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CASE STUDIES of GENOA and MARSEILLE PORTS

Genoa port

Marseille port

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WORKPACKAGE 9

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GENERAL PRESENTATION OF THE SITE

The port of Genoa is situated at 40° 24’15’’of latitude North and 8° 54’ 20’’of longitude Est and it is surrounded by a mountainous land which degrades very close to the sea or, in some cases, falls straight into it.
The port area extends over about 20 km of coast from Voltri to Nervi (AMGA et al, in press) and covers 5000000 m^2 of marine surface, where the water depth varies from 9 to 15 meters, with a maximum of 50 meters on areas for the discharging operations of oil tankers. Five seawalls (Airport, Cornigliano, Foranea, Molo Duca di Galleria and Porto), with an overall length of 9975 meters, protect the port.
Marine activities of Genoa port develop about 47 km of length, 30 of which consist of modern quays (see Fig. 1), equipped to receive more than 200 ships of different dimensions. The occidental area of the port consists of a terminal for containers management (Voltri Terminal Europe) which occupies an overall surface of about 1200000 m^2. Moreover, located in the same area is the Cristoforo Colombo airport.
For the reasons mentioned above and for its geographical position, the port of Genoa is one of most important way of communication between the industrial and commercial systems of north Italy and central Europe with the south Mediterranean and north Africa countries.

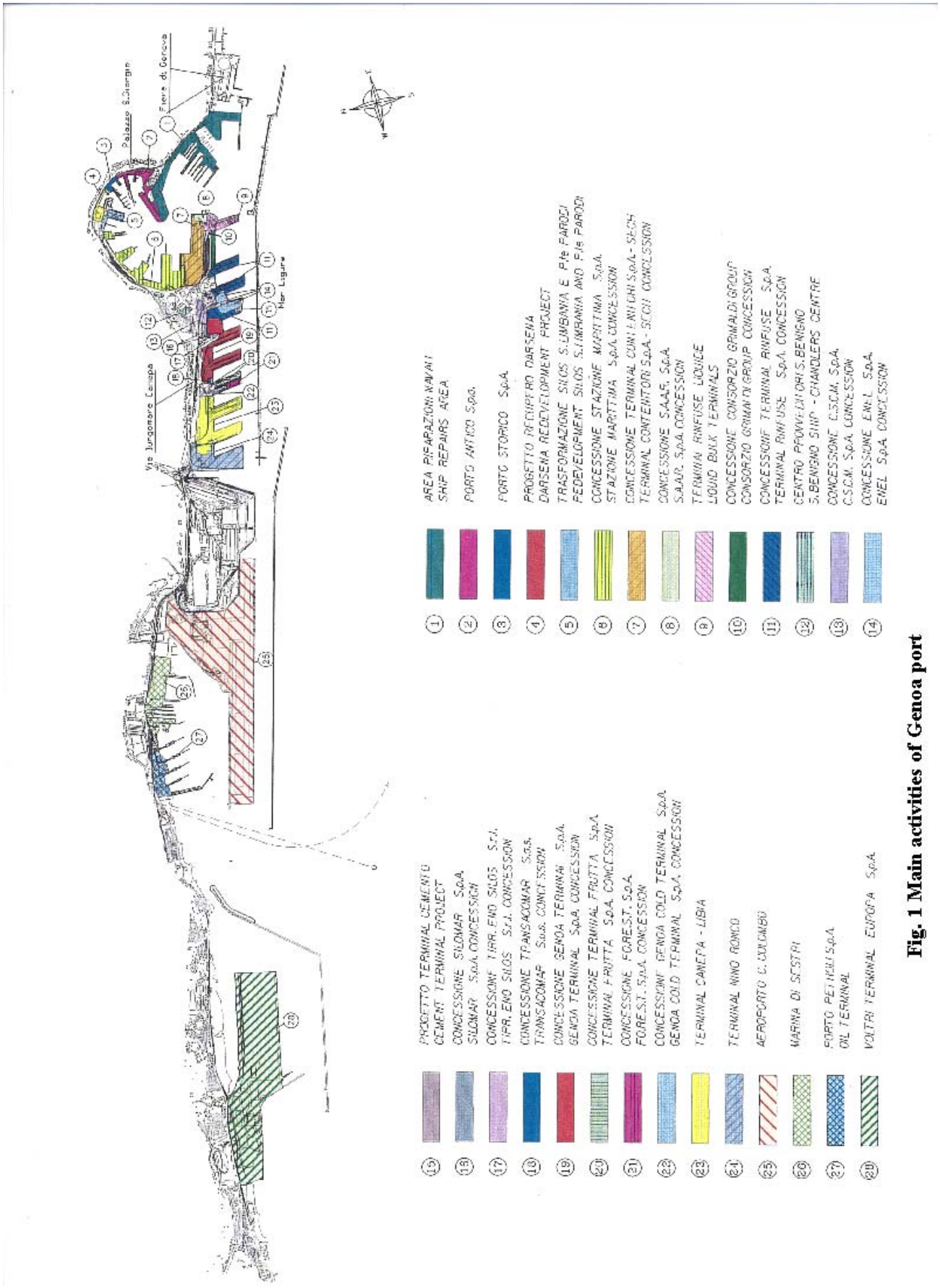

Fig. 1 Main activities of Genoa port

Within the port area, the industrial, urban and commercial activities representing the major polluting sources are the following:

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

The terminal is based in a port area covering 425000 m^2 and is designed for ship repair, ship sandblasting and painting. It is located in a area to the east of the the “Porto Antico”, extends over “Calata Gadda”, “Calata Giano”, “Levante” and it is one of the most important shipyards in the Mediterranean. These yards play an important role in Genoa productivity and have 2710 m of piers. The activity of ship repairs, managed mainly by the “Ente Bacini” (that employs 1.800 workers) distributes orders to approximately 100 medium-small sized companies employing another 500.

b) ILVA (steel factory of Cornigliano)

This industry is situated on the right bank of the stream Polcevera and produces about 2400000 ton/year of liquid steel.

c) ENEL (electric power station)

The station is fed by coal, develops an electric power of 298 MW_e and consumes 1210000 m^3/day of sea water for its cooling system.

URBAN ACTIVITIES

d) Waste disposal plant of Scarpino.

The waste produced in Genoa and surrounding area (Tigullio) are sent to the disposal plant of Scarpino. Only in the 1995, the plant treated about 325756 ton of waste.
The plant is situated in the high land of Sestri Ponente, at the border of the Municipality of Ceranesi, on the top of the Rio Cassinelle basin.

COMMERCIAL ACTIVITIES

e) Terminal Petroli of Multedo and Terminal Petrolchimico

Due to the great amount of crude oil handled, port of Genoa covers an important roll on the economy of several European countries.

Terminal Petroli of Multedo (Porto Petroli), situated between Voltri and the airport, extends over an area of 345000 m^2, disposes of 211000 m^2 of water surface and consists in five internal piers and two off-shore buoys. Crude oil pipelines connect the terminal to Swiss and north Italy oil refineries. In the 1997, the marine traffic on the terminal has been of 533 ships, and 15.6 million of ton of mineral oils. Moreover, 365752 ton of chemical substances have been handled.

Terminal Petrolchimico is situated in the occidental bank of the old Ponte Paleocopa basin, between the docks of Canzio and Oli Minerali. It extends over 70000 m^2 and can host two oil tankers and

three chemical tankers simultaneously. The storage capacity of the terminal is about 17000 m^3 per year of mineral oils and 159000 m^3 of chemical substances.

f) Terminal Rinfuse

Docks of Rubattino, San Giorgio and Idroscalo are reserved for handling the following materials:

• Coal (landed on the platform)
• China clay
• Sand (ceramics)
• Sodium chloride
• Iron
• Pig iron
• Pearlite
• Magnesite
• Fertilizer (landed directly into the train)

The terminal extends over an overall surface of 147615 m^2, 12000 m^2 of which for storing 80000 ton of coal reseved to the electric power station of ENEL. The coal is in part delivered with trains of 15 wagons, with a frequency of ten per week.

g) Voltri Terminal Europa

Berthings for 1400 lm are able to assure full operations for 3 container ships of last generation, post panamax type. Besides container ship, the terminal can grant berthings for 3 RoRo vessel type. Voltri's Basin is well connected to the railroad tracks and toll roads. The terminal is quite near to the airport, so this give more strength and efficiency to the general and full connection for Railroad-Airways-Toll Road-Sea traffics.
Within the area of the terminal operate the following devices:

- 8 post - panamax berths cranes (portainers)
- 13 yard gantries (transtainers)
- 2 railway siding gantries (transtainers)

The impact of port waters pollution on the city of Genoa

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THE IMPACT OF PORT WATERS POLLUTION ON THE CITY OF GENOA CASE STUDY

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1. DESCRIPTION OF ACTIVITIES

Most of several activities carried out on the port are potential sources of water pollution. An example is the ships repairing of the Terminal Bacini Portuali, located on the oriental area of the port. Other examples are the steel production of ILVA and the electricity production by the coal power station of ENEL, both located between Sestri and Sampierdarena. Moreover, commercial (Porto Petroli di Multedo, Trerminal Rinfuse, etc.), military and touristc activities contribute to the pollution of Genoa marine system.

Together with the activities mentioned above, the high urbanization of last fifty years contributes to degrade the quality of Genoa marine waters.
The particular configuration of the area around the port (a narrow strip of land between the mountains and the sea) has been the cause of an high density of urbanization. In the 1996, Genoa counted 653529 inhabitants with a density of population reaching also 134 inhabitants per hectare in areas of city center and, the existing urban waste water depuration plants, operated already in overloading conditions, contributing to increase the pollution of coastal waters. Heavy raining conditions, maintenance problems and overfeeding of industrial waste waters, still contribute to compromise the good operating conditions of depuration plants.
Discharge of urban waste waters implies an higher environmental risk in port areas where, due to the morphologic characteristics, the exchange of oxygen is limited. Such areas are Porto Antico and Sestri.

Several water streams, often full due to rain, discharge into the sea sedimentation material and dangerous substances from chemical and manufacturing plants situated along the rivers (e.g. Bisagno). Domestic waste is often discharged into the sea by rivers. All this influences the seabed characteristics and, consequently, the related biocenotic systems.

The propagation of polluting substances into the sea is strictly dependent on wind and sea conditions. Therefore, for a good monitoring of the pollution situation, it is also essential a constant monitoring of meteorological an hydrographic conditions.
In the Ligurian sea, the depth of the water where windy conditions prevail, results equal to 20-30 m in the summer season and even higher in the winter season. During summer, southern winds blow a great amount of superficial waters towards coastal areas while during winter, northern winds blow surface waters to the south, causing the motion of cold waters towards the coast.

In general, the environmental problems of Genoa port waters are mainly due to the presence of several discharges of untreated urban waste water, industrial waste water only partially purified, first rains, maritime traffic (civil and commercial), loading and unloading of goods.

1.1. Legislation

- National law 10 May 1976, n. 319 “Norme per la tutela delle acque dall’inquinamento” (also knew as “Merli’s law”).

- Governmental deliberation 4 February 1997 “Criteri, metodologie e norme tecniche generali della L. 10 maggio 1976, n. 319 recante norme per la tutela delle acque dall’inquinamento”.

- Directive 78/659/EEC concerning the fresh water quality related to the fishes life.

- National law 24 December 1979, n. 650 “Modifiche alla legge Merli”.

- Decree 8 June 1982 n. 470 “Acque di balneazione”.

- Legislative Decree 27 June 1982 n. 133 “Attuazione della Direttive Europee 76/464/CEE, 82/176/CEE, 83/513/CEE, 84/156/CEE, 84/491/CEE, 88/347/CEE e 90/415/CEE in materia di scarichi industriali di sostanze pericolose nelle acque”.

- National law 8 August 1985, n. 431 “Disposizione urgenti per la tutela delle zone di particolare interesse ambientale” (also knew as “Galasso’s law”).

- Directive 91/271/EEC 21 May 1991, n. 271 concerning the treatment of urban waste waters.

- National law 17 May 1995 n. 172 “Modifiche alla disciplina delle pubbliche fognature e degli insediamenti civili che non recapitano in pubbliche fognature (modifiche della Legge Merli)”.

- Ligurian regional law 16 August 1995 n. 43 “Norme in materia di valorizzazione delle risorse idriche e di tutela delle acque dall’inquinamento”.

2. POLLUTION SOURCES (RELATED SUBSTANCES AND BY-PRODUCTS)

The main industrial, urban and commercial activities and environmental factors representing the major polluting sources of port waters in Genoa, can be identified below.
Table 1 shows the main polluting substances that consequently can be found in Genoa port waters.

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

Such an area, due the high industrial concentration, can result in a source of risk due to the quality of marine waters.

The work in order to prepare ships for painting consists in two phases. In the first phase, vapour is sprayed on the area to be painted in order to remove the fouling. The second phase consists in spraying on the same area a suspension at high pressure of sand in water, which removes the old paint. The next step consists in the reparation and repainting. During the first two preparatory phases, large quantities of water containing polluting substances such as hydrocarbons, paint an suspended material are released. Treatment of this waste water before discharging into the sea is very important to prevent the pollution of marine environment.

b) ILVA (steel factory of Cornigliano)

One of the main environmental problems of this plant consists on the discharge of warm waters reach in calcium into the sea.

c) ENEL (electric power station)

The main environmental problem consists in the discharge into the sea of consistent quantities of cooling water, which is warmer than the marine water. The temperature of discharged water varies between 21 (winter) to 35 (summer) °C.

URBAN ACTIVITIES

d) Urban waste water discharges.

Due to the high density of urbanization, Genoa produces relevant quantities (about 2514000 m^3/day) of domestic waste waters particularly reach in organic matters.

e) Waste disposal plant of Scarpino.

The waste disposal plant generate an eluate that can pollute the nearest rivers and the soil.

ENVIRONMENTAL FACTORS

f) Morphologic situation of the port

The port of Genoa extends over the basins of Pegli, Sestri, Polcevera, Porto Vecchio, Punta Vagno e Voltri which, due to their morphologic characteristics, have a low circulation of sea water and, consequently, low exchanges of oxygen.
The discharges of industrial and/or waste water in these areas cause relevant damages to the quality of marine environment.

g) Streams

Besides the industrial and urban waste waters from activities carried out in the port, relevant quantities of polluting substances deriving from inland industries are transported to the sea by several streams flowing into the area of Genoa port.
Main of these streams are: Bisagno (94.6 km^2 of surface), Polcevera (134.8 km^2 of surface), Chiaravagna (3.2 km lenght), Varenna (21.96 km^2 of surface, 9.1 km length), Prà, Leiro, Cerusa, S. Anna and Carbonara.

COMMERCIAL ACTIVITIES

h) Terminal Petroli of Multedo and Terminal Petrolchimico

The activities that can generate a potential water pollution are:
- the disposal of the water ballast of old ships;
- the accidents involving the terminal structures or the ships.

i) Terminal Rinfuse

The main potential risk of water pollution related to the terminal activities is the dispersion of china clay, sodium cloride and fertilizers during the loading operations.

Table 1: Main substances can be found in Genoa port waters

Organic substances	Crude oil Mineral oils Syntetized substances Coal dust
Inorganic substances	Heavy metals Nitrogen (Nitrite and Nitrate) Nitrogen (Ammonium) Total phosphorus
Pathogenic micro-organisms	Total coliforms Faecal coliforms Faecal streptococci

3. CONSEQUENCES

Despite the self-purification capacity of the Genoa port waters, due to their morphology and to the industrial and civil discharges, some of the port areas are at high environmental vulnerability. The combination of anthropic, natural and environmental factors affects the quality of waters and marine life in particular areas of the port.
The main environmental consequences of the activities described above can be identified below.

CONSEQUENCES OF INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

In order to prevent environmental problems to the marine ecological system, the treatment of sand and waste waters resulting from the vessel surface preparation for painting is required. Moreover, the operations carried out in the shipyards result in acoustic problems and atmospheric pollution by dust and volatile organic compounds. This substances are easily transported by the wind towards the city, causing several damages to the public health and private properties (deposit of paint on cars, houses, etc.).

b) ILVA (steel factory of Cornigliano)

The discharge into the sea of process waters, forms massive calcic plates on the right side of the mouth of stream Polcevera, causing relevant hydrogeologyc damages.
In fact, the presence of calcium into the water causes the cementation of solid materials transported by the streams during the alluvial occasions, causing relevant obstruction to the stream flow.

c) ENEL (electric power station)

Few differences between the temperatures of cooling water flowing out the station and the sea water can cause several problems to the life of marine species. The national law 319/76 fixes a maximum temperature of 35 °C for the effluents discharged into the sea. The same law also fixes in 3 °C the maximum increment of sea water temperature beyond 1000 meters far from the effluent discharging point.

CONSEQUENCES OF URBAN ACTIVITIES

d) Urban waste water discharges.

Due to the presence of the Foranea seawall, the effluent of the Darsena depuration plant can't be discharged off-shore by a proper pipeline and this makes the basin of Porto Vecchio an area at relevant environmental risk.
Worse situation arises in basin of Sestri where, the presence of several industrial activities, beside the discharge of Sestri depuration plant, make of this basin the one at higher environmental risk.

e) Waste disposal plant of Scarpino.

Several risks for marine environment looking over the Chiaravagna mouth result from the possible flow of some percolate into this stream.

CONSEQUENCES OF ENVIRONMENTAL FACTORS

f) Morphologic situation of the port

Besides the pollution resulting from industrial and civil effluents, due to the morphologic conformation, most of basins of Genoa port are affected by a low circulation of sea water which causes a low concentration of oxygen into the water.

The waters of Pegli basin are affected by the waters of Porto Petroli of Multedo and for several months of the year the concentration of polluting substances exceed the yearly average.
The water quality of Polcevera basin is conditioned by effluent of ILVA steel factory and by the insufficient circulation of the sea water. Moreover, the waters of Polcevera stream show relevant values of pollution due to the inland activities.
The situation of Punta Vagno and Voltri basins is quite better. Here, the good quality of sea waters is guaranteed by its good circulation. More over, there is an irrelevant contribution of external activities to the pollution of Voltri basin.

However, the realization of seawalls to limit the coastal erosion caused several changes on marine currents intensity and direction, involving a decrease of water circulation, which is normally essential for the dilution of polluting substances.

g) Streams

Along the stream Varenna, there are several soil creeps with consequent transport of a considerable amount of sediments into the sea. This involves relevant changes of the stream mouth morphology, causing problems of access to Porto Petroli and modifications to the surrounding marine morphology, emergent and submerged beaches included.

The same problems affect the stream Polcevera, where the presence of ILVA steel factory contributes to made worse the problems of stream mouth obstruction. Several effluents from chemical and manufacturing industries contributes to increase the port waters pollution.

The stream Chiaravagna flows into the basin of Porto Petroli. Several effluents of industrial (electromechanical, etc.) and urban activities (untreated domestic waste waters, etc.), together with the possible percolate of Scarpino disposal plant, contribute to make of this stream the more polluted one between the streams flowing into the Genoa port area.

CONSEQUENCES OF COMMERCIAL ACTIVITIES

h) Terminal Petroli of Multedo and Terminal Petrolchimico

In order to allow the stability of navigation, tankers can't leave the ports empty. For this reason, after the unloading operations, they are normally filled with sea water (ballast water). Once in the port of destination, before to proceed to the loading operations, the ballast water must be unloaded (deballasting operation) into temporary storage tanks to be treated and discharged into the sea. Unfortunately, for economical reasons, several tankers throw untreated ballast waters into the sea. A similar problem arises with the bilge washing waters, which are often discharged into the sea without to be properly treated.
The port of Genoa is equipped with a plant for the treatment of the greasy waters mentioned above, but sometimes, an incorrect management of this plant can cause some problems of pollution to the looking over waters. Moreover, some problems of air pollution often occur, due to the venting of the tankers during the ballasting operations.

i) Terminal Rinfuse

Between the bulk materials handled on the terminal, the coal is the only one to be first unloaded on the terminal yard, to be than loaded on the railway trucks. These operation cause the dispersion of coal dust on the atmosphere, with consequent damages to the public health. Moreover, during the operation for cleaning the yard, several quantities of coal dust fall on the surrounding surface water, with consequent increase of water pollution.

4. ACTIONS TAKEN

Due to the several number of activities carried out on port area, in order to limit the damages to the environment ,competent Authorities have made much effort to force the concessionaire companies of the terminals to improve work procedures and technologies.
In order to solve the problems described above, actions taken or in project are illustrated below.

ACTIONS TAKEN FOR INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

The goal is to purify the waste water resulting from the activities of ship repair, sandblasting and painting carried out on the dry docks.
In particular, the suspension water-sand resulting from the sandblasting operation will be treated in a plant where the water will be separated from the sand by physical separation. Besides the separation from the sand, water will be also purified from metallic dust and hydrocarbons removed from the surface of the ships. Waste waters from ship repair and sandblasting operations will be collected into a series of drain wells by a canalization network. In order to separate the solid materials from the water, the wells will be equipped with strainer filters. Filtered water will be then pumped to a depuration plant.
Gates of dry docks will be made as hermetic as possible in order to limit the amount of waters in circulation. Actions will be taken on the water pumping system, in order to avoid the mixing of waste waters with the dock filling waters. A store yard will be realised for handling and temporary storing the solid material resulting from the operations mentioned above. The same area will be utilised to build the waste water depuration plant. The treated water discharged into the see will meet all the law requirements (national law 319/76). The sand recovered, will be sent to the waste disposal plant.

The plant described above will have capacity of treatment of 30 m^3/h of water-sand suspension and it is foreseen an investment cost of about 2250000 Euro (1997), split as follows:

- Civil works = 1175000 Euro
- Electromechanic works = 750000 Euro
- Technical expenses = 100000 Euro
- VAT = 208500 Euro
- Others = 16500 Euro

b) ILVA (steel factory of Cornigliano)

In order to reduce the content of calcium discharged into the Polcevera mouth, ILVA realized a decalcification unit for the treatment of the water effluent from the plant. Moreover, the stream mouth is regularly dredged.
Relevant actions to modify the factory have been recently started:

decommissioning of the hot workings (coke blast furnace, etc.)
increasing and improving of cold workings

reclamation of the areas mentioned above
realization of new production activities and public facilities on the decommissioned area.

c) ENEL (electric power station)

A collection basin will be realised in order to reduce the temperature of discharged water. Moreover, in order to reduce the quantity of handled coal, Region of Liguria, Province of Genoa, Municipality of Genoa, Port Authority of Genoa and ENEL, stipulated in the 1996 an agreement for the power station reconversion. The agreement foresees the realization of a new plant of solid waste incineration, in order to integrate the electric power production.

ACTIONS TAKEN FOR URBAN ACTIVITIES

d) Urban waste water discharges

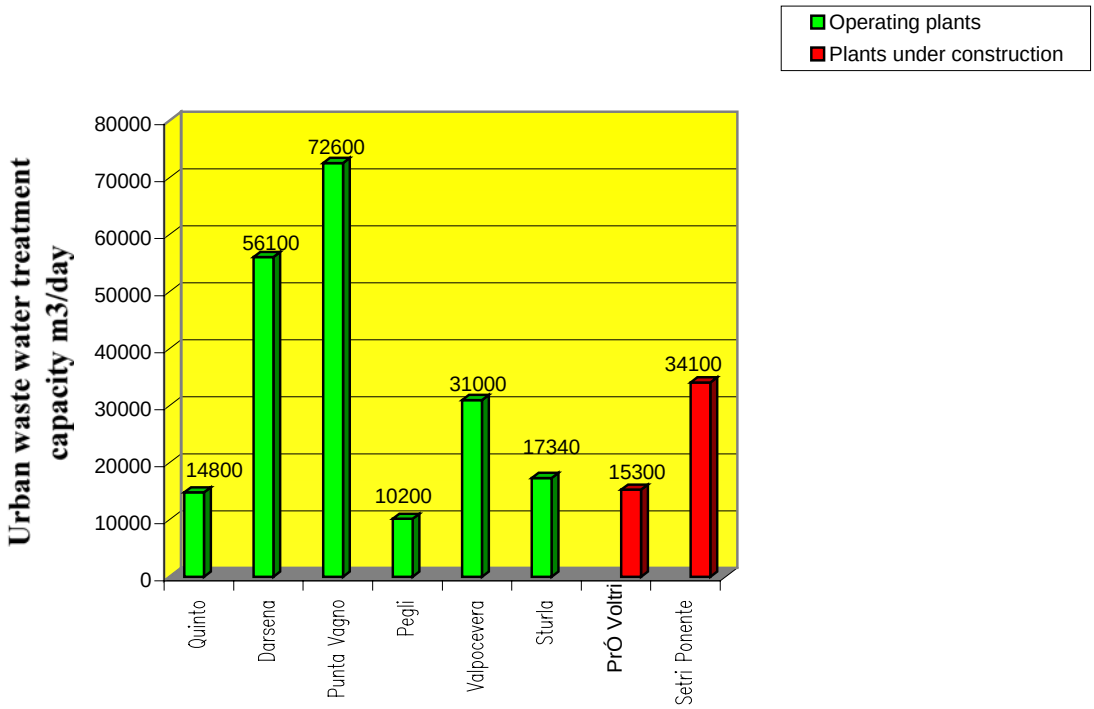
Since the 1976, before the enforcement of the national law 319/76, the Municipality of Genoa has been working to increase the capacity of the depuration system, realizing several plants of waste water treatment. The plants have been directly managed by the Municipality until the August 1995. After this date, the plants management has been committed to AMGA (Azienda Mediterranea Gas e Acqua) S.p.A.
The depuration system of Genoa consists of six plants. Further two plants are in construction. The plants operating at the moment (Quinto, Sturla, Darsena, Punta Vagno, Pegli, Valpolcevera), treat an overall flow/rate of about 202000 m^3/day of waste waters, corresponding to 731000 equivalent inhabitants (Ligurian Region, 1991).

Main characteristics of the plants

At the moment the system removes 63000 kg/day of COD, 24000 kg/day of BOD_5, 33000 kg/day of suspended solids and 1800 kg/day of sediments, working at 92% of its treatment capacity (Collivignarelli C., et al. 1996). Two plants (Quinto and Sturla) carry out only the riddling operation, others (Darsena, Punta Vagno, Pegli and Valpolcevera) carry out a complete waste water treatment (riddling, primary and secondary treatments). The plants of Darsena and Valpolcevera discharge their effluents in areas with a particular morphologic conformation where the delicate marine equilibrium can be compromise. Due to the potential risk of eutrophication in these areas, these plants must respect both the legislation requirements of the regional law 43/95 and national law 319/76. The plant of Darsena effects also the treatment of water purification.
Fig. 2 shows the depuration capacity of the system, while table 2 gives an indication of the depuration costs.

Fig. 2

Waste water purification system of Genoa



Sludge treatment

The plants of Darsena, Pegli and Valpolcevera are equipped with sludge digestion, dewatering and thickening units, except of Punta Vagno plant which, due to the small area available, doesn't carry out this treatment. Here, sludge are sent by a pipiline to a treatment unit situated 6 km far from the depuration plant. Solid waste and thickened sludge (15000 ton/year) are sent to a urban waste disposal plant which is located outside the Ligurian Region.

Further developments

The depuration plant of Sturla will be restructured by the realization of a primary treatment unit. Waters effluent from plants should be discharged at least 1000 meters off-shore at a minimum depth of 30 meters (regional law 45/95). Just few plants are equipped with such a type of discharging pipeline, while other plants are making much efforts to meet this legislation requirement.
The realization of two further depuration plants (Prà-Voltri and Sestri Ponente) and a new sewer collector will improve the system efficiency. These plants will guarantee a further treatment of about 49000 m^3/day (15300 m^3/day for Prà-Voltri and 34100 m^3/day for Sestri Ponente) of waste water, increasing the system capacity to 1022000 equivalent inhabitants. Particular solution will be studied for the off-shore discharging pipeline of Sestri Ponente plant, since this is situated straight in front the Cristoforo Colombo airport.

Table 2: Indicative depuration costs

ACTIVITY	COSTS (EURO)
Purification of 1 m^3 of waste water	0.25
Sludge digestion, thickening and dewatering	150÷200 per ton
Disposal of treated sludge (as solid urban waste)	102.2 per ton
Discharging pipeline to the sea	1250 per meter
Sewage sludge pipeline (6 km of length and 150 mm of diameter)	1500000
For one plant of waste water treatment: · Operating · Electric power · Chemicals · Maintenance · Mortgage	Per year: · 450000 · 300000 · 100000 · 300000 · 250000

e) Waste disposal plant of Scarpino

In order to avoid possible infiltration of percolate, an insulation layer of polymeric matter is spread on the floor of the plant. Moreover, in order to reduce the punching effect of the waste load, scraped tyres are spread on top of the layer before the waste discharge.
Moreover, Region of Liguria, Province of Genoa, Municipality of Genoa and AMIU, are identified a series of actions to realize a percolate pre-treatment and its subsequent pumping to the depuration plant of Valpolcevera (area of Cornigliano). Obviously, the plant capacity will be increased in order to process this overload. Moreover, the same plant will be equipped with a deodorization unit and an off-shore discharging pipeline longer than 1 km. The estimated cost of this operation amounts to about 25000000 of Euro.

ACTIONS TAKEN FOR ENVIRONMENTAL CAUSES

f) Morphologic situation of the port

The construction of longest pipelines for the off-shore discharge of urban and industrial effluents, will allows to increase the port water quality, with particular reference to Sturla and Quinto areas.

g) Streams

The mouth of the sterams needs a constant maintenance, consisting in a periodical dredging. This operation decreases the risk of catastrophical alluvions; moreover, the utilization of resulting material for the reconstruction of surrounding eroded coasts has been studying.

ACTIONS TAKEN FOR COMMERCIAL ACTIVITIES

h) Terminal Petroli of Multedo and Terminal Petrolchimico

In order to adopt a proper system of environmental management of this area, Port Authority intends to proceed with the ISO 14000 certification. This will involve an expense of about 165000 Euro.

Further actions have been taken.

- All piers have been equipped with loading/unloading arms with automatic interception valves and rapid back off devices for emergency situations. This avoid the spilling of dangerous substances on the water and a consistent safety increase during the handling operations.
- In order to avoid oil spill into the sea, the manifolds of the ships and off-shore facilities are connected by special hoses equipped with special casing joints which, in case of rupture, are automatically intercepted.
- A new plant has been designed in order to handle about 440000 m^3/year of deballasting waters. The estimated investment cost of the plant is about 1000000 Euro.
- Gases resulting from venting operations of oil tankers, will be collected to a catalytic combustion unit. This will require an estimated investment cost of about 1050000 Euro.
- Some moorings will be relocated far from the Lanterna area.
- Open berth permanence of filled oil tankers has been reduced by an ordinance of local harbour office.
- All the areas for crude oil unloading are equipped with sophisticated fire faiting systems. A modern operations centre allows the management of emergency situations. In case of environmental disaster, the terminal is equipped with all the devices for spilled oil recuperation and storage. Constant training of operating personnel is programmed. To guarantee high safety standards, ship-owners must certify their Safety Management System (S.M.S.).

i) Terminal Rinfuse

Relevant investments have been dedicated to the coal handling and storage system of S. Giorgio store yard.
In order to reduce the dispersion of dust in air and into the water, handling of the coal is carried out by means hermetic conveyor belts. Hoppers have been positioned at a maximum height of 60 meters and surfaces of coal bulks are insulated by the treatment with a particular spray.
The regular cleaning of the roads and trucks reduces the dust dispersion (100000 Euro/year). 300000 Euro have been invested to buy two special brushing-machines for the store yard clean up. Moreover, it is also foreseen the following plan of intervention, which involves an investment cost of about 11000000 Euro:

- purchasing of handling buckets whit hermetic valves
- installation of an automatic loading/unloading system with showering and film covering of bulk material on a surface of 10000 m^2.

The effects of the actions mentioned above will consist in better air quality, commercial risk reduction, economical benefits (reduced loss of goods), control of the cleaning costs and control of the contamination of goods during unloading operations (e.g., china clay mixed with coal cannot be used for ceramic).

5. MONITORING

Since the September 1995, the monitoring of Genoa port waters has been carrying out by AMGA. The monitored area goes from Voltri to Quinto and the results are property of the Region of Liguria. On request, AMGA supplies these data also to the Ministry of the Mercantile Marine.
Institutionally, ARPAL (Ligurian Regional Agency for the Environment Protection) carries out the activities of inspection and control in order to verify the compliance of the sea water quality and effluents of depuration plants with the legislation requirements.
Monitoring points of port waters have been located close to the discharges of depuration plants and other discharging points of port activities. The location of monitoring points has been also influenced by prevalent marine current (WEST to EST) and wind direction (NE to SE) of Genoa port. Measurements for sea water quality are normally carried out half meter from the sea surface and half meter from the seabed surface respectively.
The number of monitoring points around the discharge of each depuration plant depends on the plant topology, basin morphology, etc.
For the depuration plants of Sturla and Quinto, two monitoring points have been identified. Particular attention has been paid to the discharging area (Porto Antico) of Darsena depuration plant, where five monitoring points have been concentrated. This is due to the presence of the Foranea seawall, which involves a low sea water circulation and, consequently, a low concentration of oxygen in the water. Three different monitoring points have been identified for each depuration plant of Voltri, Pegli, Sestri, Polcevera e Punta Vagno. A first point close to the discharge, a third point located where the sea depth reaches about 30 meters and a second point between the previous ones. Samples and on site measurements on the first and second points are carried out on sea water surface and at 5 meters of depth. Samples and on site measurements on third point is carried out on sea water surface and in correspondence to the seabed.
A part of the determination of ammoniacal nitrogen and faecal coliforms, normally carried out in laboratory, others parameters are accurately measured on site by means multiparametric probes. Measured values are saved on a data logger and later on processed.
AMGA utilizes multiparametric probes which allow the measurement of conductivity, salinity, pH, redox, dissolved oxygen and temperature until a depth of 100 meters.
At the moment, the utilization of oceanographic buoys is not foreseen, also if these instruments could allow a continuous and remote monitoring of several problems as, for example, the port traffic, the cetaceans passage, etc.

MONITORING COSTS

Table 3 shows the AMGA estimated costs to carry out the laboratory analysis of the main monitored parameters.
The average cost of a multiparametric probe (standard version) for on site measurements is about 10000 Euro and increases with the number and the type of measurement sensors.

Table 3: Estimated analysis costs

PARAMETER	COST FOR SINGLE ANALYSIS (EURO)
Analysis of water	
pH	4.5
Dissolved oxygen	5
Temperature	1
Salinity	4.5
Conductivity	4.5
COD	15
BOD_5	12.5
Nitrite-nitrogen	8
Nitrate-nitrogen	8
Ammoniacal-nitrogen	8
Total phosphorus	5
Detergents	15
Aromatic hydrocarbon compounds	40
Halogen hydrocarbon compounds	40
Heavy metals (Ni, Cr, Cu, etc.)	15 (each one)
Total coliforms	7.5
Faecal coliforms	7.5
Faecal streptococci	7.5
Analysis of sediment	
Heavy metal (Ni, Cr, Cu, etc.)	15 (each one)
IPA	125
PCB	100
Determination of the prime biotic community	500 to 1500
Analysis of biota (mollusks)	
Heavy metal, Halogen compounds, total and faecal coliforms, faecal streptococci, salmonella	Not available

6. INDICATORS AND CRITERIA: ASSESSMENT/EVALUATION OF MONITORING RESULTS

From 1996 to 1997 AMGA identified 25 monitoring points inside the area of Genoa port, carrying out a campaign of measurement of a several number of parameters. The results allowed the screening of most significant parameters to keep under control and consequently, since the November 1997, AMGA designed a new monitoring map of the area, identifying 85 monitoring points (fig. 3) to give a sound statistical representation of the areas at isoconcentration. Tables and figures 4, 5 show the yearly mean values of monitoring survey carried out on port waters quality from November 1997 to November 1998.

