservation of biological diversity. The attitude that no restriction should be applied to impacts on the resources and environment results in the *a posteriori* need to adopt a policy of environmental restoration having greater costs than the relative cost of initial prevention. Such an approach also involves the loss of opportunities for providing other goods and services at that time or the restoration and must be undertaken without prior knowledge of whether the degradation will be reversible by future generations.

From a social perspective the concept of the environment relates to the quality of life of the population and the consequent need to reach a minimum level of well being in order to achieve an adequate threshold of satisfaction beyond merely meeting the basic needs for survival. Such objectives extend beyond the objectives of conservation as they relate to the physical or biological environment and to pollution control, and include issues such as the distribution of wealth and income as well as security and personal survival. At this social or socio-cultural level the environment encompasses human inter-relations, the relationship of man to society and society's view of environmental problems which is itself conditioned by the subjective perception each individual has of the environment.

Therefore in attempting discussing the economics of environmental management it is important to point out the following:

1. It is necessary to recognise and accept the need for environmental conservation to be compatible with issues raised by the development process in contributing to the quality of life of the population. It is necessary therefore to reconcile the technical aspects related to conservation with the economic and social aspects related to development.

2 The scientific mission, for both natural and social scientists is to analyse such problems from a technical viewpoint both from the perspectives of their own disciplines and through integration in inter-disciplinary groups to provide the greatest possible number of alternative solutions.

3) Whoever takes the decisions in environmental matters, usually politicians must choose the most suitable from among several options, taking into account other types of variable and information that are not considered by the above specialists.

In the following sections the economics of environmental protection are discussed and some suggestions made concerning regional considerations in the field of the economics of environmental management.

NOTIONS ABOUT THE ECONOMICS OF ENVIRONMENTAL PROTECTION

In general environmental problems can be described in terms of economic alternatives and to characterise the environment as economic "goods" implies that its capacity for providing services is limited, and that at the same time the requirement for these goods depends on a fixed demand. This scarcity determines the framework which must be defined for its use. The environmental demands of different uses and activities means that a value must be assigned which all the effects that a specific use involves, both in the short and long term.

In the first instance when demands on the environment are in terms of its use as a productive resource, costs involve the economic costs of using the resource on a short and long term basis. These costs include the direct costs of exploitation and the indirect costs to the ecological systems in which the exploitation occurs, and on which ultimately depends the well being of the people whose lives depend on those resources.

In the second place when demands on the environment involve its use as a receiving site for the dumping of wastes the economic cost of such use should be related to a value placed on the total environmental capacity in terms of its sustainable use and limited capacity for absorption of wastes. Since such use again affects the well being of the persons living in the environment that has been altered by this use the price should also include a policy premium for the future generations.

In the third instance when the environment itself takes the form of "goods" the value that is assigned to its depends on social economic and cultural factors which affect the demands and use, and vary between different countries and regions and reflect amongst others factors such as education, values, judgement, and stage of development of the country concerned.

Economics provides an analytical framework that permits us on the one hand to consider the costs and benefits associated with each alternative form of environmental protection and on the other to contribute to developing an overall environmental management policy that has as its basis the application of properly evaluated solutions.

In order to analyse the costs and benefits of each alternative form of environmental protection, a knowledge and understanding of the basic elements of a well balanced economy are required. This branch of economics is concerned with determining the conditions that are required: to attain the greatest possible level of social well being; to establish the conditions necessary to achieve maximum economic efficiency in terms of greatest production with a given quantity of resources; to achieve certain economic goals considered desirable from a social viewpoint; and finally attempts to define criteria that are useful in deciding whether the proposed policy actually represents an improvement in the well being of society as a whole.

In considering the implementation of an action, regardless of whether it is a particular activity, a project, a programme or more generally a policy, the analysis must include the social benefits and the social costs and the potential effect of this action on the well being of society over time. A decision in favour of executing the action should be taken only if society benefits from the action, and the concept of social cost includes the cost of opportunities or social values sacrificed when assigning resources for this action in place of another. In other words the analysis should answer the question of whether society would benefit more from implementing the action than from not undertaking it and not merely consider alternative actions and which is better in terms of social improvements.

Within the social cost benefit analysis not only should those values that are directly related to the benefits and cost of the action be included but it is also necessary to take into account the external effects that result from the action, since these will also affect the well being of society. External influences are the consequences of the actions of economic agents affecting third parties which are not taken into consideration in the decisions of the agent initiating the action. In particular external costs that are generated by the productive activity or in the consumption, degradation or pollution of the environment are not included in the calculations or decisions of the agent of production. It is important in this regard to state that the cost term in the analysis must include all the generated adverse effects and this requires precise determination of what are really adverse effects and by thus to attempt a valuation of the environmental degradation in physical and if possible damage function terms.

The reasons for the existence of the external component of the analysis are based on the fact that the major part of the services provided by the environment are not included under property rights (the right of property is what allows an individual to enjoy the use of goods without paying compensation to an owner) implying the non-existence of a value for this use. As a consequence such uses of the environment do not form part of the market economy and are not subject to normal market forces. On the other hand, the environment as a resource is in general considered as public goods, and pollution is thus public damage, such that market prices do not reflect agents preferential and inappropriate use of the environment.

For these reasons market prices do not reflect external effects and existing non-incentives for the contaminating agency to take into account the environmental damage. This results in an imbalance developing between payments and costs resulting in private production costs being lower than public costs. To solve this failure of the market system of economics Government intervention through norms and regulations is necessary so that values are properly assigned to the environment. It is important to appreciate the planning role required of Government in this regard and to acknowledge that it is not possible to do or make everything due to a lack of resources.

As already stated a primary prerequisite is to incorporate external influences into the market economy and wait to determine whether the market prices truly reflect the property rights of the affected resource. If this is individual property in terms of use but belongs to everyone when it must be cared for or maintained, then the resulting appropriation of benefits and socialisation of costs could lead to a disaster for conservation, since there is no incentive for the agent to take into account long-term environmental damage. Although the inclusion of the costs of environmental damage in the market economy is a simple task some uses of the environment are not amenable to such valuation, what is paid in order to conserve or protect a natural reserve for example would not reflect the true value of the reserve.

To achieve an adequate evaluation of the costs and benefits of alternative proposed measures for protection, to assess their feasibility and to comply effectively with them in the near future requires information concerning the causes and effects of environmental damage, and alternative solutions. Suggestions for measures and policies to eliminate the discharges; for general price control, taxes or subsidies; and for setting quantities of discharges or emission quotas, will vary in each case. It must be recognised that there is no benefit if regulations are not complied with, one may have beautiful standards but no results at all, a situation which happens regularly when there are difficulties in meeting agreed standards.

On the basis of this discussion it may be concluded that society has gone a long way in terms of identifying possible solutions but that it is necessary to balance as fully as possible the costs and benefits.

REFLECTIONS AND SUGGESTIONS CONCERNING THE ECONOMICS OF ENVIRONMENTAL MANAGEMENT IN THE SOUTH EAST PACIFIC

In the first section we have attempted to give a brief overview of the broad concepts involved in a consideration of environmental issues. In this and the following sections some ideas are presented and suggestions for action in analysing the environmental problems of the Southeast Pacific Region.

The first reflection concerns the concept of sustainable development, in which the objectives of economic equity and conservation are integrated and co-dependent such that neither can be achieved without simultaneous advances and integration with the other. Within this concept science and technology must be adapted to the human needs. In other words arguments about the supposed incompatibility between the economic development and the environment, resulting in the need for policies of restraining economic growth are framed within a traditionalist concept of growth, and fail to consider the differences in economic and social environments between the countries. In contrast to the theoretical concept of sustainable development, conservation and economic growth are traditionally treated as individual entities which are analysed on the basis of the elements that differentiate them. It is not enough that investment projects are technically feasible and economically convenient, it is necessary that they result in socially acceptable changes and contribute to an improvement in social well being.

Even if each country is prepared to face the challenge of effective preservation of the environment and to reconcile conservation with development it will only be achieved when effective implementation of the environmental/economic plan for the region is undertaken by concerned institutions and organisations that can play a defined and fundamental role in the study, analysis and definition of environmental standards. This requires at national level the establishment of priorities, identification of resources and the power to adopt policies and strategies as well as the chart the course for specific actions that are to be developed.

Recognition of the need for the protection of the marine environment and coastal zone by the government of the region has been demonstrated by the adoption of several regional co-operative agreements within the framework of the Southeast Pacific Action Plan adopted in 1981. Components of the Action Plan include environmental evaluation, environmental management, legal, institutional and financial components and support measures. Despite consideration of those aspects of economics concerned with evaluating the feasibility of proposed technical solutions to environmental problems there is a further need to incorporate the study and analysis of economic elements and to establish linkages between appropriate technical, economic, and legal institutions.

Within the field of these regional agreements it has been recognised that there are certain kinds of environmental degradation such as pollution of the regional sea and the global problem of climatic change which it is important to examine on a regional and global basis if uniform standards are to be established and adopted. In contrast, the economic costs associated with reaching a pre-determined level of water quality reflect the particular conditions of each country including for example the level of development, the structure of society, the technological capabilities, the location of industrial activity, topography and climate, the location of human settlements and many other factors particular to each country or location. Such issues imply the need for particular consideration and care at national level of the interaction between development and environment and the achievement of sustainable development.

The inclusion of economic considerations and analyses in the evaluation of different solutions for environmental protection is fundamental, the prerequisite for which is the possession of the maximum possible volume of information, and which requires the formulation of explicit and defined policies. This information should in general include on the one hand information on the causes and effects of the environmental damage and on the other data on the alternative solutions, and their associated costs.

From this it can be seen that there is a need both at a regional and national levels to design a system of environmental statistics that includes both scientific and economic data and information. Regarding the field of the environment economics, the system should include information on stocks, flows, values and effects attributed to natural resources. From both the scientific and socio-economic points of view the advantages of having such a databank include:

a) It would allow the practical development of explanatory models of economic and environmental inter-relations as well as their perfection and theoretical improvement.

b) It would provide general and objective support to the economics of environmental management in the region and in particular it would support the design of policy instruments through:

- contributing to answering questions concerning the current state of the environmental in the region and development of projections based on the current status and levels of contamination, existing controls and costs in corresponding geographic areas;

- permitting realistic analysis of the suitability, at different stages, of political measures that might be adopted in defined circumstances such as projections of when pollution must be reduced; the cost of this reduction for the government, for producers and consumers; the impacts on production levels, employment; and consequences for private and public expenditure; and

-it would facilitate the comparison and correlation of major environmental trends between the countries of the region as well as providing the basis for establishing standards that are required for inter-regional co-operation.

This set of complementary statistics could be related to the national product expanding the qualitative and quantitative view of the national system, and providing a scenario of regional validity. It is well known that the magnitude of the National Product is an indicator of the level of growth in the economy however it is neither an indicator of social equity, nor of conservation since it incorporates only changes in the level of production of goods and services achieved by the economy within a defined period. The measurement of the national product is made on the basis of market prices, which do not include external effects as discussed above. More precisely this measure only values what is sold so that services that are provided *gratis* appear in the cost valuation and not as a positive valuation in the sale of goods. Even if it is valued, the gas used by congested traffic for example, or the payments for medical services to look after patients with bronchitis resulting from high smog pollution, the index fails to include the cost of the congestion or environmental degradation.

Despite the limitations of statistics of national product as reliable indicators on which to base environmental policy they nevertheless provide information which cannot be ignored. In addition the multiplicity of environmental effects does not permit the definition of a single, global indicator of environmental quality.

The design and technical specifications for such a system require the interaction of different disciplines that provide a comprehensive overview of environmental science and as such represents a open field for research. Consequently it is necessary to evaluate what characters should be measured, and what empirical advances and existing programmes are available to provide basic scientific information, what are the deficiencies in the scientific and economic fields, such as the absence of good correlates between scientific measures and production costs, that are needed to develop deterministic modelling and in particular stochastic models.

Examining the economics of environmental management through such a statistically based system as that outlined above requires a database of technical issues related to the processes of self-reliance and of pollution. A basic requirement for such a system is a regional inventory of the state of the environment including both physical and social aspects that enables us to examine the causes of environmental degradation against the natural, dynamic background, hence all environmental phenomena in the pertinent geographic area need to be included.

In order to reach a predictive capability regarding future sources of contamination it is necessary to assemble information about the possible future development of industry, including advances in science and technology and the rates of technology transfer, and about the behaviour and structure of human settlement in the region. The reliability of projections for certain time horizons, based on such information, is dependent on the reliability of the estimation methods used in building scenarios and risk analyses.

Evaluation of environmental impact

Environmental impact assessment is a necessary requirement for future developments in marine and coastal activities in the region that could have significant environmental effects. Such assessments should include consideration of the dynamic, natural absorptive capacity of the environment as well as the net resultant effects. It is probably still the case that not enough is known about species life cycles, the functioning of different ecosystems and the influence of human activities on them. Furthermore it is recognised that as a consequence of the cumulative nature of many environmental phenomena there exists a time lag between the time of production of a pollutant and the time at which its resultant impact is noticed. Similar time lags occur in the case of economic and environmental interactions; in the relationships between scientific models and their effects in the fields of economics; or in the time between developing technological advances for treating wastes and their implementation. The proposed system should be designed to identify such time dependent processes and where possible minimise delays in the transfer of information from one discipline to another.

Monitoring and Surveillance networks

To implement environmental management a surveillance or monitoring network is necessary to detect and predict the changes that are occurring in the environment, both negative and positive, natural and man-induced. Such a network should provide advance warning of problems and hence permit the avoidance or mitigation of negative impacts and allow advantage to be taken of positive environmental changes. Complete evaluation of the changes should include basic information about the environment itself, about the technology that could be used for pollution control and its associated costs; and evaluation of the effectiveness of control measures adopted for similar activities elsewhere. The evaluation of environmental impacts with a methodological focus has already been established in the region and such studies should provide the basic data needed for integration into the economic and environmental information system, thus constituting a basis for the explicit management required under regional agreements.

It should be noted that even where the availability of technical information is limited this does not imply that nothing should be done in the field of economic-environmental management. Often it may be deduced that long term changes to certain ecological processes although inadequately documented, necessitate taking decisions on the basis of existing information. Rather than waiting for an improvement in the basis database or conclusive proof that resources are being slowly depleted or that environmental damage is becoming irreversible, decisions should be made as promptly as possible. In this sense the environmental monitoring procedures that are adopted must be sufficiently flexible to allow expansion of the knowledge base concerning ecological interactions and residue impacts and hence provide a better basis for the elaboration and proposal of concrete political measures to reduce the problems of pollution to a level considered optimum or acceptable.

Policies for environmental protection

In any consideration of the development and adoption of environmental protection policies it is important to examine, discuss and propose methodologies that adequately encompass the need for an integration of local efforts with global and international developments concerning decision

making in the field of the economics of environmental protection; and, efforts that facilitate an appreciation of the advantages and disadvantages associated with alternative solutions.

Regarding the first point there exists an extensive international literature concerning: the economic processes of production, consumption, investment and growth; the waste products associated with different production systems; alternative technological treatment of residues; the process of environmental assimilation; ecological processes; cost benefit analyses of environmental management; and the political and institutional structures needed to develop and implement environmental protection measures. Evaluation of environmental impacts of development constitute a fundamental part of the methodological process.

In regard to the second point it is important to understand the nature of the relationship between economics and the environment since the selection of one of two measures or policies or concrete actions will be related to how well each alternative has been defined. For example, a policy of regulation of the quantity of residues through emission controls or a permit system might be selected in preference to a policy of price adjustment or *vice versa* depending on the form of the cost functions and resulting damage which is dependent on the way in which the damage and control costs change with respect to the level of pollution. These relationships are unlikely to be linear hence alternative one may be preferred under low levels of emission, alternative two under conditions of high emission.

In addition it is important to understand from an economic viewpoint the reasons why concrete policies applied in other countries or regions have succeeded or failed, in order to appreciate whether such policies could be successfully applied within the framework of market incentives that currently exists within the economies of the region.

For the purpose of obtaining a clearer and wider understanding of the possible strategies, actions or methodological approaches which might be appropriate to different situations, it is necessary to develop technical, inter-disciplinary scenarios that enable one to develop an economic appreciation of environmental management methodologies.

At a wider level the protection of the environment is a question of individual responsibility since the formation and capacity of the human resources is a determining factor in the use of natural resources and the environment, its conservation and destruction. In regard to this point environmental education plays a fundamental role in creating a comprehensive attitude towards environmental conservation and protection, and hence it is pertinent to suggest the inclusion of conservation in the curicula of elementary and middle level educational programmes.

CONCLUSIONS

Recognition of the existence of environmental problems is not a recent phenomenon, on the contrary such problems have been well known for many years. Neither is the desire to solve such problems a new development since there exists environmental legislation in many countries requiring specific action on the part of industrial enterprises and the community at large. What is new, is the wider awareness of environmental issues among agents of production both private and public, consumer groups, government agencies, and labour organisations. This wider recognition of the problems of environmental degradation has lead to recognition of the need for measures to limit such environmental damage among a wide cross section of the community.

To successfully implement environmental protection measures it is vital that a closer relationship between the disciplines of economics and environmental science is established in order that and integrated approach may lead to achieving sustainable development.

LEGAL ACTION FOR THE PROTECTION OF THE MARINE ENVIRONMENT AND COASTAL AREAS OF THE SOUTH-EAST PACIFIC

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Comision Permanente del Pacifico Sur, Colombia.

ABSTRACT

Existing regional and international agreements applicable to the protection and management of the marine and coastal environments of the South-East Pacific are outlined and proposed additions to this legal framework are discussed.

INTRODUCTION

The Permanent Commission of the South Pacific (CPPS) was established by an International agreement signed on August 18th 1952 by the Governments of Chile, Ecuador and Peru. Its legal status was further detailed in the "Convention on the International Legal Capacity of the Permanent South Pacific Commission, signed in Peru in 1966. The Government of Columbia subsequently joined the Commission in 1979.

The CPPS is an action oriented, maritime agency, with objectives directed towards:

a) the protection, conservation and utilisation of the marine resources within the 200 mile Exclusive Economic Zone; and,

b) the establishment of regulations covering the exploitation, exploration and management of living resources;

Of these two areas of concern to the CPPS and the governments of the region, the first involves a number of regional and international legal agreements and measures and is of most interest within the framework of inter-regional co-operation. The work of the CPPS in these fields is directed towards the protection and conservation of the marine environment; promotion of scientific research; promotion and transfer of technology related to the resources of the sea; education and training of scientific and technical personnel; exchange of scientific, technical and other experts; distribution of knowledge and information about marin science, and related activities; and, co-ordination of regional projects and programmes of marine research.

FRAMEWORK FOR ACTION

In the field of protection and conservation of the marine environment the member countries of the CPPS signed in 1981 a regional Convention and Action Plan for the protection of the marine environment and coastal areas of the South-East Pacific. The Action Plan was developed with the assistance of the United Nations Environment Programme (UNEP) and is designed to address a number of areas of direct concern to member governments.

Its articles cover evaluation of the state of the marine environment and coastal areas, including assessment of the environmental impact caused by marine and coastal or land based activities affecting the marine environment. The purpose of these activities is to advise the governments on how they might address the problems of marine environmental protection and to provide the basis for regional co-operation in this field.

Other articles cover the proper management of those activities that could affect the quality of the marine environment and coastal areas, measures to develop criteria that will allow determination of the economic impact of environmental degradation.

The CPPS is also charged with formulating legal instruments, both national and regional for the protection of the marine environment and coastal areas; with providing assistance to regional governments in the execution of their responsibilities under International Agreements as well as the implementation of legal measures to obtain compensation resulting from environmental damage.

The establishment of institutional, financial and supporting instruments to implement the action plan in a progressive and efficient manner, including the establishment of structures and mechanisms of regional and national co-ordination are also detailed in the Convention[1/].

The action plan for the implementation of the terms of the Convention is designed to contribute to the solution of the common environmental problems faced by signatory countries and to strengthen international and inter-regional co-operation within the framework of global programmes concerned with the study and monitoring of ocean pollution. Such activities involve collaboration with international organisations and adherence to the principles and institutions outlined in the United Nations Convention on the Law of the Sea.

NATURE OF THE ACTION PLAN

The Action Plan is executed by national institutions and co-ordinated regionally by the CPPS. The main sections and areas of activity are outlined below.

Environmental Evaluation

Evaluation of the state of the marine environment is a principal component of the Action Plan and provides support and justification to the execution of the other components of the plan through the provision of a sound scientific knowledge base.

The following activities are currently underway within the region.

An intensive programme of personal training for the evaluation of oil spill contamination; evaluation of domestic waste contamination and evaluation of marine pollution from thermal discharges.

Activities concerned with evaluating the scale of pollution from oil spills, industrial sources, mining and agricultural residues and their environmental effects; determination of the magnitude of contamination from domestic residues their effects and trends in production; and, evaluation of the magnitude of contamination of the marine environment from atmospheric sources.

Specific studies involve determining the magnitude of pollution in selected areas of ecological interest, in particular swamps, coastal lagoons and estuaries.

Environmental management

Major activities in the field of environmental management cover amongst others the revision, expansion and/or adoption of national, regional and international projects concerning

1/ Copies of the Convention and other regional legal agreements referred to in this paper may be obtained from either the CPPS or the Oceans and Coastal Areas programme Activity Centre (OCA/PAC) of the United Nations Environment Programme.

various aspects of environmental and resource management in co-operation with agencies such as UNEP, FAO and Unesco.

The formulation and application of programmes concerning the prevention, monitoring, reduction and control of pollution from oil spills and programmes for the prevention, monitoring, reduction and control of pollution from domestic, industrial and agricultural sources are currently in hand. Management plans for specially protected areas such as swamps and swampy areas are also being developed.

The CPPS actively co-operates with different governments and organisations in the prevention, reduction and control of pollution in port areas, and in providing assistance to governments in the establishment and strengthening of institutional structures and co-ordinating mechanisms for environmental management of the marine environment and coastal areas, and in strengthening the capabilities of personnel involved in environmental management activities.

Under the Action Plan the CPPS is also responsible for the periodic updating of the directory of institutions active in the region in matters related to environmental management and other components of the Action Plan. The Action Plan also calls for periodic review of the state of the environment which is undertaken by national authorities through the preparation of inventories including evaluation of the sources, levels and effects of pollution. On the basis of such activities the CPPS advises governments on possible adjustments to the Action Plan.

Legal component

The legal component of the Action Plan covers *inter alia*:

(a) Analysis of the legal implications for member countries of international agreements such as the UN Convention on the Law of the Sea as far as these relate to the Protection and Preservation of the marine environment.

(b) Maintenance of an updated register of National legislation of member countries, regarding the protection and preservation of the marine environment from all sources of pollution;

(c) Formulation and/or recommendations for modifications to existing National Legislation in order to achieve effective implementation of existing and future regional and international agreements.

It is recognised in the region that a number of International Agreements relating to the preservation of the marine environment and its protection against pollution are relevant to the implementation of the Action Plan. These include:

a) OILPOL, 1954 concerning the prevention of oil pollution;

b) MARPOL, 1973 and its protocol of 1978, concerning the prevention of marine pollution from vessels;

c) The international agreement related to Intervention in the case of oil spill accidents (Intervention, 1969)

d) The London Dumping Convention (LDC) 1972, concerning the dumping of wastes and other substances in the marine environment; and,

e) SOLAS, 1974 and its protocol of 1978, concerning the security of human life at sea;

The CPPS assists member Governments to implement their responsibilities under these International Agreements, and in this connection the CPPS is responsible as Secretariat for the

Regional Agreement on co-operation in combating pollution in the case of oil spill emergencies adopted in 1981 and its supplementary regional protocol on combating pollution adopted in 1983.

EXISTING PROTOCOLS ASSOCIATED WITH THE REGIONAL CONVENTION

In addition, two further protocols to the Regional Convention on the Protection of the Marine Environment and Coastal Areas of the South-East Pacific, have been developed following the principles contained in various international agreements, these are:

The Protection of the South-East Pacific against land based sources of pollution, which covers pollution from coastal outfalls, disposal or discharge; river discharges including canals, rivers and watercourses and any land based source situated within the territories of the contracting parties, regardless of whether the mechanism of discharge is via water, directly from the coast or through the atmosphere.

The Conservation and Management of Protected Marine and Coastal areas of the South-East Pacific under which contracting parties agree to adopt measures for the protection of fragile vulnerable or unique coastal ecosystems and to establish appropriate protected areas in the form of Parks, Reserves, Sanctuaries and other categories of protected area.

