ASSESSMENT AND MONITORING OF MARINE POLLUTION IN MANZANILLO AND SANTIAGO BAYS, COLIMA, MEXICO

by

Sergio Alberto Lau Cham

Special Project Report

Submitted to

Marine Resource Management Program
College of Oceanography
Oregon State University

in partial fulfillment of the
requirements for the degree of

Master of Science

Completed August 30, 1984
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In Memoriam

Arturo Lau Sin
Ma. Luisa Cham de Lau

To Rosalba and Nancy Carolina

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I am indebted to Dr. Neal for his advise and help, without which I would never have been able to complete my degree.

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ASSESSMENT AND MONITORING OF MARINE POLLUTION IN MANZANILLO AND SANTIAGO BAYS, COLIMA, MEXICO

I. INTRODUCTION

I.1) THE NEED FOR A MONITORING PROGRAM

During the last 10 years or so, enormous amounts of money have been invested in Manzanillo for several new installations and improvement of others. Some of the most important are the building of the thermoelectric power plant, the development of the interior port, construction of new highways, exploitation of iron ores, and the development of new touristic complexes.

These investments were the starting point for many others, which together will make Manzanillo the principal port of the Mexican Pacific coast in both commerce and services (1), since its strategic location makes it ideal to be the connecting point of three important zones of Mexico: the Central part of the Pacific coast, the West, and the Center.

In order to achieve this goal, the State government has developed the Plan Colima, in which the main projects to be done are outlined. The Plan involves not only Manzanillo, but also the rest of the counties, and the objectives are those that have been set in the Plan Nacional de Desarrollo (National Plan of Development) presented by the President of the country for the period 1983-1988 (2), which is intended to do the following:

1. Keep and reinforce the democratic institutions.

2. Overcome the economic crisis.

3. Recover the capacity for economic growth.

4. Start the qualitative changes required by the country in its economic, political, and social aspects.

The National Plan is in compliance with the National Project of Development enforced by Article 26 of the Mexican Constitution.

For the development of Manzanillo, the Plan Colima has emphasized the primary areas to be considered:

A) Communications and transport

1. To improve and complete the works that have been started in the maritime terminal in order to increase the efficiency of the port activities.

2. Completion of the operations of dredging and construction of piers in the interior port.

3. Improvement in the railroad system.

4. Completion of the four-lane highway between Manzanillo and Guadalajara.

5. Increase in the uses of the microwave station.

B) Fisheries

1. Construction of tuna canning and fish freezing facilities.

2. Enhancement of aquaculture activities.

C) Tourism

1. To improve and enhance the present resort areas.

2. To stimulate the development of new resort areas.

D) Navy

1. Construction of the principal naval base of the Pacific Pacific coast of Mexico.

2. Evaluation of the degree of pollution in Manzanillo

Bay.

Almost all the activities above cited will impact, in one way or another, the marine environment. Perhaps the most important from an ecological point of view, is the dredging of the Laguna de San Pedrito for the construction of the interior port. In this area, a large marsh zone had to be destroyed and a tremendous amount of sediments were dredged and discharged into the ocean through a pipeline. The ecological impact is unknown since no data are available either for the pre- or for the post-dredging. It is important to note that this lagoon is the sink for runoff, particularly from the surrounding hills and agricultural lands, during the rainy season, which will make continuous dredging necessary.

This zone, also, will be the central point for the desired economic development of Manzanillo. The interior port, still under construction, will have to support many of the already listed activities, i.e. marine transportation, sport and commercial fishing, and naval installations, besides the tuna canning and fish freezing facilities, and other expected industries such as seafood processing. There will be piers for vessels varying in size and shape from small recreational craft including sport and commercial fishing boats, to naval vessels and merchant ships.

In view of the complexity and nature of the programs that have been started in Manzanillo, there is an obvious need for a program to evaluate the health of the marine environment. The Plan Colima, following the national tendency that began during the late 1960's for protection of the environment and the maintaining of the ecological balance (3), also proposes that the bay be monitored in order to prevent heavy damage to the environment. The Secretaria del Desarrollo Urbano y Ecologia (Urban Development and Ecology Secretariat) and Secretaria de Marina (Secretariat of the Navy) are the organizations in charge of this task, but no specific program has been established.

Many programs have been done in the area in order to evaluate the quality of the water of Manzanillo Bay. Most of them have been made to ensure the safeness for recreational purposes, particularly in the more popular beaches. Unfortunately, these analyses have been sporadic, and there has been a lack of communication among responsible agencies to share results and prevent duplicity of efforts.

Some of the Federal agencies that are concerned with the problem of marine pollution are:

Secretaria de Salubridad y Asistencia
(Secretariat of Health and Social Services)

Secretaria de Marina
(Secretariat of the Navy)

Secretaria de Pesca
(Secretariat of Fisheries)

Secretaria de Agricultura y Recursos Hidraulicos
(Secretariat of Agriculture and Hydraulic Resources)

Secretaria de Desarrollo Urbano y Ecologia
(Secretariat of Urban Development and Ecology)

Subsecretaria del Mejoramiento del Ambiente
(Subsecretariat for the Improvement of the Environment)

Comision Federal de Electricidad
(Federal Commission of Electricity)

Most of them have had participation in some sort of activities tending to have information about the degree of pollution in Manzanillo, but, again, those activities have been isolated and the objectives diverse, depending on the particular needs of the agency.

The sparse results so far obtained have shown that Manzanillo Bay is under a continuous load of sewage, garbage, organic matter, oil and other wastes of municipal and maritime operations. The sources are varied, and mostly caused by the lack of good systems for disposal of wastes; i.e., the lack of a good sewage system and a sewage treatment plant. At the present, only a small fraction of the community is connected to a very old system that discharges to the bay. The rest of the houses either have septic tanks or discharge directly to the nearest water body.

On the other hand, during the loading and unloading of oil at the Petroleos Mexicanos pier, some spills occur and the bay and beaches become affected by the oil. The problem can last for several days, depending on the amount spilled. After incidents like this, though, Secretaria de Marina tries to clean the bays as soon as possible by using booms and a vessel especially designed to pick up spills, i.e. a continuous-belt type oil skimmer.

Important contributors for the oil and garbage floating on the ocean and often reaching the beaches are clandestine littering and tank washing from ships anchored in the bay in a waiting lane for a space at the pier for loading and unloading cargo.

There are several federal laws and regulations to prevent the disposal of wastes in the sea. Even so, Manzanillo Bay receives large amounts of pollutants because those laws have not been sufficiently enforced, and the results have been the closure of some beaches for recreational uses and even the temporary banning of seafood consumption.

With the opening of the new maritime installations, some of the past problems will be solved, e.g., better services and installations for ships; but also it is likely that some new problems will appear, for instance an increase in organic matter due to discharges from the canning factory, an increase in turbidity due to the necessary continuous dredging, and others. Concerning the sewage problem, the state government has initiated studies for the construction of a sewage treatment plant which should treat the wastes of almost the whole population, and even when no specific plan is available at the present, it is probable that the effluents of the treatment plant are going to be discharged in the sea.

It is not possible at the present to predict long-term changes in the ecosystem, or to evaluate the effects of dredging on the lagoon habitat, or to distinguish significant changes on the well being of those systems from other natural variations, or to get warning signals of potentially serious damage, or to provide the necessary data for wise management decisions. In turn, the following problems and deficiencies have been identified or can be inferred on the basis of the projects now under development:

- Lack of coordinated efforts to obtain and manage information about the conditions of the marine environment,

- loss of swimming and beach areas because of sewage pollution,

- loss of benthic communities,

- loss of aesthetic values because of oil slicks, solid floating material, and suspended solids,

- possible presence of pesticides and fertilizers washed into the lagoon and then redistributed with the dredge material,

- possible increase in organic matter content in the bays and lagoon from the wastes of the seafood processing plants, and

- an increase in nutrients in the bays from the effluents of the sewage treatment plant.