Table 4: Monitoring of Faecal Coliforms in port area
[log of concentration of Faecal Coliforms (MPN / 100 ml)]

	Monitoring points of Fig. 3												
	8	16	35	38	40	44	49	57	83	84	VI	VII	VIII
Nov. 97	3.08	2.73	4.7	3.91	3.03	5.26	3.2	3.34	4.11	2.61	4.46	3.93	4.95
Dec. 97	4.2	3.53	3.65	3.51	3.85	5.07	3.46	2.65	4.73		4.2	4.32	4.34
Jan. 98	4.03	2	4.8	4.24	4.12	4.65	3.84	2.58	4.2	0			
Feb. 98		1.85	4.36	4.01	3.2	1.91	1.89	1.9	4.65		1.59	2.1	2.98
Mar. 98	1.81	2.38	4.19	2.36	2.67	5.03	2.48	1.92	4.27		1.08	1.2	3.55
Apr. 98	2.48	2.7	4.48	3.33	2.38	5.08	2	2.79	4.43	2.22			0.3
May 98	2.93	3.45	4.65	3.98	2.76	5.03	1.85	1.26	2.22	2.26	0.6		4.18
Jun. 98	3.71	2.04	3.43	3.4	2.65	4.86	2.04	2.88	2.65	2.51	2.54		
Jul. 98	3.83	3.32	4	3.38	2.6	4.43	2.46	3.68	3.83	1.08	0.3	1.54	1.64
Aug. 98	4.43	3.11	3.92	3.88	2.98	4.65	1.73	2.48	4.43	2.71	0	1.45	4.8
Sep. 98	2.77	0	3.58	3.32	0.3			2.02					
Oct. 98	4.08	3	4.33	1.86	1.54	5.91	2.45	2.78	3.98	3.05	2.95	1.41	4.91
Nov. 98	3.79	2.19	4.27	3.26	2.04	4.54	3.43	2.65	2.42	1.65	1.34	1.4	3.56

Notes: VI Offshore of waste water treatment plant of Punta Vagno; VII Offshore of waste water treatment plant of Sturla; VIII Offshore of waste water treatment plant of Quinto

Table 5: Monitoring of Ammonia Nitrogen [$N\text{-}NH_4^+$ (mg/l)] in port area

	Monitoring points of Fig. 3												
	8	16	35	38	40	44	49	57	83	84	VI	VII	VIII
Nov. 97	0.71	0.15	10.3	2.5	1.37	5.7	0.59	1.23	0.36	0	0.24	0.17	0.49
Dec. 97	1.47	0.9	17.3	4.08	1	65	0.32	0.22	0.1		0.13	0	0.21
Jan. 98	0.18	0	15.1	1.55	2.19	1.03	0.02	0.01	0.09	0			
Feb. 98		0.74	12.3	4.73	0.52	3.1	0.93	4.15	0.31	0	0	0.17	0.08
Mar. 98	0.16	0.15	9.98	7.46	1.04	20.85	1.52	2.25	0.53	0.21	0.14	0.04	0.22
Apr. 98	2.39	0	0.95	0.06	0.04	0.89	0.3	0.88	0.02	0	0.06	0.03	0.03
May 98	0.5	0.92	0.62	2.72	0.17	11.2	0.14	0.96	0.11	0.1	0.12	0	0.03
Jun. 98	1.87	0.54	13.55	5.5	2.28	32.05	0.4	1.73	0.9	1.07	0		
Jul. 98	0.31	0.19	21.6	5.5	2.3	11.92	0	1.82	0.06	0	0	0	0
Aug. 98	0.4	0.02	2.72	1.23	0.49	2	0	0.17	0.02	0.01	0	0	0.16
Sep. 98	0.56	0.08	5.7	3.81	0.09			0.55					
Oct. 98	0.1	0.03	5.9	0.04	0	1.96	0	0.11	0.01	0	0.1	0	0.21
Nov. 98	0.22	0.25	5.23	0.53	0	2.9	0.47	0.34	0	0	0	0	0.12

Notes: VI Offshore of waste water treatment plant of Punta Vagno; VII Offshore of waste water treatment plant of Sturla; VIII Offshore of waste water treatment plant of Quinto

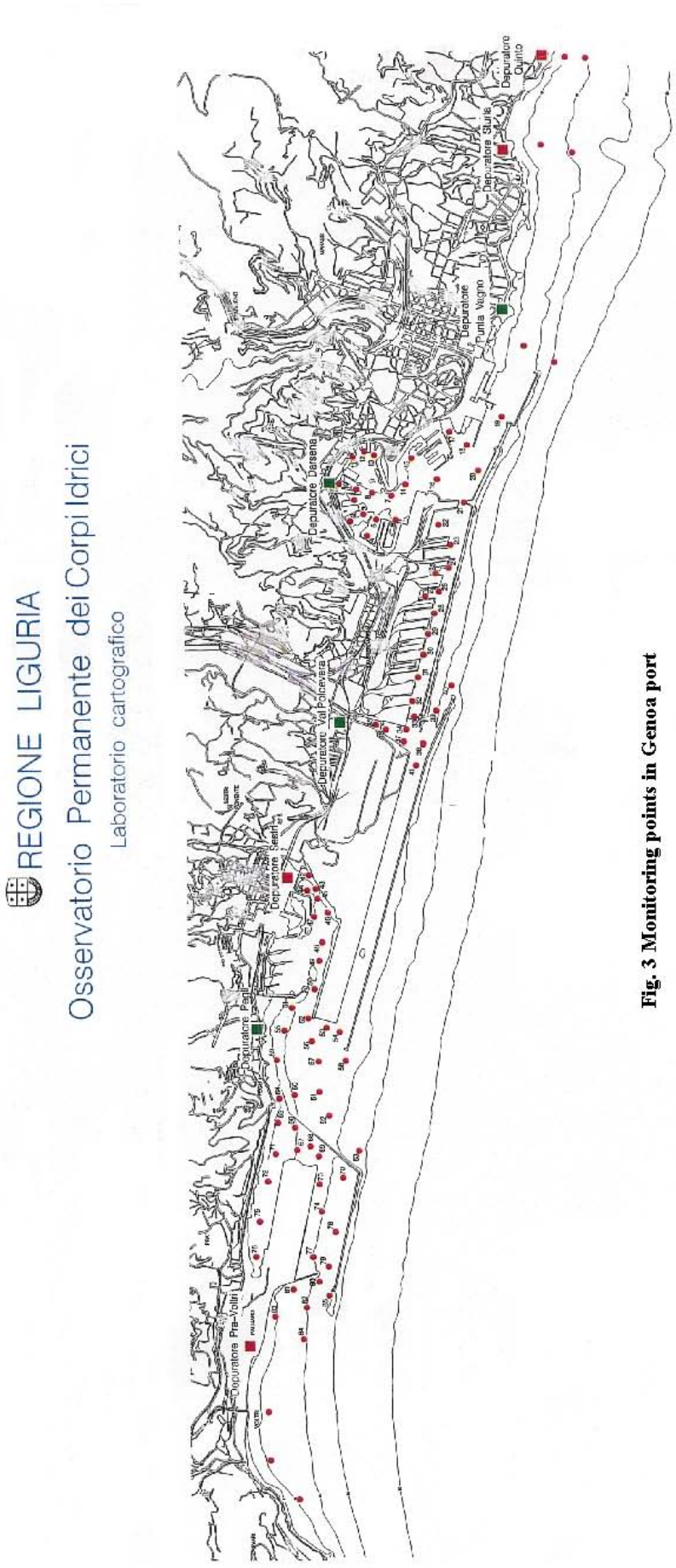


Fig. 3 Monitoring points in Genoa port

Fig. 4 Monitoring of Faecal Coliforms

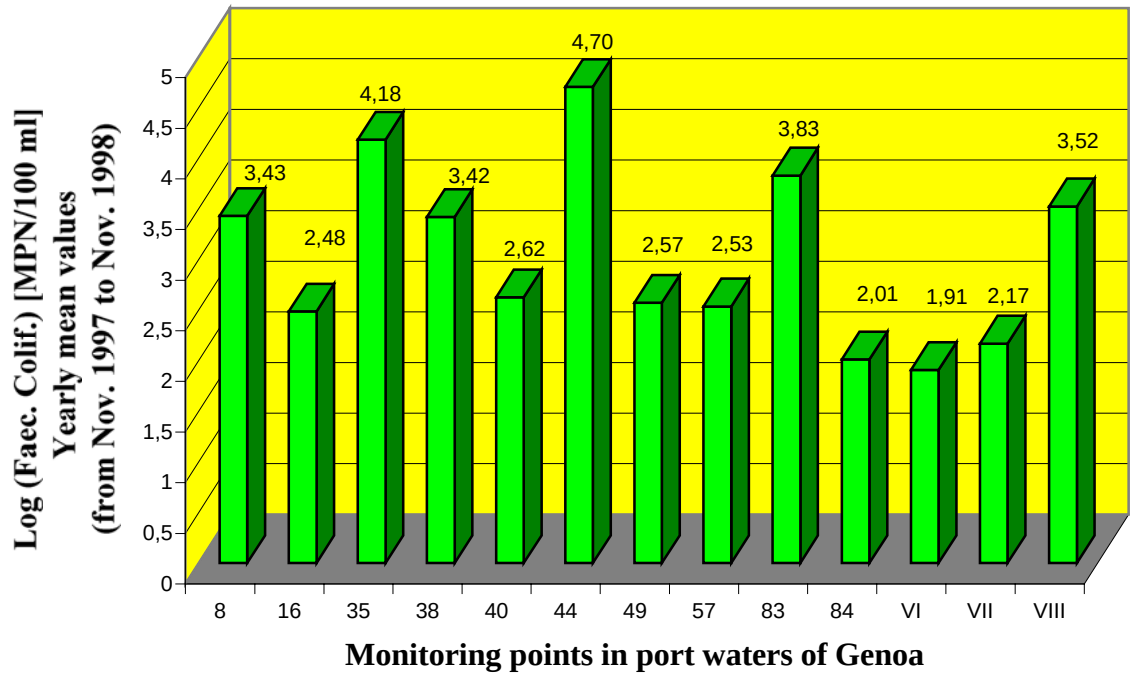
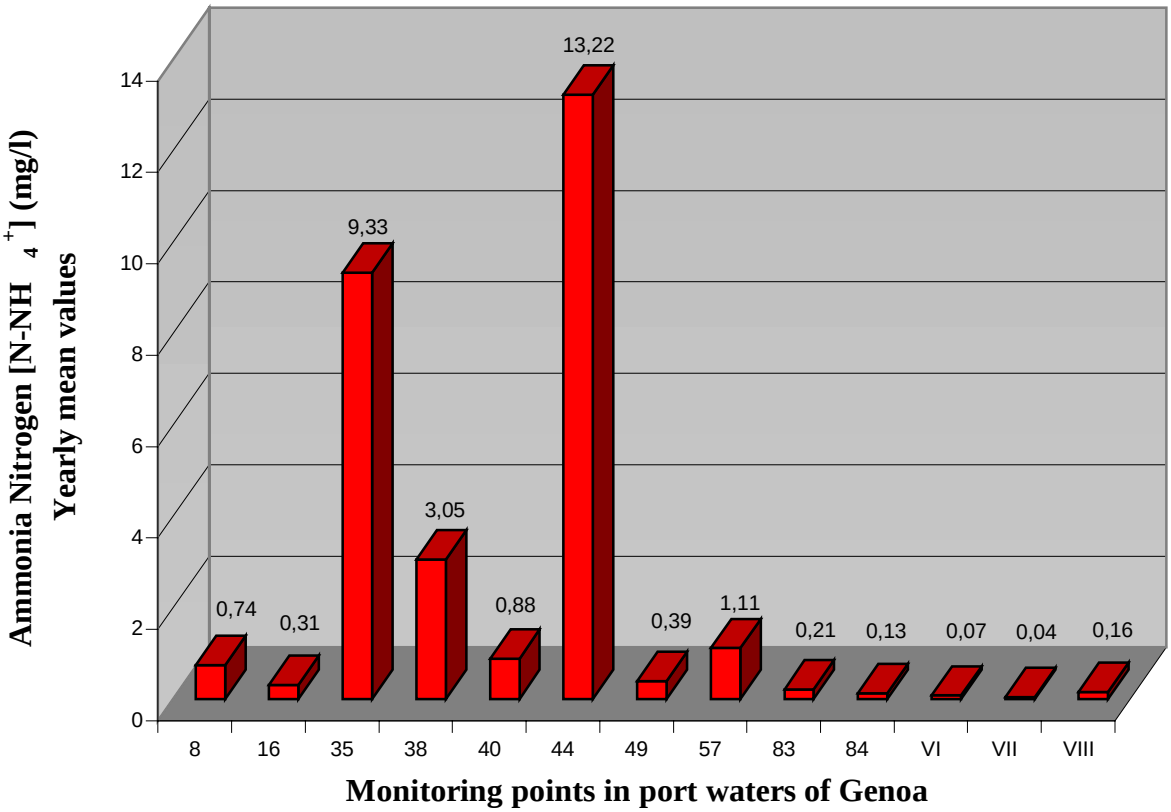


Fig. 5 Monitoring of Ammonia Nitrogen



ANALYSIS OF SEA WATER

From August 1996 to October 1997 AMGA monitored the following parameters:
Dissolved and % oxygen saturation, pH, salinity, conductivity, COD, BOD_5, temperature, total phosphorus, total nitrogen, detergents, oil, aromatic hydrocarbon compounds, halogen hydrocarbon compounds, heavy metals (Ni, Cr, Cu), total coliforms, faecal coliforms and faecal streptococci.
From October 1997 to present AMGA has been monitoring the following parameters:
pH, dissolved and % oxygen saturation, temperature, salinity, conductivity, ammonia and faecal coliforms.
Main methods of analysis are shown on table 6.

ANALYSIS OF SEDIMENTS

In the 1995 AMGA carried out a survey on the quality of seabed sediments, analysing its granulometry and its main biotic communities. The results of this activity have been utilized in order to build a general map representing the main characteristics of Genoa seabed and its biotic communities distribution.

ANALYSIS OF BIOTA

Studies of bio-monitoring of Genoa port waters are in progress (Santi L.). By the utilization of the mussel, the following parameters will be analysed:
total coliforms, faecal coliforms, faecal streptococci, salmonella, heavy metals (Hg and Cd), halogen hydrocarbon compounds, PCB and detergents.
Sampling will be carried out every three or six months, at 500, 1000, and 3000 meters off-shore.

Table 6: Main methods of analysis of water

Parameter	Method of analysis	Standard of reference
pH	Potentiometry	UNICHIM 929
Dissolved oxygen	Amperometry	UNICHIM 937
Temperature	Thermometry	UNICHIM 928
Conductivity	Conductimetry	ISO 7888
Amm.-nitrogen	Spectrofotometry	IRSA 4010-A
Heavy metals	Absorption Spectrophotometry	UNICHIM
Faecal coliforms	Filtering membranes	Standard Methods 9222-E

MAIN GUIDE-REQUISITES AND LEGISLATION REQUIREMENTS

The maximum concentration of polluting substances in the water discharges (urban, industrial, etc.) is regulated by the national laws 319/76 and 172/95, the Ligurian regional law 43/95 and the legislative decree 27 June 1982 n.133.

European Directive 271/91 concerning the treatment of urban waste waters is going to enter into force in Italy. At the moment, waste water discharges in internal superficial waters is regulated by the national law 319/76 (also knew as Merli's law). Waste water discharges into large coastal basins are regulated by local laws, as for example in Liguria, where these aspects are regulated by the regional law 43/95 (see table 7). Same as the Directive mentioned above, this regional law fixes the maximum concentration limits of polluting substances in urban waste water discharges, depending on number of equivalent inhabitants. Compliance controls of these legislation requirements are carried out by AMGA once a week.

Table 7: Requisites of effluents of urban waste water depuration plants (table A of law 319/76 and table 6 of Ligurian regional law 43/95)

Parameter	Max. concentration (r.l. 43/95)	Max. concentration (n.l. 319/76)
BOD_5	80 mg/l	40 mg/l
COD	200 mg/l	160 mg/l
Ammonia nitrogen	-- (1)	15 mg/l NH_4^+
Nitrous nitrogen	-- (1)	0.6 mg/l N
Nitric nitrogen	-- (1)	20 mg/l N
Total phosphorus	-- (1)	10 mg/l P
Total coliforms	-- (1)	20000 MPN/100 ml
Faecal coliforms	-- (1)	12000 MPN/100 ml
Faecal streptococci	-- (1)	2000 MPN/100 ml

(1) For effluents of depuration plants, the regional law doesn't requires the control of this parameter.

Industrial and whatever waste water, either directly discharged into the sea than collected to the urban sewage system, shall meet the requirements of Ligurian law 43/95 (see table 8).

Table 8: Requisites of effluents directly discharged into the sea or collected to the urban sewage system (Ligurian regional law 43/95, sewage systems of class A and class B serving more than 40000 inhabitants)

Parameter	Maximum value
Total toxic metals and not metals **(As, Cd, Cr VI, Cu, Hg, Ni, Pb, Se, Zn)**	3 [(a)]
Aluminium (mg/l like Al)	2
Arsenic (mg/l as As)	0.5
Barium (mg/las Ba)	20
Boron (mg/l as B)	10
Cadmium (mg/l as Cd)	0.02
Chromium III (mg/l as Cr)	2
Chromium VI (mg/l as Cr)	0.2
Mercury (mg/l as Hg)	0.005
Nickel (mg/l as Ni)	2
Lead (mg/l as Pb)	0.2
Copper (mg/l as Cu)	0.1
Selenium (mg/l as Se)	0.03
Tin (mg/l as Sn)	10
Zinc (mg/l as Zn)	0.5
Total Cyanides (mg/l as CN^-)	0.5
Active Chlorine (mg/l as Cl_2)	0.2
Sulfides (mg/l as H_2S)	2
Sulfites (mg/l as SO_3^-)	2
Florides (mg/l as F^-)	12
Animal and vegetable fats (mg/l)	20
Mineral oils (mg/l)	5
Phenols (mg/l like C_6H_5OH)	0.5
Aromatic organic solvents (mg/l)	0.2
Nitrogen organic solvents (mg/l)	0.1
Chloride solvents (mg/l)	1
Surface-active agents (mg/l)	2
Chloride pesticides (mg/l)	0.05
Floride pesticide (mg/l)	0.1
Total suspended materials (mg/l)	80
Sedimentable materials (mg/l)	80
Temperature °C	30
pH	5.5 – 9.5
Colour: No perceptible after a dilution 1:20	
Odour: Inconveniences and disturbs are not allowed	

(a) See national law 319/76.

Moreover, referring to Directive 78/659/EEC, in order to guarantee the life of marine species, AMGA proposed the respect of parameters indicated on table 9 (AMGA, 1997).

Table 9: Recommended requisites of sea water in order to allow the fishes life

Parameter	Limit value
Dissolved oxygen	Minimum 5 mg/l (average value)
BOD_5	Maximum 9 mg/l (average value)
Dissolved phosphorus	0.14 mg/l (average value)
Ammonia	1 mg/l (average values for all the sites)

The following average values in Genoa port waters have been measured from August 1996 to April 1997:

- Dissolved oxygen: 6.5 mg/l
- BOD5: 1.7 mg/l
- Dissolved phosphorus: 0.01 mg/l
- Ammonia: 0.47 mg/l

In particular, the quality of port water are generally influenced by two parameters which determine its eutrophication degree.
These parameters are the quantities of dissolved oxygen and phosphorus into the water. A low concentration of dissolved oxygen causes several problems to the life of marine species and is normally due to a low circulation of the water (limited marine currents). An high concentration of dissolved phosphorus causes a large algae growth. These decompose, causing further decreases of oxygen concentration on the water.
For Genoa port waters, AMGA identified the following threshold limits:

- Dissolved oxygen must be no less than 70% of saturation;
- Dissolved phosphorus must be no more than 30 mg/l.

7. PRINCIPLES AND GUIDELINES FOR IMPROVEMENT: LESSONS LEARNT FROM THE CASE STUDY

- Environmental impact of human activities carried-out in port areas must be assessed by taking account of the global effect produced from the single source of pollution.
- Planning of the investments.
- Follow and evaluate the actions.
- Have objective information to incite the ports managers to research good solutions in order to eliminate the pollution at its sources.
- Plan the environmental littoral development, globally and locally, improve the knowledge about the area and protect the area, with quality objectives.
- Needs for procedures of environmental and safety management.
- Sensitise and communicate.
- Need for research improvement, starting from a careful analysis of ports and their surrounding infrastructures.
- Consistency in monitoring the parameters and indexes specified in previous sections.
- Need to constitute territorial branches specialised in marine environment protection and related emergency management.
- Need for continuous monitoring networks of port waters by installing appropriate equipment and related systems of remote sensing; these systems should be directly managed by competent territorial authorities (port authorities, etc.) and specialised branches.
- Need for more appropriate equipment for emergency operations in case of environmental disasters.
- Need to keep under control the concentration of dissolved oxygen in port waters; it is recommended that this value never fall below 5 mg/l.
- A careful examination of benthic communities, at least once per year, is recommended to identify quality modifications in marine environment.
- Need for continuous monitoring of toxic heavy metals concentration on seabed.
- Need to increase the auto-purification capability of marine waters. For this, appropriate piping systems (1000 to 3000 meters off-shore, 30 meters deep) for discharging treated waste waters are recommended.
- Need for improvement of urban depuration plant efficiency.

8. ANALYSIS OF TRAINING NEEDS

During latest years, Port Authority of Genoa has been making much efforts to increase the professional level of its operative personnel and managers. Moreover, the decision taken in order to certify the port management system (ISO 14000) highlighted the necessity to improve the training of involved personnel. Every year the Authorities invests an average of 10000 Euro for personnel training. The main courses recently attended are as follows:

- Protection and management of the port ecosystem
- Methodologies of sea water cleaning and recovery
- Dredging operations: health and safety legislation requirements (Legislative decree 626/94 and 494/96)
- Waste management and disposal on the port
- Waste recovery
- Waste water treatment and recovery
- Hydrogelogic accidents
- Soil reclamation
- Others

9. PUBLIC COMMUNICATION

In order to inform Genoa citizens on monitoring activities and related results, Port Authority of Genoa organizes periodical meetings and daily stages open and free to the public partecipation.
All costs (printing and distribution of illustrated material, teachers and experts fees, exhibit sessions, poster sessions, refreshments, etc.) are normally supported by the Port Authority of Genoa and AMGA.
Moreover, Port Authority of Genoa often utilize the local press for the publication of environmental data.
The Authority is also equipped with an Internet site where is possible to find many information concerning the general environmental situation of the port or particular information as, for example, the quality of port waters.
Table 10 shows the estimated costs of main communication tools adopted by the port of Genoa.

Table 10: Estimated costs of communication tools of port of Genoa

COMMUNICATION TOOLS OF GENOA PORT	ESTIMATED COSTS (Euro)
- Internet site	25000 (operating cost per year)
- Congresses	75 (cost per person all inclusive)

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Dredging Activities in Port of Genoa

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DREDGING ACTIVITIES IN PORT OF GENOA
CASE STUDY

1. DESCRIPTION OF ACTIVITY

Dredging is the activity of removing solid matter from the bottom of the harbour area for maintains a controlling depth. The geologic accumulation of sediments can be dangerous for navigation and others port activity.

1.1. Dredging activity in Port of Genoa

In the Port of Genoa are used both mechanical and hydraulic dredging system.
In the Port of Genoa dredging is done in three different areas:

bottoms near the piers - by mechanical dredging;
bottoms between the wharves and the moles by mechanical dredging;
bottoms near the harbour inlets - by hydraulic dredging.

The grabbing crane pontoon and the tank barge are used for case 1.
The bucket Dredger is used for case 2.
The trailer Dredger is used for large volumes of sediment.

The total amount of sediment dredge in the last 10 years was 350.000 m^3.
The interested areas was:

- Site 1: Colmata di Voltri (land disposal area);
- Site 2: Porto Petroli (oil harbour) inlet. Total volume of sediments dredged 110.000 m^3.
- Site 3: Foce Torrente Chiaravagna (mouth of Chiaravagna River). Total volume of sediments dredged: 60.000 m^3.
- Site 4: Vasca Polcevera (Polcevera basin). Total volume of sediments dredged: 180.000 m^3.

1.2. The Laws

The International Conventions, which interest dredging and sea dumping, are:

- the 1954 London Convention about the discharge of hydrocarbons in coastal waters (OLIPOL 1954);
- the 1972 London Convention on the marine pollution prevention by wastes and other materials;
- the 1973 London convention on the marine pollution prevention by oil (MARPOL); the 1974 Oslo Convention about marine
- pollution prevention;
- the 1976 Barcelona Convention on protection of Mediterranean Sea and the enclosed Athens protocol on marine pollution prevention by dumping of waste and other substances (1982);
- the 1982 Montego Bay Convention on Marine Low, Part XII, articles 192-137 "Protection and preservation on marine environment";
- the Protocol on Mediterranean particularly protected areas (articles 3 and 7).

The Italian Laws, which interest dredging and sea dumping, are:

- Legge n. 319/1976 (*sulla tutela delle acque dall'inquinamento*): Law for water protection from pollution;
- Legge n. 979/1982 (*disposizioni per la difesa del mare*); regulations for sea protection;
- D. M. 24 Gennaio 1996 (*direttive inerenti le attività istruttorie per il rilascio delle autorizzazioni di cui all'art 11 della legge 10 maggio 1976, n. 319, e successive modifiche ed integrazioni, relative allo scarico nelle acque del mare o in ambienti ad esso contigui, di materiali provenienti da escavo di fondali di ambienti marini o salmastri o di terreni litoranei emersi, nonché ad ogni altra movimentazione di sedimenti in ambiente marino*), concerning the permission of dumping dredging materials.

In this Law of Environment Ministry is forbidden the sea dumping of sediments containing:

1. halogenated organic compounds, mercury an his compounds, cadmium and his compounds, arsenic and his compounds, antimony and his compounds, beryllium and his compounds, chrome and his compounds, nickel and his compounds, lead and his compounds, copper and his compounds, selenium and his compounds, vanadium and his compounds, zinc and his compounds, cyanides, fluorides, crude oil and hydrocarbons, pesticides and derived organic compounds, stannic organic compounds, radioactive wastes.
2. potentially harmful micro-organisms.

Protected marine areas in Liguria Region (regional law n. 12/1995) were is forbidden dumping :

◊ Parco naturale delle Cinque Terre (Cinque Terre natural park);
◊ Parco naturale regionale di Portofino (Portofino regional Park);
◊ Riserva naturale regionale dell'Isola di Gallinara (Gallinara Island regional Reserve);
◊ Riserva naturale regionale di Bargeggi (Bargeggi regional Reserve).

2. POLLUTION SOURCES

The pollution can come from a nutrients superabundance which, on its turn, can give rise to enrichment of the ecosystem, or from a harmful, toxic (or potentially carcinogenic, mutagen, teratogen) compound.
The biological pollution can come also from pathogenic organism (e.g. virus, bacteria, parasitic Helminths).
The finest part of sediments (clay) is the more contaminated; in effect the clay particles scavenges and is very efficient to adsorb/absorb chemicals. When environmental conditions (pH, Eh, salinity) change the sediment can release the pollutants.

In the Port of Genoa all the sediments dredged are landfilled in the Voltri Fill Area.
This solution have not environmental impacts, the dredged sediments are not in contact with port waters.

- Site 2: Porto Petroli (oil harbour) inlet. Total volume of sediments dredged 110.000 m^3.

- Site 3: Foce Torrente Chiaravagna (mouth of Chiaravagna River). Total volume of sediments dredged: 60.000 m^3.

- Site 4: Vasca Polcevera (Polcevera basin). Total volume of sediments dredged: 180.000 m^3.

3. CONSEQUENCES

3.1. Impacts on environment

3.1.1. Effects on the sea environment

Dredging installations :

They induce some modifications of the Red-Ox (Oxidation-Reduction potential) conditions in the water-sediment interface when the sediments are stirred up. Heavy metals are released.

Dredged materials :

From a functional point of view pollutants can be divided in two major groups: those that affect the physical environment and those that are directly toxic to organism, including humanity.

The pollution can come from a nutrients superabundance which, on its turn, can give rise to enrichment of the ecosystem, or from a mix of toxic potentially carcinogenic, mutagenic (cause damage to genes) or teratogenic (cause abnormalities in developing embryos) compounds. The physical changing of the environment can be also considered.

Dredging can also seriously damage the shallow-water habitats. Clay and silt suspension decreases the penetration of light into the water, can cause a decrease in the primary productivity in the water column; this in turn reduces the amount of oxygen in the water and the supply of phytoplankton at primary trophic level. The burial and the massive injection of nutrients perturb the benthic communities: hence the original ecosystem is destabilised. Risks of chemical contamination on the deposit ground site are very low, because the sedimentology and geochemistry (then the pollutant concentrations) of the dredged material must be similar to the receiving area. The contamination of the water body is possible, but if the deposit site is enough far from the coast, it will not pollute the coastal water.

There are not relevant long-term effects. The possibility of long term effects are due to bio-transformation, bio-concentration and bio-magnification phenomena.
Some bacteria transform the pollutants like arsenic. They create toxic gas products accumulating in organisms.

The waves and the wind forced currents can put again in suspension the finest material. This phenomena is studied by the rheologic properties of the materials dredged.

3.1.2. Effects on the physical area of the port

Dredging installations :

Wind conditions have to be less than 8 m/s (16 knots), because afterwards the evolution and the manoeuvre of the loaded barge can became difficult.
Installation alters the natural flow in the port.

Dredged materials :

In fact, the current and the swell have two hydrodynamic impacts on the disposal activity :
Dispersion of the dredged material on the water body (turbide cloud).
Shifting material on the bottom after deposit.

3.1.3. Effects on the sedimentation

Dredging installations :

Installations alter the sedimentation in the port.

Dredged materials :

According to their physical characteristics, sediments have not the same comportment :

The rough elements (with a diameter of 1 mm) have sedimentation around 10 cm/s. So the sediment takes 3 to 4 minutes to reach the bottom of the deposit site, assuming 25 m water depth.

It takes ten times more for sediments of 100 μm having speed sedimentation of 1 cm/s, so the deposited material reaches the ground 30 to 40 minutes latter.

Flocculation can be used to help the sedimentation of fine particles.

Fine sediments are slow to packing down because of the water in it (Migniot, 1998).

The sediment seep shows us that most of the material reaches the ground in less than one hour. The only problem could be with the clay sediments of less than 2 μm. They will disperse in the water body for a long period. A temporary turbidity of the water body will disturb the benthic fauna as the photosynthesis processes.

3.2 Impacts in the environment and the users

3.2.1 The biologic impact

Dredging installations :

Benthic population is crushed and fishes avoid dredging area. Organisms living into the sediment are destroyed.

Dredged materials :

The integration of the pollutant is done at the sediment water interface. We talk about bio-mobilisation (integration of the pollutants in the living organism) giving bio-accumulation (accumulation of chemical substances directly by the aliments) and then bio-concentration (retention of the pollutants in the tissues).

The impact on the plankton is not important. The communities will develop resistance against the perturbation or “disturbance”. So there are no precautions or protection needed to be taken. The heavy metals alliterated the biological functions at the macroscopic, biochemical levels and on the natural cycle. The organic pollutants are mutagen, carcinogen and genotoxic agents for living material.

The impact for the benthic population will depend on the materials dumped. The benthic population is notably disturbed. Then slowly there will be a restoration of the community, but it will never be has it was before. The existing organisms are robust, and well adapted to a changing area, with the difficult condition of life. The quality of the material can cause damage, in particular if it is rich in organic elements (more than 10 %).

Most of the species will disappear and a new community of worms would take place like *Capitella capitata*. The worms are opportunist species that have the maximum density near the pollution sources. But those conditions should not stay longer than three to four months if no more polluted material are deposited. Then other species would take their place.

It is better to dredge during winter time. The consequences will be less important in reproduction activity and algae are in reduced form (cyst, spore).

The quantity of dredged material laid on the deposit site can have an impact if it is over 2 - 5 mm. It would destroy the most fragile population, and incur modification on the keel of the ecosystem. Three to four months latter the community should recover and find again here keel after 1 or 2 years.

The impacts are different in the environment (table 1) according to the activity and the resources.

Table 1 : Different types of impact in the environment.

	Activity	Dredging	Transport	Marine disposal	Land disposal
Resources					
1. Ecosystem					
1.1 Biotic components		R1*l*	L1*l*	R1*l*	L1*i*
1.2 Abiotic components		R1*l*	Z0*n*	R1*l*	L1*i*
1.3 Scenic values		Z0*n*	Z0*n*	Z0*n*	M1*i*
2. Space					
2.1 Settlement		L1*l*	L1*l*	Z0*n*	Z0*n*
2.2 Movement		L1*l*	L1*l*	Z0*n*	Z0*n*
2.3 Communication		L1*l*	L1*l*	Z0*n*	Z0*n*
3. Culture					
3.1 Archaeological remains		*	*	*	*
3.2 Man made structures		L1*l*	Z0*n*	Z0*n*	*
3.3 marine knowledge		Z0*n*	Z0*n*	Z0*n*	Z0*n*

* : possible impact

Codes to read table 1 :

Impact strength	Zero = Z	Low = L	Medium =M	Relevant = R
Impact dimension	Null = 0	Little ~ 1km ^{2} = 1	Local ~ 10 km ^{2} = 2	Regional ~ 100 km ^{2} = 3
Impact duration	Null = *n*	Low = *l*	Medium = *m*	Irreversible = *i*

3.2.2 Impact in the human area

Dredging installations :

The navigation and the fishing near the dredging activity should be defended during all the operation (48 hours). It is to facilitate the barges movements.

The dredging activity will modify the area of fish's frequentation.

Dredged materials :

The dredging activities increase the turbidity near the dredged and the deposit area. The turbidity can have negative impact in the aquaculture facilities.

Some pollutant like mercury can concentrate in fishes, them when humans eat those fishes they will have nerves problem.

3.2.3 Impact in the users

Dredging installations:

Disturbance of navigation and sailing activities.

Disturbance of occupational fishing.

Disturbance on tourism activities because of noise, view and smell.

Suspension of bathing activity and water sports.

Dredged materials :

Turbidity induce avoidance of dredging area by fishes.

Disturbance of waters quality in turbide cloud area.

Disturbance on tourism activities because of noise, view and smell.

Leisure fishing is forbidden in turbide cloud area.

4. ACTION TAKEN AND MONITORING

The solution of fill is the best solution available in the Port of Genoa.

- Increasing of pollution and turbidity in dredged area.
- Not effect in the area of Voltri fill.

