Chrysostomos Stylios
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Sustainable Development of Sea-Corridors and Coastal Waters

The TEN ECOPORT project in South East Europe

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Preface

This book gathers the final research works that were submitted, accepted and presented at the 1st International Conference on "Sustainable Development of the Sea-Corridors and Coastal Waters", which was held in Tirana, ALBANIA, on 3 April, 2014, organized under the "Transnational enhancement of ECOPORT 8 network" (TEN ECOPORT) project with code SEE/D/0189/2.2/X, co-financed by the European Union within the SOUTH EAST EUROPE Transnational Cooperation Programme.

The Conference highlighted the progress in the management of environmental pollution, principally in ports and coastal regions, with particular attention to the scientific fields of marine biology and ecology. The main themes of the Conference were on:

(1) Assessment on environmental quality issues, (2) environmental monitoring methods and tools (3) sustainable environmental management systems, (4) environmental impact of Port processes and operations and (5) the historical influence of ports.

Conference put emphasis on water quality, issues that concern the marine environment of sea corridors and coastal waters especially in regions surrounding ports. Research works on methodologies, data and instrumentation of monitoring water quality were presented along with innovative monitoring methodologies, systems and instrumentation regarding marine environment.

The Conference was organised by the Polytechnic University of Tirana and the Port Authority of Durres with the support of the National Institute of Meteorology and Hydrology of the Bulgarian Academy of Science, the support of the Technological Educational Institute of Epirus and the support of all the partners of the project TEN ECOPORT.

TEN ECOPORT project is implemented since October 2012, aims to define common rules for the environmental management of the port areas along the Adriatic, Ionian and Black Seas. The development of maritime traffic in the same areas is the principal objective of this project comprised of 16 partners coming from Italy, Greece, Bulgaria, Romania, Montenegro, Croatia and Albania.

TEN ECOPORT is inspired by the great number of initiatives undertaken at EU level, aimed at improving sustainable mobility of people and freight along the sea-network, as well as by the extensive review process of the Trans-European Transport Network (TEN-T) policy, TEN ECOPORT aspires to a Common Model of Environmental and Sustainability Development & Sustainable Accessibility of the sea-networks.

There are two steps to ensure the sustainable development of the sea-corridors: the first one is to work on the implementation of common policies creating same opportunities in the involved countries and not affecting the concurrency among ports. The second one is to verify the quality of the process results.

TEN ECOPORT is focused on the creation of a permanent discussion platform organized in two levels: the first one among the Port Authorities aimed at establishing common rules, and the second one between individual ports and the stakeholders operating within each port area aimed at verifying the process results and proposing amendments of the environmental protocols in the long term.

The editors of this book would like to express their gratitude to Ms Andriani Oikonomou who was the heart of organizing the 1st International Conference on "Sustainable Development of the Sea-Corridors and Coastal Waters", and then gathered and compiled the research papers and supported us to the preparation of this book.

Acknowledgments

This book is produced within the SOUTH EAST EUROPE Transnational Cooperation Programme, Project Code SEE/D/0189/2.2/X, Acronym: TEN ECOPORT

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Part I
Assessment

Chapter 1
Integrated Assessment of the Quality of Harbor Sediments: Case Study Based on a Comparative Analysis of Sediments Quality of Two Industrial Ports: Bourgas (BG) and Bari (IT)

Matilda Mali, Maria Michela Dell'Anna, Piero Mastrorilli, Leonardo Damiani, Nicola Ungaro, Jordan Marinski and Magdalena Korsachka

Abstract In order to evaluate the pollution status of the sediments of two industrial and commercial harbors, an integrated approach was applied. A closer look of chemical and bio-toxicological data selected in 23 different stations located in the different internal basins of Bari port (IT) and Bourgas port (BG) is provided; integration of data by multivariate analysis was conducted, and a comparison procedure is presented as useful tool to elucidate the potential risk of sediments and helpful step towards a harmonized assessment criteria.

1.1 Introduction

Ports play an important role in human society, being areas where economic activities related to transportation, exchange and production of goods are concentrated, but they can heavily influence the marine environment. The port's effectiveness depends on its maritime accessibility, and for this reason, capital or maintenance dredging is frequently needed to ensure an adequate depth for navigation for vessels that visit the port. Depending on their chemical, physical, and ecotoxicological characteristics, dredged sediments may be managed in several ways. For example, unpolluted sediments with an appropriate grain size may be used for beach nourishment, or dumped at sea, while contaminated sediments must be isolated, treated, reused on land, or disposed in confined disposal facilities (CDF). The management of dredged material is usually controlled by a license system, which requires the preparation of a complex and often economically expensive

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managing dredging plan (MDP) based on the pollution level of the sediments. It is therefore clear that an adequate and correct characterization of harbor sediments impact seriously the whole dredging plan. International conventions such as the London Convention (1996, 2007), Barcelona Convention, OSPAR and Helsinki Convention, PIANC (1997) provide useful guidelines on the management of dredged sediments. Nevertheless, all abovementioned guidelines are usually nonmandatory for European countries. Literature studies confirmed that currently the EU legislation does not deal specifically with dredging sediments (Alvarez-Guerra et al. 2007, 2009; Hamburg Port Authority 2011), i.e., harmonized limit values of the contaminants for dredged material are not yet established; thus, the issue of the contaminated dredged material is regulated in each European country with legislation based on different approaches. This heterogeneity of approaches, on one hand, leads to a different assessment of sediment quality and on the other hand, often creates complex, expensive, and sometimes needless execution procedures, difficult to be understood (Choueri et al. 2009).

In this study, an integrated method for the assessment of the quality of sediments sampled in two industrial and commercial ports of two different countries, Bourgas port in Bulgaria and Bari port in Italy, was proposed. The method is based on the combination of the chemistry and biology/ecotoxicology measurements (Chapman 2006). Chemistry gives information on the presence, quantity and chemical form of substances linked to port activities. The integration of biological investigations allows an assessment of toxicity and bioavailability of contaminants, to understand the mechanisms of their toxic action and identification of the area of potential biological impact within port's basins (Hoellert et al. 2002). This method was aimed to develop a general protocol able to standardize the procedure for the quality assessment and managing of contaminated sediments of different countries, thus, allowing an inter-comparison of the obtained results in laboratories of different nationalities.

1.2 Materials and Methods

1.2.1 Study Areas and Sediment Sampling

The port of Bari (IT) and the port of Bourgas (BG) are two important hubs of the port-network respectively alongside Adriatic Sea and Black Sea. Both ports cover a key role in the freight and passengers traffics within the South East European area. The port of Bari is one of the most important harbors of the southern Adriatic coast. It was traditionally considered the gateway of Europe to the Balkan Peninsula and the Middle East. Nowadays, it is a multipurpose stopover equipped with docks for handling all different goods and freight. Several quays for different types of commercial traffic (solid and liquid bulk, containers, packaged goods, steel products, forest products, etc.), as well as wharfs for Ro-Ro ferries and platforms for cruise ships, are daily used. The water design depth varying from 6.9 to 14.9 m, allowing handling of bigger size ships and vessels. The important activity and the increased ship traffic within the port

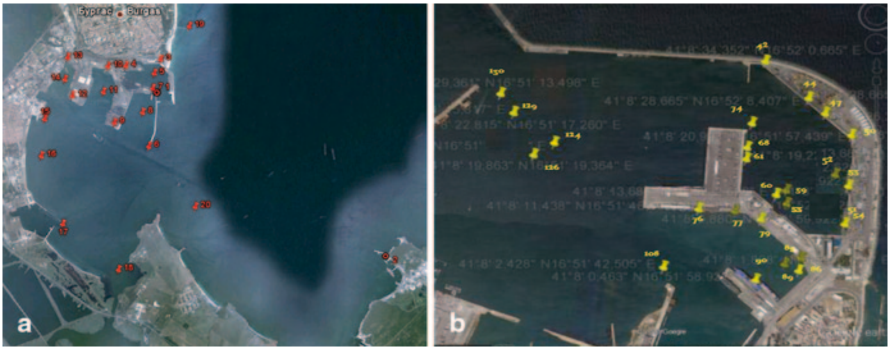

Fig. 1.1 Sampling map. **a** Port of Bourgas. **b** Port of Bari

area impact seriously the quality of port aquatorium and therefore of harbor sediment quality that acts as final sink of all the contaminants ending up in the water column.