The first of these protocols was signed in Quito in 1983 and the second in Paipa, Columbia in 1989.

FUTURE PROTOCOLS TO THE REGIONAL CONVENTION

Regional Governments have recognised the need for additional agreements covering various matters related to the protection of the marine and coastal environment including amongst others:

a) radioactive waste disposal and dumping;

b) evaluation of environmental impacts;

c) contamination resulting from exploration and exploitation of the resources of the continental shelf;

d) responsibility and compensation for damage resulting from marine pollution;

e) scientific and technical co-operation in matters related to the protection of the marine environment;

Of these, the first two are currently under preparation.

<u>Radioactive waste disposal at sea, the London Dumping Convention and the proposed regional protocol</u>

Highly radioactive wastes as detailed in Annex 1 of the London Dumping Convention cannot be discharged by contracting parties; other radioactive wastes as detailed on the "grey list" may be dumped under special permit. There are divurgent opinions as to whether article 3 of the London Dumping Convention applies to dumping of radioactive wastes in and under the sea-bed. According to some interpretations such dumping is not prevented provided that the marine environment is not damaged, in contrast other interpretations suggest that such dumping is prohibited since it is encompassed within the definition of "dumping at sea".

The contracting parties to the LDC have approved a suspension of the dumping of radioactive substances at sea pending further investigations of the environmental implications of such actions. Opposition to the dumping of radioactive wastes at sea has been strengthened by the difficulties associated with controlling such dumping including inspection and surveillance in comparison with disposal sites on land.

Several regional Governments have emphasised that any regional agreement concerning such dumping in the South-East Pacific should be more strict than the London Dumping Convention in this regard. Accordingly the CPPS has drafted a protocol to the regional convention designed to prevent any form of disposal or dumping of all radioactive wastes within the geographic area covered by the Convention, regardless of the level of radioactivity, and regardless of whether such dumping or disposal involves sea-bed deposition or burial.

The regional protocol goes beyond the provisions of the London Dumping Convention which prohibits only dumping of highly radioactive wastes, and furthermore the regional protocol suggests the prohibition of sea-floor burial of such wastes. Such a provision within the regional agreement eliminates the kind of controversy surrounding the interpretation of the terms of the LDC concerning what is and what is not "dumping".

Under the proposed protocol the contracting parties agree to collaborate in surveillance monitoring, in collective action in the case of emergencies involving radioactive contamination of the marine environment and in the promulgation of national laws and regulations which conform to the terms of the regional protocol.

Draft protocol for evaluation of environmental impacts in the South-East Pacific

This draft protocol is designed to ensure that development projects and other activities which may have adverse effects on the marine and coastal environments of the region are subject to a proper environmental impact assessment prior to their implementation.

Under the proposed protocol the contracting parties will be obliged to: designate responsible national authorities; develop technical directorates responsible for planning development projects that minimise adverse environmental impacts; advise neighbouring countries of any potential impacts resulting from development activities; solicit the opinions of affected communities; and develop national legislation providing the nationally designated authority with administrative and legal authority to ensure compliance with environmental requirements.

Within the framework of their national legislation contracting parties would be obliged to develop criteria and procedures for the identification of potentially harmful activities; specially sensitive marine areas and vulnerable natural resources.

The draft protocol details the requirements for such an evaluation which should include: a detailed description of the planned activity and the affected area; identification and evaluation of the potential effects of the activity in the marine environment; a description of the possible alternative modes of development; measures to mitigate or reduce the identified impacts; and possible implications for neighbouring states.

CONCLUSIONS

In a number of areas the regional governments of the South-East Pacific have proved to be more forward looking than governments elsewhere and developments in the region have influenced the course of inter-national agreements such as the UN Convention of the Law of the Sea. UNCLOS adopted a 200 mile Exclusive Economic Zone following the precedent set by the Santiago Declaration signed by Ecuador, Chile and Peru in 1952 which set a 200 nautical mile limit in

order that those countries might provide adequate conservation and protection of their maritime resources.

At the present time the framework of regional agreements covering the protection and management of the marine and coastal areas of the South-East Pacific is extensive. Further expansion of these legal agreements is required however if the member states of the region are to adequately control existing and potential environmental problems.
The CPPS, as a well established legal entity having responsibility as Secretariat for a number of existing regional agreements will continue to assist the Governments of member countries in the further development of necessary measures for the protection and management of the marine and coastal environment of the region.

"THE COMMON HERITAGE OF MANKIND: TOWARDS ITS RATIONAL ADMINISTRATION FOR THE PROTECTION AND PRESERVATION OF THE MARINE ENVIRONMENT"

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ABSTRACT

This paper outlines some implications of the UN Convention on the Law of the Sea for the management of the Global Commons; the area of the world's oceans outside national jurisdiction. Experiences in the management and control of pollution of the marine environment are related to possible developments in terms of mineral exploration and exploitation in the sea-bed areas under international jurisdiction.

INTRODUCTION

This presentation is to some extent atypical of the others made to this symposium since it aims principally to present some reflections on new problems posed by the utilization of the sea and its resources, problems which may result in serious degradation of the marine environment, and consequently call for a thorough analysis.

This presentation is based on experiences gained by the Economic Commission for Latin America and the Caribbean (ECLAC) in the field of marine resource use, which is close to many of the main concerns and interests of Latin-American countries in terms of international negotiations relating to ocean affairs.

The subject under consideration is the potential menace of pollution from activities carried out in the sea-bed and ocean floor beyond national jurisdiction, considered as a common heritage of mankind (subsequently referred to as "the global commons"). The future of the resources in this area and consequently of the surrounding marine environment is currently being negotiated in the world forum via the Preparatory Commission of the International Sea-bed Authority.

These negotiations have resulted in similar concerns being expressed by developing countries which may need to increase their efforts through existing mechanisms such as the UNEP Action Plans in order to strengthen their negotiating capability for safeguarding the marine environment. Many studies have been carried out on the general aspects of pollution covered by the Convention, but there has been no assessment of risks which might result from activities in the global commons.

THE UNITED NATIONS CONVENTION ON THE LAW OF THE SEA

The signing of the United Nations Convention on the Law of the Sea in 1982 represented an innovative approach to the international management of the ocean and its resources. It presently bears 159 signatures and 37 ratifications, more than half of the total number required for it to enter into force. It deals with practically every aspect of the use of the sea and promotes a global focus on problems which are clearly interrelated.

The convention establishes the general principles and policies which govern the prevention, reduction and control of pollution throughout the marine environment, as well as the defining the specific rights and duties of States concerning the realization of environmental and ecological goals. The allocation of rights and the burden of responsibility varies according to the location

and/or type of pollution involved, and specific safeguard and enforcement provisions are included. The Convention is intended to be compatible with existing treaties in this field and to provide a broad framework for the conclusion of future, more specific agreements.

From the Preamble itself, the Convention gives a prominent place to the preservation and protection of the marine environment. In it the States which are party to the Convention place among the goals to be achieve, the goal of protecting and preserving the marine environment, as a mean to the realization of a just and equitable international economic order.

Part XII of the Convention, which deals specifically with the Protection and Preservation of the Marine Environment, establishes the obligation to protect and preserve the marine environment and details measures to prevent, reduce and control pollution; deals with global and regional co-operation in this area and considers different situations depending on the spatial area in which the pollution takes place.

In terms of international cooperation, the Convention is designed to foster mutual assistance both on a global and regional basis, and includes amongst other provisions, the need for notification of imminent or actual damage, contingency plans against pollution, studies, research programmes and exchange of information and data and scientific criteria for regulations.

The Convention calls upon states to co-operate in the promotion of studies, implementation of programmes of scientific research and encourages the exchange of information and data concerning pollution of the marine environment. An appeal is made to countries to actively participate in regional or global programmes designed to assess the nature and extent of pollution, exposure to it, and its pathways, risks and remedies.

THE INTERNATIONAL SEA-BED AUTHORITY

The object of this paper is to consider pollution which might arise from activities in the area of the global commons; that is, the sea-bed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction, considered common heritage of mankind. All rights in the resources of this area are vested in mankind as a whole, on whose behalf the International Sea-Bed Authority will act. The Authority is one of the entities to be established once the Convention enters into force, and will be the Organization through which the States which are party to the Convention shall organize and control activities in the Area, particularly with a view to administering its resources.

According to the Convention, international rules, regulations and procedures shall be established to prevent, reduce and control pollution of the marine environment resulting from activities in the area of the global commons. In turn, States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from activities in this area undertaken by vessels, installations, structures and other devices that fly their flag. The requirements shall be no less effective than the afore-mentioned regulations.

The Convention establishes that measures shall be taken in respect of activities in the area of the global commons to ensure effective protection for the marine environment from harmful effects which may arise from such activities. The Authority shall be responsible for adopting appropriate rules, regulations and procedures for the prevention, reduction and control of pollution and other hazards to the marine environment. These responsibilities cover pollution of the coastline, and interference with the ecological balance of the marine environment, particularly in relation to activities such as drilling, dredging, excavation, disposal of waste, construction and operation or maintenance of installations, pipelines and other devices. Such protection must extend to the prevention of damage to the flora and fauna of the marine environment, which is of utmost importance since these resources do not belong to the Common Heritage of Mankind.

In the light of this it is important to pay particular attention to present negotiations being conducted in the Preparatory Commission for the International Sea-Bed Authority and the International Tribunal for the Law of the Sea, which proposes draft regulations covering many aspects of concern in the Administration of the Common Heritage of mankind before the Convention enters into force. The Commission's proposals will be submitted to the Assembly of the Authority once this is established. It is beyond the scope of this paper to analyze the organization and functioning of the Preparatory Commission detail, however, there are two areas within its competence which are relevant for the joint work carried out by ECLAC and the UNEP Action Plan for the South-East Pacific.

The first of these relates to the so called "pioneer investors", which are states or entities which the Convention recognizes as having made certain investments before determined points in time in activities concerning the identification, discovery, and systematic analysis and evaluation of polymetallic nodules and in the evaluation of the technical and economic feasibility for their exploitation.

As mentioned before, the area of the global commons is considered as the common heritage of mankind and cannot be explored or exploited except under special arrangements with the future Authority once the Convention has entered into force. Since some countries have expressed concern that once the Convention enters into force important investments made in exploring this Area could be lost while waiting for eventual allocation of such sectors, a special resolution of the Third United Nations Conference on the Law of the Sea allows; under very special conditions and through different payments and undertakings; for those countries to continue the initial activities of exploration.

The second issue relates to submissions made by a number of experts to the Preparatory Commission, pointing out that pollution caused by mining of the sea-bed could be of considerable importance since, contrary to what happens on land, sea bed mining activities were not localized. They have also remarked that too little is known about the ecology of the ocean floor and the recovery rates of benthic flora and fauna following disturbance. In addition, there exists the risk of environmental contamination resulting from benthic sediments brought to the surface.

Another significant factor it that the technology employed in deep sea-bed mining is highly complex and its operation may involve certain environmental risks. Such potential risks and problems must be studied now despite the fact that effective solutions may only be found once operations have commenced, now is the moment to assess the potential environmental impacts of such activities.

Another important issue relates to the negotiation of draft regulations on prospecting, exploration and exploitation of polymetallic nodules in the area of the global commons, known as draft mining, which will be the framework governing activities in the international maritime zone. The incorporation of environmental considerations into the draft mining code seems indispensable, particularly in view of the fact that the code is meant to be autonomous and although being drafted within the framework of the Convention is to be applied independently and without permanent references UNCLOS. It is considered essential then, to develop a system of regulations concerning environmental protection for the area of the global commons which could be put forward by the Group of 77 to the Preparatory Commission.

RELEVANCE OF CURRENT REGIONAL ACTIVITIES

It seems especially important in the light of the above to consider relevant national experiences and the international assistance in this field, mainly provided through the United Nations Environment Programme. Since 1983, ECLAC and CPPS as the Regional Coordinating Unit for the UNEP South-East Pacific Action Plan, have promoted the study environmental impacts in the marine environment, national exchanges among different Latin American

countries, and have initiated a series of work-shops and seminars. Under the auspices of the CPPS and UNEP, these activities represent a valuable endeavour in strengthening the scientific capabilities of CPPS member countries.

As one related issue, UNEP was requested to provide technical support for the incorporation of the environmental dimension into the Workshop on the Mineral Resources of the Sea-bed: Technical, Legal and Environmental aspects of their exploration and exploitation, held in Cartagena de Indias in September 1987. Following recommendations arising from that Seminar, the CPPS and UNEP organized the First Meeting of the Groups of Cooperation in ocean mining in the South-East Pacific, in June 1989 to which ECLAC voiced similar concerns through a paper presentation.

It is interesting to consider the contents of the UNEP "Guide-lines and Principles of Environmental Law for Off-shore Mining and Drilling" which although focused on national legislation may provide an basis for defining regulations referring to the area of the global commons..

During a meeting of the Ad-hoc advisory expert group to the Latin American Group in the Preparatory Commission for the International Sea-Bed Authority and for the International Tribunal for the Law of the Sea, held in Santiago in November 1988 participants agreed that support from UNEP was urgently needed during the present stage of the Preparatory Commission's work.

They also asked ECLAC to provide technical support to the Latin American countries in terms of environmental considerations both as regards the pioneer investors fulfilment of their obligations and as regards the design of provisions for the draft regulations on the prospecting, exploration and exploitation of polymetallic nodules in the area of the global commons.

The experts also decided to request the Latin American Group to ask UNEP to study the applicability of the "Guide-lines and Principles of Environmental Law for Off-shore Mining and Drilling" to the mining activities in the area of the global commons and, if necessary, to prepare other rules in this respect.

POSSIBILITIES FOR INTER-REGIONAL CO-OPERATION

The above considerations suggest the possibility of approaching these issues on an inter-regional basis, since the problems are of real interest to the Group of 77 to which countries on both sides of the Pacific basin belong. Particularly since the Pacific is precisely the ocean where the highest concentrations of polymetallic nodules occur.

Legal instruments in the context of the Action Plans for the South-East Pacific may contain useful guide-lines for proposing regulations to be incorporated into the draft mining code for the area of the global commons. It seems also that the convention for the Protection of the Natural Resources and Environment of the South Pacific Region could be also an appropriate framework for involving other countries in the Pacific Basin in these endeavours.

Article 8 of the Convention states that Parties to it shall take appropriate measures to prevent, reduce and control pollution in the Convention Area resulting directly or indirectly from exploration or exploitation of the sea-bed and its subsoil. Thus providing the basis for possible background negotiations at the Preparatory Commission.

The Permanent Commission for the South Pacific (CPPS) has called upon its Secretariat to put forward to member countries programmes to enlarge the Commission activities across the Pacific Basin, and has established among its priority areas, policies concerning environment and preservation of species. This idea is also linked to cooperation within the United Nations System such as the various actions initiated between ECLAC and ESCAP.

ECLAC resolution 459 adopted during its XX Session, concerning Technical and Economic Cooperation among developing countries, could also provide an appropriate framework for the promotion of cooperative efforts across the Pacific Basin, since member States have requested the Executive Secretary to promote joint inter-regional, technical and economic-cooperation and to co-ordinate with other competent organizations of the United Nations System.

Member countries of ESCAP have developed considerable experience in the field of evaluating mineral resources through the Programmes operated by the Coordination Committee on joint prospecting of mineral resources in off-shore areas of the South Pacific (CCOP/Ea and CCOP/SOPAC), which could provide further support in any inter-regional efforts in this area.

CONCLUSIONS

These developments suggest that there are certain problems of common concern for countries of the 77 on both sides of the Pacific Basin, which are presently being negotiated in international fora such as the Preparatory Commission for the International Sea-bed Authority and which directly relate to the protection of the marine environment.

This suggests the need for consultative mechanisms which could be incorporated in some joint scheme established between UNEP supported Action Plans for the East Asian, the South Pacific and the South-East Pacific Regions.

What might be proposed initially, is an examination of the possibility of establishing some form of co-ordination mechanism among Regional Seas across the Pacific Basin, in order to advise respective regional groups on the environmental impacts of sea-bed mining. This would provide the Group of 77 with strong elements to negotiate the incorporation of environmental dimensions into both the arrangements with pioneer investors, and in the draft regulations for prospecting, exploration and exploitation of polymetallic nodules in the area of the global commons.

THE NEW LAW OF THE SEA AND COOPERATIVE REGIMES IN THE PACIFIC: SELECTED TOPICS.

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ABSTRACT

This paper reviews some recent developments in legal and international agreements concerned with the protection of the marine environment and the exploitation of living marine resources, in particular highly migratory pelagic species which occur beyond the 200 mile limit of the Exclusive Economic Zone.

INTRODUCTION

When dealing with such a broad topic, it is necessary to be selective and this paper discusses some issues of particular interest to Latin American coastal states, and reviews aspects of legal and international relations concerned with marine affairs in the Pacific basin.

Relations that are still being developed in connection with the non-living resources of the deep seabed area and which have become the main issue of the Preparatory Commission for the 1982 UN Convention on the Law of the Sea are not considered in this discussion. Even though the resources involved are largely in sectors of the Pacific Ocean where State and private owned company interests are in competition, developments are frequently a response to the dynamics of technological developments and the international mineral market which reflect global economic phenomena. A major question which still remains unanswered in this regard is whether or not the USA will take part in any eventual negotiations related to the seabed mining provisions of the 1982 Convention and the possibility of reaching some kind of agreement among the mining nations in order to achieve a closer and more flexible relationship with the Group of 77. These issue are outside the scope of the present paper which considers issues of environmental protection and the exploitation of living resources in the Pacific basin.

DEVELOPMENT OF INSTITUTIONAL CO-OPERATION

In order to analyse existing cooperative regimes we need to consider three main aspects of the development of present relationships:

1. The origins of institutionalised cooperation and the Latin American experience, which has developed mainly through the Permanent Commission for the South Pacific (CPPS);

2. The search for a new role for traditional institutions and their involvement in functional cooperative arrangements (the cases of fisheries and environment protection together with the scientific, technical and economic factors must be taken into account in this regard);

3. Potential elements for future cooperation in marine affairs between Latin American and Pacific basin nations.

A basic assumption of this analysis is the relevance of the process leading to the development of the UN Convention on the Law of the Sea, a process characterised by initiatives towards a stronger cooperation in political fields and the promotion of joint programmes at technical and institutional levels.

THE ORIGINS OF INSTITUTIONAL COOPERATION AND THE ESTABLISHMENT OF EXTENDED ZONES OF NATIONAL JURISDICTION IN LATIN AMERICAN COUNTRIES.

It is well known that the origins of a 200 nautical mile Exclusive Economic Zone (EEZ) are to be found in the political decision to protect national interests with respect to living marine resources in the southeastern Pacific region. Following the second world war, it appeared useful to Chile and Peru to support a fisheries policy which extended national jurisdiction and competences in the marine environment to encompass off-shore living resources which were considered of importance for the economic and social development of these countries.

The period of the nineteen sixties and seventies was characterised by a highly nationalistic approach to resource and their exploitation and it is perhaps appropriate to consider whether this nationalistic approach has evolved since then. It must also be borne in mind that this change in policy with regard to marine resources provided Latin America with a unique opportunity to successfully express political independence and economic nationalism.

From the viewpoint of the south-east Pacific countries (Chile, Ecuador and Peru), their marine policies reflect the positions of a wide spectrum of national actors wishing to influence the unequal relationship with other countries. The evolution of these national positions seems to be connected with a national reaction to international influences as evidenced by the case of whaling in Peru and Chile, and tuna fishing in Ecuador.

The Comision Permanante del Pacifico Sur (CPPS) had its origins in the Declaration of Santiago, adopted in 1952, a first step in the regional cooperative process. The CPPS was established as a regional organisation with legal competence to adopt measures regarding marine resource management. Its structure is simple, operating through an ordinary meeting of member states whose members are guided by national committees, where representatives of governmental agencies interact. The functions of the CPPS have subsequently evolved in the fields of political, scientific and technical cooperation and the development of a more active presence both in the region and within the Pacific basin as a whole.

In this respect it is interesting to note that the different views expressed by member states concerning the 1982 UN Convention of the Law of the Sea has not been an obstacle to the furtherance of regional cooperation. Neither Peru nor Ecuador, signed the Convention, while Chile and Colombia did.

Following acceptance of the importance of the regional interactions and the recognition of the existence of differences in national policy, one of the issues which needs to be examined is the implications of these differences in national perception for regional co-operation. One might contrast for example the clear territorial approach adopted by Ecuador with regard to the 200 nautical mile zone and the contrasting internal debate in Peru which has prevented this country from adopting a clear-cut decision on the Exclusive Economic Zone. One might also note that the Peruvian proposal regarding the establishment of a zone of peace in the south-east Pacific region has encountered some difficulties in political and legal acceptance because it is seen by some as encouraging a territorial concept of the 200 nautical miles zone.

The CPPS has chosen to avoid highly contentious issues and to focus on issues involving bilateral or multilateral relations between its members which might provide new understanding and inter-actions on a regional basis. After thirty years of existence, the principles and functions of the CPPS remain in force, but its influence in terms of the marine policies of member states has grown to encompass three additional elements:

a) the co-ordination of interests with other Latin American Pacific coastal states;

b) the relationships between these countries and distant water fishing nations, some of which have a long history of involvement in the area (eg, Japan, USA and USSR); and

c) the development of common interests with other developing countries or medium size powers throughout the Pacific, through consultative mechanisms.

A NEW ROLE OF TRADITIONAL INSTITUTIONS.

The initial dimension of sub-regional cooperation provides the basis of the search for a new role for the CPPS, which was enlarged in 1979 through the accession of Colombia. This process of change was continued through the Declaration of Vina del mar, in 1984, which serves as the starting point for the current reorganization of the internal structure of the CPPS and which contains a clear statement that the CPPS should have a new co-ordinating role in relation to the rest of the Pacific basin. This represents an explicit enlargement of the field of its activities. Five years later, in 1989, the National Committees for Economic Cooperation in the Pacific, met in Santiago, in order to define the first steps for more advanced cooperation within that region. The CPPS continues to have responsibilities with respect to marine resources and marine affairs leaving the wider spectrum of political and economic questions not covered by these areas of competence to other agencies.

On the other hand, the issue of co-operation with countries outside the CPPS region implies the need for an imaginative approach as exemplified by the evolving relationship with Mexico and other Central American countries. Mexico is an emerging fishing power in the Pacific and a highly influential country in OLDEPESCA, an organization concerned with fisheries development, which in certain respects has overlapping responsibilities with the CPPS. Recent difficult negotiations concerning tuna fisheries have shown that potential differences and sometimes rivalries are present. The recently signed agreement in Lima, in 1989, concerning tuna fisheries, established an international organization for the purpose or regulating tuna fisheries, but also made apparent the lack of unanimity among these countries. Although the new agreement is a clear sign of the need for an accommodation, it is far from a reflection of a common Latin American approach to the subjects covered by that agreement.

Mexico, Ecuador and Peru recognize in this agreement a positive value to jointly managing these highly migratory species. Other countries, such as Costa Rica, Colombia and Chile, have adopted a more cautious position, supporting the establishment of maximum global quotas for annual catches to be set by the council of this new organization. This agreement represents an attempt to try and solve a long tradition of conflict and compromise with the USA, a tuna fishing power which is also the main tuna market and which maintains a strong position in terms of not recognising the sovereign rights of coastal states over these species. From this point of view this agreement, although not yet in force, may be a way of solving one of the main issues concerning access by foreign fishing vessels to marine living resources.

In relation to this, the general acceptance of enlarged national jurisdiction over maritime space, does not mean that there is a common approach among the CPPS member states towards the existence of a surplus of marine living resources. Although the new tuna fishing agreement of the eastern Pacific coast is based on the assumption that such a surplus exists to be managed. In the case of Chile and Peru, different perspectives regarding the surplus and the issue of fisheries management are held. These differences in approach explain in part the reason why in the case of Chile, fisheries development based on agreements with foreign fishing nations is a highly controversial issue, while in the case of Peru a more positive attitude is observable.

In general, one issue which is becoming increasingly important is the recognition of the necessity to include areas outside the EEZ's of the South American countries within the framework of such agreements. The present lack of research should be addressed by an initial legal and scientific program at a subregional level and in 1983 the CPPS commenced moves to develop such a co-ordinated approach. The shortage of scientific research capabilities and political elements, partly involving the USSR as fishing power in this area, have prevented the further organisation of these efforts.

Internal discussion in countries like Chile, Colombia and Peru concerning the development of new fishing laws or modifications to existing ones, have resulted in a reconsideration of legal issues and economic measures needed for management and sustainable development of fisheries. This reconsideration is particularly important in the case of highly migratory species and recently introduced species such as salmon in Chile which necessitate an updating of long-standing fishing agreements.