	Porto Petroli Channel	
	Sample 1	Sample 2
Sediment size (%)		
Gravel (phi > 2mm)		
Sand (2mm> phi >0,036 mm)	Dominant	dominant
Silt (0,036 mm> phi >0,004 mm)		
Clay (<0,004 mm)		
Biological pollution (MPN/g)		
Total coliform bacteria	< 20	< 20
Fecal coliform bacteria	< 20	< 20
Fecal Streptococci	< 20	< 20
Organic compounds (mg/kg)		
Oils and fats	612.00	680.00
Hydrocarbons	2332.70	370.00
P.C.B.s	0.00	0.00
Pesticides and polyclorurated compounds	0.00	0.00
Polycyclic aromatic compounds	0.00	0.00
Phenols	0.36	0.51
Nutrients (mg/kg)		
Total nitrogen	273.00	370.00
Phospates	1560.90	1454.50
Metals (mg/kg)		
Aluminium	17987.00	15000.00
Iron	Not analysed	
Manganese	Not analysed	
Heavy metals (mg/kg)		
Total arsenic	3.90	0.85
Total cadmium	0.00	0.00
Total chromium	1165.00	980.00
Chromium VI	0.00	0.00
Total mercury	8.50	0.84
Total zinc	971.00	294.00
Total lead	340.00	206.00
Total copper	874.00	69.00
Total nickel	573.00	588.00
Other pollutants (mg/kg)		
total cyanides	-	

	Chiaravagna River				
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5
Sediment size (%)					
Gravel (phi > 2mm)	76.00	55.00	88.85	69.95	45.25
Sand (2mm> phi >0,036 mm)	22.60	45.00	10.50	29.60	51.15
Silt (0,036 mm> phi >0,004 mm)	0.50	0.00	0.50	0.40	0.10
Clay (<0,004 mm)	0.00	0.00	88.60	0.00	0.00
Biological pollution (MPN/g)					
Total coliform bacteria	not analysed		70000.00	330.00	1300.00
Fecal coliform bacteria	not analysed		260.00	260.00	790.00
Fecal Streptococci	not analysed		270.00	490.00	80.00
Organic compounds (mg/kg)					
Oils and fats	376.10	447.20	452.05	400.95	318.95
Hydrocarbons	290.30	251.50	179.60	279.80	234.85
PCBs	0.00	0.00	0.00	0.00	0.00
Polychlorinated biphenils and halocarbons	0.00	0.00	0.00	0.00	0.00
Polycyclic aromatic compounds	0.00	0.00	0.00	0.00	0.00
Phenols	1.03	2.20	1.56	2.32	1.28
Nutrients (mg/kg)					
Total nitrogen	135.10	140.00	129.90	158.55	160.15
Phospates	479.50	354.00	438.80	396.20	593.25
Metals (mg/kg)					
Aluminium	23862.00	28100.00	23901.00	22540.50	22807.50
Iron	not analysed		not analysed	not analysed	
Manganese	not analysed		not analysed	not analysed	
Heavy metals (mg/kg)					
Arsenic	52.20	40.00	77.20	73.75	90.80
Cadmium	0.00	0.00	0.00	0.00	0.00
Total chromium	1269.00	1015.00	1015.00	896.00	1073.00
Chromium VI	0.00	0.00	0.00	0.00	0.00
Mercury	0.00	0.40	0.12	0.00	0.00
Zinc	92.00	78.50	141.00	105.00	107.00
Lead	202.00	162.00	194.50	114.50	238.00
Copper	19.50	30.00	68.00	38.50	53.50
Nikel	689.00	725.00	296.00	704.00	704.00
Other pollutants (mg/kg)					
total cyanides	0.00	251.50	0.00	0.00	0.00

	Polcevera Basin	
	Average	Stand. Dev.
Sediment size (%)		
Gravel (phi > 2mm)	58.70	42.70
Sand (2mm> phi >0,036 mm)	39.80	56.00
Silt (0,036 mm> phi >0,004 mm)	1.05	1.10
Clay (<0,004 mm)	0.45	0.20
Biological pollution (MPN/g)		
Total coliform bacteria	700000.00	1200000.00
Fecal coliform bacteria	330.00	221.00
Fecal Streptococci	1720.00	1720.00
Organic compounds (mg/kg)		
Oils and fats	96.00	130.00
Hydrocarbons	traces	68.00
Polychlorinated biphenils and halocarbons	0.00	0.00
Polycyclic aromatic compounds	0.00	traces
Phenols	0.00	0.00
Nutrients (mg/kg)		
Total nitrogen	76.00	88.00
Phospates	7.90	5.00
Metals (mg/kg)		
Aluminium	1025.00	1443.00
Iron	not analysed	
Manganese	not analysed	
Heavy metals (mg/kg)		
Total arsenic	0.05	0.23
Total cadmium	< 0.1	< 0.1
Total chromium	74.00	102.00
Chromium VI	0.00	0.00
Total mercury	0.00	0.00
Total zinc	not analysed	
Total lead	19.00	21.00
Total copper	not analysed	
Total nikel	100.00	127.00
Other pollutants (mg/kg)		
total cyanides	0.00	0.00

	Voltri Harbour fill					
	Point 1	Point 2	Point 3	Point 4	Point 5	Point 6
Sediment size (%)						
Gravel (phi > 2mm)	0.00	0.40	0.00	0.00	1.50	0.00
Sand (2mm> phi >0,036 mm)	54.00	80.60	17.00	73.00	90.00	84.50
Silt (0,036 mm> phi >0,004 mm)	35.60	6.80	63.50	19.50	1.00	4.50
Clay (<0,004 mm)	10.40	12.20	19.50	7.50	7.50	11.00
Biological pollution (MPN/g)						
Total coliform bacteria	-	-	-	-	-	-
Fecal coliform bacteria	-	-	-	-	-	-
Fecal Streptococci	-	-	-	-	-	-
Organic compounds (mg/kg)						
Oils and fats	1.00	0.40	< 1	0.20	0.20	785.00
Hydrocarbons	traces	traces	traces	traces	traces	traces
Pesticides organochlorited	-	-	-	-	-	-
Polychlorinated biphenils and halocarbons	-	-	-	-	-	-
Polycyclic aromatic compounds	-	-	-	-	-	-
Phenols	not analysed	not analysed	not analised	not analysed	not analysed	not analysed
Nutrients (mg/kg)						
Total nitrogen	2600.00	5934.00	1340.00	350.00	3000.00	2770.00
Phospates	5750.00	530.00	3440.00	5980.00	16250.00	4600.00
Metals (mg/kg)						
Aluminium	21700.00	14700.00	16200.00	9400.00	15600.00	14500.00
Iron	not analysed	not analysed	not analised	not analysed	not analysed	not analysed
Manganese	not analysed	not analysed	not analised	not analysed	not analysed	not analysed
Heavy metals (mg/kg)						
Total arsenic	2.80	2.40	3.50	1.80	2.80	2.80
Total cadmium	traces	0.10	0.20	0.10	traces	traces
Total chromium	545.00	368.00	420.00	440.00	299.00	234.00
Chromium VI	-	-	-	-	-	-
Total mercury	0.30	0.20	0.10	0.20	0.30	0.10
Total zinc	0.20	186.00	256.00	114.00	161.00	254.00
Total lead	0.10	65.00	104.00	50.00	76.00	132.00
Total copper	0.10	32.60	65.40	27.00	30.70	30.60
Total nickel	580.00	214.00	305.00	261.00	69.00	305.00
Other pollutants (mg/kg)						
total cyanides	-	-	-	-	-	-

Voltri Harbour fill - water sample before and after dumping of sediments dredged in Porto Petroli area	Sample 1 before the dumping of sediments	Sample 2 after the dumping of sediments	Sample 3 after the dumping of sediments	Sample 4 after the dumping of sediments
pH	7.60	7.50	7.50	7.50
Salinity at 105°C	43.00%	43.00%	43.00%	43.00%
Suspended solids	-	-	-	-
	mg/l	mg/l	mg/l	mg/l
Nitrites	0.02	0.02	0.02	0.02
Nitrates	17.40	18.30	15.00	15.04
Total nitrogen	17.43	18.40	15.04	15.04
Phosphates	-	-	-	-
Phenols	0.24	0.44	0.21	0.17
Arsenic	-	-	-	-
Mercury	-	-	-	-

4.1. Impacts on users

- The only effect is on navigation, the dredging activities can interest the transport corridors and areas and can low dawn activity as navigation or ships discharge.

MONITORING COSTS

- The costs of monitoring are around 70 ECU for sediment core and 30 for water sample.

5. PRINCIPALS AND GUIDELINES FOR IMPROVEMENT/ NEEDS FOR TECHNOLOGICAL INNOVATION

- Improvement of monitoring in the port area.
- Geographic informative system for port activity knowledge about navigable depths.
- Knowledge about all the sediments and her pollution in the port area.

6. ANALYSIS OF TRAINING NEEDS

- Preparation of the personal concerned the dredging operation.

7. PUBLIC COMMUNICATION

- All the operation must be communicated in radio and local TV.

The impact of Air Pollution on the City of Genoa

INDEX
OF THE IMPACT OF AIR POLLUTION ON THE CITY OF GENOA CASE STUDY

1. DESCRIPTION OF ACTIVITIES

Air pollution is the contamination of air by the discharge of harmful substances. Air pollution can cause health problems including burning eyes and nose, itchy irritated throat, and problems breathing; it is necessary to consider also the damage to the environment and property.

The major air pollutants generated by Genoa port activities are the following:

- Carbon monoxide (CO);
- Carbon Dioxide (CO_2);
- Nitrogen oxide (NO_x);
- Particulate matter;
- Sulfur Dioxide (SO_2);
- Volatile Organic Compounds (VOCs).

The potential effects of this substances on citizens health and environment are strictly related to the atmospheric conditions and to the operational ways chosen by the activity responsible. These two aspects have to be developed to manage properly the air pollution problem.

1.1. Legislation

1.1.1. European laws

- Directive n° 96/61/EEC dated 24/09/1996 concerns the integrated prevention and reduction of pollution.

- Directive n° 96/62/EEC dated 27/09/1996, concern the evaluation and the management of the air.

- Decision n° 94/904/EEC dated 22/12/1994, concern a list of dangerous wastes according to article 1, paragraph 4 of Directive 91/689/EEC concerning the dangerous wastes.

- Decision n° 94/3/CE dated 20/12/1993, concern a list of waste according to article 1 a) of Directive 75/442/EEC concerning the wastes.

- Decision n° 93/389/EEC dated 24/06/1993, concern a control mechanism of CO_2 and other gases emissions that can produce a greenhouse effect into the Community.

- Directive n° 93/12/EEC dated 23/03/1993, concern the sulfue tenor in any liquid fuels.

- Directive n° 92/57/EEC dated 24/06/1992, concern the minimum safety and healt prescriptions to be realized in temporary and mobil yards.

- Directive n.° 91/689/EEC dated 12/12/1991, concern the dangerous wastes.

- Directive n° 91/325/EEC dated 01/03/1991, concern the twelfth adaptation of directive 67/548/EEC concerning the dengerous substances classification, packaging and labelling.

- Directive n° 89/429/EEC dated 21/06/1989, concern the reduction of the atmospheric pollution deriving from existing urban waste incineration plants.

- Directive n° 89/369/EEC dated 08/06/1989, concern the prevention of the atmospheric pollution deriving from new urban waste incineration plants.

- Directive n° 88/609/EEC dated 24/11/1988, concern the limitation of the atmospheric emissions as regard some pollutants generated from big combustion plants.

- Regulation EEC n° 3528 dated 17/11/1986, concern the protection of the Community forest against the atmospheric pollution.

- Directive n° 85/203/EEC dated 07/03/1985, concern the atmospheric quality rules for nitrogen dioxide.

- Directive n° 84/360/EEC dated 28/06/1984, concern the actions against the atmospheric pollution generated from industrial plants.

- Directive n° 82/884/EEC dated 03/12/1982, concern the limit value for lead in the atmosphere.

- Decision n° 82/459/EEC dated 24/06/1982, concern a reciprocal change of imformations and data deriving from network and single pollution environment measurement stations.

- Decision n° 81/462/EEC dated 11/06/1981, concern the convention on the atmospheric pollution through the border at big distance.

- Directive n° 80/779/EEC dated 15/07/1980, concern the air quality limit values and guide values about sulfur dioxide and suspended dusts.

- Directive n° 89/656/EEC dated 30/11/1989, concern the minimum safety and health prescriptions about the use during the work of personal protection devices by the workers.

- Directive n° 88/379/EEC dated 07/06/1988, concern the classification, the packaging and the labelling of the dangerous preparation.

- Directive n° 82/605/EEC dated 28/07/1982, concern the workers protection against the risk joined to an exposure to metallic lead and to its ionic compounds during the work.

- Directive n° 77/728/EEC dated 07/11/1977, concern paint, varnishes, print inks, adhesives classifications, packaging and labelling.

- Directive n° 76/769/EEC dated 27/07/1976, concern the restrictions about the market immission and the use of dangerous substances and preparation.

- Directive n° 73/173/EEC dated 04/06/1973, concern the dangerous preparates (solvents) classification, packaging and labelling.

- Directive n° 67/548/EEC dated 27/06/1967, concern the dangerous substances classification, packaging and labelling.

1.1.2. Italian laws

- Ministerial decree dated 21/12/1995: “Disciplina dei metodi di controllo delle emissioni in atmosfera degli impianti industriali”.

- Prime Minister decree dated 02/10/1995: “Disciplina delle caratteristiche merceologiche dei combustibili aventi rilevanza ai fini dell'inquinamento atmosferico nonché delle caratteristiche tecnologiche degli impianti di combustione”.

- Ministerial decree dated 25/11/1994: “Aggiornamento delle norme tecniche in materia di limiti di concentrazione e di livelli di attenzione e di allarme per gli inquinamenti atmosferici nelle aree urbane e disposizioni per la misura di alcuni inquinanti di cui al decreto ministeriale 15 aprile 1994”.

- Ministerial decree dated 15/04/1994: “Norme tecniche in materia di livelli e di stati di attenzione e di allarme per gli inquinanti atmosferici nelle aree urbane, ai sensi degli articoli 3 e 4 del D.P.R. 24 maggio 1988, n. 203, e dell'art. 9 del D.M. 20 maggio 1991”.

- Ministerial decree dated 12/11/1992: ”Criteri generali per la prevenzione dell'inquinamento atmosferico nelle grandi zone urbane e disposizioni per il miglioramento della qualità dell'aria”.

- Ministerial decree dated 12/07/1990: “Linee guida per il contenimento delle emissioni degli impianti industriali e la fissazione dei valori minimi di emissione”.

- President of the Republic decree n° 203 dated 24/05/1988: “Attuazione delle direttive CEE numeri 80/779, 82/884, 84/360 e 85/203 concernenti norme in materia di qualità dell'aria, relativamente a specifici agenti inquinanti, e di inquinamento prodotto dagli impianti industriali, ai sensi dell'art. 15 della legge 16 aprile 1987, n. 183”.

- President of the Republic decree n° 322 dated 15/04/1971: “Regolamento per l'esecuzione della L. 13 luglio 1966, n. 615, recante provvedimenti contro l'inquinamento atmosferico, limitatamente al settore dell'industria”.

Regional laws

- Regional law n° 3 del 20/01/1997: “Integrazione alla Legge Regionale 7 Luglio 1994 n. 35 "Nuove norme in materia di inquinamento atmosferico e rete di rilevamento della qualità dell'aria"”.

- Regional law n° 35 del 07/07/1994: “Nuove norme in materia di inquinamento atmosferico e rete di rilevamento della qualità dell'aria”.

- Regional law n° 20 del 24/03/1989:”Norme a tutela dell'ambiente dagli inquinamenti”.

- Regional law n° 20 del 24/03/1980: “Norme a tutela dell'ambiente dagli inquinamenti”.

2. POLLUTION SOURCES (RELATED SUBSTANCES AND BY-PRODUCTS)

2.1. Potential pollutant activities

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

This area, in consequence of the high industrial concentration, can represent a source of air pollution.

The work in order to prepare ships for painting consists in two phases. In the first phase, vapor is sprayed on the area to be painted in order to remove the foul. The second phase consists in spraying on the same area a suspension at high pressure of sand in water, which removes the old paint. The next step consists in the repairs and repainting. During the sand - blasting and the painting there are the dispersion of pollutant substances in the atmosphere such as solvents, metals and dust.

b) ENEL (electric power station)

The main environmental problem is related to the coal transport and to the emissions of sulfur oxides and dusts.

COMMERCIAL ACTIVITIES

c) Terminal Rinfuse

The main environmental problem is related to the operation of loading, unloading and transport of the materials handled in the area.

2.2. Potential air quality pollutants

2.2.1. Particulate matter

Particulate matter is solids in the air in the form of smoke, dust and vapors which can remain suspended for extended periods. Aside from reducing visibility and soiling clothing, microscopic particles from air can be breathed in where they lodge in lung tissue causing increased respiratory disease, and lung damage. Particualtes are also the main source of haze which reduces visibility.

2.2.2. Sulfur Dioxide

Sulfur dioxide is an odorless gas at low concentrations, but can have a very strong smell at high concentrations. SO_2 is a gas produced by burning coal, most notably in power plants.

Like nitrogen oxide (NO_x), SO_2 is a major contributor to smog and acid rain. $SO_2$is closely related to sulfuric acid, a strong acid. It can harm vegetation and metals, and cause lung problems, including brething problems and permanent damage to lungs.

2.2.3. Volatile Organic Compounds (VOCs)

Volatile Organic Compounds are organic chemicals. All organic compounds contain carbon and organic chemicals are the basic chemicals found in all living things, and all products derived from living things. Many organic compounds we use do not occour in nature, but were sinthesized by chemist in laboratories. Volatile chemicals produce vapors easily. At room temperature vapors readily escape from volatile liquid chemicals.VOCs include gasoline, industrial chemicals such as benzene, solvents such toluene and xilene, and perchloroethylene (principal dry cleaning solvent). VOCs are released from solvents, paints, glues and other similar products. Vehicle emissions are an important source of VOCs. Many volatile organic chemicals are hazardous air pollutants.

3. CONSEQUENCES

The effects on the external atmosphere deriving from the use of the varnishing products are identified with the potential toxic effects involving the workers who carry out the paint job operations and the surrounding population. Such effects can come out from the action of the following kinds of substances:

- **solvents**, contained in elevated percentages inside the varnishes (up to the 70-75%). The kinds of found solvents in varnishes are:

Table 1: Type of solvents in paints

Alcohols	butyl, isobutyl, isopropyl, diacetone alcohol
Ketons	acetone, methyl ethyl keton, methyl isobuthyl keton, cyclohexanone
Esters	ethyl, isobuthyl, buthyl, isopropyl acetate
Aliphatic hydrocarbons	hexane, heptane, turpentine
Aromatic hydrocarbons	toluene, xilene, solvent naphtha
Chloro compounds	dichloropropane, trichloroethane, perchloroethylene, trichloroethylene
Glycol	butylcellosolve, carbithol, butilcarbithol, propylenic glycol methylic ether

The solvents, in general, if inhaled in great concentrations are all narcotics, and many are considered neurotoxic also to low concentrations. The solvents, being liposoluble substances, can interact with the structures of the central and peripheral system, provoking irreversible lesions also with deficit of the psychical abilities. In particular way, great part of solvents frequently provokes characterial alterations associated to the loss of memory and modification of the personality. Moreover, the exposure in the long term involves annoying effects to the breathing ways, the skin and the ocular mucosae; are not rare also breathing ways and cutaneous allergies. It would seem also that the extended exposure to organic solvents produces cancerogenous and degenerate effects.

- **metals** (inside the pigments). According to the pigment added to the varnish the typology of organic or inorganic compounds may vary, that could interact with the living organisms:

Table 2: Type of pigments in paints

Whites	titanium dioxide, lithopone, zinc oxide
Yellows	lead chromate, cadmium yellows, natural and synthetical iron oxids, arilamidi, poliazoici, pirantroni, diarylanilide
greens	trivalent chromate greens, phtalocianine greens
oranges	lead chrome molybdates, cadmium oranges, diarylanilide, poliazoici, arilamidi, naphtols
reds	natural and synthetical iron oxids, molybdenum reds, cadmium reds, naphthols, toluidins, chinacridone, lithols
metallic	aluminiums, bronzes
anticorrosives	zinc chromates and tetraoxidechromates, strontium chromate, lead minium, lead silicochromates, zinc phosphates

All the metals listed in the table can potentially produce a great variety of toxic effects. In some cases it is possible that this is due to the inhibition of a single enzyme or a single biochemical process, while in other cases the metals cause acute local irritation of the breathing ways or, like in the case of some compounds of the aluminium, can provoke, after extended exposures, serious alterations of the bronchopolmonar tissue.

- **dusts**, deriving above all from the operations of preparation of the surfaces before the treatment of paint job. They can be characterised taking into account their dimension; the most dangerous for man turn out to be those having dimensions less than 15 μm that can be easy inhaled interesting several parts of the breathing system until arriving to lungs (dimensions less than 1 μm). The extended particle inhalation can provoke in the breathing apparatus chronic fibrous reactions and necrosis of the tissues that take the name of pneumoconiosis. The dusts have some

effects also to the external atmosphere reducing the visibility and the brightness of the atmosphere and provoking corrosions and erosions to materials and metals.

Moreover to these polluting agents, we must consider also the noise that is cause for multiple disturbs for the man and, under shape of vibrations, also for the external atmosphere.

In particular, the disturbing effects for the man are in charge:

- of the organism;
- of the sleep;
- of the psycho-physical performances;
- of the oral communications,

that turn out altered regarding the condition of noisiness absence. In particular, the acoustic impact can in this way be related to the level of noisiness:

Table 3: Acoustic impact related to the noise level

NOISE LEVEL [DB(A)]	ACOUSTIC IMPACT
< 55	very low
between 55 and 60	low; may disturb very sensible persons (old persons)
between 60 and 65	may have effects on sleep and may disturb a wider part of population
>65	heavy constriction situation

4. ACTIONS TAKEN

In order to limit the air pollution derived from the port activities, Genoa Port Authority (APG) and other Public Authorities (Province of Genoa - PG) have forced the involved activities to analyse the problem and to find solutions to restrain the damage to the environment. The solutions proposed and applied by the activities decribed in this case study are explained below.

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

The APG issued in 1980 an ordinance and the relatives rules about the sand - blasting operation, specifying:

- the operational and administrative modalities to carrying out the activities;
- the characteristics of the materials (metal grit) that had to be used;
- the personal protection devices that must be used during the operation.

Particularly, the enactment identify the different zones where the ship can be sand - blasted, the information that the enterprise have to communicate to the APG before start the operation, the time in which the enterprise can work and the executives modes to conduct the activity and to avoid the diffusion of the product of the sand - blasting (cleaning).
It's important to underline that the choice of the metal grit instead of sand has allowed a considerable reduction of the diffusion of the dust in the environment and in the workplace.
Actually the enterprises that manage the paint and sand - blasting operations have adopted also the following technicals solutions to furher reduce the environmental impact of their work:

Painting

- Progressive replacement of the paint normally used with the high solid paint, with a more less quantity of halogenated solvent in its composition;
- In indoor painting, to reduce the diffusion of the dust, the operators use some dust collectors that collect a flux of air variable between 10000 and 30000 m^3 / h.

Sand - blasting

- Usage of metal grit with high or medium - high granulometry, that reduce the risk of diffusion of dust, typical of the smallest granulometries.

Table 4: Granulometry of materials used in sand - blasting operation

GRANULOMETRY	FRACTION
> 0.5 mm	41 %
125 - 500 µm	57%
63 - 125 µm	1.8%
< 63 µm	0.2%
< 10 µm	< 10 ppm

b) ENEL (electric power station)

The coal coming from Terminal Rinfuse by means of conveyors identified as N10 and N11 is loaded, unloaded and transported by ENEL with a system of belt conveyors to the power station. All the conveyors and the others devices involved in the handling of the coal are totally covered with specific coverage to limit the dust dispersion in environment.

Moreover, in order to reduce the quantity of handled coal, Region of Liguria, PG, Genoa Municipality, APG and ENEL stipulated in the 1996 an agreement for the power station recoversion. The agreement foresees the realisation of a new solid wastes incinerator, in order to integrate the electric power production.

COMMERCIAL ACTIVITIES

c) Terminal Rinfuse

In 1995 Region of Liguria, PG, and APG induced the Terminal Rinfuse management to search a solution to environmental problems resulting from their activities. This requirement was suggested principally from two conditions:

- for some years before Genoa Municipality and Province of Genoa have received a big number of complaints from the citizens that live in the area surrounding the Terminal Rinfuse regarding the dusts generated from the terminal activities involving coal and cina clay.
- the monitoring activities managed by PG in 1995 have underlined an enviromental problem of overcoming of the Italian laws limits in matter of air quality and dispersed dusts.

As a consequence of this inducement, Terminal Rinfuse have programmed and realised some intervention to improve various aspect of the coal (Ponte S.Giorgio and Idroscalo docks) and the cina clay (Ponte Rubattino dock) handling.

Coal - Actual solutions

- The most relevant investment have involved the trasportation plant, that have been modified covering all the conveyor belts with hermetic systems to reduce the dispersion of dust in air.
- To pursue the same objective also in the storage area, the terminal have bought some sweeping machines that continuosly keep clean the area, abating the risk of dragging of coal by the truck weels and the dispersion of dust in windy days (investment cost: 300000 Euro)
- Other contributions to the solution to the dust dispersion problem was the choice of a bigger granulometry for coal (mean value: 50 - 60 mm; lowest value: 1 - 5 mm, but only for 10% of the total quantity) and the regulation of the unloading operation with the prescription that oblige the operators to position the hopper at a maximum height of 60 cm from the truks loading platfom.
- One of the sweeping machine are employed to sprinkle some coal bulks with a particular product that lag the coal with a film that stop the dust diffusion. The same treatment is carried out with other specific devices on the coal bulks located in the North zone of the terminal.
- The weighing - machine have been ripositioned within the terminal area. This solution have eliminated the dispersion of dust joined to the motion of the trucks between the storage area and the weighing area.

Coal - Future solutions

- Installation of a plant to wash trucks weels before they leaving the terminal area;
- installation of buckets with ermetic valves;
- extension of the film coverage also to the other storage areas.

Cina clay - Actual solutions

The society have already started the building of some basins to stock the undegradable materials such as sand, bauxite and pyrite. Upon the basins is forecast the building of mobile cover that have to be open only during the loading and unloading operations.
To stock the degradable materials (china clay, fertilizers), the society have decided to put it within some existing covered storehouse to improve the actual storage method that foresee the reservation of the material in covered wagon or trucks. This choice will permit to stock outside only the iron and the pig iron, reducing sensitively the dust diffusion.

The total investment costs of this interventions are 11000000 Euro. The direct investment costs for the costruction plant are: 100000 Euro/year (salary of the personnel employed on showering streets and in / out means) and 300000 Euro (for the purchase of the brushing – machines).

5. MONITORING

5.1. Monitoring networks

According to Italian law, the air monitoring is entrusted to every Region that have to manage the monitoring operations as regard to the productive activities and the quality of air. Often, neverthless, like as happened in Liguria, the Department delegate to the Province the management of the air monitoring.
The Province of Genoa, since 1988, have builded a monitoring network with 17 stations that automatically measure the following atmospheric parameters:

Table 5: Monitoring network of Province of Genoa

PARAMETERS	
Sulpure dioxide (SO_2)	Ozone (O_3)
Dusts	Nitrogen dioxide (NO_2)
Lead	Non methanic hydrocarbons
Carbon monoxide (CO)	Hydrogen sulfide (H_2S)

and send the data via modem to the operative center, where the data are statistically processed; the significative results of the elaboration have to be compared to law limits, that can be maximum limits or, according to an improvement of the quality air management, guide limits.

Others measurement campaign is directly carried out from APG that take the value of some of the air control parameters to check the right conduction of the port activities and the respect of the air quality law limits.

Finally, some port activity (such as ENEL) monitors directly their emissions and send the measure results to the Operative Centre of the PG.

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

In this area there aren't any specific monitoring system and the control of the quality of air is guaranteed by the Presidio Multizonale di Prevenzione (PMP) station of Piazza Barabino (identification code 304) and the ENEL station n.° 4 (identification code 505). Particularly, the two stations measure only the interesting parameters, such as dust and SO_2.

b) ENEL (electric power station)

ENEL monitors directly its emission in atmosphere through an internal network of six stations that measures the concentration of dust and SO_2.

COMMERCIAL ACTIVITIES

c) Terminal Rinfuse

As specified in chapter 4 ("action taken") PG required to the management of terminal the definition of a plan of intervention to solve some environmental problems linked to their activities. To satisfy one of these requirements the terminal administration should had to locate three measure point in which install six deposit gage (two for every point) to determine the concentration of sedimentable dusts. Actually, the three points aren't locate yet, but it will choosen within a short time.

5.2. Monitoring costs

In the following table are specified the cost involved to install and manage a monitoring station that measure dust, aromatic organic substances (BTX), noise and meteo parameters.

Table 6: Cost of installation and management of a monitoring station

DEVICE	COST (EURO)
1 cabin equipped for air monitoring	20658
installation of telephonic and electric connections	12911
1 local acquirer	10329
1 statistical noise analysers	7747
1 BTX analyser	46481
1 hydrogen generator	5165
1 sample calibration air generator	2066
1 sequential dust sampler	6198
1 meteo monitoring station	25823
1 sampling and chromatographic analysis of VOS	155
1 sampling of suspended dust	52
1 noise analysis	155
management of monitoring station	5165

6. INDICATORS AND CRITERIA: ASSESSMENT/EVALUATION OF MONITORING RESULTS

The interventions realised by port activities have had some positive consequences on relation between the control organisations (PG, APG, Municipality) and the citizen from one side and the activities from the other side. These consequences can be easily undelined comparing it to the law prescription or to other indicators such as the satisfaction of citizens or the reduction of complaints.
The guide limits interesting this activity as regard tha quality of air are defined by the following regulations:

- national President of Republic decree n.° 203 / 88
- ministerial decree dated 12 / 7 / 90
- ministerial decree dated 15/4/94
- ministerial decree dated 25/11/94

Table 7: D.P.R. 203/88 - Air quality guide values

POLLUTANT	LIMIT
SO_2	100 - 150 µg/m^3 (on 24 h)
Suspended dusts	100 - 150 µg/m^3 (on 24 h)

Table 8: D.M. 12/7/90 - Conveyed emission from industrial plants limit values

POLLUTANT	LIMIT
SO_2 (class V)	if weight flux ≥ 5 g/h ⇨ limit = 500 mg/m^3
Inorganic substances as dusts Dispersed dusts	*Cd (class I)* weight flux≥ 1 g/h ⇨ limit = 0.2 mg/m^3 *Sb, Cr, Pb, SiO_2(class III)* weight flux ≥ 25 g/h ⇨ limit = 5 mg/m^3 50 mg/kg for class I
Organic substances as gas, vapors or dusts (as example solvents) Dispersed dusts	class I weight flux≥ 25g/h ⇨ limit = 5 mg/m^3 class II weight flux ≥ 0.1 Kg/h ⇨ limit =20 mg/m^3 class III weight flux ≥ 2 Kg/h ⇨ limit = 150 mg/m^3 class IV weight flux ≥ 3 Kg/h ⇨ limit = 300 mg/m^3 class V weight flux ≥ 4 Kg/h ⇨ limit = 600 mg/m^3 class I weight flux ≥ 0.5 Kg/h ⇨ limit =50 mg/m^3 class II weight flux ≤ 0.1 Kg/h < 0.5 kg/h ⇨ limit = 150 mg/m^3

Table 9: D.M. 15 / 04 / 1994 - Air quality alarm and attention values

POLLUTANT	ALARM	ATTENTION
SO_2	125 µg/m^3 (on 24 h)	250 µg/m^3 (on 24 h)
Suspended dusts	150 µg/m^3 (on 24 h)	300 µg/m^3 (on 24 h)

COMMERCIAL ACTIVITIES

a) Terminal Rinfuse

As a consequence of action taken, the neighbours have send no more complaints to PG, APG and Municipality. The effectiveness of the solutions choiced are confirmed also by the monitoring measures relatives to Piazza Barabino and ENEL 4 stations, that underlines an improvement on the level of suspended and diffused dusts, as summarised in the following tables:

Table 10: ENEL 4 emission data

MEAN VALUE	LIMIT VALUE	MEASURE TIME
45		1990 – 1991
35		1991 – 1992
45		1992 – 1993
52	150	1993 – 1994
69		1994 – 1995
46		**1995 – 1996**
47		**1996 – 1997**
48		**1997 – 1998**

Table 11: Piazza Barabino - Suspended dusts

MEAN VALUE	LIMIT VALUE	MEASURE TIME
54		**apr 96 - ago 96**
49		**mag 97 – dic 97**

Table 12: Piazza Barabino - Sedimentable dusts

MEAN VALUE	LIMIT VALUE	MEASURE TIME
11.74		**1996**
8.9		**1997**

All the values are expressed in g /100 m^2/die.

The underlined values point out clearly that after the 1995, when the terminal have realised the intervention, the situation is sensitively improved.

7. PRINCIPLES AND GUIDELINES FOR IMPROVEMENT: LESSONS LEARNT FROM THE CASE STUDY

- Choice of dangerous substances towards that with minimal toxic contents, such as , for example, high solid powder or water varnishes, that allow to considerably reduce the risk of solvent emission;
- choice of the application technology that makes minimum the risk of emissions. As an example, if a pneumatic atomisation paint job equipment is used, is advisable to change it with those ones that use the hydraulic atomisation to medium or high pressure;
- regulation of the activities so that is prevented the manage of goods or spray paint in presence of determined anemologic situations;
- adoption of active coal filters on the conveyed emissions deriving from the forced aspirations enslaved to the activities of painting inside the ships;
- installation of stills to recover solvents used for the cleaning of the machines;
- agreements in order to give back to the supplying companies the varnishes and solvents empty containers.
- Public administration have to use their authority to induce and to help port activities to find solution to the environmental problems joined with their activities. With this way, it can achieve important results, such as an improvement of:

  the relation between the port activities, the public administration and the citizens
  the work conditions and of the related health of the workers
  the quality of air
  the control of the commercial risk
  the lost of goods, with economical benefits
  the cleaning costs, that can be better controlled
  the risk of contamination of goods during unloading operation (as example, china clay mixed with coal cannot be used in ceramic industry.

8. ANALISYS OF TRAINING NEEDS

During latest years, APG has adressed much efforts to increase the professional level of its operators and managers; the actual investment that APG devote to the training of their employees is about equal to 10000 Euro. Moreover, this effort must be improved in the future, to sustain the decision of APG to certify its port management system in accord with the ISO 14000 standard.

The training meeting have recently gone into the following arguments:

- Protection and management of the port ecosystem
- Methodologies of sea water cleaning and recovery
- Dredging operations: health and safety legislation requirements (Legislative decree 626/94 and 494/96)
- Waste management and disposal on the port
- Waste recovery
- Waste water treatment and recovery
- Hydrogeologic accidents
- Soil reclamation

9. PUBLIC COMMUNICATION

The result of the monitoring activity and the environmental data are diffused by APG and PG through various way such as local newspapers and the APG Internet site. This one, particularly, represent a communication medium very effectiveness to reach a very large part of the citizen and have to be developed to improve the quality of communication. Within a short time, the PG too will be able to diffuse the environmental informations in its Internet site, with the advantage the information can be updated in real time.

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Volume N° 2 - Case studies

The impact of Noise on the City of Genoa

INDEX
OF THE IMPACT OF NOISE ON THE CITY OF GENOA
CASE STUDY

1. DESCRIPTION OF ACTIVITIES

The acoustic impact of the port on the residential part of Genova is limited to some fraction of it thank to the city shape that present some important traffic infrastructures (road and railway) along the coast line, and to the insertion, ever along the coast line, of some important industrial (iron plant of Cornigliano and power plant ENEL near the Lanterna) and transport (Airport) infrastructures. Each of these infrastructure constitute, with different rate of impact and importance, a sound source that often produce a noise that act as a shielding for the noise produced by the port. It have to underline, moreover, that between the port area and the residential city there is a sort of “fracture”, composed by road and building (sheds or other buildings) and industrial installations and infrastructures that represents an obstacle to the noise propagation.
The critical sites, thus, are usually the residential areas simultaneously close to port zones with noisy activities (located near to “windows” in the shield structures) and to zones characterised by a limited acoustic impact from other source (first of all traffic). Of course, the port noisy is more perceptible when the impact of traffic is small (i.e. during the night).

Actually, the residential areas more exposed to the port noisy impact, on the base also of the analysis of the citizens complaints directed to the Public Authority, are located behind port areas or on neighbouring hills along the coast line, in raised position. As a consequence of this particular location, this houses have a direct view on the port infrastructures and a shielding effect of the below houses that act only along the coastline (Aurelia way).

