Basic Concepts to Develop a Marine Pollution Monitoring Program at the Tijuana-Ensenada Corridor, Baja California, México

by

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CHAPTER 1
INTRODUCTION

INTRODUCTION

The development of a Marine Pollution Monitoring Program (MPMP), in any coastal area of the world, requires a precise knowledge of the functioning of the local ecosystem. Because of the differences found in every coastal ecosystem, it is important to recognize and characterize the reservoirs and significant environments that maintain such a system. When these information is not available, some basic ideas should be delineated so that a MPMP could be established to preserve and conserve natural coastal resources. This could be defined as sustainable development of the coastal zone.

Currently the state government of Baja California, México is implementing a program to develop the Tijuana-Ensenada corridor, the Program for Urban, Touristic and Ecological Development of the Corridor Tijuana-Ensenada (PRDUTE). It is intended to reach sustainable development of the corridor by managing human activities, and preserving the corridor's coastal ecosystem. This is a very important step with regard to Coastal Zone Management Programs (CZMP's) in México. However one consideration should be made before the PRDUTE is successfully implemented.

The PRDUTE should account for marine pollution processes along the Tijuana-Ensenada corridor, but because there is not enough data regarding oceanographic, marine pollution or environmental processes within the area, the PRDUTE lacks that kind of information. Thus, it would be difficult to attain sustainable development at the Tijuana-Ensenada corridor if the PRDUTE is only implemented as it was enacted.

The idea of the present research work then is to delineate some basic concepts and ideas, that would be useful in developing a better understanding of the marine pollution processes found along the Tijuana-Ensenada corridor, and that would help in developing a marine pollution monitoring program for the area.

To develop the ideas and concepts required to understand the corridor's environment, first an overview of the overall problem of marine pollution problem in the corridor is given. The results of reviewing and evaluating the Mexican, federal and state of Baja California, environmental laws, and the PRDUTE in relation to marine pollution in the Tijuana-Ensenada corridor, are delineated, and the comparison of the available oceanographic information in the corridor with current marine pollution problems is delineated. Conclusions regarding the actual sistuation of the corridor's environment are ginven, as well as short and long term reccomendations, where I did delineate some actions to be taken, to develop an understanding of the corridor's environment. In this manner a Marine Pollution Monitoring Program (MPMP) can be elaborated and implemented, and it would be more likely for the corridor Tijuana-Ensenada to reach the so called sustainable deveolpment.

The present research then focuses on delineating the basic ideas required to gain some insight on the Tijuana-Ensenada corridor's ecosystem, rather than developing the Marine Pollution Monitoring Program for the area.

Organization

This research report is organized in three chapters. The first chapter gives an overview regarding CZMP's in México. One would expect that México, with its extensive coast line, has developed and implemented CZMP's in order to conserve and preserve its natural coastal resources. In fact, this is not the case, and a discussion is presented to address this matter.

The Mexican-U.S. border, where the cities of Tijuana, Baja California, and San Diego, California meet, has been the site of several environmental problems, among them marine pollution issues. I briefly summarized why this might be happening.

Chapter two focuses on marine pollution issues in general. It defines the concept of marine pollution according to the Joint Groups of Experts on the Scientific Aspects of Marine Pollution (GESAMP). The three main questions, in regard to marine pollution are developed: 1) can we stop pollution; 2) are we willing to stop marine pollution at the expense of economic growth; 3) should we pay high costs to prevent marine pollution, instead of bearing much higher costs if we do not set adequate marine pollution control devices and regulations. Chapter two also describes the common forms of marine pollution to which research has been focused for decades, according to several authors (p.32). These common forms of pollution are related to the marine pollution processes found along the Tijuana-Ensenada corridor. At the same time I tried to explain the actual situation of the corridor, i.e. what is known about the different forms of pollution in the area.

Finally, chapter three is devoted to define why and how a MPMP is important for the Tijuana-Ensenada corridor to reach sustainable development. It reviews some basic concepts regarding reservoirs and significant environments that should be understood, so that a MPMP could be elaborated. Discussions, conclusions and recommendations that should be accounted for a more integrated development of the Tijuana-Ensenada corridor are described.

Objectives

The objectives of this work are to:

a) Review and evaluate the Mexican federal and Baja California state laws, regarding marine pollution issues.

b) Review and evaluate the Baja California state Program for Urban, Touristic and Ecological Development of the Tijuana-Ensenada Corridor, regarding marine pollution issues.

c) Give an overview of the current marine pollution conditions of the Tijuana-Ensenada corridor, with reference to marine pollution processes elsewhere. And, determine whether or not we can assess what is the actual health of the corridor's coastal environment.

d) Delineate basic actions to be taken, in order to start the development of the data base required to elaborate and implement a Marine Pollution Monitoring Program for the Tijuana-Ensenada corridor.

Methodology

An extensive literature search was conducted to retrieve as much contaminant and pollution information as possible along the Tijuana-Ensenada corridor, and that pertain with the coastal area of Southern California.

I conducted computer searches as well, on the CD rom system, at the Oregon State University (OSU) library. The data base consulted included pollution abstracts, aquatic sciences and fisheries abstracts, biological abstracts, oceanographic abstracts, and applied science and technology abstracts. I also consulted marine pollution literature from the OSU library.

Data from environmental consulting firms in Tijuana, Baja California, and in San Diego, California, and from research institutes, was obtained.

The search was focused on work published from 1985 to the most recent. However I included information published in previous years, which I believe is important. Some of the information obtained has not yet been published.

BACKGROUND

México has 11,592 km of coast line, approximate 1,567,000 hectares of water bodies, and about 600,000 hectares of wetlands. It has many attractive beaches, some important coral reefs, and more than 130 estuaries (Contreras and Zabalegui, 1988).

The coastal zone of México supports important economical and social activities. It is a significant source of food, it has a high productive potential (e.g. aquaculture), and the climate and landscapes are attractive to national and international tourism. There are also important industrial and commercial zones due to the disponibility of water, and easy access for marine transportation (Contreras and Zabalegui, 1988).

With all these characteristics, one would think that México could have developed a Coastal Zone Management Program (CZMP), to administer all its coastal activities. Unfortunately this is not the case. According to Sorensen and Brandini (1987) coastal countries in Latin America have to exceed a threshold of resource degradation, natural hazard degradation, or conflict among resource uses before leaders will take notice and make coastal management a topic on their public agenda. Perhaps México has arrived at that point today. Currently México is facing several issues that have prompted consideration of developing a CZMP. Brandini and Sorensen (1987) summarized those issues or problems as: domestic and industrial pollution nationwide; hazards (e.g. statewide natural induced shoreline erosion), and inadequate public services nationwide. Although all these problems exist, there is practically no policy in México intended to protect, preserve and wisely manage marine and coastal resources. The Federal government has not been able to implement an instrument to analyze and solve the problems. This generates conflicts among regulating agencies at the federal, state and local levels, since there are a variety of groups with different interest on coastal resources (Contreras and Zabalegui, 1988).

To date the legal federal tool for environmental protection in México is La Ley General del Equilibrio Ecológico y Protección al Ambiente (LGEEPA). Its principal objectives of this law is to adopt the normativities to conserve, protect, preserve, and restore the environment and its components by controlling pollutants and their causes (Beltrán del Río and Du Mars, 1988). Accordingly to this definition, it might be logic to think that the coastal resources in the country are protected under the federal law. However the LGEEPA is far from being able to do so. Coastal ecosystems and their resources are only briefly mentioned within the document, and the regulations are vague and general.

Some states and local governments had implemented their own legislation, trying to cope with the pace of development and conservation of natural resources in their jurisdictions. One of those is the state of Baja California, which developed and approved its own environmental regulations. The state law, Reglamento de la Ley General del Equilibrio Ecológico y Protección al Ambiente del Estado de Baja California en Materia de Impacto Ambiental (LEEPABC), presents the same problems as LGEEPA. It is general and vague in definitions, and lacks adequate implementation for the coastal zone and its resources, despite the fact that the coast line of the state represents 11.05% of the total coast line in México. As a result of this lack of attention to the coastal resources, two of the most important activities in the state, fisheries and tourism, are threatened.

The marine pollution problem along the México-U.S. border on the Pacific coast has been perhaps the most important issue among the environmental problems between the two nations. Since 1938, Several agreements, have been developed and signed to cope with this problem. However the problem still persists, and will increment if no adequate management actions are taken.

CHAPTER 2
MÉXICO-UNITED STATES BORDER ZONE:
THE TIJUANA-SAN DIEGO CASE

MEXICO - UNITED STATES BORDER ZONE:
THE TIJUANA - SAN DIEGO CASE

To understand why a CZMP, or at least a program dealing with the coastal environment and its resources, is required in the Tijuana - San Diego border, I will summarize some of the issues dominating the environmental agenda of the Mexican and American federal, state and local governments.

The existing environmental problems between Tijuana and San Diego are due in part to the accelerated growth of both cities. In Tijuana new human settlements are developed where no basic services are available (e.g. water, electricity, transportation, etc.). This has brought undesirable conditions for living, and caused an adverse effect to the environment. At this time the impact is not well understood. Besides new human settlements, the maquiladora industry has increased in large numbers, and constitutes another part of the problem. This special type of industry has developed in the northern Mexican border. Its products are integrated to a large production system of foreign-owned operations, after being elaborated by Mexican industries that provided raw materials, and smaller component parts. Many maquiladoras utilize chemical substances for their processes, generating hazardous waste byproducts. These materials are not adequately managed. Other maquiladoras are polluting the air with aerosols from paints or larger particles derived from their processes. When these particles reach the atmosphere, they are carried across the border to the city of San Diego due to the regional wind patterns. Water is also contaminated by diverse chemical materials, and some industries are still draining their water without treatment. Municipal water discharges entering the marine environment have also crossed the border, creating a pollution conflict within the coastal areas of Border Field, California. On the other hand, the rapid population growth in San Diego has been the cause of large environmental problems within that area as well. Air pollution in the city has become an important issue, but perhaps the most publicized case has been the short capacity of the county to treat their municipal and industrial waters at the waste water treatment plant of Point Loma. It has been determined that marine pollution within the border is not only due to the drainage problem of the city of Tijuana, but in a much larger part due to the water drained from the outfall off the Point Loma treatment plant.

San Diego Bay is highly contaminated with excess concentrations of metals such as copper, petroleum hydrocarbon residues, polychlorinated biphenyls (PCB's), and tributyl tin (TBT) (San Diego Interagency Water Quality Panel, 1990). Coastal waters also receive a large amount of sewage drained from the Oceanside and San Elijio California waste water treatment plants (Sánchez-Rodríguez, 1990).

The environmental problems in Tijuana can be attributed to the federal, state and local authorities in Mexico. SEDUE, the Mexican federal environmental protection agency, has the role to protect México's environment, accounting for Mexican-U.S. border areas as well. In 1991, SEDUE implemented a program along the México-U.S. border to cope with the difficulties of environment pollution. Under the program, qualified people were hired to act as environmental surveyors, in order to enforce the Mexican Federal environmental law (LGEEPA). However the program presented some inconveniences. The number of surveyors hired was too small in order to cope with all the industry. For example, in Tijuana only twelve (12) surveyors were in charge of 760 maquiladoras in the city. Short funding, and the lack of consistency due to the bureaucratic system constrained the opportunity to develop the program as it was envisaged. Furthermore, after one year of program's implementation, and after SEDUE agreed with the U.S. EPA to develop a long term program for environmental protection along the Mexico-U.S. border, SEDUE was dissolved, and a new federal agency tooks its place. This new agency (SEDESOL) does not regulate air and water pollution. Therefore the burden went to other federal and state agencies that had never dealt with the issue of implementing or enforcing water and air pollution laws before.

Environmental problems were always allocated at the federal level; meanwhile state and local governments solved different social issues. Now, when environmental problems have increased in a rapid manner, they are trying to develop ways to solve these issues. But the lack of experience, funding, research, and qualified people for the job is an enormous barrier that will be overcome only with time. Concurrently environmental problems are still accumulating.

The American authorities of the county of San Diego have also being neglecting their incapacity to cope with the problem of waste water treatment. The rapid growth in the county requires the installation of a new drainage system. This has not yet happened, and the water drained to the ocean after its treatment is really of poor quality. Actually the U.S. federal government is considering the construction of an advanced secondary treatment plant to be located near the border line within the city of Tijuana, and some major repairs in the outfall system of the current waste water treatment plants in southern California.

In conclusion, both Mexican and American authorities from Baja California, and California, are responsible for not implementing an adequate protection management program in their border environment.

THE ENVIRONMENTAL PROBLEM

Although there are a myriad of problems causing impact on the surroundings of the Tijuana - San Diego transboundary zone, the largest source of trouble is the drainage system of both cities. According to Sánchez-Rodríguez (1990) the conflict of the drainage of the city of Tijuana goes back when the municipal waters were drained directly to the Tijuana river. The problem has evolved with time. In 1938 San Diego and Tijuana shared a submarine emissor to drain the effluent near the international border line. After the decade of the 1950's Tijuana developed a separate drainage system to discharge the effluent near the coast of Rosarito, i.e. 12 miles south of the border on the Pacific coast (Fig.1). Failure of the system caused the effluent to spill across the border. Trying to solve the problem, Tijuana and San Diego agreed to develop an emergency system that permitted some of the waste water of Tijuana to be sent to San Diego for treatment (Conway et al., 1987). In 1986 San Diego decided to cancel the agreement arguing that the system was overloaded by Tijuana's effluent. To date, constant spills continue across the border in three localized areas: 1) the Tijuana river, 2) along the international avenue, and 3) the littoral zone of Playas de Tijuana (Fig.2). According to Sánchez-Rodríguez (1990), the largest conflict is created by the spills over the Tijuana river, since it drains into the Tijuana Estuary and denominated a natural preserve area by the government of California in 1982, affecting its natural conditions (San Diego Union in: Sánchez-Rodríguez, 1990). These discharges have not been controlled yet, and have been the principal source of pollution of coastal waters of Imperial Beach (Fig.3). The waste water treatment plant localized in Punta Bandera, B.C. is presenting problems with its capacity (Medina-Parra personal communication), therefore it is questionable if the water drained to the ocean meets the existing federal criteria. In September 1993, high concentrations of metals were detected in one of the oxidation lagoon, even though the water received by the plant is supposed to be only municipal water, not industrial water. Although no more information is available on this, the waste water treatment plant could be an important source of pollutants, such as metals, to the coastal environment.

San Diego also contributes continuous spills into the bay and coastal waters. As mentioned above, its waste water drainage system has old drainage pipes, and the San Diego River and Torrey Pines beach receive wastewater discharges due to the deficient operation of the pump system. The submarine outfall of the waste water treatment plant of the city, localized at the Point Loma, discharges about 170 millions of gallons per day (mgd). The EPA showed that the water does not meet the federal standards for dissolved oxygen, oil, solids, turbidity and coliforms. Conway et al. (1988) reported similar numbers for biological oxygen demand, nutrients, coliforms, and metals when comparing the water quality from both Tijuana and San Diego drainage systems. The discharge of the city of San Diego is larger than the discharge of the city of Tijuana by 8 times according to Sánchez-Rodríguez (1990).

The continuos spills from both sides of the border has impacted the water quality of their coastal zones. Morales-Chávez and Orozco-Borbón (1986) (in: Calderón-Torres, 1993) reported a wide distribution of coliforms off the outfall of the waste water treatment plant of the city of Tijuana. The bacteria distribution was 5 to 8 km and 2 to 3 km along and offshore respectively. In her studies on bacteriological pollution off the littoral zone of the México-U.S. border, Calderón-Torres (1993) reported that the distribution of the bacteria along and offshore the coast depends upon the dispersion coefficients at the site (10^4 cm^2/s; Bravo-Chávez, 1989), that is predominantly to the south. These results along with the results of Morales-Chávez and Orozco-Borbón (1986), suggest that high concentration of bacterial pollution is transported to the south from the outfall of the waste water treatment plant of Point Loma within the 60 m isobath. Although the concentration of total and fecal coliforms diminished off the outfall of the Punta Bandera treatment plant, and other influenced zones, the problem still existed in 1992 (Calderón-Torres, 1993).

It can be assumed that the environmental problem of major concern at the site is then caused by waste water discharges from both sides of the border. And even though only organic pollution has been considered, it is important to keep an eye on other type of pollutants, such as metals. Lately, Sañudo-Wilhelmy and Flegal (1991) made some studies along the U.S.- Mexican coastal waters boundary. They assessed the distribution of trace elements (Pb, Cd, Mn, Fe and Zn) due to natural processes and anthropogenic inputs, in order to evaluate the magnitude of heavy metal contamination. They concluded that the high trace metal concentrations were associated with physical oceanographic processes (upwelling and advection), rather than anthropogenic inputs. One year later, the same authors reported their results assessing anthropogenic inputs of silver into the Southern California bight. This time they suggested that the waste water treatment plant at Point Loma discharging off San Diego accounts for essentially all of the silver in coastal waters along the U.S.-Mexican border during summer conditions. These two observations do not contradict each other. They suggest that a more detailed characterization of trace elements and heavy metal distribution, concentration, species, sources and sinks at this coastal line is required.

THE IMPORTANCE TO PROTECT AND PRESERVE THE TIJUANA-SAN DIEGO BOUNDARY COASTAL WATERS

Although the maquiladora industry has been central to the economic growth of the region shared by Tijuana and San Diego, and other cities of the state of Baja California, there are other economical activities taking place due to the extension of the coastal line in the state. According to Merino (1987) the three main coastal activities in Mexican coasts are oil extraction, fisheries and tourism. Out of these three, fisheries and tourism occupy a very important place in the state. México's fisheries are placed among the most important in the world (Contreras and Zabalegui, 1988). The city of Ensenada, B.C., located just 100 km south of the Tijuana - San Diego border is number one in the Mexican fleet in number of ships as well as in number of tons of tuna captured. Some other 107 marine and coastal species are also exploited, and either consumed locally (e.g. the case of the lobster), or exported, mainly to Japan. Of the total number of people involved in this activity (58,584), 39% are distributed between the cities of Tijuana and Ensenada. Considering all the species captured, the total value of fisheries on the state in 1991 was of 243,017,902 pesos (~75,943,094 dlls) (INEGI, 1992).

The touristic sector in the country is placed among the top 5 in the world as suggested by the Federal Secretary of Tourism (TV. interview 1993). In 1990 the hotel industry in Baja California was the 6th largest in México (Estadísticas de Turismo, 1992). Within the state of Baja California, the coastal corridor (i.e. the transect from Tijuana to Ensenada) is highly touristic oriented, and is the most visited part in the state. These touristic oriented uses support some other commercial activities such as transportation, and restaurant and hotel services, among others. Of the total number of people involved in these activities 68% and 71% are in among the cities of Tijuana and Ensenada respectively (INEGI, 1992). The touristric sector still is expanding, which is one of the primary goals of the state government.

From the above, it is clear that both fishery and tourism are of regional importance, and are being encouraged to be sustained and improved with time. In order to comply with this sustainability and developmental purposes it is necessary to maintain and preserve the physical characteristics of the coastal environment that permit good fish captures and that do attract people from around the world.

The quality of the marine environment in the Pacific coast of Baja California depends on the natural atmospheric and oceanographic processes occurring within the area. All conditions together (i.e. physical, chemical, geological) are important in setting up the biological characteristics of the ecosystem. One particular feature is the high productivity of the area, due to the enrichment of surface waters with upwelled cold and nutrient rich waters. The high biological productivity is responsible for sustaining higher trophic levels, which in turn support the fishery stock of Baja California. However, the ecosystem may had felt an impact due to human activities, and unfortunately there is not much known about its extent. Fisheries are still harvesting many tons of their products a year, but how long this can be sustained if no protection is imposed upon coastal resources is not determined. The touristic sector is threatened by alteration of coastal resources as well. Baja California coastal water quality has been reduced due to municipal and industrial waste water discharge. If this continues, with time no adequate water quality conditions will be found, and a possible shift in touristic destination is plausible.