The port of Bourgas is one of the biggest and busiest Bulgarian ports. It is situated at the head of the Homonym Bay, on the west coast of the Black Sea. Due to its strategic location, it is actually considered the gateway of the Pan-European Corridor VIII from Italy via Albania and the former Yugoslav Republic of Macedonia to the Middle Asia, Russia and other commonwealth of independent states (CIS) countries. The harbor area has a very easy access from the sea and is well protected from the winds and waves. The port comprises 28 berths with a total length of 4800 m and 24 operative quays with a whole mooring length of 4800 m. The water depth ranges from 6.1 to 15.5 m, allowing the handling of vessels up to 125,000 DWT. There are railway lines in the majority of quays. The port of Bourgas is relatively well equipped with passenger, container, and Ro-Ro terminals, almost linked directly with the cold storage area.

In the present work, the sampling campaign was carried out in 2010–2011, and it was accurately planned, according to Loring and Rantala (1991). Representative samples for each basin's feature were collected, taking into account the problems associated with trace level cross-contaminations. Depending on the sampling location, the data were divided into several groups representing particular features of harbors (Fig. 1.1).

The devise used for sampling is a vibro-corer PF1, equipped with liner for the Bari sediments and grab samplers for Bourgas sediments. In both cases, the support of vessels provided with the differential system global positioning system (GPS) for positioning of sampling cores was utilized. The samples were individually transferred into precleaned polyethylene boxes and stored at 4 °C till they reached the laboratory.

1.2.2 Determination of Total Organic Carbon (TOC)

In Bourgas sediments, TOC was determined by Turin's method based on dipotassium dichromate oxidation (Kaurichev 1980), while loss of ignition and gas chromatography separation techniques through Carbon, Hydrogen and Nitrogen (CHN) analyzer were used for TOC determination in sediments collected in the port of Bari. The analytical procedure was checked with reference-certified materials, 277 Community Bureau of Reference (BCR) and National Research Counsil of Canada (in original language *Conseil national de rechershes Canada*)(NRC CNRC) HS-1 for organic compounds, which allow agreement with certified values higher than 90 %.

1.2.3 Determination of Petroleum Hydrocarbons Content (THC)

Petroleum hydrocarbon content in sediments was determined in two different methods: gravimetrically for Bourgas sediments and by solvent extraction and infrared (IR) spectrometry (USEPA 1994) for Bari sediments.

1.2.4 Determination of the Heavy Metal Concentration

The distribution of 7 heavy metals was analyzed (Cd, Cr, Ni, Pb, Cu, V e Zn). Two analytic methods were used for the determination of the heavy metal concentration. The Bourgas port's sediments were analyzed with the energy dispersive X-ray fluoresce method, while in the Bari port's sediments the heavy metal content was assessed, after sample mineralization, by inductively coupled plasma–mass spectroscopy (ICP-MS, Thermo X Series). Standard reference materials for trace elements offered by advanced research projects agency (ARPA) were used to control the analysis quality. Mineralization of the different matrices prior to metal analyses was carried by microwave irradiation after addition of HCl/HNO3/HF solution to each weight sample. The procedure was followed twice for each sample. As to the Hg concentration, it was determined by cold vapor atomic fluorescence spectroscopy following HNO3–H2SO4 procedure.

1.2.5 Bio-Toxicological Tests

Two different biotests are used: The toxicity of Bourgas port sediments were analyzed using the phosphatase activity of sediment bacterial communities. Phosphorus is the growth limiting factors for phototrophic organism in the sea and its supply depends largely on the regeneration of phosphate from organic matter accumulated on the sea bottom. The regeneration process is carried out by exoenzymes called phosphatases. Sediment bacteria capable of polyphosphate metabolism are directly implicated in sediment phosphorous dynamics and control phosphorus metabolism of marine ecosystems. Therefore, their activity can be used as a sensitive indicator of toxic effects of pollution on marine ecosystem; hence, the test indicates whether

Table 1.1 Toxicity scale according to the criteria reported in ICRAM–APAT (2007)

Bio-species	Class A Absent/negligible toxicity	Class B Moderate toxicity	Class C High toxicity	Class D Severe toxicity
Vibrio fischeri	S.T.I. ≤ 3	3 < S.T.I. ≤ 6	6 < S.T.I. ≤ 12	S.T.I. > 12
Dunaliella tertiolecta (elutriate)	EC20 ≥ 90 % Δ ≤ 15 %	EC20 < 90 % eEC50 > 100 % 15 < Δ% ≤ 30	40 % ≤ EC50 100 % 30 < Δ % ≤ 80	EC50 < 40 % Δ > 80 %
Paracentrotus lividus (elutriate)	EC20 ≥ 90 % Δ ≤ 15	EC20 < 90 % e EC50 > 100 % 15 < Δ % ≤ 30	40 % ≤ EC50 < 100 % 30 < Δ % ≤ 80	EC50 < 40 % Δ% > 80

sediment bacterial communities in the different points of sampling are intoxicated, and the level of intoxication was determined by the reduction of the bacterial phosphatase activity.

On the other hand, the bioassay battery was used for monitoring of the toxicity of Bari sediments. The bioassay battery includes three tests: the Microtox® Solid Phase Test (SPT), an acute toxicity test for solid matrices based on inhibition of natural bioluminescence of the marine bacterium *Vibrio fischeri*. This test was applied directly to the solid phase (whole sediment or after removal of pore water). In addition, bioassay using the sea urchin *Paracentrotus lividus,* conducted on the extracted liquid phase (elutriate) of the sediments and the algal growth inhibition test (using *Dunaliella tertiolecta)* was also conducted. The analytical methods and toxicity classification criteria were applied according to national or international official procedures (Table 1.1).

1.2.6 Statistical Analysis

Principal component analysis (PCA) was performed with statistical software (STATISTICA (v.7)). The number of factors was detained by the total variance explained.

1.3 Results and Discussion

1.3.1 Chemical Data

The data obtained by chemical analyses showed different levels of contamination within inner basins of both ports due to intensive human activities. Total hydrocarbons (Fig. 1.2) confirmed the literature data for the port of Bourgas. The pollution of Bourgas Bay was well documented by many researchers (Kamburska and Valcheva 2003; Dencheva 2010; Rojdestvenski 1986; Moncheva et al. 2001, 2002) and in