The major acoustic impact on the city are related to three port infrastructures:

A Voltri Container Terminal (Voltri Terminal Europe - VTE);
B Multedo Oil Terminal;
C “Bacini Portuali” sites

For this sites, the citizens have directed to the Public Authority some written and telephonic communications to complaints about the noise disturbance.

1.1. Legislation

1.1.1. European laws

- EEC Directive n. 61/96 concerning integrated pollution prevention and control.
- EEC Directive n. 25/94 on the approximation of the laws, regulation and administrative provisions of the MS relating to recreational crafts.
- EEC Directive n. 533/84 on the approximation of the laws of the MS relating to the permissible sound power level of compressors.
- EEC Directive n. 534/84 on the approximation of the laws of the MS relating to the permissible sound power level of tower cranes.
- EEC Directive n. 535/84 on the approximation of the laws of the MS relating to the permissible sound power level of welding generators.
- EEC Directive n. 536/84 on the approximation of the laws of the MS relating to the permissible sound power level of power generators.
- EEC Directive n. 113/78 on the approximation of the laws of the MS relating to the determination of yard machinery and materials noise emissions.

1.1.2. Italian laws

- President of the Republic decree n.° 459 dated 18/11/1998: “Regolamento recante norme di esecuzione dell’articolo 11 della legge 26 ottobre 1995, n.° 447, in materia di inquinamento acustico derivante da traffico ferroviario”.

- Ministerial decree dated 16/03/1998: “Tecniche di rilevamento e di misurazione dell’inquinamento acustico”.

- Prime Minister decree dated 14/11/1997: “Determinazione dei valori limite delle sorgenti sonore”.

- Ministerial decree dated 11/12/1996: “Applicazione del criterio differenziale per gli impianti a ciclo produttivo continuo”.

- National law n.° 447 dated 26/10/1995: “Legge quadro sull’inquinamento acustico”.

- Prime Minister decree dated 01/03/1991: “Limiti massimi di esposizione al rumore negli ambienti abitativi e nell’ambiente esterno”.

- Legislative decree n° 277 dated 15/08/1991: “Attuazione delle direttive n. 80/1107/CEE, n. 82/605/CEE, n. 83/477/CEE, n. 86/188/CEE e n. 88/642/CEE, in materia di protezione dei lavoratori contro i rischi derivanti da esposizione ad agenti chimici, fisici e biologici durante il lavoro, a norma dell'art. 7 legge 30 luglio 1990, n. 212”.

1.1.3. Regional laws

- Regional law n° 12 dated 20/03/1998: “Disposizioni in materia di inquinamento acustico”.

- Regional law n° 20 dated 24/03/1989: “Norme a tutela dell'ambiente dagli inquinamenti”.

2. POLLUTION SOURCES (RELATED SUBSTANCES AND BY-PRODUCTS)

2.1. Potential pollutant activities

The acoustic impact that the port activities have on the city of Genoa is only partial because it are often shielded by the communication ways and the important industrial and transport infrastructures (Cornigliano steel plant, Enel power station, airport) located near the coastal line. More than this shielding factors, there are also a lot of other buildings and manufactures that prevent the noise diffusion.

The exposed areas, therefore, are only that are located near the noisy port zones that are not shielded by any obstacle, that results, often, already subjected to the traffic noise.

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

The work in order to prepare ships for painting consists in two phases. In the first phase, vapour is sprayed on the area to be painted in order to remove the foul. The second phase consists in spraying on the same area a suspension at high pressure of sand in water, which removes the old paint. The next step consists in the repairs and repainting. All this operations generate a high noisiness that cause disturb to the neighbours often living in areas surrounded by sheep repair dockyards. Particularly, there are two contribution to the noisiness: the noise of the machines and the noise characteristic of the activity.

As an example of the noisiness characteristic of this terminal, it can report the results of a monitoring campaign carried out by PG in September 1998 in an area of the city in front of the ship repairing zone. To analyse the results it have to keep in mind that in the course of the measure in the terminal the noise was generated only by repairing activities, without painting and sand-blasting activities.

Table 1: Noise generated only by repairing activities

Leq (dBA)	Lmax (dBA)	Lmin (dBA)
67	80	63

b) Oil Terminal Multedo

Oil Terminal Multedo is located near Multedo town, that is moreover interested from other noise generated by important transport infrastructure, like as the state way n.° 1, the freeway A 10, the railway Genoa - Ventimiglia, the airport C.Colombo.

The mainly noise source related with the terminal activities are the following:

- pumping stations located on the mainland, that works only when within the port area are moored some tankers involved in unloading operations;
- service motors, eventually linked with the charching pumps of the moored tankers.

The noisiness caused by the ships are appreciable from the neighbours at night and in living zone located on the hills, at 600 m from the docks.
Following some complaints of the citizens to the competent District of Genoa Municipality, PG have monitored the terminal area and the nearest areas of the city during the night with the following results:

Table 2: Noise level in the terminal area (night)

	Leq (dBA)
Near the houses	50 - 52
Near the docks	54 - 62

COMMERCIAL ACTIVITIES

c) Voltri Terminal Europa

Voltri Terminal Europa is located on a landfilling zone realised in front of Prà town, at some hundred meters from the nearest houses. Between the terminal and the city there are a channel, the railway Genoa - Ventimiglia and a part of the state way n.° 1 (Aurelia). The built - up area is developing up of the state way n.° 1, along the coast and the near hills.

In consequence of this particular land conformation, the people that live nearest of the way are subjected to the traffic noise and only the people who live in the hills are interested from the terminal noise.

Some studies have pointed out that the source of noise that cause most disturbance to the neighbours are the bitonal horns placed on the cranes and the gantries (portainers and transtainers) to signalise to the workers their motion. The direction of the acoustic signal emissions is the same of the translation (only one axe) and start when the crane or the gantry starts their motion.

There isn't any specific national law that fix the sound level of the horn, but, according with health and safety laws, it have to be clearly heard by the operators near the area involved by the motion.

Other noise sources can be identified with:

- the positioning of the containers on the ships, on the trucks or on other containers when there are a knock against the ship, truck or container surface. The nearest houses is partially interested from this noise because it is shielded from the other containers stacked within the terminal.
- the trucks motion.

This situation give cause for complaints from the citizens, particularly the part that living on the hills; consequently, the District VII "Ponente" of Genoa Municipality, direct involved by the complaints, proposed the constitution of a work group involving the same District VII, Genoa Municipality, Province of Genoa, APG, Local Health Unit 3, the terminal administration and the habitants representative.

Within the work group activity, PG have monitored in some houses the level of noise generated from the horns. The results of the measure can be summarised as the following:

Table 3: Noise generated from the horns

Leq (dBA)	Frequency (Hz)
61 - 63	1250

3. CONSEQUENCES

To fully understand the possible effects and the possibilities for a correct management of the noise problem, have to be analyzed the external and inner areas, separately, of the same harbour area, distinguishing therefore between work places, "the free" zones, in which can transit or carry out activities those people that approach or are employed in harbour services, and the inhabited zones, surrounding the harbour area. In this various within, in fact, different acoustic phenomena, in particular for the intensity of the levels and therefore characterised by various consequences on the exposed subjects, sually taken place.

Various types of effects of the noise on man can be characterized as follows:
- *Damages of specific type*: auditory damage;
- *Damages of not specific type*: action on the nervous, endocrine and cardiovascular system, action on the psyche, disturbance and alteration of the sleep;
- *Psycho - social effects*: subjective disturbance, effects on the social relations.

3.1. Effects in the environment

Exists no human activity that does not contemplate, in any measure, the transformation of mechanical energy in pressure waves that, through the air, catch up our ear, evoking in us some sonorous feeling.

Our place of life, work, fun and rest, is abundantly polluted by the noise that our same activity produces.
The environmental impact connected with the noisiness has to be at least considered as potential origin of disturbance to the quiet or the accomplishment of working activities that demand concentration: sensitive increments of the noisiness can involve one true damage on the psycho-physical equilibrium and even on the auditory apparatus therefore, in a generalized manner, on health.
As for the other fields involved in the environment definition, also in the field of the control of the noise the progress calls for ulterior progress in order to cancel the deleterious effects of the previous step, and at this rate we proceed to the gasping attempt to realize a "quality of life" that unavoidably escapes from our hands.

3.1.1. Damages of not specific type

In the greater part of the cases the levels of noise which the man is subordinate to, outside of the work places, are such not to determine a specific damage to the auditory apparatus. However, the levels endured in the course of the daily life can, in the long run, give origin to disturbs that can be distinguished, in a generalized manner, in effects in the short term and in the long term.
The effects in the short term (as an example temporary movements of the auditory threshold, alteration of the cardiac heartbeat and of the respiration, muscular contractions and effects on the peripheral circulation) are due to stimulations of short duration of generally unexpected character (from few minutes till to the maximum of few hours); it seems that the effects in the long term can directly involve also tissues and inner organs.
The harmful effects of extended exposures to the noise, in fact, influence not only the auditory apparatus, but they can also damage the cardiovascular and the neurovegetative systems causing hypertension, insomnia etc.

3.1.2. Psycho - social effects

To these closely physiological effects can be added also others disturbs of psycho - social type. Psycho - social disturbs are those effects caused indirectly through the psychological mechanism of stress, which can hit in a relevant way in relation also to the individual predisposition.
These, also without carry out a direct action on the organs, systems or tissue, determine however an action of disturbance that can be limited in the personal within or can reflect itself on interpersonal relations and on relationships between the man and the collectivity.
Another noise closely-related disturbance is the alteration of the sleep; this determines difficulties or slowness in falling asleep and quantitative and qualitative alterations in the cycle of the sleep.
A great number of studies demonstrated that, in order to guarantee a good sleep, in a generalized manner, the optimal value of noise in a room does not have to be higher than 30-35 dB(A).
The OECD supplies the following general indications on the expected effects according to different levels of noise:

- under a 55 dB(A) diurnal equivalent level of exposure (Leq), the possible disturbs are very light; between 55 and 60 dB(A) the acoustic impact is still limited but it can begin to cause disturbance for the more sensitive persons, in particular the old ones;
- between 60 and 65 dB(A) there can be effects on the sleep and, in particular, the degree of disturbance increases remarkably;
- above the 65 dB(A) the behaviour is determined by a constriction situation and this is symptomatic of a serious damage caused by the noise.

3.2. Impact in the work place

3.2.1. Damages of specific type

The damages of specific type are usually due to the exposure to the noise in the work place, in which the levels of noise are usually higher than those in the extraworking life places.
Generally, the damage to the hearing caused by the noise can be distinguished in "acute" damage and in "chronic" damage, the damage of acute type being related to stimulations of elevated intensity (more than 125 dB).
The damage of chronic type is caused by the continued and extended exposure to levels of noise for a period of many years; the evolution of the disease is usually slow, depending also on the predisposition of the single subject, and is generally characterized by an auditory loss at first limited to vhf (3 - 6 Khz) that later extends to the lower frequencies (including also those correspondents to the voice).
Norm ISO R 1999 (1971) supplies percentages of risk that a loss of hearing takes place, in function of the level of exposure to the noise and of the duration of the exposure (in years) in the work place; according to such norm the percentage of risk, that turns out low under the threshold of 80 dB(A) (the fixed one from the same norm), increases with the growing of the level of exposure and its duration.

4. ACTIONS TAKEN

In order to limit the noise derived from the port activities, Genoa Port Authority (APG) and other Public Authorities (Province of Genoa - PG) have forced the involved activities to analyse the problem and to find solutions to restrain the damage to the environment and to the citizens. The solutions proposed and applied by the activities described in this case study are explained below.

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

According with the article 6 of the national law n.° 447 dated 26/10/1995: “Legge quadro sull’inquinamento acustico”, the Municipality have almost finished the zoning of the town territory. Consequently, how better explained in chapter 6: “Indicators and criteria: assessment / evaluation of monitoring results”, for zoned lands the law foresee more restrictive limits than for non zoned lands. APG has proposed that this terminal became a industrial district, to apply the most restrictive limits compatible with the typology of the activities carried out in the area. In the future, if the monitoring will point out a overcoming of the law limits, the terminal management will must to prepare a acoustic healing plan that will specify the intervention to reduce the noise level. This intervention will be integrated by APG with other prescriptions (organisational or technical) or suggestions on technical solutions (i.e. sound adsorbent panels).

b) Oil Terminal Multedo

As a consequence of the citizen’s complaints, the Sea Heat Office induced the administration of the terminal to install a continuos analyser of noise level characteristic of the docks, provided of an alarm that enter upon office when the noise exceed a prefixed safety level related to a limit that have not to be exceed near the houses. The set - up of the measure system is controlled by the Multizoning Prevention Remedy.

The controls of the overcoming of the alarm level isn’t referred to a single value to avoid that the alarm enter upon office after a noise very intensive but also very short, not related with the analysed noise.

So, the analyser calculate a means of the instantaneous values on a sufficient long time and the alarm enter upon office only if the limit have been exceeded from a big number of consecutive measured values. Of course, the limit value is setting out in relation to the noisiness variation in specific areas.

COMMERCIAL ACTIVITIES

c) Voltri Terminal Europa (VTE)

As consequences of the citizens complaints, the VTE management has ordered a study on the acoustic emissions of the horns placed on the cranes and the gantries (portainers and transtainers) to signalise to the workers their motion.

This study, with a confrontation of the noise generated by the horns and the other sources (positioning of containers and trucks traffic) have pointed out that the level of noise characteristic of the horn can be decreased without decrease also the power of the signal necessary to guarantee an high level of heat and safety for the workers. Particularly, the operational conditions suggested by the study was the following:

Table 4: Operational conditions suggested for the translation speed

	Max. translation speed (m/sec)	Decrease of noise level (dBA)
Yard gantries	2.34	**-10**
Berths cranes	0.67	**-6**
Railway siding gantries	1.34	**-6**

This abatement of noise is corresponding to a reduction of at least four time of the noise level to which are subjected the neighbours.

5. MONITORING

5.1. Monitoring networks

According to Italian law, the noise monitoring is entrusted to every Province that have to manage the monitoring operations.
The Province of Genoa have built a monitoring network with 17 stations, of which 7 automatically measure also the level of noise and send the data via modem to the operative center, where the data are statistically processed; the significative results of the elaboration have to be compared to law limits.

Others measurement campaign is directly carried out by PG that measure the noise level to check the right conduction of the port activities and to point out the contribution to the total noisiness of other noise sources, such as the traffic.

Finally, some port activity (such as Multedo) monitors directly their noise level..

INDUSTRIAL ACTIVITIES

a) Terminal Bacini Portuali

In this area there isn't any specific monitoring system and the control of the noise level is carried out with instrumental monitoring campaigns.
When the Municipality will finish the zoning of the town lands, APG will define a monitoring plan according to this criteria:

- measure area: 100 x 100 m

number of measures	time of measure (min.)
30	15
3	60
1	1440

b) Oil Terminal Multedo

As pointed out in the previous chapter, Oil Terminal Multedo monitors directly its noise level through an internal analysers connected to a personal computer that pick up the data and elaborate it to compare with the alarm level.

COMMERCIAL ACTIVITIES

c) Voltri Terminal Europa (VTE)

Like as specified for Terminal Bacini Portuali, also in this area there isn't any specific monitoring system and the control of the noise level is carried out with instrumental monitoring campaigns.

5.2. Monitoring costs

In the following table are specified the cost involved to install and manage a monitoring station that measure some atmospheric parameters and noise.

Table 5: Cost of installation and management of a monitoring station

DEVICE	COST (EURO)
1 cabin equipped for air monitoring	20658
installation of telephonic and electric connections	12911
1 local acquirer	10329
1 statistical noise analysers	7747
1 BTX analyser	46481
1 hydrogen generator	5165
1 sample calibration air generator	2066
1 sequential dust sampler	6198
1 meteo monitoring station	25823
1 sampling and chromatographic analysis of VOS	155
1 sampling of suspended dust	52
1 noise analysis	155
management of monitoring station	5165

6. INDICATORS AND CRITERIA: ASSESSMENT/EVALUATION OF MONITORING RESULTS

The interventions realised by port activities have had some positive consequences on relation between the control organisations (PG, APG, Municipality) and the citizen from one side and the activities from the other side. These consequences can be easily underlined comparing it to the law prescription or to other indicators such as the satisfaction of citizens or the reduction of complaints.

The guide limits interesting this activity as regard the noise level are defined by the following regulations:

- national law n.° 447/95
- Prime minister decree dated 14/11/1997

Table 6: Prime minister decree dated 14/11/1997 - Definition of the areas

CLASS	DEFINITION
I	Particularly protected areas
II	Mostly residential areas
III	Mixed type areas
IV	Highly human activities areas
V	Mostly industrial areas
VI	Only industrial areas

Table 7: Prime minister decree dated 14/11/1997 - Emission limits

CLASS	LIMITS (DBA)	
	Day (06.00 - 22.00)	Night (22.00 - 6.00)
I	45	35
II	50	40
III	55	45
IV	60	50
V	65	55
VI	65	65

Table 8: Prime minister decree dated 14/11/1997 - Absolute immission limits

CLASS	LIMITS (DBA)	
	Day (06.00 - 22.00)	Night (22.00 - 6.00)
I	50	40
II	55	45
III	60	50
IV	65	55
V	70	70
VI	70	70

Table 9: Prime minister decree dated 14/11/1997 - Quality limits

CLASS	LIMITS (DBA)	
	Day (06.00 - 22.00)	Night (22.00 - 6.00)
I	47	37
II	52	42
III	57	47
IV	62	52
V	67	57
VI	70	70

7. PRINCIPLES AND GUIDELINES FOR IMPROVEMENT: LESSONS LEARNT FROM THE CASE STUDY

Aiming to pursue a continuous improvement of the modalities to resist the environmental effects produced by the harbour activities and by the technologies applied in such activities, it is necessary to make reference to some guidelines, contained in instruments such as the dispositions established by EC Directives, the national legislation, the ISO (or CEN for Europe) specific for the acoustic thematic technical norm, to which the directives UNI EN ISO 14000 and EMAS can be placed side by side, that allow to face in a total and rationalized way the environmental problematic.
In particular, deepening the aspect of the technological innovations for the control and the mitigation of the noisiness in the harbour within, some main actions are needed:

- Acquisition of new machinery characterized by a lower level of acoustic emissions:
  - machines constructed with phono-absorbing materials (metal layers alternate with medium density mineral wool layers).
- Development of more efficient (and economically convenient) arranges of discouragement of the noisiness:
  - realization of coverings with high acoustic absorption and strengthening of the acoustic isolation with phono-absorbing panelling;
  - realization of acoustic barriers protecting the inhabited sites;
  - insertion of external noises suppressor on the fans, evaporative towers, etc..., aimed to decrease the level of noisiness outside;
  - insertion of high acoustic seal locking.

- Processing of new models of organization of the various workingphases that concur, as an example, to limit the duration of the noisiest activities and/or to confine the same ones in the less sensitive hour bands:
  - limiting the use of heavy means for the internal movement of the materials in the diurnal hours;
  - trying not to carry out particularly noisy activities in the nocturnal hours, that are those dedicated to rest (22:00 - 06:00);
  - reorganizing the staff.

8. ANALYSIS OF TRAINING NEEDS

During latest years, APG has addressed much efforts to increase the professional level of its operators and managers; the actual investment that APG devote to the training of their employees is about equal to 10000 Euro. Moreover, this effort must be improved in the future, to sustain the decision of APG to certify its port management system in accord with the ISO 14000 standard.
The training meeting have recently gone into the following arguments:

- Protection and management of the port ecosystem
- Methodologies of sea water cleaning and recovery
- Dredging operations: health and safety legislation requirements (Legislative decree 626/94 and 494/96)
- Waste management and disposal on the port
- Waste recovery
- Waste water treatment and recovery
- hydrogeologyc accidents
- Soil reclamation

9. PUBLIC COMMUNICATION

The result of the monitoring activity and the environmental data are diffused by APG and PG through various way such as local newspapers and the APG Internet site. This one, particularly, represent a communication medium very effectiveness to reach a very large part of the citizen and have to be developed to improve the quality of communication. Within a short time, the PG too will be able to diffuse the environmental informations in its Internet site, with the advantage the information can be updated in real time.

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French Partners case study

THE PORT OF MARSEILLES AUTHORITY (PMA), WESTERN BASINS

These basins are in the south of France, exactly in the Gulf of Fos, on the Crau plain. This plain is composed about alluvial deposits brought by the Durance and the Rhône rivers.
This area is under maritime influence. The soil is composed about fine and silt sands with silting up and warping trends. The vegetation is sparse but the fauna and flora of this area are considered like originals.
This plain is delimited by Raphèle, Salon de Provence and Fos cities. The western PMA is in the Fos marshes.

This area is highly industrialised. Port areas are divided up into specialised terminals according to what goods are being handled, such as :
- Oil products : 64 million tonnes,
- Solid bulk : 13 million tonnes,
- Natural gas : 2.7 million tonnes,
- Petroleum gas : 1.6 million tonnes,
- Chemicals : 2.8 million tonnes,
- General cargo : 11 million tonnes,
- Passengers : 1.2 million passengers per year.

The industrialised zone covers 10,000 Ha. The PMA is the France's and Mediterranean's leading port, ranks third in Europe. The global trade figures of 90 million tonnes per year. There is a shipping to every part of the world.

The order to the prefect dated March 19th, 1986 regulates access and circulation conditions in the enclosed areas of the PMA. There is not occupational fishing in the port area. The marine culture is very controlled : the shellfishes must stay in purification basins before consumption.
There are two beaches in the Gulf of Fos whose have good quality waters. There are a sailing port and a camping site too (Figure 1).
The port-industrial hub is distant about the road traffic.

The law n° 65-491 of 29th June 1965, about the maritime port authorities, was modified by the decree n° 65-1175 of 31st December 1965 and the decree n° 84-844 of the 18th September 1984.

The PMA is a State controlled establishment but is independent financially and has corporate status. The port's main fields of endeavour are industrial, commercial, design, development, operations matters and the maintenance of port facilities and industrialised zones.
The decree n° 72-328 of 21st April 1972 delimits the circumscription of the PMA and the order to the prefect of 30th march 1938, modified by the order to the prefect of 17th December 1968, delimits the administrative authority of the PMA for the application of the police regulation.

Dredging Activity

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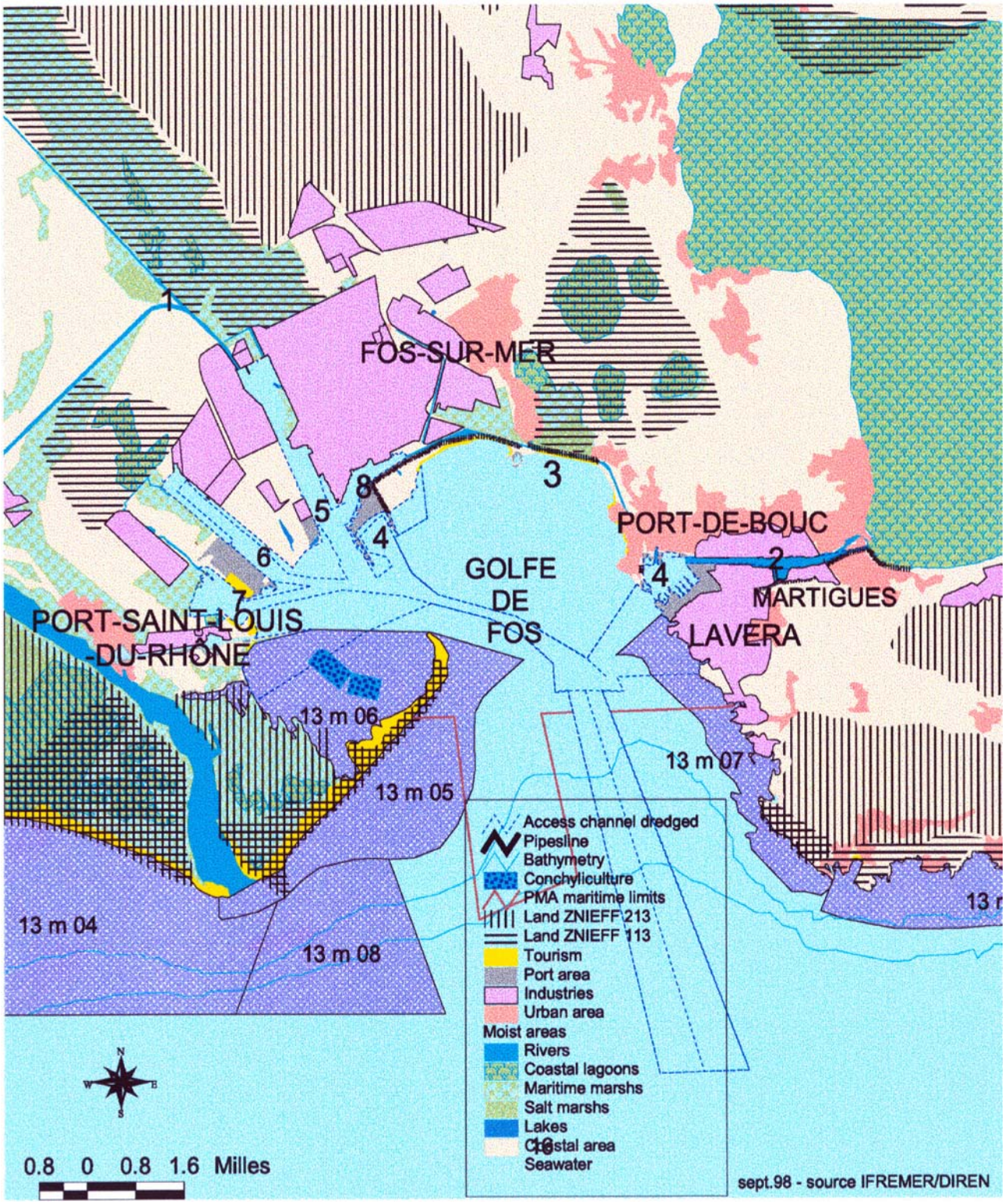
1. DESCRIPTION OF THE ACTIVITY

1.1 Situation of the dredging activity



Source: CLC (IFEN) IFREMER, 1998

Figure 1: Localisation of the western PMA dredging activities

1.2 Dredging activity

1.2.1 Generalities

Dredging is an essential activity for ports and offers a solution to the problems of silting up of channels and to the trends of increasing ship sizes. Dredging scarps the bottom of canals or access passages of ports, to have a constant depth and to facilitate the way for the ships. Over the past ten years, the PMA has dredged more than 150,000,000 cu.m of every conceivable kind of land. The dredging operations are guided by :

- the laws,
- the need for the exploitation,
- the availability of the machines and the opportunity to do the work.

The PMA makes a sounding every five years, or when a port manager requests it, because his ship has touched the bottom. The sounding evaluates the depth and determines the required dredging. Dredging is divided in three steps that are, the excavation (first step), the transport (second step) and the disposal of dredged material (third step).

1.2.2 Excavation (first step)

1.2.2.1 Techniques used by the PMA

There are two principal types of excavation : hydraulic dredging and mechanical dredging.
The PMA use the excavation by **mechanical dredging** to remove material with a grab (or a dredge). This technique is optimal to take out coarse non-cement sediment.
Buchet dredger is used for cohesive sediments, coarse sediments and broken rocks, excavated material is discharged in a barge.
Dipper dredger is used for cohesive clays and broken (or weak) rocks, excavated material is discharged on a inclined ramp to a barge.

The material is removed by a dredge or grab and transported in the deposit site by barges or pontoons. The advantages of this technique are the possibility to work at great depth, with a high precision in sediment removal, with low cost and short time environmental impact, and limited to a local scale (suspended material, turbidity, chemical oxygen demand and nutriments scattering increase).

Different companies having a valve dredge with a capacity from 50 cu.m to 400 cu.m do the dredging activity. The valve dredge must be controlled by the Security of Vessels Centre.
According to the order dated July 17th, 1996 they must have a positioning machine like GPS system.
The choice of a company depends on the dredging cost.

1.2.2.2 The excavation is done in eight different sites of the Gulf of Fos (Figure 1)

Site 1 : navigation canal from Fos to the Rhône
Site 2 : canal of Caronte
Site 3 : navigation canal from Port-de-Bouc to the Rhône
Site 4 : petroleum berth of Lavera and Fos
Site 5 : harbour area 1, and accosting berth and wharf
Site 6 : harbour area 2
Site 7 : harbour area 3
Site 8 : access canal to Port of Fos.

1.2.2.3 The dredging material can be classified by the particle sizes

- Gravel : Diameter > 2 mm
- Sand : 2 mm > Diameter > 0.036 mm
- Silt : 0.036 mm > Diameter > 0.004 mm
- Clay : Diameter < 0.004 mm

The entrance passage is dominated by natural sandy sediment. The harbour areas have the same characteristic of sediment with an increasing percent of silt and clay into the direction of the bottom basins.

1.2.2.4 Volume of materials dredged

The total volume dredged for a period of 15 years is 150,000 cu.m. Usually, the dredging is done every five years.

There are 30,000 cu.m dredged by the PMA from the bulk terminal. Sollac, the steel metallurgy industry, dredges the same quantities in front of their wharf.

The dredging volumes are low compared to other ports because the PMA is in the Mediterranean sea and there are only weak tides, and low quantities of sediments discharged (Photo 1).

1.2.3 Transport (second step)

The materials dredged from the different sites are transported in the deposit sites by barge.

1.2.4 Disposal of dredged material (third step)

Near-shore (marine disposal) or offshore (land disposal) deposition has different impacts.

Near-shore deposition occurs in confined areas named Confined Disposal Facilities, out of the area there is no impact.

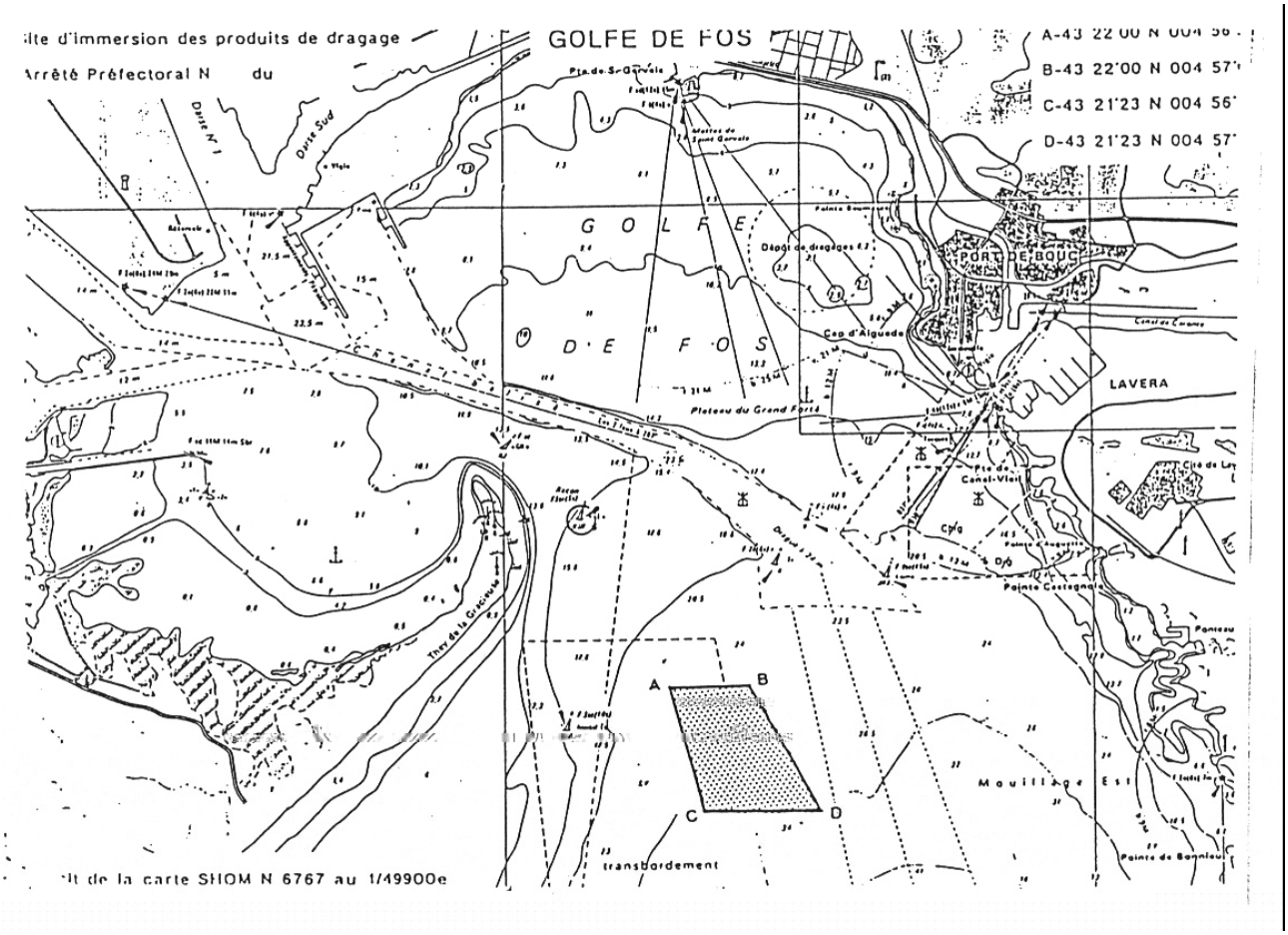
Photo 1 : A general view of the PMA access channel dredged (source : PMA).

Different problems can occur with off-shore deposition: eutrophication caused by released nutrients; increase in biological and chemical oxygen demand due to decomposing organic matter; heavy metals and chlorinated organic compounds release.

1.2.4.1 Marine disposal

Non polluted dredged material is deposited in a special marine area near the coastline (Figure 2). The depth average of the disposal site is 30 meters. The total capacity is 35,000 cu.m. The deposit site is under authorisation policy since July 17th, 1996. The geographic positions are :

A: 004°56'37E - 43°22'00N
B: 004°57'07E - 43°22'00N
C: 004°56'70E - 43°21'23N
D: 004°57'70E - 43°21'23N



Source: extract from the Oceanographic, Hydrographic navy map n° 6767 at 1/49900e

Figure 2: Immersion site of the dredging material

The dredging material is dumping between the 1st of October and the 31st of May (order dated July 17th, 1996). The dredged material will not recover the area with more than 10 cm. The order specifies that only the clay and sandy materials are authorized to be deposit. Other materials are totally forbidden.
When the PMA starts the dredging operations, they have to inform the Water Police (SM-13) and the Research Department of Archaeologist Sub-Marine (DRASM). The DRASM can stop the activities if the extraction contained archaeological material.

The dredger operator has to inform the PMA harbour master office, which is located at "Port-de-Bouc". It insures the organisation of the ship movements and gives the advice necessary for traffic harbours. It can forbid the access to the dumping site too.

1.2.4.2 Alternative solution : land disposal

- The dredging sandy materials, are noble material, lowly contaminated and can be deposited on the ground to be used in public works, embankment, civil engineering, creation of platform, loading of the beaches, cement works, sea walls, agriculture, creation of artificial reef.
- The heavy contaminated sediment cannot be deposit in the sea. They will be either treated by the Merex company, or stored in a special dump that is located at 60 Km from the western PMA in Bellegarde (between Nîmes and Arles in the Department of the Gard) or lead in a 3 Ha lagoon, situated in Fos harbour. The Merex company incinerates the chemical wastes.

If the dredging operation is upper to 1,880,000 EURO impact study is necessary.

1.3 Laws

The disposal of dredged material receives increasing attention, especially for sites where the material is contaminated. The requirements to reduce contaminant inputs to the sea are controlled by international conventions.