Another important point to consider is the significance to protect the coastal water environment in the area. Seawater plays a major role as the last available resource of fresh water for the region, thus it is important to maintain its quality.

I think that it is very legitimate to conclude that the alteration of any of the coastal natural processes within this region would lead to a severe impact on the economical activities of the state, especially those located at the Pacific coast.

AGREEMENTS TO PROTECT THE B.C. BORDER ENVIRONMENT

Because authorities and the population from both sides of the border are aware of the pollution problems within the region, several agreements have been enacted (Sánchez-Rodríguez, 1990). Since 1884, the dispute was the water distribution from the Colorado and Bravo Rivers, and its pollution. In 1928, the International Border Water Commission (IBWC) was created to negotiate this debate, but it was not until 1944 that México and the United States arrived at an agreement on how the distribution of the water would take place. The water quality that México should receive from these rivers was suggested in March of 1965 by the IBWC. Problems arose when in 1961 farmers from Arizona drained water into the Gila River, near the confluence of the Colorado River. The salinity of the water was 2700 ppm, 2 times the limit required for agriculture. Many crops were lost in the valley of Mexicali, B.C. (Sepulveda, 1983 in: Sánchez-Rodríguez, 1990).

In 1972, Presidents Nixon and Echeverría reached an agreement called "La Minuta 241 del 14 de Julio de 1972 de la Comisión Internacional de Límites y Aguas".

In 1979, the IBWC expanded its authority through "La Minuta 261" to regulate water pollution problems. With this new role, in 1980 "La Minuta 64" was passed, enacting control of water pollution in the Nuevo River, from industrial and urban waters drained by Calexico, California, and Mexicali, Baja California.

In 1978 a Memorandum of Understanding was acorded by the Subsecretaría de Mejoramiento del Ambiente (SMA), part of the Mexican federal health secretariat Secretaría de Salubridad y Asistencia (SSA), and the U.S. Environmental Protection Agency (EPA). By this agreement both agencies agreed to cooperate with each other to solve the environmental problems along the border, by information and personnel exchange, and by developing projects both parties thought important. The agreement, however, did not established a regulatory framework. The principal problem was that it was agreed to by two agencies not at the federal level, therefore it did not developed enough strength to be on the binational agenda. The document was also general in its objectives, and did not specified particular tasks that the agencies involved should perform. It also lacked coordination between federal, state and local efforts in order to solve the environmental problems within the region.

In August 1983, after all the experience gained by previous agreements, Presidents Reagan and De la Madrid signed the "Binational Agreement". It was again aimed at solving the environmental pollution problems within the border. This time the document was stipulated at the federal level between the Secretaría de Desarrollo Urbano y Ecología (SEDUE) and the U.S. EPA. The agreement's priorities were to find solutions to the environmental problems within the Mexican and North American border, to establish a line of communication between both sides in order to develop the points accorded in the document, and to define a specific geographic area. Four agreements were summarized within this document: 1) the drainage system problem of the city of Tijuana, 2) the binational contingency plan, 3) the management problem of hazardous waste, 4) the solution to the air pollution problem, and 5) an air quality monitoring program for the cities of Ciudad Juárez and Chihuahua.

The most recent agreement between the Mexican and North American governments is the "Plan Integral Ambiental Fronterizo" (PIAF). In November 27, 1990, Presidents Bush and Salinas de Gortari met in the city of Monterrey, N.L. México. They pointed out the environmental problems within the border, and recommended to the U.S. EPA and SEDUE the task of developing an environmental border plan that could solve the border pollution problems, and that could be revised periodically. Those periodic revisions should be the forum for the participation of local and state authorities, as well as the public and private organizations. The plan is intended to be the base for an adequate growth and development of the border zone, preserving its natural resources, and be an essential part for solving the potential pollution problems due to North American Free Trade Agreement (NAFTA). The primary goal of the PIAF is related to the preservation of the natural environment within the border, giving priority to the high biodiversity of the area, parks and national forests, as well as marine resources. The goal in itself is indeed valid, however, and as we have seen in the history of the Mexican-United States relations regarding environmental problems, México is at clear disadvantage compared with the United States. The U.S. has developed its own environmental legislation based on its particular social and natural problems. The North American society structure had led the way and dictated the criteria on which their environmental regulations are fixed. These regulations then are intended to solve the problems in the United States. However the environmental legislations, and standards adopted by the Mexican federal government are those approved by the EPA (Flores, PIAF 92-94, Tij. p.32). Adopting these criteria has not proved to be useful in the Mexican society. The Mexican federal government does not have the potential to cope with the environmental problems in the country, and in general the problems outside of the city of México had been left aside. For example, until 1991 the former federal agency, SEDUE, adopted a plan to mitigate environmental problems along the U.S.- México border. Not much was accomplished in the course of a year due to insufficient funding. Furthermore, in 1993 SEDUE was dissolved to create a new federal agency, the Secretaría de Desarrollo Social (SEDESOL). SEDESOL focuses only on management of hazardous materials and waste.

Another disadvantage that México is facing compared to the U.S. is that the latter had determined their environmental agencies through private consulting firms, research institutes and several university departments. The case of México is different. Governmental agencies supposed to implement environmental regulations and standards lack human and technical resources. Private firms do not conduct research, and universities and their departments had developed a research system where community environmental problems are considered far below of the scientific reach, i.e. that research results is thought not to be used to solve environmental problems (Contreras and Zabalegui, 1988). Yet another disadvantage that México faces is the fact that there is no diffusion of the data obtained from research to other than the scientific community. The U.S. differ in this respect since scientific research is often developed from public concern with respect to a problem. For example, people concerns about coastal resources was expressed by the Stratton Commission in the study called "Our Nation and the Sea" in 1969.

Regarding to the preservation of marine resources, as stated by the PIAF, México is also not in a favorable condition compared with the U.S. The Southern California Bight, for example, is one of the most studied along the U.S. west coasts. Federal agencies, e.g. NOAA, as well as research institutes as the Scripps Institution of Oceanography of the University of California, San Diego (UCSD), have produced very large data from the area. The California current, its causes and biological and chemical processes are well characterized. Other studies are related to marine pollution within the area. For example, anthropogenic input sources are defined an quantified (Huh et al., 1992; Flegal and Sañudo-Wilhelmy, 1992; Bruland et al., 1974; Finney and Huh, 1989). Mexican research institutes, as well as federal agencies have not conducted as many studies along the México-U.S. border as the U.S. within the Pacific coast. This limited information does not permit a clear understanding of the natural coastal processes on the Mexican side. This presents a problem. The PIAF states that the Mexican and North

American activities, conducted by federal, state and local agencies, to control the marine pollution problem of the area are implemented by the measures adopted within the document. This simply is not true. It is not possible to define which actions, and what regulations must be implemented to preserve the marine environment if there is no clear understanding of the natural processes of the area. Although the U.S. have characterized their Pacific coast area within the border, they have not conducted any studies on the other side of the border, the Mexican Pacific coast. It is important to note that for the marine ecosystem no boundaries are valid. So there is more information required, on the behavior of the Mexican coastal ecosystem, in order to manage its resources. The PIAF implies that inland planned activities are enough to protect the health of Baja California's coastal resources. However several Mexican scientists (Lizárraga-Arciniega, Tij. p.1; Navarro-Olache, Tij. p.3; Torres-Moye, Tij. p.5 in: PIAF 92-94) have expressed their concern for this border marine environment, assuming that the PIAF will be the federal tool empowering environmental protection to this coastal area, and because no measurements are eneacted in that regard. They suggested that first a scientific study should be conducted, in order to determine the characteristics of the area, and then to specify which are the sources ands sinks, kind and concentrations of pollutants entering the marine environment. To what extent this will take place depend on funding and research interests. Funding is scarce, and SEDUE, the federal agency supposed to monitor and implement the PIAF in the Mexican side, is no longer existing. The largest scientific community in México is located in the state of Baja California in the city of Ensenada (100 km south of the Mexican-U.S. border). Most of their research was focused on the Gulf of California, or within the Ensenada bight. Not until lately has some interest been shown on the Tijuana-San Diego marine environment.

The time scale on which the marine environment natural processes of the Pacific coast of Baja California are going to be addressed will depend on funding and research interests.

Before this characterization is done, no environmental regulations can adequately implemented.

In short, successful or not, the agreements between México and the United States to protect the border environment have something in common; the marine environment and its resources have never been dealt with direct by either of them. Recent studies of the Southern California bight, and a few off the Pacific coast off Baja California, have revealed that the marine ecosystem at the border along México and the United States Pacific coast is suffering severe human impacts due to the development of the region. However, lack of previous knowledge of this situation does not justify the fact that the authorities, federal, state and local, from both sides of the border never accounted for pollution of the marine environment in their "binational agreements of environmental border problems".

MEXICAN ENVIRONMENTAL LAWS

The Mexican environmental regulations were enacted in the late 1960's by experts in the field when the problems of the environment in México city were the object of public attention (Du Mars and Beltrán del Río, 1988). In 1971, the Mexican legislature passed a federal law to prevent and control environmental pollution. Its goal was to restore the quality of the environment by eliminating the causes of pollution of air, soil and water. The implementation of the act was made by three sets of regulations to control and prevent air, water and sound pollution. These regulations were enacted in 1971, 1973 and 1976 respectively. In 1983, the law was amended, and since then it has become the federal tool to enforce pollution regulations in the country (it became officially the LGEEPA). Within the new approach of the law to protect the environment, and prevent the causes of its pollution more concepts were defined, and the federal government, through SEDUE, was given the absolute power to regulate any kind of pollution in the country. With all this power, it would be reasonable to think that in some way the concept of marine pollution, or coastal resource preservation were addressed. LGEEPA prohibits the discharge or infiltration without previous treatment of residual water which may contain pollutants, waste materials, radioactive materials, or any harmful substance in collector nets, river, watersheds, and seawater (Du Mars and Beltrán del Río, 1988) . Then, in theory the definition agrees with the concept of preventing marine pollution, at least in some degree. In fact, chapter 4, articles 29-33, refers to the protection of the marine environment. Although the scope of the LGEEPA seems to be adequate for marine pollution regulations, problems to implement the law exist. The current regulations for water pollution are the same as those enacted in 1973. Obviously the requirements to protect water quality had changed according to the population growth, and water use and demands.

SEDUE was created as a super agency for environmental protection, and that has been a big barrier to overcome in order to protect the Mexican environmental resources accordingly. Another problem is the lack of economic and human resources, as well as lack of consistency with the Mexican federal programs. In 1986, as pointed out by Du Mars and Beltrán del Río, SEDUE was unable to find a maximum standard for air pollution by sulfur dioxide. In 1993 SEDUE was dissolved and a new federal secretariat was formed (SEDESOL).

A point to be stressed, is the that coastal resources in México are still under pressure of human activities, and therefore threatened to an extent that in our days is not known. Yet another important factor to consider is that Mexican authorities do consider that conservation and preservation of Mexican natural coastal resources are implicitly protected by regulating water quality inland. This is true in one sense, since the regulation of waste water drained to rivers and estuaries will eventually reach the ocean. However there are more aspects to consider in marine pollution than only water quality issues (e.g. sea water interface exchange of airborne particles such as Pb, or gases as

CO_2). Another point to consider is that the LGEEPA does not consider possible synergistic or antagonistic effects among the pollutants entering the marine and coastal environment by diverse routes.

Direct regulation of marine pollution by the LGEEPA is given under title 4, chapter two, article 117 (II). It endorses the principle that both federation and society must prevent river, marine waters, water bodies and water deposits from pollution. Article 131 mandates marine environment protection, empowering the federal Executive to emit standard criteria to exploit, preserve and manage the marine environment. Articles 132 and 133 command federal agencies (environmental protection, energy, fisheries, communications and health) to survey and mitigate marine pollution, and Environmental Protection, Agriculture and Health secretariats to monitor water quality, respectively. Although on paper, these regulations are not implemented in their full potential. If they were, marine pollution in México would be less of an issue. However it is known that marine pollution is not controlled, and coastal management does not yet exist to support this governmental initiatives.

Next, I would like to consider the case of the state of Baja California. The environmental law of the state of Baja California (LEEPABC) was implemented on March 1, 1992, and even though I am not familiar with how it has been applied in terms of surveying and preserving the natural environment of the state. It is evident that the regulations are general and vague. The ideas to preserve and protect specific resource, for example water quality, are mentioned but the process or processes to follow to comply with any standard are not specified. Further more, no standards or regulations are specified. The standards are supposed to be implemented by the state through the ecological gazettes, official norms, and technical and state norms. The problem with all these regulations is that they are either copied directly from the LGEEPA, or are adjusted to be more restricted than those in the LGEEPA. Anyway, although much work has to be done to set adequate state standards, Baja California is one of the Mexican states that has developed its own environmental legislation.

It was mentioned earlier that there is a historic marine pollution problem between Tijuana and San Diego coastal waters. It then would be expected that the LEEPABC comprises some coastal and marine pollution regulations, but it does not. About water issues its only focus is water quality for industrial and commercial activities. If the state is going to implement the LEEPABC, then it should consider the marine ecosystem adjacent to its coasts.

Coastal management is far from being even mentioned in the state law. However la Dirección General de Ecología (general ecology secretariat of the state "DGE") (Dirección General de Ecología -DGE-) in coordination with other Federal and state agencies, and institutions of higher education, created a regional program for touristic and urban development in the coastal corridor Tijuana-Ensenada. Next I would like to consider the program in more detail because it could be considered the first attempt to structure a coastal management program in the state of Baja California.

TOURISTIC AND URBAN DEVELOPMENT ON THE TIJUANA-ENSENADA CORRIDOR

The touristic corridor is a narrow band along the coast between 32° 32' and 31° 40' N, and 116° 40' and 117° 03' W (Fig.1). Nowadays it represents the principal touristic attraction of the state, where a myriad of human activities, (agricultural, industrial, recreational and commercial) can be found. These activities have increased the pressure to the natural inland and marine ecosystems. Because the purpose is to have a major development of the area, some measurements have been postulated by the Program of Urban and Touristic Development (PRDUTE) to enhance biodiversity and protect natural resources. The main objectives of the PRDUTE are: 1) to determine the actual ecological, urban and touristic conditions in the corridor, 2) to determine the policies that human activities must comply in order to create an equilibrium between development and natural resources conservation, 3) to establish zonation for land use, 4) to define urban, touristic and ecological programs to maintain a sustainable development of the corridor, and 5) to determine planning tools to regulate land uses of the area.

In general the PRDUTE does a good job in defining what are the actual natural, urban and touristic conditions of the corridor. It describes the physical set up as the climate, geology and geomorphology, hydrology, physical oceanographic processes, flora and fauna, as well as natural potential natural hazards upon the corridor. It shortly covers some topics as environmental problems related to vegetation and pollution and defines the distribution of land and the infrastructure developed for touristic and other human activities performed within. Some strategies for sustainable ecological preservation, urban and touristic development are summarized. It also displays what kind of actions will be taken towards a specific activity or resource (i.e. preservation, restoration, utilization). Finally it describes what are the agencies and instruments that will provide funding, and how diffusion and education about the corridor policies are to be managed.

In my personal point of view, the PRDUTE covers basically all the points that should be considered to implement an adequate coastal zone management program, therefore the program itself is a good start for management of coastal resources in Baja California. However I think that there are gaps in the implementation of the program. For example, in presenting the marine pollution problem, the PRDUTE accounts only for organic pollution, from the waste water discharges of the treatment plants. The importance of this type of pollution was mentioned before, and even though the problem has apparently decreased, organic inputs from the waste water discharges persist. The importance of the potential for inorganic pollution by some other anthropogenic substances such as metals and atmospheric gases is only mentioned, and does not cover all the marine pollution categories that has been recognized and studied in the last decades. Yet, there is another possible source for marine pollution; underground storage tanks located near the coast. Some oil spills from these tanks have been reported in one area of the corridor (personal environmental survey).

Therefore if a complete description of marine pollution problems is to be addressed by the PRDUTE, a better understanding of the sources, sinks, and fates of pollutants is required. Research is the backbone for this outline, however it is not contemplated within the PRDUTE.

It is difficult to determine whether or not the document is a regulatory tool for the government. Certainly it is a document elaborated at the local and state level that guides the direction of the urban, touristic and environmental development of the corridor. Nevertheless it does not state clearly the mandatory policies to follow to attain the so called sustainable growth of the corridor. The description of the elements of the corridor are well defined, but the actual procedures must be delineated clearly. The regulatory policy implementation by the PRDUTE does present another problem. The federal and state environmental laws are the regulatory policies that the program utilizes. The feasibility that these are the adequate regulations is not known.

In terms of funding, financial institutions and federal agencies are assigned to cope with the process. With exception of the financial institutions, the experience with federal institutions is that they have not been able to implement their own programs because of lack of funding. These funds, or lack of funds, are going to be a decisive point in determining whether or not the program can be implemented as envisaged. Research must be an important part of the program. However by historical experiences, funding has been used for other purposes, such as touristic facilities construction, and commerce, rather than research.

In order to determine whether or not the PRDUTE as a regulatory program would work, we can refer to the conditions presented by Sabatier and Mazmanian (1983), that are required for a program to depart from the state of status quo.

Perhaps the PRDUTE meets conditions 1,3,4 and 5. Condition 1 mandates clear and consistent policy objectives. In some way, the policy that would regulate the corridor and its sustainable development is presented on the document, and even defined in three sectors, urban, touristic and environmental. Condition number 3 requires the statue to give implementing agencies sufficient jurisdiction over target groups, and the power to structure its own processes to maximize the probability that target groups will perform as desired. Power or jurisdiction over target groups is clearly stated for the Federal, state and local agencies. A shortcoming might be their lack of funding. Implementation or structuration of new processes will be difficult if proper funding is not in place. To date, condition number 4 is hard to satisfy. It requires that leaders of the implementing agencies possess substantial managerial and political skills, and to be committed to statutory objectives. Mexican leaders are not always in the "right place". Bureaucracy had permitted some people to be on regulatory positions, for which they are not trained, or they do not have the skills to perfom the job encomended. Therefore to be committed to the objectives of the state policy will be difficult, if not impossible. The problem is rather simple, leaders would not know the purpose of the regulations, and the facts that led to developed the actual policy. Condition number 5 states that the program should be actively supported by organized interested groups, and by few key legislatures throughout the implementation process. In the case of the Mexican legislature and political groups, it is possible to find several groups and interests, from which most of the time, policy support for some programs are just windows of opportunity to get a better political status, rather than truly support an specific set of regulations. Therefore once the political group achieved their particular goals, support of the policies that drew it to the actual position, disappear.

No changes in the relative priority objectives of a set of regulations is envisage by condition number 6. This means that the statutory policies do not weaken because the emergence of other public policies or changes in relevant socioeconomic conditions. I could define the case of México as "going with the flow". That is, for example, when some domestic problems are envisage from external authorities or agencies, the first step is giving priority to solve the issue, and policies and statutory regulations are developed. After some time (days, months or years, depending on the magnitude of the problem) the issue becomes a secondary issue because someone else pointed out a new and larger problem. In this way policies are in place but do not solve the issues that they were created for, and get old since no amendments to those are done.

In the specific case of marine pollution in the State of Baja California, and the approach by the PRDUTE, is perhaps the point on which the statutory policy of the program should work on. The definition is given by condition number 2, and it requires legislation to incorporate and identify the principal factors and causes affecting policy objectives. That is, if the goal of the policy in place is to attain adequate seawater quality levels to support coastal and marine biodiversity, it must identify all factors involved or causing an adverse impact. It would also be required to understand what kind of pollutants, and at what concentrations, are entering coastal and marine waters. It is important to understand its biogeochemical route as well as synergistic and antagonistic reactions.

Although many of the conditions for an appropriate regulation by the PRDUTE might be in place, it is important to consider that an adequate regulatory policy would require a greater effort, in order to change all those points that might obstruct its implementation.