As pressures and usages of the coastal region increase, the necessity for assuring that multiple activities and modifications do not seriously damage the useful qualities of the marine ecosystem is of priority importance. Monitoring is required to provide the needed information and to carry the above evaluations.

In this paper, a program for monitoring Manzanillo and Santiago Bays is proposed. The main objective is to obtain data to:

1. Indicate the present condition of the bays and lagoon and establish environmental baselines,

2. Identify long-term changes in the environment,

3. Provide information to ensure protection of human health and living marine resources,

4. Provide information for wise coastal management decisions,

5. Assess the effectiveness of measures taken to reduce pollution in the bays, and

6. Develop a prototype program applicable to other coastal areas in Mexico.

As indicated above, the program will be conducted by Secretaria del Desarrollo Urbano y Ecologia and Secretaria de Marina through the Instituto Oceanografico de Manzanillo (Manzanillo Oceanographic Institute). However, in order for the program to be useful and effective, it will be necessary to have coordination and interaction with other agencies, e.g. Secretaria de Pesca and the University of Colima School of Marine Sciences at Manzanillo, by having them participate in the project.

I.2) GENERAL ASPECTS OF MANZANILLO

I.2.1) Geography

Manzanillo is located in the southwestern part of the Mexican Republic, bordering on the north with the commonland Jalipa, to the south with the rocky hills, to the east with the Laguna de Cuyutlan, and to the west with the Pacific Ocean.

This city belongs to the state of Colima, which borders with the states Michoacan and Jalisco to the southeast, north and east, and with the Pacific Ocean to the southwest.

Its geographic coordinates are:

Latitude: 19°03'30" North
Longitude: 104°19' West

The mean height above the sea level is 8 m.

I.2.2) Climate

The climate of the region corresponds to the classification tropical, that is, sub-humid, with scarce rain during the winter but abundant rainfall during the summer.

The average temperature is 26°C, in agreement with the tropical climate, although in the near mountains the climate becomes temperate.

Other climatologic data are:

Mean monthly temperature	26°C
Maximum monthly temperature	33°C
Minimum monthly temperature	20°C
Average anual rainfall	825 mm
Average relative humidity	74 %

I.2.3) Hydrology

There are many fresh and salt water bodies in the area. Some of the more important are discussed below.

Salt water. To the northwest of Manzanillo, Manzanillo and Santiago Bays, separated by the Peninsula de Santiago; further west, Laguna de Juluapan; to the east, Laguna de Cuyutlan, and to the northeast, Laguna de San Pedrito, also called Valle de las Garzas.

Fresh water. Several fluvial streams run in the region, such as the Rio Salahua and its influents Rio Verde, El Buey, Chiquerio and San Jose; about 50 km to the east, runs one of the larger rivers in the state, the Rio Armeria. There are also abundant underground fresh water aquifers, whose depth varies between 50 to 150 m.

I.2.4) Communications and Services

The town has a very good system for national and international communication and transportation.

By land, Manzanillo is connected by roads with Guadalajara and Mexico City through Colima City, and through Autlan. Along the coast, Manzanillo has easy access to Puerto Vallarta to the north, and to Acapulco to the south by a still-unfinished highway. A four-lane highway between Manzanillo and Guadalajara is under construction, which will substantially shorten the travelling time. The railroad system connects Manzanillo, through Colima City, with the western region, and with all the country through Guadalajara.

The International Airport receives flights from the interior of the republic and from abroad. The main connections are Monterrey, Guadalajara and Mexico City, as well as several cities of the United States and Europe.

By sea, there is an intense traffic of ships between Manzanillo and other Mexican ports of the Pacific, such as Mazatlan, Puerto Vallarta, Acapulco and Salina Cruz. Cargos from and to other countries, especially Japan and South America, are abundant.

Manzanillo has all sorts of public services, including a post office, telegraph and radio stations, telephone, television retransmiters, schools, urban transportation, etc.

I.2.5) Population

The metropolitan zone of Manzanillo includes several urban developments alongshore on Manzanillo and Santiago Bays: La Central, El Naranjo, Miramar, Juluapan and Santiago are located along Santiago Bay, while Salahua, Playa Azul, Tapeixtles and Manzanillo are found adjacent to Manzanillo Bay. There are other small colonies that, although not in the immediate vicinity of the bays, also are considered as a part of Manzanillo, such as Campos, where the power plant is located, to the south of Manzanillo Bay and Laguna de Cuyutlan, and El Colomo, between

Laguna de San Pedrito and Laguna de Cuyutlan.

In 1980, the total population in this area was 78,280 inhabitants. However, during peak tourist seasons, the floating population can account for another 62,500 people (1). During the period 1970-1980, the population showed a demographic increase of 7.2%, the larger ever since the turn of the century (4). This increase was promoted by the creation of many jobs for the construction of the new facilities, i.e. resort areas, power plant, interior port, etc., and it is expected that the trend in the population growth will continue for quite a long time.

II. POLLUTANTS IN THE MARINE ENVIRONMENT

II.1) DEFINITIONS

Marine Pollution: "Introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairing of quality for use of seawater, and reduction of amenities" (5).

Marine Pollution Monitoring: "a) The repetitive observing, for defined purposes, of elements or indicators of the marine environment according to pre-arranged schedules in space and time, including the interpretation and the assessment of collected data.

b) In a regulatory context, the assessment of the effects of pollutants on man or specified elements of the marine resources for reasons related to the control of the effects of those pollutants." (6)

II.2) EFFECTS OF OCEAN POLLUTION

The presence of pollutants in the ocean can arouse a diversity of feelings, including disappointment for recreational users due to visible floating matter, or fear of getting ill from eating contaminated seafood, or even impotency of being unable to stop the pollution to protect the marine resources. In any case, the effects of pollution, although apparently obvious, are a rather complex issue that includes not only the evident, but also the subtle changes in the ecosystem. For the purposes of studying marine pollution, however, the important effects are those acting upon human health, living resources, and recreational and aesthetical values (7).

Human Health.- This is an area that has had the greatest influence on the study of pollution, including patterns, quantification, sources, prevention and control. Human health can be affected directly and indirectly by ocean pollution. In the first case, contact of swimmers with water contaminated with pathogenic bacteria or toxins, or eventual drinking of that water, poses a big threat. On the other hand, bioaccumulation and concentration of certain pollutants (e.g. metals, some chemicals, toxins, and pathogens) in marine organisms can pose a danger to humans who consume them. Both cases may be found as isolated individual cases or alarming epidemic diseases.

In Manzanillo, fortunately, no epidemic outbreak has been detected. Nevertheless, it is well known that some gastroenteric diseases are sometimes linked to the consumption of contaminated seafood, particularly oysters, and to the presence of pathogens in some bathing beaches. For the many tourists visiting the place, especially from other countries, the risks of getting ill are even larger because they don't have enough immunity to these endemic problems (5).

Living Resources.- Oceans, particularly nearshore areas, support many living marine resources, i.e. fish, crustaceans, mollusks, birds, etc. Man has used those resources for different reasons, such as food, industrial uses, studies, collection, entertainment, and sport. For their purposes, humans have caught them from the sea or have cultured them. In many countries, marine living resources represent the basis of their economy, which in some instances may be in jeopardy because of pollution problems.