Concerning subjects where the search for common interests extends beyond the Latin American coast, it can be seen that the most dynamic developments lie in the area of marine environmental protection. The methodology proposed by the Regional Seas Program has resulted in an efficient co-ordinated approach to the scientific, technical and legal components of environmental problems. This has permitted work to proceed in a series of scientific and legal projects with a minimum of political interference among the CPPS member countries.

The recent adoption in 1989 of a Protocol against dumping at sea of radioactive wastes, a few years after the South Pacific nations signed the Convention For the Protection of the National Resources and Environment of the South Pacific Region (the SPREP Convention of 1986 and its Protocols) illustrates the common concern of these regions of environmental degradation from radio-active sources of contamination.

The conclusion of the 1989 Protocol for the South-east Pacific also covers the lacunae of the 1972 London Dumping Convention, through the prohibition of dumping of all nuclear wastes or other radioactive substances in the sea, in the area covered by the Convention. Although there are some differences with the Convention for the Protection of the Natural Resources and Environment of the south Pacific Region, especially in relation to the definition of "dumping" the overall interpretation under the South-east Pacific Protocol being more strict, some important similarities are apparent. This is particularly the case in terms of these legal instruments relating to the implementation of the environmental impact assessment processes. A common problem for the nations in these regions is the establishment of technical guide-lines and appropriate legislation, either through harmonized domestic regulations or internationally agreed measures. Adoption of common rules applicable to liability and compensation for damage resulting from pollution from different sources, could also be the object of inter-regional cooperation.

POTENTIAL ELEMENTS FOR COOPERATION ON MARINE AFFAIRS.

The above discussion highlights a number of potential elements which might favour cooperative arrangements among Latin American and Pacific basin nations in the field of marine affairs. In this connection it is interesting to examine the growing signs of inter-regional cooperation across the Pacific basin.

Within a multinational framework some substantive efforts have been made in relation to the co-operation between South Pacific nations. Recent studies underscore the important similarities between the Rarotonga and Tlatelolco Treaties, although the latter has more important implications for the Atlantic region due to the presence of emerging Latin American nuclear powers.

In broader terms, additional elements should be mentioned which depend on functional cooperation, at both intergovernmental and non-governmental levels including the various consultative mechanisms and the on-going search for common definitions relating to fisheries development and the development of larger regional fishing agreements.

An initial effort is being made by ASEAN member countries, the Pacific Islands Nations and Latin American coastal states, in the area of fisheries, where the access by foreign distant water nations remains the main problem. The Task Force on fisheries established by the Pacific Economic Cooperation Conference represents an important development in this regard.

The issue of fisheries is a fundamental one for Latin American countries such as Ecuador, Peru and Chile which have export oriented fisheries development programmes. At the same time, a major debate regarding the entry into force of new legislation for managing marine living resources has taken place in Chile during recent months, revealing a wide variety of viewpoints in this field. The fact that some of the fishing nations of the Pacific are potential or actual members of the distant fishing fleets influences their position in this regard. The relationships between foreign investments, access to the markets and scientific and technical cooperation programmes are all important in the framework of these developments.

Members of the CPPS and, Latin American coastal states in general, have not discussed these subjects in depth. However, the need to consider the opinions of other Pacific basin nations related to these questions, is forcing the CPPS member states to take a revised and more comprehensive view of these issues. The Chilean experience between 1984 to 1986 in terms of the legal, scientific and economic elements involved in the development of a distant water fishing project based on pelagic species at the 200 nautical miles limit and beyond, has highlighted these problems.

CONCLUSIONS

It may be concluded that there is a need to strengthen cooperation within the framework of the CPPS so as to provide a more concrete basis for proposals involving external interests and co-operation. Scientific and technical efforts in environmental fields, particularly those relating to the enforcement of the terms of agreements for the protection of the marine environment, could lead to integration of goals between CPPS members and countries with similar problems such as the South Pacific Commission members.

The impact of other forms of interrelationship particularly bilateral agreements providing for cooperation with fishing powers such as Japan and the USSR need to be re-evaluated on scientific and technical levels. Having undergone some evolution since their inception, the models on which such agreements are based need to be discussed as a mechanism for assessing the divergent perspectives of developed and developing countries in field of fisheries development.

INVESTMENT IN ENVIRONMENTAL MANAGEMENT AND PROTECTION IN THE PACIFIC COASTAL REGION OF COLUMBIA

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INTRODUCTION

This paper focuses on the approaches of national and international organizations engaged in efforts related to environmental, social and natural resource protection in the Colombian Pacific Coastal region, a marginal area currently under-going major socio-economic development.

DESCRIPTION AND LOCATION

The Pacific Coast of Columbia comprises a unique ecological, economic, social and cultural unit that may be clearly distinguished from the rest of the country. It is composed of twenty-three municipalities located in the provinces of Choco, Valle, Cauca and Narino covering over 49,663 square kilometres, or around 6.3 % of the country's total land area. The region houses some 500,000 inhabitants along its 1,300 km coastal length which borders Panama to the North and Ecuador in the south. Along this coast the following geographical features stand out: Cape Corrientes and Cape Manglares; the Gulfs of Eupica and Tortugas; Tumaco and Utria Coves; the Bays of Buenaventura, Humboldt, Malaga and Solany; and the islands of Gorgona, Gorgonilla and Malpelo.

MAIN ECONOMIC ACTIVITIES

The exploitation of natural resources represents the main source of income and provides the major basis for employment among the people who live along the Colombian Pacific Coast. These resources provide an important source of foreign exchange to the country. Amongst main activities mention could be made of the forestry and fishery industries, both industrial and artisanal (CPPS/FAO, 1987). A third source of income is derived from mining which has been in operation since early pre-Columian exploitation gold reserves. Nowadays, in addition to the extraction of gold, platinum is mined from alluvial deposits, using traditional small-scale mining techniques including, *"mazamorreo"*, open-cut and shafts. More advanced techniques used in the medium- and large scale mining operations include the dredging of riverbeds and shores for placer deposits. This mining method is responsible for serious environemntal degradation, particularly in the marine environment where fishing stocks have become depleted.

Only five cities of the twenty-three centres located in the region have reached some degree of urban and industrial development, albeit in a somewhat unplanned manner due in part to the lack of roads a fact that has contributed to a substantial rise of the value of real estate. The most developed urban centre is Buenaventura partly as a consequence of its being a maritime port linked to the rest of the country by means of good roads. Approximately 516 vessels use the port carrying on board a total of 4,637,442 tons of cargo.

Construction of a Navy Base on Malaga Bay in the Pacific has been completed at a cost of approximately US$ 150 million and facilities at the Base included a deep channel which enables navigation of large draught vessels.

SOURCES OF INVESTMENT

Tables 1 to 5 indicate sources of investment and disposition of funds for the protection of the environment over the last few years. These investments have been made by various governmental institutions such as the Ministry of Health, the Ministry of Agriculture, INDERENA, regional governmental offices, regional corporations and are derived from duties and tarifs charged for the right to exploit natural resources.

Table 1. Planned investment by source and sector in the Pacific Coastal region of Columbia (Source: CVC/PLAIDECOP, 1983).

Projects, No by sector	Sources of funds Government	Sector	External	Annual disbursements Year 1	Year 2	Year 3	Year 4	Year 5	Total
Forestry									
3	1,233,420	-	-	-	351,840	411,050	268,950	201,580	1,233,428
Fisheries									
4	5,055,260	-	6,338,950	-	5,260	1,021,580	6,202,890	4,164,470	11,394,210
Health									
3	5,268	78,950	128,950	22,630	70,000	42,110	41,840	36,500	213,160
Sanitation									
2	131,500	92,110	215,790	-	307,890	131,500	-	-	439,480
TOTAL									
12	6,425,520	171,060	6,683,690	22,630	734,990	1,606,320	6,513,680	4,402,630	13,280,270

Table 2. Technical Assistance costs (Source: CVC/PLAIDECOP, 1983).

Project	Source of funds Government	Sector	External	Total
Documentation centre	-	5,260	-	5,260
Estuary canalisation	-	197,370	-	197,370
Forestry	52,630	-	-	52,630
Mineral Resource Inventory	52,630	-	26,320	78,950
Shrimp pilot project	52,630	105,260	52,630	210,520
Tuna fishery	-	6,580	6,580	13,160
Alternative fishing port study	52,630	-	52,630	105,260
Buenaventura Fishing Port	-	-	898,950	898,950
Tourism in Choco	-	26,320	-	26,320
Rural water supply	6,580	-	-	6,580
Water source inventory	3,950		1,316	5,266
South East Pacific Action Plan	-	-	190,000	190,000
Total	221,050	340,790	1,228,426	1,790,266

Table 3. Investment in infrastructure projects (Source: CVC/PLAIDECOP, 1983).

Project	Source of funds Government	Sector	External	Total
Expansion & Maintenance Jurado-Curicho	7,890	-	-	7,890
Canal, Buenaventura-Guapi	526,320	-	-	526,320
Buildings Guapi-Tumaco	-	-	789,470	789,470
Total	534,210	-	789,470	1,323,680

Table 4. Investment in fisheries resource use projects (Source: CVC/PLAIDECOP, 1983)

Project	Source of funds			
	Government	Sector	External	Total
Fishing port construction	-	-	6,338,950	6,338,950
Fishing industry	3,438,420	-	-	3,438,420
Pelagic fishing fleet	1,598,420	-	-	1,598,420
Artisanal fishing	18,420	-	-	18,420
Total	5,055,260	-	6,338,950	11,394,210

Table 5. Investment by INDERINA in the Pacific coastal region of Columbia. (INDERENA, 1987;1988a; 1988b)

Project	Funds
Fisheries research	22,930
Fisheries Administration	8,250
Artisanal fishing communities	11,840
CESPA- 'Extension Centre for artisanal fisheries	2,630
Freezer storage development	5,260
Project CEE-PEC	626,320
Total	677,230

Particular mention should be made of INDERENA whose goals are to assist in raising the standard of living of the population engaged in activities related to the agricultural sector through protection of the environment, research management, conservation, preservation, handling and development of renewable resources throughout the country.

To achieve these goals, INDERENA invested US$ 25,025 in 1988 and US$ 22,930 in 1989 in research activities related to fisheries. The development of artisanal fisheries was allocated the amount of US$19,730 whilst US$8,250 were allocated to the management of fish resources.

COMPONENTS OF THE PROGRAMMES

Forestry

Forestry reserves in the Colombian Pacific Region equal 16 % of the country's total reserves compared with forestry reserves in the Amazonian region which represent 71 % of the total. Timber reserves amount to a commercial volume of 198 million cubic metres which is composed of some 250 - 300 species. Species which have been subjected to intense exploitation are Mangrove and Mahogany which are nearly depleted in some regions where forest conditions are relatively uniform and the species composition is of low diversity. Those regions where forest composition is more mixed have not been subjected to such exploitation efforts on account of problems of access due to rugged topography, extreme climatic conditions and a lack of extraction and transportation facilities.

Some work has been undertaken to restore the forests to their previous condition. In this context, INDERENA has established four silvicultural stations in Bajo Calima (Valle del Cauca), Tumaco (Narino), Lloro and Bajaca (Choco) where the species native to these areas are cultivated

to replenish the forests. The work of these stations includes activities covering fertiliser and planting trials; development of nursery techniques and agroforestry trials.

Table 6. Specialised industral timber processing plants.

Plant	Number of installations
Manual sawmills	800
Industrial sawmills	168
Molding plant	1
Triplex plants	3
Chip-Board plant	1
Paper pulp plant	1

Fisheries

For the most part, marine fisheries resources (Table 7) are exploited by artisanal and industrial methods. Artisanal fisheries are generally coastal and this activity was limited to meeting the subsistence requirements of the fishermen themselves. Later on as market centres were established and new fishing gear devices were introduced, such as the electronic trammel net, nearly the entire fish catch began to be sold (Mora, 1987;1988).

Specialized fishing vessels (Table 8) fitted with modern fishing gear, are involved in industrial fishing. This activity requires land facilities to process and market marine produce. Species being exploited include shallow water shrimps, such as the crawfish or white shrimp, *Penaeus occidentalis* which is exploited both by artisanal and industrial fishermen and white-fish both coastal and oceanic pelagic species. The catch of these species has declined apparently as a consequence of over-exploitation, while the catch of tuna has increased, Table 7. Approximately 90 % of the shrimp catch is exported; 96 % of tuna catches are also exported due to lack of refrigerated facilities. In contrast 100 % of the whitefish catch is consumed in-country.

Table 7. Fisheries landings during 1988 and 1989.

Resource	1988	1989
Shrimp	5,658 Ton	2,938 Ton
Tuna	1,962 Ton	15,964 Ton
White Fishing	6,768 Ton	4,566 Ton

Table 8. Numbers of fishing vessels in the Columbian Pacific fishing fleet specialising in different species.

Fisheries resource	No of boats
Shallow Water Shrimp	91
Deep Water Shrimp	35
Tuna	18
White-fish	28
Combined Tuna & white-fish	2
"Carduma" and "Plumuda"	4
Total	178

Health

The real extent of health problems is unknown due to the lack of reliable information and the isolation of the region which lacks adequate means of communication. The Colombian Pacific Coast apparently has one of the highest child mortality rates (approximately 19 %) in the country. The main cause of death may be attributed to gastrointestinal infections, nutritional defficiencies and broncho-pneumonia. The local population is also prone to malaria in spite of governmental efforts to eradicate the disease.

Malnutrition affects children of less than 5 years of age. It is caused by poor eating habits since the daily diet is mostly based on plantains, maize, rice, and some fruit such as coconut.

In spite of the fact that the area is endowed with large water bodies, 90 % of houses lack fresh water supplies. In addition sewage systems are non-existent and people are forced to use beaches, rivers, estuaries and bushes as toilet areas. This practice accounts for the serious pollution of water sources and croplands thus accounting for the high rates of parasitism and water borne diseases.

There are four regional hospitals, six health centres and 44 aid posts which have been established in the Pacific Region. Most of these facilities lack electrical power only seven of them having access to electric supplies. Medicines are unavailable and there are only 1.4 physicians for every 10,000 people, whilst in the rest of the country, five physicians look after the same number of people.

ON-GOING PROGRAMMES

In 1988, INDERENA enforced a prohibition on fishing shrimp down to a depth of 30 fathoms (50 metres) on account of overfishing of this resource (Baneto, 1989). US$ 35,296 was invested in the area stretching from Punta Piedras, in the North, to Punta Cocos in the South. During 1989 US$ 73,684 was allocated to similar activities in the same area. The Government provides some of these resources whilst the rest are derived from duties, penalties and fees charged to industrial fishing vessels operating in the region. INDERENA is also engaged in an "Assessment of the Current Status of White Shrimp (*Penaeus occidentalis*) Populations" and has contributed US$ 25,027 to this activity whilst contributions from other agencies amount to US$ 42,105. CENIPACIFICO has also contributed to these activities with an assessment of 40,000 hectares which have been adopted for marine shrimp cultivation and 100,000 hectares for fresh water shrimp cultivation ponds.

Regional institutions such as the Universidad del Valle are supporting environmental protection through their involvement in the environmental impact assessment of domestic discharges into the Buenaventura Bay and the potential impacts resulting from the construction of a channel to link Buenaventura and Tumaco through an estuarine area.

Work is continuing on the eradication of malaria from the region. This endeavour was initiated in 1956 when the Servicio de Erradicacion del la Malaria started biannual door-to-door fumigation efforts. Due to a lack of financial resources, this activity is rather sporadic however.

Through the Centro de Control de Contaminacion del Pacifico, the Colombian Navy is engaged in monitoring activities to locate, identify and assess pollution sources and private organizations such as COLCIENCIA are involved in environmental and scientific research activities.

The Permanent South Pacific Commission (CPPS) is the only institution making real efforts to develop and promote environmental activities through providing assistance to regional institutions via courses and the provision of equipment to enable training and follow-up activities

concerned with marine pollution and environmental impact assessment of industry and marginal human settlements along the Pacific Coast.

DIFFICULTIES IN IMPLEMENTING ENVIRONMENTAL MONITORING ACTIVITIES

One of the main difficulties facing the implementation of sound management in coastal areas is the lack of information on the conditions necessary for the protection of natural resources as well as the duplication of responsibilities and competence monitoring and management efforts in such areas.

A new Code for the Protection of Natural Renewable Resources has been adopted by the various entities concerned with management of natural resources. Although this Code should be seen as the main legal instrument it is disarticulated from existing legislation which means that any efforts to achieve sound environmental management will meet with a great many difficulties. In addition, the Government's decision to descentralize official administrative activities has made matters worse.

Poor ecological training, a lack of interest and of financial resources are also responsible for much of the disregard for and non-compliance with standards related to the exploitation, management and protection of natural renewable resources and the environment, both on the part of private persons and government officers.

It would be advisable to clearly define fields of action for the various organizations and unify marine policies in accordance with their sound development and sustainable management. A single governmental institution should be created to monitor, manage and protect the natural resources and environment of the Columbian Pacific Coast.

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EFFECTS OF CLIMATIC CHANGES IN THE CORAL REEFS OF THE SOUTH-EAST PACIFIC

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ABSTRACT

An increase of 1.5°C in the sea surface temperature and a 20 cm rise in mean sea level by the year 2025, were adopted by the United Nations Environment Programme regional task teams on climatic change as future scenarios for assessing the possible impacts of expected climatic changes in marine and coastal environments.

Palaeobiological information suggests that coral reef communities have been able to survive greater environmental changes than those predicted to occur as a consequence of global climatic change. The predicted increase of 1.5°C in sea surface temperature may have a positive effect on hermatypic corals living near the lower limit of their range of temperature tolerance. Although this might be the case for coral reefs located in or near zones of upwelling or in close proximity to moderately cool ocean currents, such a response may be short-term only and may be countered by increased predatory activity on the part of corallivores. A 20 cm increase in mean sea level would, on the basis of present information seem unlikely to cause irreversible changes in reefs, or reef communities.

INTRODUCTION

Various climatic models suggest global warming due to an increase in the atmospheric concentration of carbon dioxide and other greenhouse gases will occur (Charney, 1979; Smagorinsky, 1982). These predictions of warming vary from 1.5°C to 4.5°C in global mean temperature with the highest increases occurring at high latitudes. The warming of the Earth's atmosphere would affect sea level through thermal expansion of the upper layers of the ocean and through melting of glaciers and possibly polar ice. Hoffman *et al.* (1985) estimated that an increase in global mean temperature of between 1°C and 2.6°C could result in thermal expansion contributing to sea level rise by 12 to 26 cm by the year 2050. According to Revelle (1983) the temperature increase would produce an expansion sufficient to raise the sea level by 30 cm in 33 years. The contribution of glacier melting to a rise in sea level has been estimated at between 8 and 25 cm in the next century (Revelle, 1983; Meier, 1984), assuming a global warming of 1.5 to 4.5°C.

In response to concern regarding these projected global climatic changes an international conference was convened by the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), and the International Council of Scientific Unions (ICSU). The conference was held in Villach in October, 1985, and recommended the study of possible effects of climatic changes on marine and coastal ecosystems. The Villach meeting suggested as guide-lines for the studies increases of 1.5°C in sea surface temperature and 20 cm in sea level by year 2025.

For the purposes of studying possible climatic change impacts on the coral reefs of the South East Pacific Region (which includes Panama, Ecuador, Columbia Peru and Chile) it has been found useful to consider the consequences of the 1982-1983 "El Nino" event. Although this event has the limitation of being short term it represented a severe climatic disturbance involving sea surface warming and sea level increase. El Nino has been defined as a large scale anomaly in

the ocean-atmosphere interaction (Wyrtky, 1982). Temperature anomalies related to El Nino are in the range of 2°C to 3°C above the mean surface temperature, and the increased mean sea level is up to 30 cm (Fonseca, 1985). These values fit within the sea level and temperature ranges suggested by the Villach meeting as guide-lines for establishing scenarios for the study of climatic change impacts.

CORAL REEFS IN THE SOUTH-EAST PACIFIC.

Distribution and extent

Coral reefs in the South-East Pacific may be small in size, discontinuous and somewhere limited in their development, but they are nevertheless abundant in the region (Glynn & Wellington, 1983). Coral reefs are reported in the Pearl Islands, Gulf of Panama; Contreras and Secas Islands in the Gulf of Chiriquí, Panama (Glynn, 1972); in Gorgona Island, Colombia (Von Prahl *et al.*, 1979); in the oceanic islands of Cocos (Bakus, 1975), Malpelo (Birkeland *et al.*, 1975) and the Galapagos (Durham, 1966) Figure 1.

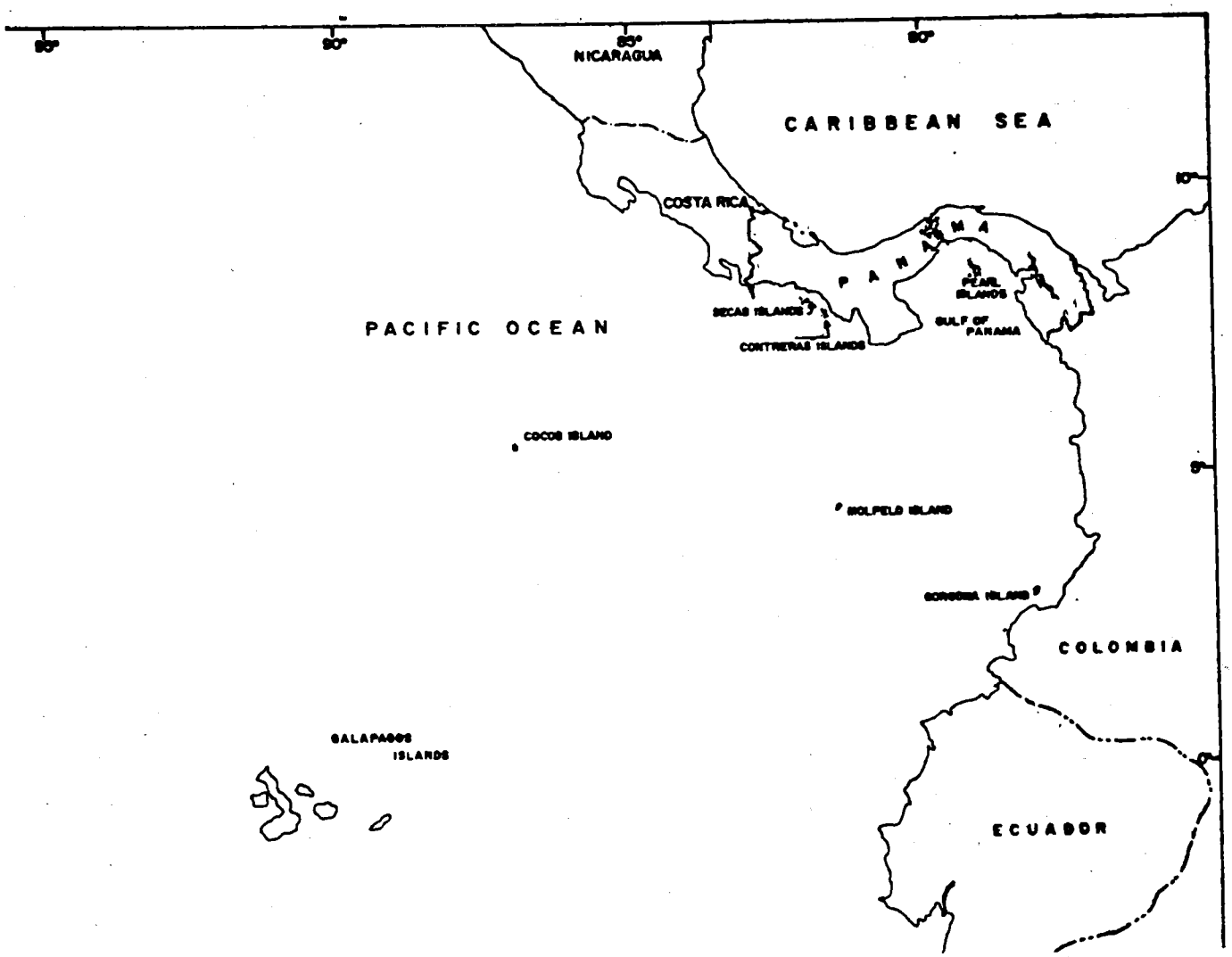

Figure 1. Map of the eastern Pacific region indicating the areas referred to in the text.