1.3.1 International conventions

They concerning the disposal of dredged material were set up in the 1970. These conventions are the London Convention (LC'72), the Oslo/Paris Convention (OC'72) and the Helsinki Convention.

1. The London Convention, LC' 72 dated December the 29th, 1972 is applicable for all the seas, and it is very similar to the OC' 72 Convention specified to Atlantic Ocean. LC' 72 Convention regulates the dumping of the dredged material. A certain number of articles, address the obligations of the contracting parties to ensure the properties of the material disposed of at sea in accordance with the convention requirements. The Parties encourage co-operation between them and seek the formation of regional agreements.

Those measures are taken to prevent and punish any behaviour in contradiction to the convention. Other articles are concerned mainly with the details of procedure for setting up and operating the convention.

2. The Barcelona Convention dated February 16th, 1976 is about the monitoring of dredging activity. The monitoring is done : by the analyse of the composition of the material, by the place of the dumping, by the method used for dumping the dredged material in the deposit site, and at last by measuring the effects on benthic organisms.

3. The draft treaty of the Barcelona Convention prohibits the dumping of certain wastes described on the Annexe I (article 4) like mercury, cadmium, persistent plastics crude oils and hydrocarbons derived of petroleum, acid compounds...

The protocols were set up primarily to regulate the disposal of noxious substances into the oceans, and to protect the marine environment and other legitimise sea utilisation. Dredged material disposal at sea generally comes under these conventions. Specific guidelines for dredged material have been incorporated. At the heart of the conventions there are two basic principles (the precise wording varies and is abbreviated here) :

- The precaution principle; by virtue of which preventative measures are to be taken when there are reasonable grounds for concerned substances or energy introduced into the marine environment may bring about hazard, harm, damage or interference, even when there is no conclusive evidence of a causal relationship between inputs and the effects.
- The polluter pays principle; by virtue of which the costs of pollution prevention, control and reduction measures are to be borne by the polluter.

1.3.2 French laws

1 Law n° 79-861 dated October 1st, 1979 art. 1, R.*153-1., R.*153-2. (Code of maritime ports) concerns dredging material.

2 Decree n° 74-494 dated May 17th, 1974 publishing the Oslo Convention of 15th February 1972 is relative to the prevention of marine pollution by dumping operations from vessels and aircraft.

3 Decree n° 77-1145 dated September 28th, 1977, publishing the London Convention of 29th December 1972, is relative to the prevention of marine pollution by dumping of wastes.

4 Decree n° 85-453 dated February 1985 is relative to the public enquiry and the impact study before a dredging operation.

5 The dredged deposit operations are to the right of a special authorisation. They are directed by the law n° 76-599 dated July 7th, 1976 and the statutory order dated September 29th , 1982 (chapter V) relative to the prevention and the repression of marine pollutants. They are particular disposition for the deposit of material in a special marine site. The procedures followed to have the authorisation to dump in the sea the dredged material of the PMA are under the decree n° 82-842 dated October 3rd, 1982 :

– Article 21 : An impact study is necessary to have an authorisation to dump dredged products in the deposit site. The research organisation are competent to do these studies. The Prefect of the department (whom is concerned by the dredging operations) will consult the Maritime Prefect, the head of the Maritimes Affairs, the head of the Maritimes Services, as the head of the telecommunications and extern net. Those persons have to give an advice on the impact with two months of delay.

– Then the administration opens a public inquiry (15 days) for the most interested parties.

– Article 9 specifies the containing of the public inquiry :
  - Identity of the petitioner.
  - Place of the dredging activity.
  - Characterisation of the dredged material.
  - Justification of the dumping.
  - Geographical situation of the dumping site.
  - Possible effects on the marine fauna and flora and on the activity.
  - Dumping conditions.

– After the instruction of the inquiry and the impact study, the administration will give or not the authorisation to dump the dredged products.

– The authorisation is given for a five-year period after signature of the order. If the dredged volume authorised has not been reached at the term of the order, there will be a renewal of the authorisation, only if the conditions are not changed. The demand will have to be asked six months to one year before the end of the authorisation.

– The modification of the dumping authorisation can only be done to :

  - Reduce the pollutant of the dredged material dumped.
  - Reduce the environmental pollution, inconvenience and danger resulting from the dredging operation.
  - Facilitate the operation of the dredging dumping.
  - Know the impact of the dredging operation.

1.3.3 Uniform protection areas

1. ZNIEFF, are areas itemised for the national inventory of the natural patrimony, presenting an ecological interest. It is a tool for knowledge, and have a juridical value. The area of the Gulf of Fos has two ZNIEFF :
- The ZNIEFF n° 13M06 called “Anse de Carteau” it has an interest for fishing and for the biologic species (*Posidonia oceanica* meadows…).
- The ZNIEFF n° 13M05 is in the area of the “They de la Gracieuse”.

2. The marine preserved areas (coastal law n°86-2 dated January 3rd, 1986) are :
- Marine ZNIEFF, *Posidonia oceanica* meadows, Shellfish seam area, Spawn area for ichthyo-fauna.

2. POLLUTION SOURCES (CONCERNED SUBSTANCES AND BY - PRODUCTS)

2.1 Generalities

Dredging activities can be source of pollution if the dredged material is polluted. In fact sediment are contaminated by pollutants coming from the industrial discharged : waters, ships, soils washed by the rains, polluted rivers, ports activities as ore dry bulk or noxious liquid....

The pollutants founds in the sediments can be : nutrients (consummation of oxygen), pathogen elements (bacteria, virus), metals (aluminium, iron, manganese) heavy metals (arsenic, cadmium, chromium, mercury, zinc, lead, copper), total hydrocarbon and chemical toxic products (organochloride affecting the genetic code, as polychlorobiphenyl).

Dredging activities have a variety of negative effects on marine flora and fauna from habitat disturbance of benthic communities in the dredged area, to physical smothering or chemical contamination of those on the disposal site.
During the dredge most of the silt particles are swept in suspension, transporting the contaminants in an adsorbed form. The finest sediments (clay) can bind nutrients (nitrogen, carbon, phosphorus) or pollutants (heavy metals, organic pollutants) scavenged, adsorbed and absorbed into their structure.

2.2 Granulometric analysis

This analysis gives the percentage of sediments with a diameter less than 2 mm. The canal and “Port Saint-Louis” (Figure 1) represent the finest elements. On the other side the highest percentage of rough elements are in the western harbour area and at the petroleum posts (Figure 1). The granulometric size is linked with the quantity of pollutants. Sediment with a high percentage in clay minerals has a high fixation rate of the pollutants.

2.3 Organic material, organic carbon and Polychlorobiphenyls (PCB)

- The quantity of organic material is upper to 15% for all the area.
- The organic carbon has a high percentage (11.40%) only at the mineral harbour, with a rough sediment granulometry (11% of silt), that will have an important dilution effect.
- The maximum contents in PCB are about 0.1 mg/Kg near “Port Saint-Louis”.

Metals :

- Aluminium is the natural element the most represented after iron. The silicates of alumnus are easily attached to clay (less than 2 μm). The mineral quay has a concentration of 80 mg/Kg, because it is a place of loading.
- Iron in the harbour area represents a medium concentration of 13,000 mg/Kg for 22,500 mg/Kg in the Gulf of Fos.

- Manganese has also inferior concentration in the harbour (300 mg/Kg) compared to the Gulf.

Heavy metals :

- Arsenic are in low rate in the harbour area (0.1 mg/Kg) compared to the Gulf of Fos (6.9 mg/Kg).
- Cadmium concentration is at 0.02 mg/Kg (mineral wharf) and has a medium rate of 0.33 mg/Kg.
- Chrome has a high rate at the mineral wharf (121 mg/Kg) compared to the Gulf of Fos (42.2 mg/Kg).
- Mercury is around 1 mg/Kg at the mineral wharf and reduces in Gulf of Fos.
- Zinc has a low value at the mineral wharf but higher than in Gulf of Fos (37.5 mg/Kg).
- Lead mean level in Gulf of Fos is of 37.5 mg/Kg.
- Copper has the lowest contamination in the western wharf (7.11 mg/Kg) and a mean level of 32 mg/Kg for the Gulf of Fos.
- The total hydrocarbon means level in Gulf of Fos are around 66 mg/Kg. The mineral wharf has the highest rate with 1,980 mg/Kg.

All those heavy metals are representative of the quality of the dredge material. We noticed that the mineral wharf has the highest rate especially for the hydrocarbon and the organic carbon.

The problem of sediment quality is usually due to finest materials (less than 63μm) process vector of heavy metals and organic pollutants. They fix contaminants by ions exchange.

The release and fixation of harmful element is function of the sediment stability. This stability depends on :

- The metals concentration,
- Quantity of organic matter,
- Water salinity,
- pH, Eh (reduction-oxidation potential [1]),
- The mixing quality of the sediment / water,
- Micro-organism activity,
- Hydrodynamics.

Between the different pollutants present in the sediments, the metals are the most dangerous species related to their ability and mobility. The most toxic metals for the living organisms are:

- **Mercury** by solubility increases in the water. Bacteria methylate the free form of mercury (which is the process the most toxic). The methyl forms of mercury are stocked into living organisms.

[1] Red-Ox potential characterises the evolution of the chemical and microbiological conditions in the sediments (Hily, Glémarec, 1990).

- **Lead** becomes mobile if the pH decreases or the area gets oxygen. It will also have methylation process like mercury.

- **Cadmium** also becomes mobile in oxidising areas and will be very toxic.

The most polluted part of the sediment is usually the finest (less than 63µm), vector of heavy metals and organic pollutants. The metals are fixed through water-sediment ions exchanges.
The physical-chemical conditions of the environment play an important role in the dissolved materials are mostly ionic shapes. Some of them can precipitate with insoluble complex of other elements by Oxidation-Reduction reactions.

Heavy metals have different reactions in the environment which undergoes chemical transformations (Table 1).

Table 1: Chemical transformations led by the reactions of heavy metals in the environment

COMPLEX FORM	RESULT
Carbon monoxide, carbon dioxide	Heavy metals are released when the salts are dissolving
Adsorbed on iron oxide or manganese oxide	The complexes become unstable and release metals
Bond with organic matter	Great stability of the complex
Sulphide	Instability, oxidation in sulphates and release of metals

The evaluation of metals effects discharged into the sea is difficult because :

- It is not easy to differentiate the anthropic and the natural origin of the pollutant.

- Metal in particular has a pollution degree harmful for a specific ecosystem at long or short term. It is difficult to appreciate it. The effects depend on the physical-chemical characteristics of the water and sediment compartments.

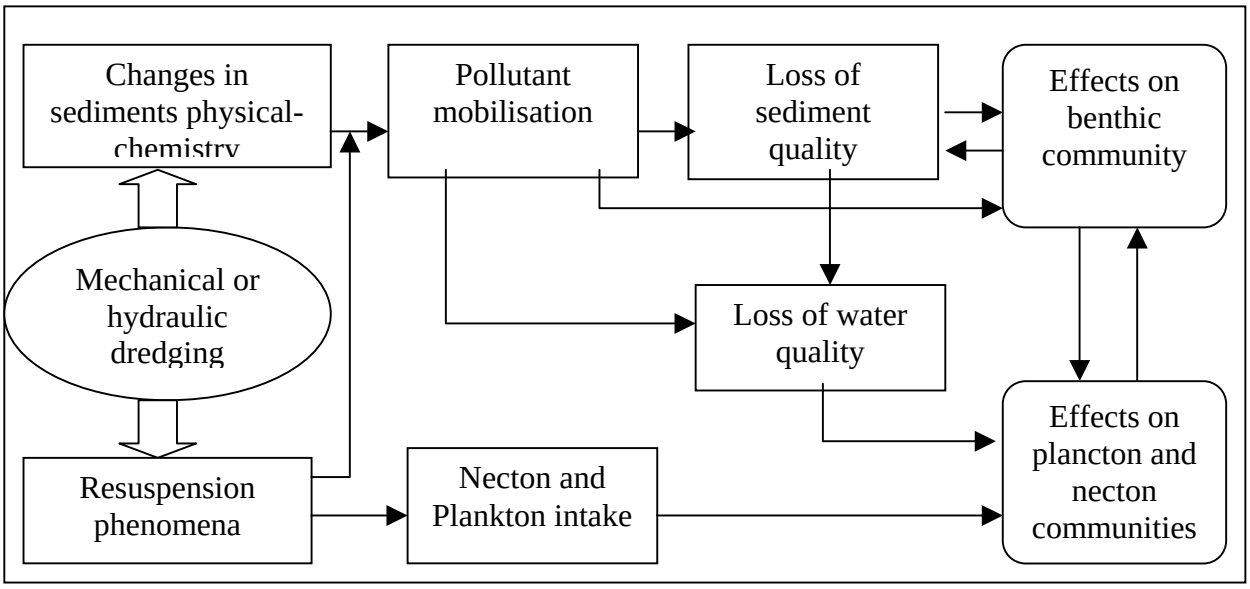


Figure 3: Different effects of heavy metals discharged into the sea

For the western PMA, the polluted dredged material represent low quantities. They are usually due to accidental pollution. For example in 1996, 200 cu.m of polluted dredged material was sent to the special dumpsite of "Bellegarde". This accidental pollution of the sediments was due to the collision of an oil tanker with a submarine.

3. CONSEQUENCES

3.1 Effects in the environment

3.1.1 Effects on the sea environment

3.1.1.1 Dredging installations

They induce some modifications of the Oxidation-Reduction conditions in the water-sediment interface when the sediments are stirred up. Heavy metals are released.

3.1.1.2 Dredged materials

From a functional point of view pollutants can be divided in two major groups : those that affect the physical environment and those that are directly toxic to organism, including human life.

The pollution can come from a nutrients superabundance which, on its turn, can give rise to enrichment of the ecosystem, or from a mix of toxic potentially carcinogenic, mutagenic (cause damage to genes) or teratogenic (cause abnormalities in developing embryos) compounds. The physical changing of the environment can be also considered.

Dredging can also seriously damage the shallow-water habitats. Clay and silt suspension decreases the penetration of light into the water, can cause a decrease in the primary productivity in the water column; this in turn reduces the amount of oxygen in the water and the supply of phytoplankton at primary trophic level. The burial and the massive injection of nutrients is a disruptive factor for the benthic communities : hence the original ecosystem is destabilised. Risks of chemical contamination on the deposit site are very low, because the sedimentology and geochemistry (pollutant concentrations) of the dredged material must be similar to the receiving area. The contamination of the water body is possible, but if the deposit site is enough far from the coast, it will not pollute the coastal water.

There are not relevant long-term effects. The possibility of long term effects are due to bio-transformation, bio-concentration and bio-magnification phenomena.
Some bacteria transform the pollutants like arsenic. They create toxic gas products accumulating in organisms.

The waves and the wind forced currents can put again in suspension the finest material. This phenomena is studied by the rheologic properties of the materials dredged.

3.1.2 Effects on the physical area of Gulf of Fos

3.1.2.1 Installations of the activity

Wind conditions have to be less than 8 m/s (16 knots), because afterwards the evolution and the manoeuvre of the loaded barge can became difficult.

The dredging installations alter the natural flow in the port.

3.1.2.2 Dredged materials

In fact, the current and the swell have two hydrodynamic impacts on the disposal activity:

- Dispersion of the dredged material on the water body (turbide cloud).
- Shifting material on the bottom after deposit.

On the deposit site, the numerical model approach simulates a medium swell north/north-east by Mistral or a south/south-west by south/south-east wind direction. The dispersion of the material will be on the north-south axis.

In north-west wind direction, the dredged deposits transit in the entry canal of the port of Fos. In south-east wind, it goes in the other direction. The weak wind period corresponds to 50% of the wind in the year, and induces a weak current, which limits the dispersion of the turbid plume.

3.1.3 Effects depend on the sedimentation speed

3.1.3.1 Installations of the activity

The dredging installations alter the natural sedimentation in the port area because they constant move seawater and sediment. So, the suspended materials cannot deposit sediment.

3.1.3.2 Dredged materials

According to their physical characteristics, sediments have not the same comportment :

- The rough elements (with a 1 mm diameter) have speed sedimentation around 10 cm/s. So the sediment takes three to four minutes to reach the bottom of the deposit site, assuming 25 m water depth.

- It takes ten times more for sediments of 100 μm having sedimentation speed of 1 cm/s, so the deposited material reaches the ground 30 to 40 minutes latter.

The most of the material reaches the ground in less than one hour but the clay sediments, less than 2 µm, will disperse in the water body for a long period. A temporary turbidity of the water body will disturb the benthic fauna as the photosynthesis processes. These fine sediments are slow to packing down because of the water in it (Migniot, 1998).
The flocculation can be used to help the sedimentation of fine particles.

3.2 Impacts in the environment and the users

3.2.1 The biologic impact

3.2.1.1 Installations of the activity

The benthic population is crushed and fishes avoid dredging area. The organisms living into the sediment are destroyed.

3.2.1.2 Dredged materials

The integration of the pollutant is done at the sediment water interface. We talk about bio-mobilisation (integration of the pollutants in the living organism) giving bio-accumulation (accumulation of chemical substances directly by the aliments) and then bio-concentration (retention of the pollutants in the tissues).

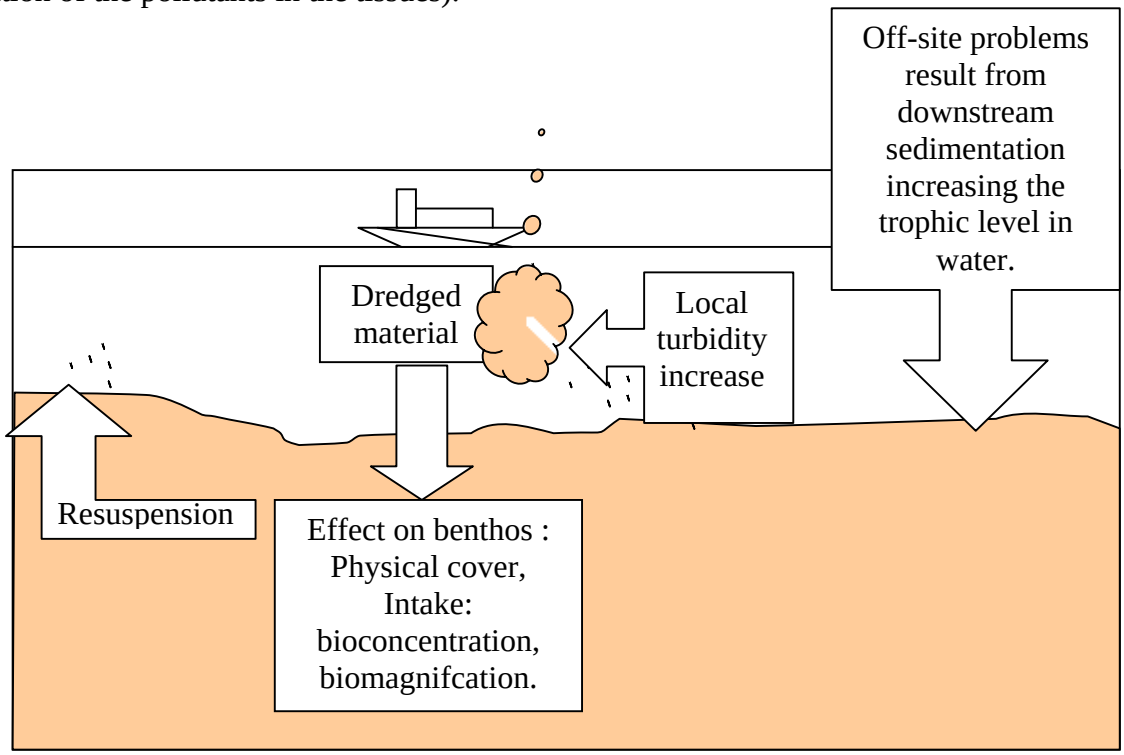


Figure 4: Different impacts of the dredged materials

The impact on the plankton is not important. The communities will develop resistance against the perturbation or “disturbance”. So there are no precaution or protection needed to be taken. The heavy metals alliterated the biological functions at the macroscopic, biochemical levels and on the natural cycle. The organic pollutants are mutagenic, carcinogen and genotoxic agents for living material.

The impact on the benthic population has been important since the beginning of dredging in 1965. The benthic population has been notably disturbed. Actually there is a restoration of the community, but it will never be has it was before.

The existing organisms are robust, and well adapted to a changing area, with the difficult condition of life. The impact for the benthic population will depend on the materials dumped. If the material are slits this influence will not be too important. But if most of the material is rough the species living in silts will be affected.

The quality of the material can cause damage, in particular if it is rich in organic elements (5 to 10%). In fact most of the species will disappear and a new polluted community would take place *(Capitella capitata, Malacoceros, Fuligionsa, Nereis caudata).*
But those conditions should not stay longer than three to four months if no more polluted material are deposited. Then other species would take their place *(Tharyx sp, Abra sp, Lumbrineris latreilli, Corbula gibba..).*

The quantity of dredged material laid on the deposit site can have an impact if it is over 2 - 5 mm. It would destroy the most fragile population, and incur modification on the keel of the ecosystem. Three to four months latter the community should recover and find again here a keel after one or two years.

The impacts are different in the environment according to the activity and the resources.

Table 2 : Different types of impact in the environment

	ACTIVITY	**Dredging**	**Transport**	**Marine Disposal**	**Land Disposal**
RESOURCES					
1. Ecosystem					
1.1 Biotic components		R1*l*	L1*l*	R1*l*	L1*i*
1.2 Abiotic components		R1*l*	Z0*n*	R1*l*	L1*i*
1.3 Scenic values		Z0*n*	Z0*n*	Z0*n*	M1*i*
2. Space					
2.1 Settlement		L1*l*	L1*l*	Z0*n*	Z0*n*
2.2 Movement		L1*l*	L1*l*	Z0*n*	Z0*n*
2.3 Communication		L1*l*	L1*l*	Z0*n*	Z0*n*
3. Culture					
3.1 Archaeological remains		*	*	*	*
3.2 Man made structures		L1*l*	Z0*n*	Z0*n*	*
3.3 marine knowledge		Z0*n*	Z0*n*	Z0*n*	Z0*n*

*: possible impact

Codes :

Impact strength	Zero = Z	Low = L	Medium =M	Relevant = R
Impact dimension	Null = 0	Little ~ 1km ^{2} = 1	Local ~ 10 km ^{2} = 2	Regional ~ 100 km ^{2} = 3
Impact duration	Null = *n*	Low = *l*	Medium = *m*	Irreversible = *i*

3.2.2 Impact in the human area

3.2.2.1 Installations of the activity

- The navigation and the fishing near the dredging activity are defended during all the operation. It is to facilitate the movements of the barges.
- The dredging activity and the disposal of dredged materials will modify the area of fish's frequentation.
- The national navy will also be disturbed for their research in mines. In fact, the dredging activity will modify the water depth.

3.2.2.2 Dredging materials

- The dredging activities increase the turbidity near the dredged and the deposit area. It has an impact for the shellfishes production.
- Some pollutant like mercury can concentrate in fishes, them when humans eat those fishes he will have system nerves problem.

3.2.3 Impact in the users

3.2.3.1 Installations of the activity

- Disturbance of navigation and sailing activities.
- Disturbance of occupational fishing.
- Disturbance on tourism activities because of noise, view and smell.
- Suspension of bathing activity and water sports.

3.2.3.2 Dredged materials

- Turbidity induce avoidance of dredging area by fishes.
- Disturbance of waters quality in turbide cloud area.
- Disturbance on tourism activities because of noise, view and smell.
- Leisure fishing is forbidden in turbide cloud area.

4. ACTIONS TAKEN

4.1 Western PMA environmental control of the dredging activity

The PMA has to inform the Water Police (CQEL-13), three months before the beginning of the dredging activity. The PMA must specify the volume dumped, and the area that will be dredged.
This information given to the Water Police permits to control the quality of the dredged material. In fact the dredged material can be immersed only if it correspond to non polluted referenced values.
Those referenced values correspond to the Group of Study and Observation about the Dredging and the Environment ("GEODE"[2]) recommendations.

The dumping area is represented in four zones, A, B, C, D chosen alternatively by the Water Police.
The physical monitoring of material at the deposit site is essential. A complete monitoring programme goes from the collect of data before and after the deposit of the dredged material, to the observation of the physical modification of the site during the deposit.
The sediments of the PMA are low-grade in metals and so it is very important to have strict analysis protocols, knowing the margin of error. Also particular care with the sampling has to be taken to avoid sediment contamination.

The Water Police (CQEL 13) controls the quality of the dredged material at each dredging, systematically or unexpectedly. It has the free access to the dredging activity.
The Water Police has the responsibilities of the analyses. So, the dredged material will be sampled by it and analysed by a laboratory agreed by the Environment Ministry. The number of samples will depend if the area is confined or no.

4.1.1 Free exchange area

The number of samples need to be done depends of the volume dredged (Table 3).

Table 3: Number of samples according to the volume dredged.

VOLUME DREDGED (m^3)	NUMBER OF SAMPLES
V < 25,000	1
25,000 < **V** < 100,000	2
100,000 < **V** < 250,000	3
250,000 < **V** < 1,000,000	1 sample / 100,000 cu.m
V > 1,000,000	10 samples + 1/1,000,000 cu.m

[2] The GEODE was created in 1990. It is a reflection group. It aims to inform the French delegation which participates at the works of Oslo and Paris conventions. The GEODE studies are about :

- The strategy of the dredging operation and dumping.
- The evaluation of the impact of the dredged materials.
- The critic of the orientation and procedures.

4.1.2 Confined area

Those areas are characterised by a low water circulation. It is the case of most of the port area. One analyse will be done for each operation and for 5,000 cu.m.

An automatic diagnostic is done by the dredging activity. The dredging operator records all the parameters necessary to make a good operation : date, hour, minute, origin, nature of the materials, volume, co-ordinated, and bathymetry of the dredged site.

A copy of this register is addressed each week during the dredging work, to the Water Police. Then at the end of the dredging campaign, the dredging company addresses an assessment to the Water Police.

4.2 Western PMA environmental control in the environment

Coastal zone is devised in “homogeneous” areas. Three level of impact are studied :

1. The first field is the nearest zone to the coast. It corresponds to the area where are the dilution of the rejects. In the Gulf of Fos, it goes up to the bathymeter 30 m.

2. The medium field starts at the bathymeter 50 and goes up to 100 m. In this area the pollutant concentration are all mixed up.

3. Then the last field starts at the bathymeter 100 m, and it is related to the background noise.

The area of the Gulf of Fos is covered by the coastal zone n°16, between the Rhone mouth and Cap Couronne (Figure 5). Different analysed are done :

1. The **RNO** (National Observation Network), is a network managed by IFREMER (French Institute of Research in the Sea) for the Environment Ministry. The RNO existing for more than 20 years; it measures, in the Gulf of Fos, the quality of :

- The water column on three stations once per trimester.
- The sediments every time the dredging operation is done.
- The living matter on three stations once per trimester.

2. The **REPHY** (Phytoplanktonic Network) and **REMI** (Microbiologic Network) measure the phytoplanktonic and microbiological quality of the water.

The measurements are done by IFREMER which measure, in the Gulf of Fos, the quality of :

- The water column on two stations REPHY every 15 days in winter and every week in summer.
- The living matter on two stations REPHY and five stations REMI once every month or more frequently in case of pollution.

3. The **RSP** (Posidonie Watching Network) measure the global quality of the area using the vitality of the vegetal plantation as a biologic indicator. The observations are done once a year by GIS-Posidonie, a research organisation.

4. The **CQEL-13** (Water Police) controls the PMA actions and monitors the direct discharge of the industrial waters and their impacts on the quality of the port area :
– 8 stations are analysed in the area of the Gulf of Fos.

5. The **DDASS** (Departmental Direction of Social and Sanitary Actions) monitors the microbiological quality of the water in the bathing area.
– 12 measurements are done per year in summer time in the water column on 7 stations along 5 towns in the Gulf of Fos.

6. **REPOM** (National network to the survey of the maritime ports), will constitute for the France, an international scale of network reference. The circular dated March 7th, 1997 from the Environment Ministry, asks at the CQEL to put in place this REPOM.

The objectives of the REPOM are to monitor the water quality and the sediments quality of the port areas. This monitoring will permit to :

– Have a global view of the pollution created by ports.
– Bring to the GEODE group, actualise data on the quality of the sediments.
– Create adequate standards relating to the disposal of the dredging wastes.
– Evaluate the port quality.
– Have objective information to incite the port managers to research good solutions permitting to eliminate the pollution at the source.

The REPOM will study the water and the sediment quality on the PMA. The water quality analyse will be done on more than two stations four times a year (one analyse every three months). The parameters analysed will be bacteriological (*Escherichia Coli, coliforms faecal, Streptococcus faecal.*.), and physical-chemical (temperature, salinity, percent of dissolve oxygen, suspended matter, ammonium, transparency...). The contaminants analysed in the sediment will be done at each dredging operation.

Source: CLC (IFEN), IFREMER, 1998

Figure 5: Homogeneous area n°16: Mouth of Grand Rhone to Cap Couronne

5. MONITORING

5.1 How to plan environmental controls on the activity

5.1.1 General environmental controls of the dredging activity

5.1.1.1 The environmental control must be done by the reliability of the technique used

- Watertight integrity of the valve barge.
- Good positioning in the area of the activity.
- Good weather (wind) and sea conditions (waves) for the barge.
- Analyse of the impact to the recreational activity depending to the current.
- A control of the bathymetric condition in the disposal area.
- The instantaneous deposit of the material will induce a quick sedimentation and a good management of the quantity and an equal spread of material at the disposal area.

5.1.1.2 The environmental control must be done with the respect of the rules

- Chemical and physical analyses of the dredged material before dumping in the sea.
- If the dredged materials are polluted they will be stored in special ground site.
- If the dredged materials are radioactive, immersion is forbidden.
- The sediment deposit should not be over 10 to 20 cm. So the deposits have to be equally laid out on the disposal area.
- Interdiction to dump large volume with metals compounds.
- The granulometry of the deposit must be similar to the natural sediment.
- Eliminate all floating elements from the dredged material.
- Limit the use of the disposal site (the concession is authorized for a volume).
- Maritime traffic, around the deposit site, will be deal by the harbour master’s office.
- The contractor will have to take note of the dredging and deposit positions.
- The port will have to control the bathymetry once a year all around the disposal area.
- In bad meteorological conditions the dredging activity will be stop.
- The operation should not be done in winds over 8 m/s (16 knots), or over 1 m of swell.
- The technique of dredging should avoid mixing up sediment and water, because more the material is concentrated better the deposit of the sediment at the marine deposit site will be done. Also low water quantities in the sediments will permit to reduce the quantities and the weight of the total sediment transported.

5.2 How to plan environmental controls in the environment

The test of embryo-toxicity on the bivalves (oyster larvae, mussels…) gives a good indication of the quality of the area. Routine ecotoxicological monitoring requires simple, rapid and inexpensive methods. Determining the percentage of abnormalities in D-larvae after 18 hours assesses water quality. If the percent of D-larvae abnormalities is above 50%, the toxicity of the sample is very high.

The water law (1992) and the coastal law (1986) remind users of the importance to monitor the coast in a uniform way. It will be done by the **RLM: Littoral Mediterranean Network**. This network is being set up and totally monitored by the Water Agency of the Mediterranean basin. It is the knowledge integration and the quality evaluation of the French Mediterranean coastal zone.

The objectives of the RLM are to :

- Plan the environmental littoral gestation, globally and locally.
- Help for planning and investments.
- Protect immediately the area, with quality objectives.
- Follow and evaluate the actions.
- Improve the knowledge about the area.
- Sensitise and communicate.

A lot of measures are done with mussels *Mytilus galloprovincialis* which can filter a great quantity of water and storage the pollutants.

The RLM will allow a good general information about the quality of the marine environment of the Gulf of Fos. But to plan a good environmental control in the Gulf of Fos environment, other analysis should be done.

5.3 Monitoring costs

5.3.1 The bathymetric activity

This activity needs hydrographic management from the planning services of the industrial area of Fos. This management is :

- Hydrographic stands by ship CALEMBO II (800 EURO/day).
- The equipment for the bathymetric measurements. It includes the CALEMBO II ship, and the crew, the data gathering equipment, the positioning equipment and two hydrographers (2,000 EURO/day).
- The engineer staff (530 EURO/day).
- The ground treatment equipment : the computer equipment, the elaboration material, the processing of the plans by one hydrographer (620 EURO/day).

So the bathymetric survey costs approximately 590 EURO/hectare.

5.3.2 Cost of the analyses

The cost to analyse one sample of the dredged sediment is about 540 EURO (heavy metals, polychlorobiphenyls, hydrocarbons).

5.3.3 Cost of the dredging

The dredging activity costs around 15 EURO/cu.m of sediment dredged.

6. DEFINITION OF INDICATORS AND CRITERIA: ASSESSMENT / EVALUATION OF MONITORING RESULTS

The prevention of the contamination risk needs knowledge about the sediment : physical-chemical conditions as oxidation-reduction conditions of the area that will receive the dredged sediments, the way of the metals associated to the sediment. So it is important to have a normalisation technique to analyse it.

GEODE, C. LATOUCHE and C. ALZIEU propose two referenced levels for different metals. These referenced values allow to know in an objective point of view the quality of the dredged material and then to decide if the material can be deposited in the sea.
Reference values have been calculated for each metal (the unity is : mg/kg of dry weight) :

Table 3: Referenced levels for different metals

	BACKGROUND NOISE	LEVEL 1 (2 md)	LEVEL 2 (4md)
Mercury	0.2	0.4	0.8
Cadmium	0.5	1.2	2.4
Arsenic	4.4	25.0	50.0
Lead	47.0	100.0	200.0
Chrome	45.0	90.0	180.0
Cooper	35.0	45.0	90.0
Zinc	115.0	276.0	552.0
Nickel	20.0	37.0	74.0

For PCB compounds there is no background noise because they are from anthropological origin. It is toxic for phytoplankton and larval development at weak concentration (1µg/l). The PCB are accumulated in lipid tissue. By analogy with metals, the level 1 is 0.5 mg/Kg of dry weight.

The level 2 is calculated for dredged sediment having a quality permitting the consumption of the fish living above it. The level 2 is equal to 1 mg of PCB per Kg of dry weight.

For all the compounds, under the level 1 : the dredged material can be dumped without any complementary study.

Between the levels 1 and 2 : a further study should be necessary to precise to risk for the marine environment.

These studies can be ecotoxicological approach which addresses more directly the impact of contaminated sediments in the ecology.

- The elutriate test assesses toxicity by measuring the releasable contaminants to evaluate potential contamination of adjacent surface and ground waters. They can be used to indicate the bioavailable fraction and potential exposure of surrounding environments.
- The bioassay approach observes the responses of selected test species to specific contaminants under laboratory conditions (Fletcher and *al*.).

The classification done by GEODE prohibits sea disposal of dredged material, if selected contaminants have a concentration above the level 2.

7. PRINCIPALS AND GUIDELINES FOR IMPROVEMENT / NEEDS FOR TECHNOLOGICAL INNOVATION

7.1 The dredging activity

The control of the depth can be done by :

- Positioning systems (GPS, SYLEDIS, TORAN, AXYLE…).
- Technique of drawing (DALI). This is a logical improvement in precision and reliability. It gives a quick view of the evolution of the water depths. Consequently the control of water depth quality is more efficient, which allows quick intervention. It is also an improvement for the navigation conditions and an actualisation of the water depth dredged in real time.
- It is also possible to use a sounding camera to study the thin coat of dredged material that has been deposit and to determine its physical proprieties.

7.2 Knowledge about the pollutants dredged

The high levels of pollutants are always in the harbour area. Those places are favourable to settling of fines material and pollutants. The same phenomenon happens in stale area, with low water dynamic. The port areas represent only a small percentage of all the dredging works.