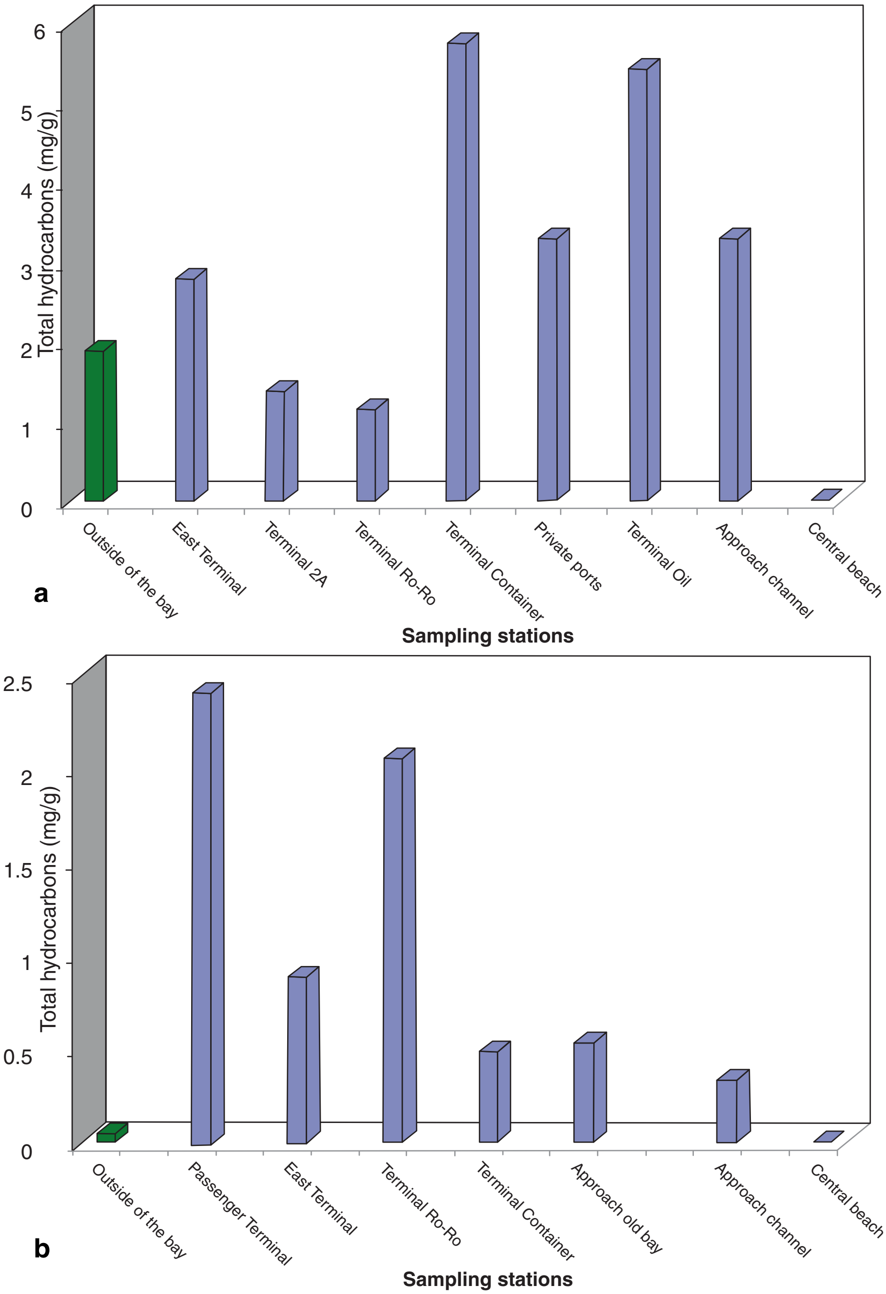

Fig. 1.2 The levels of total hydrocarbons. **a** In the port of Bourgas sediments. **b** In the port of Bari sediments

some monitoring programs (Dencheva 2008) of Black Sea. On the contrary, for the port of Bari, pristine data are not available. In Italy, national guidelines established specific threshold levels of contamination aimed to support the classification of sediments in different risk classes, while in Bulgaria sediment quality guidelines are not yet established at national level and pollution threshold level are not available. For these reasons, the obtained data were herein compared with two guidelines, threshold effect level (TEL) and probable effect level (PEL) according to MacDonalds et al. (2000).

The level of hydrocarbons in Bourgas bay sediments is high—up to 8.97 mg/g dry wet sediment. Based on some published works, the total hydrocarbons content in sediments more than 0.5 mg/g is indicative of pollution, while sediments containing less than 0.01 mg/g of total hydrocarbons may be considered as unpolluted. In accordance with this rule, the following situation was observed: For the Bourgas port, the stations 19, 22, 4, 7, 23, 10 and 12 can be considered as unpolluted since the level of hydrocarbons revealed are under the threshold level allowed; sediments from stations 8 and 9 can be considered as low polluted and the others as heavy polluted. Totally, the basins "Terminal Container" and "Terminal Oil" are the most impacted of oil pollution.

The most polluted stations within the port of Bari are those dedicated to the container and Ro-Ro traffics represented by the stations BA42, BA44, BA51 (an average of 3.0208 mg/g) and near the Passenger Terminal—BA89 and BA90 (accounting 6.25 mg/g). The sampling stations located in the approach channel of the port and those located in the open sea (account 0.02 mg/g) can be considered as unpolluted. The other stations revealed a moderate concentration of pollutant accounting a range of 0.2–1.8 mg/g dry wet sediments.

As to the sediment organic matter, it should be highlighted that in most of the sampling stations in both ports, the bottom bay is quite muddy. Different levels of total organic matter are accordingly revealed. The concentration of organic matter in Bourgas (Fig. 1.3a) varies from 28 mg/g (station 20) to 372 mg/g dry wet sediment (station 13) and the sediments richest in organic matter are those of "Terminal Container," as well as station 19, where it is recorded decayed biomass of mussels. The accumulation of high concentrations of organic matter on the sea bottom, especially on that of "Terminal Container" is a result of the low self-purification capacity of the Bourgas Bay. Less, but relevant concentrations are revealed within the port of Bari (Fig. 1.3b). High concentration of organic matter is revealed in stations 89, 90, and 76 and 81 (respectively 5.8, 2.5, 4.1, 3.1 mg/g) alongside the Passenger Terminal. Noteworthy, also the high concentration respect the mean of the whole Bari *port aquatorium* in the station located within the Ro-Ro Terminal (BA42, BA44—an average of 4.5 mg/g) and Container Terminal (BA53, BA56—an average of 3.2 and 3.0 mg/g). The lower concentration level of organic matter within the port of Bari is probably related to a different hydrodynamic design of Bari port that permits a major self-purification of sea bottom.

With regard to the heavy metals, the data obtained revealed for both ports higher concentration of heavy metal. The Bourgas Bay sediments revealed higher concentration of copper (Cu), zinc (Zn) and lead (Pb). The concentrations of Cu in the

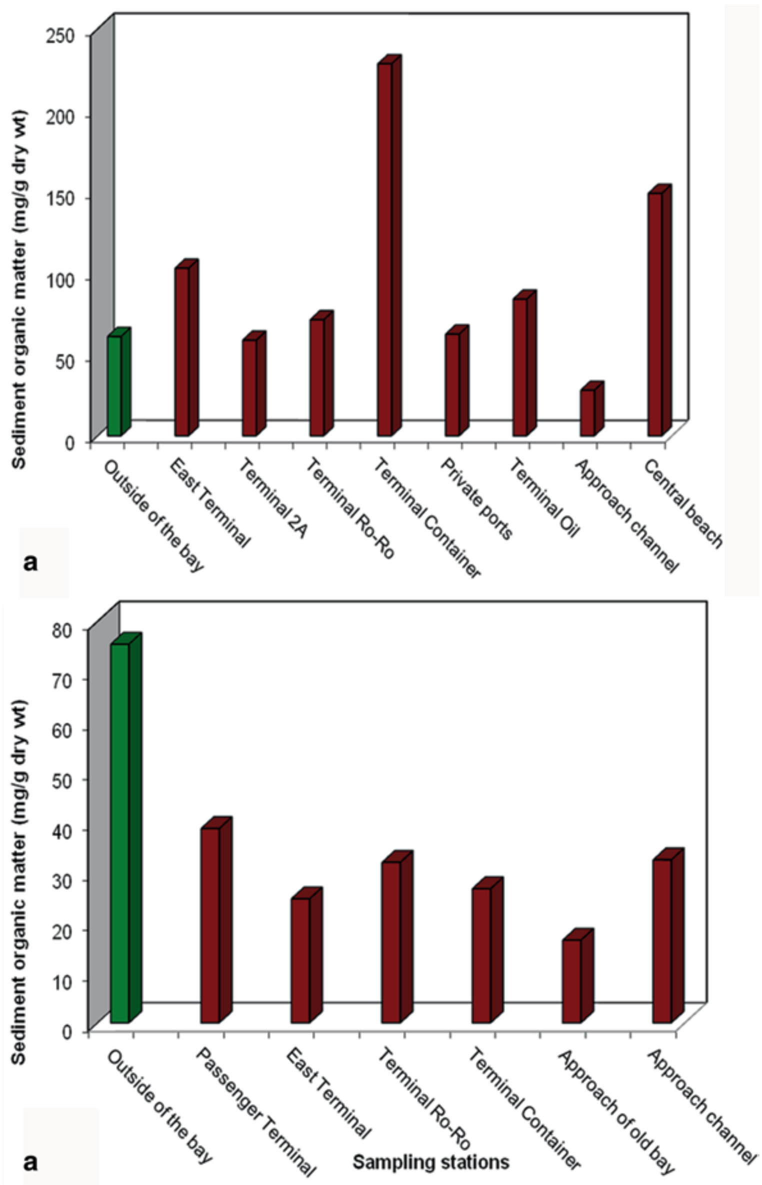

Fig. 1.3 Organic matter concentrations. **a** In the sediments of the Bourgas port. **b** In the sediments of Bari port