These reefs are characterized by the relatively small number of frame-building coral species, generally ranging between 8 to 10 species per reef (Glynn, 1982). Although 20 species of hermatypic scleractinian corals and 49 ahermatypic species are frequently listed as occurring in the Eastern Pacific (Durham, 1962; Glynn *et al.*, 1972) these figures have been reduced by synonymy and reassigned to 13 and 31 species respectively by Wells, (1983). Generally the chief frame-builder in Panamanian reefs and at Gorgona Island is the branching coral *Pocillopora spp.* while large massive colonies of *Pavona spp.* and *Porites spp.* are usually common at the reef base (Glynn *et al.*, 1972; Glynn, 1976; Glynn *et al.*, 1982; Glynn and Wellington, 1983). *Porites spp.* is dominant in coral reef communities at Malpelo and Cocos Islands (Birkeland *et al.*, 1975; Bakus, 1975). In the Galapagos Islands pocilloporid corals are common at shallow depths, and massive corals, mainly *Pavona* and *Porites spp.* are prominent at the reef base (Glynn & Wellington, 1983).

Climate and coral reef distribution in the South-East Pacific

The distribution of coral reefs in the region is strongly affected by cool, upwelling ocean currents and high river flows into the marine environment. Coral reefs are generally absent from mainland coasts, possibly because of the high river drainage and consequent high turbidity and low salinity. Nearshore salinities in the Panama Bight may be as low as 20 $^{o}/_{oo}$ during the rainy season (Forsbergh, 1969) due to high rainfall and river drainage. Since the lower limit of tolerance for reef-building corals is between 26 to 27 $^{o}/_{oo}$ (Wells, 1957; Glynn, 1974) this may explain why the most well developed coral reef communities in the South-East Pacific are in the vicinity of off-shore islands. Examples of such reefs are found around the Pearl, Contreras, and Secas Islands in Panama (Glynn, 1972); Gorgona Island in Colombia (Von Prahl *et al.*, 1979); Malpelo Island (Birkeland *et al.*, 1975) and the Galapagos Islands, of Ecuador (Durhan, 1966).

It is well known that coral reefs develop in warm waters generally within the range of 2 t 2 o (Wells 1957) Although cooler water (1 t 20oC) has an adverse impact on hermatypic corals (Wells 1957; Jokiel & Coles, 1977; Glynn, 1977) reefs may be found near the lower limit of thermal tolerance. Coral reefs at Pear Island, Gulf of Panama for example are subjected to temperature between 1 to 20o during the upwelling season (Glynn, 1977). In contrast reef communities in the Secas and Contreras Islands are located in a warm and thermally stable environment. Coral reefs at Gorgon Island, Colombia are diverse and relatively mature (Prah *et al.*, 1979) since despite their location near the southern limit of coral reef development, the island is beyond the influence of upwelling and the cool Peruvian Current (Glynn *et al.* 1982).

The Galapagos Islands exhibit a wide range of environmental conditions, the western islands are under the influence of up-welled water from the Equatorial Undercurrent while the moderately cool Peruvian current affects the south and east side of the archipelago. The northern islands receive tropical water mass from the Panama Bight (Glynn & Wellington, 1983). Coral reefs in the Galapagos Archipelago generally show their best development on the northeast coast of the islands, facing the inflow of warm tropical sea-water. Sparse coral communities are reported for the western sector which is affected by the up-welled water (Glynn & Wellington, 1983). Sea temperatures seem to be among the most likely causal explanations for the pattern of coral distribution in this archipelago.

The growth rates of hermatypic corals are also affected by the thermal regime. Growth of *Pocillopora damicornis* in Panama is significantly lower in upwelling environments where the corals are exposed to episodes of low temperatures when compared with the same species growth in warm and thermally stable environments (Glynn, 1977). Cool ocean currents and upwelling affects the western sides of Isabel and Ferdinand Islands, in the Galapagos Archipelago, and may be the cause of the meagre development of hermatypic corals in this location (Glynn & Wellington, 1983). Growth rates of *Pavona sp* are higher at the east side of Ferndinand Island when compared to the cooler west side of the island (Glynn & Wellington, 1983).

Coral predators on reef communities of the South-East Pacific

Predation on coral species is common in the Eastern Pacific (Glynn *et al.*, 1972; Birkeland, 1977; Glynn *et al.*, 1979; Glynn *et al.*, 1982; Glynn & Wellington, 1983). Fishes, crustaceans, molluscs and echinoderms are among the most active corallivores and some of these organisms may contribute to alteration of the structure and composition of the coral reef community. The activity of some of the coral's predators varies between different coral reef communities in the region due to local conditions (Table 1).

Table 1. Differences in corallivore preferred prey in various coral reef communities in the South-East Pacific (Data from: [1] = Glynn *et al.*, 1972; [2] = Glynne *et al.*, 1979; [3] = Glynn *et al.*, 1982; [4] = Glynn & Wellington, 1983).

Species	Galapagos	Gorgona Islands	Pearl islands	Contreras/Secas Islands
Eucidaris thouarsi	*Pocillopora* & *Pavona*[2,4]	Algae, seagrass & sponges[3,4]	Algae, seagrass & sponges[1]	Algae, seagrass & sponges[1]
Acanthaster planci corals[1]	absent[4]	absent[3]	absent[1]	*Pocillopora* & non-pocilloporid
Nidorella armata	*Pavona*[4]	?	Algae & sponges[4]	Algae & sponges[4]
Jeneria pustulata	Uncommon[4]	*Pavona*[3]	*Pocillopora*[1]	*Pocillopora*[1]
Arothron meleagris	Uncommon[4]	*Pocillopora* & *Porites*[1]	*Pocillopora* & *Porites*[1]	*Pocillopora* & *Porites*[1]

Examples of these important interactions and differences in feeding activity between localities are discussed below:

- Herbivory is important in coral reef communities controlling the growth of algae and therefore affecting the colonization of new spaces by corals (Birkeland, 1977). This role is frequently filled by fishes and sea urchins, however the activity of some herbivores may have different impacts on the growth of corals in different communities as is the case of the sea urchin *Eucidaris thouarsii* (Glynn *et al.*, 1979). This sea urchin is present in coral reefs in Colombia and Panama, where it is known to feed on algae, sea grasses and sponges. In the Galapagos Islands *Eucidaris* grazes actively on live *Pocillopora* (Glynn & Wellington, 1983). This feeding pattern appears to be unique to the Galapagos reefs and may be the result of lower fish predation in the Galapagos compared to mainland coral communities. The grazing of *Eucidaris* on *Pocillopora* reduces reef growth in the Galapagos (Glynn *et al.*, 1979).

- The starfish, *Acanthaster planci* is an important predator of corals but it seems to be restricted to the off-shore islands of the Gulf of Chiriqui, Panama (Glynn, 1974) in southwestern Panama. This starfish feeds preferentially in deep reef zones and over non-pocilloporid corals, however it will also feed on small colonies of *Pocillopora*. Crustacean symbionts in *Pocillopora* (*Trapezia* and *Alpheus*) can repulse the attack of *A. plancii* and protect the colony against predation (Glynn, 1976). Massive corals lack this protection which may explain the preference of this predator for non-pocilloporid corals.

- The starfish, *Nidorellia armata* was observed by Glynn & Wellington (1983) feeding on live coral in the Galapagos but has not been reported as corallivorous elsewhere in the South-East Pacific.

- The gastropod, *Jenneria pustulata* is reported to consume large amounts of *Pocillopora*. Although common on Panamanian reefs and at Gorgona Island (Glynn *et al.*, 1972; 1982) the species is uncommon in the Galapagos (Glynn and Wellington, 1983).

- The pufferfish, *Arothron meleagresis* eats *Pocillopora* biting off the branch tips of the colony (Glynn *et al.*, 1972; Glynn *et al.*, 1982; Glynn & Wellington, 1983). This fish, although reported as abundant in coral reef communities in Panama and Colombia (Glynn *et al.*, 1982) is uncommon in the Galapagos (Glynn & Wellington, 1983).

Climatic changes and possible effects on coral reef communities in the South-East Pacific

Palaeobiological information suggests that during the Pliocene and Quaternary periods there occurred changes in sea level and temperature which altered the suitability of habitats for the growth and distribution of coral reefs (Wells, 1956). Against this extensive database of past changes in sea-level a 20 cm increase in mean global sea level by 2025 does not seem to be a likely cause of irreversible changes in the coral reef communities of the South-East Pacific.

Changes in the sea temperature regimes throughout the coral reef communities in the region however, could result in significant impacts. The best coral growth and reef development are usually related to areas with warm sea temperatures (Wells, 1957; Shinn,1966). However, since coral reef communities in the South-East Pacific are exposed to an wide range of thermal conditions at the present time (Glynn & Stewart, 1973; Glynn, 1977; Glynn & Wellington, 1983) any increase in temperature may have quite different impacts in different areas. In part these difference may result because of the close adaptation of corals to local thermal regimes (Coles & Jokiel & Coles, 1977). Such differences in response were evident in coral mortalities related to the 1982-1983 El Nino. Prolonged sea temperature anomalies during this period were greater in environments affected by upwelling or cool ocean currents when compared to warm and stable areas. Probably because of this, mortality in pocilloporid corals reached over 90 % in the Galapagos and Pearl Islands, whereas in the warm and stable Contreras and Secas Islands it was comparatively lower around 50 to 75 % (Glynn *et al.*, 1988).

Corals showed evidence of stress throughout the reefs of the region during the 1982-1983 El Nino event (Glynn, 1984; Robinson, 1985; Von Prahl, 1985; Glynn *et al.*, 1988). High temperature tolerance experiments with *Pocillopora damicornis* (Glynn & D'Croz, in press) simulating El Nino conditions resulted in bleaching of the corals' tissue, deterioration, and decline in zooxanthellae densities, chlorophyll content, and coral (animal) protein content. These abnormalities in the coral's tissues were similar to those observed in the field during the 1982-1983 El Nino.

Although an increase in sea temperatures would mainly affect corals living near the limits of thermal tolerance (as evidenced by coral mortalities related to El Nino 1982-83) this may also be a short-term response to the stress and recovery of the community may be possible. Regardless of whether this is the case corals were severely affected by the 1982-83 warming event, and two species of hydrocorals disappeared from the region (Glynn, 1984). It is unlikely that this episode has been the only strong warming event in the history of the South-East Pacific and hence the present distribution of coral reef communities in the region may reflect the interplay of such events with more normal conditions. Despite such large disturbances (Dana, 1975) coral communities continue to exist and develop in the region.

As discussed elsewhere, coral growth in Panama is higher in warm and thermally stable areas when compared with upwelling areas (Glynn, 1977). Growth of *Pavona spp.* in the Galapagos Islands is accelerated during the periodic occurrence of minor El Nino events and under the influence of the tropical current from the Panama Bight (Glynn & Wellington, 1983).

Thus, unless the warming reaches the extreme levels recorded during El Nino 1982-83, mild increases in temperature may promote coral growth in general. On the other hand it must be remembered that the warming expected from global climatic change is not an abrupt process, (like El Nino) but a progressive which will perhaps permit a greater degree of gradual adaptation amongst the coral community.

According to Dana (1975) low temperatures caused the temporary extinction of the East Pacific reefs during the Pleistocene. This implies South-East Pacific reefs are youthful (Glynn & Wellington, 1983) and probably the result of recolonization by larvae from the Central Pacific dispersed by ocean currents. The hypothesis of long-distance dispersion of coral larvae and rafting of adult colonies (Dana, 1975; Jokiel, 1984; Richmond, 1987) may be important factors in assessing possible future changes in the distribution of coral reefs in the South East Pacific. It may be important to consider the idea that the most resistant coral reef communities could act as source of species of propagules for new immigration or recruitments to other reefs within the region.

Numerous additional questions arise in relation to the possible impacts of sea warming in the South East Pacific. For instance:

- during the El Nino warming *Pocillopora* and *Millepora* were severely affected, but massive corals had comparatively better survival (Glynn, 1984) will such changes occur under conditions of global warming and hence will changes in species dominance occur ?

- massive mortalities of *Pocillopora* in the Gulf of Chiriqui, Panama, during El Nino were followed by an increase in the predatory activity of *Acanthaster planci* on the massive corals formerly surrounded and protected by *Pocillopora* and their symbiotic crustaceans (Glynn, 1985). Would this lead to degradation of the coral community in the Gulf of Chiriqui if massive forms are the main survivors following global warming?

- the corallivore starfish *Acanthaster planci* is currently restricted to the Gulf of Chiriqui, Panama, possibly because larvae are adversely affected by low temperatures during upwelling in the adjacent Gulf of Panama (Glynn *et. al.*, 1982). Will sea surface warming attenuate this upwelling thus allowing the larvae to spread throughout the South-East Pacific?

- will the new thermal regime affect the predatory patterns of corallivores throughout the region?

Although coral reefs have survived greater disturbances than the predicted increase of 1.5°C in sea temperature and 20 cm in sea level, these questions, and many other, will have to be answered in any assessment of the impact of the expected climatic changes.

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IMPLICATIONS OF SEA LEVEL RISE AND CURRENT RESEARCH IN THE EAST ASIAN SEAS REGION

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ABSTRACT

Problems of using existing tidal data in predicting future sea level changes and potential impacts from such changes in the ASEAN region are outlined and a proposal for future studies is outlined.

INTRODUCTION

When the United Nations Environment Programme (UNEP) launched the climate change impact study for the three countries in the East Asian Sea Region (Malaysia, Indonesia, and Thailand), titled "Socio-Economic Impacts and Policy Responses Resulting from Climate Changes" in 1987, the sea level rise component was one of the major issues given priority within the research program. As climate change and sea level rise were new concepts at that time, organizing local scientists and researchers to address the issue has been difficult. In 1989, the East Asian Seas programme established the task force to study the implications of climate changes, which held its first meeting in Singapore in May 1989, and a subsequent meeting will be held in November this year. The first meeting agreed that they can perform only limited studies at this time due to a lack of time and resources for undertaking detailed impact analysis. The findings of such initial studies may lead to several research proposals in the areas needed, and action plans may be formulated to facilitate and co-ordinate the region's effort in this field.

NATIONAL ACTIONS AND REGIONAL CO-OPERATION

As Thailand is a member of both UNEP and the regional task force, contacts have been made by the Ministry of Science, Technology and Energy, which acts as the national co-ordinating agency, with authorities and scientists interested in conducting research on the topic. Following initial in-country discussion it was recognised that sea level rise impacts represented the component on which it was most difficult to conduct quantitative research. The uncertainties associated with potential sea level rise also presents problems in presenting future scenarios to government personnel and high level decision markers.

When the task team met in Singapore in May, 1989, the meeting was optimistic about the possibilities of data exchange between countries. The problem is that in order to study sea level rise impacts, site specific studies are always required. For example when the Ministry requested the Naval Hydrographic Department to undertake a sea level rise impact study for the coastline of Phuket, Thailand, the Department stated that, data on annual and inter-annual sea level variations; extended time series of measurements to provide a measure of response to low frequency atmospheric forcing; and, further information on various phenomena observed only in the tropical region were all needed in order to undertake such an analysis. In short, to assess in detail the impact of sea level rise on Phuket, sea level measurements and data are required which are currently unavailable if the problems beach loss in coastal areas was to be predicted with any certainty.

As Phuket is an important tourist destination in Thailand, and there have been several studies on the island, including the USAID supported Coastal Resource Management Plan (CRMP) which is a cooperative programme between Thai institutions and the University of Rhode Island. In addition there have been other studies in the coastal area of the island, such as environmental impact assessments of several activities (i.e. mining of tin) suggesting that a wealth of data should be available.

It is the opinion of the Naval Hydrographic Department that more extensive research and data are required and could be obtained only by the detailed study proposed, to obtain data on sea level height, inter-annual variations and current trends in sea level rise. While the major data requirements are for tidal data, observations on the geomorphological characteristics of the entire coastline are needed, including the physical nature of coastal areas and beaches, in order to predict and assess potential impacts resulting from sea level rise. The proposed project would cost in the vicinity of US$ 60,000 and is scheduled to last about two years.

The proposal for a more detailed study was also supported by an Australian expert on sea level and coastal morphology, who supported the idea of detailed studies on specific sites, the results of which could then be extrapolated to other similar areas. The simplistic concept of drawing new coastlines on the basis of existing map contours is not fully realistic, as the coastline responds dynamically to changes in sea level. In this report to UNEP, five or six sites were identified in each country, for future research on the impacts on coastal morphology, mangroves, human settlements, corals, and other coastal systems. Obviously the cls

ost of such research would run into millions of dollars and UNEP has indicated that the countries will have to pursue individual funding, since UNEP serves as a catalytic agency, rather than a major funding source.

When looking at the tide data for the East Asian Seas Region, it is surprising that there are insufficient data available to assess future impacts given the extensive network of existing tide gauges operated by countries in the region (Figures 1 & 2, Annex 1) and additional tide gauges installed under the ASEAN-Australian program on Marine Science (there are two sub-projects, one in Tide and Tidal Phenomena and the other on Living Resources). This ASEAN program involves Thailand, Indonesia, Philippines, Malaysia and Singapore, and is operated by the ASEAN Working Group on Marine Science under the ASEAN Committee on Science and Technology (COST). In 1976 the Working Group was formed to develop proposals for several projects in marine science, and the Tides and Tidal project was supported in 1985 by a grant of A$ 1.8 million. The aim of the project is to install a network of tide gauge stations, establish a data bank for exchange among members, and to develop a numerical model to simulate natural tides. The data is to be used mainly for navigation purposes and for predicting dispersion of pollutants in the water bodies, including oil spill and industrial wastewaters in coastal areas.

For oceanographic purposes, the data were to be used in tidal current and tidal prediction particularly in respect of particular events such as El Nino. Tidal data from this project have not been very satisfactory, as reported in the Workshop in Singapore, 1988 when problems such as difficulties with instrument time settings; damaged parts; short battery life; and, barnacle growth were all identified as having affected data quality. In management terms, spare parts, and the availability of technicians for routine maintenance were also identified as major problems. The project which was planned for 1986-88 was extended for a further year to 1989. In the feasibility study for the continuation of this programme institutional constraints including a lack of capability to support tidal and ocean current monitoring activities, the lack of specialized training and the weakness of regional cooperative and co-ordinating mechanisms.

Data are sent to Flinders Institute for Atmospheric and Marine Sciences (FIAMS) in Australia for processing with FIAMS software and development of numerical models and their testing. The Steering Committee, at their 5th meeting in August 1988 decided to continue phase 2 of the project and which was approved in the 6th meeting in January 1989 and will be considered by the ASEAN Standing Committee prior final approval via the ASEAN-Australian Forum.

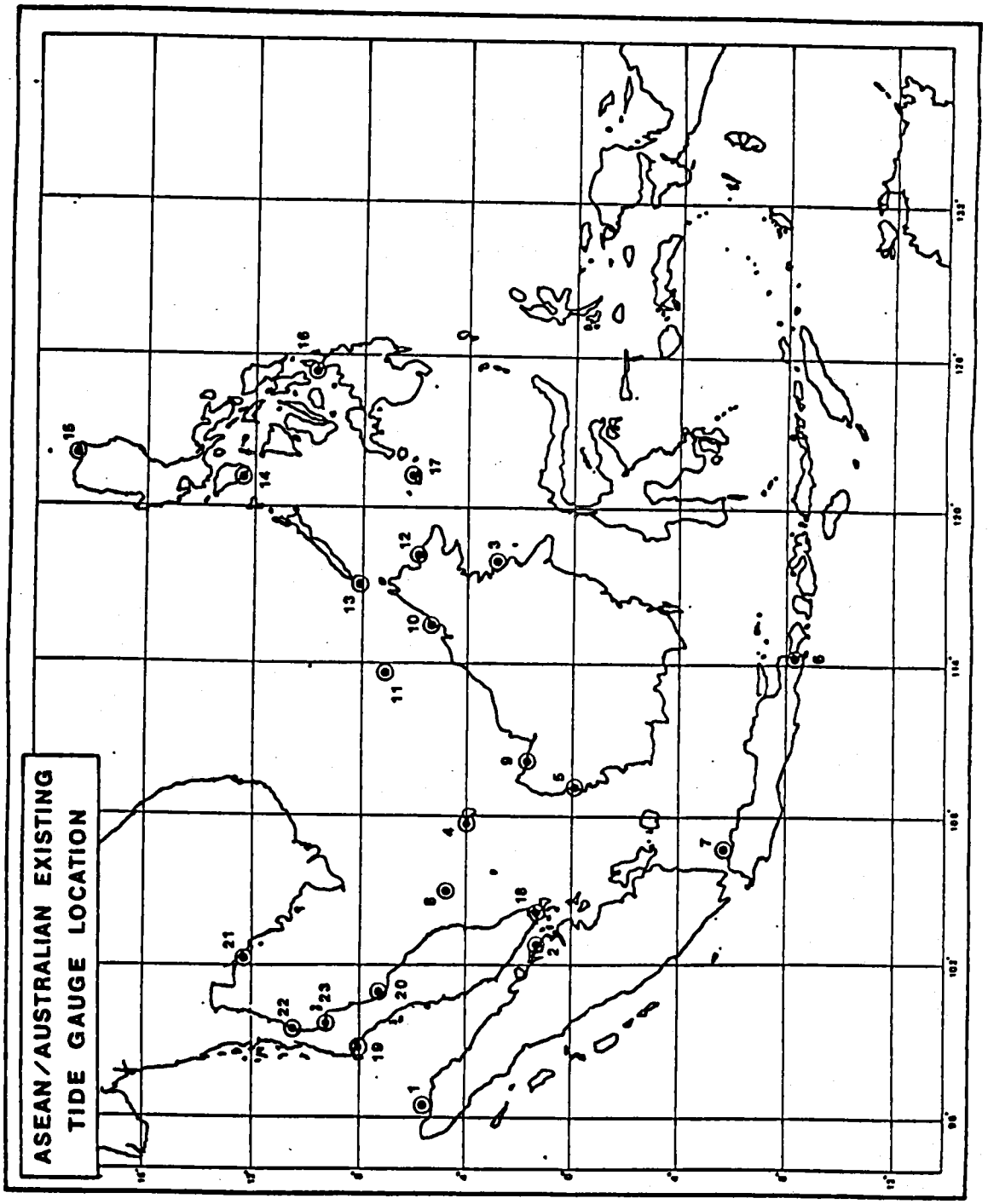

Figure 1. Tide Gauges established under the joint ASEAN/Australian programme.

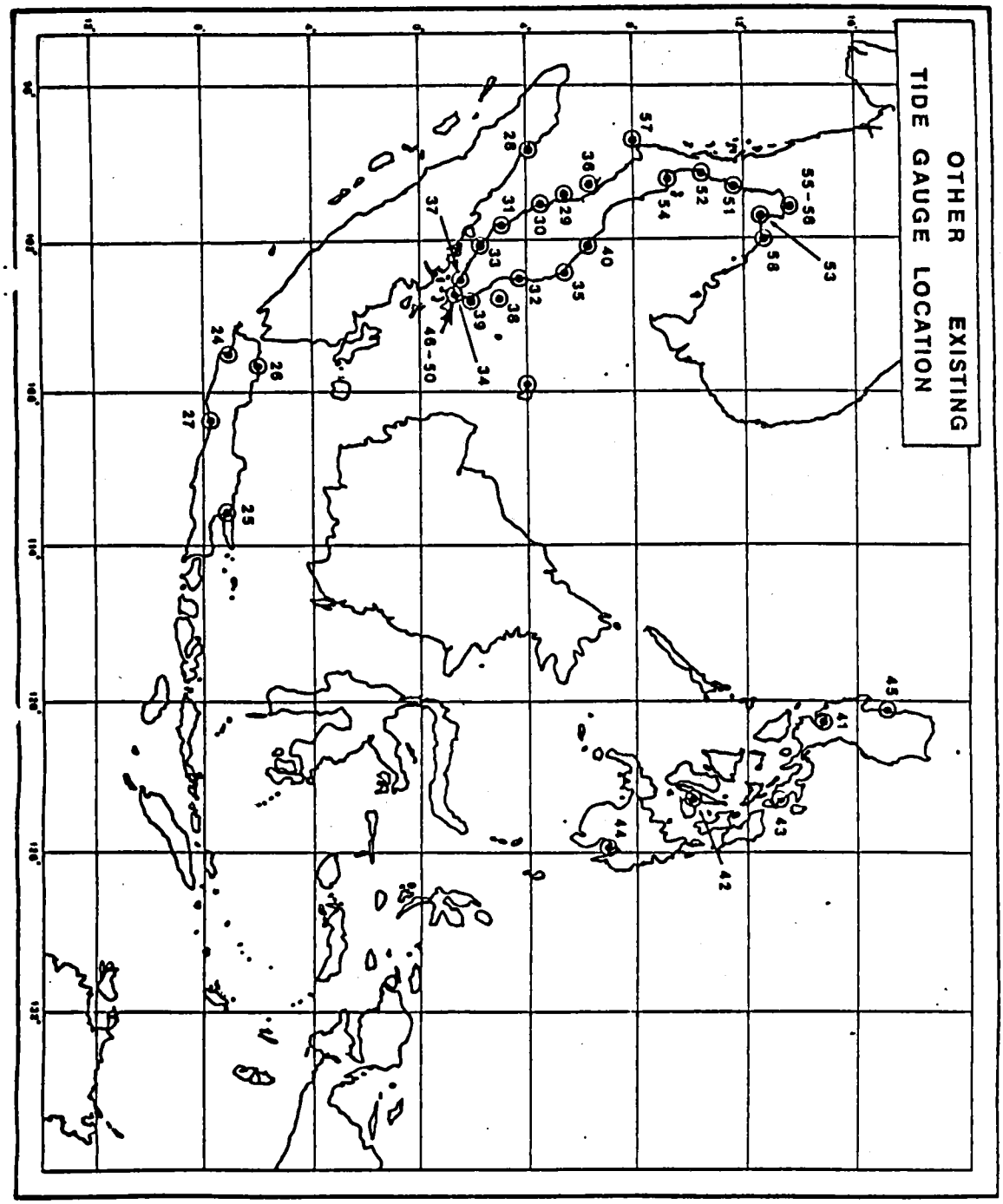

Figure 2. Existing tide gauge locations in the Asean Region.