Marine pollution can affect living resources in many ways, and the main mechanisms for these adverse effects are:

- Loss of habitat,
- Physical perturbations, and
- Domestic, hydrocarbons and chemical pollution.

Loss of habitat occurs through the gradual intrusion by population growth, industrial development, and recreational activities along the coastline. Areas once used for spawning are lost due to dredging and filling for coastal development and other uses, as was the case in the interior port of Manzanillo.

Physical perturbations include changes in temperature due to discharges of heated cooling waters; decrease in transparency by dredging and dumping, and sediment deposition. The effects of physical perturbation depend on the type of organisms present; some organisms can avoid the polluted area by swimming away, but much of the other benthos would be impeded in the performance of their basic functions (e.g. hunting for food), and even be killed, by sediments.

Chemical pollutants may have acute effects, such as fish and bird kills caused by oil spills, or sublethal, chronic effects. The latter, even when not as obvious as the acute effects, are possibly more dangerous. Sublethal, long-term effects, resulting from uptake, transformation and bioaccumulation of metals, synthetic organics, and other chemical pollutants, in the food chain, can alter the physiological, genetic, and reproductive functions of the organisms, including humans. Other chemical pollutants acting on the environment also have effects on living resources, e.g. the decomposition of organic matter may create anoxic conditions making impossible the existence of those resources. On occasion, synergistic effects of chemicals can worsen the already bad situation for many forms of life, although antagonistic pollutants can also be present.

Recreation and Aesthetics.- Marine recreation is perhaps one of the most important uses for the coastal zone. There is an ever growing demand for access and development of facilities on the shoreline for recreational uses. Activities include fishing, boating, swimming, diving, sun bathing, skiing, or just enjoyment of the landscape. Some coastal communities have evolved from the sole exploitation of recreation activities, while others have combined industrial development and recreation, as is the case for Manzanillo, where the commercial and industrial port is concentrated in the southeastern portion of Manzanillo Bay, and the tourist resort areas are found mostly on Santiago Bay, to the west.

However, the aesthetic value of coastal zones is greatly reduced by the presence of pollution. Oil slicks, floating material, tar balls, and garbage in general, all contribute to degradation of the quality of the beaches for recreational uses. Littering from ships and users of beaches is a common practice, particularly when little, if any, enforcement is given to the regulations that tend to keep the coast line healthy and clean. The results of this practice is a very unpleasent place to be in, being a possible source of infection because the appropriate conditions for the proliferation of diseases are present. The costs for restoring the quality of beaches that have been used as a dumping site or that have not been maintained in a good, healthy condition are high, both for cleaning and for restoring the confidence of the public to use those places; the tourist businesses, i.e. restaurants and hotels, being affected the most.

II.3) POLLUTANTS IN MANZANILLO AND SANTIAGO BAYS

For the purposes of having a complete understanding of the health of the bays and trends in their quality, it is necessary to take into consideration many pollutants. This would give a very good knowledge of the kinds, concentrations, source, and trends of these pollutants, and would provide enough information to develop plans for controlling their discharge into the ocean. However, since this task would be time consuming and expensive, the best option is to take into account those pollutants that have been shown to represent a serious hazard to the environment and at the same time have been found to be ubiquitous. In this paper, four groups are considered as having those qualities: sewage, chlorinated hydrocarbons, petroleum hydrocarbons, and metals.

Sewage.- Sewage is probably the most common pollutant found in coastal waters, and is mainly correlated with the distribution of human populations. It contains domestic wastes, and sometimes industrial wastes and/or storm water and surface run-off as well.

For this reason, sewage is extremely heterogeneous with a highly variable composition. Domestic sewage is rich in organic matter, nutrients, microorganisms (bacteria and viruses, some pathogens), and may contain oil and grease, metals (8), petroleum hydrocarbons (9), and many other solid and liquid substances; industrial wastes may be as varied as the industries themselves can be, and many of the substances contained in them (e.g. acids, bases, heavy metals, organics, etc.) are extremely toxic.

Some of the problems associated with disposal of sewage in the sea include the potential disease transmission by pathogenic bacteria, the possible eutrophication caused by the oversupply of nutrients which act as overstimulant of plant growth, the eventual depletion of oxygen levels in the water occasioned by aerobic bacterial decomposition of the organic matter in the wastes, and the suspended solids which when settled out, smother bottom-dwelling organisms or clog the feeding apparatus of filter feeders or the gills of fish (10).

Sewage treatment is designed to separate the wastes into two phases _a liquid and a sludge_ and the characteristics of those effluents will depend on the degree of treatment given to the sewage, varying from simple separation of solids and settlement of heavy particles, to chemical or biological treatment to produce a more stable and nutrient rich effluent by breaking down the organic matter. Usually, the liquid effluent is dissinfected prior to disposal; however, this procedure can give rise to increased quantities of chlorinated organic compounds (5), a phenomenon that is enhanced by sunlight.

Manzanillo, as many other coastal cities, has disposed of its sewage by discharging it to the sea, i.e. Manzanillo and Santiago Bays, either by direct discharge, or run-off. Even when some plans for the construction of sewerage and sewage treatment plant have been proposed, it is still unknown what kind of treatment is going to be given to the sewage or where and how the effluents are going to be disposed of. In any case, the convenience of the closeness to the sea makes it an easy site for disposal. However, careful analysis of the place where the effluents are going to be discharged into has to be performed, since they will become rich in nutrients, such as phosphates and nitrates.

Nitrates are the limiting nutrient for marine plant growth (7), and the accumulation of these in closed areas or with little water exchange, like the interior port, would intesify plant growth, and when such plants die, oxygen necessary for bacterial aerobic decomposition would be taken up from the water, leaving low levels of dissolved oxygen or even anoxic conditions, detrimental for other macro-organisms. On the other hand, dumping of undigested sewage sludge can also create a large demand for dissolved oxygen (high BOD). If the required oxygen is not present due to poor oxygenation from the atmosphere and photosynthetic plants, low dissolved oxygen concentrations are created, and subsequent anaerobic decomposition of organic matter by bacteria would release toxic gases, i.e. methane and hydrogen sulfide, which at the same time influence the presence of metals in the sediments and in the water column by precipitating solids in the form of sulfides or by dissolving sediments (11), besides of being aesthetically very unpleasant.

Chlorinated Hydrocarbons.- Since the synthesis of urea, a huge number of synthetic organic compounds have been produced in laboratories to replace natural sources, e.g. dyes, vitamins and food flavouring compounds. It has been estimated that 20,000 new organic compounds are synthesized every year, that 10,000 of those may reach the developmental stage to be produced commercially, and that actually about 1,000 new synthetic chemicals reach the market every year (12).

A group of synthetic compounds that has raised environmental concern all over the world is that of chlorinated hydrocarbons. Some of these chemicals, for example PCBs and DDT, have received a large attention due to the ecological damages that are linked to them, and because they are ubiquitous pollutants in the oceans. They have the characteristics necessary for persistence and accumulation in the food chain, i.e. slow biodegradability, they are water insoluble but lipid soluble (13), and indeed they have been found in the fatty tissues of animals from remote areas, such as the Arctic and the Antarctic.

PCBs, polychlorinated biphenyls, are mixtures of many different isomers with varying chlorine content from 1 to 10 atoms per molecule, and the total possible number of isomers and homologues has been calculated to be 209 (14). The physicochemical properties of the mixtures, as well as their effects on living organisms, also vary widely.

DDT has been perhaps the most used pesticide in the world, beeing applied to almost every kind of agricultural cropland and for protection of public health by controlling mosquitos and other bug proliferation. DDT can be slightly degraded and metabolized, the rate of which is influenced by some atmospheric parameters, i.e. sunlight, temperature, humidity, and possibly in tropical climates this rate is higher. Nevertheless, DDT and its main metabolites (DDD and DDE) can be considered to be relatively stable (5).