sediments of Bourgas Bay's basins exceeds from 7 to 26 times that of control station (32 ppm) as the most polluted is the station 11 located in the Ro-Ro Terminal. The same consideration was provided for Bari port. Higher concentration values are related to Cr, Cu, Pb, and Zn, and the most polluted stations are those related to the Passenger Terminal and Ro-Ro and Container Terminal. In order to establish the toxicity of the each basin, the concentration levels of heavy metals are compared with TEL and PEL sediment quality guidelines according to MacDonald et al. (1996). Overall, more than 95 % of all metal concentrations exceeded the TEL and 45 % exceeded the PEL sediment quality guideline. Highly variable exceedances of the TEL and PEL values, in both ports, were revealed (in Bari: 0 % Cd, 71 % Cr, 100 Cu, 90 % Pb, 100 % Ni, 95 % Zn and V and the PEL (65 % Pb); in Bourgas: 100 % Cd and Cr, 77 % Cu, Ni, Pb, Zn and the PEL (50 % Cu, Ni, Cr, 33 % Pb and Zn); Fig. 1.4a, b).

1.3.2 Bio-Toxicity Data

Bacterial phosphatase activities (µg/mg sediment organic matter) in the basins of Bourgas bay are lower than the average activity of the referent stations (outside of the bay) and the rate of inhibition varies from about 4 % (private ports) to about 57 % (Terminal 2A and Terminal Container) (Fig. 1.5). The sediment bacterial communities from basins "Terminal Container" and "Terminal 2A" could not overcome the anthropogenic stress resulting in inhibited phosphatase activities and therefore reduced share in nutrients' cycling.

Basin "Terminal Container" is high eutrophic and unfavorable for the growth of sediment aerobic bacteria while the values of environmental factors measured in "Terminal 2A" are much better. The low bacterial phosphatase activity in "Terminal 2A" basin may be a result of the toxicity of Zn whose concentration is the highest among the basin's sediments measured or with the grater probability—the impact of unstudied factor/factors (environmental and/or anthropogenic) in the survey.

Bioassay battery used for the toxicity of the port of Bari revealed that the worst biological effects were highlighted in the Passenger Terminal. A significant reduction of bioluminescence in the bacterium *V. fischeri* applied to the solid phase of samples was revealed in almost all stations, except the approach channel of the port where low toxicity results are registered. The algal bioassay with *D. tertiolecta* on elutriate underlined a high toxicity in the stations located within some station within the Passenger Terminal, the Ro-Ro Terminal and the Container Terminal (BA 42–BA 51). Similar results are revealed with sea urchin *P. lividus* that evidenced severe toxicity within the same stations revealed by bioassay with algae *D. tertiolecta*. The total toxicity of each sampling stations was expressed as ratio among the R_i = score value assigned for each sampling station and R_{ij}, the maximum total score value achievable ($T = R_i / \sum R_{ij}$) (Fig. 1.6). The worst values registered in the Passenger Terminal are probably related to the bioavailability of contaminants mixtures within this area.

1.4 Multivariate Analysis

The integration of chemical and bio-toxicological data is performed through different multivariate analysis. The analysis of the variables aggregated by PCA, a representation of estimated factors score from each station of the centroid of all

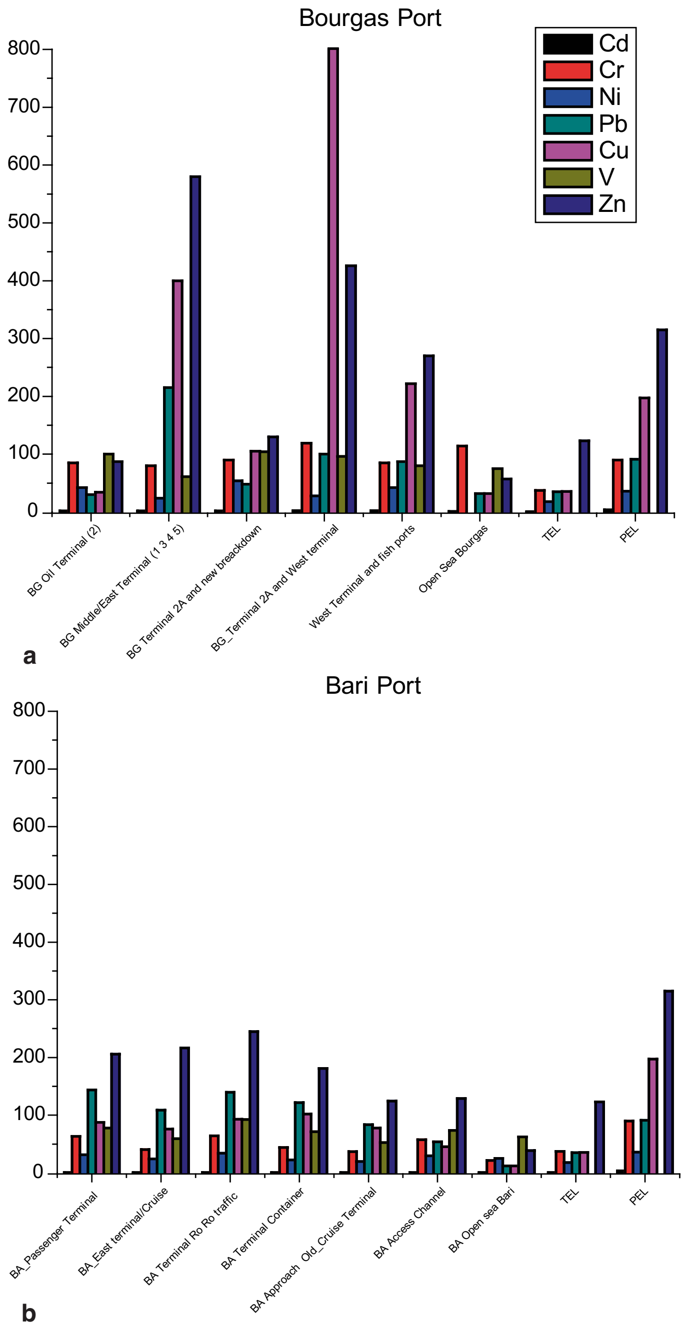

Fig. 1.4 Heavy metal concentrations and comparison with *TEL* (threshold effect level) and *PEL* (probable effect level) threshold values according to MacDonald et al. (1996). **a** Within the sediments of the Bourgas port. **b** Within the sediments of Bari port