CHAPTER 3
THE MARINE POLLUTION PROBLEM

THE MARINE POLLUTION PROBLEM

As mentioned in chapter one, the coastal border zone between Tijuana and San Diego has been exposed to the impact of human activities. This in turn has developed a marine pollution condition for the area, affecting directly the Tijuana-Ensenada touristic corridor. It is not known to what extent the natural biotic and abiotic processes of this coastal marine environment have been altered. This lack of understanding is what, in my opinion, represents the largest problem in trying to implement the proposed Program of Urban and Touristic development for the Tijuana-Ensenada corridor (PRDUTE). According to the Secretariat of Tourism of the state of Baja California, the key for development of its touristic program is defined by the protection of the the beauty of the natural environment, offering larger facilities for the economic development of the state. If the government's goal is to attain an equilibrium between the natural environment and the economic sector, an understanding of the biotic and abiotic processes in coastal areas is an imposed requirement. There is practically no information compiled or available to determine whether or not the quality of the coastal environment of the corridor is adequate for recreation, or to sustain the state's commercial fisheries nowadays. Few data on organic pollution is available. The work summarized by Calderón-Torres (1993) is an example. She determined distribution and concentration of total and fecal coliforms along a transect of the Tijuana-Ensenada corridor, for 1987 and 1992. However many other potential pollutants that could find their way into the corridor such as oil and its products, organic and inorganic compounds produced by the industrial and tourisitic sector, had not been adequately or not characterized at all. Between the Tijuana-Ensenada corridor some agricultural lands are located, and no data on PCB's or pesticides for the coastal environment within the corridor exist. In terms of inorganic pollution, perhaps the studies by Sañudo-Wilhelmy and Flegal (1991, 1992, 1994 not published) are the only ones describing trace metal concentrations and distribution in coastal waters along the Pacific ocean of U.S.-Mexican boundary. Although some information is available, much more research is required to better understand spatial and temporal distribution of metals along coastal waters of the touristic corridor. It is also important to consider that some other possible metal sources to the ocean, such as atmospheric input, are not defined. Yet, the quality of the air in the region is not characterized, despite the fact that the U.S. EPA has implemented research and technical support to state and federal authorities of México for this purpose.

The marine and coastal environment along the corridor could be a very useful index to understand and to manage human activities inland. Little changes in the environment can be detected by the coastal and marine natural processes. These changes are not easily identified however, they represent a potential and very powerful management tool to implement a program whose goal could be described as "sutainable development".

In order to understand how a marine pollution monitoring program could be developed for the Tijuana-Ensenada corridor, first we need to account for the processes, natural and anthropogenic, that cause an impact on the coastal and marine environment of the area. In doing this, I will review some of the general concepts regarding marine pollution, and I will try to match the general points of view to the specific problems along the coastal area of the Corridor Tijuana-Ensenada.

The concept of marine pollution which I will recall on, is the one defined by the Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP). The reason for this is because it specifies, in a clear manner, that anthropogenic inputs have a potential for altering the normal relations between the biotic and abiotic factors in coastal and marine environments. Thus, pollution means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, resulting in such deleterious effects as to harm living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of seawater and reduction of amenities. Based on this definition, and knowing that the trend for coastal areas to be inhabited is increasing, and that in the particular case of México 45.9% of its population is settled in coastal states, we must first ask ourselves some questions that have been asked before, but that have not been answered satisfactorily yet. Can we stop marine pollution? Are we willing to stop marine pollution at the expense of economic growth? Should we consider to pay high costs in pollution control devices to prevent marine pollution, instead of bearing much higher costs if no marine pollution control devices are used? The answers to these questions are not quite straight forward, however lets try to deal with them in theory.

Marine pollution cannot be stopped if we are to still developing technology in order to obtain commodities. There will always be a residue of human activities on the environment, and specially in the marine environment, since it can be considered the last big reservoir of human wastes. Yet this answer is what new research programs are aimed at. Actually there is consensus in determining the possibility for the oceanic province to be used as a "dump site" for hazardous waste. Then we can securely say that pollution would not be stopped.

The next question is even difficult to answer. The relationship between the cost and the technology levels to improve the quality of the environment (which ever it is, e.g. marine or terrestrial) shows that the initial costs of controlling pollution are relatively inexpensive, but the final 5 or 10% of pollution control may cost as much as the initial 90 to 95% (Fig. 4a). On the other hand, if we plot a benefit control curve we obtain a parabolic shaped curve (Fig. 4b). Here the benefits in the initial cleanup phase are quite large, while the benefits from the final stage are quite small. (Fig. 4b). We might consider some sort of a cost benefit ratio based on these two functions. According to Williams (1979), the optimum cost benefit ratio is determined on the basis of the incremental cost per incremental benefit. If, for example, an additional dollar of the environmental control will produce benefits more than a dollar's worth benefits, then it is more effective to spend additional money on control. If however additional control results in fewer dollars worth of benefit, then it appears that the control process has been carried out to far. In Fig. 4c the optimal level of pollution control is not at point A, where the cost of pollution control and benefits are the same, but at point B, where the rate of increase of cost per unit pollution control is equal to the rate of increase of benefit per unit control. Then from a cost benefit analysis it appears that it is not desirable to completely clean up the environment since the benefits accrued would not be worth the expenditure required (Williams, 1979). From this point of view one might think that spending money for pollution control would not necessarily be an economical burden, implying that we are willing to spend money to stop marine pollution. Unfortunately this is not the complete story. There are certain cases in which even a small amount of pollutant is not acceptable because of the danger to health. Then we need to start considering the risk of a pollutant to be in the environment, and that the costs of removing a small concentration of a pollutant would increase considerably.

At this point one might consider then not to pay the high cost for stopping marine pollution, since there are many pollutants that are known to have deleterious effects on natural resources in coastal areas as well as in humans.

Then we can see that the second question is not easily answered, yet we are at the beginning stage, trying to determine if we have the desire to stop marine pollution.

The third question is neither more difficult nor easier to answer. The possibility of investing in expensive technological equipment to remove pollutants from any before they end up in the marine environment is reasonable, and perhaps the best option up to date. This is the behind the idea of implementing discharge standards and regulations in federal, state and local laws, and to set risk assessments, conduct environmental impact studies, among other initiatives. Our experience on this shows that even in places where maximum permissible levels (MPL's) for discharges are in place, and expensive equipment is used to meet the criteria, marine pollution problems have not been solved completely. One good example for this is the San Diego bay in southern California.

According to the San Diego bay report (1989-1990), by the 1950's coliform bacteria concentrations in some part of the bay were regularly ten times the standards now accepted for swimming, and one hundred times the standards for shellfish harvesting. A high nutrient loading contributed to create offensive red tides, sludge banks up to six feet thick, and dissolved oxygen levels approximately half normal levels. In 1951 up to fifty million gallons per day of domestic and industrial wastes were disposed in the bay. After an unsuccessful attempt in the 1950's to find an improved sewage system, the Metropolitan Sewerage Agency System came on line in 1963. The improvement in the water quality of the bay was noticed. However during the last decade new concerns for toxic chemical effects on marine life and human health were raised. Although extensive data from research is available to determine hot spots, and regulations and standards have been changing, the consensus from the San Diego bay symposium (1989-1990) is that determining the trend of contamination (increasing or decreasing) in the bay is difficult to assess because of the lack of long term contaminant monitoring programs in the region. So one might think that the acquisition of expensive anti pollutant devices is not worth the cost, if after their implementation there is still a problem of pollution. In my opinion, the acquisition of pollution control devices represent the best option to date to keep up with social and economical development, and at the same time to protect and conserve our coastal natural resources.

From all the experience acquired in trying to answer the questions posed above, we have acknowledged that we require a better understanding of : the natural processes in our coastal and marine environments; the types of pollutants discharged to the atmospheric, terrestrial and aquatic environments; how they are transported to coastal areas; what kind of sources for the vast diversity of pollutants do exist; and how we or the environment alter them. We also need to be able to quantify their amounts, to understand their fate within the different reservoirs (sediments, tissue, water column, sea-surface interface) once in the marine or coastal environment, and to comprehend their physical and chemical characteristics and the behavior of the pollutants among them (synergism, antagonism). At the moment we characterize all these features, we might be able to determine which pollutants we need to keep an eye on, instead of spending money on trying to regulate chemical substances that do not pose a threat to key species for an specific ecosystem. The understanding of chemical compound concentrations, fates and interactions of these in different reservoirs would give a clearer idea in developing appropriate standards and regulations for waste discharged into the natural environment.

All the ideas expressed above are currently being developed, and worldwide research programs related to the topic are in progress. The study of the CO_2 cycle is an example, although it is not directly linked to marine pollution issues. It is studied in order to understand the carbon budget, related to global warming.

As it can be seen there are no easy answers to the three basic questions mentioned above. However to develop a better understanding of the natural processes and to identify what considerations need to be made to create a marine pollution program, we can define some forms of pollution and the processes acting upon them.

Several authors (Williams, J. 1979; Gerlach, S.A. 1981; Bishop, P.L. 1983; Albaigés, J. 1989; and Clark, R.B. 1989) dedicated to the study of marine pollution had defined the common forms of pollution on which research has been focused for decades. The classification can be divided as follows: a) oxygen-demanding wastes, b) oil pollution, c) conservative pollutants, d) radioactivity, and e) solid wastes and heat.

The most recent definitions of these forms of marine pollution, according to Clark (1989) are shown next. At the same time the problems of marine pollution in the Tijuana-Ensenada corridor are discussed.

a) Oxygen demanding wastes: By far the greatest volume of waste discharged to water courses, estuaries and the sea is sewage which is primarily organic in nature and subject to bacterial decay. Bacterial degradation results in the oxidation of organic molecules to stable inorganic compounds. Aerobic bacteria make use of oxygen dissolved in the water to achieve the reaction:

$$C_6H_{12}O + 6O_2 \rightarrow 6H_2O + 6CO_2$$

As oxygen is reduced below 1.5 mg/l, the rate of aerobic oxidation is reduced , and anaerobic bacteria can oxidize the organic molecules without oxygen. The end products include compounds such as hydrogen sulfide (H_2S), ammonia (NH_3) and methane (CH_4) which are foul-smelling and toxic to organisms. Because the anaerobic process is much slower than the aerobic degradation, there is a good chance for accumulation of wastes in addition to the production of noxious end-products. Some inorganic wastes become oxidized in water without the intervention of bacteria, and these too deplete the water of oxygen.

When planning the discharge of waste water, it is important to know how much oxygen would be taken up from the environment due to the organic matter oxidation process. In doing that we will avoid undesirable consequences such as oxygen depletion and phytoplankton species shifts on coastal areas. This is done by measuring the chemical and biological oxygen demand of the waste, and to achieve acceptable values of BOD (~ 8-8.5 mg/l), dilution or waste water treatment is recommended. Human health risks are also associated ot waste water, as human sewage contains enteric bacteria, pathogens and viruses, as well as eggs of intestinal parasites that have a potential to contaminate sea food.

In the Touristic Corridor Tijuana-Ensenada the problem of waste water discharges is known, and perhaps we can say that is one of the best documented for the region. Calderón-Torres (1993) reported some bacteriological results along the shoreline from the Mexican-U.S. border, down to about 20 km, in the months of March and April during 1987 and 1992. The average surface distribution for total and fecal coliforms for both years are shown in Figs. 5a and 5b. It can be seen that the maximum value obtained for 1987 by the NMP/100 ml method ranged from 100,000 to 10,000. These maximum value is associated to the outfall of the Tijuana waste water treatment plant. A larger dispersion to the south along the coast was found and attributed to the fact that the longitudinal diffusion coefficient is larger than the offshore diffusion coefficient (Calderón-Torres, 1993), and predominantly to the south. Distributions from the same year, for summer and winter seasons, varied due to physical processes along the area. According to Álvarez-Sánchez et al. (1987 in: Calderón-Torres, 1993) the coefficient of perpendicular diffusion was 10^4 cm^2/s, while the lateral coefficient was 10^5 cm^2/s for winter. During summer, due to the diffusion advection and rip tide processes, the coliform count did show a larger offshore direction. The most polluted areas for this year were found in waters adjacent to the waste water treatment plant, and along the transboundary zone, but in less proportion for the later. Non-point sources discharges are responsible for this coliform pollution along the Mexican-U.S. border (Calderón-Torres, 1993).

In 1992 a decreasing trend in total coliforms was recorded. In 1987 the distance offshore of the tongue of coliforms reached 4 km, whereas for 1992 it was only 1 km. According to Calderón-Torres (1993) this decrease is due to governmental regulations adopted by the Mexican federation through La Comisión Nacional del Agua (CNA) as an action to prevent some enteric problems (e.g. colera) presented in recent years.

b) Oil pollution: Oil spills are perhaps the most noticed pollution events when catastrophic incidents, such as the Exxon Valdez oil spill in March 24, 1989, happen. Chronic events, due to harbor and municipal activities also occur, and they have been suggested to be the largest source of environmental problems because of the constant inputs of oil to the marine environment (Collier personal communication). Natural processes putting oil into the oceans are via submarine seeps.

Although difficult to quantify recent estimates of the total amount of petroleum hydrocarbons entering the sea vary between 1.7 and 8.8 million t/yr. The best estimate is a little over 3 million t/yr (Clark, 1989). The contributory sources are shown in table 3.

It can be seen that during the transportation process, tanker operations, tanker accidents and bilge and fuel oils make up most of the oil inputs to the sea. For fixed installations, coastal refineries are larger sources than offshore production and marine terminal sources. Some other sources, such as municipal and industrial wastes account for almost 30% of oil input sources to the marine environment. Urban runoff and atmospheric fallout are also considerable in the oil budget into the ocean (~ 13%). Natural inputs, accounting for about 8% of oil sources, should also be regarded as considerable in the total budget. We can see the complexity of oils sources. An that is perhaps the reason why chronic inputs of petroleum hydrocarbons might represent a larger threat to the marine ecosystem than episodic events.

It is not well known how large the consequences of an oil spill to coastal and marine ecosystems are. There are different kinds of oils, formed by a complex mixture of hydrocarbons. Some polar substances such as N, S, O, are incorporated into the oil molecule. The exact composition varies from one oil field to another. Clark (1989) noticed that much of the North Sea oil is light, with little sulfur and low in tars and waxes, while oil from the Beatrice field in the Moray Firth, and that to the west of Shetland in England, is a very waxy oil, which requires heating to be pumped through the pipelines. Thus the environmental impact due to an oil spill depends on the composition of the oil, besides some site and species characteristics. The removal of oil by natural processes occurs at the sea surface, and it proceeds according to the oil molecular structure which conferes different physical characteristics and chemical properties.

Oil removal can be classified into two categories, a) natural and b) human induced. Natural removal processes can be in turn divided into redistribution and remineralization. The former does not degrade the oil, it just moves it around to different compartments (Fig. 6), as dictated by the molecular properties of the hydrocarbons forming the structure. Evaporation, solubilization and adsorption are the natural forces that act upon the oil in this redistribution process. On the other hand, natural remineralization represents a "true" removal process. The molecular structure of the oil is altered by photochemical and biological degradation. This happens when 25-50% of the crude oil has been removed from the sea surface to the atmosphere via evaporation within a few days. What is left then undergoes dispersion, emulsification and sedimentation processes to finally get to the biodegradaton and photooxidation stages (Fig. 7). Biodegradation of oil occurs compound specifically. That is, that not all the chemical compounds that constitute the oil will be degraded. The time of degradation it is also different, structurally simple molecules (e.g. n-alkanes) are attacked first, meanwhile structurally complex molecules (e.g unresolved complex mixtures) are attacked last. The later are known as the "residual oil" or "residuum". These are the heavier elements of the oil spilled, and the ones that pose the largest threat to the marine environment.

Humans had developed physical and chemical techniques to artificially speed up the weathering of oil slicks. Absorption of oil by mechanical devices, and the use of dispersants are an example of those. It is difficult to asses whether or not the implementing these techniques is useful. Because of the structural complexity of crude oils, one cleaning technique might work for a specific type of oil, but not for all of them. For example, dispersants are not effective for heavy oils, or oil that has been on the sea surface for some time. Also dispersants are quite often more toxic than the oil itself. Oil absorption, by mechanical processes using slick-lickers cannot deal with large quantities of oil, and are useful in harbors and sheltered waters rather than in open sea (Clark, 1989). Thus, although oil weathering might be speeded up, larger adverse effects to the environment could be developed. That is the reason why a response to any oil spill will depend on: 1) the nature of the oil, 2) the physical area or extension of the slick, and 3) the place where it takes place.

So deciding on cleaning up any kind of oil spill will be based on the economical and technical feasibility, as well as how important is the presence of the oil in the place or places where it was spilled. Perhaps it is worth to speed up the cleaning process of an oil spill near an important touristic beach by the use of dispersants. This will return the site to its natural conditions (e.g. natural beauty), even though the biological community might be impacted due to the effects of the dispersants used.

The toxicity of petroleum hydrocarbons is not well determined yet. Water-soluble compounds of crude oils and refined products include a variety compounds that are toxic to a wide spectrum of marine plants and animals as suggested by Clark (1989). Aromatic compounds and middle molecular weight constituents are more toxic than aliphatics and high molecular weight tars respectively. Since lower molecular weight components are more volatile and rapidly lost to the atmosphere, a spillage of diesel fuel with high aromatic content is therefore much more damaging than bunker fuel and weathered oil with a low aromatic compounds content. So it is rather difficult to determinine the toxicity of each type of oil, and will depend on its molecular structure and the biological community upon which the oil is being spilled.

The ecological impact of oil pollution is not yet determined. Although severe changes on beach communities have occured due to oil spills (e.g. in South-West England following the wreck of the tanker Torrey Canyon in March of 1967, among several other events); according to Mielke (in: Maki1991), a senior scientist advisor to the Exxon Company in Anchorage, Alaska, in charge of conducting the initial environmental impact assessment on the Exxon Valdez oil spill, a recently published congressional research service report concluded that "to date, pollution from offshore petroleum activities has not appeared to be a significant threat to the survival of various species". They argue that despite short term media attention to the catastrophic nature of major oil spill events, the chemicals contained in petroleum have long been part of the marine environment, and physical impacts are likely to be temporary in nature in the natural dynamic flux of the coastal environment. Clark (1989) supports this point of view; he pointed out that it cannot be doubted that sufficiently severe oil pollution events killed marine organisms such as plankton, however it has not been possible to detect more than very transient effects, and sometimes not even those. The same considerations are made by him for marine mammals and invertebrates. He concluded that whatever losses present in the marine environment , they are rapidly restored by either renewed growth or immigration of biological communities to unaffected areas.

As can be seen, oil pollution must be considered a complex pollution problem, unique in its characteristics, so that for examining marine pollution problems due to oil, several points should be taken into account. The fate of the oil should be considered depending on its molecular structure and the chemicals involved, since the chemical compounds of oils might pose a threat to some organisms rather than others. On the same line of considerations, the types of residues, and the way they should be removed, if it is in the best economical interest, must be considered even though the removal process might possibly bring more adverse effects than the oil spill itself.

Natural degradation and remobilization may be the best way to remove an oil spill, since organisms are adapted to the kind of chemicals in oils because of their natural presence in the environment. This has proved to be true for catastrophic events, rather than for chronic events, which up to date should be seriously considered because their constant intermittent input to the ocean.

As for the present conditions on the Touristic Corridor of Baja California Nishikawa-Kinomura et al. (1988) argued that because of the difficulty in the technical analysis of this pollutant to distinguish between biogenic from petrogenic compounds, little research has been accomplished in this field at the region. However several anthropogenic sources of petroleum hydrocarbons had been identified: municipal sewage, storm runoff, aerial fallout, vessel related sources, and natural sea bottom seepage. The first two are probably the most important according to the author. For aerial fallout and vessel sources no data exists, and for natural sources no direct evaluation has been performed yet. Although no quantification of petroleum hydrocarbons are available, we must expect certain levels of these kind of pollutants in the Corridor. Risebrough et al.