Both PCBs and DDT are carried to the oceans and coastal waters mainly in the atmosphere and in water streams, but they can also be transported in the sewage (15) particularly DDT, and apparently their sinks, other than animal tissue, are sediments and deep ocean waters (16).

In Mexico, like in other countries, uses of PCBs and DDT have been banned or restricted, and changes in their concentration in the marine environment would indicate whether or not the regulations have been followed, besides giving information about the fate of those pollutants. However, other chlorinated hydrocarbon pesticides, for example Dieldrin and Aldrin, have replaced DDT, and surveillance of their presence in the marine ecosystem is necessary to achieve our goal of protecting both human health and marine living resources.

Petroleum Hydrocarbons.- Pollution of the oceans by petroleum has had high publicity in recent years, particularly for crude oil spills from exploitation and drilling activities, and from infortunate disasters of oil shipping vessels. However, these accidents, although dramatic and in most of the cases release tremendous amounts of oil into the oceans, are only a couple of the many sources of this pollutant into the marine environment. It has been estimated that only less than 5% of the total input of petroleum, crude and products, actually comes from offshore production and tanker accidents, but considerable volumes enter the sea as a result of tanker operations (17).

In Manzanillo, most of the oil entering Manzanillo and Santiago Bays, mainly fuel oil, comes from general vessel operations (pumping of bilge water, spills during transfer operations of oil products, illegal tank washings, and ballast water) carried out in Manzanillo Bay, or other accidents, e.g. grounding of ships, although other potential sources may be included, such as the conduction line of fuel from the PEMEX pier to the storage tanks, or from PEMEX to the power plant. From Manzanillo Bay, the oil slick follows a northwestern direction due to currents and wind, affecting Santiago Bay, and in consequence, some beaches become soiled with tar balls and oil slicks and thus reducing their value for recreational uses. Even when many organisms are also affected by the spill, particularly diving birds and some crustaceans and mollusks along the shoreline, the principal damage is in the economic aspect, i.e. vessels stained, loss of amenities, and costs inherent for cleaning of beaches and water surface, since the ecological effects, albeit in almost all the cases with fatal consequences for many organisms, are usually of relatively short term duration (12).

Once petroleum or its products enter the sea, many physical, chemical, and biological processes act upon them (18). First, the spill will spread rapidly to form a thin film, and at the same time evaporation of the more volatile, and usually more toxic, components will take place, leaving an oil richer in the less volatile and more viscous ones. The rate of evaporation is controlled by wind, temperature, sunlight, roughness of the sea, and type of oil. Other natural processes acting on an oil spill include dissolution, dispersion, emulsification, and chemical and biological degradation. Nevertheless, it takes several weeks or months for these processes to eliminate an oil film from the sea surface.

<u>Metals.-</u> When dealing with metals as a pollutant, the terms "heavy metals" or "trace metals" are commonly used. They include a variety of chemical elements, some of which are not truly metals, but the importance of them in pollution programs is that they can be toxic to organisms at relatively low concentrations and can bioaccumulate to toxic levels in organisms (5), they are the most persistent of substances in the environment and can be

neither transmuted nor destroyed, although they can be combined in various compounds and complexes including metallo-organic complexes (12).

Most if not all metals are found in the marine environment, some in relatively high concentrations, e.g. sodium, calcium and magnesium, and others in very low concentrations, e.g. gold and silver. Marine pollution by metals is primarily observed in coastal waters as a result of river and industrial and domestic sewage discharges, except for lead, which enters the oceans principally via the atmosphere, to where it is transportated with the emission products of leaded gasoline powered engines. The chemical forms of the trace metals introduced to the oceans by human activities can be different from those released by natural processes such as volcanic activity, weathering, etc. The chemical states of trace metals in sea water are particulate, dissolved, and colloidal. In the dissolved form, the metal atom is usually bonded to other molecules to form complex radicals.

The importance of differentiating the chemical form is because an organism can accumulate one form of the metal more easily than another form, and because some species of metal are toxic whilst others are not (19). For example, some micro-organisms can convert the divalent mercury to methyl mercury and dimethyl mercury, potent neurotoxins, and in these forms mercury is rapidly taken up by other organisms.

Several trace metals, e.g. Fe, Cu, Zn, Co, Mn, Cr, Mo, Ni and Zn, are known to be essential nutrients. However, when any of them reaches a threshold concentration, organisms exposed may suffer damage, either acute or chronic. This concentration does not necessarily have to be found in the water, but could be reached in some organisms due to the fact that metals can be bioaccumulated.

The toxicity of metals to marine organisms have been studied, and the order of toxicity for some common trace metals is as follow (12): mercury (Hg^{2+}) > silver (Ag^{+}) > copper (Cu^{2+}) > zinc (Zn^{2+}) > nickel (Ni^{+}) > lead (Pb^{2+}) > cadmium (Cd^{2+}) > arsenic (As^{3+}) > chromium (Cr^{3+}) > tin (Sn^{2+}) > iron (Fe^{3+}) > mangansese (Mn^{2+}) > aluminium (Al^{3+}) > beryllium (Be^{2+}) > lithium (Li^{+}). This relative toxicity may change depending on the species and on the life stage of the organism, i.e. larval or adult. Certain conditions in the marine environment affect the degree of toxicity and the concentration of those metals in the water column. For instance, high calcium and magnesium concentrations, or the presence of some chemical radicals (e.g. carbonate, hydroxide, sulfate), tend to inhibit or reduce the toxic effects; on the other hand, fine sedimentary material can sorb metal particles and thus remove them from the sea water to the sediments (19). Also, changes in pH and Eh due to the decomposition of organic matter or other causes, affect the concentrations of trace metals both in sediment and water.

It is well known that many industries release trace metals in varying concentrations and composition, depending on the type of industry; for example, electroplating industries are likely to discharge cadmium and chromium. In the particular case of Manzanillo, even when there are not too many industries, trace metals can enter the bays with the discharges of municipal and marine transportation wastes, from urban and rural runoff, from uses of antifouling paints to protect ships and marine structures, from the wastewater of the iron pelletizer plant that is discharged into the lagoon, or from other sources.

The use of antifouling paints containing copper, lead, tin, zinc, or mercury, has been blamed as the major source of trace metals near docks and marinas (10). These paints are used to kill organisms that may attach to the bottoms of the boats by a constant leaching of those bactericide metals.

III. MONITORING THE MARINE ENVIRONMENT

It has been established that the main goal for this program is to obtain data by repetitive observations of determined parameters in specific schedules of time and space, in order to set an environmental baseline and determinate their trends in the environment. NOAA (7) has defined Marine Pollution Monitoring as "the continual systematic, time-series observation of predetermined pollutants or pertinent components of the marine ecosystem over a length of time sufficient to determine 1) existing levels, 2) trends, and 3) natural variations of parameters of the water column, sediments, or biota".

That definition, together with the objectives of the program, implies that:

- The program should have a long-term duration (a minimun of five years is proposed),

- Predetermined parameters have to be measured at specific locations and on a given schedule of time, and

- The program should include studies on the water, sediments and/or organisms.

The results thus obtained should be useful for wise management of the coastal zone, and for assessing the effectiveness of the measures taken to control and prevent the presence of pollutants in the bays. Hence, easy access for the public in general and for coastal zone managers in particular has to be given to the data generated, together with adequate advice on how to interpret and use them.