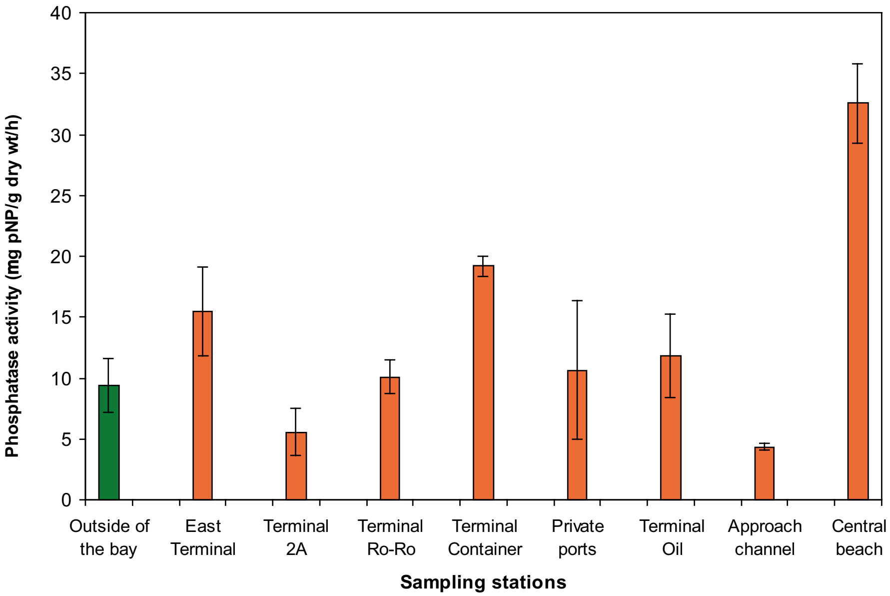

Fig. 1.5 Bacterial phosphatase activity (μg/mg organic matter/h) in the sediments of sampling stations

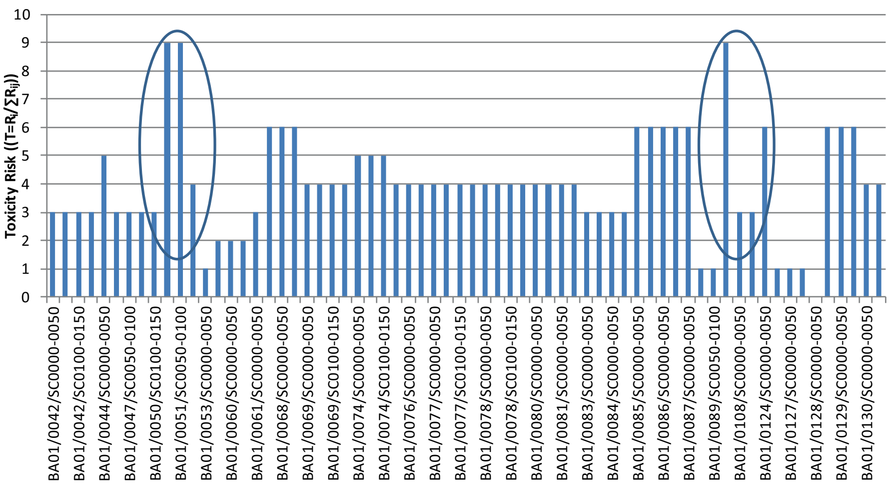

Fig. 1.6 Toxicity in the sediments of Bari sampling stations. The stations which are marked with a *circle* belong to the Ro-Ro Terminal (BA51) and Passenger Terminal (BA89)

cases for the original data was done in the present work, in order to confirm the factor descriptions and to characterize the quality of the sediment at each port.

1.4.1 Port of Bourgas

By means of the application of a PCA, the chemical and bio-toxicological data were represented by three new variables, or principal factors, which explain 89.79 % of the variance in the original data set (Fig. 1.7). The first principal factor (F1) is predominant and accounts for 46.55 % of the variance; this factor related almost all heavy metals (except Ni, V, THC) to toxicity responses in the whole sediment toxicity tests with bacterial phosphatase activity. The correlation between chemical and bacterial phosphatase activity is very much lower in factor 2 and in factor 3 (both accounting 23.60 and 19.64 % of the total variance, respectively). In any case, they show the expected relation between total organic matter and phosphatase activity.

1.4.2 Port of Bari

Chemical concentrations in port of Bari sediments were associated by PCA with toxicity resting in three principal factors (Fig. 1.8). Such factors explained 93.82 % of the total variance in the original data set. The first principal factor (F1) was predominant and accounted for 67.96 % of the total variance. This factor combines the toxicity with the concentration of Cu, Pb, and Zn. The second factor accounts for 16.76 % of the variance and combines the toxicity with total hydrocarbon and concentration of Cd in sediments. The contribution of the Passenger Terminal and Ro-Ro/Cruise Terminal is determinant for the correlation detected.

The results of this investigation show that the contamination is closely related the high concentration of heavy metals in both area, as in Bari as in Bourgas area. It means that the binding forms of such metals or chemical mixtures within sediments are available for the benthic community. The environmental degradations related by hydrocarbon are also revealed in both areas. Almost all the toxic areas identified are related to the anthropogenic activities within port basins. Because of the environmental degradations in the studied ecosystems and the different legal frame assessment, it was difficult to find a satisfactory referee area. By using the PCA, such problem was minims, and thus inferences could be made about the sediment quality of both ecosystem with or without reference area. The multivariate analysis approach was considered also very useful since it combines different types of data—chemical and biological in different ecosystem. A common approach for both areas could lead into definition of international protocols.

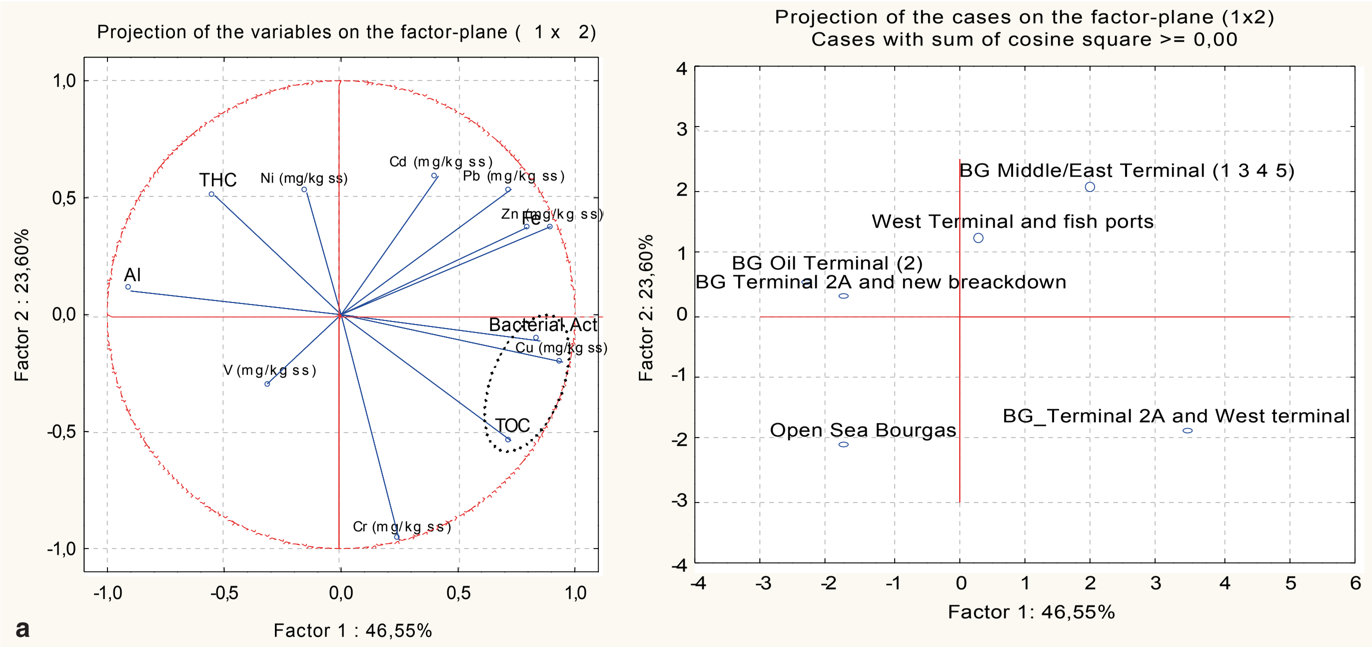

Fig. 1.7 Factor loading projection on factor plans for Bourgas port. **a** Projection of score and loading plot in the 2D on PC1–PC2. **b** Projection of score and loading plot in the 2D on PC1–PC3. *TOC* total organic carbon