(1980 in: Nishikawa-Kinomura et al., 1988) showed that mussels from large urban areas, such as La Jolla, contained high concentrations of petroleum. Being so close geographically to the Corridor of Baja California, we must consider that Mexican coastal waters on the Touristic Corridor Tijuana-Ensenada could be impacted also by considerable levels of petroleum. Furthermore, the author identified the source of petroleum accumulated in La Jolla mussels as originating outside of the Southern California Bight. Perhaps the petroleum facilities from the Mexican federal government facility (PEMEX) located about 12 miles south of the Mexican-U.S. border, in Rosarito, has been an important source of oil into this border marine environment. According to the PRDUTE the PEMEX plant in Rosarito, Baja California has sporadical spills from vessels. A large event was recorded in 1971, when the tanker "Plan de Ayala" spilled over 60,000 barrels of heavy oil near Rosarito beaches.

Another source of oil not yet quantified, and perhaps not even identified by managers and planners in the Tourisitic Corridor Tijuana-Ensenada is via underground water, contaminated by underground storage tanks which are not in good operational conditions, and oil leakage does occur. This problem was evident in 1991, when public complaints from a resort called Quintas del Mar, came to SEDUE since ground water extracted from wells for domestic use showed the presence of oil. Obviously ground water, not pumped out of the well, must find its way out to the ocean due to the natural topographic seaward downslope of the area. This was only one case that we were able to observe because of the proximity of the underground storage tank to the well that supplies water to the resort. However there are more storage tanks like this, which contain the fuel for gas stations along the Corridor. These are neither studied nor quantified yet, and there is a very good chance that they are a considerable source of oil to that coastal area. Thus we must account for these too.

It seems that there are more questions than answers for oil pollution issues in the Touristic Corridor of Baja California. They are complex, and there is a need for research in the site for determining whether or not oil is a problem in that region of Baja California's coastal waters.

c) Conservative pollutants: Pollutants considered in this category are not subject to bacterial attack or other type of breakdown, or are degraded in long time scales, such that for practical purposes they represent permanent additions to the marine environment (Clark, 1989). Substances belonging to this classification are heavy metals and halogenated hydrocarbons, which include such insecticides as DDT, dieldrin, and industrial chemicals in the group of the polychlorinated biphenyls (PCB's). An important consideration for this kind of pollutants is that they tend to bioaccumulate, i.e. metals and halogenated hydrocarbons which cannot be excreted by some organisms, because a lack of regulatory mechanisms or because their system is saturated, will tend to accumulate during the life time of the organisms, as pollutants are continually added to the marine environment. When the accumulated pollutant reaches certain levels or concentration, it can be lethal to the organism. Another process related to bioaccumulation is biomagnification. Animals feeding on bioaccumulators have a diet enriched in these conservative substances, and if they are also unable to excrete them, or do so slowly, they will acquire an even greater body-burden of the material. This has implications for top predators (e.g. man) that may be exposed to large concentrations of conservative substances in their food. If the substances are toxic, the risks are obviously greatest to these top predators. Conservative substances subject to bioaccumulation and biomagnification have been responsible for human deaths. For this reason conservative pollutants are regarded very seriously (Clark, 1989).

c.1) heavy metals

Metals are natural constituents of seawater. This makes it quite complicated to assess the effect of anthropogenic inputs of metals into the natural environment. Natural sources of metals are erosion of ore-bearing rocks, wind blow dust, volcanic activity, forest fires and vegetation (Clark, 1989). Rivers make the major contribution of metals to the sea; and if their watershed passes through an urban or industrialized areas, the burden can be considerably incremented by human wastes and water discharges.

Another important input route of metals to the ocean and coastal areas is via the atmosphere. According to Clark (1989) atmospheric processes are still poorly understood. Estimates of inputs of metals to the sea by this route vary quite widely, but all estimates suggest that atmospheric input is considerable. Smaller quantities of metals to the sea are added by direct discharges of industrial wastes and other waste pipelines. However, a chronic or constant input by these means causes only a localized impact with time.

As pointed out by Galindo et al (1994) heavy metals constitute a category of pollutants of great interest for the study of coastal waters because of their widely known toxic effects on different levels of biological organization. Goldberg (1992) suggested that toxic metal events in the marine environment can be reduced to three episodes with certain commonalities: a) they involved metals associated with organic moieties (i.e. tributyltin, methyl mercury and organically chelated copper), b) two events were identified at maricultural activities, and c) catastrophic results were necessary to bring the problems to the attention of the scientific community.

Methyl mercury pollution was involved in the Minamata Bay episode. In the first years of the Minanamata Bay tragedy (1950's to 1960's) scientists were set off track by the fact that, although there may have been a sense of involvement of mercury, the disease itself did not produce in victims symptoms of classical mercury poisoning (Goldberg, 1992). According to Goldberg (1992) it took about three years following the first observations of mortalities in the 1950's to ascertain that there was some form of mercury in high concentrations in fish and in dead patients. In the early 1960's the prevailing mood was that a still unidentified organic compound of mercury was the toxin. In 1963 methyl mercury was identified as the toxic agent. Although it took over two decades for the Japanese government to halt the discharge of mercury into the coastal zone and to establish acceptable levels of mercury in sea food, the important fact is that scientists did reach an understanding of this critical pollution problem.

Tributyltin (TBT) was recognized as a pollutant more than a decade ago (Goldberg, 1986 & 1992), through crop failures in oyster farming in France. TBT was used as a biocide in antifouling paints for marine vessels and marine constructs. According to Goldberg (1992) it is perhaps the most toxic substance deliberately introduced to the ocean environment. Whether or not this is true, TBT is known to cause deformations in some gastropods at levels of parts per trillion. This distress, known as imposex (females developing male characteristics), affected whelks in many coastal waters through the world (Ellis and Pattisina, 1990 in: Goldberg, 1992).

Policies for the regulation of TBT in marine paints were formulated by the French in 1982, and subsequently taken up by many countries. In some heavily impacted marinas, following decreases in TBT use in marine paints, deformed oysters and whelks with imposex are gradually disappearing.

A recent case of pollution occurred in the Chartung mariculture area of Taiwan as pointed out by Han and Hung (1990 in: Goldberg, 1992). Green coloration of oysters (maricultured and wild) was observed off the west coast of the island with mortalities observed about three months later. Copper was held responsible in the coloration of oysters and subsequent mortalities. The copper content in maricultured oysters around Taiwan ranged from 16-337 ppm dry weight, whereas in the Chartung area the values rose to 2000-3000 µg/l as reported by Goldberg (1992). The highest concentrations of the polluting metal were found in the gills of the organisms. When the copper concentrations reached values of 500 ppm, oysters became green. Although lead and cadmium were not enriched in the organisms, zinc displayed a similar behavior to copper. Hung and Tsai (1991 in: Goldberg, 1992) showed that the correlation between copper and zinc was 0.89.

Thus, whether we are concerned with copper or zinc pollution is not clear yet. Moffet et al. (1990 in: Goldberg, 1992) argued that marine chemists mood is that copper in sea water is nearly totally associated with organic ligands, but yet unidentified, and like tin and methyl mercury, copper enters marine organisms by its association with organic groups.

Perhaps we should be more selective when studying or identifying metal pollutants in coastal waters. The master variable then for this should be speciation. Metals tend to change their species when entering from one environment to another (e.g. river water to sea water, atmosphere to sea water, and sediment to sea water). Metal speciation changes will make them readily available for adsorption or desorption from water column particles. Those associated to organic compounds will find an easier pathway into organisms by the processes of bioaccumulation or bioconcentration. Other metals, chromium and silver for example, need to be in their ionic forms to cause biological impacts. In this case organic association of these metals with ligands will reduce the risk of biological adverse effects, but will allow the complex to penetrate the biological membrane. Once inside the organism, if the metal, finds special conditions so that the ionic form of it will prevail, a potential danger to the well being of the organism will be developed.

Several studies in this area have been made by the field of environmental toxicology. Marine chemists should start to have a look to these transformation processes in order to accurately asses the effect of metals and their species within the organisms. For example, silver and lead concentrations in the Southern California Bight appear to be the only elemental concentrations somewhat elevated. Lead inputs seem to be diminishing, whereas silver is still entering coastal waters of the bight.

Silver predominant species in sea water is in the ionic form according to Klein (1978). This provides a site for halides, and other negative charged chemical elements or ligands to cleavage to, and then to precipitate from solution decreasing the availability of its toxic form. However, constant inputs of silver to coastal waters could result in increasing the concentration of silver organic compounds. Higher levels of organic compounds then will be more readily available for marine organisms to introduce silver to their systems. Despite the fact that there is no data available to support this hypotheses, we should consider the possibility of studying organo-metallic relationships in Baja California's coastal waters, in order to understand their implications to the biosphere of the corridor.

c.2) halogenated hydrocarbons

Like metals, halogenated hydrocarbons are essentially permanent additions to the environment, but unlike metals, most of these compounds are man made and do not occur naturally. The great majority contain chlorine and are also known collectively as chlorinated hydrocarbons or organochlorine compounds.

Halogenated hydrocarbons include a very wide range of compounds. Low molecular weight hydrocarbons, particularly methane, are synthesized by marine algae and possibly by a few invertebrates. Elevated concentrations of these substances in sea water may therefore come from natural sources and not be the result of human activity (Clark, 1989). However low molecular weight hydrocarbons are manufactured in large quantities, and because of their volatility, all this production is eventually lost to the environment as suggested by Clark (1989). The greatest production of these compounds are industrial solvents such as dichloroethane (CH_3CHCl_2) and vinyl chloride ($H_2C{=}CHCl$). Some other solvents, with less industrial production include carbon tetrachloride (CCl_4) and perchloroethylene ($Cl_2C{=}CCl_2$).

Chlorofluorocarbons or freons (CCl_3F and CCl_2F_2) are used as coolants, aerosol propellants, and in foam plastics. Some of these compounds have become very widely distributed in the atmosphere and can even been detected in the air of Antarctica, far from any possible source. They occur in detectable quantities in sea water close to industrialized areas. Although freons are considered to have effects upon the ozone layer in the atmosphere, low molecular weight hydrocarbons in the sea are not regarded as serious threat to the marine environment, since they appear not to accumulate in marine organisms (Clark, 1989).

Much attention has been focused on higher molecular weight chlorinated hydrocarbons which do accumulate in animal fat tissues. These include pesticides and polychlorinated biphenyls (Fig. 8).

DDT (dichloro-diphenyl-trichloroethane) was introduced as an insecticide in 1939. It has ideal characteristics as a pesticide. It is extremely toxic to insects, and less toxic to other animals; it is very persistent, with half life in soil of about ten years. It continues to exert its insecticidal properties for a very long time. It has now been almost completely replaced by less persistent insecticides.

The "drins" group includes aldrin, dieldrin, endrin, and heptachlor among others. They are extremely persistent and their degradation products are also toxic. Heptachlor degrades to heptachlor epoxide, which is even more toxic than its parent compound. Although now used in very small quantities because of their persistence, "drins" are widespread in the environment and continue to leach out of agricultural land into rivers and the sea.

Gamma hexochlorocyclohexane (gamma HCH) or lindane, came into use at about the same time as DDT and acts as a contact poison to insects. It is volatile and stable at high temperatures and so can be used as a smoke to fumigate crops. Because of its tendency to accumulate in food chains, it has been banned or its use restricted in a number of countries. However, it is still used widely in agriculture as an insecticide on crops, and in veterinary products to control sheep-scab mite. It is also used in some countries as a wood preservative against timber pests (Clark, 1989).

Hexachlorobenzene was used as a soil fumigant and as a seed dressing for grain or as a fumigant in grain storage. It has been largely replaced by other pesticides but it occurs as by-product in the manufacture of carbon tetrachloride and perchloroethylene.

Toxaphene is used as an insecticide on cotton and vegetable crops, and in livestock dips. It is acutely toxic to fish and is occasionally used as a piscicide in fresh water lakes. Since its introduction (mid 1940's) it has been the most heavily used pesticide in the United States.

PCB's have been used since the early 1930's. They are not pesticides, but are used in electrical equipment, in the manufacture of paints, plastics, adhesives, coating compounds, and pressure sensitive copying paper. They have also been used in transmission fluids in fluid drive systems, and as dielectrics in transformers and large capacitors. Following concern about the environmental accumulation of chlorinated hydrocarbon pesticides, a number of steps were taken to reduce the use of PCB's. Up to the time the use of PCB's came under restriction, the total world production already amounted to more than 1 million t, most of which has been in the natural environment.

Inputs of these substances to the marine environment include atmospheric transport, river runoff, and blown dust. The input route depends on the chemical and physical characteristics of the substance introduced to the natural environment, and the way and site they are used and dumped. For example DDT, the "drins", and toxaphenes adsorb strongly on to particles and are carried by wind borne dust. On the other hand, low molecular weight chlorinated hydrocarbons are volatile, and both HCH and HCB are rapidly lost to the atmosphere in the presence of water vapor.

Biological effects of halogenated hydrocarbons

There is evidence that chlorinated hydrocarbons are difficult to excrete, thus tending to accumulate in the fatty parts of the body due to their lipophylic character. According to Clark (1989), this fact introduces two risks: 1) in times of poor feeding animals mobilize and use fat reserves, so increasing the concentration of chlorinated hydrocarbons circulating in the body, possibly to dangerous levels; 2) as with other bioaccumulating compounds there is a strong possibility of transmission through food webs and magnification.

It is difficult to be precise about the effect of halogenated hydrocarbons on plants and animals (Clark, 1989). Because of the low solubility of these substances in water, there is a considerable uncertainty about the dose actually received by aquatic organisms in laboratory tests unless the organochlorine is administered by a dietary route.

Because organochlorine compounds are stored in the fatty tissues of the body, they become biologically available and exert their influence only when the fat tissues are metabolized. Therefore animals may acquire an important body burden of halogenated hydrocarbons, but show no effect until certain conditions are met (e.g. saturation). This make laboratory studies difficult, but for natural conditions additional problems are present. Wild animals may be contaminated with a variety of halogenated hydrocarbons and it becomes almost impossible to determine which is responsible for whatever the symptoms are (Clark, 1989).

The most important characteristic of these pollutants has to be recognized as their persistence in the environment. Because of their long life, their effect may continue for some years after an input has been brought under control. Until 1971 the ocean outfall of the Los Angeles sewer system carried a large quantity of DDT residues from a factory manufacturing the insecticide. Offshore sediments were heavily contaminated over a wide area (Fig. 9-), but despite a dramatic reduction in DDT emission after 1971, contamination of fish in the area persisted for years (Clark, 1989).

The bottom line of the discussion above lies in the fact that halogenated hydrocarbons have been identified as marine pollutants. For example DDT and PCB's had been found to reduce primary productivity as much as 50% at a concentration of only 1 ppb in laboratory cultures of whole phytoplankton from the Caspian and Mediterranean

Sea. Thus we could argue that more research is required to identify what are the halogenated hydrocarbon substances reaching the ocean, what are their fates and transport routes, and at what levels, and environmental and biological species conditions they pose or may cause an impact to biological ecosystems along coastal waters.

The actual condition of the Touristic Corridor Tijuana-Ensenada associated with conservative pollutants is not clear. In terms of metal pollution Sañudo-Wilhelmy and Flegal (1991) measured trace element concentrations of lead, cadmium manganese, iron, and zinc along four surface water transects across the continental shelf off Baja California. Their results showed offshore concentration gradients, with highest levels in coastal waters. These higher concentrations were found to be primarily associated with physical processes, such as upwelling and advection, rather than anthropogenic inputs. 1% of cadmium, 9% of zinc, and 29% of lead of the total concentrations measured, were related to urban discharges.

Galindo et al. (1994) characterized metals distribution in marine surface sediments (0-5 cm) of the Baja California border region. Their results suggest larger concentrations of aluminum, manganese, chromium, zinc, copper, and silver in sediments of the 60 m isobath, with a gradient towards the shoreline. This behavior is explained by the association of the elements with grain size, and with clay and organic matter. In general, their results show a decrease in zinc (15%), copper (16%), silver (20%) and cadmium (22%) with respect to the values measured in coastal sediments in San Diego, California in 1979.

Nishikawa-Kinomura et al (1988) reported that the highest values for trace metals in municipal waste water were found in 1971 in the entire transboundary region, but low concentrations for silver and chromium. With respect to temporal changes silver concentrations were increased according to the author in the combined mass emission from the five largest municipal waste water discharges. Arsenic, mercury and lead showed fluctuations but with little or no change over time. Cadmium, chromium and nickel showed a definite decrease, while copper and zinc concentrations in Point Loma varied, and did not present a well define trend (Schaffer, 1982 in: Nishikawa-Kinomura et al., 1988).

Although these figures refer to concentrations in waste water discharges, a close correlation should exist with the sediment underlying the waste water outfall. Thus we are facing different points of view; one tells us that the metal input in the sediments is less than in 1979. This in turn could be associated with a decrease in waste water metal concentrations. Schaffer's point of view suggests an increasing tendency in silver concentrations, and a not well defined trend for copper and zinc. Sañudo-Wilhelmy and Flegal (1991), on the other hand, pointed out that the higher concentrations in coastal waters are due to physical processes rather than anthropogenic inputs.

There are not many studies in the region on the subject. Perhaps a clearer picture of which processes are controlling metal concentrations and their distribution could be accomplished by conducting studies such as those made by Finney and Huh (1989), where an update on the history of metal pollution in the Southern California Bight was made using box cores to sample sediments up to 30 cm deep. And the study by Huh, Finney and Stull (1992) where anthropogenic inputs of several heavy metals to nearshore basins off Los Angeles were assessed. This could give a time frame, and tell us the history of how and which metals enter the Touristic Corridor coastal waters. It also should be useful to sample some other sites that have not been sampled, and to make measurements at the same stations for water column and sediments. Once these results are obtained, removal processes, such as scavenging , could be evaluated.

Pesticides in the Mexican-U.S. border area, along the Pacific coast, were assessed by Nishikawa-Kinomura et al. (1988). Their results showed a decrease in the introduction of organochlorine compounds (DDT and PCB's discharged from discrete point sources since 1971. Schafer (1982 in: Nishikawa-Kinomura et al., 1988) reported that the input from the five largest municipal waste water discharges diminished from

21,700 kg/yr of DDT's and 8,730 kg/yr of PCB's in 1971 to 474 and 1,250 kg/yr respectively, in 1981.

Although the emissions from the Point Loma treatment plant showed a similar reduction for the period of 1971 to 1982, there was a marked increase in PCB's from less than 35.6 kg/yr in 1980 to 119 kg/yr in 1981 (Schafer, 1982 in: Nishikawa-Kinomura et al., 1988). Farrington et al. (1983 in: Nishikawa-Kinomura et al., 1988) suggests that this result is not uncommon, and that high values of PCB's in the San Diego bay have been detected since 1976. According to the mussel watch program the highest values of PCB's in the northern part of the bay were 24,000 ng/g dry weight. At the same time Ladd et al. (1984 in: Nishikawa-Kinomura et al, 1988) reported high values in the sediment.

The sharpest decrease in total values of DDT for mussels from the open coast of California coincides with the decline of the mass emission rate by the largest municipal waste water discharges of the Southern California Bight from 1971 to 1974. Since then, DDT levels in California mussels have been fluctuating (~ 200 ng/g dry weight) without further increase or decrease, suggesting a long term slow cycling (Nishikawa-Kinomura et al., 1988). On the other hand, Martin et al. (1980 in: Nishikawa-Kinomura et al., 1988) reported that PCB's followed a decreasing trend, but reducing their value to only about half of the ones found in 1971.

In general, the north-south distribution of organochlorinated pesticides showed a definite gradient from higher values in Oceanside, U.S. to low values south of the border, in Bajamar, México (Nishikawa-Kinomura et al., 1988).

It is important to point out that aldrin, heptachlor and heptachlor epoxide were found in mussels from Mexican stations, but they were not found in the U.S., suggesting that the source of these compounds might be located in México. Perhaps the Tijuana waste water outfall (Nishikawa-Kinomura et al., 1988).