III.1) THE PROGRAM

A specific number of stations in suspected polluted and unpolluted areas will be visited at intervals of 1 week to 12 months, to be determined by the particular characteristics that have to be assessed in each station.

In every station, the general hydrographic parameters, i.e. dissolved oxygen, salinity, turbidity, pH and temperature, are going to be measured, besides the other particular variables for the site. This may include examinations of water, sediments, and/or organisms.

For the water quality studies, the parameters to be evaluated are nutrients (phosphate, nitrate, nitrite and ammonia), biochemical oxygen demand (BOD) and bacteria content.

In the sediments, variables of importance to be evaluated are grain size, trace metals (lead, copper and cadmium), bacteria (coliforms and streptococci) and total organic carbon content.

The organisms to be used as a sentinel to monitor pollutants will be oysters either of the genus Crassostrea or Ostrea, which will be measured for bacteria (coliforms and streptococcus) content, metals (lead, copper and cadmium), and chlorinated hydrocarbons (PCBs, DDT, dieldrin, aldrin and hexachlorobenzene).

The parameters above mentioned have been choosen because of their possible impacts on marine living resources or human health and because their presence and persistence may serve as indicators of contamination or processes leading to it. However, as mentioned before, this list represents the initial step in the program, and may be modified as necessary, either by adding or eliminating variables.

On the other hand, for petroleum hydrocarbons pollution only a visual monitoring is to be followed, since the Plan Nacional de Contingencia (National Plan of Contingency) has been set for this pollutant in particular, in which several agencies are involved in operations of recovery, cleaning and evaluation of oil and other hazardous substances spills (20).

III.2) USERS OF THE DATA

The program is designed so that the data generated can be used by the pertinent agencies to improve the quality of the marine environment, and at the same time to protect the health of humans and marine organisms , as well as other coastal resources.

Users of information and results obtained during the monitoring program may include many groups in the community. Since the major concern of monitoring the environment is to detect changes that may be harmful to human health or the marine ecosystem, early warnings must be released to the public and appropriate agencies when results of the analyses show dangers for swimmers and bathers or consumers of seafood from contaminated areas. These warnings could reach the public by using the media of public communication, i.e. radio announcements, newspapers, bulletins, and by putting notices on the beaches.

For the protection of the marine ecosystem, data thus acquired would indicate the presence of pollutants being discharged into the aquatic system and would allow prompt intervention by the authorities to stop such contamination, and would also indicate whether or not the quality of discharged wastes is in compliance with aproved standards. In other words, users of data include public groups, federal and state regulatory agencies, local government, industries (e.g. seafood processing, tourism, aquaculture) as well as many other diverse groups concerned with coastal and marine resources.

Outputs will be in the form of monthly, quaterly and yearly reports, statistical analyses, and the reports of sudden changes in the quality of the environment already mentioned.

These reports shall be useful for wise decisions of waste disposal, living resources exploitation, coastal development, industrial permits, etc., by providing information on what areas are the best choice to perform those activities and identifying "hot pots" and points and non-points sources of pollutants.

III.3) OPERATIONAL

Sampling and measurements at the given stations should be carried out by members of the Instituto Oceanografico de Manzanillo. Since this job requires the use of winches and a wide and stable platform, especially for sampling sediments, the Navy should provide some of its ships, e.g. the oceanographic vessel "Mariano Matamoros", to accomplish successful operations. For the nearshore sampling, a small boat belonging to the Instituto can be used.

The analyses of the samples for the ordinary parameters are to be done at the laboratories of the Instituto Oceanografico, while that for the detection and measurement of the content of trace metals in sediments, and trace metals and chlorinated hydrocarbons in organisms, which require more sophisticated methodology and equipment not available at those laboratories, have to be sent, previously preserved, to the laboratories of the Secretaria del Desarrollo Urbano y Ecologia (SDEU), in Mexico City, for further processing. The advantages on doing so is that, if this project is accepted as a prototype and then adopted and adapted for its application in other coastal regions of the country, the data thus obtained can be comparable and in this way it would be possible to develope a complete program for all the coastal waters of Mexico that could be incorporated into global studies of marine pollution, which require standardized methods of analysis.

IV. MATERIALS AND METHODS

It has been previously established that the resources to be monitored in this program include water, sediments, and organisms. Each of them has its own needs and methods for collection, handling, preservation, and analysis, as well as the parameters to be examined. Nevertheless, some routine measurements have to be made in the water column during every sampling visit.

In general, water samples will be taken at different depths (one meter below the surface and one meter above the seafloor, and every ten meters in between) using Niskin bottles with reversing thermometers attached to them, aided by the ship's winches. At the same time, recording of salinity, temperature, depth, and pH will be taken by means of a CTD or a Hydrolab or other suitable apparatus. A separate surface sample shall be taken for the determination of bacteria counts using an adequate (sterilized) bottle, following the procedures recommended by the American Public Health Association (21).

Once aboard, subsamples are taken and preserved, if required, or analyzed. The use of a Technicon Autoanalizer will be very helpful for running the analyses of nutrients immediately after collection, avoiding the undesirable delay between collection and analysis of the samples.

Some of the routine measurements do not require any special treatment and can be performed *in situ* with the use of appropriate instruments, providing the recommended procedures by the manufacturers are followed. Others, however, will need to be preserved and stored for further analysis in the laboratory. The methodologies and equipment to be used for the examination of these general parameters are:

- Salinity: A water sample is taken in either a glass or plastic bottle, previously rinsed three times with the sample, and kept well stopped until its processing at the laboratory, where the conductivity of the seawater will be measured by using a conductivitymeter, calibrated with Standard Seawater (Eau de Mer Normale). The salinity of the sample can be obtained transforming the conductivity read by using tables conductivity-salinity, since there is a direct relationship between conductivity and salinity (22).

During the sampling, the conductivity of the water will also be measured by means of either a CTD or a Hydrolab. However, the conductivitymeter readings will be prefered when more precise vertical and horizontal profiles of salinity are desired.

- Temperature: For this parameter, as for conductivity, two readings can be obtained, one from the CTD or Hydrolab, and the other from the reversing thermometers. The latter will be prefered for the most accurate values, on condition that those thermometers have been previously calibrated.

- pH: Water samples are taken from the Niskin bottles immediately after dissolved oxygen sampling in polyethylene bottles with a tight-fitting screw cap, stored in a cool, dark place for not longer than 2 hr. The sample has to be warmed to laboratory temperature before measurement, which will be made by a glass electrode and electrometer-type pH meter.

- Turbidity: The Nephelometric Method will be used in which the intensity of light scattered by the sample is compared with the intensity of light scattered by a standard reference suspension made of hydrazine sulfate, $(NH_2)_2 \cdot H_2SO_4$, and hexamethylenetetramine, $(CH_2)_6N_4$, the measures of which are made in a turbidimeter consisting of a nephelometer with a light source and photoelectric detectors.

- Dissolved Oxygen: To be measured by the Winkler (Iodometric) Method, in which a manganous (Mn^{2+}) solution, followed by strong alkali, is added to the sample to precipitate manganous hydroxide, part of which is precipitated to basic hydroxides of higher valence states in an amount equivalent to the dissolved oxygen present. When the solution is acidified in the presence of iodide, the oxidized manganese reverts to the divalent state, and iodine equivalent to the original dissolved oxygen in the sample is liberated. The iodine is then titrated with a standard solution of thiosulfate, with a starch indicator.

IV.1) WATER QUALITY

For the particular case of water quality, practically two different studies are to be done: a) evaluation of the physico-chemical characteristics of the water in the bays, and b) distribution of sewage contamination along the beaches of both bays. In both studies, the main purpose is to obtain data about the present conditions in the bays and to be able to distinguish natural, seasonal variations, from those that are expected after starting the operations of the port at maximum capacity.