CONCLUSIONS

In summary, the use of tidal data from the ASEAN-Australian project in assessing future impacts due to sea level rise should be tried. At least in terms of a preliminary study, for rapid assessment of coastal area losses. Thai scientists are concerned that even interpretation of the existing tide data may prove to be a difficult task. However, they agree that it will be necessary to use this data in the study of the implications of sea level rise. In October this year research issues including consideration of future directions will be undertaken through a National Conference on Climate Change Impacts. Research methodology and data availability will be among the topics of discussion. It is hoped that this will result in a good proposal which will make use of existing systems and databases, and the results of this conference will also be passed to other ASEAN members.

ANNEX 1

The ASEAN Australian Tide Gauge Network, locations are indicated in Figure 1.

Country	Station	Location	Latitude	Longitude
Indonesia	1	Blang Lancang	05° 13' N	97° 06' E
	2	Pasir Panjang	01° 07' N	103° 20' E
	3	Tarakan	03° 17' N	117° 35' E
	4	Tarempah	03° 15' N	106° 15' E
	5	Pemangkat	01° 10' N	108° 58' E
	6	Meneng	08° 07' S	114° 23' E
	7	Pulau Pari	05° 51' S	106° 37' E
Malaysia	8	Tapis Alpha	05° 19.8' N	105° 29.6' E
	9	Pulau Lakei	01° 44.8' N	110° 29.6' E
	10	Labuan	05° 14.7' N	115° 14.5' E
	11	Pulau Layang	07° 22.6' N	113° 50.4' E
	12	Sandakan	05° 48.5' N	118° 05.0' E
Philippines	13	Balabac	07° 59.3' N	117° 03.8' E
	14	San Jose	12° 19.9' N	121° 05.2' E
	15	Port Irene	18° 23.1' N	122° 29.8' E
	16	Port Surigao	09° 46.9' N	125° 29.8' E
	17	Jolo[1/]	06° 03.5' N	120° 59.9' E
Singapore	18	Raffles lighthouse	01° 09.6' N	103° 44.6' E
Thailand	19	Laem Panwa	07° 47.0' N	98° 24.3' E
	20	Ko Nu	07° 14.0' N	100° 36.1' E
	21	Laem Thammachat	12° 10.5' N	102° 19.8' E
	22	Ko Mattaphon	10° 26.7' N	99° 15.4' E
	23	Ko Samui	09° 25.0' N	99° 55.5' E

1/ Instrument and housing in need of replacement.

Annex 1. continued: Existing tidal stations in the ASEANS region

Country	Station	Location	Latitude	Longitude
Indonesia	24	Pelabuhan Ratu	05° 50' S	107° 30' E
	25	Surabaya	06° 50' S	112° 30' E
	26	Jakarta	06° 10' S	106° 05' E
	27	Cilacap	08° 05' S	109° 00' E
	28	Asahan	04° 00' N	98° 30' E
Malaysia	29	Penang	05° 23' N	100° 21' E
	30	Lumut	04° 14' N	100° 37' E
	31	Port Kelang	03° 03' N	101° 22' E
	32	Tanjong Gelang	03° 59' N	103° 26' E
	33	Tanjong Keling	02° 13' N	102° 09' E
	34	Johor Bahru	01° 28' N	103° 48' E
	35	Chendering	05° 16' N	103° 11' E
	36	Telok Ewa	06° 26' N	99° 45' E
	37	Kukup	01° 13' N	103° 27' E
	38	Pulau Tioman	02° 48' N	104° 08' E
Philippines	39	Manila	14° 35' N	120° 58' E
	40	Cebu	10° 18' N	123° 54' E
	41	Legaspi	13° 09' N	123° 45' E
	42	Davao	07° 05' N	125° 38' E
	43	San Fernando	16° 37' N	120° 18' E
	44	Jolo	06° 04' N	121° 00' E
Singapore	45	Jurong	01° 18.4' N	103° 43.2' E
	46	Sultan Shoal	01° 14.4' N	103° 39.0' E
	47	Raffles	01° 14.4' N	103° 44.6' E
	48	Kepple Harbour	01° 15.8' N	103° 49.3' E
	49	Sembawang	01° 27.9' N	103° 50.2' E
Thailand	50	Kok Lak	11° 47.7' N	99° 48.9' E
	51	Koh Mattaphon[2/]	10° 32' N	99° 15' E
	52	Sattahip[2/]	12° 45' N	100° 00' E
	53	Koh Prap[2/]	09° 15' N	99° 30' E
	54	Tha Chin[2/]	13° 33' N	100° 10' E
	55	Chao Praya River[2/]	13° 45' N	100° 33' E
	56	Phuket (Eastern)[2/]	07° 50' N	98° 30' E
	57	Laem Sing[2/]	12° 25' N	102° 05' E

2/ Locations are approximate.

THE IMPLICATIONS OF EXPECTED CLIMATIC CHANGE AND SEA-LEVEL RISE ON THE COASTAL AND MARINE ENVIRONMENT OF THE EAST ASIAN SEAS REGION

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ABSTRACT

The preliminary results of the East Asian Seas Task team on the implications of climatic change and sea level rise on the area are reviewed and the directions of future work outlined. In the light of the importance of the coastal zones to the countries of the region it is anticipated that impacts could be potentially severe in terms of effects on coastal habitats such as coral reefs, seagrasses and mangroves and in terms of increased coastal erosion and geomorphological changes.

INTRODUCTION

The Oceans and Coastal Areas Programme Activity Centre of the United Nations Environment Programme proceeded in 1987 to establish Task Teams to examine the implications of climatic changes and sea-level rise within each of the six regions (Mediterranean, Wider Caribbean, South Pacific, East Asian Seas and South-East Pacific regions) covered by the UNEP Region Seas Programme.

The composition of the Task Team for the East Asian Seas was finalised in early 1989 and the Team met for the first time in May of the same year in Singapore. Its terms of reference included examining:

a) the possible effects of sea level changes on coastal ecosystems;
b) the possible effects of temperature elevation on terrestrial and aquatic ecosystems, including the possible effects on economically important species;
c) the possible effects of climatic, physiographic and ecological changes on socio-economic structures and activities; and,
d) determining areas or systems which appear to be most vulnerable to the changes.

This paper is based largely on the work carried out by members of the team, which was discussed during the first meeting in May, 1989, and focuses, in particular, on the marine and coastal environment of the participating countries, namely Indonesia, Malaysia, Philippines, Singapore and Thailand. The scenario adopted is a rise in global atmospheric temperature of 1.5°C and a corresponding sea level rise of 20cm by the year 2025.

COASTAL AREA UTILISATION AND MANAGEMENT

The five countries in the region have an extensive combined coastline of 99,092 km (Table 1), compared to a combined land area of 295,063 thousand hectares. These countries presently support a total population of 312.7 million that is projected to increase to 491.5 million by the year 2025. It is estimated that approximately 75 % of the current population live in coastal villages and towns, and the rate of development is rapid along the coastal areas. The dependence

on coastal and marine resources is evident from the rate of habitat destruction and loss. The seas provide an average annual marine catch (1983-85) of 5,766,000 metric tons.

The coastal zone of the region is heavily utilised to support a broad range of socio-economic activities, such as industry, transport and commerce, recreation, farming, etc. Mariculture and coastal aquaculture development is extensive within the region.

Table 1. Land, population and marine catch figures of the East Asian Seas countries (adapted from World Resources Institute, 1988).

Country	Land area (thousand hectares)	Coastline length (km)	Population (millions) 1989	2025	Annual marine catch (thousand metric tons)
Indonesia	181,157	54,716	178.5	272.7	1,732
Malaysia	32,855	4,675	17.0	26.8	670
Philippines	29,817	36,289	59.7	102.8	1,330
Singapore	57	193	2.7	3.3	22
Thailand	51,177	3,219	54.8	85.9	2,012

Observations on sea level and climate change

Data from radiometrically dated shoreline indicators in tectonically stable, Peninsular Malaysia suggest that actual sea level can be expected to recede by 1.5 to 2.0 mm annually in the near future. Taking this into consideration, the projected 20 cm rise in sea level due to temperature elevation by the year 2025 will result in a net rise of 13 to 15 cm.

Existing records of temperature and rainfall in the coastal areas of Peninsular Malaysia since 1930, and East Malaysia (since 1953), show an upward trend in temperature, but no definite trend in rainfall. The data indicate average rates of increase per 100 years of 2.1°C in mean maximum temperature; 1.7°C in 24-hour mean temperature; and 0.8°C in mean minimum temperature. The 112-year record of rainfall in Singapore also did not reveal any clear trend. However, with the expected further rise in air temperature by 2025, rainfall is also expected to increase.

Change in Oceanographic Conditions

Global warming will cause changes in the physical characteristics of the seas in the region. Present sea surface temperature of 20°C to 28°C during the colder months of the higher latitudes of the East Asian Seas, and 27°C to 29°C for the warmer months of the higher latitude areas and throughout the year for the equatorial areas, are expected to increase by 1°C. This will be caused by increased long wave energy re-radiated downwards by the atmosphere. However, it can be anticipated that there will be a lag time in the response of the surface layers and a much longer time lag in the response of the bottom layers. Enhanced evaporation and increased precipitation will primarily affect salinity. Vertical stability of the already stable surface waters of the tropics will increase further, thus inhibiting vertical mixing which has implications for the biological productivity of the marine environment.

Implications on marine productivity

Direct as well as indirect influences on marine productivity can be expected to result from climatic changes. Small-scale temperature increase could result in higher productivity by enhancing the growth of most species. Increased precipitation, if frequent and intense, can however lead to decreased salinity in shallow coastal areas much to the detriment of species inhabiting them. The increased levels of nutrients washed out to sea could have the positive effect of encouraging growth of primary producers as well as a negative effect where enhanced blooms of algae may be detrimental to other marine organisms and mariculture operations. Large amounts of sediment washed out to sea will reduce light penetration which is damaging to coastal reefs or marine plants.

Implications for natural coastal ecosystems

Most of the coral reefs in the region are of the fringing type, with a shallow reef flat extending out across varying distances before descending along a steeper slope to the sea floor. Present knowledge of reef dynamics indicates that modern day reefs can cope with a sea level rise of 5 mm yr^{-1}. Sea level rise may provide the necessary environmental conditions for reefs to optimise structure and orientation. Many reefs in the region appear to have attained their maximum limits of growth under present conditions. Reef flats, being relatively shallow, are subject to greater stress factors and thus support less coral growth. A sea level rise will reduce the frequency of reef flat aerial exposure and may promote growth in this zone. These assumptions however, have been made without considering erosional factors caused by increased rainfall induced erosion which will blanket suitable substrates as well as smother sessile organisms with sediment. Depressed salinity will also be detrimental to species unable to tolerate large salinity fluctuations. It is also known that a increases in water temperature may also cause corals to bleach, resulting in mass mortality.

Seagrasses and macroalgae can be expected to shift their distribution landward in response to sea-level rise provided that the newly submerged shore areas are suitable for the primary settlement of spores or seedlings. Seagrasses in particular, are frequently exposed at ebb tide and have become adapted to ambient air temperature and rainfall. However, increased air temperature and increased precipitation may exceed their environmental thresholds and result in a reduction of these resources, which would in turn affect certain economically important fish and shrimp species.

Mangroves can theoretically migrate landward in response to sea level rise as long as freshwater supply remains adequate. Salinity is of critical importance as the fluctuating regimes of sea-water inundation and freshwater dilution influence distinctive zonation patterns from the seaward to the landward side. A change in salinity regimes through increased rainfall will affect the non-tolerant species and determine the survival or death of affected zones. Mangrove species are also expected to be stressed by elevated temperatures.

COASTAL EROSION AND GEOMORPHOLOGY

Sea-level rise will cause loss of low-lying coastal land especially in areas with gentle gradients, while increased precipitation will lead to enhanced runoff. Coupled with changes in near-shore current patterns, coastal erosion and deposition rates will increase and result in changes to coastal geomorphology. This will be further aggravated by the loss of natural ecosystems which, if unable to tolerate the changed conditions, will deprive the shore-line of its natural protection.

Coastal dykes and other man-made protection devices will have to be raised or modified to overcome increased wave overtopping, provided geotectonic stability is maintained.

Salt-water intrusion

Apart of the direct loss of low-lying coastal plains and islands, sea-level rise will cause salinity intrusions further inland primarily through the rivers, which will have implications on low altitude forestry and agriculture. Salt-water intrusion into coastal aquifers will also result and a general raising of water tables can be expected.

Long-term strategy

The dense concentration of coastal populations and the rapid development of coastal areas within the region highlights the seriousness of potential impacts resulting from climatic changes to the region. Coastal zone management plans must take into account these long-term effects and must build in mitigation measures against these future impacts. This will ensure that control measures taken against flooding, erosion, saline intrusion and sea-level rise, can minimise the

expected scales of impact. Groundwater resources and waste management will also need to be considered. Steps will also have to be taken to protect natural coastal ecosystems, as anthropogenic effects often accelerate their degradation to levels which do not allow natural adaptation to changing environmental conditions. Research is required to fill existing data gaps which are considered important in long-term policy planning and responses.

ACKNOWLEDGEMENTS

The authors wish to express their appreciation to the members of the UNEP Task Team on the Implications of Climatic Change in the East Asian Seas region, whose working documents provided much of the material contained in this paper. These documents are listed in the references. The team members apart from the authors are: Dr. Henk Uktolseya (Ministry of State for Population & the Environment, Indonesia), Prof. Tjia Hong Djin (Dept. of Geography, Universiti Kebangsaan Malaysia), Dr. Sieh Kok Chi and Dr. Lee Say Chong (Coastal Engineering Technical Center, Drainage and Irrigation Dept., Malaysia), Dr. Chong Ah Look (Malaysian Meteorological Service), Dr. Jorge G. de las Alas (Dept. of Meteorology & Oceanography, University of the Philippines), Mr. James Paw and Dr. Chua Thia Eng (International Center for Living Aquatic Resources Management, Philippines), Assoc. Prof. Wong Poh Poh (Dept. of Geography, National University of Singapore), Dr. Sangsant Panich (National Environment Board, Thailand), Dr. Suraphol Sudara (Dept. of Marine Science, Chulalongkorn University, Thailand). The authors are also grateful to UNEP for providing travel assistance to enable the second author to attend this special meeting.

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EFFECTS PRODUCED BY CLIMATIC CHANGES AND VARIATIONS OF THE SEA LEVEL IN THE COASTAL AREA OF THE COLOMBIAN PACIFIC

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INTRODUCTION

Colombia is a privileged country in that it is bathed by two Oceans; the Atlantic maritime zone covers an area of 589,160 km^2 and has a coast line of 1,600 kilometres; the Pacific maritime zone has an area of 339,500 km^2 and a total coastal length of 1,300 kilometres (Figure 1). This report, summarises the results of a study conducted to evaluate the potential impacts of climatic change and sea level rise on the Colombian Pacific coastal region.

Colombia is politically and administratively divided into 23 Departments, 4 Intendencies and 5 Commissariats; 4 of the Departments are located on the Colombian Pacific Coast. For the purposes of this report the following divisions of the coastal region are recognised: Choco, Zone 1; Valle del Cauca, Zone 2; Cauca, Zone 3; and Narino, Zone 4.

The geomorphology of the Colombian Pacific coast varies considerably, with a range of features including, shelves, beaches, deltas, marshes and mangrove areas. Communities with their own characteristic, costumes, culture and modes of subsistence have developed around each of these areas according to the environment where they live, but in general, all of these communities depend on the sea as an essential means of support.

During the last four years, the whole country has turned its eyes to the Pacific coast which was for a long time considered a national reserve area. Today, along its coasts, projects important for the national economy have been undertaken and other extensive developments are being planned.

Businessmen both national and foreign, have invested large amounts of capital in the shrimp culture industry. At present, there are 27 shrimp culture industries covering a total of 35,000 hectares of land developed int ponds for the culture of captive shrimp, some 150,000 hectares of mangroves having been left as a reserve area. This industry is concentrated in the Southern part of the Colombian Pacific which is suitable for such development. The port of Tumaco with a population of 100,000 people is located on the Pacific and at present is an important site for development due to its geographical location and because it is an expanding industrial centre. Ninety five per cent of the population are economically dependent on marine products.

In the Central zone we find the largest movements of maritime cargoes through the port of Buenaventura, which has a population of 195,000 inhabitants. In contrast the Northern zone of the Colombian Pacific is today a jungle area, supporting small towns and fishing villages. In the very near future this region will become extremely important due to a construction project; the Darien Inter-oceanic land bridge, that will link the Uraba Gulf on the Atlantic with Cupica Bay on the Pacific.

This report is qualitative and considers possible scenarios since no detailed studies and insufficient data are available to provide accurate predictions of future conditions. Data were obtained from available publications including those of the National Administrative Department of Statistics (DANE, 1987), the National Institute of Geological and Mining Research (INGEOMINAS 1983; 1984; 1985) and from information obtained from the inhabitants of the various regions.

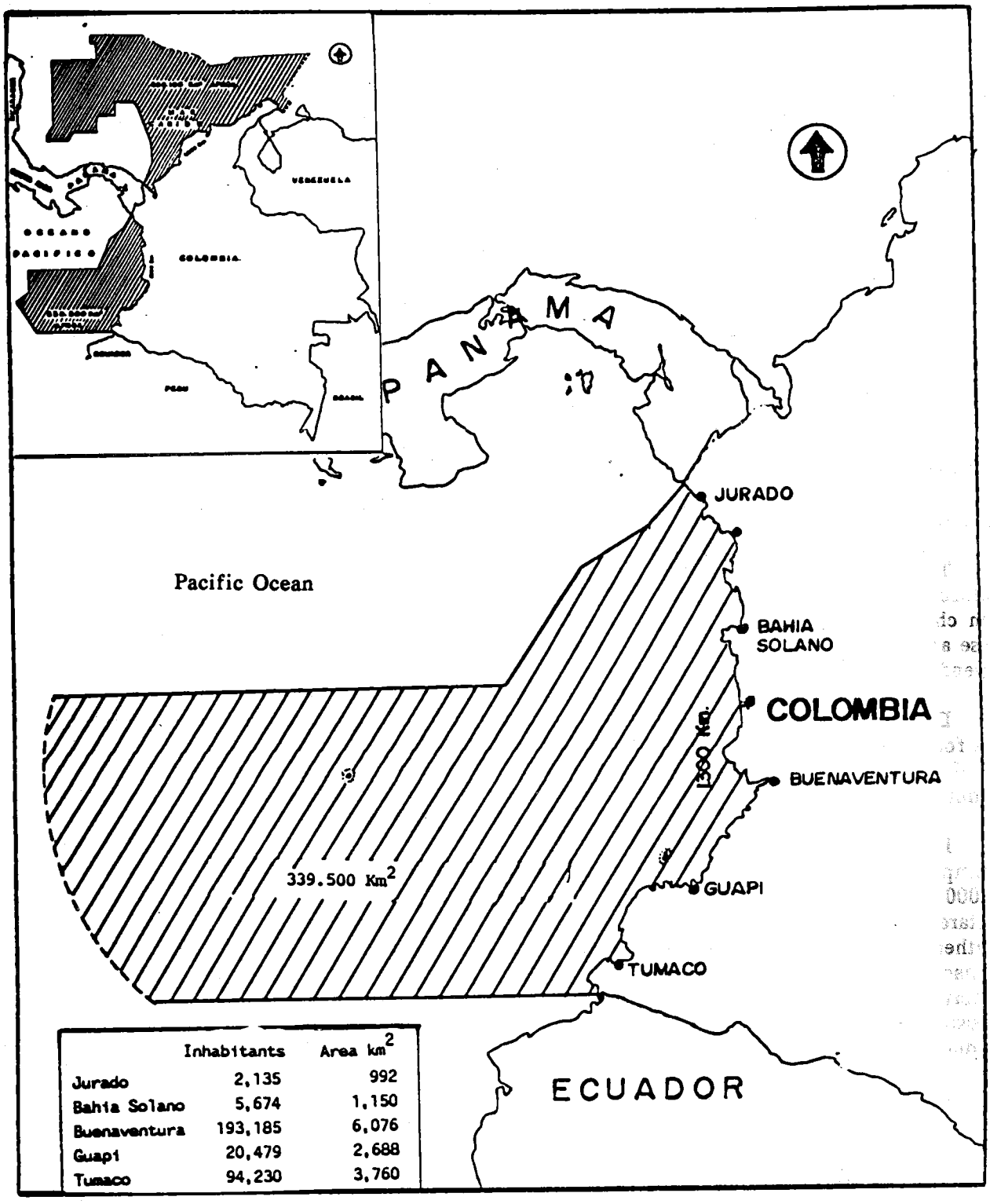

Figure 1. Caribbean and Pacific Maritime areas of Colombia.

Having only a superficial knowledge of some of the more important data relating to the Colombian Pacific and being aware of the significance this region has for the country's development, the need to analyze the possible consequences resulting from changes in sea level and climate is apparent.

FACTORS AFFECTING RELATIVE SEA LEVEL ON THE COLOMBIAN PACIFIC COAST

The approach adopted in this study is based on the global study, "the Impact of increasing Sea Level on Society", (ISOS) a project developed by Delft Hydraulics (Delft Hydraulics, 1989) and facilitated through a Memorandum of agreement signed by UNEP and the Dutch Government. This served as the guide-lines for conducting a small scale study of the Colombian Pacific Coast.

One of the expected consequences of the greenhouse effect resulting from increasing concentrations of CO_2 and other radiatively active gases in the atmosphere, is an expected increase in global mean surface temperature. This effect may produce an acceleration of the rate at which sea level is currently rising. This acceleration is partly due to the thermal expansion of the surface waters of the seas and oceans and partly due to ice melt.

The accelerated change in sea level will have a strong impact on coastal populations, structures, socio-economic systems and ecosystems, especially in the coastal areas subject to erosion and subsidence.

In preparing this paper, the physical factors that affect Colombia, such as its geographic location, the current steady rise in sea level, and the regions with the highest risk in terms of tectonic movements and subsidence and the effects of increases in sea level during "El Nino" events were all taken into account.

In the first instance, the increase in sea level caused by the greenhouse effect, currently considered to be as high as 2.4 mm yr^{-1} may increase in the future to approximately 3.0 mm yr^{-1} if the global temperature is elevated by 0.6-1.0 °C. In this report the assumption is made that by the year 2090 sea level will have risen by approximately 0.3 m. Therefore areas of elevation lower than this would be the first to be impacted and are referred to as the "Primary Impact Area" (P.I.A.) (Figure 2).

Movements of the Naska tectonic plate along the South American Pacific coasts have produced catastrophic earthquakes and cause considerable changes in the coastal geomorphology, particularly in the Southern area of the Colombian Pacific. During the last earthquake in 1979, this region experienced movements resulting in a subsidence and lowering of the land surface by an average of 60 cms. Geological studies carried out by INGEOMINAS show that this region is in a formative geomorphological stage, soils have not yet consolidated and subsidence is continuing resulting in a lowered land surface through tectonic accommodation. This area is referred to as the "Accommodation Impact Area" (A.I.A.).