A model of the hydro-sediment area should be made, with a special attention to the suspended solids. In fact an improvement of the physical-chemical and geochemical processes in the suspended solids comportment needs more investigation and research.
It is important to define biological criteria to know the effect on the environment. The dredging activity is not there to create disaster or unacceptable risk.
The dredging is a necessary activity bringing modification of the physical, chemical and biological environment. So it is important to evaluate the impacts between the different dredging methods.

One important point is to try to reduce the suspended solids by using good dredging equipment and adequate dumping sites.

A good way to reduce the cost of the dredging activity is to find the pollutant at is source, and see if there are not any methods to stop the pollution of the sediments.

7.3 Environmental situation

It is important to characterize the dredged material (granulometry,% of clay,% of organic matter…). The adsorption and absorption processes of sediments depend on it.

The knowledge of the disposal area characterisation is essential too (the dredged sediments must be similar with the sediments of the disposal area).. It consists of the geography, the physical characteristics, the biologic characteristics, the human activities and the users, and the protected areas existing there.

7.4 Valorisation of the dredged sediments

The non-polluted dredged sediments can be valorised by different ways. If they are concentrated in organic material they can be lead on plants and serve as a fertiliser, or use for the building of route embankments. The sandy material can be spread on beaches.

There is a classification of valorisations :

- Environmental valorisations : wild environment (damp areas, habitats with high biodiversity) and public environment (leisure areas, shoreline protected areas).
- Long-time valorisation with financial interest.
- Social valorisation : tourism, farming, employment, industrial activity.
- Construction materials.

The valorisation of the dredged material is done because there is a benefit that can be taken compared to the deposit in the disposal site. Even if most of the times advantages of the valorisation mode cannot be transferred in money value (it is notable the case when there is a improvement for the environment). The choice of a valorisation option is not only based on the comparison of it is cost and intrinsic advantage, but has to take into account all the other factors affecting the opinion.

8. ANALYSIS OF TRAINING NEEDS

The maritime service (Water Police) should monitor the dredged material deposited at sea (it will be done), and control the ships doing the dredging activity, to survey what it is really deposited and where it is done (approximate site).

The PMA has a large maritime area, with no real database, no real study about the quality of the marine fauna and flora, at this time. So a lot of study needs to be done to improve the environmental control of this marine area.

The GEODE group has defined indicators. But they should have defined the value of the natural aluminium or manganese elements (per coastal zone) of common geological substratum, in the dredged sediments used for the scale analyse of pollutants. It would have been a useful reference because aluminium and manganese have constant natural value in all sediments (whether they are polluted or not).

Those values will have to be agreed by the administration before being introduced in the national legislation as norma. Actually the Water Police, use those values as recommendations.

The acquisition of synthetic database about dredging activity should always be kept, and the evolution of the dredged sites monitored.

Bathymetric data of the Gulf and port of Fos is done every five years, it permits to follow the evolution of the depths in the disposal area too. But this information is not enough to evaluate the impact caused by sea dumping.

Soon, the PMA will do a bathymetrical survey of the deposit sites. The results will be addressed to the maritime service (Water Police) and to the Hydrographic navy (EPSHOM).

Among its other activities, the port organizes practical training courses in Marseilles in the following matters :

- Pollution combat,
- Firefighting,
- Dealing with other types of accidents.

The PMA distributes a handbook “Fire and accident control, pollution abatement”.

9. PUBLIC COMMUNICATION

Before the dredging operation a public consultation done as the law n° R 300.2 dated July 18th, 1985 and the decree dated March 15th, 1986 says so in the Urbanism code.

The consultation is there to allow all the person that are concerned by the activity to give an advice, and be informed of what is being, or will be done.

In the classified installations, a public enquiry must be done during one month to have the authorisation. This enquiry permits a good information of the public and the workers.

French decrees and laws allow the public to give an advice to the port projects and port development.

Where to get information : at the Information Centre of the Port of Marseilles Authority (ICPMA). Here, you will find :

- General and specialized information
- An exhibit on the facilities operating in the Zone and the Port
- A conference room seating 100 people. The room is air conditioned, sound proofed and has a projection room.

The CYPRES association (law 1901) is a public information centre about the industrial risks awareness and the protection of environment. They can answer to questions about technologic risks and industrial environment; they purpose information and communication for everyone.

The PAM publishes some information handbooks for masters of ships, booklet about reception and safety of vessels, handbooks about pollution detection awareness, magazines : “PAM magazine” and “port of Marseilles letter”, where it informs public about the different operations made in the port area.

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Port water industrial pollution

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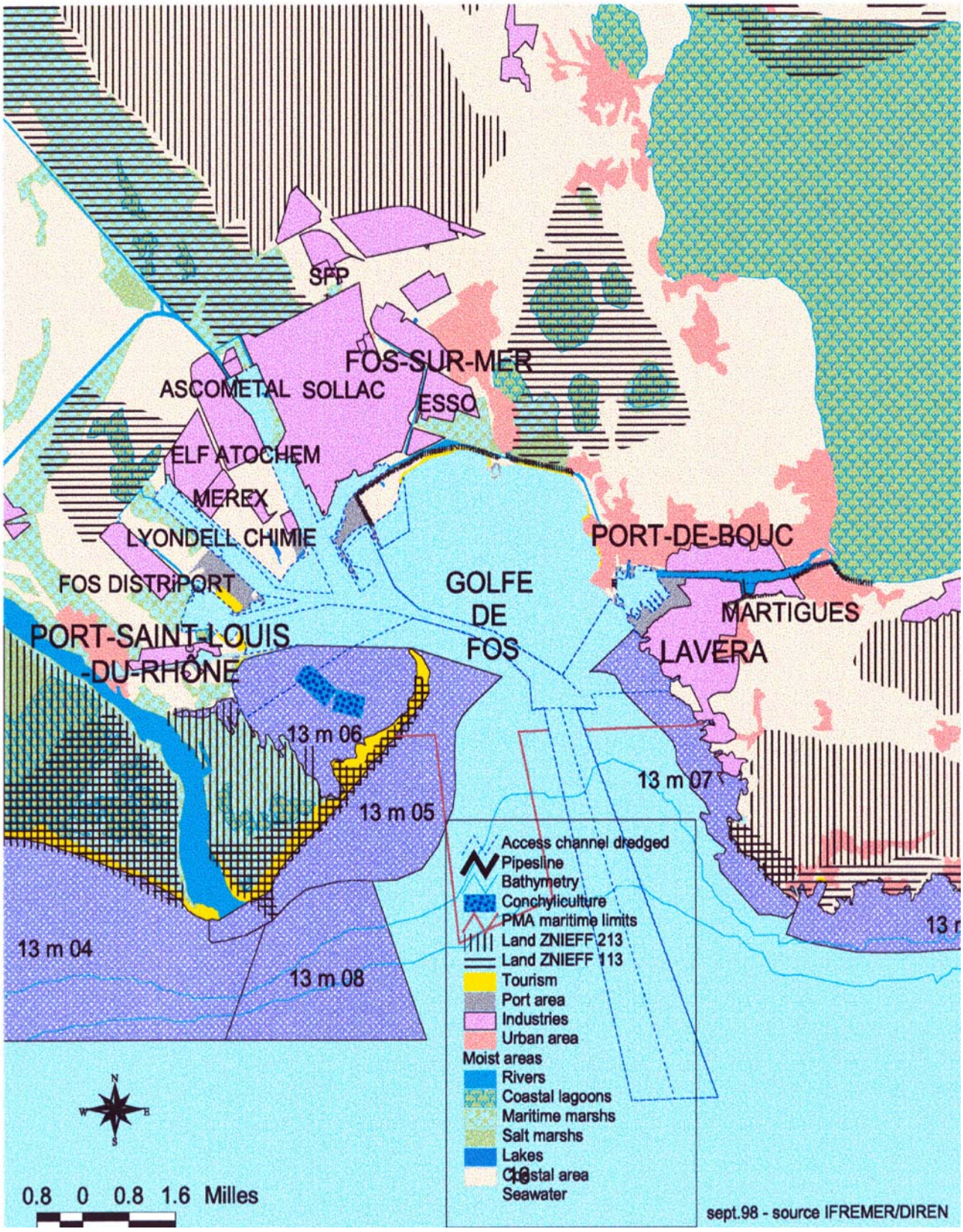
1. DESCRIPTION OF THE ACTIVITY

1.1 Situation of the activity



Source : CLC (IFEN) IFREMER, 1998

Figure 1 : Localisation of the western PMA industries

1.2 Industrial polluted waters

1.2.1 Generalities

In 1996, the PMA made a healthy contribution in support complex mainly devoted to oil refining, base chemicals, iron and steel industry and off-shore construction.
The industries of Fos are under strict laws, they are classified installations. They are grouped in SPPPI (Permanent Secretariat for Industrial Pollution Problems), permitting :

- Diffusion of information and dialogue about environmental problems.
- Obligation of the transparency of the information about industrial polluted waters.
- Application of national rules, to improve the environmental protection action.

Polluted treated waters from the industries are discharged into different docks :

- Dock 1 for Gaz de France, Ascometal, Sollac and Air Liquide Tonkin;
- Dock 2 for Elf Atochem, SCVF, and Lyondell Chimie France;
- South dock for Esso;
- Lavera port for Ferro.

The total discharge of suspended matter is 1.4 tonnes per day for all the industries. We will only study the discharges for six of them.

1.2.2 The six industries of the PMA

1.2.2.1 Elf Atochem (Photo 1, Figure 1)

Its activities are : storage, transhipment and chemistry of first transformation. The products manipulated are : chlorine, soda, bromine and bromine derived, pentasulphide of phosphorus, chloride of vinyl monomer. The industrial production in 1994 was :

- Chlorine (chlorate of vinyl) : l ,270,000 T/year.
- Soda (Paper, aluminium and glass industry) : 300,000 T/year.
- Chloride of vinyl monomer (plastic matter, PVC) : 400,000 T/year.
- Trichloride of phosphor/phytosanitary : 18,000 T/year.
- Pentasulphide of phosphorus (additive for the synthesis of lubricant) : 20,000 T/year.

1.2.2.2 Ascometal

Its activities are production, lamination, special steels metallurgy. The products manipulated are special steels. The industrial production in 1994 was 261,231 T/year for the expedition of steel.

Photo 1 : Elf Atochem industry (source : PMA).

Photo 2 : Lyondell Chimie France industry (source : PMA).

1.2.2.3 Lyondell Chimie France (Photo 2, Figure 1)

Its activities are : transformation, storage and transhipment. The products manipulated are : Methyl tertio butyl ether (MTBE), polyols, glycols and propylene oxide.

Industrial production in 1994 was :

- Oxide of propylene : 220,000 T/year.
- Methyl tertio butyl ether : 600,000 T/year.
- Propylene glycol : 80,000 T/year.
- Polyols : 110,000 T/year.

1.2.2.4 Esso Raffinage (Figure 1)

Its activities are : refining and storage. The products concerned are crude oils and gas. The industrial production in 1994 was :

- Liquefy gas, propane/butane : 200,000 T/year.
- Propylene : 30,000 T/year.
- Mixture (petrol) : 840,000 T/year.
- Mixture reactor (plane) : 250,000 T/year.
- Gasohol and fuel suspended solid : 1,600,000 T/year.
- Heavy fuel : 750,000 T/year.
- Bitumen : 155,000 T/year.

1.2.2.5 Sollac (Figure 1)

Its activities are production, lamination, expedition of finished goods, loading, unloading and storage. The products concerned are soft and special steels, ore, coal and others solid combustibles. The industrial production in 1994 was :

- Melting : 4,255,537 T/year.
- Steal : 4,109,465 T/year.
- Coils : 4,015,397 T/year.

It is a integrate metallurgy factory making laminate tools in bobbin.

1.2.2.6 Polytelene Fos Society (SPF, Figure 1)

The industrial production in 1994 was :

- Ethylene polymerised : 100,000 T/year.
- Polyethylene grades film : 55,000 T/year.
- Polyethylene grades induction : 45,000 T/year.

1.3 Laws

1.3.1 European laws

- Directive 73/404/EEC dated November 22nd, 1973, concerns the rapprochement of the legislation of the States Member about detergents. It is modified by the directive 86/94/EEC dated March 10th, 1986.

- Directive 76/464/EEC dated May 4th, 1976, concerns the pollution deriving from dangerous substances unloaded in water environment of the Communities. An authorisation of reject is necessary.

- Directive 77/585/EEC dated July 25th, 1977 IS relative to the conclusion of the convention for the protection of the Mediterranean Sea against pollution.

- Decision 81/420/EEC dated May 19th, 1981 concerns the conclusion of the draft treaty relative to the cooperation in the struggle against pollution of the Mediterranean Sea by hydrocarbons and other dangerous substances.

- Directive 82/176/EEC dated March 22nd, 1982 and 84/156/EEC dated March 8th, 1984, concern the discharge of mercury. French application are in November 21st, 1991 and March 1st, 1993 decrees.

- Directive 82/242/EEC dated March 31st, 1982 and 82/243/EEC of the same day, concern the discharge of detergent.

- Directive 82/501/EEC called SEVESO I, concerns the risk of accident of some industrials activities. The Directive SEVESO II dated December 9th, 1996 n° 96/82/EEC concerns the control of danger due to accident. This Directive substitute the Directive SEVESO I.
- The principles of these directives are : the industrials manipulating dangerous substances must take precautions to prevent accidents who can have consequences on humanity and environment.

The article 5 specifies that the States Member must dispose about a regulation requiring industrials to make danger study and to pass on competent administration.

- Directive 83/513/EEC dated September 26th, 1983 concerns the limit values and the objectives of quality for cadmium rejects. French application is in September 26th, 1985 decree.

- Directive 84/156/EEC dated March 8th, 1984 concerns the limit values and the objectives of quality for mercury rejects coming from other sector than the electrolyse of alkaline chlorides.

- Directive 84/491/EEC dated October 9th, 1984 concerns the limit values and the objectives of quality for hexachlorocyclohexane (HCH) rejects.

- Directive 84/513/EEC concerns the cadmium discharge from industries.

- Directive 84/891/EEC about the HCH discharge are in March 6th, and 1986 March 1st, 1993 decrees.

- Directive 86/280/EEC about pesticides defines the limiting values as the objective of quality. French applications are in March 1st, 1993 decree.

- Directive 90/164/EEC is there to prevent and reduce the environmental risk.

- The Gulf of Fos is not classified sensitive area as define by the European directive 91/271/EEC.

- Directive 96/61/EEC on Integrated Prevention Pollution and Control "IPPC" dated September 24th, 1996 is a copy of the French Classified Installations legislation.

1.3.2 French laws

- All discharges of liquids or solids having negative effect for the marine environment will be punished by the article 7, decree January 9th, 1952.

- Law dated September 12th, 1973 defines the norms of quantity and quality of the water discharge. Then when SPPPI was created in 1973, they fixed objectives to reduce impacts and industrials risks. They also fixed more restrictive rules on the Fos area than the national rules.

- July 19th, 1976 law relates to «classify installations for the protection of the environment» permits the checking of those activities, and limits the impact of the pollutants on the environment. The industrials file an authorisation ask which is composed by a study about the impact in the environment and a danger study.

If there is pollution caused by an industrial classified installation, a punishment will be made by the July 19th, 1976 law and September 21st, 1977 decree.

Those industries have an authorisation to work only if they comply to strict criteria proposed by the DRIRE (Regional Direction of Industry and Environmental Research) and imposed by order of the prefect. Each industry has his specific order of the prefect and has to respect it. They can be inspected to control if they respect the prescriptions.

- The water law n° 92.3 dated January 3rd, 1992 concerns the treatment of the polluted waters coming from industry. This law classifies the industrial installations that have an impact on water :

    1. The discharges, which can disturb the marine water, are under the rules of the classified installations (art. 11). Those rules were modified by the law dated February 2nd, 1995.
    2. The order of the prefect brings information concerning the area where the discharge is authorized as the condition of the discharge (art. 2). The limiting values have to be compatible with the objective of quality of the ecosystem. For that purpose, the order of the prefect defines different levels according to the flow, the level of dissolved oxygen and a lot of other parameters.

3. The points of rejection in the sea have to facilitate a good distribution of the pollutants (art. 49).
4. Each canalisation has to be specially equipped to measure the quality of the water (art. 50 and 51).
5. The inspector of the classified installations (art. 60) regularly controls the results of the water quality (every month).

- The adopted prevision to implement dated March 1st, 1993 concerns classified installations. The decree n° 93-742 was adopted in March 29th 1993.

- Decree dated February 2nd, 1998 is about the classified installations. The decree precisely defines the values of the discharged industrial polluted waters.

1.3.3 Uniform protection areas

The decision 84/132/EEC dated March 1st, 1984 concerns the conclusion of the draft treaty relative to the special protected areas in the Mediterranean Sea.

The ZNIEFF are areas itemised for the national inventory of the natural patrimony, presenting an ecological interest. It is a tool for knowledge, and have a juridical value. The area of the Gulf of Fos has two ZNIEFF :

- The ZNIEFF n° 13M06 called “Anse de Carteau” which has an interest for fishing and for the biologic species (*Posidonia oceanica* meadows…).
- The ZNIEFF n° 13M05 is in the area of the “They de la Gracieuse”.

The marine preserved areas (coastal law n° 86-2 dated January 3rd, 1986) are :

- Marine ZNIEFF, *Posidonia oceanica* meadows, Shellfish seam area, Spawn area for ichthyofauna.

2. POLLUTION SOURCES (CONCERNED SUBSTANCES AND BY-PRODUCTS)

2.1 Generalities

The Gulf of Fos is a semi-enclosed area with intense and variable weather phenomena. The weather creates a high variability (spatial and on the time) for the water quality in the area.

The industrial polluted waters discharged in the sea come from different activities : chemical or metallurgic activities, treatments of oils products. They bring organic matter and toxic elements like pesticides, detergents, heavy metals, hydrocarbons, nutrients, and salts in the marine environment.

The marine water movement is controlled by south-east winds, which push to the coast the water body and increase the water turbidity in the port basin.
With the Mistral wind (north-west) the phenomenon is inverse and pushes to the large the Rhodanien flux and the coastal maters.

Fresh woody water and the seawater have difficulties to mix at the outlet. The initial dilution will depend upon :

- the flow of discharged water,
- the difference in density of the effluent and the seawater,
- the presence of diffusers at the outlet,
- the depth of the emissary,
- the topographic conditions of the area.

In the immediate area of the discharge, if the effluent reaches the same density as the seawater at a certain depth, the effluent will “float” at this level. But if the sea density stays heavier the effluent will float above the sea level.

The winds and currents will disperse the effluent, increasing the vertical and horizontal dispersal. But, the horizontal dispersal is preponderant and the plume stays in surface.
In surface, waters are no much salted, but the temperature, the pH values and oxygen concentrations are highest.

There are different groups of pollutants found in industrial polluted waters. For example, near the mineral wharf, mercury, chrome and hydrocarbons are in high values.

2.2 The groups of pollutants found in industrial polluted waters

2.2.1 Pesticides

Pesticides cover a wide range of chemical structures and exhibit a great variety of physical-chemical properties, which control their fate in marine organisms.
The majority of them are highly toxic for marine species as well as for man. Some pesticides containing chlorine or other halogens groups are known to be highly persistent in the marine environment.

The most dangerous pesticides are the more stable because they give off stable and toxic elements.
Organochlorinated compounds (DDT, DDE, TDE and PCB) are more stable so more toxic than organophosphorus substances very toxic but rapidly hydrolysed by the seawater.

The insoluble pesticides in marine water have the tendency to get fixed on organic substances. Marine organisms apply an important role on the concentration and on the transport of those pollutants.

The marine organisms can be contaminated directly by the environment area or by eating prey already contaminated. The more dangerousness effect is up in the food chain.

The pesticides absorbed by marine organisms are concentrated in fat corps (fat and liver). The marine organisms present different resistance to the pesticides. The larval forms are more sensitive than adult forms.

The pesticides can affect the motor comportment of the fish. It is due to the inhibition of an enzyme essential for the functioning of the neuralgic system.

It can also affect the photosynthesis of the plankton. It is harmful for the fish because there is a decrease at the base of the food chain. The pesticides get more concentrated in sediments containing important percentages of organic matter, but the concentration decreases with the time. After a certain time of contact the pesticides are spread in the sea, and are as a consequence disposable to all other organisms.
In the Gulf of Fos there is an average of 5 μg/l (background noise) of the pesticide value. The maximal values are measured up to 51 μg/l.

2.2.2 Detergents

Detergents are complex molecules, composed with base product of adjuvants, and solvent charges. The variety of the detergent is due to the electrochemical property of the base products.
There are anionic (sulfates, sulfonates, phosphates, carbamates... are the most used in commercial products) cationic and non ionic detergents.

Detergents bring important supplies of nutriment elements inducing a quick increase of the algae population, and eutrophisation problem in an enclosed marine area.

The most toxic detergent to marine organisms are first the cationic, then the non-ionic and at least the anionic detergent. The detergent affects the different phases of the biological cycle of the animal species and specially the laying and the maturation of eggs.
The detergent backgrounds in the Gulf of Fos are around 5 μg/l, but the concentrations can go up to 40 μg/l.

2.2.3 Alcohol

Alcohol above C7 is mobile waxy solids at mostly ambient temperatures and would, if it released into the marine environment, cause some interference with the amenity use of the bathing water.
Primary saturated alcohol shows an increase in toxicity to marine organisms with increase in carbon number, but in practice the extent of this increase is limited by their water solubility.

2.2.4 Chlorinated paraffin

They are produced in large quantity and have a wide use. They accumulate in mammals, both in fat tissues and in the nervous system.
The carbon chain length is important for the bio-accumulation potential. Short chain and high level of chlorination give the slowest excretion rate, and retention could last for more than ten months. Low-chlorinated paraffins with short carbon chain length are the most toxic.

2.2.5 Heavy metals

Heavy metals correspond in the Mendeleiev classification to all the metals that are between the chrome and the zinc (manganese, iron, cobalt, nickel, and copper).
Some other metals are also called heavy metals like cadmium, mercury, lead, arsenic and molybdenum.
The most toxic are the cadmium and the mercury. Cadmium is used in plating process (55 to 60%), pigment fabrication (30 to 60%), metallurgic industry (7 to 10%). Mercury is used for the fabrication of electronic displays, and painting fabrication.

The water compartment of Gulf of Fos are lowly contaminated by heavy metals, comparing with natural values (Table 1) :

- Mercury has a medium average of 0.05 μg/l with a maximum of 0.13 μg/l.
- Cadmium has a medium average of 0.08 μg/l with a maximum value in July of 3.10 μg/l.
- Lead has a medium average of 12 μg/l with a maximum value of 42 μg/l.

Table 1 : Natural concentrations of the metallic trace elements in the seawater (Kennish, 1990; United Nations Environment Programme, 1989)

HEAVY METAL	TENOR (in µg/l)
Silver	0.5 - 1.5
Cadmium	0.02 – 0.25
Cobalt	0.05 - 0.4
Chrome	0.2 - 0.5
Copper	0.2 – 0.5
Iron	0.2 - 10
Mercury	0.01-0.2
Molybdenum	0.2 - 10
Manganese	0.2 - 4
Nickel	0.4 – 10
lead	0.02 - 4
Zinc	2 - 12

The toxic values are different to invertebrate and fish (Table 2).

Table 2 : Toxic values to invertebrate and fish, by IFREMER

TOXIC VALUE OF	TO INVERTEBRATE	TO FISH
Copper	0.15 mg/l	0.12 mg/l
Zinc	14.3 mg/l	0.14 mg/l
Chrome	7.35 mg/l	0.07 mg/l
Lead	16.5 mg/l	0.16 mg/l
Mercury	0.68 mg/l	0.13 mg/l

The heavy metals discharged in the marine environment are adsorbed by the sediments, and concentrated by the phytoplankton, the superior algae, the benthic and pelagic fauna... all along the food chain.

The marine organisms accumulate toxic elements from the water but also by eating prey contaminated. The factor of transfer of the toxic elements to the marine organisms will depends upon the metallic elements, but also upon the marine species.

The algae, first link in the food chain is highly contaminated, so are the larval stages and the marine mollusc, which is due to their great capacity to filter the seawater. In fact, all those organisms are used to detect marine pollution (they are bio-indicators).

The mercury is toxic but even more with the methyled form. The biological period of the methyl mercury vary between 480 days and several years depending on the methyl form. The methylation is the result of the microbial activity. It is a very slow process. If the animals are contaminated by the methyl mercury there is a very slow elimination and so the muscles also get very contaminated.
The localisation of the zinc concentration in human beings is first in the liver, then in the spleen, and at least in the muscles and bones. The liver and kidney are also organ, which have high rate of contamination by mercury and cadmium. If the animals are contaminated by the methyl mercury there is a low decontamination. The ionic forms of metal are quickly assimilated because they come through the biological membrane.

The pollution forms in the sea are very variable. Synergistic or antagonistic effects can accelerate or stop the retention of the heavy metals in cells.

The toxicity of the mercury elements is due to their great affinity to the sulfydryles-SH group. The –SH group is vital for the enzyme and the cell of the membrane. Also in high concentration the metal perturbs and inhibits the activity of the enzymes.

The pathological effects of the cadmium show themselves in marine organism by a cells proliferation. The death can then occur by asphyxia. For low concentrations, cadmium can create morphological and histological deterioration of internal organs (liver and spleen).

2.2.6 Nitrogen and phosphorus

The values of the nitrates are low, with an average of 2 μg/l in the Gulf of Fos area. We can observe short term peaks in 1985, 1988, 1989 and 1991.

The lethal dose for fish are around 0.1 mg/l. The water becomes dangerous when the concentration are above 10 mg of phosphorus/cu.m for assimilated forms or 200-300 mg N/cu.m for inorganic forms.

Between 1985 and 1988 the values are above 1 μg/l with the maximum equal to 6.45 μg/l. Since the second trimester 1988, there has been a decree of the rate concentrations due to the amelioration of the water treatments.

The lethal doses for the fishes are around 0.5 mg/l of ammoniac.

2.2.7 Polycyclic aromatic hydrocarbons (PAH)

The PAH were studied in surface waters, in Rhone delta in September 1986, January and June 1987. Both dissolved and solid phases were analysed.
Major unsubstituted PAH in the solid phase showed concentrations from 1 to 20 ng/l. Seasonal variations indicated high inputs in winter and in late summer.
The PAH in the dissolved phase were more abundant than those associated with particles. Their concentrations varied from 4 to 119 ng/l and highest inputs occurred in winter period (Bouloubassi and Saliot, 1992).

3. CONSEQUENCES

3.1 Effects in the environment

The discharge of industrial waters in the marine environment has three types of pollution effects :

- A superficial pollution (light products, oils..) that will essential drift with the wind.
- A dissolved pollution that will be in the water column more or less thick.
- A settled pollution that will sediment and accumulate on the bottom.

3.1.1 Physical effects

The wind creates a surface current which induces vertical mixing and horizontal diffusion.

If the effluent stays in the surface, during its course, there are slow diffusion and dilution. These phenomena are studied by marking methods with colorants or radio-elements.

The outlets are buried in rocks. The effluent flow and the modifications of natural physical characterisations are as harmful than natural agitation conditions, in strong wind conditions.

The dock is a reception and settlement zone. But the physical characteristics of the sediment and the topography are not modified near the outlet.

3.1.2 Biological effects

The discharge waters bring particles in suspension. The heaviest particles sediment and create a dejection cone around the outlet which covers benthic population.

All the organisms have not the same comportment against heavy metals and metal forms. Except mercury, each organism does not assimilate and eliminate heavy metals with the same way. This variation is dependant on biological, physical-chemical and hydrobiological factors (IFREMER, 1985).

A single mussel is able to filter up to 10-15 litres of water per hour, concentrating in it a quantity of micro-organisms 100-200 times higher than the sea.
The macrofauna and meiofauna in loose sediment are characteristic of unstable sites where the particular matter is often putting back in suspension. The high density of filter organisms indicates the importance of the suspended particles in the food mode, near the outlet (CREOCEAN, 1997).

The bio-concentration is a major interest in the monitoring of the pollutants. The algae and bivalves are bio-indicators of accumulation. During their long life, they integrate the medium contamination and its variations in the time.

There are positive bio-indicators which are tolerant against the pollution and negative bio-indicators which are sensible against the pollution.

In fact, the bio-indicators are irreplaceable tolls of investigation in the conservation of the littoral ecosystems of the Mediterranean Sea (Ramade, 1992).

3.1.3 Chemical effects

The treatments of polluted industrial waters induce some products increase :

- Discharge of free chlorine or chlorinated compounds in water;
- Discharge of metals;
- Discharge of derived products of synthesised organic molecule and products of biological decomposition (lagoonage, biological reaction).

3.2 Impacts in the environment and the users

3.2.1 Physical impacts

In the nearest field the concentrations are the highest, and the impacts on biota are clearly due to a dominant origin. More the wind is strong best will be the dilution of the industrial water.
In the faraway field, the pollution can be due to a reappearance of hydrodynamic flux. The pollution found can be caused by different industrial origins.

3.2.2 Biologic impact

Active filtrated organisms such as mussels, asides and passive filtrated organisms as tubicols worms characterize the area near the discharge.
A thin cover of clay can recover the organisms, whom are opportunists invidious feeding themselves by catching suspended particles brought by the discharges. Those organisms living in loose area are a sign of instability.

During summer time, alteration of the water quality can occur due to the high concentration of organic substances. In this situation there is a proliferation of phytoplankton and algae that can lead to a lack of oxygen.

3.2.3 The impact on the users

The PMA is subjected to different constraints : harbour constraint, social constraint (bathing activity, amateur fishing…), and natural constraint (protected area in the Saint-Louis-du-Rhône canal).

The problems of micro-pollutants are theirs accumulation in marine organisms all along the food chain. For example at “L’Anse de Carteau” in the Gulf of Fos there is a shellfish production, and because humans eat sea products, we are also concerned by the quality of the shellfish farming.

Pollution also affects bathing coastal areas : pathogenic micro-organisms and algae are toxic for the health of the bather.

Last but not least there are problems related to the corrosive effects of some substances (which might increase their effects in combination to other polluting substances in the water). Those substances erode the under building structure of ports and ships, shortening their life. A similar effect is caused by a high concentration of deposits, which have a corrosion effect due to continuous friction, wave motion and streams.

4. ACTIONS TAKEN

Safety, protecting the environment and pollution control represent three of the PMA priorities. Apart from being one of the major oil ports of the world, further motivation comes from managing southern largest port industrial zone in Europe, an intensive steel, refining and chemical complex.

4.1 Western PMA control of the industrial polluted waters

The treatment of waste water was reinforced since 1996. For its part, the PMA has reinforced protection of substrata and installed an anti-salt barrage on the Arles-Fos freshwater canal. Industrial waste solids are disposed of on-site at in special treatment centre.

4.1.1 Elf Atochem (Photo 1, Figure 1)

The collection and treatment of industrial polluted waters are composed of :

- The washing of the spout of the outlet,
- The process water that contains mostly minerals salts, chloride, sulphate and sodium (pH near the neutrality).

The global norms defined by the order of the prefect on site are : - Debit : 7,550 cu.m/day - Suspend solid : 130 Kg/day – Carbon Organic Dissolved (COD) : 390 Kg/day - and pH between 5.5 and 9.5. The quality of the water after treatment is indicated in Table 3.
When industrial site was created it already had techniques to limit industrial polluted waters :

- Two incinerators for gas and liquid,
- A biological and chemical treatment for the waste water.

The capacity of industry has increased in 1990 – 1992, without changing the impact on the environment site. It is due to the permanent research done to improve and to reduce industrial waste.

Table 3 : Quality of the water after treatment

DATE OF MEASUREMENT	BICHLORE (Kg/day)	HYDROCARBONS (Kg/day)	SUSPENDED SOLIDS (Kg/day)
1st trimester 1998	0.47	142.02	73.73
2nd trimester 1997	0.31	165.57	66.45
1st trimester 1997	0.34	211.94	91.86
4th trimester 1996	0.38	143.89	73.50
3rd trimester 1996	0.51	197.36	112.91

4.1.2 Ascometal (Figure 1)

The collect and the treatments of industrial polluted waters are composed by :

- Neutralisation station for acids used during the cleaning,
- Five mini-stations for water treatment,
- Three discharge separators of the oil.

Analyses are done regularly, every week (Table 4). A new method is being thought of to reduce the consummation of cleaning water.

Table 4 : Quality of the water after treatment

DATE OF MEASUREMENT	HYDROCARBONS (Kg/day)	SUSPENDED SOLIDS (Kg/day)
1st trimester 1998	1.47	69.19
2nd trimester 1997	12.68	41.58
1st trimester 1997	1.66	28.94
4th trimester 1996	1.52	28.13
3rd trimester 1996	0.29	43.02

4.1.3 Lyondell Chimie France (Photo 2, Figure 1)

The network that collects and treats industrial polluted waters are composed of :

- Thunderstorm basin for rainwater.
- Homogenisation basin for the used water.
- Primary physical-chemical treatment.
- Biological treatment in three basins of 3,600 cu.m (output > 98%; capacity 65 T/hour).
- Thickening of the mud and deshydratation.
- Lagooning of 72 hours (superficies : 10,000 sq.m).

The results of these treatments are notified in Table 5.

Table 5 : Quality of the water after treatment

DATE OF MEASUREMENT	DISSOLVED ORGANIC CARBON (Kg/day)	HYDROCARBONS (Kg/day)	SUSPENDED SOLIDS (Kg/day)
1st trimester 1998	170.80	3.19	26.27
2nd trimester 1997	224.75	15.51	24.41
1st trimester 1997	148.89	3.73	35.70
4th trimester 1996	223.24	77.10	32.67
3rd trimester 1996	152.32	48.80	34.35

4.1.4 Esso Raffinage (Figure 1)

The collection and treatments of industrial polluted waters are composed of :

- Efficient purification station.
- Distillation station.
- Unity of cracking catalytic.
- Unity of reformation.
- Unity of purification.
- Unity of recuperation of sulphur.
- Unity of purification of propylene.

The quality of the final water discharge is guaranteed by sampling continuously and by a daily analysis (Table 6).

Table 6 : Quality of the water after treatment

DATE OF MEASUREMENT	DISSOLVED ORGANIC CARBON (Kg/day)	HYDROCARBONS (Kg/day)	PHENOL (Kg/day)
1st trimester 1998	572.52	49.42	0.33
2nd trimester 1997	301.89	6.71	0.09
1st trimester 1997	449.07	14.49	0.08
4th trimester 1996	451.97	5.03	0.07
3rd trimester 1996	354.66	7.18	0.07

4.1.5 Sollac (Figure 1)

The collection and treatment of industrial polluted water are composed of :
- The purge of the cool down circuits, from the fabrication unit,
- The water treatment is a plant with three steps : physical-chemical, biologic, lagoon.

The results are notified in Table 7.

Table 7 : Quality of the water after treatment

DATE OF MEASUREMENT	CYANIDE (Kg/day)	DISSOLVED ORGANIC CARBON (Kg/day)	AMMONIUM (Kg/day)
1st trimester 1998	0.66	882.42	180.46
2nd trimester 1997	1.88	1,038.40	249.60
1st trimester 1997	2.29	1,357.10	303.32
4th trimester 1996	0.72	403.44	279.35
3rd trimester 1996	0.59	884.95	235.24

4.1.6 SPF (Figure 1)

The collection and treatment of industrial polluted waters (Table 8) are composed of a station with two stages of physical separation : effluent aqueous/granulated, water/oils.