IV.1.a) Chemical Characteristics

Besides the general examinations before mentioned, other chemical parameters to be evaluated include measurements of nutrients (i.e. phosphate, nitrate, nitrite, and ammonia), biochemical oxygen demand, and coliforms and streptococcus content.

In Figure 1 are pointed the locations of the stations, whose sampling has to be performed every month, preferably following the same route and schedule every time. The methodologies for collecting, preserving and analyses of the samples are those recommended by the Standard Methods (23), or by Strickland and Parsons (24):

- Phosphate (ortho-): To be measured by the Ascorbic Acid Method, in which the phosphates present in the seawater sample react with a reagent containing ammonium molybdate, potassium antimonyl tartrate and ascorbic acid in an acid medium to form a complex heteropoly acid which is then reduced to give a coloured (methylene blue) solution and its absorption of light is then measured at 885 nm.

- Nitrate: The Cadmium-Copper Reduction Method should be used. In this spectrophotometric method, the nitrate in sea water is reduced almost quantitatively to nitrite by running a sample through a column containing cadmium filings amalgamated with metallic copper. The nitrite thus produced plus any nitrite initially present in the sample is determined by diazotizing with sulfanilamide and coupling with N-(1-naphtyl)-ethylenediamine to form a highly coloured azo dye that is then measured colorimetrically at 543 nm.

- Nitrite: The Diazotization Method is to be used, in which the nitrite present in the sea water reacts with the coupling of diazotized sulfanilic acid and N-(1-naphtyl)-ethylenediamine dihydrochloride in an acid solution to form a highly coloured azo dye, the absorbance of which is measured colorimetrically at 543 nm.

- Ammonia plus Amino Acids: The Direct Method is recommended, in which the ammonia and amino acids in the sea water are oxidized to nitrite by the oxidizing action of hypochlorite in excess in an alkaline medium; the excess is then neutralized by the addition of arsenite. The nitrite thus obtained is determined by the diazotization method.

- Biochemical Oxygen Demand: BOD bottles containing samples mechanically supersaturated with DO are incubated for 5 days at 20 C, at the end of which the DO content is measured. The difference between the initial and the final dissolved oxygen represents the oxygen demand produced by bacteria to degrade carbonaceous and nitrogenous compounds.

- Coliforms: To be measured by the Most Probable Number (MPN). For this bacteriologic examination, samples of sea water shall be collected in clean sterile bottles, either glass or plastic, and kept at a temperature at or below 10^{o} C until examinated, for a maximum of 30 hr.

The coliform group of organisms include all of the aerobic and facultative anaerobic gram-negative, nonspore-forming rods that ferment lactose with formation of gas within 48 hr at 35° C. The formation of gas within 48 hr in a fermentation tube with lactose broth or laurlyl sulfate lactose broth constitutes a positive Presumptive Test. A positive Confirmed Test is said to be obtained when the positive presumptive test samples produce gas within another 48 hr at 35° C in a brilliant green lactose bile broth.

IV.1.b) Fecal Contamination

Water samples from beaches along both bays are going to be taken every week for coliforms testing. The methodology to be used is the same as described above, and the station locations are indicated in Fig. 2.

IV.2) SEDIMENTS

Sediments will be sampled and analyzed monthly for determination of grain size, bacteria counts and organic carbon, and every three months for analysis of metals. Figure 1 indicates the location of the monitoring sites.

Bottom sediments are going to be collected with a van Veen grab, and the top centimetre removed for the analyses. Individual cautions for handling and storage will be followed for each of the parameters to be examined, and if necessary two or three samples will be taken in every station.

IV.2.a) Fecal Coliforms

For this examination, the top one centimetre of the sediment surface is removed with a sterile spatula and placed in a sterile French square bottle followed by storage under refrigeration for a maximum of 30 hr until examination according to APHA (21), although no appreciable changes in the coliform count occur when stored at 4° C for up to 4 days (25).

Fecal coliform densities are determined by the multiple-tube most probable number (MPN) as recommended by Standard Methods (23). For the presumptive test of the coliform group, sediments are incubated at 35° C for 48 hr in a lauryl tryptose broth. The positive presumptive tubes, i.e. those that show generation of gas within the 48 hr incubation time, are reincubated at 44.5° C for 24 hr in an EC medium. Gas production in the fermentation tubes within 24 hr indicates that the coliforms present in the sample are of fecal origin from warm-blooded animals. If required, it is possible to determine if bacteria present are probably due to human or animal sources by analyzing the streptococci count and looking at the ratio fecal coliforms/fecal streptococci; a ratio greater than 1 shows that most of the bacteria are of human origin, since the ratio for humans is around 4.4 and for animals is less than 0.6 (26).

IV.2.b) Organic Carbon

For the determination of organic carbon in sediments, we will use the modified Walkley-Black titration method, which has been shown be as accurate as but less expensive than an organic carbon gas analizer (27).

For this method, the sediment sample is sieved through a 10 mesh sieve (ASTM) to remove large particles, and then is dried, ground and sieved again through an 80 mesh sieve, and weighed. A 0.2 to 0.5 g portion of the sample is put in a reaction flask, and 10 ml of $K_2Cr_2O_7$ 1N and 20 ml of concentrated H_2SO_4 are added. After 30 minutes, the solution is diluted to 200 ml with distilled water, and 10 ml of H_3PO_4 85%, 0.2 g NaF and 15 drops of diphenylamine are added, and finally back titrated with ferrous ammonium sulfate 0.5 N solution until a brilliant green color is reached.

The results are reported in percent of organic carbon calculated with the following equation:

$$\% \text{ Organic Carbon} = 10(1-T/S)[N(0.003)(100/W)]$$

Where T = ml ferrous ammonium sulfate solution

S = ml ferrous ammonium sulfate solution for a blank
N = normality of $K_2Cr_2O_7$
0.003 = meq weight of carbon
W = weight of sediment sample in grams.

IV.2.c) Trace Metals

Ocean bottom sediments have been considered as the sink for many of the pollutants entering the marine environment, for instance, trace metals (28). Many studies have been done to elucidate the effects of ocean dumping of sewage sludge and tracking their route by using heavy metals in sediments as a tracer (29). However, some difficulties arise when dealing with trace metals in sediments, e.g. trace metals concentration in sediments varies in function of the rate of sedimentation, the particle size and nature, and the amount of organic matter in the sediments. Nevertheless, the pattern of distribution can be used to track the source and direction of the sediments.

For monitoring programs including studies in sediments, the first step is to establish the extent to which a determined area has been subjected to metal pollution, which would require a technique to provide a rapid, inexpensive gross evaluation of the kind and degree of metal pollution in sediments, such as that proposed by Chester and Voutsinou (30), in which 5 g of sediment is treated with 75 ml of 0.5N HCl during 16 hr, filtered, and the filtrate is then sprayed into an atomic absorption spectrophotometry. Once it has been determined what trace metals look for, more elaborate and accurate techniques have to be performed, focused on those metals that showed in the prior estimation.

For the program proposed in this paper, portions of the sediment samples are taken for the determination of size particle by wet sieving, and organic carbon content. Another portion will be stored in polyethylene bags to be sent to the laboratories of the Secretaria del Desarrollo Urbano for their analysis.