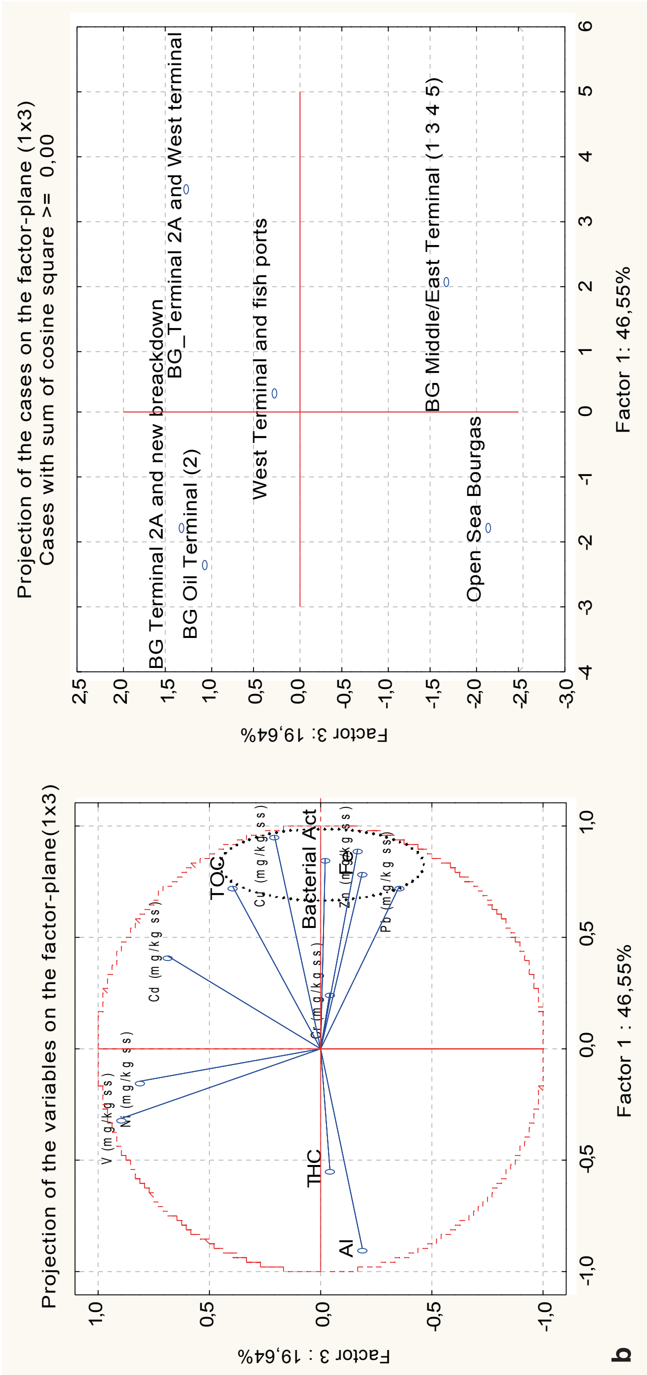

Fig. 1.7 (continued)

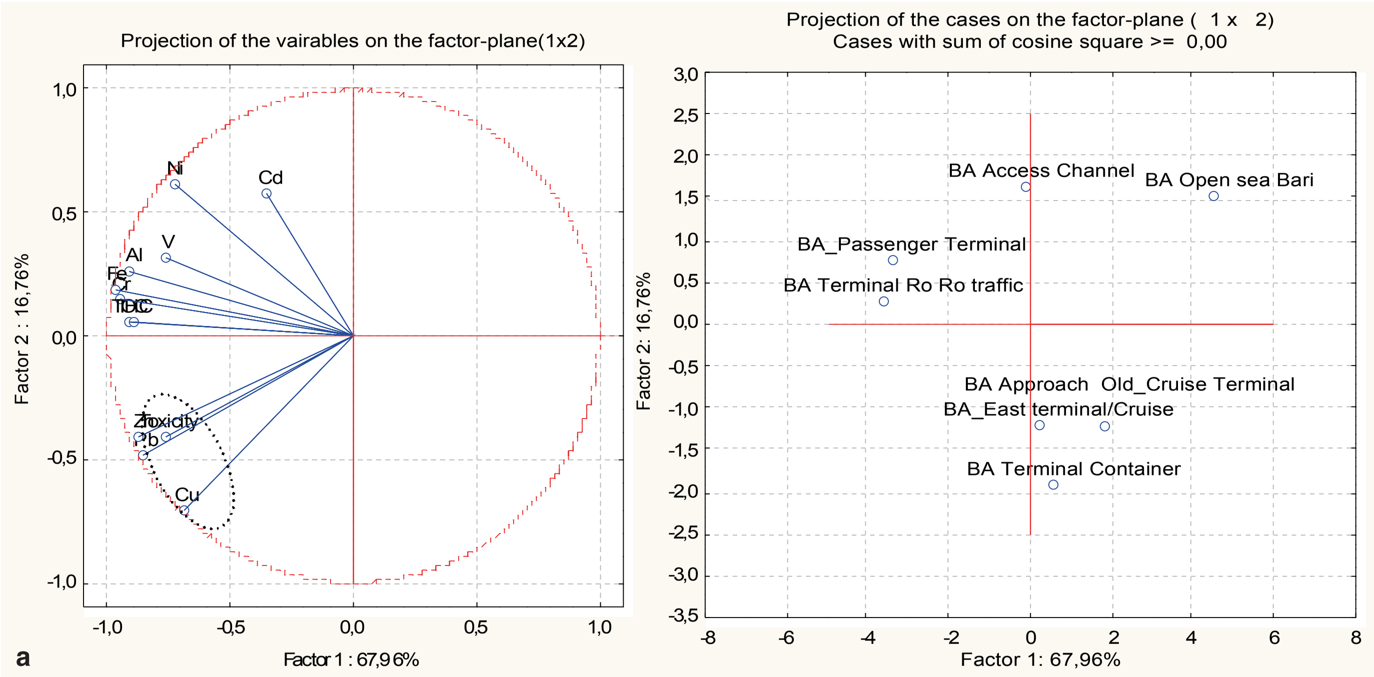

Fig. 1.8 Factor loading projection on factor plans for Bari port. **a** Projection of score and loading plot in the 2D on PC1–PC2. **b** Projection of score and loading plot in the 2D on PC1–PC3. *TOC* total organic carbon