The third consideration is the variations in sea level which occur during an "El Nino" event where the water mass accumulated on the West returns to the East increasing relative sea level by approximately 60 cms, this is referred to as the "Secondary Impact Area" (S.I.A.) (Figure 2).

The impacts in coastal areas, of all of these factors, together with the normal tidal variations, which range from 0.70 to 3.45 meters, were considered over the next 100 years.

It is clear that the aspects that the "Delft Hydraulics" study used and which are applicable to this paper were taken into consideration as an important and definite guide throughout the preparation of this report.

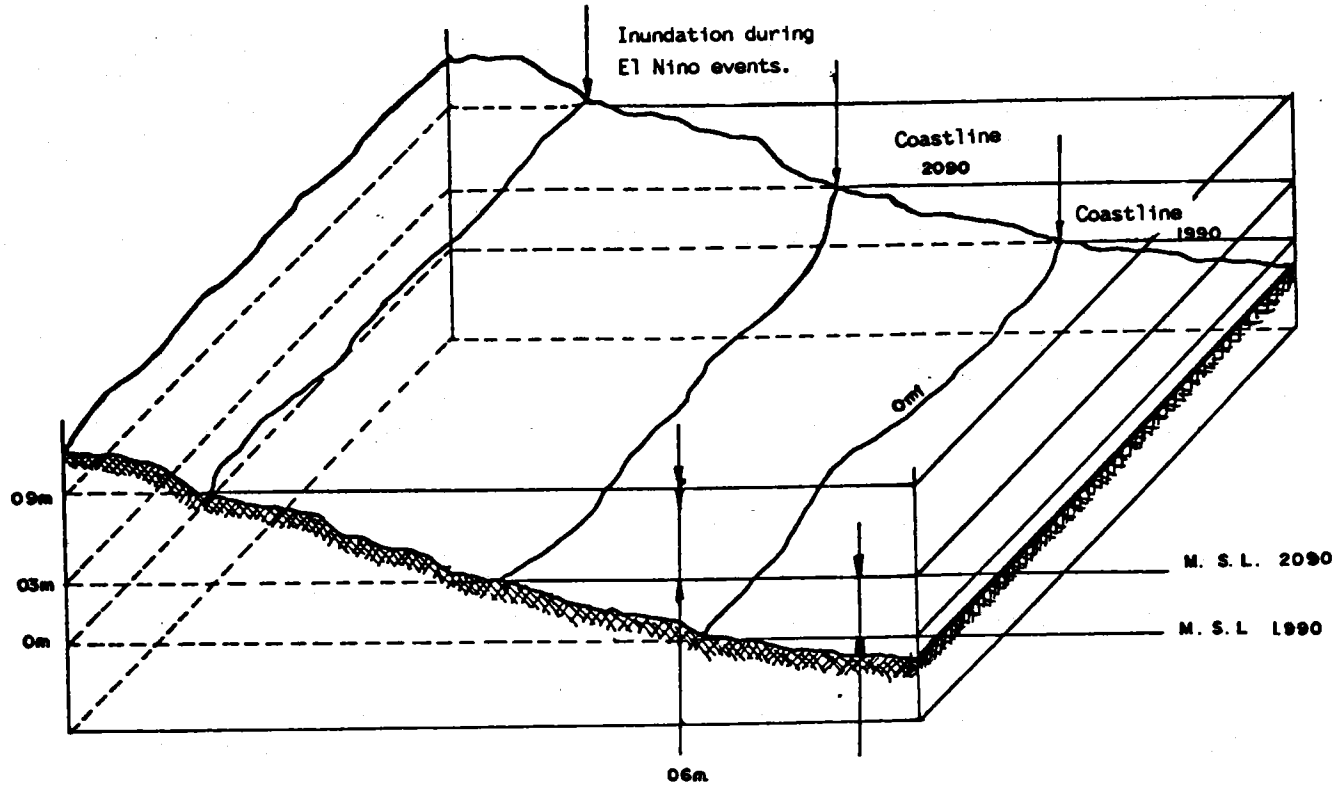

Figure 2. Designation of primary and secondary impact areas.

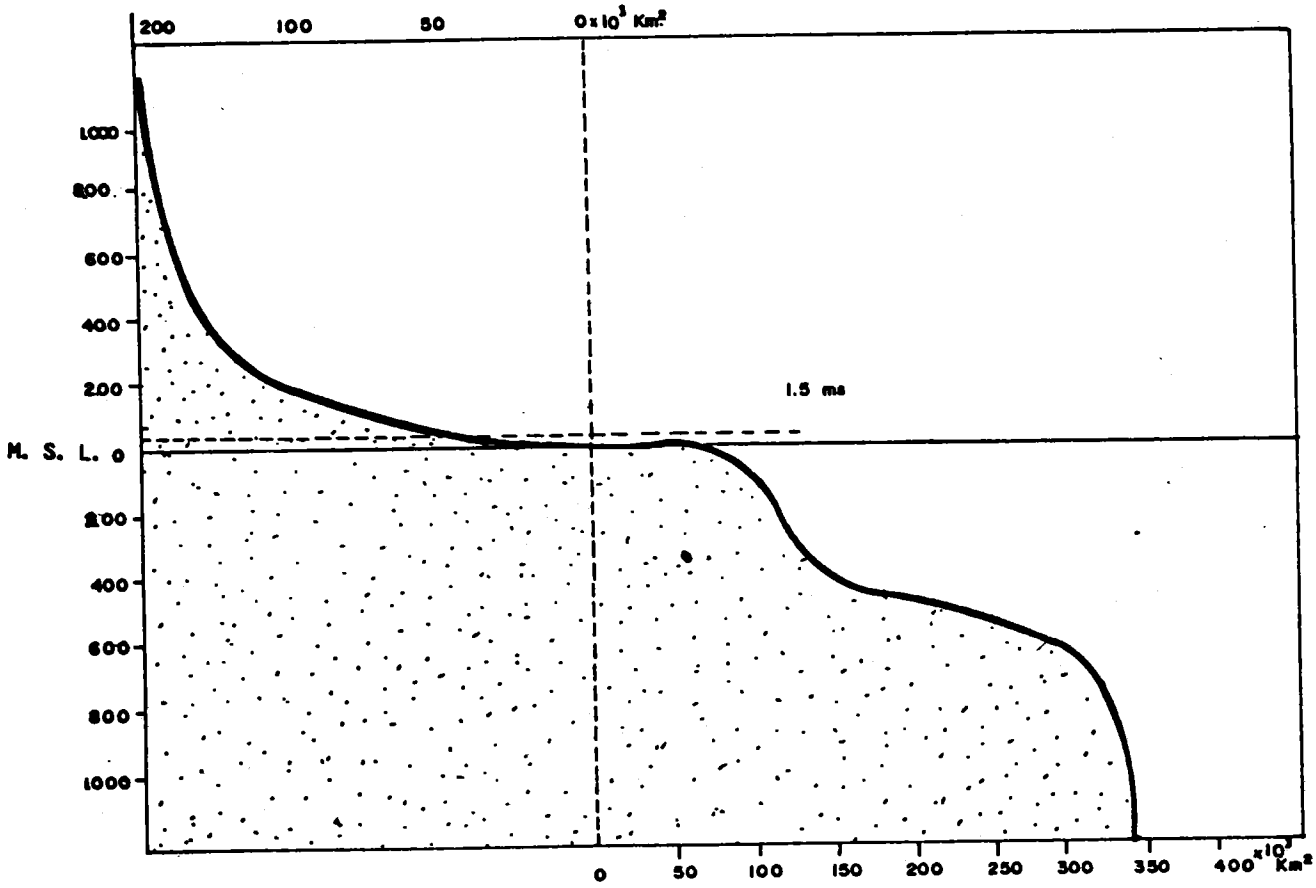

Figure 3. Effect of mean sea level rise on the Colombian Pacific coast.

It is evident that an acceleration in mean sea level as a result of global changes will also result in changes to the wind and wave climates and in the occurrence of storms and other meteorological events that constitute a threat to coastal areas, both directly in the hydrodynamic sphere and indirectly through changes in the transport of sediments and coastal biotic dynamics (Delft Hydraulics, 1989).

The possible impacts that all of these factors may produce, will have direct repercussions on the terrestrial environment, the population, and on the economies of each of these zones which are examined in more detail below since each zone has its own specific features.

GENERAL CHARACTERISTICS OF THE AREA

An overall examination of the Colombian Pacific coast demonstrates that 90% of the shoreline is composed of beaches and tidal depositional areas (Figure 4). From the level of the high tide, families have concentrated to form small towns or villages. There are extensive mangrove forests, especially in Zones 2, 3 and 4 that extend approximately 15 kilometres inland; the shrimp culture industry has concentrated in these areas utilising a large area of land for the construction of culture ponds. Furthermore, estuaries, deltas and marshes occur along the coast and are used by the people of the region to transport and market their products.

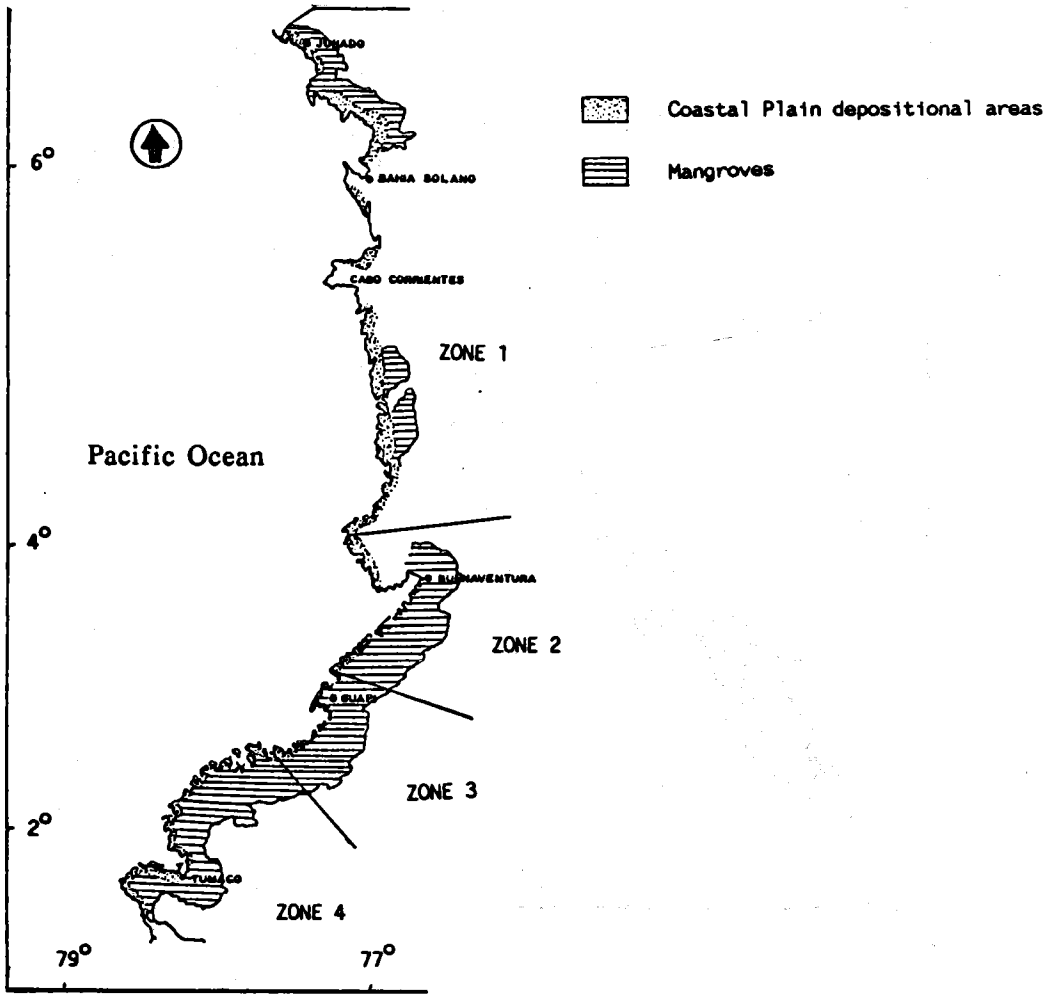

Figure 4. Map of the major geomorphological features of the Colombian coast by zone.

The coastal zone is comprised of two well defined sectors separated by Cape Corriente; to the North the area is high and steep as it is backed by the Baudo mountains; in contrast, the South is low, subject to flooding, covered by mangroves and crossed by numerous distributary branches, narrow channels and marshes used as a means of communication.

RESULTS

Data compiled from field studies carried out by the various agencies working in fields related to the topic of this report demonstrate the recent occurrences of different ocean-atmosphere processes which are altering the shoreline. 100 year predictions of the impacts on the human, geographical and economic factors are summarized by zone in Figure 5 and Table 1, and may be considered as the consequences on this region of the factors outlined above. The predictions are based on population and economic data for 1988 and projections of the physical environment one century ahead on the population and socio-economic conditions of 1988.

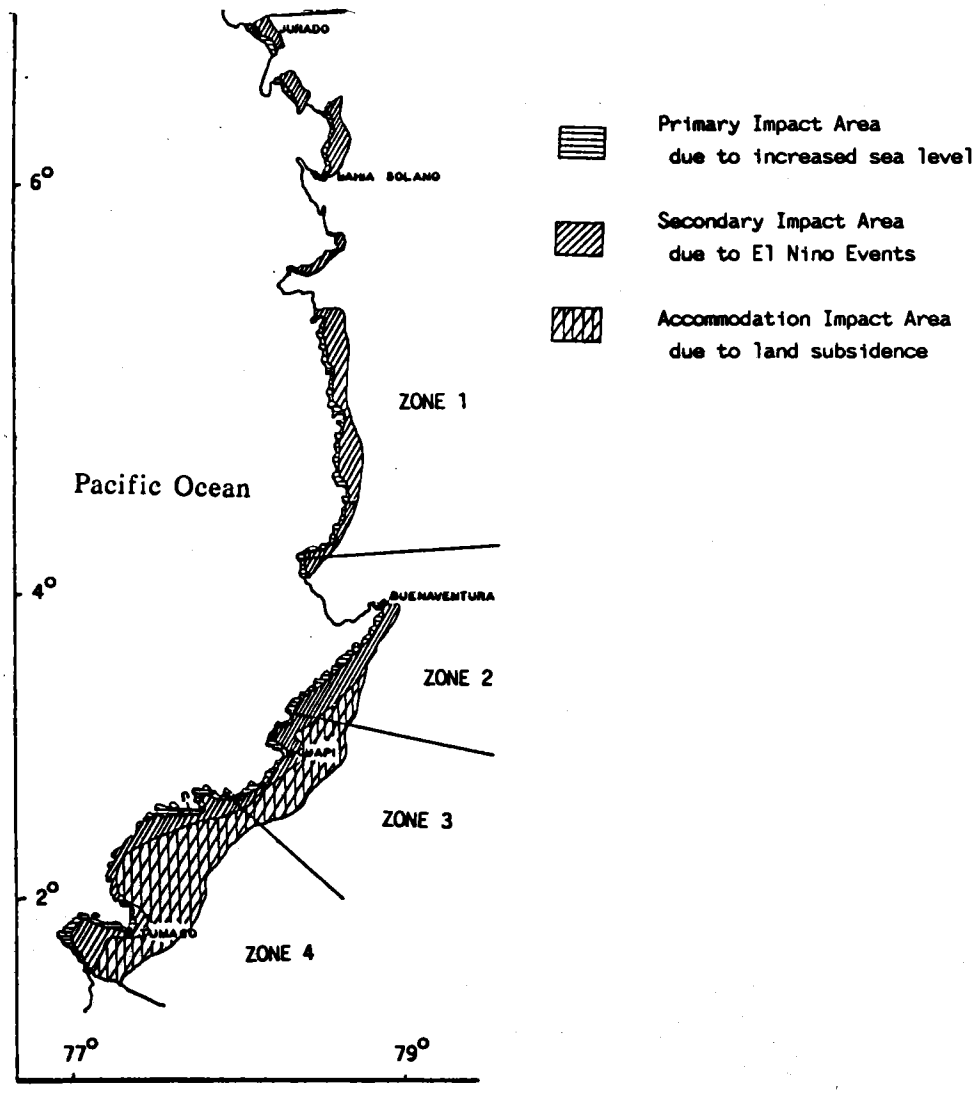

Figure 5. Impact areas by zone in the primary, secondary and accommodation impact categories (see text for explanation).

Table 1. Total land area, population density and numbers of people by economic sector in thecoastal zone of each Colombian Pacific region.

ZONE 1: Northern coastal areas.	Totals	P.I.A	S.I.A	A.I.A	All impact areas
Area km^2	21,310 (42.7)	600 (3)	1,300 (6)	0 (0)	1,900 (9)
Population total	22,155 (6)	1,000 (5)	3,800 (17)	0 (0)	4,800 (22)
Density km^{-2}	1.1	166	2.9	0	2
ECONOMIC SECTOR					
Agriculture	8,150 (40)	0 (0)	2,870 (35)	0 (0)	2,870 (35)
Industry	0	0	0	0	0
Fishing	11,240 (51)	0	0	0	0
Others	2,765 (9)	0 (0)	890 (32)	0 (0)	890 (32)
ZONE 2: North Central coastal areas.	**Total**	**P.I.A**	**S.I.A**	**A.I.A**	**All impact areas**
AREA km^2	6,078 (12)	150 (2)	200 (3)	30 (0.5)	380 (6)
Population total	193,185 (52)	4,800 (2)	18,500 (9.5)	1,000 (0.5)	24,300 (12)
Density km^{-2}	32	32	92.5	3.3	64
ECONOMIC SECTOR					
Agriculture	12,000 (6)	1,200 (10)	2,500 (21)	0 (0)	3,700 (31)
Industry	10,000 (5)	0	0	0	0
Fishing	20,000 (10)	0	0	0	0
Others	30,000 (16)	1,500 (5)	4,000 (13)	500 (2)	6,000 (20)
ZONE 3: South Central coastal area.	**Total**	**P.I.A**	**S.I.A**	**A.I.A**	**All impact areas**
AREA km^2	7,602 (15)	700 (13)	1,600 (29)	500 (9)	2,800 (51)
Population total	32,451 (9)	300 (1)	2,500 (8)	2,500 (8)	5,300 (16)
Density km^{-2}	4	0.4	1.6	5	1.9
ECONOMIC SECTOR					
Agriculture	4,800 (15)	600 (12)	1,300 (27)	1,800 (38)	3,700 (77)
Industry	200 (0.6)	0	0	0	0
Fishing	16,500 (51)	0	0	0	0
Others	10,951 (34)	1,600 (14)	2,500 (23)	2,800 (26)	6,900 (63)
ZONE 4: Southern coastal area.	**Total**	**P.I.A**	**S.I.A**	**A.I.A**	**All impact areas**
AREA km^2	14,940 (28)	488 (4)	2,762 (21)	8,650 (66)	11,900 (91)
Population total	122,769 (33)	4,800 (4)	65,000 (53)	43,200 (35)	113,000 (92)
Density km^{-2}	8.2	9.8	23.5	5	9.5
ECONOMIC SECTOR					
Agriculture	32,000 (26)	4,000 (12)	3,000 (10)	5,000 (16)	12,000 (38)
Industry	8,000 (6)	800 (10)	1,900 (24)	3,500 (44)	6,200 (78)
Fishing	4,500 (37)	0	0	0	0
Others	32,000 (31)	4,000 (11)	13,000 (34)	16,000 (41)	33,000 (87)
Total Area	49,930 km^2 (IGAC, 1983)				
Total Population	370,560 Inhabitants (DANE, 1987)				
Mean Density	7.5 persons km^{-2}				

INGEOMINAS has been conducting studies on coastal geomorphology and the results show that the sea has eroded large areas of land. This is particularly evident in the Buenaventura area, in the tourist complex of Ladrilleros, where the sea has moved 40 m inland of the previous high tide mark. Similarly, in the San Juan River delta, the action of the sea together with the winds, has changed the coastal morphology such that over the eleven months during which this location has been monitored, shoreline retreat has averaged 15 meters. In Zone 2, South of Buenaventura up to Punta Aji, the sea has flooded and killed a large strip of mangroves.

Climatic variations have resulted in impacts in various regions; Zone 1 and part of Zone 2 have the highest rainfall world-wide, reaching up to ten metres a year. During February and March of 1989, there was a 45-day drought (La Nina) that resulted in cracking of the plains, especially those of Juanchaco and Ladrilleros; later, as a result of the rain extensive erosion occurred in this sector.

These are current events, actually documented through field work carried out by experts. Let us now consider what would be the effects on this region of the three sources of change outlined above, namely, change in sea level, occurrence of an "El Nino" event, and subsidence effects, over the next 100 years.

CONCLUSIONS

In the primary impact area, due to the 0.3 m increase, 85% of the shoreline would change, resulting in inundation of approximately 1,938 km^2 of land; flooding would affect 9,900 residents directly and 13,700 people indirectly from a socio-economic viewpoint.

In the secondary impact area, in the event of an "El Nino" occurrence, floods would be more extensive and would cover nearly 4,760 km^2, destroying the dwellings of 89,800 people and affecting another 31,960 persons from the socio-economic viewpoint.

In the accommodation impact area, the most affected sector, would be the Colombian Southwest because as a result of land subsidence an approximate area of 9,180 km^2 would be affected by flooding. In this area, the dwellings of almost 46,700 people would be destroyed and 29,600 would be affected socio-economically.

In general, Zones 3 and 4 would be the most affected due to their topographic conditions and soil characteristics. The emerging industries would suffer a set-back, especially the captive shrimp culture because the pools were not designed taking the effects of sea level changes into account.

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SEA LEVEL RISE AND CLIMATIC CHANGES: POLICY AND PLANNING FOR REGIONAL CO-OPERATION IN THE SOUTH-EAST PACIFIC

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ABSTRACT

Within the framework of the terms of reference provided by UNEP for the preparation of regional studies of the possible implications of expected climatic changes in the marine and coastal environment: the Comision Permanante del Pacifico Sur (CPPS) as the Regional Co-ordinating Unit for the Action Plan for the Protection of the Marine Environment and Coastal Area of the South-East Pacific invited a group of experts from Panama, Colombia, Ecuador, Peru and Chile to participate in the preparation of the South-East Pacific Regional Study.

The experience gained through CPPS programmes and International co-operative investigations in the region, such as ERFEN (Regional Study of EL Nino Phenomenon) and CONPACSE (Monitoring and Research of Marine Pollution in the South-East Pacific) is being applied to the administration and organisation of regional activities related to studies of sea level rise and climatic changes, which are reviewed in this paper.

BACKGROUND

Within the framework of the terms of reference provided by UNEP for the preparation of regional studies related to possible implications of expected climatic changes in the marine and coastal environment, the CPPS as the Regional Co-ordinating Unit of the Action Plan for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific, in consultation with the Intergovernmental Oceanographic Commission (IOC) and the World Meteorological Organization (WMO) invited a selected group of experts from Panama, Colombia, Ecuador, Peru, and Chile to participate in the preparation of the South-East Pacific Regional Study.

The group met in Bogota in December 1987 and decided to adopt the scenarios issued by the UNEP/ICSU/WMO, Villach international Conference (1985) as guide-lines for the preparation of the Regional Report. It was also decided to include the El Nino Phenomenon as a case study, on the basis of the fact that the long term impacts of climatic changes on the ecosystems and socio-economic structures of the South-East Pacific Region might be similar to those which occur during El Nino events

THE EL NINO PHENOMENON

The "EL Nino Phenomenon has been described as the occurrence, along the coastal areas of Ecuador, Peru and Chile of a large scale anomaly in the oceanic-atmospheric interaction, mainly affecting the Pacific equatorial strip but having consequences for many other regions of the world. Such events have dramatic impacts in the coastal areas of the countries of the South-East Pacific which include positive temperature anomalies, and increases in the mean sea level. The appearance of unusually warm waters in this region results in significant alterations to the local meteorological oceanic and biological regimes.

EL Nino events may reflect on a regional basis the conditions which could result from global warming even though the Phenomenon generally occurs over a short time scale. In the coastal areas of the countries of the region positive temperature anomalies occurred during the 1982-83 event of between 2-3°C above mean surface temperature and these were accompanied by sea level increases ranging from 40 to 50 cm. Such values surpass the scenarios adopted by the 1985 Villach Meeting of a 1.5°C rise in sea surface temperature and 20 cm relative sea level rise by the year 2025.