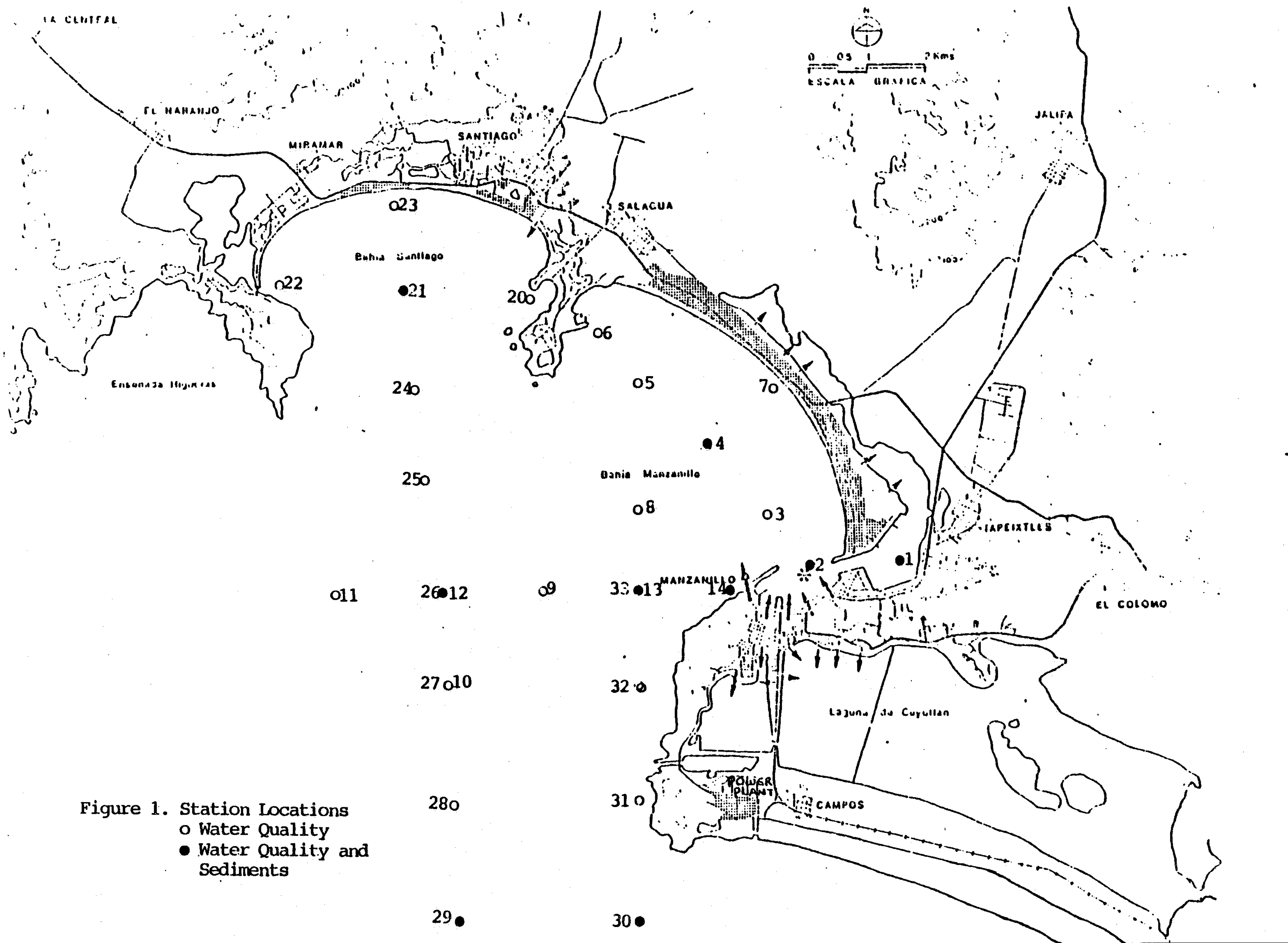

Figure 1. Station Locations
o Water Quality
● Water Quality and Sediments

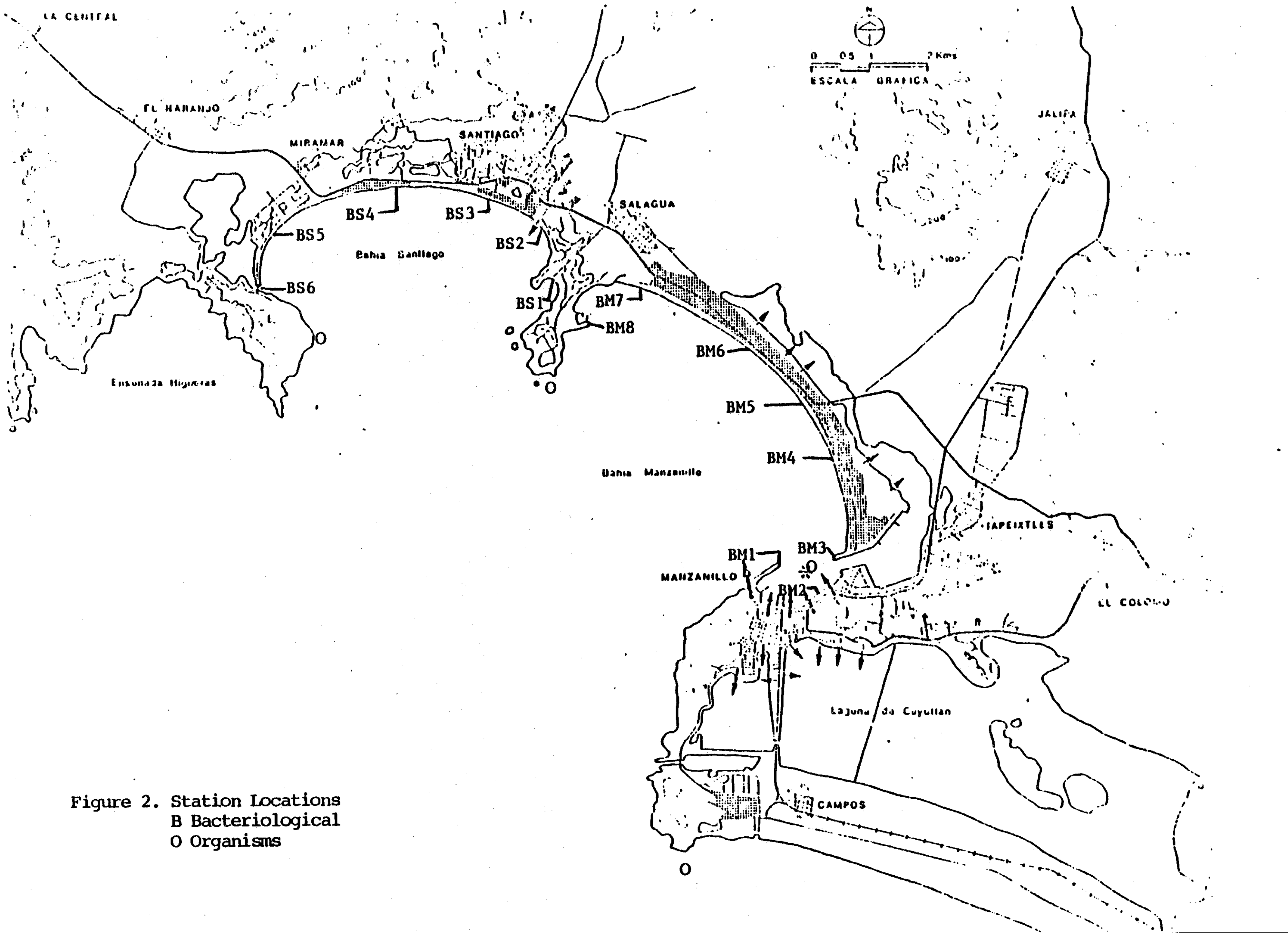

Figure 2. Station Locations
B Bacteriological
O Organisms

IV.3) ORGANISMS

The use of marine organisms to define the degree of pollution in certain areas has had great acceptance among environment researchers due to their capacity to concentrate pollutants such as trace metals (29,31), pathogenic bacteria (32), hydrocarbons (33,34), and chlorinated hydrocarbons (12, 35,36). The most popular organisms used are filter feeding bivalve molluscs, which have the ability to filter large volumes of water and thus retain pollutant particles from food, from solution, and from the ingestion of inorganic particulate material.