A new data set in the distribution of halogenated hydrocarbons is required to asses their presence in the environment, since the maquiladora industry has been growing in the city of Tijuana, and these type of compounds are still being used in the electronic and electric manufacturing processes.

c) Radioactivity: Radioactivity or radioactive decay is the name given to the natural process by which the atomic structure of an atom changes to a more stable state. The modes of radioactive decay can be regarded as alpha (α) decay; spontaneous emission of α particles; beta (β) decay ; electron capture decay, branched decay; and spontaneous fission decay. Radioactivity is a natural phenomenon. Sea water is naturally radioactive largely through the presence of potassium-40, but it also contains decay products of uranium and thorium, and recent and continuous input of cosmogenic nuclides.

Heavy radionuclides have low solubility in water and tend to be adsorbed on to particulate matter. Thus they accumulate in sediments, preferentially in fine grains that present a larger surface area, in contrast to coarser material. Some values found in marine sands are around 200-400 Bq/kg, while for muds 700-1000 Bq/kg (Clark, 1989).

Anthropogenic input of radioactivity to the sea began in the later stages of the second world war with the explosion of the first nuclear weapons, and continued with nuclear weapon testing until the signing of the test ban treaty between the U.S., the former USSR, and the U.K. in 1963. These nuclear weapons contained enriched uranium and plutonium, and when exploded under water or near the ground produced over 200 different fission products and isotopes. These were carried in fine dust into the stratosphere where they circled the globe many times before settling back to the earth again as a fallout (Bishop, 1983). Because of the global pattern of atmospheric circulation, most of the fall out has occurred between latitude 45°N and 45°S, with higher levels in the northern hemisphere where most of the explosions took place (Clark, 1989).

In the Touristic Corridor Tijuana-Ensenada, or even in the central Southern California Bight, adjacent to the Mexican-U.S. border zone, the levels of anthropogenic radionuclides have not been studied as extensively as xenobiotic hydrocarbons or trace metals (Nishikawa-Kinomura et al., 1988). The only recent information was published in 1983 by Goldberg and his colleagues in the Mussel Watch Program. Goldberg's data reported from Oceanside, La Jolla and San Diego is consistent with other areas affected by oceanographic processes such as strong upwelling, which tend to elevate their values (Goldberg et al. 1983 in: Nishikawa-Kinomura et al., 1988).

e) Solid wastes: Dredged material and plastic debris are the best representatives for the category of solid wastes. Ports, harbors rivers and channels are regularly dredged to keep them open to shipping. The dredge material may be used on land, but it is more often dumped at sea. The composition of the material is varied, according to Clark (1989) for routine dredging it is usually fine silt, but if new channels are built or old ones deepened, it may consist of clay or chalk. Dredged spoil is often anoxic and contaminated with metals and persistent oils (Gerlach, 1981). Spoil from harbors and estuaries with intense shipping activity and heavy industry is much more contaminated than that from other areas.

The immediate impact of dumping dredged spoil is smothering of the benthic fauna in the dumping grounds. According to Clark (1989) one study carried out in the fjord at Uddevalla on the west coast of Sweden, showed that immediately after dredging of the new channel there was a loss of diversity at stations near the site of operations. This is due to a failure of recruitment of several bivalves, perhaps because of the increased sediment load in the water. Nevertheless , diversity was restored a year later. Benthic animals in the area showed accumulation of high concentration of metals as well, when dredging was in progress, but returned to prior levels within ten months. In all, the conclusion is that while dumping of the dredged material at sea transfers contaminants from one place to another, but it has little effect on the fauna of the dumping grounds according to Clark's findings.

Plastic debris is perhaps one of the most common pollutants in the marine environment. Small pellets of polyethylene, polypropylene and some times polystyrene are widespread in the ocean (Gerlach, 1981). Their presence has been reported on beaches and in surface waters near industrial areas or major shipping routes since the early 1960's, but they have also been found in the South Atlantic and South Pacific, several thousand kilometers away from any industrial source, and it must be assumed that their distribution is now worldwide (Clark, 1989). One of their characteristics is that they are virtually indestructible and buoyant, and presumably steadily accumulating in the sea and coasts (Bishop, 1983). They are too small to cause an aesthetic problem on beaches, and it is not certain if they are harmful to marine organisms but they are certainly ingested by surface feeding marine birds as suggested by several authors (Bishop, 1983; Clark, 1989; and Gerlach, 1981).

Larger plastic debris, mostly from packaging, occurs in great abundance in the sea. Much of it is derived from shipping. Plastics are not biodegradable (Clark, 1989), and although some may be subject to photodegradation, most are extremely durable and have long life in the sea. The average age of containers is 2.9 years, judging from plastic litter on beaches (Gerlach, 1981). Generally plastics are inert to marine organisms, and floating articles that have been at the sea for some time acquire a fauna of barnacles and other encrusting organisms (Clark, 1989). Thus, plastic litter is an aesthetic problem on amenity beaches, more than a hazard in the marine environment.

Along the Touristic Corridor of Baja California the next characteristics present in the coastal environment, regards solid wastes.

Two marine ports are located in the southern part of the Corridor. One in El Sauzal, and the other in the port of Ensenada. The former handles small boats, while the latter is used for large vessels from the shipping industry. For both facilities no data for dredging activities were available. Obviously sediments from the port in Ensenada must be highly contaminated by organic and inorganic pollutants. According to the PRDUTE, Ensenada's port is one of the most contaminated places in the marine environment from waste water discharges from the treatment plant of the city, where water either does not receive an adequate treatment, or it is discharged to the coastal waters without any treatment, when the plant is saturated. The canning industry, from fisheries activity, also discharges their raw waste water to the port's coastal area.

Plastic debris can be observed easily on all beaches along the Corridor. Each of the beaches present a different amount of this material, according to the use of the beach. For example, just south of the Mexican-U.S. border, no swimming is allowed, therefore people go there to enjoy the landscape, and do not stay a long period of time. However with their short stance plastic debris is left behind. Rosarito Beach, a 100% touristic place, embraces hundreds of visitors that usually stay overnight for holidays or weekend periods. From these, the amount of debris left behind is much larger compared to the amount of debris left south of the border. The same is true for the beaches placed at he end of the Corridor in Ensenada. Beaches such as Monalisa and El Faro, receive hundreds of visitors for holidays and weekends. Some other beaches are not as visited as the ones previously mentioned, so that the amount of plastic debris is therefore much smaller.

e) Heat: The last category of a common form of marine pollution to which research has been focused for decades is heat. The source of heat into the marine environment is cooling water, and often industrial effluents discharged at a higher temperature than that of the receiving water.

As mentioned by different authors (Bishop, 1983; Clark, 1989; and Gerlach, 1981), by far the greatest amount of heat discharged to the sea is via cooling waters from coastal power stations. About 20 million m^3 of cooling water, 12°C above the ambient sea temperature, is discharged by oil or coal-fired power stations. Nuclear power stations are a little less efficient and the cooling water from them is about 15°C above ambient temperature (Clark, 1989).

The greatest discharge of cooling water, in temperate regions, is during the winter because of the amount of power demand. On the other hand, in subtropical regions the peak is during summer, where more power is demanded for air conditioning purposes. At the tropics the power demand is steady throughout the entire year, and the temperature changes of the sea are almost negligible.

The major problem when discharging hot water is when sea water temperatures are as high as 30-35°C (maximum temperature for the sea). At this point many organisms are near a thermal death stage; if more heat is added, then that point can easily be exceeded. In colder waters heat dissipation is faster, and perhaps less effects or impacts to marine organisms would occur.

Cooling of the heated discharge is almost entirely by mixing with the receiving water, therefore the area affected is limited to the plume of hot water and its immediate surroundings. However the direction taken by the plume may change with changing tidal currents, so that the total area under its influence is greater than it appears at first sight.

It is difficult to asses the effects of hot water in the marine environment because the hot water discharges present other features. Cooling water is usually treated, at least intermittently, with chlorine to discourage the settlement of organisms in the heat exchange system. The seabed fauna is likely to be influenced by the scour action of the flowing water on a soft substratum. Metals are leached from the cooling system, and according to Clark (1989) the disappearance of abalones (*Haliotis*) from the neighborhood of the Pablo Canyon power station is attributed to copper in the water, not to its elevated temperature.

As mentioned above, where surrounding waters have a temperature between 30-35°C, a further increase in temperature (~ 5°C) by the cooling water is damaging to certain species. For example, in the Turkey Point, Florida's power station complex, the turtle grass *Thalassia*, the basis of a specialized community on which characteristic fauna is supported, has show reduced growth in 30 ha, and has been destroyed in about 9.3 ha of the region (Clark, 1989).

It has been found that tropical marine animals are generally unable to withstand a temperature increase of more than 2-3°C, and most sponges, molluscs and crustaceans are eliminated at temperatures above 37°C. In general, intertidal species appear to be more tolerant of high temperatures than benthic species (Bishop, 1983). On the other hand, in temperate regions hot water discharges have the characteristic of enhancing the growth of bivalves and fish, instead of being damaging. At the nuclear power station in the Firth of Clyde, the copepod *Asellopsis intermedia* blooms two months earlier than elsewhere in the region (Clark, 1989).

The problem with hot water discharged to sea water then is more dependent on latitud, than the mere fact of releasing cooling water to the marine environment, as well as the characteristics of the species inhabiting the surroundings of the outfall. Along with the cooling water discharges other substances, such as organochlorines and metal complexes, reach the marine waters. Organochlorines are formed due to the prior water treatment with chlorine. We have seen in previous discussions that organochlorines represent a considerable threat to marine organisms. In the category of metals, besides lead and iron leached from the structure of the cooling system, TBT is used as a biocide, and as well as chlorine, it is used to discourage organisms settlement in the system.

The Touristic Corridor Tijuana-Ensenada has one power plant discharging cooling water to the ocean. No information is available from it, perhaps due to the fact that it is federal property. A private consulting firm from Tijuana, Geomar Consultores, has been commisioned to determine its area of influence. Until their studies are concluded, no information of the area will be at hand.

CHAPTER 4
A MARINE POLLUTION MONITORING PROGRAM

A MARINE POLLUTION MONITORING PROGRAM

There are some considerations that the state government of Baja California should take into account to implement the Program of Urban and Touristic Development for the Tijuana-Ensenada corridor (PRDUTE) to reach its goal, sustainable development. One of those considerations is to develop a Marine Pollution Monitoring Program (MPMP) that could be implemented in conjunction with the PRDUTE. In my opinion this would be the best management strategy used to reach sustainable development for the Tijuana-Ensenada corridor.

It was mention before that the PRDUTE has adequate ordinance strategies for the corridor, such as the planification and zonification of land along the coastal area from Tijuana to Ensenada. It also delineates the strategies to follow for community participation, and land use practices in a very clear manner. Thus complementing the PRDUTE with a MPMP would create a more complete framework to protect and preserve the corridor's coastal resources. The importance of implementing the PRDUTE with a MPMP can be addressed by reviewing the study that the Office of Technology and Assessment (OTA) conducted regarding Wastes in the Marine Environment. OTA's study reported that estuaries and coastal waters receive the vast majority of pollutants and that their overall health is declining or threatened, and that without new measures continued degradation will occur. To date degradation of U.S. coastal waters is occurring despite the fact that in 1972 the Coastal Zone Management Act (CZMA) was passed by the U.S., where funding incentives, as well as technical support was provided by the federal government so every coastal state in the U.S. could developed a Coastal Zone Management Program (CZMP) to keep the well being of the coastal natural resources of the country. So even though the U.S. federal government spent money for that purpose, degradation of the U.S. coastal areas still is an issue. If the U.S. coastal states would have developed their MPMP's and integrated them to their CZMP's, degradation of the U.S. coastal resources should be less severe. On this issue, what the state government of

Baja California can learn is that although their regulations on the PRDUTE are considerably adequate, marine pollution processes should be characterized.

In essence the state of Baja California is repeating what the U.S. did when they developed their CZMP's. The state Congress will pass the PRDUTE before the year 1995, when there is still a poor understanding of the coastal environment in the region. Therefore reaching sustainable development on the corridor, as it is envisioned by the PRDUTE, would be very difficult to attain if no attention is paid to the existent and potential marine pollution problems of the area.

An advantage that could be taken by the state government of Baja California is that there is an intense public interest and awareness about environmental quality in the corridor. This can be perceived in the documents elaborated for the Environmental Border Integral Plan (EBIP) meeting: evaluation and analysis through 1992-1994. The academic sector of Baja California suggested propositions aiming to the preservation of the corridor's coastal and marine environments. The public sector has shown interest in the protection of the Tijuana-Ensenada corridor environment. Unfortunately public participation has not been as active as it could be, because education and information on environmental issues regarding the Tijuana-Ensenada corridor is not at hand.

Considering that it is important to develop a MPMP to be implemented in conjunction with the PRDUTE for the Tijuana-Ensenada corridor, my attempt now is to delineate some basic concepts that would be useful in its elaboration. Since public interest is in place, the elaboration and implementation of such a program could be accomplished so that citizen's concerns are addressed.

Lets start first by defining the meaning of a marine pollution monitoring program, what it is required to be established, and why it could be useful in supporting the sustainable development of the corridor in Baja California.

Monitoring is defined by Risebrough (in: Albaigés, 1989) as "the process of repetitive observing for defined purposes of one or more elements or indicators of the environment according to pre arranged schedules in space and time, and using comparable methodologies for environmental sensing data and collection" . One of the best examples of environmental monitoring has been the measurements of atmospheric levels of carbon dioxide, undertaken over a period of years at the same localities, which have shown a continuing global increase, resulting from the combustion of fossil fuels (Keeling et al., 1976a, 1976b; Freyer, 1979 in: Albaigés, 1989). Another example in a more localized area could be described as the program conducted in the New York bight after bottom waters became anoxic in 1976, killing fish and benthic organisms (Swanson and Sindermann, 1979 in: Albaigés, 1989). Repeated measurements over time and space of dissolved oxygen, among other parameters, were taken. The relation found was that the oxygen depletion is associated with the offshore dumpsite for sewerage sludge from the region (Suszkowski and Santoro, 1986; Levine, 1986 in: Albaigés, 1989). The monitoring program has enable management strategies, so that nowadays the oxygen levels are not depleted so acutely.

According to Risebrough (in: Albaigés, 1989) most programs dealing with contaminants in coastal and marine environments are more properly considered as "surveillance", i.e. "watching out for trouble". Such programs employ whatever combination of sampling and measurements that might best characterize the distribution or effects of contaminants, whether or not these are repeated over time or space.

Although the latter approach is acceptable and widely used nowadays in coastal areas in México, including Baja California, monitoring and surveillance could be used in conjunction to obtain a better marine pollution assessment approach. When I refer to monitoring of the marine environment it should be understood as the periodic measurements over space and time. I will refer to surveillance only as a "warning" signal. That is a signal that might suggest that pollution levels are increasing on the coastal area.

The establishment of a Marine Pollution Monitoring Program requires a precise knowledge of the functioning of the system.

We know that the marine environment is neither static nor an homogeneous system, but highly dynamic, both physically and chemically. The ocean also continually exchange chemical burdens with another dynamic system, the atmosphere (Albaigés, 1989). Thus before making any statement concerning the effects of possible pollutants in the marine environment, we must be able to predict their transport pathways, regions of concentration, and to know about the chemical characteristics and biological fate of the material. As soon as a pollutant is released into the sea it is subject to a series of diverse processes that cause distribution of the products into the environment, and at the same time, produces changes in its physical and chemical characteristics. All these processes that occur simultaneously, and are interrelated, define the biogeochemical cycle of the pollutant.

The usefulness of a Marine Pollution Monitoring Program is stated by the National Research Council (NRC) in the document called Monitoring Southern California's Coastal Waters (1990). They suggest that when questions about the coastal or marine environment pollutant inputs increase as well as human impact, a regional program should be established that: 1) addresses specific questions about current environmental conditions of the coastal and health impacts, spatial and temporal trends in natural resources, non point source and riverine contribution, nearshore habitat changes, and cumulative or area wide impacts of large and small point source inputs; 2) incorporates standardized sampling for analysis and data management methods; and 3) develops a database management system for all monitoring and resource data in the coastal and marine environments, which could provide access to the historic and current data needed to perform comprehensive analyses. The data base management system can be: 1) facilitated through coordination of local, state and federal entities, which integrate their regulatory data and management needs, and responsibilities to optimize the utilization of available resources; 2) achieved through coordination, integration and modification of existing efforts, rather than through addition of another layer of monitoring; and 3) developed to involve the public and the scientific community as participants in the program, including mechanisms to ensure that its conclusions are effectively communicated to the public, and to require periodic review and to allow easy alteration or redirection of monitoring efforts when they are justified, based on the results of the monitoring or new information from other sources.

The effort to develop a regional program will need to address the needs of the agencies and parties involved in monitoring, to synthesize existing data and information to elaborate meaningful questions and hypotheses, to elaborate an organizational framework and a monitoring program, and to allocate the financial resources required to carry out the program. If properly implemented, the benefits and the costs of a regional monitoring program can be shared by all sectors of society. In a regional approach, the program has to consider the effects of competing uses on land, water and air quality, and tradeoffs between short and long term costs and benefits.

The implementation of a monitoring program for marine pollution then requires a comprehensive data base and coordination efforts between the federal, state and local governments, as well as public and private sectors involved in one or another way in the monitoring process. Particularly for the Tijuana-Ensenada corridor there is a lack of information on the coastal environment. In the following discussion I make some suggestions that will help to increase an understanding of the physical and chemical characteristics of the corridor. My goal is to establish some basic considerations that would be useful in the future to develop the Marine Pollution Monitoring Program for the region, in the quest to pursue the so called sustainable development.

First we need to recognize what are the important reservoirs and significant environments of the region. In general these are defined as rivers, estuaries, coastal areas, open ocean and the atmosphere. The next step is to look at the interaction of these reservoirs in the environment as a whole. i.e. the physical and chemical properties of each reservoir. It is important to determine the distribution and nature of "primary phases" such as water, gases, suspended solids, sediments and other interfaces such as the sea-air or sediment-water interface within the reservoirs. Next we need to characterize the circulation pattern of fluids (water and atmosphere) since they are important in the process of pollutant dispersion. The chemistry of the dominant medium, e.g. fresh water, salt water, sediment, etc., has also to be characterized, as well as biological distribution, human uses, and the distribution of pollutant inputs. In short every reservoir and significant environment must be studied and understood.

RESERVOIRS AND SIGNIFICANT ENVIRONMENTS

a) rivers

Rivers are important because of their global distribution. Historically they are considered the first "sewage pipeline", removing pollutants downstream (Collier and Prahl personal communication). Their chemical and physical characteristics are important since they remove some natural elements (e.g. metals) through the weathering process, so human inputs can increase the burden of their natural load. Their chemical characteristics such as low ionic strength, low pH, high particles content and high dissolved organic carbon burden, make the rivers a very different environment when compared to coastal waters. Thus a variety of chemical reactions acting upon pollutants occur when rivers meet saltier water.

For the touristic corridor Tijuana-Ensenada only the Tijuana river and the San Diego river are of interest according to Nishikawa-Kinomura et al. (1988). Both of these rivers discharge their waters north of the Mexican-U.S. border. Because 3/4 of the watershed of the Tijuana River is in Mexican territory, and 1/4 of it in North American territory, it is important to keep track of its chemical and physical behavior in order to protect the well being of the Tijuana estuary, since it is a very important part of the regional ecosystem. Water quality data for the Tijuana river is monitored by an agency of the state of Baja California, La Comisión Estatal de Servicios Públicos de Tijuana (CESPT). It keeps track of the Tijuana River water quality records for regulatory purposes. It is important to continue this water quality characterization, so that the behavior of pollutants in the river watershed, and at the end members of the river can be adequately addressed. Thus with the understanding of the Tijuana river environment better regulations and management strategies can come into place.

It is also important to mention that it would be also be helpful to measure some other non conventional pollutants in the Tijuana River watershed, i.e. those possible chemical substances that are present in the region, but that have not been characterized in these river waters. The reason behind this is because many new industries are establishing in the area, and their production processes include chemical compounds that have not been used in the region before.