Table 8 : The quality of the water after treatment

DATE OF MEASUREMENT	DISSOLVED ORGANIC CARBON (Kg/day)	HYDROCARBONS (Kg/day)	SUSPENDED SOLIDS (Kg/day)
1st trimester 1998	28.059	0.94	4.78
2nd trimester 1997	18.770	0.69	3.35
1st trimester 1997	14.960	0.82	4.50
4th trimester 1996	24.629	1.85	4.36
3rd trimester 1996	27.719	2.37	2.20

4.2 Western PMA control in the environment

Coastal zone is devised in “homogeneous” areas. Three level of impact are studied :

1. The first field is the nearest zone to the coast. It corresponds to the area where are the dilution of the rejects. In the Gulf of Fos, it goes up to the bathymeter 30 m.

2. The medium field starts at the bathymeter 50 and goes up to 100 m. In this area the pollutant concentration are all mixed up.

3. Then the last field starts at the bathymeter 100 m, and it is related to the background noise.

The area of the Gulf of Fos is covered by the coastal zone n°16, between the Rhone mouth and Cap Couronne (Figure 2). Different analysed are done :

1. The **RNO** (National Observation Network), is a network managed by IFREMER (French Institute of Research in the Sea) for the Environment Ministry. The RNO existing for more than 20 years; it measures, in the Gulf of Fos, the quality of :

- The water column on three stations once per trimester.
- The sediments every time the dredging operation is done.
- The living matter on three stations once per trimester.

2. The **REPHY** (Phytoplanktonic Network) and **REMI** (Microbiologic Network) measure the phytoplanktonic and microbiological quality of the water.

The measurements are done by IFREMER which measures, in the Gulf of Fos, the quality of :

- The water column on two stations REPHY every 15 days in winter and every week in summer.
- The living matter on two stations REPHY and five stations REMI once every month or more frequently in case of pollution.

3. The **RSP** (Posidonie Watching Network) measures the global quality of the area using the vitality of the vegetal plantation as a biologic indicator. The observations are done once a year by GIS-Posidonie, a research organisation.

4. The **CQEL-13** (Water Police) controls the PMA actions and monitors the direct discharge of the industrial waters and their impacts on the quality of the port area :
   - 8 stations are analysed in the area of the Gulf of Fos.

5. The **DDASS** (Departmental Direction of Social and Sanitary Actions) monitors the microbiological quality of the water in the bathing area.
   - 12 measurements done per year in summer time in the water column on 7 stations along 5 towns in the Gulf of Fos.

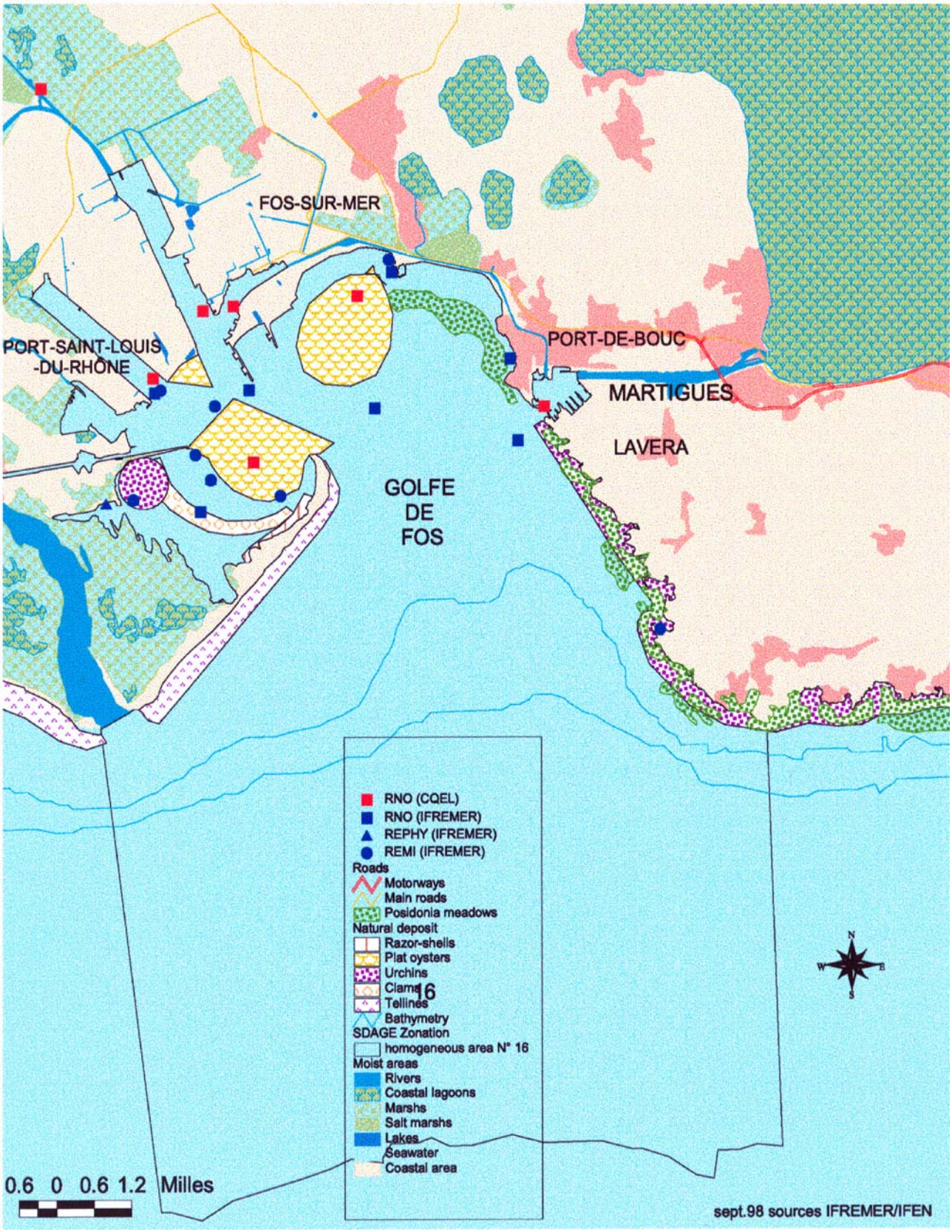
6. **REPOM** (National network to the survey of the maritime ports), will constitute for the France, an international scale of network reference. The circular dated March 7th, 1997 from the Environment Ministry, asks at the CQEL to put in place this REPOM.

The objectives of the REPOM are to monitor the water quality and the sediments quality of the port areas. This monitoring will permit to :

- Have a global view of the pollution created by ports.
- Bring to the GEODE group[3], actualise data on the quality of the sediments.
- Create adequate standards relating to the disposal of the dredging wastes.
- Evaluate the port quality.
- Have objective information to incite the port managers to research good solutions permitting to eliminate the pollution at the source.

The REPOM will study the water and the sediment quality on the PMA. The water quality analyse will be done on more than two stations four times a year (one analyse every three months). The parameters analysed will be bacteriological (*Escherichia Coli, coliforms faecal, Streptococcus faecal.*.), and physical-chemical (temperature, salinity, percent of dissolve oxygen, suspended matter, ammonium, transparency...). The contaminants analysed in the sediment will be done at each dredging operation.

[3] GEODE : Group of Study and Observation about the Dredging and the Environment.



Source : CLC (IFEN), IFREMER, 1998

Figure 2 : Homogeneous area n°16 : Mouth of Grand Rhone to Cap Couronne

5. MONITORING

In 1971, the French interministerial group for marine pollution problems proposed the creation of a national network for the survey of marine environment. The Oslo and Paris conventions created the Working Group on Environmental Assessment and Monitoring Strategies (WGEAMS), in 1992. They monitor :

- The quality of the marine environment and each of its compartments,
- The activities or the natural or anthropic supplies which can influence the quality of the marine environment,
- The effects of activities and supplies.

The objectives of this monitoring are to :

- Describe the spatial distribution of a serial of physical, chemical and biological parameters.
- Determinate chronological tend with adapted indicators.
- Define the relation between anthropic activities.

The monitoring is about :

- Parameters of the general quality.
- Chemical contamination and its effects.
- Bacteriological contamination.
- Toxic plankton.

Three conventions induced international programs of monitoring :

- The Helsinki convention (HELCOM) relatives to the protection of the marine environment and the Baltic Sea.
- The Paris convention (OSPAR) relatives to the protection of the marine environment and the north-east Atlantic.
- The Barcelona convention (BC) relatives to the protection of the marine environment and the Mediterranean Sea, with the MEDPOL program of monitoring.
- The North Sea Conference (NSC) which induced the North Sea Task Force (Joanny, 1997).

5.1 How to plan environmental controls on the activity

Industries are required to provide a comprehensive safety organisation involving a local contingency plan tool.

Each industry has to do self-checking of it is polluted waters. An industry is engaged in a continuous improvement of its technique to limit the pollution of the marine environment, in accordance with the law from the prefect orders.

The frequency, the characteristics of the pollutant analysed, the methods applied are defined in the authorisation order from the prefect. The analysis of the water quality will be done with different parameters :

- **BOD_5** (Biochemical Oxygen Demand) determines the quantity of the oxygen necessary to aerobic micro-organisms to assimilate and degrade the organic substances contained in liquid sewage or other matrices. The methodology is set out by the standard ISO 5815 : 1989 Water quality - Determination of BOD_5, dilution and seeding method.
- **COD** (Chemical Oxygen Demand) indicates the quantity of oxygen necessary to chemical oxidation in a standard operational way the organic substance. The methodology is set out by the standard ISO 6060 : 1989 Water quality - Determination of the Chemical Oxygen Demand.
- **Total suspended solids** are above 0.5 μm.

The results of the industrial water quality are transferred to the DRIRE (Regional Direction in Industry and Environmental Research). Since 1993, all the results are computerised (MAIRAN system) which allow a quicker treatment of the information. The DRIRE is then rapidly informed about the industrial water quality. When the standards of quality are not respected, the DRIRE makes a report for infraction.

The DRIRE and the Water Police can do surprised control on industrial water discharges. They measure the quality of the water, and for this, they detect the concentration of metals (Zinc, Copper, Aluminium, Cobalt,…), ortho-phosphates, total phosphate and Biologic Oxygen Demand during five days ($BOD_{5,...}$) contained in the effluent.

The DRIRE has priority to monitor toxic discharge in the marine environment (Table 9).

Table 9 : Priorities of the DRIRE

PRIORITY/TOXICITY	1 to 10 g/day	10 to 100 g/day	100 to 1 Kg/day	> 1 Kg/day
Very toxic substance and harmful (36 substances).	Priority 3	Priority 2	Priority 1	Priority 1
Toxic substance and harmful (39 substances).		Priority 3	Priority 2	Priority 1
Noxious substance for the organism, and low toxic substance (57 substances).		Priority 3	Priority 3	Priority 2

Each industry has specific authorisation depending to the products rejected. As an example the parameters specified (prefect order n° 48–1995 dated January 1st, 1996) for Efl Atochem chloride of vinyl monomer activity are listed bellow.

The values of the treated industrial water have to be as the authorisation say so :

- Medium flow < 4,000 cu.m/day,
- DCE = 2.5 mg/l/month or 5 Kg/day,
- CVM = 8 mg/l or 2 Kg/day,
- Aluminium = 5 mg/l or 4 Kg/day,
- Colbalt < 15 µg/l,
- Total phosphorus = 2.5 mg/l/month or 20 Kg/day,
- Colour has to be colourless,
- pH between 5.5 and 9,
- Cooper = 0.5 mg/l or 0.9 Kg/day,
- Suspended solids = 35 mg/l or 80 Kg/day,
- Dissolved Organic Carbon (DOC) = 125 mg/l or 240 Kg/day.

The parameters measured daily in the effluent are the flow, the pH, the Suspended Solid, the DOC, chloride and the total phosphorus.

A global study on industrial discharge impacts has been engaged since 1994 for the Gulf of Fos. It is due to the order of the prefect dated March 1st, 1993 (article 64) relative to industrial discharges authorisation. It is also due to the aim of the DRIRE and the Water Police asking for a better knowledge of the marine environment receiving industrial discharges.

An ecological monitoring about the effects of industrial water discharge is done. This survey evaluates the impact and determines if in the time the discharges affected the area.
The objectives of the survey are :

- Description of the industries and treatment installations,
- Characterisation of the effluents,
- Description on the initial state of the environmental area,
- Analysis of the direct and indirect effects, temporary or permanent of the industrial discharges,
- Determination of the discharge extends panache, to reveal the area of influence and calculate the dilution,
- Determination of the physical-chemical quality of the sediments, the quality of the living matter with the study of the benthic population, the macrofauna and macroflora to establish the biological diagnostis in the panache area.

After the analysis of the results the Water Police and the DRIRE will carry out a monitoring programme.
Sea water are often sampled by the Water Police, to check their quality for the PMA. The Water Police belongs to the Ministry of the Environment. Water is sampled all the way into the docks on five sites (Figure 2).

The analyses are done ten times a year (one analyse per month except on June and December).

The parameters taken in account to evaluate the quality of the seawater area are :

- Physical (temperature, …),
- Chemical (SiO_3, NO_3, NO_2, NH_4, PO_4, hydrocarbons, PCB, salinity, suspended solids …),
- Biological (marine organisms, chlorophyll…).

The suspended matter reduces the luminosity, which decreases the vegetal productivity and the development of the benthic fauna. There is also a fall of the dissolved oxygen because it limits the photosynthetic phenomena.

The nutrients are chemical species straight assimilated. They can be toxic like nitrogen, ammonium. Nitrate and phosphate are partly responsible of the eutrophisation phenomena, which induce the anoxia of the area and consequently the death of the fauna and flora.

Sampling and analyses of the bathing water are done in seven sites. A unit that belongs to the Ministry of Health performs them. Every beach near the PMA has been registered in category A (water of good biological quality). In 1993 and 1994, Fos village, was awarded the Blue Flag given to the cleanest beaches in Europe. The positions of the stations are located on the Figure 2.

In 1995, industries of Gulf of Fos invested different amounts to get rid of the aqueous pollution (Table 10).

Table 10 : Industrial investments

INDUSTRY	NATURE	COSTS IN EURO
LYONDELL CHIMIE FRANCE	- Anti pollution barrage - Phosphate analyser for the biological treatment plant.	34,375 62,500
ASCOMETAL	- Modification for the storage of Hydrochloric acid, with amelioration of the retention basin	171,875
BP LAVERA	- Acid canvas covers for the treatment station - SEREP analyser	10,938 29,688
ELF ATOCHEM à Martigue	- Stocking - Planning parc CVM	609,375 734,375
ELF ATOCHEM à Port de Bouc	- Basin refraction, waterproffness of acid basin (HCl, HBr, H2, SO4) 100% efficient	343,750
ESSO refining SAF	- Reduction of forage water (working since 1997) - Installation of a piezometer, recuperation hydrocarbon TK 2801 - Detector for lagoon oil, working since May 1997 - Replacement of pomps - Changing the coagulant from the purification station	214,062 6,250 39, 062 20,312 1,562
NAPHTACHIMIE	- Improvement in the measure of the flow and sampling. - Improvement in the filtering of the propylse.	26 ,562 50,000
GAZ DE FRANCE	- Reduction of the water pollution, 95% efficient	101,562

5.2 How to plan environmental controls in the environment

The test of embryo-toxicity on the bivalves (oyster larvae, mussels…) gives a good indication of the quality of the area. Routine ecotoxicological monitoring requires simple, rapid and inexpensive methods. Determining the percentage of abnormalities in D-larvae after 18 hours assesses water quality. If the percent of D-larvae abnormalities is above 50% the toxicity of the sample is very high.

The water law (1992) and the coastal law (1986) remind users of the importance to monitor the coast in a uniform way. It will be done by the **RLM : Littoral Mediterranean Network**. This network is being set up and totally monitored by the Water Agency of the Mediterranean basin.

It is the integration of knowledge and the evaluation of the quality of the French Mediterranean coastal zone. The objectives of the RLM are to :

- Plan the environmental littoral gestation, globally and locally.
- Help for planning and investments.
- Protect immediately the area, with quality objectives.
- Follow and evaluate the actions.
- Improve the knowledge about the area.
- Sensitise and communicate.

A lot of measures are done with mussels *Mytilus galloprovincialis* which can filter a great quantity of water and storage the pollutants.

The organisms situated in the outlet axis are suspended particles and rubbish consumers. There are more Polychetes than Bivalves, so the ecosystem is unbalanced or highly enriched in organic matter (CREOCEAN, 1997).

5.3 Monitoring costs

The monitoring cost done on the industrial water discharge was paid by the PMA to the Water Police.

The sample activity costs 2,440 EURO/year, the pollutants analyse costs 1,120 EURO/year. In 1997 the total cost was around 3,555 EURO.

The RNO measure and analyse cost 16665 EURO for the RLM programme developed in the area of Fos.

6. DEFINITION OF INDICATORS AND CRITERIA : ASSESSMENT / EVALUATION OF MONITORING RESULTS

A good criteria to measure the concentration of a pollutant substances in the coastal zone is with a sample of mussels. Mussels filter and stock informations about the quality of the water. So they are very good indicators of industrial water pollution.
IFREMER gives a scale of the quality of the seawater (Joanny and *al*.,1993) in function of the concentration of pollutants (C) found in the mussels (Table 11).

Table 11 : Scale of the quality of the seawater (d.w. : dry weight)

	VERY GOOD QUALITY	GOOD QUALITY	MEDIUM QUALITY	BAD QUALITY
Zinc (mg/Kg d.w.)	C < 100	100 < C < 150	150 < C < 200	C > 200
Cooper (mg/Kg d.w.)	C < 5	5 < C < 10	10 < C < 15	C > 15
Mercury (mg/Kg d.w.)	C < 0.2	0.2 < C < 0.3	0.3 < C < 0.4	C > 0.4
Cadmium (mg/Kg d.w.)	C < 1	1 < C < 2	2 < C < 4	C > 4
Lead (mg/Kg d.w.)	C < 2	2 < C < 4	4 < C < 6	C > 6
PCB (mg/Kg d.w.)	C < 250	250 < C < 800	800 < C < 1,350	C >1,350
PAH (mg/Kg d.w.)	C < 50	50 < C < 125	125 < C < 200	C > 200
Σ DDT (µg/Kg d.w.)	C < 2	2 < C < 4	4 < C < 6	C > 6
α HCH (µg/Kg d.w.)	C < 5	5 < C < 10	10 < C < 15	C > 15
γ HCH (µg/Kg d.w.)	C < 4	4 < C < 12	12 < C < 20	C > 20

This method was applied in the petroleum dock and the Gulf of Fos. The results are given in Table 12.

Table 12 : Quality of the water in the petroleum dock and the Gulf of Fos

	PETROLEUM DOCK	GULF OF FOS
Zinc	Medium quality	Good quality
Cooper	Very good quality	Very good quality
Cadmium	Very good quality	Good quality
Lead	Very good quality	Good to medium quality
PCB	Bad quality	Good quality

To know if the prevention measures are effective, the reduction of the impacts can be measured in the area near the outlet which is influenced by the effluent. The measures of accompaniment are :
- The survey of the marine environment (sediment compartment),
- The chemical characterisation of the sediments,
- The evolution of the granulometry and the living organisms (CREOCEAN, 1997).

Some biologic indicators can be used to calculate an index of pollution and to survey the alteration of the environment. Some species are used : Bryozoaires, Echinodermes, Polychetes, Crustaceans (IFREMER, 1985). The benthic population is a good indicator of the evolution of the environment because it only lives in the same place.

Few guidelines proposed for evaluating threshold values for tainting of seafood by chemical substances. These guidelines propose a procedure for measuring the ability of a chemical substance to taint seafood when the substance is present in the water.

Measurement of the capacity of a chemical to taint seafood concerned is conducted in two stages : exposure of the organism to the chemical, and evaluation of the exposed organism for taint.

In fact, to have a better analysis of the dangers of toxic elements to human health, more experiment will have to be done. For the moment, all the experiments that have been done are only estimation and research efforts. In fact, experiments are not as exact as the natural environment.

7. PRINCIPLES AND GUIDELINES FOR IMPROVEMENT / NEEDS FOR TECHNOLOGICAL INNOVATION

There is still a problem concerning the knowledge of the impact of industrial treated water dispersed in the sea. In fact, we can wonder what are the concentrations and the maximum pollution tolerable for the environment?

This is why the studies monitored by the DRIRE **(**Regional Direction in Industry and Environmental Research) and the Water Police, concerning the general impact of industrial polluted waters discharged on the environment, have to go on.

Actually, the analysis concerning the extent of the discharge panache and the quality of the fauna and flora are being carried out for all the industries. This monitoring allows the Water Police to propose to the industries a following of the effects on the marine environment receiving those treated waters.

The concept of “biological indicators” (and a biological clues) applies to all levels of integration, from subcellular to ecosystem.
From simple data, of synthetic value (taxon, reduce groups of taxons, function, metabolite, etc.) a global holistic approach is made possible, which leads to an accurate interpretation of a phenomenon as well as to the prediction of its evolution.
Nevertheless, their choice, their use, their interpretation indeed their validity necessitate more than precautions : they require competence (Bellan, 1992).

The establishment of a network to assess pollutant effects is a current concern of international bodies such as the North Sea Task Force, the International Council for the Exploitation of the Sea and the Intergovernmental Oceanographic Commission. With respect to the French coasts, three major considerations have been defined : the choice of monitoring areas; the determination of a target species according to different criteria such as wide distribution, limited migration and contact with pollutant-rich sediments; and the selection of suitable parameters (Galgani and *al*., 1992).

The *Posidonia* survey network has two aims :
- Long term monitoring of the evolution of *Posidonia* sea beds;
- Use of the sea beds as a biological indicator of global quality of shore water (Nieri and *al*., 1992).

Changes over space and time in patterns of trace metal concentrations would appear to indicate that:
- The content levels recorded may have a relation to those present in the environment;
- Posidonia oceanica might be capable of memorising trace metal content levels over long periods of time (Pergent-Martini and *al*., 1992).

The Water Agency has elaborated a directive scheme for the fitting-out and the management of the environment (SDAGE). This scheme wants to promote a social and economical lasting development.

One of its principles is to continue the struggle against pollution. The categories of pollutants to fight in priority are :

- The nutrients (nitrogen and phosphorus).
- The micropollutants including radio-elements.
- The bacterial pollution with a global objective to protect the Mediterranean Sea.

An other of its principles is to assure a quality of water in accord with the exigencies and the users : drinking water, irrigation, industrial water, bathing, leisure, fishing… The absolute priority is the public health.

In an other part, it wants to improve the management and the prevention for all the risks, investing in the knowledge and the monitoring.

In last, one principle is to develop the concerted management of the water resource. So, it has to improve the knowledge, the public communication and management mode adapted for each situation.

8. ANALYSIS OF TRAINING NEEDS

The control of the littoral environment has to be made in accord with the nature and each type of pollution.
There are three types of criteria :
- Subjective (smell, colour, appearance);
- Link with the hydrobiological factors (temperature, pH, turbidity, salinity, nutritive salts…);
- Toxic factors (origin, nature, toxicity threshold…).

The three compartments must be considered : water, sediment, organisms (Arnoux, 1992).

The biological tracers could be used too. They are biochemical or cellular responses which indicate that an organism has been subjected to a chemical or an anthropogenic stress (Galgani and *al*., 1992).

More studies should be done to know the influence of the waste water coming from the industries. There is measure to know where the waste water is dispersed and what is its evolution for different weather forecast conditions :

- Summer period with no wind.
- Summer period after a storm.
- Winter period with no wind.
- Winter period with Mistral.
- Period with south-east winds and rainfalls.

The article 8 of the Directive “SEVESO” mentions that the Members States have to see to : the persons who can be affected by a major accident are being informed about the comportment to adopt in that case. So, workers and public have to be informed to improve prevention and to prepare intervention.

Some group (CEDRE[4]) has developed struggle operations in accidental chemical pollution case. Their objectives are to decrease the risks, to protect the persons, environment and goods, and to return to the initial conditions. The struggle against hydrocarbon pollution scheme has inspired these operations.

In the case of chemical pollution, three attitudes can be adopted :

- We note that we can not intervene because of the intervention time or the comportment of pollutant (colour, density, solubility, viscosity, reactivity…).
- We decide to not intervene because the risks are very diversified, the teams can be being in danger, and the pollutant can not being known.
- We decide to intervene.

[4] Centre of Documentation, Research and Experimentation about Accidental Pollution of Waters.

9. PUBLIC COMMUNICATION

The decision 86/85/EEC dated March 6th, 1986 institutes a community system of information to control and to reduce the pollution caused by discharge, in seawater or in intern waters, of hydrocarbons and other dangerous substances. It is modified by the decision 88/346/EEC dated June 16th, 1988.

According to the Directive “SEVESO”, the Members States have to collaborate and to exchange informations. The public has to be informed too about the comportment to adopt in accident case and emergency.

In the classified installations, a public enquiry must be done during one month to have the authorisation. This enquiry permits a good information of the public and the workers.

French decrees and laws allow the public to give an advice to the port projects and port development.

Where to get information : at the Information Centre of the Port of Marseilles Authority (ICPMA). Here, you will find :
- General and specialized information
- An exhibit on the facilities operating in the Zone and the Port
- A conference room seating 100 people. The room is air conditioned, sound proofed and has a projection room.

The DRIRE does public communication by the SPPPI (Permanent Secretariat for Industrial Pollution Problems) meeting held once every year. It concerns all the classified industries of the Gulf of Fos. The SPPPI meeting informs the public about the industries discharge in the air, and in the water. It informs also, about the industrial wastes and about the industries risk.

There is also an public association (law 1901) called C.Y.P.R.E.S who does communication. This association was created in order to keep the public informed of what is meant by prevention of industrial risk and sea guarding the environment. The association produces brochures, tapes, organises a mobile exhibit, training courses, guided tours and conferences. Also a public network communication server exists. This tool permits the public to see the results of the industries analyse done on the waters, the air, the wastes, and the risk. C.Y.P.R.E.S. has a contribution to keep the public fully informed and let people know what to do in the event of an emergency.

The PAM publishes some information handbooks for masters of ships, booklet about reception and safety of vessels, handbooks about pollution detection awareness, magazines : “PAM magazine” and “port of Marseilles letter”, where it informs public about the different operations made in the port area.

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Ore dry bulk activity

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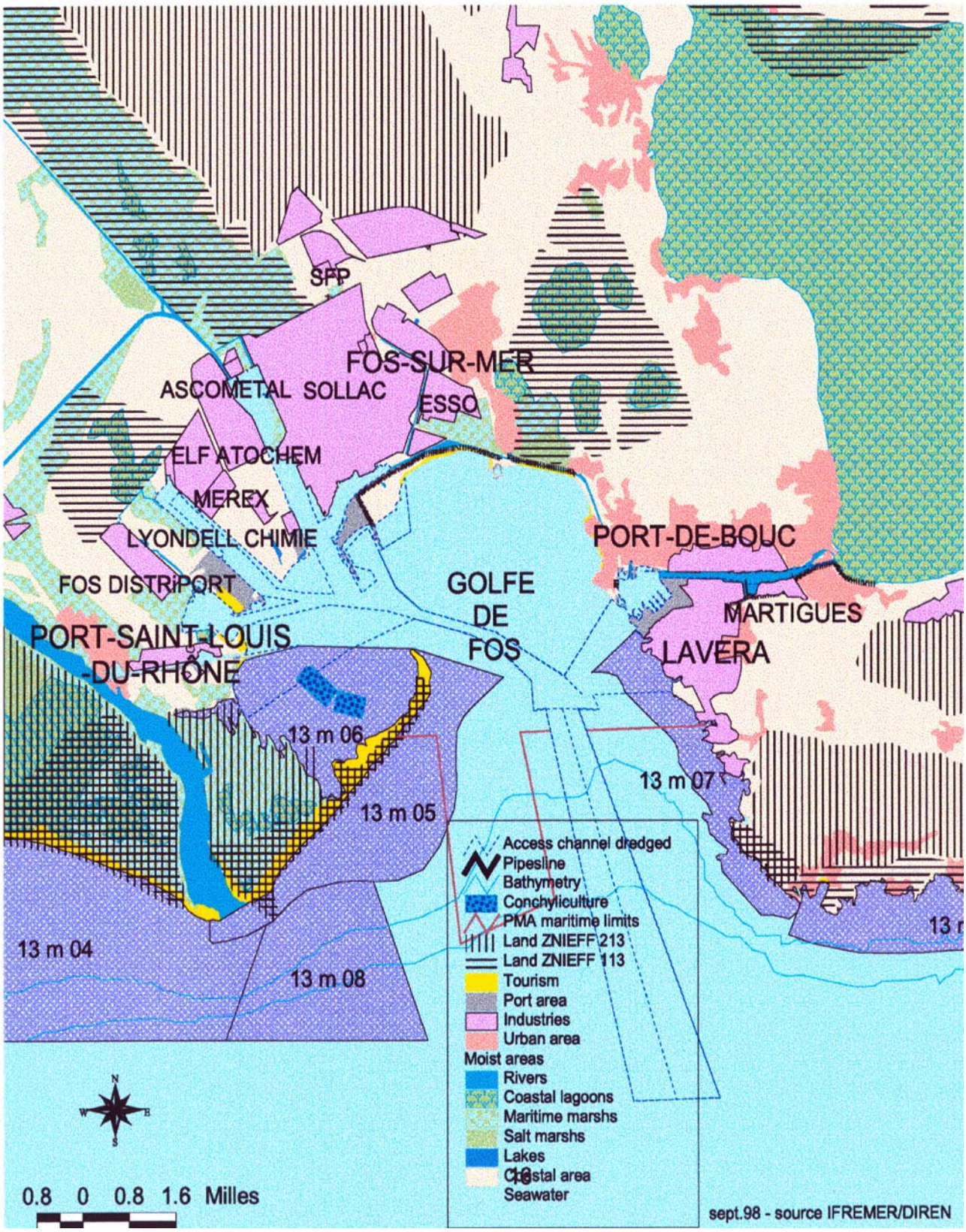
1. DESCRIPTION OF THE ACTIVITY

1.1 Situation of the activity



Source: CLC (IFEN) IFREMER, 1998

Figure 1: Localisation of the western PMA ore dry bulk activities

1.2 Ore dry bulk activity

1.2.1 Generalities

To understand the smooth running of the PMA ore dry bulk terminals, it is important to know how are the intervenes and what are their roles :

- **The client** is the owner of the goods. The clients confide the goods to a stevedore whom realise the operation of loading and unloading ships.

- **The stevedore** belongs to a firm. He ensures (on request of the clients) the direction of the packaging operation and the co-ordination for the dockers. The stevedore is an intermediate between the client and the Storage Park.

- **The operator of the Storage Park** realises investments on the terminal to store the ore (as Carfos).

- **The PMA** ensures the control and the deal of the maritime traffic. The PMA is also proprietary of the quay, tools and storage places. But the PMA is not the responsible of the storage.

1.2.2 Carfos (Figure 1)

Carfos is a private company specialised in handling dry bulk since 1925. The dry bulks treated are ore, coal, heavy bulk, fertiliser, phosphates, oil seeds, oil cake…
Carfos handles and stores all kinds of industrial dry bulk in optimum conditions whilst affording the fullest development potential for the terminal as a whole. The equipment used by Carfos are the propriety of the PMA as the area of 20 Ha (Photo 1).

Carfos is located on the ore terminal of the PMA on the western side of the dock 1. The terminal does not present any inconvenient for the residents population situated at more than 10 Km (Fos or “Port Saint-Louis”). The public ore terminal is located in the heart of a remarkable shipping centre in Gulf of Fos.

Carfos uses three deepwater berths able to take bulk carriers of up to 140,000 and 150,000 dead-weight tons (dwt) at all times of the day or night, whilst ensuring maximum safety and an exceptional loading and unloading capacity.

Carfos is normalised ISO 9002, it is a classified installation that has the storage activity under regulations (declaration system).

Stockfos is a society of Carfos. Their activity is under regulation (authorisation system n° 87-33/70-84-A dated April 21st, 1987). Stockfos store and pack important quantities of coal on the ore terminal of Fos. The site has a surface of 180,000 cu.m for the storage of the coke and the coal. The total storage capacity is 1,200,000 tonnes. The rate of handling is approximately 3,000 T/hour.
For extension of the activity, the operator will have to obtain a new authorisation, if the loading and unloading flow is above 2,000 T/hour.

Thanks to the enormous amount of linear space on the quay, the ore terminal offers a wide range of services, which can be used simultaneously. Among the operation, mention may be made of the following :

- Unloading and storage in addition to transhipment,
- Unloading and simultaneous loading of cargo in two different places.

A staff of 35 persons works on the technical department. The tools are composed by quayside handling equipment (propriety of the PMA).

The unloading is done by :

- Two unloading gantries, with buckets, of 20 tonnes (peak output 2x800 T/h),
- One tracked cranes, with buckets of 15 tonnes at 30 m, and 12 tonnes at 35 m, (2x600 T/h),
- One hoppers of 70 cu.m which can be coupled to cranes,
- One continuous loader (2,200 T/h peak rate, d = 0.8).

The loading is done by :

- One conveyor belt loading gantry, (1,500 T/h peak rate) privately-owned (Aluminium Pechiney),
- One conveyor belt loading gantry, (peak output 1,500 T/h),
- One barge loading berth (peak 800 T/h).

The fixed conveyors are (for a total length of 4,5 Km) :

- One longitudinal conveyor supplying loading gantry,
- One reversible two-speed longitudinal conveyor (1,600 and 2,000 T/h),
- One reversible conveyor (1,600 T/h),
- One non reversible two-speed transverse conveyor (1,600 and 3,400 T/h),
- One reversible two-speed longitudinal conveyor (1,600 and 3,400 T/h),
- One reversible longitudinal conveyor (output 1,600 T/h),
- One non reversible transverse conveyor (1,600 T/h),
- One non reversible transverse conveyor (2,400 T/h) privately-owned (Stockfos),
- One non reversible transverse conveyor (1,600 T/h) privately-owned (Carfos),
- Privately-owned equipment (Aluminium Pechiney) for reloading wagons (400 T/h).

The mobile conveyors are :

- One chain of mobile conveyor 1,200 T/h.
- A second identical mobile two speed conveyors privately-owned (Carfos),
- One assembly consisting of a wheeled belt-feeder and reclining mobile conveyor (positioned downstream of the belt-feeder) with an output of 1,500 T/h for loading small ships.
- A wheeled belt feeder 1,400 T/h privately-owned (Carfos).

The storage equipment is :

- One wheeled stacker (jib : 18 m, staking height : 8 m, orientation : 180°, throughput : 1,600 T/h),
- One wheeled stacker [jib : 18 m, staking height : 8 m, orientation : 180°, throughput : 1,600 to 2,000 T/h privately-owned (Carfos)],
- One rail-mounted stacker [jib : 2x21 m, staking height : 12 m, throughput : 2x600 T/h privately-owned (Carfos)],
- One rail-mounted stacker [jib : 30 m, staking height : 14 m, orientation : 210°, throughput : 2,400 T/h privately-owned (Stockfos)].

The commercial capacities vary as a function of the density and the quantity of the product, type of vessel, operating conditions, …etc.

The daily commercial capacity is composed by three shifts (19.5 hours of work) for products with a density of either 0.8 (coal) or 1.3 (bauxite).

The storage capacities are :

- 1,000,000 tonnes/year for the bauxite (it cost is 50 EURO/tonne).
- 400,000 tonnes/year for the coal.
- 200,000 tonnes/year for the clinker.
- 145,000 tonnes/year for the aluminium (it cost of 230 EURO/tonne).

The capacity of loading or unloading of Carfos are around 3,000 tonnes/hour. So for seven hours the packs capacities are between 15,000 to 35,000 T/day.

On Carfos area there are more importation (1,400,000 tonnes/year) than exportation (200,000 tonnes/year).

The main activity of the terminal is the packaging of the bulk without any transformation. So the spill, the blow of the wind or the rain-washing will bring ores into the sea.