Goldberg (37) proposed a strategy of using those bivalves, like mussels, oysters, and clams, as sentinel organisms for monitoring environmental levels of certain pollutants in the marine environment. This technique was used effectively in Europe and the United States during the late 1960s, and by the 1970s it was adopted by many countries seeking for a global scale monitoring program that would indicate the health of the oceans of the world (38).

In the International Mussel Watch Program, the pollutants that are being monitored are hydrocarbons, trace metals, halogenated hydrocarbons, and radionuclides. In this paper, however, only trace metals and halogenated hydrocarbons, besides fecal bacteria counts, are proposed. The procedures for their examination are those recommended by the American Public Health Association for the bacteriologic analyses (20), and the analytical procedures used in the International Mussel Watch as a standard methods.

IV.3.a) Bacteria

Shellfish, as it was observed before, can filter large amounts of water and have the capacity to concentrate bacteria present in the surrounding water, an important aspect that can be useful in detecting low levels of organic contamination, especially fecal, which would be neglected by the traditional bacteriologic analysis of the water (28). This property is also important to take into account when dealing with shellfish, like oysters and clams, for human consumption or when deciding the site for oyster culture, since those bacteria may include pathogens.

For this program, oysters will be sampled every week in specific areas, the locations of which are indicated in Fig. 2. A minimum of 12 oysters have to be taken in order to obtain a representative sample, and then kept in waterproof containers at 4^{o} C for at most 20 hr. Prior to opening, the shell has to be scraped and scrubbed, and then allowed to drain. The oysters shall be opened by using a sterile knife, and the liquid and meat shall be collected and blended in a sterile blender, after that a sample is weighed and diluted with an equal amount of 0.5% sterile peptone water.

Tests for organisms of the Coliform group shall be carried out, using the technique of MPN by taking 5 tubes per dilution. Procedures for Presumptive and Confirmed tests are the same as those for coliforms counting for sea water. The coliform content shall be expressed as Most Probable Number (MPN) per 100 g of sample.

IV.3.b) Trace Metals

Different types of organisms have been used in the past for studies of metal pollution in coastal and estuarine environments. Phillips (26) has given a resumè of the results obtained by many workers concerning the uptake and accumulation of trace metals. He concluded that bivalves are one of the best indicators of metal pollution, since they can accumulate trace metals by factors of 10^3 to more than 10^6, depending on the species and the metal. However, he also noted the need for taking into account the effects of season, age, weight, and size of the individuals, sampling techniques, salinity, temperature, and the coexistence of several metals, on the ability of the organisms to concentrate metals as well as the degree of toxicity of metals.

In order to minimize those effects, some procedures have been recommended (38), e.g. annual sampling during the winter months; a maximum range of shell lengths of 50 to 80 mm, with a mean shell length of 75 mm; an approximately equal number of males and females; samples should be taken at the mid-tide level, and a minimum sample size of 25 individuals.

Those procedures are to be followed for the realization of this program, in which the oysters will be placed in 20 liters of water from the site of collection, after sediment and organisms have removed, for a period of 24-48 hr to let them excrete the gut content which may contain food and sediments rich in metals. After this depuration period, and another 5 min for draining, the individuals are kept frozen in polyethylene bags at -10 to -20_{o} C until further analysis at the laboratories of the Secretaria del Desarrollo Urbano y Ecologia. There, samples should be thawed and sucked, by using stainless steel implements to avoid contamination with metals. Liquor and meat of the 25 individuals per site are homogenized, and wet and dry weights are determined, as well as the dry-weight/wet-weight ratios. Finally, the samples are acid digested to destroy organic matter and dissolve all metals, and the determination is accomplished by flame atomic absorption spectrophotometry.

IV.3.c) Chlorinated Hydrocarbons

As for the case of using organisms as indicators of metal pollution, Phillips (36) has also reviewed their use for monitoring chlorinated hydrocarbons in aquatic environments. Species that have been used as indicator organisms include bivalve molluscs, macroalgae, and fishes, although many studies have used crustaceans, mammals, and birds, organisms that have high lipid content since organochlorine compounds, although only slightly soluble in water, are largely fat and lipid soluble. Despite the limitations outlined by Phillips of the former organisms, i.e. rapid rate of uptake and excretion of the organochlorine compounds, differences in assimilation of them depending on the species and the compound as well on the size, age and sex, and other factors, these represent a better indicator for local contamination, since others, e.g. fishes, particularly migratory species, besides being more difficult for sampling, do not reflect the actual conditions of the catching site.

For this part of the study, oyster samples will be taken at the same time and from the same place as for trace metals examination (annually), the specimens being later wrapped in aluminium foil and kept under refrigeration until their initial treatment at the laboratories of the Instituto Oceanografico. There, they will be sucked and homogenized, and a weighed fraction (10 to 20 g) extracted with hexane in a Soxhlet, according to the procedures reccomended by Goldberg (39), and the extracts will be sent for their analysis of PCBs, DDTs, dieldrin, aldrin and hexachlorobenzene, by gas-liquid chromatography (GLC), to the laboratories of the SDUE.

V. CONCLUSIONS AND RECOMMENDATIONS

This paper identifies some of the priorities in matters concerning protection of the marine resources by preventing damage to them due to the effects of pollutants, both known and expected to be present. For a global point of view, the proposed project represents a very local program; indeed, it is. However, as it was mentioned before, this would be the starting point for other regional areas that could include the coast line of the state, and thus the estuarine portion of the rivers Marabasco and Armeria to the southwest and southeast of the state, respectively, and the states of Jalisco and Michoacan.

Again, the purpose of the program is to provide information about the actual condition of the marine environment in the bays, information that can be useful for making proper coastal decisions. In spite of the general belief, developing countries like Mexico do care about their resources. Decisions made in the past may have had mistakes due to lack of data on the environment, but decision making in the future will not be much better unless that information is available for coastal zone managers.

Related to the project, the advantage of having a central laboratory for the processing of samples requiring special instrumentation and skills is that the results can be comparable and easy to interpret if a national program were set up. Nevertheless, exercises of intercalibration with other laboratories are needed and widely recommended for the purpose of including the program in global studies like the International Mussel Watch.

In order to avoid the same mistakes that have been made in the past, that is duplicate of efforts, it is necessary to have an organization that coordinates all or most of the programs related to studies of the marine environment. Officially, the Secretariat of the Navy is the agency in charge to protect the quality of the Mexican coastline, thus the Instituto Oceanografico de Manzanillo, belonging to that agency, could be the general coordinator for that purpose. Moreover, the data generated for all of those studies can be stored in the computer available in that institution for ease of retrieval and interpretation, either by statistical analyses or by mapping and identifying the localized polluted zones, as well as the trends in the concentrations of the pollutants.

However, it is also necessary to remember that those changes can occur in a relatively short time, thus the need for a continue monitoring following a given schedule of time. On the other hand, some of the analyses require the skills of experienced technicians. It is recommended, then, that the determinations be performed by the same individuals and under the same circumstances, when possible, in order to have reliable data that can be correlated with changes in the same area and with values of other regions.

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