For the San Diego river more information exist. Thus to set management strategies for the Tijuana-Esenada corridor, managers should look to the available database of the San Diego River at the International Border Water Commission (IBWC).

b) estuaries

Estuaries are the next category of significant environments to be considered. They are very important in controlling pollutant transport, both physically and chemically. Physically they "slow down" the velocity of the river water when it enters any estuarine system. Chemically, estuaries act as "trapping reservoirs". The chemical characteristics of river water and estuarine water are different so when they mix, several reactions occur causing chemical compounds as well as pollutants to get trapped and not continue their course to the ocean. e.g. many metals tend to precipitate in basic environments (estuaries) rather than in neutral environments (rivers).

Hydraulic processes of the estuary also influence the behavior of pollutants, either in the water column, the sediment or in the surface. The circulation pattern of an estuary is a function of tides, morphology and fresh water flows. Different types of stratification occur when those three characteristics change. Therefore it is important to determine with what kind of estuary we are dealing . In this way we will have more tools to determine management strategies, so that behavior of pollutants can be understood and regulated.

Estuaries are also important in terms of biological productivity, since the amount of light and nutrients are optimum for some primary producers. Athropogenic impacts on biological habitats are due to physical changes in estuarine structure such as the change in size and timing of fresh water inflows, hydrology, sedimentation patterns, and sea level rise.

In the Tijuana-Ensenada corridor there is only one estuary, the Punta Banda estuary. Perhaps it is one of the most studied environments along the corridor, and its characteristics might be well defined. Nevertheless, touristic human activities have rapidly increased in the last decade, representing a potential threat to the estuarine environment.

The best thing to do now is to keep up research projects in the Punta Banda estuary and to determine how different the new physical and chemical conditions are from those characterized before. In this new management strategies can be developed to maintain the economical development of the region and its natural ecosystem.

The Tijuana estuary, although it does not belong to the Tijuana-Ensenada corridor, its processes are important because of its proximity to the corridor (immediately north of the corridor). Much effort has been put for its conservation and restoration by North American federal and state authorities. It forms part of the U.S. National Estuary Program, intended to preserve, conserve and restore estuarine resources throughout the U.S. However, the conservation of the Tijuana estuary largely depends on Mexican management and regulatory strategies, regulating the wastewater quality of the Tijuana River, that ultimately discharges in the Tijuana Estuary. The Tijuana estuary system is important for the well being of the northern part of the corridor Tijuana-Ensenada, so it is important that federal and state authorities as well as managers understand its characteristics and behavior to build comprehensive protection strategies, and keep with the pace to reach sustainable development on the area.

c) coastal zone

The coastal zone is another important reservoir to be considered. It is key in understanding our coastal environment. The coastal zone is divided into three areas, a) salt marshes and coastal wetlands, 2) continental shelf zone, and 3) enclosed seas.

Along the Tijuana-Ensenada corridor one salt marsh is found. It borders the Punta Banda estuary. It is perhaps one of the most studied reservoirs in that part of the corridor.

Because marshes are highly productive, it is very important to recognize their characteristics to develop management strategies. I have no data of the place at hand, but the database on these marshes at the Instituto de Investigaciones Oceanológicas (IIO), Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), and La Facultad de Ciencias Marinas (FCM) can be reviewed and evaluated. With that evaluation we can determine if accurate management approaches can be delineated or if more research is required to better understand the marshes environment.

The continental shelf of the Tijuana-Ensenada corridor occupies about 90% of the corridor's coastal ecosystem, that is the reason why it is very important to understand this system to reach the PRDUTE goals. In general continental areas are subject to larger land flows of pollutants, but at the same time they possess a higher "assimilation capacity", i.e. there is more place to store those pollutants. Here we should consider the principle of dilution when trying to limit environmental impacts. However, this does not mean that pollutants can be added to the continental area without considering the potential impact that a continuous input of these substances can create.

The continental shelf of the Tijuana-Ensenada corridor has been subject to some studies, but not as extensive as those directed on Southern California, U.S. Some of these studies have considered concentration and distribution of pollutants such as municipal waste water discharges, pesticides, trace metals, petroleum hydrocarbons and coliforms (Nishikawa-Kinomura et al., 1988; Sañudo-Wilhelmy and Flegal, 1991,1992, 1994; Calderón-Torres, 1993; Galindo et al, 1994). Some others evaluated dispersion coefficients (Bravo-Chávez, 1989).

Although there is some information in place, it is necessary to conduct more research based on a planned schedule so that temporal and spatial variations can be assessed, and to develop monitoring techniques so that results of different authors on the same topic can be compared. Past studies on the continental shelf of the corridor have been conducted on specific "compartments" of the environment and not correlated to previous results. For example the studies conducted by Galindo et al (1994) address trace metal distribution and concentrations along surficial sediments on the Baja California continental shelf, and his results cannot be associated to those of Sañudo-Wilhelmy and Flegal (1991), where trace metal concentrations and distribution in surface waters off the coast of Baja California were assessed, because their sampling transects do not fall on the same location, and because they conducted their studies at different seasons.

It is important, however, to mention that there is some oceanographic data available to date at the corridor. It would be a be very useful to compile all this information in only one document to set a database from which research needs can be delineated. The Compilation of physical, chemical, biological, and geological parameters available at the corridor must also be considered. Combining all this information should make research efforts easier.

d) atmosphere

The atmosphere is another important reservoir to account for to have a complete understanding of the coastal environment. Wind cycles are able to "trap" pollutants in local scales. There is common on-shore/off-shore circulation that tend to move pollutants back and forth from continents to coastal areas. One clear example is represented by lead (Pb) inputs to coastal waters of Southern California , where 30% of its concentration in the coastal environment is from the atmosphere. Other places, such as Puget Sound and Tacoma in Washington, where a copper-smelter is localized, have other contaminants in their coastal environment such as arsenic (As), antimonium (Sb), copper (Cu), lead (Pb) and zinc (Zn). Major contaminants in the atmosphere are volatile metals from industrial inputs, combustion products (e.g.CO_2, hydrocarbons, CO, NO_x , SO_x) and volatile organics (e.g.freons). The major mechanisms of introduction for contaminants in the ocean is gas exchange (diffusion and bubble injection), dry and wet deposition of aerosols, and scavenging by "cyclic" salts.

At the Tijuana-Ensenada corridor there is a big gap for this kind of information. There is no information regarding atmospheric patterns, type of contaminants or pollutants, and their concentrations. Some attempts to implement atmospheric monitoring programs had been done in the past; unfortunately none of them were successful. Therefore larger efforts must be emphasized in the area to characterize the atmospheric reservoir, since there is a considerable number of volatile chemical compounds in the region, produced by the maquiladora industry. Part of their production processes make use of chemical solvents as well as a variety of paints. Not every industry has adequate air pollution control devices, so chemical compounds are able to reach the atmosphere easily.

There are some other specific sources of pollutants to the atmosphere, so we must account for them as well. Leaded gasoline, for example, is still used in the corridor's region, so we might expect to find Pb in the atmosphere. The thermoelectric plant in Rosarito generates combustion products. To date there is no information on the plant's

atmospheric emissions. Another point source of particles into the atmosphere is the cement industry localized at the southern part of the coridor in Ensenada.
Thus, there is an urgent need to understand what is happening with all those contaminants and pollutants entering the atmosphere along the Tijuana-Ensenada corridor.

e) ocean

The open ocean is a significant environment that I will not account for at this moment, since I am dealing with the coastal area of the Tijuana-Ensenada corridor. Nevertheless it is worth to say that the ocean must be considered when implementing the Marine Pollution Monitoring Program for the corridor, since it is been thought to be used as a "dump site" for hazardous waste site.

MARINE INTERFACES

Once the general characterization of the coastal environment is done, there is a need to account for marine interfaces that play an important role in sustaining the coastal ecosystem. There are three marine interfaces that are important because they support primary productivity; many organisms develop their reproductive cycles within them; and the number of organisms in these interfaces is larger than in any other part of the marine environment. The marine interfaces are 1) the estuarine turbidity maximum (i.e. fresh water-sea water interface), 2) the surface microlayer (air-sea interface), and 3) the bottom sediments (sediment-water interface).

1) estuarine turbidity maximum

I discussed the aspects of the estuarine turbidity maximum before when discussing the chemical reaction processes that occur when fresh water mixes with saltier water (>5

PSU). When the mixing occurs, flocculation, adsorption and desorption of contaminants or pollutants (e.g. metals, chlorinated hydrocarbons) is driven by mixing.

The estuarine turbidity maximum interface is enriched in suspended particulate matter, particulate organic carbon, detrital plant debris, and in heterotrophic nanoplankton. Surface active aggregates then become enriched with the pollutants and contaminants present, making them more available to primary producers and consumers either by a dietary or a non dietary route. It is here where bioconcentration and bioaccumulation occurs, potentially ending up in pollutant biomagnification for higher trophic levels (e.g. humans). There are several points to study in this environment. Chemical reactions, for example, are driven because of the differences of the mixing waters, however, the flushing process (function of tidal forces and flow) must be regarded as an essential factor to be understood, since the amount of pollutants or contaminants, their availability and chemical behavior with the saltier water depend on this.

Along the Tijuana-Ensenada corridor a zone of estuarine turbidity maximum is found at the Punta Banda estuary. As mentioned before, there is a database for this environment. However it is required is to keep updating the of information to observe any changes, and to develop adequate management strategies.

2) surface microlayer

The surface microlayer interface is an important biological habitat and a collection point for anthropogenic materials according to Hardy (1982). The author presented a report on this important phase in his paper entitled "The Sea Surface Microlayer: biology, chemistry, and anthropogenic enrichment". He found that this environment provides habitat for biota, including the larvae of many commercial fishery species, which are often highly enriched in density compared to subsurface water only a few centimeters below. Common enrichments for bacterioneuston, phytoneuston and zooneuston are found. The trophic relationships or integrated functioning of these neustonic communities have not been examined (Hardy, 1982).

Another finding from Hardy (1982) is that the surface tension provide a physically stable microlayer, but one which is subject to greater environmental and climatic variation than the water column. A number of poorly understood physical processes control the movement and flux of materials within and through the microlayer (Fig.10). The microlayer is generally coated with a natural organic film of lipid and fatty acid material overlying a polysaccharide protein complex.

The microlayer serves as both source and sink for materials in the atmosphere and the water column. Among these materials are large quantities of anthropogenic substances which frequently occur at concentrations 10^2-10^4 greater than those in the water column as pointed out by Hardy (1982). These include plastics, tar lumps, polyaromatic hydrocarbons, chlorinated hydrocarbons, and potentially toxic metals such as Pb, Cu, Zn and Ni. How the unique processes occurring in the microlayer affect the fate of anthropogenic substances is not clear yet, and many important questions remain according to Hardy (1982).

I have not seen data reported on this particular environment for the Tijuana-Ensneada corridor. It is very important to develop an understanding of the sea-surface microlayer in the corridor to elaborate adequate management strategies and regulations for wastes and residues that find their way into the coastal zone of the area. This environment is perhaps one of which much research effort is needed.

3) bottom sediments

The third important marine interface is the sediment-water interface. Unlike the air-sea and fresh water-sea water interfaces where primary productivity is important, and where larvae stages of diverse species complete their cycles, the bottom sediments and its interaction with the overlaying water is what we should account for. This does not mean that life is not playing an important role within this phase, to the contrary. But the sediment water interface could be used as an index of a series of different physical and chemical processes, so regulations for pollutants and contaminants could be better approached when understanding this reservoir.

When pollutants are released to the environment, and mobilized in rivers or in the atmosphere, during their transport away from their source they may become incorporated into depositing sediments. Thus sediments may preserve a record of past pollutant inputs, and upon this concept, is based the utilization of sediment cores to determine historical pollution events (Alderton in: Historical Monitoring, 1985).

Some considerations are required before assessing any process in this sediment-water interface, as outlined below.

Redox potential:

The redox potential of a substance or compound, as well as how sediments act upon them is an important point to be considered. Chemicals can be released from the sediment phase to the water column, if their species form is such that they will prefer to stay in the water rather than in the sediments. In this way chemical compounds, which might include pollutants, are released to the ocean environment again. If bottom currents incorporate these pollutants in its course, they can end up in upwelling areas. This in turn would increase pollutant burdens where primary producers and consumers could be exposed to larger concentrations of those substances. There are some chemical species that rather than being released from sediments would remain in the sediments. About these we should consider the species that are associated to sediment particles. If the particle is small enough, it can be removed to the water column by bottom currents and upwelled to the surface. On the other hand, if particles are big enough, or deep enough not to be removed to the water phase, then we should account for benthic organisms that might be exposed to pollutants associated with sediments. If we can account for the amount of pollutants or contaminants released from sediments, and for those that remain in them, better estimates for management decisions would be at hand.

Bioturbation processes and Bottom currents:

Chemical compounds, associated with sediment particles, will be removed to the water column by burrowing organisms that inhabit the marine bottom environment. Physical processes, as bottom currents, then will have the potential to carry pollutants associated to sediment particles to upwelling areas. Bottom currents tend to scour sediment, causing particles to be mobilized to the water column, and carried to surface waters.

Sedimentation rates:

Sedimentation rates are important when estimating historical processes in the ocean, such as pollution by metals, PCB's etc., and when considering the possibility to establish a dumping site at the ocean. In order to keep the waste buried and as far as possible from any biological system, higher sedimentation rates are required.

To understand the Tijuana-Ensnenada corridor's sediment-water interface, it is required to gather existing information to delineate ideas for research projects.

CHAPTER 5

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

DISCUSSIONS, CONCLUSIONS AND RECOMMENDATIONS

The state government of Baja California along with federal agencies, state institutions, and a private firm, made a lot of effort in elaborating the Program of Urban and Touristic Development of the Tijuana-Ensenada Corridor (PRDUTE), in order to reach the so called sustainable development of the region, through coastal resources management efforts regulated by such program. As it name indicates, it contains the regulations to develop the region with an adequate urban, touristic and ecological ordinances, so that the use and exploitation of natural marine and coastal resources is possible without compromising those resources for future generations. The regulations and standards upon which the PRDUTE is supported are the federal and state laws, Ley General del Equilibrio Ecológico y Protección al Ambiente (LGEEPA), and Ley del Equilibrio Ecológico del Estado de Baja California (LEEPABC), respectively.

There is ample room to develop marine pollution regulations in the Tijuana-Ensenada corridor, and to include them as part of the PRDUTE. Even though land use planning, normativity and action strategies are well defined in the document, the problem of marine pollution is not adequately approached. Important economic activities for the corridor's region such as the tourism and fishery industry, are closely related to marine pollution processes. There is an urgent need to account for them, since they pose a serious threat to the marine and coastal resources of the Tijuana-Ensenada corridor. In fact, tourism and fishery activities could eventually disappeared from the region if there is not an adequate characterization of the marine pollution processes in the corridor.

Marine pollution regulations for the corridor are to be dictated by the Mexican federal and state laws, LGEEPA and LEEPABC, respectively. The LGEEPA is the document upon which implementation of federal environmental laws and coordination between state and local agencies is supported. The document is intended to be the tool to solve environmental problems within the country.

The former federal agency, Secretaría de Desarrollo Urbano y Ecología (SEDUE) was the federal organism through which the regulations of the LGEEPA should be empowered. Unfortunately neither SEDUE, as the authority nor the LGEEPA, as the written law, approached the marine pollution problem in the state of Baja California in an adequate manner. Numerous agreements between SEDUE and the U.S. Environmental Protection Agency (EPA) had been reached to protect the border environment. Despite this fact, and with technical and economical assistance offered by the U.S., the marine pollution problem is still an issue in the border coastal zone of Baja California, including the Tijuana-Ensenada corridor.

Perhaps the largest barrier for an adequate performance of SEDUE in the Tijuana-Ensenada corridor environment is the lack of consistency in the Mexican federal programs. For example, La Secretaría de Desarrollo Social (SEDESOL) took SEDUE's place in 1993. SEDESOL duties do not include water quality or marine pollution issues. Therefore the problem should be addressed by other federal or state agencies that had not dealt with the issue before. In any case, the problem is still there, and must be adequately managed to reach the PRDUTE's goal. This could be accomplished by developing programs where local, state en federal entities integrate their regulatory data and management needs, to avoid overlapping jurisdiction, and to determine the objectives to optimize the utilization of the coastal resources available on the corridor.

The LGEEPA, is still in place as the official regulatory document to protect the environment in México, so that the PRDUTE is supporting its ecological regulatory measurements on it. The potential problem of this is that although the LGEEPA covers some aspects of sea water quality, and marine and coastal ecosystems, its regulations are not proved to be adequate for the coastal system of the corridor, and no scientific data is available to support the criteria controlling pollutants present in the area. Further more, there is no actual data listing the kind of pollutants found along the corridor. Another drawback of the LGEEPA is that it also implies that regulating water quality inland would solve the marine pollution problem. This is questionable because pollutant sources to the coastal environment are not only related to water runoff or point discharges such as the outfalls of waste water treatment plants, as the LGEEPA considers. Airborne particles and gases have important inputs, accounting to the marine pollution processes in coastal areas, as it should be in the Tijuana-Ensenada corridor.

The regulations of the state of Baja California (LEEPABC) have the same characteristics as the LGEEPA. Its regulations have no scientific support, and the increasing marine pollution problem in the corridor is not considered. This has a remarkable importance, considering the development of the Tijuana-Ensenada corridor planned by the state government of Baja California.

The marine pollution problem in the Tijuana-Ensenada corridor is directly linked to two very important economical activities of the state, fisheries and tourism. If we do not develop an understanding of the coastal and marine environments, as well as developing an understanding of the diverse types of pollutants and their concentrations, sources, sinks and fates, the pollution problem would eventually kill those two activities on the state.

The implementation of the PRDUTE is the first step by the state of Baja California to start managing its coastal resources. The document itself represents a valuable tool for that purpose. However to reach sustainable development for the Tijuana-Ensenada corridor would be more likely if the PRDUTE is implemented in conjunction with a Marine Pollution Monitoring Program.

Developing a marine pollution monitoring program for the corridor should take time and effort. However because the touristic, urban and ecological development of the corridor is about to start (Summer of 1994) there are some actions and recommendations that should be taken into account to start the understanding of the corridor's marine pollution processes, and that will not interfere with the corridor's development plans.

This would create better management approaches for the corridor's resources in a short time basis.

The first thing to focus on is the actual marine pollution processes along the corridor, and to set regulations and standards according to the characteristics of the area.

In chapter three we described the classification of the marine pollution processes. These, according to their authors (see p. 32), are oxygen demanding wastes, oil pollution, conservative pollutants, radioactivity, solid wastes and heat. From all these, only the radioactivity category is not found along the coastal area between Tijuana and Ensenada.

In regard to the oxygen demanding wastes category what it should be done in the corridor is to keep municipal and industrial wastewater treatment, so that the BOD is low enough to avoid hypoxic and/or anoxic conditions. One of the problems with the wastewater system of the city of Tijuana that causes runoff of its raw wastewater is the malfunctioning of the pumps that transport the wastewater to the treatment plant (Sánchez-Rodríguez, 1989). It has been observed that when the system fails, flooding of the drainage occurs, and the runoff of this raw waste water ends up in the Tijuana river, downhill to U.S., in underground water reservoirs, and in coastal areas of the U.S. and México. For this the immediate solution is to have an adequate maintenance of the system, so that runoff would be avoided.

In regard to pollution of oil and conservative pollutants in the corridor, lethal and sublethal concentrations can be determined. According to the PRDUTE there are some species that are key for the ecosystem to be sustained as actually is as well as species with commercial and educative value. These species should be used to obtain more adequate lethal concentration values ($LC_{50'S}$) for the region. Sensitive stages of the different species, such as larvae, younger individuals, as well as females can be exposed to different levels of oil and conservative pollutants that had been found and evaluated for the area. One of the drawbacks of toxicity tests is that no antagonic or synergistic effects are evaluated. Trying to cope with that problem, what it should be done is to conduct additional toxicity tests where conservative pollutants and oil are mixed. Once lethal and sublethal effects of oil and conservative pollutants are determined, we should have a better idea to regulate them in the waste water discharges to the coastal area of the corridor.