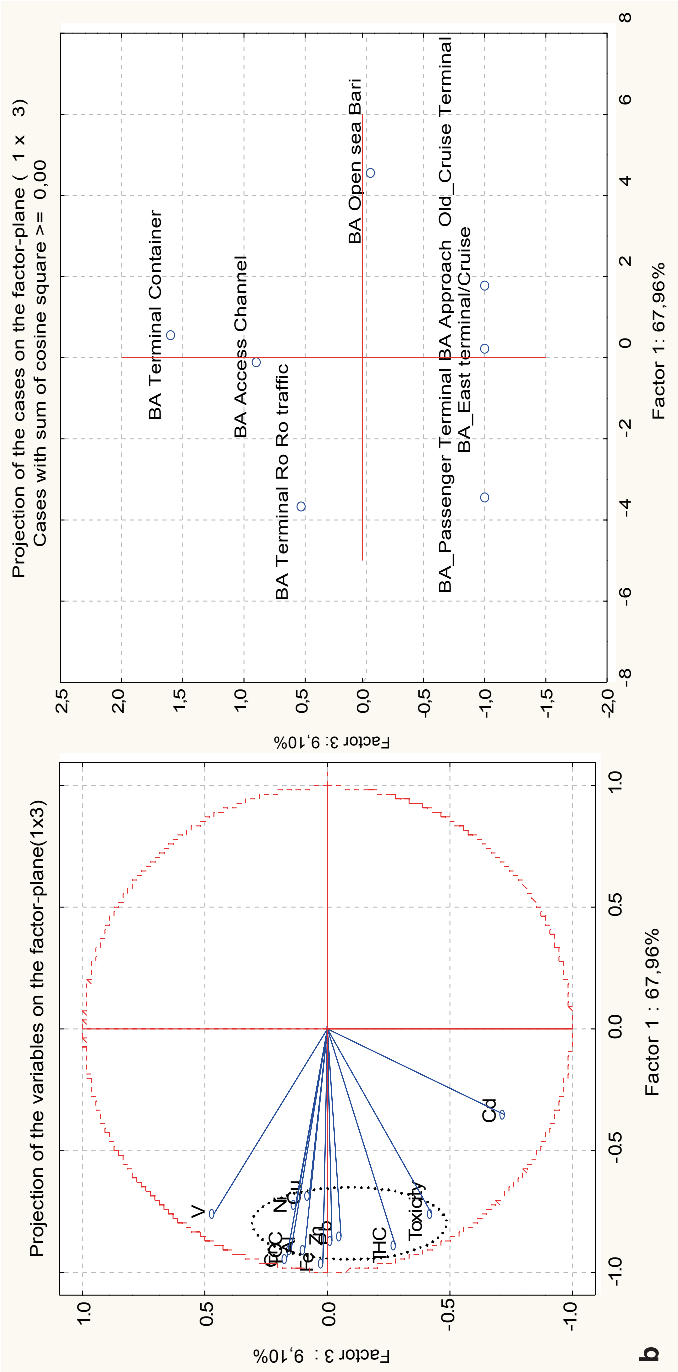

Fig. 1.8 (continued)

1.5 Conclusions

Harbor sediments are both source and sink of persistent contaminants in the port aquatorium area. It is difficult to determine cause-effect relationships resulting from mixtures of chemical contaminants found in harbor sediments, so the development of sediment quality values is moving forward on integrated approach that combines the potential cause (chemistry) and effect measurements (biology) providing a complete and powerful tools available today to determine the extent and significance of pollution-induced degradation. The integration of environmental data can be performed through different univariate and multivariate techniques: Multivariate analysis permits the integration of data of different natures (chemical, biological, toxicity endpoints, or benthic descriptors) resulting in a wider analysis that allows deeper and robust interpretation of the data. In this way, an internationally harmonized protocol would be developed available to standardize the procedures for the assessment and managing of contaminated sediment among countries allowing thus an inter-comparison of the techniques and the obtained results.

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Chapter 2
The Influence of Oil, Dispersed Oil and the Oil Dispersant SD-25, on the Heart Rate of the Mediterranean Mussel (*Mytilus galloprovincialis* L.)

Rajko Martinovic, Zoran Gacic and Zoran Kljajic

Abstract We applied an innovative technology, based on infrared light sensors, to point out the possible harmful effects of diesel oil and the oil slick dispersant Super-dispersant-25 (SD-25) on the cardiac system of the Mediterranean mussels (*Mytilus galloprovincialis* L.). Heart rate (Hr) measurements were conducted under laboratory conditions by noninvasive procedure for the registration and analysis of cardiac activity of molluscs and crustaceans. No response was observed of the Hr within a group of mussels in 2 h of exposure to 1 ml/l of diesel oil. However, a decrease of Hr in application of 10 µl/l of diesel oil dispersed by the same amount of SD-25 was recorded. Moreover, the very low concentration of SD-25, 2 µl/l and a hundred times higher one, caused a significant bradycardia which could be the evidence for high toxicity of this chemical. The resulting changes of the mussels Hr were reversible. The main advantages of the technique applied are data accuracy and real time information about changes of the environmental conditions.

2.1 Introduction

Oil spill incidents are inevitable in areas of production, transport, and the usage of oil (Etkin 2011). Oil contains polycyclic aromatic hydrocarbons (PAHs) with potent carcinogenic and mutagenic effects (Luch 2005). Blue mussels (*Mytilus edulis* L.) have a low ability to metabolize PAHs which leads to bioaccumulation in tissues (Neff 2002).

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Operational discharges from shipping and the cleaning of seashores cause an inordinate release of oil mixtures and commercial dispersants in the Adriatic Sea. Only a few dispersant formulations are widely registered and available in great quantities; one is Corexit 9527 (GESAMP 1993). Testing the influence of dispersants to a different sea species, it was found that SD-25 was less toxic than Corexit 9527 (Scarlett et al. 2005). In general, the crude oils and oil derivatives have a higher acute lethal toxicity than oil dispersants (Wells 1984).

There is a lack of available data considering the impact of SD-25 to the environment. This efficient agent has detergent properties, breaking the oil slick into fine droplets. This property makes it easier to disperse in sea conditions. SD-25 contains the following hazardous substances: 2-butoxyethanol and dioctyl sulphosuccinate (Oil Slick Dispersants ltd 2012). Accordingly, the organisms inhabiting the water column and the intertidal animals such as bivalves are particularly endangered. SD-25 was frequently used in the shipyard Bijela, Montenegro. Thus, we decided to test it on marine animals in vivo.

The Mediterranean mussel (*Mytilus galloprovincialis* L.) was suggested as a good indicator of different stress conditions in the aquatic environment (Moschino et al. 2011, Spada et al. 2013).

The human cardiovascular system quickly responded to stress, induced by oxygen depletion in arterial blood during exercises (Buchheit et al. 2004). Likewise, the occurrence of heavy metal pollution was rapidly detected by the heart of the Mediterranean mussel (Martinovic et al. 2013a) due to the activation of internal protective mechanisms that overcome this unfavourable situation. Later findings clearly determine the mussel's heart rate (Hr) as a suitable physiological parameter that provides early information about changes in environmental conditions.

One of the first methods based on infrared (IR) light sensors, used for recording the cardiac activity of molluscs and crustaceans, were designed by Depledge (1990).

We applied the innovative fiber optic method, developed by Kholodkevich et al. (2008), for the registration and analysis of the cardiac activity of invertebrates with solid skeletons. The noninvasive laser fiber-optic photopletismograph (LFOP) was used as a reliable device to provide the information about the Hr of Mediterranean mussels. Cardiac activity monitoring of eight specimens was conducted by fiber-optic IR light sensors attached to the mussel valves.

The objective of the study was to assess changes of the Hr of the Mediterranean mussel (*M. galloprovincialis* L.) from the Adriatic Sea, in short-term exposure to diesel oil, dispersed diesel oil and SD-25. Also, the aim was to create a basis for further application of IR light sensors in the biomonitoring of seawater.

2.2 Materials and Methods

Experiments were carried out at the Institute of Marine Biology Kotor on the coast of the Adriatic Sea. Sub-littoral Mediterranean mussels (*M. galloprovincialis* L.) were collected from a mussel farm in the Boka Kotorska Bay (Montenegro, 42°26′ N, 18°45′ E) at a depth of 2–3 m. After sorting, by shell length (60–70 mm) and the removal of encrusted organisms, 30 molluscs were placed in an aquarium in a temperature-controlled room for 72 h, for acclimatization to laboratory conditions (artificial salt water with constant aeration, water temperature 20 ± 1° C and salinity 20 ± 1 g/l). Water was replaced daily.

The experimental unit for Hr registration and analysis is composed of 8-channel laser photopletismograph (LFOP), optical fibers with sensors (containing an IR light emitter and detector), 14-bit analog to digital signal converter (ADC) and a personal computer (PC; Martinovic et al. 2013b).