CLIMATIC CHANGE IMPACTS

The report of the Task-Team of Experts on the effects of Climatic Changes in the South-East Pacific Region (CPPS, 1988a) noted that increased salinity in estuarine areas will be one of the most significant physical effects of climatic changes in the South-East Pacific. Climatic changes may also disrupt several, important regional pelagic fineries due to a disruption of schooling and migration patterns, changes in the distribution of species, failures in reproduction and reduced survival of eggs and larvae. The most dramatic biological consequence of a climatic change connected with EL Nino was its effect on the anchovy fishery in the early seventies. In 1970 catch levels reached 13 million metric tonnes in Peru and Chile, then fell to levels of two million tonnes in 1973.

Increases in sea surface temperature could cause adverse effects on coral reefs (see D'Croz, this volume) since during El Nino, bleaching of reefs, due to loss of zooxanthellae has been recorded. Unusually high temperatures and extremely low salinities were responsible for high death rates of the mangrove-associated fauna, although some fisheries resources, mainly molluscs and crustaceans showed high production yield during EL Nino events. In the case of grasslands, a rise in sea level would expand the area currently under the influence of flooding, thereby affecting the composition and distribution patterns of coastal vegetation. Halophytic species are likely to show higher growth-rates and wider distribution.

Extreme droughts in some areas and high rainfall in others, attributable to climatic changes associated with EL Nino resulted in rivers overflowing, erosion of wetland areas and sediment build-up in some areas. Such impacts have severe economic and social costs throughout the South-East Pacific region. The damage sustained by the agricultural sector in terms of crop losses, yield decreases, delays in sowing and increased soil salinity is substantial during each El Nino event. The cattle sector is affected by loss of stock and drying up of pastures, while damage to infrastructure such as airports, roads, bridges, and railroads, results in heavily increased operational and maintenance costs.

Climatic changes cause decline in health and nutritional status and increased mortality as malaria reaches epidemic proportions. Large numbers of urban and rural dwellings are destroyed or damaged during each event. According to some estimates, the 1982-1983 EL Nino event caused losses of approximately US$ 3,500 million in the South-East Pacific Region. The area affected by the impacts represents 12-13 per cent of the countries total surface, and some 950.000 people suffered heavy material losses.

In accordance with the recommendations of the Joint Meeting of the Task Team on Implications of Climatic Changes in the Mediterranean and the Co-ordinators of Task Teams for the Caribbean, South-East Pacific, South Pacific, East Asian Seas and South Asian Seas Region (UNEP, 1988) the South-East Pacific Group of Experts will pursue its work in order to:

a) prepare a consolidated regional report with versions suitable for government policy makers and managers, as well as the general public, schools and students;

b) present the regional report to the Contracting Parties to the Lima Convention;

c) provide the scientific basis for the preparation of a draft regional protocol concerning technical co-operation to combat the negative environmental effects of climatic changes in the South-East Pacific;

d) prepare a regional map of areas and cities highly vulnerable to sea level rise based on the EL Nino records and of other sites expected to be affected by climatic changes;

e) provide the scientific basis for a regional contingency Plan against sea level rise using the EL Nino experience as a guide;

f) prepare a programme for monitoring impacts of climatic changes, specifying areas and sites to be monitored, parameters to be measured, techniques and methods to be used, scale of impacts and training needs; and,

g) offer the Contracting Parties to the Lima convention the organization of national and regional workshops as well as other meetings regarding regional climatic changes.

REGIONAL CO-OPERATION

The coastal countries of the South-East Pacific have derived valuable experience in regional co-operation since the establishment of the CPPS. This organisation was established in 1950 by the Governments of Chile, Ecuador and Peru, and was later joined by Colombia in 1979. In addition to being responsible for monitoring the implementation of laws regulating maritime policies in their member countries and the co-ordination of political and legal efforts involving the protection and promotion of the principles of the Santiago Declaration, the CPPS directs its activities towards specific goals, with emphasis on the following:

i Protection, preservation and exploitation of resources existing within the 200 mile exclusive economic zone;

ii Regulation, exploration, exploitation and management of living resources;

iii Protection and Preservation of the marine Environment; and,

iv Promotion of scientific research.

In the framework of these objectives, the CPPS has given priority to two cooperative regional programmes: the Regional Study of EL Nino Phenomenon i.e. (ERFEN); and, Monitoring and Research of Marine Pollution in the South-East Pacific (CONPACSE).

ERFEN is a co-operative and multi-disciplinary programme developed in the seventies in which eighteen scientific institutions from the CPPS countries take part. The Programme is supported by the Intergovernmental Oceanographic Commission and the World Meteorological Organization. Within the framework of the CPPS research activities are evaluated annually by the ERFEN scientific committee, which is the technical co-ordinating body that recommends adjustments to the work programme. This committee also prepares joint reports on the progress of the oceanographic, biological and meteorological research undertaken in the geographic area covered by ERFEN (Avaria, 1985). Joint IOC/WMO/CPPS Group reports on these activities are made at the international level and the ERFEN programme is linked to many other global programmes concerned with the ocean-atmosphere interactions, amongst which are the Tropical Ocean Global Atmosphere programme (TOGA), being implemented through TOGA-Pacific. ERFEN is also linked with the El Nino Southern Oscillation (ENSO) programme which, in addition to IOC and WMO involves the participation of other organisations such as the United States National Academy of Sciences. As far as the biological component is concerned, ERFEN is linked with the Ocean Sciences in Relation to living Resources (OSLR) through the International recruitment Programme (IRP) (Jordan, 1985).

The Chapman Conference and International Symposium on the "EL Nino Phenomenon" (IOC/Unesco, 1986), highlighted the need for all information derived from ERFEN to be related to socio-economic impacts and that appropriate institutional arrangements should be developed. To implement this, a project on the socio-economic impacts of El Nino is being developed by the CPPS. this project involves the planning offices of the regional countries, together with all marine research organisations in the region. A UNDP-ERFEN project, recently negotiated by the CPPS, and involving the participation of IOC, also incorporates a socio-economic component. Since 1979 the CPPS has convened seven meetings of the ERFEN scientific committee; a regional workshop on the 1982-1983 El Nino event; an emergency meeting on the 1987 El Nino event and a technical consultative meeting on the socio-economic effects of El Nino in the South-East Pacific. All these meetings have helped to improve planning and policies concerned with regional co-operation, particularly in aspects of the co-ordination of joint scientific research (CPPS, 1988b)

In relation to CONPACSE, agreement on four complementary legal instruments, currently in force, provides the framework for a strategy aimed at the prevention and control of marine pollution in the South-East Pacific (CPPS/UNEP, 1983; UNEP, 1984). these have been developed within the overall framework of the Action Plan for the Protection of the marine Environment and coastal areas of the South-East Pacific. This Action Plan is currently being implemented by the Governments of Columbia, Chile, Ecuador, Panama and Peru, with the support of the United Nations Environment Programme and other international organisations. Activities under the Action Plan are co-ordinated by the CPPS. These instruments are as follows:

1) Convention for the Protection of the Marine Environment and Coastal Areas of the South-East Pacific (Lima, November, 1981);

2) Agreement on Regional Co-operation in combating pollution of the South-East Pacific by hydrocarbons and other harmful substances in cases of emergency (Lima, November 1981);

3) Supplementary protocol to the agreement on regional; co-operation in combating pollution of the South-east Pacific by hydrocarbons and other harmful substances (Quito, July 1983);

4) Protocol for the protection of the South-east Pacific against pollution from land-based sources (Quito, July 1983).

These legal instruments were ratified by subscribing Governments and came into force in 1987. The Extraordinary Intergovernmental Meeting of Governments participating in the Action Plan, held in Bogota, Colombia, in April 1987, approved Resolution No 3 which entrusts the CPPS, with the support of UNEP and other related institutions, with the task of developing a draft protocol for the Protection of sites of National, Tourist, Historic and cultural value in the South-East Pacific. The Commission has also been entrusted with preparing a draft protocol to evaluate environmental impacts of development on the Marine Environment and Coastal Areas of the South-East Pacific (CPPS/PNUMA, 1987).

From the institutional stand-point, a strategy based on the establishment of a regional network of National Institutions, co-ordinated at the local and regional level, was approved by Government members of the South-East Pacific Action Plan, at their first Intergovernmental Meeting, held in Quito, Ecuador in July 1983. The network was entrusted with the task of implementing the operational stages of the Plan by means of their participation in two priority programmes of regional concern and in the implementation of a Regional Contingency Plan to Monitor Oil Spills. These programmes are: Research, Surveillance and Monitoring Programme on Marine Pollution in the South-East Pacific and its Effects on Marine Communities in Selected Areas; and, Identification, Surveillance and Monitoring Programme of Marine Pollution from Domestic, Agricultural, Industrial and Mining Sources in Ecologically Vulnerable Areas of the Pacific, including Laboratory Research to assess the Effects of Pollution in Marine Organisms.

The institutions appointed to participate in the Regional Network are co-ordinated by National Focal Points at the local level. In respect of financial matters, the Regional Action Plan

foresaw the establishment of a Trust Fund (South-East Pacific Trust Fund) supported by contributions from member Governments, both monetary and in kind, together with contributions from International organisations including UNEP. The purpose of this Trust Fund is to provide financial support to research activities. The funds are accounted for as institutional support funds and co-ordination expenses and to assist those activities considered of immediate concern by intergovernmental meetings.

Each programme has included the development of a training component, intercalibration and inter-laboratory comparison exercises with a view to maintaining analytical quality and ensuring precise results, thus permitting comparison of results from different laboratories and reproducibility between sampling periods. Each programme has included organisation of workshops and meetings as venues for the discussion of topics of regional interest and for the distribution of guide-lines, standards, techniques and methods aimed at maintaining regional capabilities at an appropriate level.

The Regional Action Plan has been evaluated on three different occasions from the time of its approval, in 1981. Each time, with the support of UNEP, the CPPS has reported to member Governments on the developmental status of the Action Plan, on obstacles hindering its realization and of the achievements of its work. Each report has expanded on matters of concern at the national level and has demonstrated improvements in training activities and the quality of data. The Extraordinary Intergovernmental Meeting, convened by the CPPS upon the request of the Government of Colombia, in April, 1987, approved the extension of the Regional Action Plan and introduced new elements with the purpose of further facilitating the implementation of the regional Action Plan. The achievements made under the Action Plan between 1980 and 1986 were reported by Fonseca (1988) in the previous UNEP sponsored Symposium on Regional Co-operation in environmental protection of the marine and coastal areas of the Pacific held in Korea in August 1987.

The experience gained from these two CPPS Programmes must be considered in implementing future regional activities related to studies of sea level rise and climatic changes. The legal frame of reference for such activities can be taken as the Convention for the protection of the marine Environment and Coastal areas of the South-East Pacific and its supplementary agreement (UNEP, 1984). The policy planning and co-ordinating unit for the regional Action Plan has supported the work of the regional task Team on the implications of climatic change for the region.

INTER-REGIONAL CO-OPERATION

According to Dahl (1988) inter-regional co-operation should be developed at the levels of international agencies, governments, research institutions and even individual specialists. The necessary steps in fostering inter-regional co-operation are to define the areas of common interest, and to define the kinds of co-operation that would be most effective then to analyse the problems that make inter-regional co-operation difficult, trying to identify the best ways to overcome them. Some efforts in this regard, in relation to Climatic Changes, have already been made in the Split Meeting (UNEP, 1988). For the continuing work of the Task Team established under the umbrella of the UNEP Regional Seas Programme a specific recommendation was made relative to enhancing the co-operation between the Task Teams in order to benefit from their broader global perspective and from experience gained in dealing with similar issues and problems.

As was expressed by the CPPS member countries in the Declaration of Vina del Mar in 1984, the CPPS has a role under its mandate to expedite co-ordination between the South-East Pacific region and the rest of the Pacific Basin (CPPS, 1985). At the third Meeting of Foreign Affairs Ministers of the CPPS member States, which took place in Quito, Ecuador in December 1987, the Declaration of Vina del Mar was re-affirmed and the Secretary General was asked to develop a Plan of Action for the expansion of co-operation in the Pacific basin (CPPS, 1988c). At

the same meeting the necessity for providing international co-operation was stressed , emphasising the need to establish agreements on technical and financial assistance with United Nations Agencies and other public and private organisations.

These agreements reflect the desire of the CPPS member states to strengthen regional co-operation and relations with the other Pacific basin countries and with global programmes, backed by the United Nations specialised agencies. Given the above conditions a very promising future can be envisaged through the actions undertaken by the CPPS, oriented towards the environmental protection of the marine and coastal areas of the Pacific Basin.

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REGIONAL, INTER-REGIONAL AND INTERNATIONAL CO-OPERATION IN PLANNING FOR CLIMATE CHANGE: THE CASE OF PACIFIC ISLANDS.

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ABSTRACT

A large number of States in the Pacific, Indian and Caribbean Oceans, have extremely small land areas but extremely large maritime, exclusive economic zones, such that land forms less than 0.0001% of the total area falling under national jurisdiction. Of these oceanic states, countries composed of atolls such as Kiribati in the Pacific and the Republic of the Maldives in the Indian Ocean face severe consequences as a result of global warming and sea level rise.

The environmental problems of oceanic States in general and the capital cities of such countries in particular are currently extreme. Present problems of environmental management such as sewage and solid waste disposal; oil pollution, freshwater supply, and coastal erosion are already critical in these countries. These problems are briefly reviewed as are the potential impacts of climatic change and sea level rise on the insular countries of the Pacific basin.

In the face of global climatic change and sea level rise many of the existing environmental problems will be accentuated. A failure to solve current problems may leave such countries highly vulnerable to changing environments.

Whilst the will to address the problem of sea level rise and climatic change undoubtedly exists in countries such as the Maldives, the economic and manpower resources to tackle their particular problems are either lacking or extremely limited. In this connection it is important to note that small oceanic islands have not contributed to the causes of global warming yet they may be both the first to suffer and the most dramatically affected. It is incumbent upon the international community in general and the industrialised nations in particular to both recognise the peculiar problems of such states and to mobilise the necessary resources that will enable such states to plan for a sustainable future.

INTRODUCTION:

Following the UNEP/WMO/ICSU conference to assess the role of carbon dioxide and other so-called greenhouse gases on climatic change (WMO, 1986) and the subsequent meetings in Villach and Bellagio, (WMO, 1988), world attention has been focused at a number of levels on the issues of climatic change and sea level rise. Although world leaders have stressed the need for developing policy and planning guide-lines to address the consequent impacts of predicted changes, the mode by which such guide-lines might be developed has yet to be identified.

Several of the larger developed countries have established National agencies or committees, empowered to examine the nature of predicted impacts and assess what alternatives exist for mitigating or preventing the predicted impacts. In contrast, most developing countries have yet to establish such national entities and more importantly few possess the indigenous financial or manpower resources to adequately address such issues. International agencies such as the Intergovernmental Panel on Climate Change (IPCC) have, through various working groups, commenced evaluation of the likely implications of predicted changes for various systems and

processes, yet the membership of IPCC and its working groups is almost exclusively confined to the developed countries of the northern hemisphere.

Recognising that certain of the least developed states, which include many of the smaller insular micro-states of the Pacific Basin, Indian Ocean and Caribbean do not have the capability to individually address policy and planning implications, the Oceans and Coastal Areas Programme Activity Centre of UNEP, in collaboration with other agencies such as the Intergovernmental Oceanographic Commission of Unesco, established, from 1986 onwards, a series of regional task teams whose brief was to examine the potential impacts of climatic change and sea level rise on terrestrial and marine ecosystems; on coastal environments and on the socio-economic structures of the countries within each region. Much of the data presented here are drawn from the work of the South Pacific Task Team.

THE GEOGRAPHY OF THE INSULAR STATES OF THE PACIFIC AND INDIAN OCEANS:

The Pacific Basin, contains a number of independent micro-states, dependencies and territories of major powers such as the United States, France, United Kingdom, Australia and New Zealand. For most of the 25 "countries" the land area is insignificant in global terms, being just over half a million square kilometres, of which 85 percent is contained within the boundaries of Papua New Guinea.

In contrast the areas of the exclusive economic zones are considerable and for most Pacific countries land forms less than 0.0001% of the area within the exclusive economic zone. An isolated atoll as small as one square kilometre and having no neighbouring islands represents an area of marine resources covering some 125,000 square kilometres. It is hardly surprising therefore that most countries of the region depend upon marine resource exploitation both for subsistence and commercial use. Many countries in Micronesia depend heavily on pelagic fish resources such as tuna, as a major source of income for development.

Pacific islands vary from low lying atolls at or below 4m above sea level to high volcanic islands with steep profile. Island relief is important both in terms of the potential impacts of sea level rise including coastal inundation and in terms of rainfall levels and run-off patterns. The impacts of climatic change will therefore differ in islands of differing relief.

The archipelagic States are composed of islands which can be divided into four major physical categories having different susceptibilities to potential impacts resulting from changes in sea level. A relative index of the physical vulnerability of Pacific Island countries in relation to their land area, altitude, insularity and various other parameters was developed by Pernetta (1988b), who identified four categories of susceptibility to climatic change and sea level rise. Countries at highest risk were identified as being those composed solely of atoll islands.

ISLAND TYPES

Islands of volcanic origin, are some of the highest in the Pacific with a generally steep profile and rapid oceanic drop-off into deeper waters. Within the tropical and sub-tropical zones they are usually surrounded by fringing or barrier coral reef systems of high productivity. In general, orographic rainfall is high, as is surface run-off in the form of streams and rivers. Soils are frequently fertile and the dominant vegetation is closed canopy rainforest in areas of high annual rainfall, or more open forest on drier islands.

Islands of mixed geology include those with a volcanic core and raised sedimentary facies, usually reef limestone, together with larger islands of more complex geology such as New Caledonia and New Guinea. Altitude and profile vary both within and between islands as do soils

and surface water bodies. Forest associations of differing composition dominate the natural vegetation of these islands.

Coral islands are composed of raised limestone of coral reef origin, soils are generally much poorer than those of the preceding types and surface freshwater is generally absent. Freshwater for drinking and agriculture is obtained from the subterranean freshwater lens. The vegetation although of forest type is more restricted in diversity and with a less complex layering of the canopy.

Atolls are coral reefs growing on submerged volcanic cones (Guyots). When present, atoll islands are piles of bioclastic sand heaped onto the surface of the reef flat. Called motu in the Pacific, such islands are generally no more than 4 meters above present sea level and are formed in long narrow strips either entirely enclosing a central lagoon or forming a series of small islets around its periphery. Such islands are dynamic and highly susceptible to total destruction through hurricanes; they are biotically impoverished and freshwater is confined to a small underground lens. Many such islands are currently uninhabited and they presently represent a marginal habitat for human existence.

HUMAN POPULATIONS:

In terms of density, population levels are high for most of the archipelagic States, up to 386 people per square kilometre. The absolute numbers of people are small in global terms with some of the smallest micro-states in the world both in terms of land area and population being found in the Pacific Basin.

Most island States have high population growth rates by world standards and the rate of emigration is high from Pacific micro-states. The largest polynesian city in the world is the city of Auckland, New Zealand, whilst more Tokelauans now live in New Zealand than live in Tokelau.

Not only is the rate of out-migration high but internal migration rates are also high with the remaining populations tending to aggregate around centres of services such as Tarawa in Kiribati, and Majuro in the Marshall Islands (Connell & Roy, 1989). Eauripik Island in the Federated States of Micronesia had a population density of 950/km2 in 1980, Majuro in the Marshall islands has a density of 2,188/km2

Out migration forms an important source of revenue through remittances and indeed many insular communities have become dependent upon the export of labour in order to maintain the local standard of living (Connell & Roy, 1989). In part high birth rates in some insular states are a social response to the perceived need for children both to support their parents at home in their old age and to emigrate overseas to remit money for subsistence (Schultz & Tenten, 1979; Chambers, 1986 cited in Connell & Roy, 1989).

In cultural terms the island states of the world contain a disproportionate section of the worlds cultural and linguistic diversity. Over a third of the worlds languages are spoken in four countries in Melanesia (Papua New Guinea; The Solomons; Vanuatu; and New Caledonia) and each island group is home to distinctive human cultures, having their own social and cultural mores, dance, dress, traditional knowledge and technologies. To preserve such ethnic diversity following migration to a larger, developed and more culturally uniform society would be difficult if not impossible. In part the cultures reflect the ecological and environmental characteristics of the island home and movement away from that environment would automatically weaken those elements of traditional culture dependent upon the native environment for reinforcement in each generation.

Most island societies therefore view emigration as a temporary solution to transient problems and the reaction to forced migration in response to a degrading environment and climatic change is difficult to predict. Social problems in Pacific societies resulting from forced migration albeit to other islands rather than to neighbouring developed rim countries, have been reviewed by O'Collins (1988; 1989) who concluded that emigration is likely to place severe strains on the migrant community, its host community and the resident sector of the community which resists emigration until the ultimate point of non-sustainable continuance on their traditional island home.

Economically most of the micro-states are viewed by western economists as non-viable at the present time, being heavily dependent upon remittances, aid and development monies for their present survival. As suggested by Connell and Roy (1989) this dependence on outside sources of financial assistance is a consequences of the western-style economic structures which developed pre-independence, and have continued into the post-independence era due to a lack of available alternative modes of development rather than through active choice and decision on the part of the Governments concerned.

Regrettably whilst health care has greatly improved in many island nations over the last two decades the consequent high survival of children has resulted in pressure on other social services such as education, which have been unable to cope with the exponential increase in school aged children. The consequence of this is a dramatic shortage of skilled manpower in all fields and at all levels in most island communities (For a review of scientific and technical manpower production in the Pacific, see Pernetta, 1984).

CURRENT ENVIRONMENTAL PROBLEMS IN ARCHIPELAGIC STATES

Pollution problems in coastal environments

As a consequence of past development strategies, population growth, inter-island migration and the breakdown of traditional social and cultural values, many insular societies demonstrate extreme environmental degradation.

Problems resulting from inadequate sewage disposal are widespread and range from contamination of drinking water supplies, eutrophication of enclosed lagoons, and human health problems. Solid waste disposal is a problem for all small islands, where land for dumping is unavailable. Solid wastes vary in size from items of plastic packaging to cars and ships, with the cars often being disposed of in the coastal marine environment simply because of the absence of alternative sites for disposal. Toxic chemicals including pesticides form an environmental hazard of great importance in small islands (Mowbray, 1986) particularly when disposal is required.

Virtually all sources of land based pollution in developing Island nations are imported. Few States, have any internal industrial capability which is generally confined to larger, high island states and includes mining and ore processing, large scale agriculture and processing of products such as sugar and palm oil. For most small, atoll based States some fish processing and drying of copra may be undertaken but by and large secondary processing with its attendant environmental problems occurs outside the countries producing the primary product.

Physical manipulation of coast-lines

Perhaps more significant at the present time, and of greater importance in the context of future climatic changes are the environmental problems resulting from physical manipulation of fragile island environments, particularly in terms of stabilisation of the shorelines, and the construction of harbours, wharfs, jetties, piers, groynes and other structures which modify the

local current and sediment transport regimes, resulting in erosion at other points in the archipelagic system. In some instances major biological changes have occurred in atoll lagoons as a consequence of joining, by means of solid structures previously isolated motu to form single long islands. The gaps between the motu in atolls function as channels for the interchange of lagoon and open ocean water and closing such channels has resulted in major environmental problems as for example in Tarawa lagoon in Kiribati.

In many States increased populations have resulted in increased demand for construction materials leading to mining of lagoon sediments for construction sand, or in some instances mining the coral substrate on which the entire nation depends. Not only do such activities cause direct environmental damage but increased turbidity may affect neighbouring coral communities and the area of impact may be quite extensive, beyond the confines of the dredging or mining area.

Many of the current, pressing environmental problems of the small island states will be accentuated both by climatic change and sea level rise; and by the unrestricted growth in human populations. It is apparent that a failure to adequately manage current environmental problems will leave such island nations highly vulnerable to the predicted climatic changes and hence, any policy assistance designed to assist such states in planning for climatic change and sea level rise must take an holistic view which includes the management of current problems.

IMPACTS OF CLIMATIC CHANGE:

Climate and weather

Of major importance to the small island states will be changes in regional circulation patterns which can be expected to change local climates quite dramatically. The absence of adequate regional and sub-regional climatic models which enable prediction of changes in rainfall patterns poses distinct difficulties in predicting impacts.