Heat, along with its companion pollutants such as metals (Fe, TBT), and organochlorines can also be regulated with toxicity tests. Other effects that should be evaluated are the ones that happen when oil, metals, organochlorines and heat are combined, as it happens along the Tijuana-Ensenada corridor, in the city of Rosarito, where PEMEX, the federal government's oil plant and CFE, the Mexican federal government's thermoelectric plant are located together.

In theory solid wastes should be the easiest problem to solve along the corridor, since it is a problem that we can actually "see". However it might be as difficult, as any other marine pollution problem in the corridor, to be abated. Research institutes of the locality, along with local, state and federal agencies should elaborate a comprehensive education program, so that people visiting beaches along the corridor could be aware that this problem might eventually divert tourists to other states. The wise use of solid wastes has to be taught. Recycling, and using less than what people need, has been an important effort made by the population of the U.S. and the problem, if not completely solved.

The second issue we need to focus on is to understand the actual physical and chemical characteristics of the environment along the corridor. This could be accomplished by gathering available oceanographic, atmospheric or ecological information of the corridor, and of the border zone of the Southern California coastal area. Any kind of information related to the marine environment of the corridor would be useful to determine which areas need more research, to evaluate natural processes that have not yet been characterized (e.g. metal speciation in water column, sediments and in organisms; the exchange rate of chemical compounds at the significant reservoirs;

sediment water relationships, among others). When all the environmental information is gathered, the overall health of the corridor should be characterized.

Another set of environmental information about the Tijuana-Ensenada corridor can be obtained by conducting research on the different significant environments of the reservoir. Atmospheric contaminants or pollutants are not yet characterized in the area. It should be very useful to determine what kind of atmospheric pollutants are present in the area, to determine their sources, concentrations and distributions within the corridor.

Observing the characteristics of the surface microlayer such as depth, population, type of pollutants, contaminants or substances, and how it relates to the atmospheric reservoir would give a very useful insight of the actual processes at this interface.

It is necessary to obtain physicochemical parameters of the water column and compare these values to those obtained on previous studies. The comparison of these figures should be useful in establishing research projects where they are required.

The sediment-water interface is another reservoir to look at. Measuring sedimentation rates should be useful in gaining insight on pollution data of the corridor.. Metals, PCB's, petroleum hydrocarbons, among other chemical compounds, are associated with sediment particles, so they are "recorded", and their flux with time can be assessed.

To determine the types of pollutants that are present along the corridor, first environmental information pertaining to the corridor should be gathered. Second, it is required to identify what are the substances are currently being used by different sectors of the community around the area. This identification should cover industrial and municipal sectors, as well as the services sector such as health and tourism. The agricultural sector should also be included. When this information is at hand, we should take advantage of marine pollution problems previously presented in other coastal areas of the world, and correlate the substance or substances that caused the problem at some other coastal area to the substance or substances found in the region near the corridor.

With that information we might be able to reach consensus between research institutes, environmental groups, public, state and federal authorities, as to what substances and compounds we have to account for, because its potential to cause an impact on the corridor's coastal ecosystem. For those substances chosen to be a possible threat, a literature study should be performed, so that we can get acquainted with the characteristics and behavior of the substance when it is intorduced to the natural environment. Silver (Ag), for example, has been found to have the largest concentrations of the trace metals along the Mexican-U.S. border (Sañudo-Wilhelmy and Flegal, 1991). This should be an event that must be considered to determine what kind of environmental threat is associated with that metal. If silver does not pose a threat for the natural resources of the Tijuana-Ensenada corridor, then we may remove its name from our original list that considered silver as a potential pollutant for the corridor. The same evaluation process has to be performed for each substance that is present in the corridor.

To know the amelioration actions taken by different countries that have had marine pollution problems in their coastal areas would be very helpful to develop an understanding of what kind of actions are adequate to be used for marine pollution problems on the Tijuana-Ensenada corridor. If their pollution problems have been somewhat similar to the ones experienced at the corridor we will have one more tool at hand to solve them. On the other hand, if the marine pollution problem has not been solved on other coastal regions, then we should be able to recognize what methods might not be useful to address a marine pollution problem in the Tijuana-Ensenada corridor.

To determine the sources of pollutants entering the Tijuana-Ensenada corridor is also important. There has been a lot of debate between the local, Tijuana, and San Diego governments, about pollutants transported to either sides of the border. This creates conflict in the binational relation between México and the U.S. To understand pollutant sources to the corridor should be helpful for both, assessing pollutants behavior in the coastal environment, and to develop flexible management strategies according to what it is observed through different spatial and time scales. The binational conflict should also be alleviated. Pollutant sources can be characterized by the use of chemical tracers, for example, Sañudo-Wilhelmy and Flegal (1992) suggested that Pb/Ag ratios may be used to identify and trace waste water discharges in coastal waters. According to them, mass balance calculations showed that anthropogenic inputs of silver from the Point Loma discharge off San Diego, California can account for essentially all of the silver in coastal waters along the U.S.-Mexican border, during summer conditions. The use of other chemical tracers, such as lead isotopic compositions, should be helpful to assess distant pollutant sources to the corridor's coastal area. In the North East Pacific upwelling filaments, Flegal et al. (1989) compared the isotopic composition of surface water and the surrounding coastal waters. The results indicated that lead was primarily derived from aeolian inputs of Asian industrial lead to remote waters, which was then upwelled near the North American coastline.

Molecular tracers, such as coprostanol, would be very useful to determine wastewater that has been discharged to coastal waters when associated to other kind of tracers (e.g.biological tracers). Biological tracers, such as coliforms, are being used to evaluate some pollutant sources. However because there are some limitations in this procedure, such as coliform variability in biomass according to the brackish water conditions, underestimation is possible. Thus to conduct a pollutant tracer study where coprostanol and coliforms can be used at the same time should be more accurate. There will be two kinds of measurements to assess one pollution problem, in this way results can be compared and the probability to underestimate the results is smaller.

Thus to develop a Marine Pollution Monitoring Program for the Tijuana-Ensenada corridor we need to focus our efforts in: 1) understanding the sources, fates, and effects of chemical compounds and biological substances entering the marine environment as a result of human activities; 2) understanding and being able to asses adequately the effects of losing or modifying marine habitats as a result of human activities; 3) assessing trends in the status of the marine ecosystem of the Tijuana-Ensenada corridor; and 4) determining the effects of marine pollution to human health.

To evaluate the success of the monitoring program we can use the criteria set by the parent committee that designed the Monitoring Program for the Southern California's Coastal Waters. The following six points, according to the committee, should be accomplished by the program: 1) address clear management and societal objectives, 2) address the major environmental problems that the corridor is facing, 3) that spatial and temporal scales for monitoring reflect those major environmental problems, 4) develop a high quality technical design and monitoring implementation, 5) that the monitoring program responds to the changing conditions and needs through time, and 6) allocate effectively the resources to be monitored. When all the above conditions are met, it will be more likely for the Tijuana-Ensenada corridor to reach sustainable development.

FIGURES

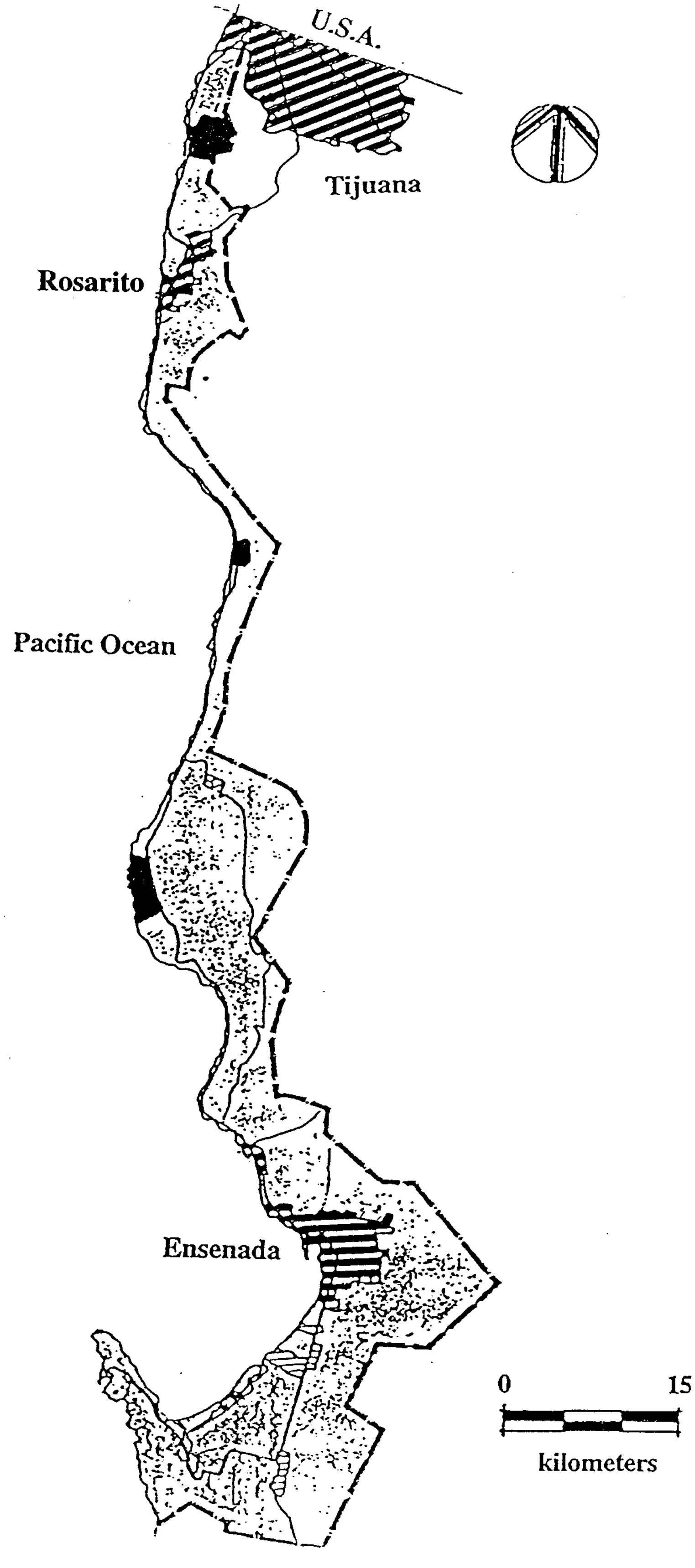

Fig. 1 THE TIJUANA-ENSENADA CORRIDOR, A NARROW BAND LOCATED BETWEEN 32° 32' AND 31° 40' N, AND BETWEEN 116° 40' AND 117° 03' W.

(State Gov. of Baja California, México, 1994)

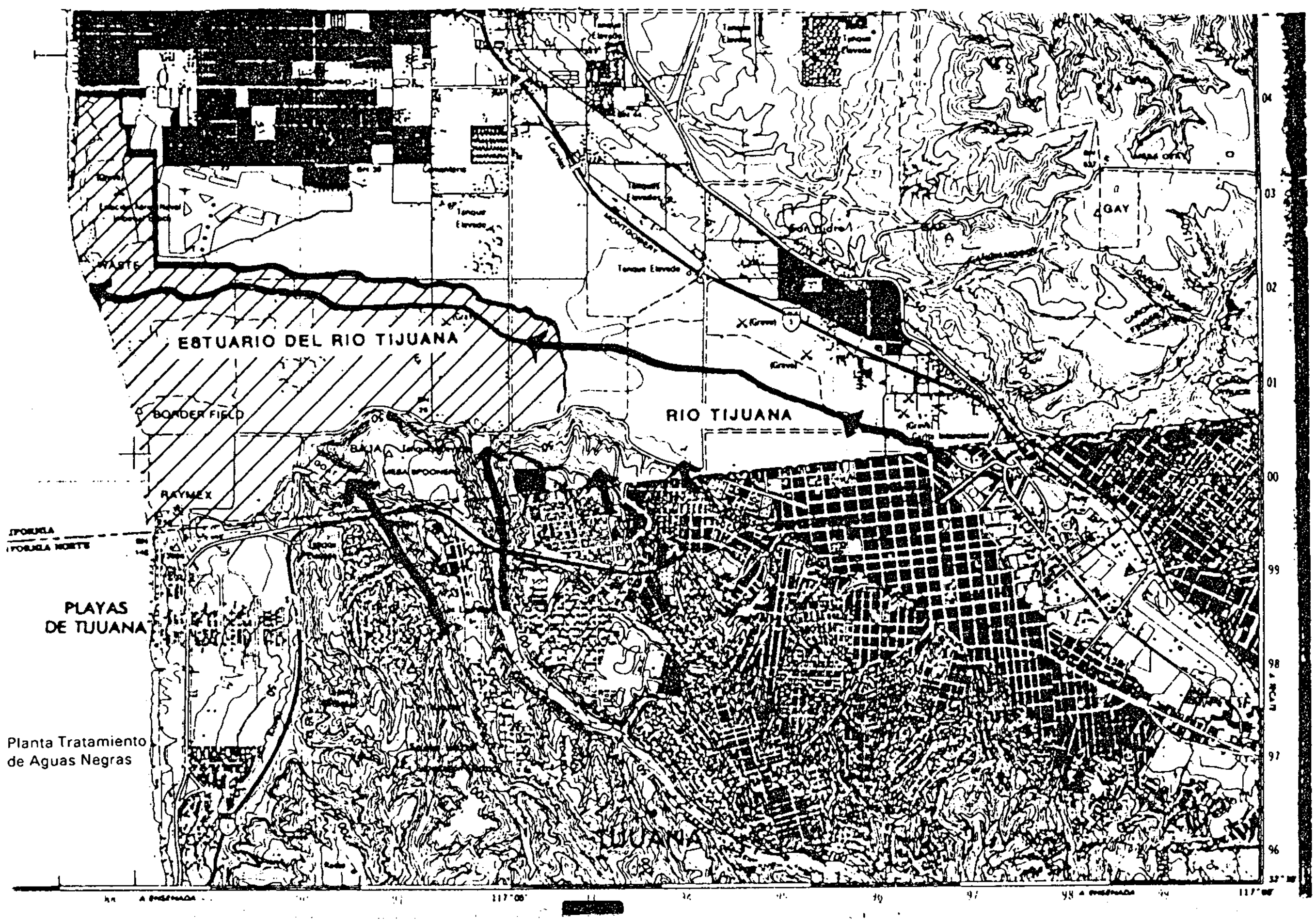

Fig. 2 WASTEWATER RUNOFF ACROSS THE BORDER.

(Sánchez-Rodríguez, 1989)

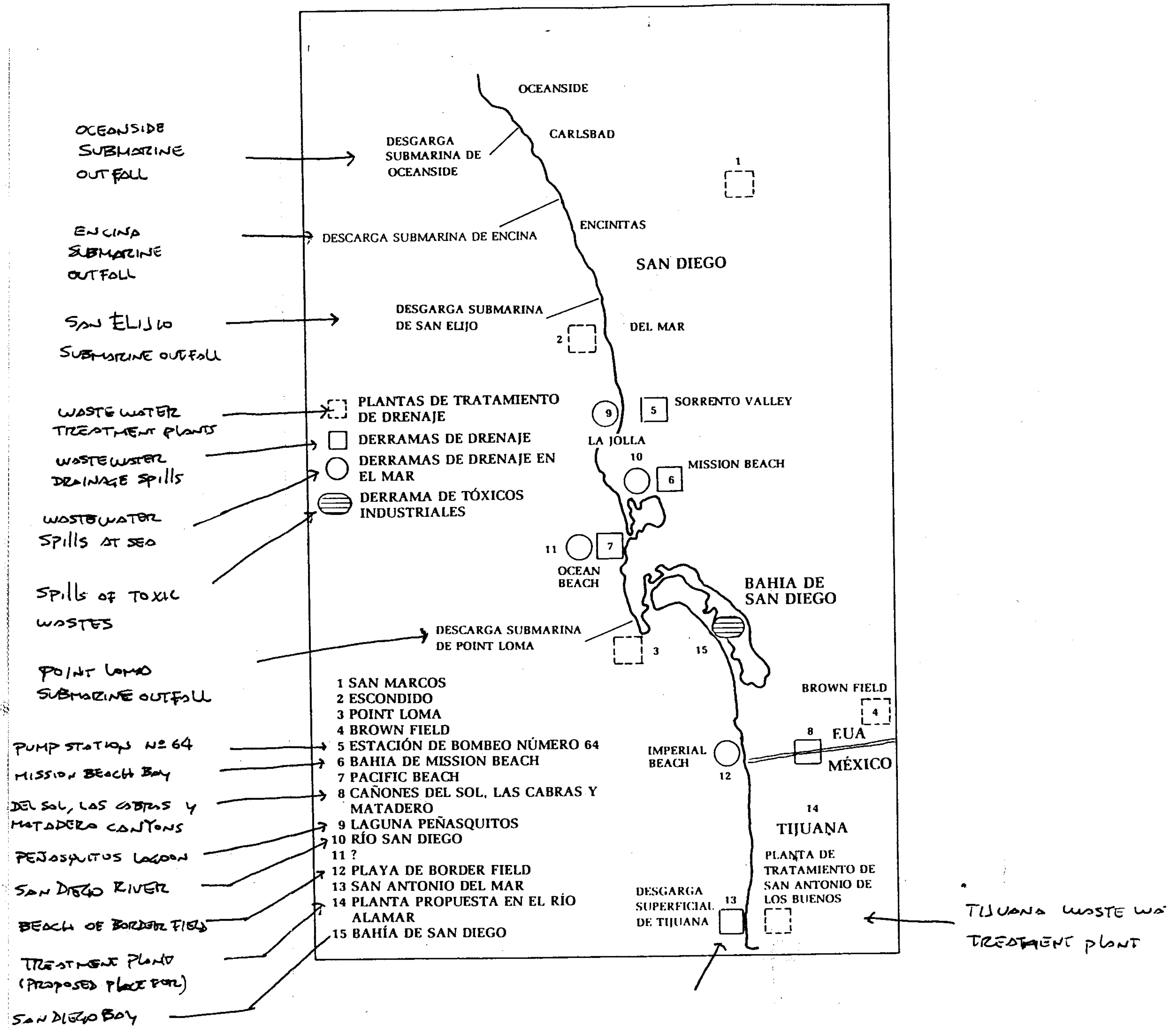

Fig. 3 THE DRAINAGE PROBLEM IN TIJUANA AND SAN DIEGO.

(Sánchez-Rodríguez, 1989)

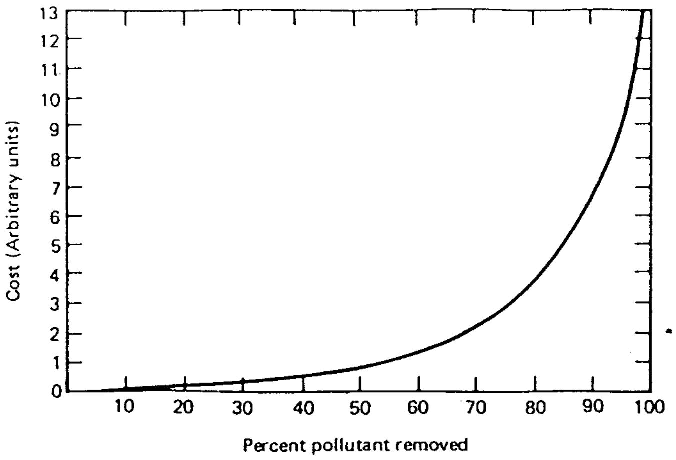

Fig. 4a POLLUTION CONTROL COST AS A FUNCTION OF AMOUNT OF POLLUTANT REMOVED.

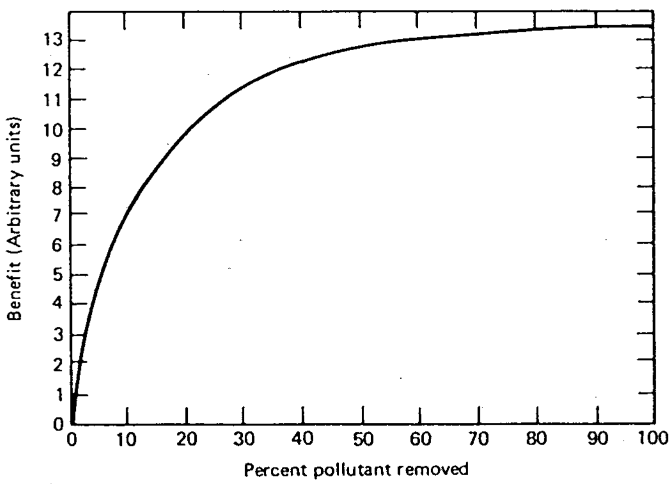

Fig. 4b POLLUTION CONTROL BENEFIT AS A FUNCTION OF AMOUNT OF POLLUTANT REMOVED.