1.2.3 Sollac (Figure 1)

Sollac is an integrated steelworks with continuous hot rolling mill for flat products. It is situated in the PMA area. It is on the eastern side of the dock 1 and at the north of the south dock (Photo 1, Photo2).

Sollac processes around 7,150,000 tonnes of ores and 3,250,000 tonnes of coals, to produce 4.5 millions of coils per year.

Photo 1 : Ore dry bulk activities of the PMA – Sollac in the background and Carfos in the first plan (source : PMA).

In general, the ores come from :

- Brazil for 48%,
- Australia for 28% ,
- Mauritania for 15%,
- South Africa for 5%,
- Spain for 3%,
- Sweden for around 1%.

In general the cocking coals come from :

- Australia for 44%,
- United States for 36%,
- Canada for 11%,
- Venezuela for 4%,
- Poland for 3%,
- Colombia for 2%.

Sollac has two unloading ships (First Venus and La Cordillera) able to discharge 220,000 tonnes. The ores and coals will be stored and prepared in special areas.

The ores used to produce steel has to contain a high percent of iron (around 65%). They permit a low production of slag. In fact, Sollac produces 12,800 tonnes of pig iron per day. Each tonne of pig iron produces around 300 Kg of slag. Actually Sollac has 1,000,000 of slag stored.
Luckily, 94% of the slag will be sell to cement works or used in embankment.

1.3 Laws

1.3.1 European laws

- Directive 76/464/EEC concerns the pollution deriving from dangerous substances unloaded in water environment of the Communities.

- Directive 77/585/EEC dated July 25th, 1977 is relative to the conclusion of the convention for the protection of the Mediterranean Sea against pollution.

- Decision 81/420/EEC dated May 19th, 1981 concerns the conclusion of the draft treaty relative to the co-operation in the struggle against pollution of the Mediterranean Sea by hydrocarbons and other dangerous substances.

- Directive 82/501/EEC called SEVESO I, concerns the risk of accident of some industrials activities. The Directive SEVESO II dated December 9th, 1996 n° 96/82/EEC concerns the control of danger due to accident. This Directive substitute the Directive SEVESO I.
- The principles of these directives are : the industrials manipulating dangerous substances must take precautions to prevent accidents who can have consequences on humanity and environment.

The article 5 specifies that the States Member must dispose about a regulation requiring industrials to make danger study and to pass on competent administration.

- Directive 85/337/EEC is relative to the evaluation of the incidences of some projects.

- Directive 86/280/EEC about pesticides defines the limiting values as the objective of quality. The French applications are in March 1st, 1993 decree.

- Directive 90/164/EEC is there to prevent and reduce the environmental risk.

- The Gulf of Fos is not classified sensitive area as define by the European directive 91/271/EEC.

- Directive 96/61/EEC on Integrated Prevention Pollution and Control "IPPC" dated September 24th, 1996 is a copy of the French Classified Installations legislation.

1.3.2 French laws

- It is forbidden to discharge solid having negative effect for the marine environment. If it is not respected it will be punished by decree dated January 9th, 1952 (article 7).

- July 19th, 1976 laws relative to «classify installation for the protection of the environment» permits the survey of the ore dry bulk storage, classified installation. This survey allows to limits the impact of the pollutants on the environment. If there is pollution caused by a classified installation, a sanction will be apply by the July 19th, 1976 law and September 21st, 1977 decree. Those classified installation have an authorisation to work only if they respect strict criteria established by the DRIRE (Regional Direction in Industry and Environmental Research) and impose by order of the prefect. The manager of the bulk storage will advise the inspector of the classified installation, in the shortest delay, if an accident happens as it is written in the article 38 from the decree n° 77-1133 dated September 1997. The inspectors of classified installations control the activity to check the respects of the prescription mentioned in the order of the prefects. The firm pays the costs due to inspection.

1.3.3 Uniform protection areas

The decision 84/132/EEC dated March 1st, 1984 concerns the conclusion of the draft treaty relative to the special protected areas in the Mediterranean Sea.

The ZNIEFF are areas itemised for the national inventory of the natural patrimony, presenting an ecological interest. It is a tool for knowledge, and have a juridical value. The area of the Gulf of Fos has two ZNIEFF :

- The ZNIEFF n°13M06 called "Anse de Carteau" which has an interest for fishing and for the biologic species (*Posidonia oceanica* meadows…).
- The ZNIEFF n° 13M05 is in the area of the "They de la Gracieuse".

The marine preserved areas (coastal law n° 86-2 dated January 3rd, 1986) are :

- Marine ZNIEFF, *Posidonia oceanica* meadows, Shellfish seam area, Spawn area for ichthyofauna.

2. POLLUTION SOURCES (CONCERNED SUBSTANCES AND BY - PRODUCTS)

2.1 Phenomena responsible of metal pollution for marine environment

2.1.1 The wind

It can blow the ore at various distances. The wind constitutes a fundamental element in the terminal context because it diffuses the fine particles of ore (Photo 2).

In Fos area, there is a predominance of Mistral wind coming from the “Crau” (north-west). The winds can reach high speeds (150 Km/h) and blow by blast.

A second wind is the eastern wind coming with sea spray and usually followed by rain (half of the rains are between September and December period).

2.1.2 The water running

The problem is caused by the intensity of these few rainfalls. In fact the water have no time to infiltrate in the ground, which induce consequent volume water streaming. These big volumes arrive in seawater with the pollutants carried along the way.

2.1.3 The loading and unloading of ore tankers

The loading and unloading of ore dry bulk induce a little loose of ore between the ship and the quay. One percent of the ore transported in the storage place goes in the sea by the wind, the loose of the grab, and the running water.

2.1.4 The cleaning

It is necessary to clean the equipment, the quays and platforms, the quay posts.

- Equipment : cleaning is operated during the operation, if the safety requires it, or in the end of the operation with the most adapted methods (high pressure, industrial aspiration, shovel…).
- Quays and platforms : during all the commercial operations, cleaning of the quay and platform are done by little loaders driven by dockers. After the vessel departure, specific operations of cleaning will be done frequently.
- Quay post : a part of ores (0.15%) falls in seawater and forms a cord in the bottom. The depths are 16 m to 17.5 m. To reduce this discharge, the PMA has developed continue loaders and unloaders which the ore transport between the vessel and the quay.

The products recuperated after cleaning activity are dumped upon the stock if their quality has not been damaged, or in special areas in the north of the terminal.

Photo 2 : Sollac ore blown away by the strong mistral wind (source : BCEOM).

2.2 The chemical substances on the ore terminal

2.2.1 Aluminium

Aluminium is contained in ores like bauxite, “l’hydragillite” and the “cryolithe”. The natural value of aluminium in the open sea is under 1µg/l. In the Gulf of Fos the pollution were lower than 0.045 mg/l in 1975. The toxicity standard given by SPPPI (Permanent Secretariat for Industrial Pollution Problems) is 10 mg/l.

2.2.2 Chromium

The chromium compounds found at dissolved forms are Cr (III) and Cr (VI). The chromium Cr (III) is an essential element for the human being nutrition. It is found in anoxic areas. Cr (III) is a reduce form that is rapidly adsorb. The chromium Cr (VI) is toxic and carcinogenic at high levels. It is found in oxygen oceanic water. Cr (VI) is an oxide form very soluble. The chromium Cr (I), Cr (II), Cr (IV), Cr (V) have not stable valences, so they are not found naturally in the environment. The natural tenors in chromium of the oceanic water are 0.5 µg/l. The concentration in Gulf of Fos are between 0.01 and 0.059 mg/l (1978).
It is important to note that if the water in the Gulf of Fos are not yet at the toxic level fixed by the SPPPI, it is not the case of the sediments. They are more polluted (10 to 53 mg/Kg, 1978).

2.2.3 Manganese

Manganese is a soluble element very common in the nature. In the coal mine we often find it in association with “pyrite”.
The natural values of the oceanic water are 0.2 µg/l. In the Gulf of Fos, the medium value is around 0.32 to 0.63 mg/l (1978).
The chlorides, nitrates, and sulphates of manganese are soluble in the water. The oxide, the carbonates and the hydroxides of manganese are partially insoluble. They deposit on the sea bottom.

2.2.4 Iron

Iron is a common metal. It is found in the nature in magnetite form, of “limonite”, “hematite” or “pyrite”.
The natural values of ocean water are around 0.03 µg/l. The maximal tenors in the Gulf water are 1,000 mg/l (1978).

2.2.5 Sulphur

Sulphur goes in the composition of a lot of chemical products : sulphates, sulphides, sulphites, sulfones, sulfomates, and acids. The impacts are very different depending to the salts and their concentrations. Sulphur becomes oxidized easily with air, then the hydrolysis reaction forms sulphuric acid. The sulphur is found in the coal. Heavy metals have a strong affinity for sulphur.

2.2.6 Coal

The composition of coals is variable. They are composed by carbon, sulphur and by heavy metals too : zinc, cadmium, chrome, lead and mercury, frequently.
Each heavy metal, separately, is noxious to the organisms living in marine environment.
The combined action of the different pollutants is no more known. But there is a synergy between pollutants like cadmium and iron. This synergy can increase the toxicity.
A preventive action is necessary to limit the introduction of pollutants in seawater.

3. CONSEQUENCES

3.1 Effects in the environment

3.1.1 Effects on the sea environment

Sediment concentration are several orders of magnitude higher than seawater constitution. The release of harmful element is function of the sediment stability. This stability depends on :

- The metals concentration,
- Quantity of organic matter,
- Water salinity,
- pH, Eh (reduction-oxidation potential [5]),
- The mixing quality of the sediment / water,
- Micro-organism activity,
- Hydrodynamics.

3.1.1.1 Aluminium

Aluminium has a low toxicity on his own. But when it is mixed with nickel, cooper and zinc, its effects are more dangerousness, particularly for the fishes.

3.1.1.2 Chromium

The chromium is not concentrated to a great extend by the living organisms in the environment.
The chromium is not a significant contaminant of the plants tissues (concentration of 5 mg/Kg of dry weight). In case of acute contamination, where the concentration can reach 50 mg/Kg (dry weight), the chromium perturbs the algae growth as the photosynthesis. The concentrations are generally about several mg/Kg in the plankton, as in the invertebrates and fishes. The toxicity level for the fishes are 0.07 mg/Kg. The chromium does not accumulate in the fishes.

3.1.1.3 Manganese

The manganese gets easily fixed on the free micro-organisms. The manganese is lowly toxic and there has to be important quantities to observe effects on the organisms.
In fact some support up to 500 mg/l. The salts of manganese are often toxic for the nerves. The permanganate of manganese is more toxic, but gets quickly destroy in the water.

3.1.1.4 Iron

Even if natural iron is present in high concentration in the human being, iron can be toxic if the metal exceeds the reasonable level. To much iron can generate asphyxia of fishes by sealing the brunches, or inducing a slower growth of algae.

[5] Red-Ox potential characterises the evolution of the chemical and microbiological conditions in the sediments (Hily and Glémarec, 1990).

The iron concentrates the most often in the fine sediment than in the rough. We have an important transfer of the iron stocked from the sediments to benthic fauna and flora. The soluble forms of the iron is accumulated essentially in the intern tissues by biological process.

3.1.1.5 Coal

A particular problem is the oxidation of the coal. This is an exothermic reaction, and it can bring an auto-combustion depending of the size of the storage. The parameters favourable to this auto-combustion are very well known, one of the principals is the time of the storage.
The exploitation law advises dispositions that have to be respected when the characteristics of the products are critical.

The coal is not toxic on his own but the heavy metals which composed it are harmful for the organisms living in seawater and sediment. The metals are the most dangerous. The most toxic metals for the organisms are :

- Mercury by solubility increases in the water. Bacteria methylate the free form of mercury (which is the process the most toxic). The methyl forms of mercury are stocked into living organisms.
- Lead become mobile if the pH decreases or the area gets oxygen. It will also have methylation process like mercury.
- Cadmium also becomes mobile in oxidising areas and will be very toxic.

Heavy metals have different reactions in the environment which undergoes chemical transformations that are given in Table 1.

Table 1 : Chemical transformations led by the reactions of heavy metals in the environment

COMPLEX FORM	RESULT
Carbon monoxide, carbon dioxide	Heavy metals are released when the salts are dissolving
Adsorbed on iron oxide or manganese oxide	The complexes become unstable and release metals
Bond with organic matter	Great stability of the complex
Sulphide	Instability, oxidation in sulphates and release of metals

3.1.2 Effects on the port area

The ore that goes in the sea reduces the depth of the dock and creates the need of dredging. It cost a lot to reach the ores. The products dredged during the cleaning operation are either put back on the storage place, if they have a good quality, or stored in special deposit area on the terminal.

3.2 Impacts in the environment and the users

3.2.1 The biologic impact

The integration of the pollutant is done at the sediment water interface. We talk about bio-mobilisation (integration of the pollutants in the living organism) giving bio-accumulation (accumulation of chemical substances directly by the aliments) and then bio-concentration (retention of the pollutants in the tissues).

The impact on the plankton is not important. The communities will develop resistance against the perturbation or “disturbance”.
The heavy metals alliterated the biological functions at the macroscopic, biochemical levels and on the natural cycle. The organic pollutants are mutagenic, carcinogen and genotoxic agents for living material.

3.2.2 Impact in the human area

The loose of ore between the ship and the quay, during the loading and unloading, increases the turbidity near the area of activity. It has an impact for the shellfishes production and the photosynthesis phenomena.

The ore spilled in the sea can be harmful for the organisms. Some of them in great quantities have a toxic impact on the trophic chain. And so the consumption of sea products by humans is dangerous.

3.2.3 Impact in the users

In the port area, there is not occupational fishing but marine culture. This activity is very controlled but exists. The contamination of fishes and shellfishes by metals is few.

The turbidity created by the loose of ore induces avoidance of this area by fishes and other organisms. They cannot reproduce them and there is a incidence in the leisure fishing.

The two beaches of the Gulf of Fos have a good quality of water. This quality could be debased by the ore lost in seawater during the loading and unloading operations. In this case, the bathing activity and the water sports will be suspended.

4. ACTIONS TAKEN

4.1 Western PMA environmental control on the ore dry bulk

4.1.1 Environmental Laboratory Control and Studies for the Steel industry (LECES)

Sollac ore storage creates flying dust. In 1988, there was 9,500 tonnes of dust from the storage area of Sollac going into the sea. Ten years after, there is seven times less flying dust. The quantities of flying dust for 1998 are around 1,400 tonnes. This is due to the Studies Laboratory Environment Control for the Steel industry (LECES).

The first operation where between 1988 and 1991. LECES and Sollac created special gluey product injected in the ore piles. Most of the flying was avoided. This technique allows reducing 4,000 tonnes of flying dust per year.

After 1991, a new technique is added, creating a cover with the gluey products on the ore piles. The method reduces 4,100 tonnes of dust per year. This technique is very useful for the finest ore that fly very easily. This process is very useful against winds bellow 70 Km/hour.

4.1.2 Modeling

Sollac works also on a model developed by MRI (Midwest Research Institute). This model takes in account :

- The nature of the materials,
- The shapes of the piles,
- The weather forecast.

The model makes estimation, and measures the incidence of the physical treatment. Sollac has also scales at the top of the piles to measure the loose of ore.

4.1.3 Organisation of the road traffic

On the bulk terminal areas, there is an organisation of the circulation to limit the dust pollution. The public circulation is forbidden, so the only circulation are the lorries. The volumes transported by Carfos are 40 trucks/day for the coal and 25 to 40 trucks/day for the bauxite.

4.1.4 Adequate methods used on the terminals

- The grabs are very wide to recuperate ore, coke, and avoid spill.
- The grabs have good waterproofs for fine materials. The grabs are systematically maintained to reduce the leaks.
- The transports of the ore and coal are covered by a “goulotte”, and have a disposition against the wind. There is also a telescopic “goulotte”, to adjust the height of the fall, and bring the solid at the nearest point of the ore or coal pile.

- To limit the loading break creating dust, some extractor loading are directly done in the trucks.
- The inspector of the classified installation can make analyse on the quality of the effluents discharge from the storage area. The owner of the storage activity pays for it.
- If there is an overflowing of ore, it will be stop by an automatic regularisation of the machines.

4.1.5 Methods set up to monitor the water running

In Carfos park there is not any washing or treatments of the materials stored. The only washings are on the surface treatments of the coal storage. Those washing watering and the rainwater are collected in special retention areas to be treated. The total retention area of Carfos is calculated for a precipitation of 130 mm in 12 hours. Up to that precipitation, there will not be any liquid discharge in the Gulf of Fos.

4.2 Western PMA control in the environment

Coastal zone is devised in “homogeneous” areas. Three level of impact are studied :

1. The first field is the nearest zone to the coast. It corresponds to the area where are the dilution of the rejects. In the Gulf of Fos, it goes up to the bathymeter 30 m.

2. The medium field starts at the bathymeter 50 and goes up to 100 m. In this area the pollutant concentration are all mixed up.

3. Then the last field starts at the bathymeter 100 m, and it is related to the background noise.

The area of the Gulf of Fos is covered by the coastal zone n°16, between the Rhone mouth and Cap Couronne (Figure 2). Different analysed are done :

1. The **RNO** (National Observation Network), is a network managed by IFREMER (French Institute of Research in the Sea) for the Environment Ministry. The RNO existing for more than 20 years; it measures, in the Gulf of Fos, the quality of :

- The water column on three stations once per trimester.
- The sediments every time the dredging operation is done.
- The living matter on three stations once per trimester.

The **REPHY** (Phytoplanktonic Network) and **REMI** (Microbiologic Network) measure the phytoplanktonic and microbiological quality of the water.

The measurements are done by IFREMER which measures, in the Gulf of Fos, the quality of :

- The water column on two stations REPHY every 15 days in winter and every week in summer.
- The living matter on two stations REPHY and five stations REMI once every month or more frequently in case of pollution.

The **RSP** (Posidonie Watching Network) measures the global quality of the area using the vitality of the vegetal plantation as a biologic indicator. The observations are done once a year by GIS-Posidonie, a research organisation.

The **CQEL-13** (Water Police) controls the PMA actions and monitors the direct discharge of the industrial waters and their impacts on the quality of the port area.

- 8 stations are analysed in the area of the Gulf of Fos.

8. The **DDASS** (Departmental Direction of Social and Sanitary Actions) monitors the microbiological quality of the water in the bathing area.
   - 12 measurements are done per year in summer time in the water column on 7 stations along 5 towns in the Gulf of Fos.

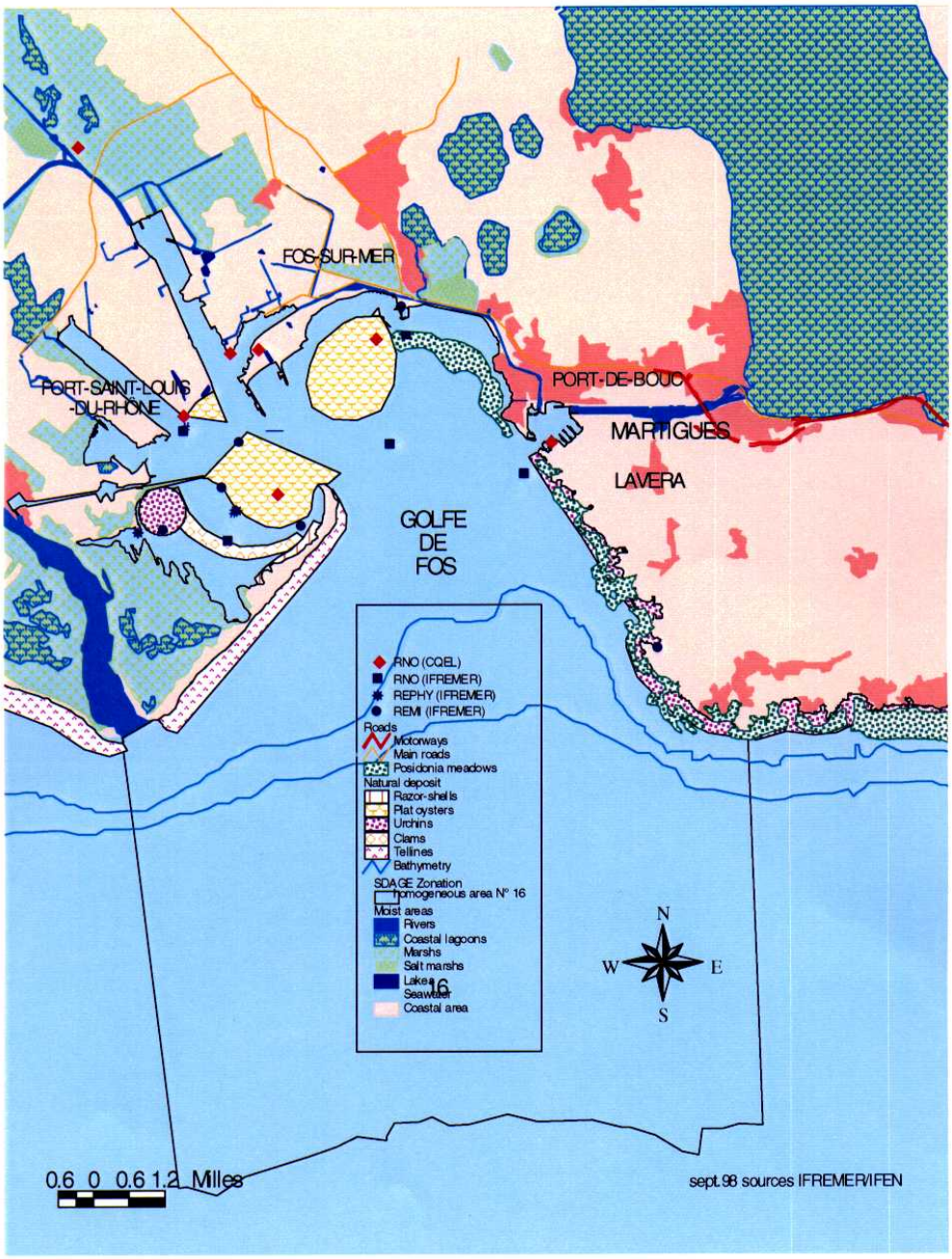
9. **REPOM** (National network to the survey of the maritime ports), will constitute for the France, an international scale of network reference. The circular dated March 7th, 1997 from the Environment Ministry, asks at the CQEL to put in place this REPOM.

The objectives of the REPOM are to monitor the water quality and the sediments quality of the port areas. This monitoring will permit to :

- Have a global view of the pollution created by ports.
- Bring to the GEODE group[6], actualise data on the quality of the sediments.
- Create adequate standards relating to the disposal of the dredging wastes.
- Evaluate the port quality.
- Have objective information to incite the port managers to research good solutions permitting to eliminate the pollution at the source.

The REPOM will study the water and the sediment quality on the PMA. The water quality analyse will be done on more than two stations four times a year (one analyse every three months). The parameters analysed will be bacteriological (*Escherichia Coli, coliforms faecal, Streptococcus faecal*..), and physical-chemical (temperature, salinity, percentage of dissolve oxygen, suspended matter, ammonium, transparency...). The contaminants analysed in the sediment will be done at each dredging operation.

[6] GEODE : Group of Study and Observation about the Dredging and the Environment.



Source : CLC (IFEN), IFREMER, 1998.

Figure 2 : Homogeneous area n°16 : Mouth of Grand Rhone to Cap Couronne.

5. MONITORING

5.1 How to plan environmental controls on the activity

5.1.1 Methods to monitor the dust

5.1.1.1 “Concentration” of the storage

The “concentration” of the storage is represented by a ratio tonnes/cu.m. This ratio is very important to limit the impact of the dust. The “concentration” is done directly by reducing the surface on which circulate the trucks as the surface offered to the wind effects. As an example, the park of Stockfos “concentrated” the storage by passing from 5.6 tonnes/cu.m to 8.25 tonnes/cu.m (products of density 1).

Other method used to limit the wind action is to round the ore stocks, and to pulverise water on it, especially in very dry or windy conditions. The watering will be adjusted with the rainy weather. So the ore storage will stay at the same level of humidity. If the watering is not efficient additive composed by “colgarde”, and “selore” is used to fix the dust.

5.1.1.2 Cleaning of the area

The cleaning is regularly done to limit the flying of little ore particles. The ore terminal has centre divider strip composed by pebble in which the fine goes and creates a fine coat. Also, the quay and the divider strip are cleaned every day during the commercial operations. It is then completed by specific cleaning operation when the ship leaves.

5.1.2 Methods set up to monitor the water running

A flat area is a good method to limit the speed of the water running.
The roof of the storage pile is regularised to avoid the running of the rainwater.

5.1.3 Oxidation of the coal

The prevention of auto-combustion of the coal is done periodically by checking the temperature on the storage staying more than two months.

For the coal rich in sulphur, the check is more important. If the temperature is higher than 70°C, the watering of the coal stock will be immediately stop and the products is spread on a spare storage area specially reserved for it. After a complete cooling down the coal is stock back as usual.

The extinguisher around the installation ensures the fire security of the storage area. Each extinguisher has a flow of 60 sq.m/hour. The coal storage is accessible on all the faces.

5.1.4 The BINDER M166

This product is subjected to the norm ISO 9001. It is a aqueous solution of polymers.

It principally used :
- Against the erosion by wind;
- Against the watching due to the erosion by rain;
- Like treatment against dust.

It does not induce reaction with flora and its biodegradability depends on its concentration and on the ore concerned.
It does not induce harmful effects for health and for environment. There is no risk of inflammation or explosion in using it.

5.2 How to plan environmental controls in the environment

The test of embryo-toxicity on the bivalves (oyster larvae, mussels…) gives a good indication of the quality of the area. Routine ecotoxicological monitoring requires simple, rapid and inexpensive methods. Determining the percentage of abnormalities in D-larvae after 18 hours assesses water quality. If the percent of D-larvae abnormalities is above 50% the toxicity of the sample is very high.

The water law (1992) and the coastal law (1986) remind users of the importance to monitor the coast in a uniform way. It will be done by the **RLM : Littoral Mediterranean Network**. This network is being set up and totally monitored by the Water Agency of the Mediterranean basin. It is the integration of knowledge and the evaluation of the quality of the French Mediterranean coastal zone.

The objectives of the RLM are to :

- Plan the environmental littoral gestation, globally and locally.
- Help for planning and investments.
- Protect immediately the area, with quality objectives.
- Follow and evaluate the actions.
- Improve the knowledge about the area.
- Sensitise and communicate.

A lot of measures are done with mussels *Mytilus galloprovincialis* which can filter a great quantity of water and storage the pollutants.

The RLM will allow a good general information about the quality of the marine environment of the Gulf of Fos. But to plan a good environmental control in the Gulf of Fos environment, other analysis should be done.

For example, they could study and measure the impact of the ore on the marine benthic fauna and flora. This study will need to sample sediments containing ore and benthic fauna and flora. This study could therewith realises cartography of the area with the representation of the different fauna and flora existing.
Then depending to the living species present it could be determined if the area is in a good or bad health, and proposed measures and solutions to improve it.

5.3 Monitoring costs

The clinker and the slag (melted rock that comes from steel) are the only ores stored in a closed area on the terminal of Carfos. One of the sheds can receive 12,000 tonnes of clinker. The other shed receives 300,000 tonnes of slag. Clinker and slag are stored in sheds, so they can keep their quality, and limits the flying of the ore. The clinker movements are between 800 to 2,000 tonnes/day. Clinker cannot be moved if it is raining. This measure is to avoid pollution.

The cost of the clinker shed is 2,344,000 EURO. The conveyor cost is 3,100 EURO and the cost for the gantry is 4,690,000 EURO. The automatic grab can carry 50% of her weight (so up to 7 tonnes of ore) and it cost 54,700 EURO.

There is other technique used to pack the ore, it is the wheel machine. It cost 7,813,000 EURO, and has fewer loos. This machine belongs to the PMA. The coal cost 46,20 EURO/tonne. By using the LECES process, Sollac saves up 8,100 tonnes per year which corresponds to 374,000 EURO/year.

6. DEFINITION OF INDICATORS AND CRITERIA: ASSESSMENT / EVALUATION OF MONITORING RESULTS

The definition of indicator for the ore dry bulk activity can be done by a good survey of the quantities of ore stored. A scale measuring the diminution of the piles is an adequate indicator. It measures the quantities of ore lost depending to different conditions (wind, rainwater, or loose during the transport).

The evaluations of the monitoring results are positive but have still to progress. The different techniques engaged concerning the diminution of the flying ores have to go on. The interest of monitoring the loose of ore for Sollac and Carfos is firstly financial, the ore is a valuable item.

A good criteria to measure the concentration of a pollutant substances in the coastal zone is the mussel. Mussels filter and stock the contamination information about the quality of the water. So they are very good indicators of industrial water pollution.

IFREMER gives a scale of the quality of the seawater (1993) in function of the concentration of pollutants (C) found in the mussels (Table 2).

Table 2 : Scale of the quality of the seawater (p.s. = "poids sec" : dry weight)

	VERY GOOD QUALITY	GOOD QUALITY	MEDIUM QUALITY	BAD QUALITY
Zinc (mg/Kg p.s.)	C < 100	100 < C < 150	150 < C < 200	C > 200
Mercury (mg/Kg p.s.)	C < 0.2	0.2 < C < 0.3	0.3 < C < 0.4	C > 0.4
Cadmium (mg/Kg p.s.)	C < 1	1 < C < 2	2 < C < 4	C > 4
Lead (mg/Kg p.s.)	C < 2	2 < C < 4	4 < C < 6	C > 6

To know if the prevention measures are effective, the reduction of the impacts can be measured in the area influenced by the ores dry bulk activity. The measures of accompaniment are :

- The survey of the marine environment (sediment compartment).
- The chemical characterisation of the sediments.
- The evolution of the granulometry and the living organisms (CREOCEAN, 1997).

Some biologic indicators can be used to calculate an index of pollution and to survey the alteration of the environment. Some species are used : Bryozoaires, Echinodermes, Polychetes, Crustaceans (IFREMER, 1985). The benthic population is a good indicator of the evolution of the environment because it only lives in the same place.

In fact, to have a better analysis of the dangers of toxic elements to human health, more experiment will have to be done. For the moment, all the experiments that have been done are only estimation and research efforts. In fact, experiments are not as exact as the natural environment.

7. PRINCIPLES AND GUIDELINES FOR IMPROVEMENT / NEEDS FOR TECHNOLOGICAL INNOVATION

The best methods set up to reduce the spill between the quays and the ship are set up by PMA continuous loading and unloading equipment. It permits the safe transport of the material and limits the spills of ore. The others (Carfos and Sollac) should use the same techniques.

But if they keep the barge methods, there should be a survey of the watertight integrity of the valve barge. It would allow fewer spills of ore during the unloading and loading of the ships.

The concept of “biological indicators” (and a biological clues) applies to all levels of integration, from subcellular to the ecosystem.
From simple data, of synthetic value (taxon, reduce groups of taxons, function, metabolite, etc.) a global holistic approach is made possible, which leads to an accurate interpretation of a phenomenon as well as to the prediction of its evolution.
Nevertheless, their choice, their use, their interpretation indeed their validity necessitate more than precautions : they require competence (Bellan, 1992).

The monitoring of the coastal environment has to be made in accord with the nature and each type of pollution.

There are three types of criteria :
- Subjective (smell, colour, appearance);
- Link with the hydrobiological factors (temperature, pH, turbidity, salinity, nutritive salts…);
- Toxic factors (origin, nature, toxicity threshold…).

The three compartments must be considered : water, sediment, organisms (Arnoux, 1992).

The Water Agency has elaborated a directive scheme for the fitting-out and the management of the environment (SDAGE). This scheme wants to promote a social and economical lasting development.

- One of its principles is to continue the struggle against pollution.

- An other of its principles is to assure a quality of water in accordance with the exigencies and the users : drinking water, irrigation, industrial water, bathing, leisure, fishing… The absolute priority is the public health.

- In an other part, the Agency wants to improve the management and the prevention for all the risks, investing in the knowledge and the monitoring.

- In last, one principle is to develop the concerted management of the water resource. So, the Agency has to improve the knowledge, the public communication and the management mode adapted for each situation.

8. ANALYSIS OF TRAINING NEEDS

There is still a needed for training concerning the control of the ore piles flying away with the wind, the running water or during the loading or unloading of the ore from the ships to the storage area.

According to its social politic, the PMA organises some formations / actions. It tries to improve the qualifications and the methods of work.

The formation is an aid to the accompaniment and to the evolution of the organisation and to the methods of work. It is destined to :
- The PMA personal;
- The clients or partners;
- Be an initial formation.

The formation awards a diploma to the concerned persons.

The PMA applies the following principles :
- On-going programme modifications according to needs as identified by a pilot group overseeing all training;
- Working groups set up in parallel with training in order to put theory into practice;
- Evaluation of training to ensure the transformation of work methods by drawing up individual and collective plans of action.

Training programmes are set at three levels :
- General or cross-function training at company level;
- Specific or technological training at departmental level;
- Personal training on an individual timescale.

The PMA has one large maritime area, with no real database, no real study about the quality of the marine fauna and flora, at this time. So a lot of study needs to be done to improve the environmental control of the marine area.

It is necessary to do observations regularly in the time, for example twice per year. These observations could be about benthic population, fishes, and all the fauna and flora.
Some analysis about water and sediment in the area of ore dry bulk activity are necessary too.
In this way, with an initial knowledge, we could see the evolution of the organisms after measures taken to improve the activity.

Also more studies should be made concerning the impact and the effects to marine environment caused by the ore spilled in the Gulf of Fos.
The ecotoxicological analysis are the most adapted to examine the effects of pollutants on the living organisms. They allow to know if there is a danger to human life who are the last link in the food chain.

9. PUBLIC COMMUNICATION

The decision 86/85/EEC dated March 6th, 1986 institutes a community system of information to control and to reduce the pollution caused by discharge, in seawater or in intern waters, of hydrocarbons and other dangerous substances. It is modified by the decision 88/346/EEC dated June 16th, 1988.

According to the Directive “SEVESO”, the Members States have to collaborate and to exchange informations. The public has to be informed about the comportment to adopt in accident case and emergency.

In the classified installations, a public enquiry must be done during one month to have the authorisation. This enquiry permits a good information of the public and the workers.

French decrees and laws allow the public to give an advice to the port projects and port development.

Where to get information : at the Information Centre of the Port of Marseilles Authority (ICPMA). Here, you will find :

- General and specialized information
- An exhibit on the facilities operating in the Zone and the Port
- A conference room seating 100 people. The room is air conditioned, sound proofed and has a projection room.

An association of the steelworks awarded a price to Sollac for their technique set up in collaboration with the Studies Laboratory Environment Control for the Steel industry (LECES). This technique allowed a good diminution of the flying ore on the storage area of Sollac. But most of the time there is no public communication done concerning the ore dry bulk storage activity.

The DRIRE **(**Regional Direction in Industry and Environmental Research) does public communication by the SPPPI (Permanent Secretariat for Industrial Pollution Problems) meeting held once every year. It concerns all the classified industries of the Gulf of Fos. The SPPPI meeting informs the public about the industries discharge in the air, and in the water. It informs also, about the industrial wastes and about the industries risks.

The PAM publishes some information handbooks for masters of ships, booklet about reception and safety of vessels, handbooks about pollution detection awareness, magazines : “PAM magazine” and “port of Marseilles letter”, where it informs public about the different operations made in the port area.

At the end of 1996, the Marseilles port community was provided with such a system, Protis Export-Import, which has become required use throughout the general cargo operations of the port. It allows the entire port community to exchange information and data regardless of individual system structures, data banks or procedures.

The arrival of the Internet as part of the evolution of international information systems made it a vehicle for opening up the Protis system to other port communities and professionals. Marseilles unveiled its Internet site in mid-1997, supplying users with general information about the port.

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