McGregor (1988) predicts changes in rainfall amounts in different areas of the Pacific depending upon the predominance of Southeast or Northwest season rainfall, and changes in seasonal duration. A northwards shift of the tropical convergence zone may result in changes to the surface wind patterns, oceanic currents and zones of upwelling. Changed wind patterns will impact via waves on depositional beach plan forms, resulting in increased shore-line retreat and erosion in some areas. Changes in the distribution of zones of upwelling may affect both subsistence and commercial fisheries production within the exclusive economic zones of Island States.

Frequency of cyclonic storms may increase in some areas currently just outside the hurricane belt such as the Milne Bay Province of Papua New Guinea, in Vanuatu and the Solomons for example. Changes to both rainfall patterns and temperature may be expected to impact terrestrial biological and human communities through changes in evapo-transpiration rates, humidity, run-off and groundwater supplies. Although impacts will vary, increased temperature will generally increase evapo-transpiration rates thus increasing drought stress in areas of current water limitation. In areas where wilting of agricultural crops is currently a serious problem an increase in the number of wilting days per annum may be expected.

Vegetation responses

Direct impacts of climatic change on vegetation include vegetational responses to carbon dioxide directly (with potentially enhanced growth of some species); to temperature and to water balance. The latter two sources of impact can be expected to have the greatest effects on natural

and anthropogenic vegetation although the impacts will vary greatly on a geographic basis dependent upon local changes in circulation patterns and rainfall.

Altitudinally delimited vegetation zones in the larger Melanesian islands of the Pacific will rise by around 330m but the time lag for the vegetation response following temperature rise is unknown. Alpine grassland habitats will be decreased in Papua New Guinea by more than 50% and will be confined to no more than 10 isolated areas. Such habitats are not found elsewhere in the region but corresponding decreases in the vegetation formations at higher altitudes on smaller islands will occur. Lower and mid-montane rainforest from 1400-2300 m altitude will experience increased human impacts due to the improved agricultural productivity which will occur in this zone.

The savannah/lowland rainforest boundary in areas of low rainfall will change towards savannah. Marginal ecotones and relict habitats will be decreased or disappear, the extent of this problem in the Pacific region is unknown.

All of the above effects can be expected to have major tertiary implications in terms of species loss; conservation; and changes in species composition with r-adapted species being at least initially favoured in comparison with k-adapted species.

Under warmer and drier conditions which will occur in some areas increased capillarity in limestone island soils may change the sodium calcium balance in the soil hence reducing soil fertility. In contrast under conditions of increased rainfall increased erosion might be expected in areas where land use practices are not designed to reduce soil loss.

Vertical shifts of the position of mean annual isotherms will extend the altitudinal limit of important subsistence crops. This will occur through an increase in the length of the growing season at higher altitudes; reduction in the number of days of frost; increased yield and reduced time to harvest (Hughes & Sullivan, 1988). Since the present limits to agriculture correspond to climatic limits reflecting land pressure in the highlands of Papua New Guinea, subsistence farmers can be expected to extend their agricultural activity to higher altitudes. Such changes in land use may have profound impacts on human demographic patterns in the highlands of New Guinea but will have lesser impacts in other Pacific Island States where the areas of land outside the current altitudinal limits of agriculture are absent or greatly restricted in extent. Increased subsistence activity will result in reduction of the extent of upper montane forests which cannot be expected to respond with a corresponding upwards altitudinal shift as rapidly as human activity patterns.

Forestry in rainshadow areas may be adversely affected by decreased rainfall, as will many commercial and subsistence crops which may require irrigation. Irrigation may be successfully increased as a response to crop wilting only in those areas where surface run-off and/or underground aquifers provide a large enough water resource. It is likely that in most areas affected by increased drought these two sources will prove inadequate for such purposes.

Changed temperature regimes apart from their direct effects on crop plants may be expected to influence agricultural production through changes in other components of the natural/agricultural system. Agricultural crops which are stressed by increased temperature and/or changed rainfall may become more susceptible to diseases, particularly pathogenically caused diseases such as bacterial wilt. The generation time of pests may be changed such that more than one generation may affect a single crop generation hence the impacts may be changed. Pollination and seed set may be adversely affected in species which are pollinated by animals through changes to the natural pollinator populations.

The nature of the resource may itself be changed, winged beans for example set tubers only under certain conditions of temperature and water availability. Stock fertility (particularly males) may be adversely affected by increased temperature. The balance between plantation and small-holder production of important cash crops may be affected, thus causing changes to national economies. Coffee in the highlands of Papua New Guinea for example is grown by both small

and large scale producers, an upward altitudinal shift will favour increased small-holder production on somewhat steeper slopes than larger plantation production which at present is largely located on the lower valley floors. Small holder coffee is of a generally more variable quality than that produced through plantation systems.

Disease and human comfort

In general epidemiological patterns can be expected to change as a consequence of changed climatic patterns. Warmer, drier conditions as predicted to occur in some areas will result in increased wind born dust, hence an increase in respiratory inflammation/infections. The patterns of incidence of tuberculosis, other respiratory diseases and skin infections can be expected to change with increases occurring in areas of higher rainfall and humidity. Perhaps the most dramatic change to health patterns in the Pacific is likely to occur through changes in the distribution patterns of vector borne diseases, in particular malaria. Altitudinal shifts in the distribution of the mosquito vector of malaria can be expected to result in chronic malarial rates occurring in the highly populated highlands of Papua New Guinea. These populations are currently at and beyond the altitudinal limit of the mosquito vector. This impact is unlikely to be important elsewhere in the Pacific since malaria is confined to Melanesia and in the Solomons and Vanuata no major centres of population are found outside the altitudinal limit of the vector.

Other regionally important vector borne diseases include filiariasis and dengue fever. Areas which experience increased rainfall and extended wet seasons are likely to experience extended breeding seasons for the mosquito vectors and hence increased frequency of outbreaks and cases of these diseases. Areas where such diseases are currently of low frequency are generally rather dry with distinct seasonal rainfall, they are unlikely to experience increased incidences of these diseases.

As measured by the relative strain index there will be a generally widespread deterioration of climate from the point of view of human comfort throughout the tropical Pacific and Indian Oceans. This will be particularly so in areas of current high humidity (McGregor, 1988). Changes to temperature and humidity affect work efficiency and whilst this may be uncontrollable in an external environment, buildings are frequently environmentally controlled. More buildings will require air conditioning or electric fans, hence increased power consumption and economic costs will result. Dramatic changes in architectural design and building materials will also be required. We can expect that workers in the primary sector will have reduced productivity, whilst workers in the service, industrial and commercial sectors will require increased environmental control if current productivity is to be maintained. Some areas within the region are currently close to the limit normally taken as that for human habitation, many of these will exceed this limit under the climatic regimes predicted (McGregor, 1988).

IMPACTS OF SEA LEVEL RISE:

Inundation and flooding

Permanent coastal inundation can be expected to occur to a significant extent in areas of high islands where the coastal profile is flat or gently sloping. The extent and nature of land loss is estimated in a number of case studies presented in Pernetta (1988a) and Pernetta and Hughes (1989) and inundation will be extremely important economically, since in the Pacific most fertile agricultural areas are at, or close to present sea level. In addition many roads and most urban centres lie in close proximity to the sea. Loss of coastal agricultural areas will result in increased agricultural activities inland, frequently in areas of increased slope with consequent increases in erosion and soil fertility problems.

In the case of high islands there will be an overall decrease in the extent of low-lying wetlands, with a corresponding decrease in freshwater species diversity and abundance for most catchments in Melanesia. By and large the biggest estuarine/deltaic systems in the region are backed by relatively flat coastal plains. Coastal regression may be extensive in such areas resulting in reduced habitats for some species of conservation concern such as crocodiles and turtles.

Inundation of outlying islands and loss of land above the high tide mark may result in loss of exclusive economic rights over extensive areas of the marine environment, this potential problem is of concern in the case of several of the smaller atoll States.

Episodic flooding of the coastal zone may be expected to increase both in frequency and geographically as a consequence of increased cyclonic activity. Flooding can be expected to have impacts on storm water drainage and sewage disposal systems in urban areas; and to detrimentally affect recruitment to populations of saltwater crocodiles and other species where reproductive success is largely determined by flooding of nests. Extension of the periods of inundation may render coastal areas, uninhabitable in the long-term, particularly in areas of beach ridges backed by swamp (Hughes & Bualia, 1988).

Coral reefs and motu

A critical question for most tropical states is the issue of coral growth rates and if one assumes that coral growth rates will keep pace with rising sea level one may also assume that existing barrier reefs will continue to provide the same level of protection to the coastline as they do at present. Should this assumption not be correct then increased wave action may result in an increase in wave generated erosion in currently protected shoreline areas.

The impact of global changes to carbon dioxide availability on the growth of symbiotic algae and hence the hermatypic, reef building corals is not known. A rise in temperature will decrease the solubility of carbon dioxide, but increase the solubility of calcium carbonate. The consequences of these two processes for symbiotic algal growth and reproduction and hence skeleton formation are not known. What is clear at the present time is that many species of hermatypic corals are currently growing at the upper limit of their thermal tolerance, and that any increase in lagoon water temperatures may well cause increased frequency of coral bleaching and death, with resultant changes to the community structure and growth of the coral community as a whole (Sullivan & Pernetta, 1989).

From the perspective of the atoll states, current models of sand genesis and movement within atoll systems are inadequate to describe and define the processes of motu formation and erosion. Since the bulk of the sand is derived from biological sources any changes to the growth rates of the organisms concerned will dramatically change the sand budgets of atolls and hence influence the rate of motu formation and destruction. Coral atolls and motu may be expected to decrease in size and/or be eroded entirely as a result of accelerated loss of sand to off-shore sinks.

Erosion, saline intrusion and coastal vegetation

Beach plan forms will be changed by changing wave patterns resulting from modification of regional and sub-regional wind patterns. Such changes will have important consequences for coastal marine communities of sea grasses, coral flats and algal beds and for sand budgets, particularly in the case of areas currently receiving sediment inputs through longshore drift which can be expected to decrease as the volume of coastal sinks increases.

In estuarine areas an inland extension of the tidal prism may be expected. In coastal plains saltwater contamination of the groundwater may have profound effects on both the suitability of areas for human occupation and upon the nature of the vegetation. A rise in sea level will cause a

rise in water table particularly a vertical rise in freshwater. In the case of sand and limestone aquifers this will result in a significant decrease in the volume of the aquifer both for human consumption and agricultural use (Buddemeier & Oberdorfer 1989). Loss or reduction in the volume of freshwater resources may render small atoll and limestone islands uninhabitable long before the loss of material results in land loss.

Changes in coastal vegetation following sea level rise and inundation may be dramatic in areas currently having a flat coastal plain (Pernetta & Osborne, 1988). The distribution and zonation of vegetation, in particular mangroves, will be altered, with the zonation being compressed, this will result not only in an overall reduction in the extent of such transitional habitats but extensive reduction in the seaward seres, and consequent reduction in important economic off-shore resources such as prawns which are dependent upon the mangrove as nursery areas. Mangrove communities may be particularly susceptible to increased rates of sea level rise and any decrease in their extent will lead to decline in both individual species abundance and species richness.

Other impacts include increased rates of coastal erosion and alteration of beach plan form, with increased impacts from "high waves"; changes to aquifer volumes with increased saline intrusion exacerbating already critical supplies for human consumption; increased demand for air conditioning and hence increased energy consumption and adverse impacts on the balance of payments through increased fossil fuel importation; adverse impacts on coral growth resulting from coral deaths under increased sea water temperature regimes; social impacts resulting from inter-island migration resulting from changes to island stability and/or habitability; loss of capital infrastructure on some of the smaller more vulnerable islands; changes in reef growth and local current patterns; increased vulnerability of human settlements due to their aggregation and increasing size.

Whilst it is clear that small islands will suffer many of the effects listed above the nature and extent of individual impacts is difficult to evaluate from a regional review of potential impacts. Site specific characteristics will undoubtedly affect the extent and severity of projected impacts not only when comparing between island nations but also when comparing between sites within such nations.

RESPONSES TO CLIMATIC CHANGE AND SEA LEVEL RISE

All of the potential problems posed by present environmental degradation and impending climatic change are exacerbated by a lack of mechanisms within Government for taking environmental problems into consideration during the planning process; a lack of guide-lines and procedures for the evaluation of environmental issues; a lack of an adequate in-country data base covering many physical and biological parameters; and a shortage of trained manpower at all levels. Thus many of the developing countries, particularly the small island states, are therefore currently ill-equipped to handle their existing environmental problems. Many of the current problems will be exacerbated by the predicted impacts of global climatic change.

Essentially response options fall into three broad categories; do nothing; take defensive action; withdraw or migrate from threatened areas. The first of these approaches is predicated on the assumption that worst case scenarios do not eventuate whilst the third option is unavailable to the populations of small island states with limited low altitude land areas. At a national level the response options of small insular states are further limited as a consequence of the constraints outlined above. Assessment of current and potential environmental problems is already proceeding via the work of the regional task teams concerned with pollution monitoring, coastal zone management and climate change, yet the financial and manpower resources available to small countries for planning and mitigation measures are severely limited.

Experience with the regional task team on climate change impacts has shown that such approaches go part way to addressing these constraints but to achieve successful joint approaches to the problem requires a larger critical mass of involved experts, hence there is a demonstrated need for greater inter-regional co-operation particularly between those regions dominated by the small insular states, namely the Pacific Indian and Caribbean regions. Such inter-regional co-operation is necessary to ensure information flow and exchange of expert personnel thus ensuring that the widest possible range of expert opinion and experience is brought to bear on the similar problems found in each of these regions

Given their low responsibility for the causes of what is a global environmental issue, small island countries should press in the international arena for the adoption of policies designed to limit greenhouse gas emissions, and to press the developed industrialised nations to accept their liabilities in respect of the environmental consequences faced by the small island states. In addition perhaps such small countries should promote the concept of international adoption of environmental accounting which includes the concept of "natural debt". All small insular states in the tropics are net importers of carbon dioxide in that the emissions resulting from fossil fuel consumption are more than balanced by the rates of natural carbon dioxide fixation via tropical rainforests, coral reefs and mangrove systems. Such countries are therefore effectively subsidising larger industrialised nations which are net producers or exporters of carbon dioxide.

It is therefore incumbent upon the industrial nations, which are largely responsible for the current global crisis, to assist, both financially and technically those small island states which may well suffer dramatic impacts as a consequence of a problem to which they themselves have not contributed.

Furthermore it is imperative that programmes of assistance should be individually tailored to the countries concerned and that they should be designed to enhance or establish general capabilities in the field of environmental planning and management. A failure to satisfactorily solve present environmental problems will mean that global climatic change will place the goal of sustainable development beyond the reach of small island states and may indeed threaten their very survival.

It might be suggested that the changes in assistance and cooperative programmes which will be necessitated by the need for a rapid development of policies and planning mechanisms for coping with global climatic change and sea level rise by developing country Governments may be as great and as far reaching as the predicted impacts of climatic change itself.

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RECORD OF DISCUSSIONS HELD DURING THE UNEP SYMPOSIUM "REGIONAL CO-OPERATION ON ENVIRONMENTAL PROTECTION OF THE MARINE AND COASTAL AREAS OF THE PACIFIC BASIN" INCLUDING RESOLUTIONS PASSED AND FORWARDED TO OCA/PAC.

John C. Pernetta, Convenor.

INTRODUCTION:

Discussions during the symposium centred on the implications of the papers presented and ways in which future inter-regional co-operation might be fostered. The following is an informal record of those discussions tabled during the final session.

REGIONAL CO-OPERATION

Action Plans

It was noted that the Action Plans developed in the different regions had served a valuable function in stimulating the development of environmental management plans and in fostering a greater degree of environmental awareness in development planning. It was suggested that the role of the co-ordinating units for the various Action Plans might be expanded in various ways including in the facilitation of evaluation of environmental impact assessments.

Development of regional programmes

It was noted that the different regional seas programmes are at different stages of their evolution. In some respects the CPPS region was further advanced than the SPREP and EAS regions, but that in other areas these latter regions had progressed further. On the basis of this it was felt that fruitful interchange of experience in implementing various aspects of the regional seas programme would be enhanced by each region being continually exposed to the experiences of the others. In this way the development of each programme would be greatly accelerated.

Environmental Impact Assessments

All participants indicated that the need for some form of Environmental Impact Assessment (EIA) policy was recognised in their respective countries. In South America, the legal basis for EIAs was either well established, as in Colombia where legislation had existed since 1974, or was being acted upon by Congress as in the case of Peru. In south-east Asia EIAs were either established by law or were mandatory under other laws such as mining acts, as in the case of Thailand. Papua New Guinea has laws applicable to EIAs, as does Guam which adheres to the US Environmental legislation.

In general EIAs are undertaken by private firms and the EIA reports or statements might be based only on literature reviews as in the case of Colombia, or on actual field studies as in the case of Guam and Papua New Guinea.

Some questions were raised concerning the evaluation of EIAs. In south-east Asian countries, the EIAs are evaluated by appropriate Government Agencies. In Peru, evaluation involves a two step process - external review by specialists in the applicable discipline and internal review by the appropriate government agency responsible for reviewing the social and

cultural aspects of the EIA. In most countries EIAs are handled by government agencies and the reports are distributed to appropriate governmental and non-governmental agencies for initial comment following which a public hearing may be held. All agreed that EIAs were essential and served as a safeguard against potential environmental damage.

Rapid Assessment Techniques

During discussion it was noted that the WHO rapid assessment techniques had been successfully employed in various studies in Peru, and a question was raised concerning their more general suitability and applicability. In response it was noted that Biological Oxygen Demand (BOD) and suspended solids determined by these methods tended to display lower values than laboratory determined analyses using more time consuming techniques. It was suggested that errors might well have occurred as a consequence of the different processes causing the pollution compared with those for which the rapid assessment techniques had been developed. It was further pointed out that in many instances complex series of pollution sources were involved in causing observed pollution levels. It was generally agreed that the rapid assessment techniques were of value in determining the overall level of pollution but that more time consuming and detailed analyses were required to pin-point pollution sources and levels.

Geographic data base

Several comments were made concerning the suitability of present maps of the Pacific Basin which generally divide the world through the centre of the Pacific Ocean, and the fact that many South American country maps omitted islands such as Easter Island and the Galapagos Archipelago. In respect of the former problem it was noted that several agencies were in the process of producing maps which centred on the Pacific. It was further noted in the case of the islands under the jurisdiction of mainland South American countries that these were frequently omitted from monitoring and control programmes due to distances and costs involved.

INTER-REGIONAL CO-OPERATION

It was agreed by participants in the UNEP Symposium that this occasion was extremely valuable in facilitating the exchange of knowledge, information, and experience between individuals implementing activities under the various action plans. The meeting expressed its appreciation of UNEP's financial support which enabled participants at this and other meetings to foster and engage in inter-regional exchanges. During the symposium discussions on inter-regional co-operation several topics were highlighted as being important in this area and these are outlined in the following sections.

Information exchange:

There was unanimous agreement that much improvement could be made in this area and several suggestions were put forward for consideration:

a) Since technical reports are produced in several languages and many collaborators are limited to one or two languages the reports are often not widely read outside their region of origin. It was suggested that each report should have an executive summary which could be translated by UNEP (or one of the Action Plan Secretariats) into several other languages and circulated widely. Individual scientists could then select those reports of particular interest to them for further study.

b) Directories of expertise in each region be prepared or up-dated on a regular basis and widely circulated inter-regionally.

c) It was suggested that much useful exchange could be achieved if representatives from each action plan region attended technical meetings of other regions eg CPPS representative to attend SPREP consultative meetings or a SPREP/ASPEI representative to attend CPPS technical meetings.

d) Inter-calibration exercises should be carried out on an inter-regional basis.

e) For areas of the Pacific not covered by the regional seas action plans, use should be made of international research cruises to collect marine pollution baseline information.

f) While it is possible to generate a substantial amount of analytical information, there is a dearth of material available to define the criteria for assessing the seriousness of pollution in any given situation. It is important that information on criteria be exchanged and tested in different regions.

g) The socio-economic assessment of marine pollution impacts is generally inadequate and carried out using a wide range of techniques. Exchange of information on criteria, methods evaluation, and software would be of considerable value. The issue of standardized techniques was discussed in some detail. Caution should be exercised in the development of standardised techniques for socio-economic assessments and EIA evaluation.

h) It was suggested that CPPS and SPREP-POL collaborate on the preparation of a document on the "Health of the Pacific Ocean". Other regional seas programmes could be asked to collaborate plus other Pacific Basin countries including the USA, Canada, USSR, Japan, China. Such a document would facilitate recognition of gaps in our present knowledge base and the development of future projects to address these areas of uncertainty.

Country Carbon Dioxide Budgets.

It was suggested that all countries in the CPPS and SPREP regions prepare CO2 budget statements covering natural fixation and production of carbon dioxide and production through fossil fuel consumption. During discussion some concern was expressed about the need for standard methods to be used in preparing such budgets and the level of detail that such an analysis might be expected to take into account. Standard methods do not appear to be available as yet and it was suggested that CPPS and SPREP might collaborate on developing such budgeting formats.

The production of such budgets would greatly assist those countries which are net CO2 "importers" in their negotiations with the producers for assistance in mitigating the impacts of climate change and sea level rise. In this regard it was noted that SPREP island countries would be sending 3 representatives to IPCC meetings and it was felt that the South East Pacific Region should arrange for at least one country to represent their region.

It was suggested that activities relating to the coastal ecosystems which are common to the three regions represented in the symposium, such as coral reefs and mangroves could form the focus for future inter-regional co-operation. The UNEP and SPREP representatives indicated that efforts are under-way to develop international task teams to address the impacts of climatic change and sea-level rise on coral reef and mangrove ecosystems.

The CPPS co-ordinator suggested that a series of preparatory meetings be held in each region to consolidate the position of each region on environmental issues in the Pacific Basin in preparation for the XVII Pacific Science Congress (Honolulu, Hawaii 1991) where the next inter-regional meeting will take place. At that time it would be possible to pursue the development of a Pacific Basin-wide consensus on these issues in anticipation of the global meeting planned for 1992. The UNEP representative outlined the topics likely to be covered in the 1992 global meeting and suggested that a Pacific Basin-wide consensus would strengthen the position of each region.

RECOMMENDATIONS

The recommendations which follow were drafted, tabled and approved by the participants prior to the closure of the meeting. Participants in the 1989 UNEP inter-regional symposium, held in Vina del Mar recommend that:

1. OCA/PAC foster the formation of two inter-regional task teams to investigate the potential impacts of climatic change and sea level rise on:

   a) coral reefs
   b) mangroves

2. OCA/PAC support the participation of observers from the South East Pacific region at the September Inter-Governmental meeting in New Zealand which is being called to draft a convention on drift net fishing.

3. All future Regional Seas Publications relating to the Pacific contain an executive summary which will be translated into English, French and Spanish. These summaries should be widely circulated, inter-regionally to facilitate more efficient information exchange.

4. UNEP support the participation of scientific representatives of each Pacific Action Plan at technical meetings of the other regions. In the first instance it is recommended that a representative of SPREP-POL attend the CPPS seminar in September on Pacific Pollution monitoring and control and that representatives of the South East Pacific and EAS attend the 1990 SPREP consultative meeting.

5. OCA/PAC prepare a directory of individuals participating in the implementation of the Pacific based Action Plans.

6. OCA/PAC support the organization of a thematically organised symposium to be held in conjunction with the XVII Pacific Science Congress scheduled for 1991 in Honolulu.

7. OCA/PAC support the preparation of a report on the "Health of the Pacific Ocean" to be finalised at the XVII Pacific Science Congress, and be presented to the UN Conference on Environment and Development scheduled to be held in 1992.

8. The secretariats of the different action plans regularly exchange and disseminate information on the criteria and methods used for assessing marine environmental quality.

9. UNEP investigate possible methods for determining National carbon dioxide budgets, with a view to developing a standard method in order that individual countries can assess their contributions to climatic change and global warming.

10. A representative of the South East Pacific Region and any other region which is not adequately represented at the present time attend the meetings of the Inter-Governmental Panel on Climate Change.

11. A theme for the UNEP sponsored symposium to be held in conjunction with the XVII Pacific Science Congress be environmental impact assessment, in order to facilitate the exchange of information and experience between regions. Emphasis should be placed on the socio-economic aspects of impact assessment and on the evaluation of environmental impact reports.

12. The UN Regional Economic Commissions should supply case studies on socio-economic aspects of environmental impact assessments to the secretariats of the regional seas action plans.