(Williams, 1978)

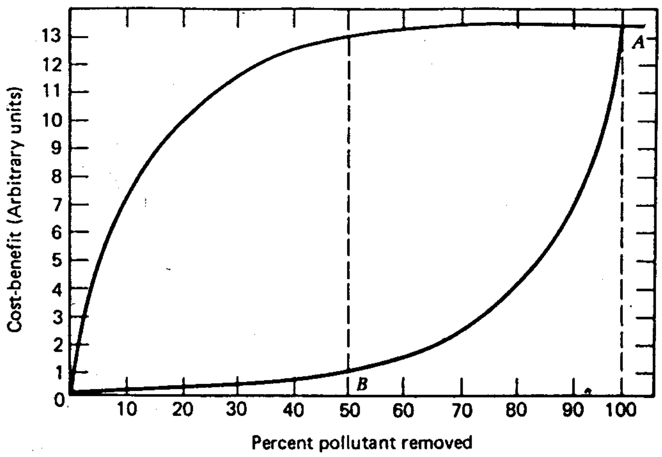

Fig. 4c COSTS AND BENEFITS OF POLLUTION CONTROL COMPARED. THE OPTIMUM AMOUNT OF POLLUTION CONTROL IS AT POINT "B" WHERE THE SLOPES OF BOTH CURVES ARE THE SAME (After Singer, 1974)

(Williams, 1978)

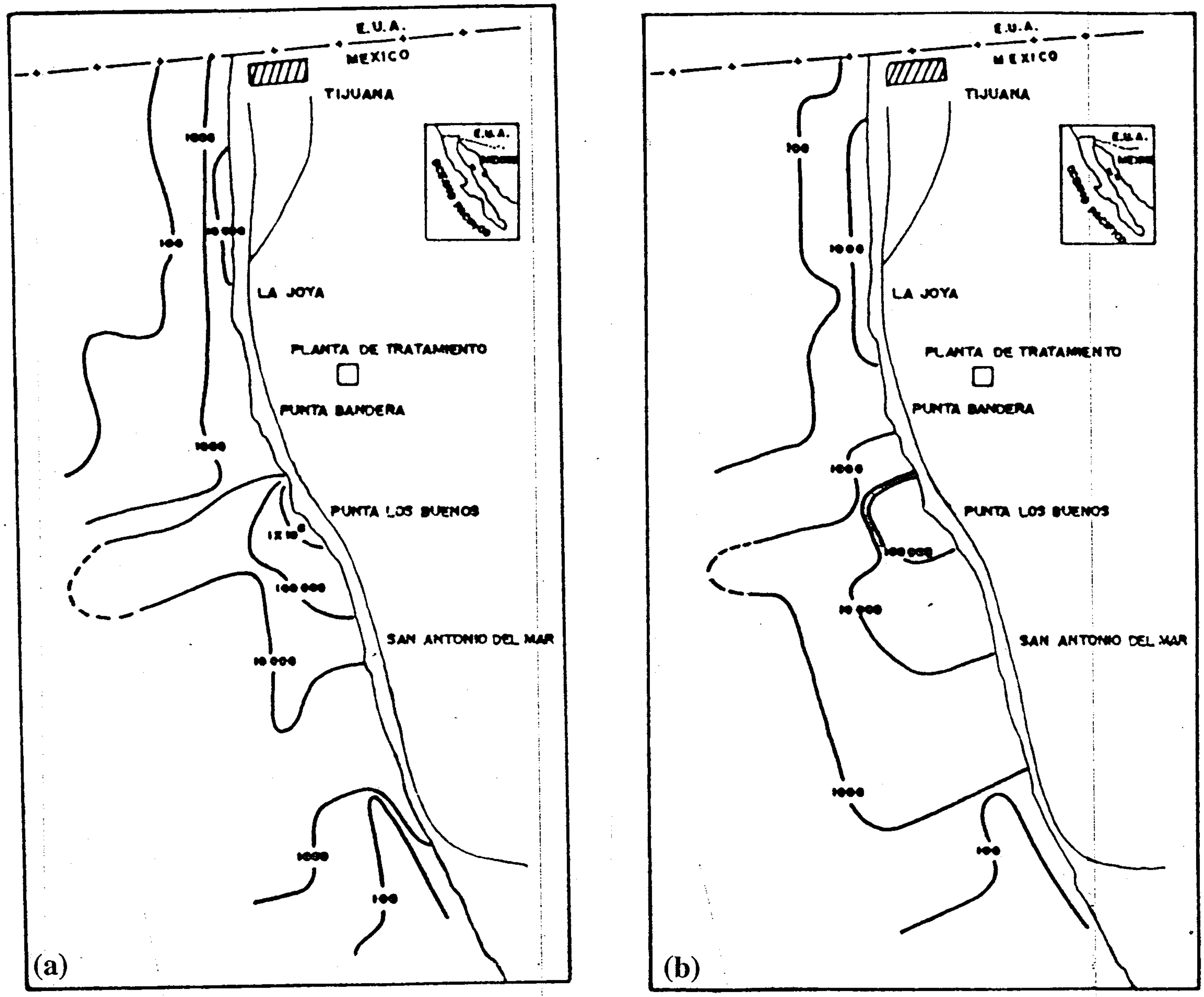

Fig. 5 DISTRIBUTION OF (a) TOTAL AND (b) FECAL COLIFORMS (NMP/100ml) DURING SUMMER OF 1987.

(Calderón-Torres, 1993)

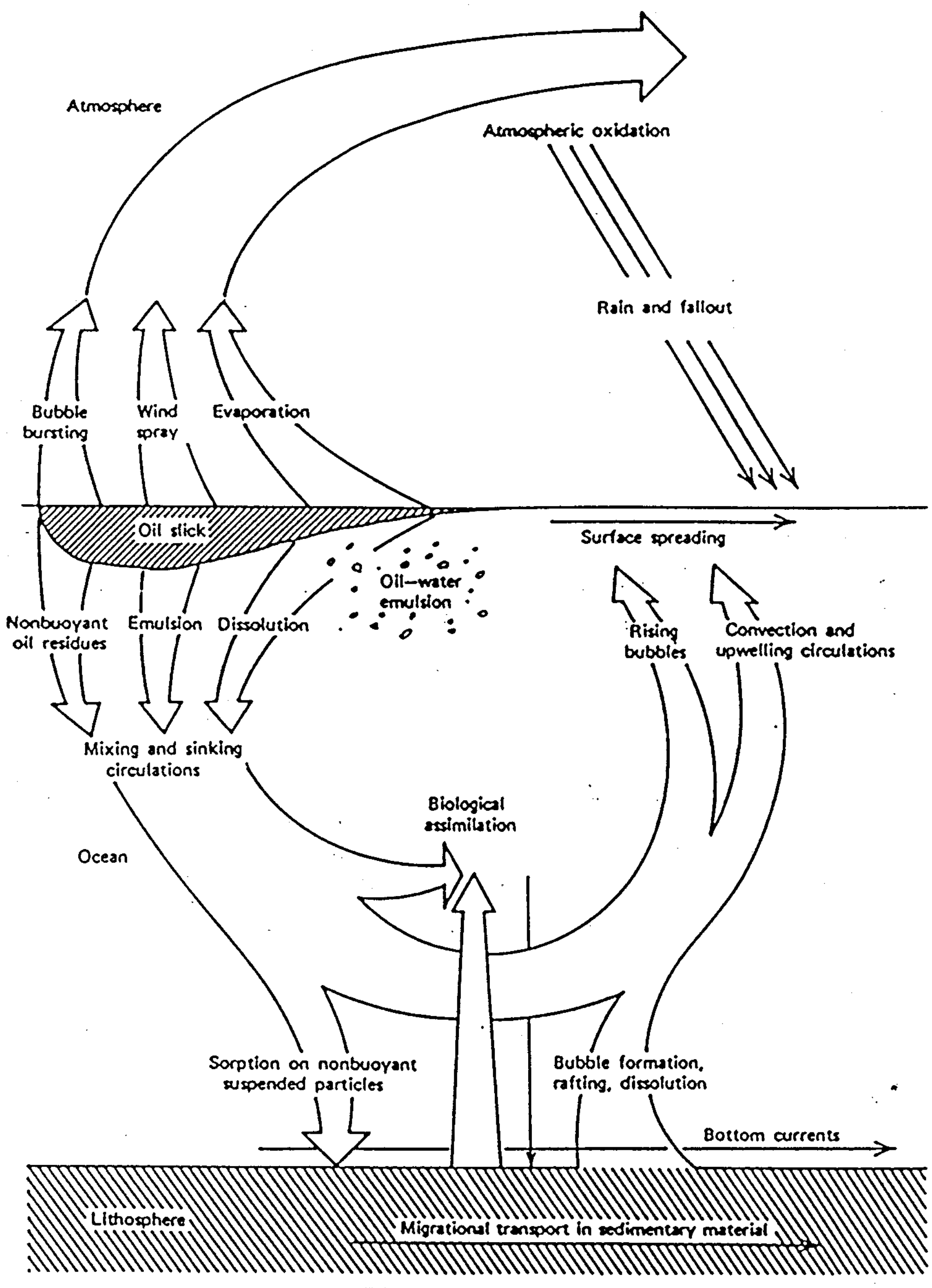

Fig.6 THE TRANSPORT OF OIL SPILLED IN THE MARINE ENVIRONMENT.

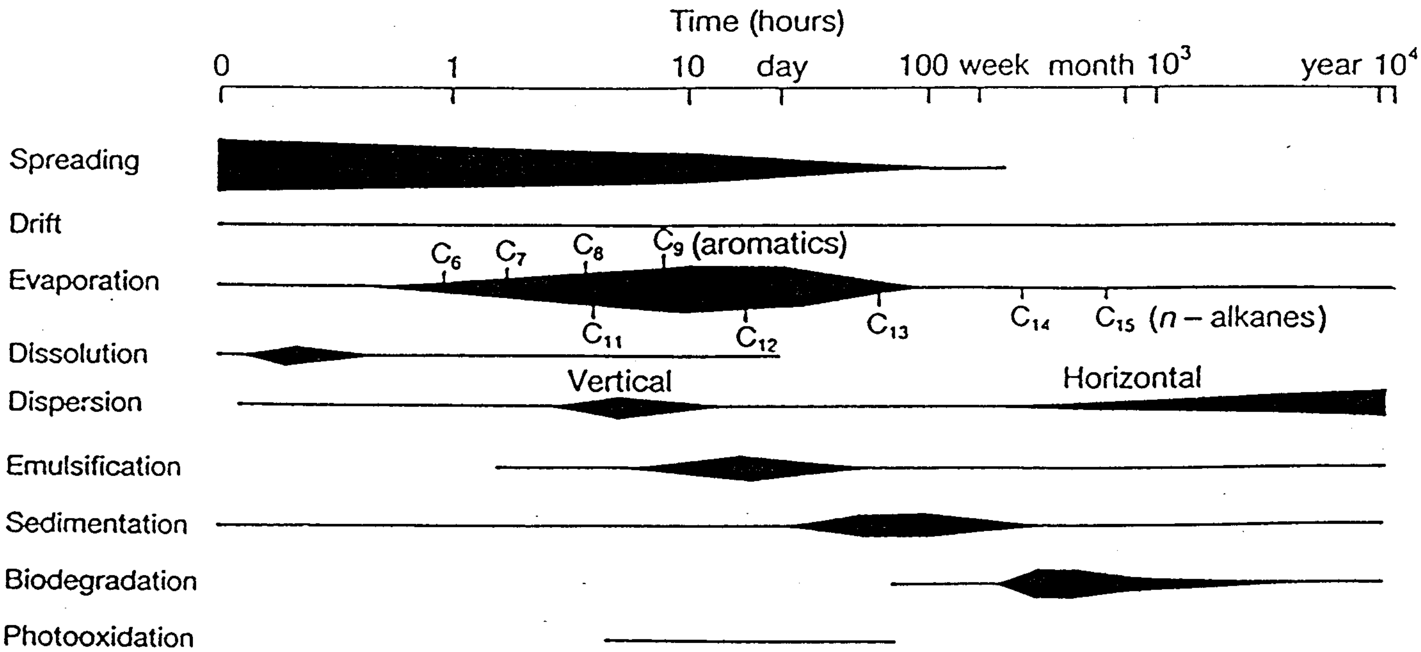

Fig. 7 TIME COURSE FACTORS AFFECTING OIL SPILLED ON THE SEA.

(Clark, 1989)

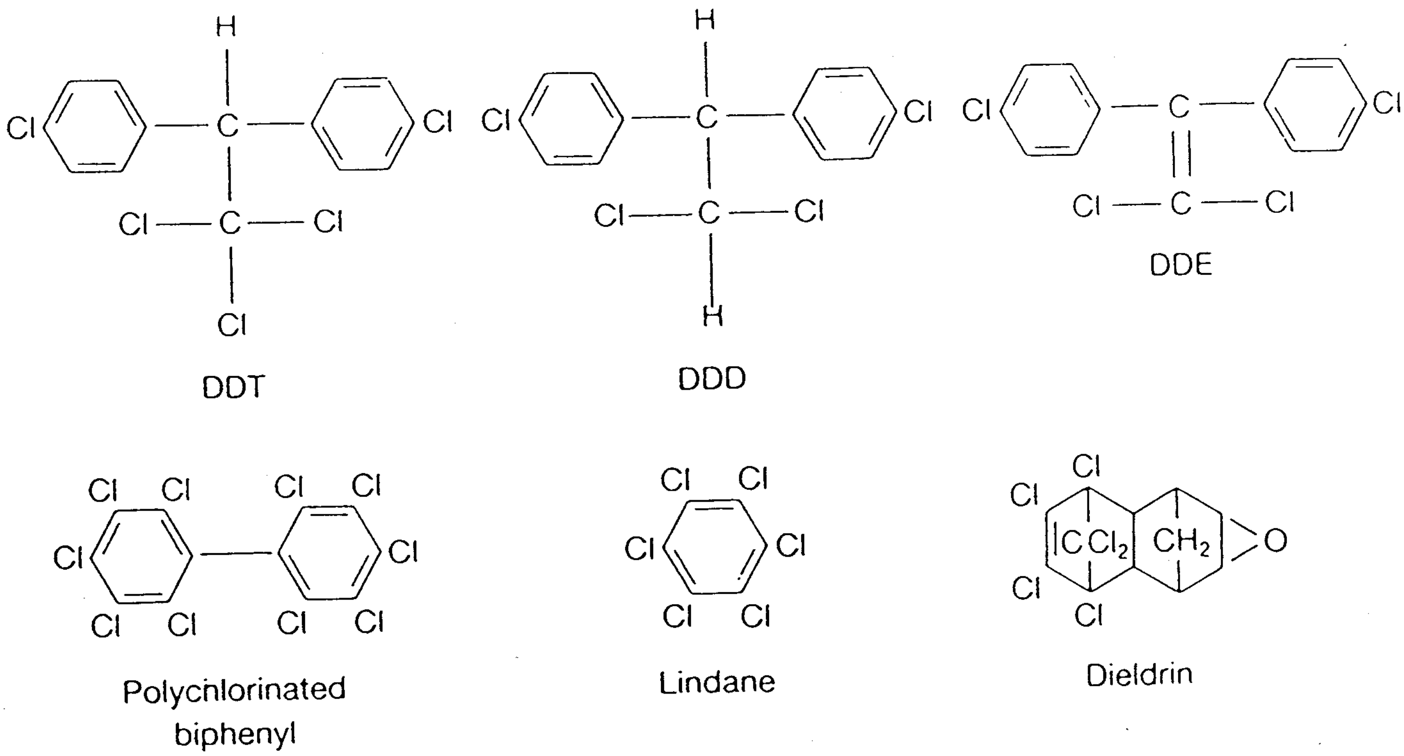

Fig.8 THE STRUCTURE OF SOME CHLORINATED HYDROCARBONS

(Clark, 1989)

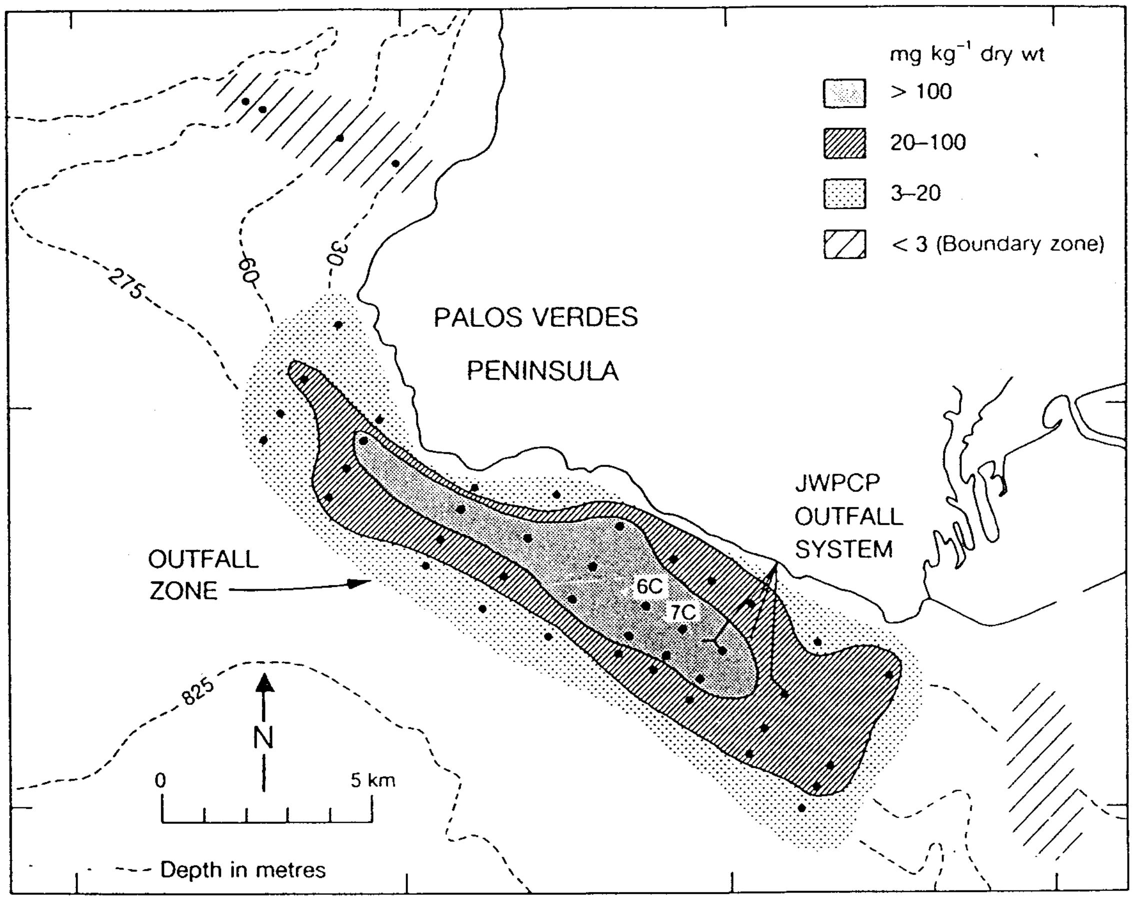

Fig.9 DDT CONCENTRATION IN THE TOP 5 cm OF SEDIMENT (mg/kg dry wt) NEAR THE OCEAN OUTFALL OF THE LOS ANGELES SEWAGE SYSTEM, OCTOBER 1983 (PERGAMON PRESS).

(Clark, 1989)

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