Eight mussels with attached sensors were maintained for 24 h, before the Hr measurements. Installing the sensors on the mussels valves above the heart area by use of harmless epoxy adhesive, allows IR light beam to pass through the shell illuminating the heart and circulatory vessels. The reflected light, modified by heart contractions, was received by an IR detector within the sensor. The obtained heartbeat signal was amplified, filtered, and digitalized by ADC and then sent to the PC.

Simultaneous recording of cardiac activity of eight individual sea shells was used for the analysis of Hr variations, caused by the applications of diesel oil, dispersed oil and the oil dispersant SD-25 as functional loadings. The oil slick dispersant Superdispersant-25 (SD-25) has all the approvals required for use at sea, on beaches and rocky shores (Oil Slick Dispersants ltd 2014).

Three different concentrations of functional loadings (10 µl/l of dispersed diesel oil; 2 and 100 µl/l of SD-25) were applied by pipette to an aquarium with 10 l of artificial seawater. For the preparation of dispersed diesel oil, we used 10 µl/l of diesel oil combined with a 1:10 water solution of 10 µl/l of SD-25. The oil mixture was placed in an automatic shaker for 12 h to enable better dispersion. After 2 h of exposure to the functional loadings, it was washed out and replaced with clean seawater.

VarPulse original software with variation pulsometry method was used to study the statistical analyzes of cardiac intervals (Kholodevich et al. 2008).

To determine the initial values of the Hr as a baseline, recording of mussels cardiac activity was started 2–3 h before the functional loading application. The Hr baseline was important as a reference point for the analysis of later-occurred Hr changes induced by the impact of tested substances.

The recovery time of an organism after stress caused by deterioration of the environmental conditions is calculated as the time needed for the restoration of Hr values before the experimental changes (Martinovic et al. 2013b). The calculation of recovery time was based on result graphs.

2.3 Results

There was no change in cardiac activity of the Mediterranean mussels in the action of 1 ml/l of diesel oil. Hr was consistently retained on the baseline level, all the time of exposure.

The influence of 10 µl/l of diesel oil, dispersed by the same concentration of the oil slick dispersant SD-25, caused a decrease in cardiac activity of mussels. The mean Hr baseline value within a group of eight mussels was stable at 18.7 beats/min with low standard deviation (SD; Fig. 2.1a). During the exposure period (*between*

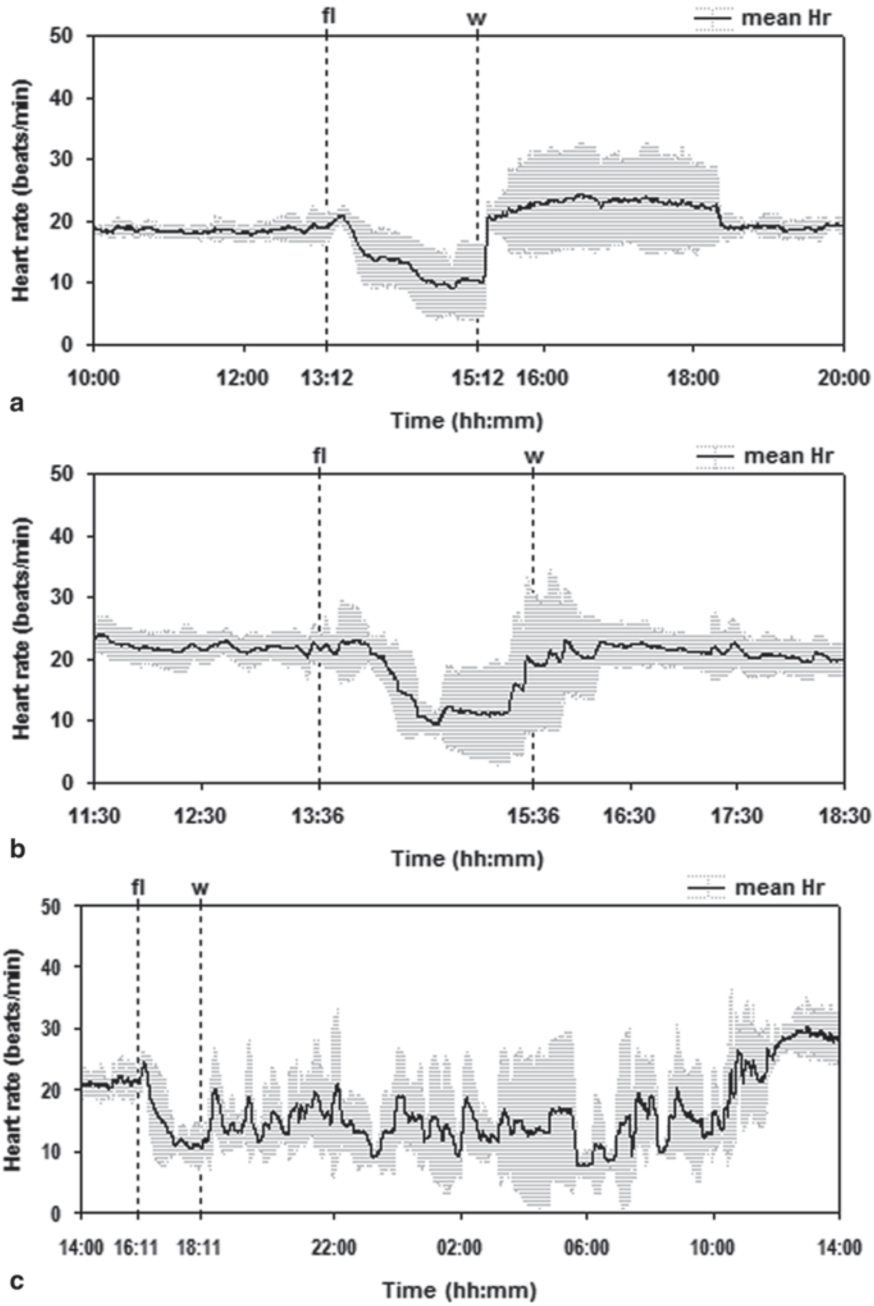

Fig. 2.1 Mean heart rate with standard deviation within a group of Mediterranean mussels *M. galloprovincialis* L. in 2-h exposure to **a** 10 µl/l of diesel oil, dispersed by 10 µl/l of SD-25, **b** 2 µl/l of SD-25, and **c** 200 µl/l of SD-25. *Hr* heart rate, *fl* functional loading, *w* washout

dashed lines), a slight increase of the Hr was observed, six minutes after functional loading application, followed by a descent to a minimal value of 9.1 beats/min and with a higher SD. The minimal Hr value was more than 50 % lower compared to the initial point. After the washout, the Hr was increased sharply with a significantly higher SD. The recovery time was calculated as the period from the moment of washout to achieving stable Hr values with a low SD. This was 3 h and 12 min.

The lowest concentration of SD-25 that impacted cardiac activity of the mussels, was only 2 µl/l. Also, we observed a large decrease in Hr activity from 23.1–9.6 beats/min followed by higher SD (Fig. 2.1b). Before the moment of washout, the mean Hr value was increased to 20.2 beats/min due to the spontaneous onset of Hr recovery. After the washout, the time of Hr recovery was only 46 min.

Five minutes after the application of 200 µl/l of SD-25, the initial Hr value rose for a short time, then sharply dropped from 23.2 to 10.4 beats/min (Fig. 2.1c). During the exposure, high concentration of SD-25 caused a great amount of foam in the aquarium due to strong dispersant activity. After the washout, Hr had ascending trend with high fluctuations retained for a long period. Also, SD was high and unstable. Accordingly, Hr recovery time was very long, 18 h and 40 min.

2.4 Discussion

The absence of Hr response in the action of 1 ml/l of diesel oil could be prescribed to the relatively short exposure period, associated with the insolubility of oil in seawater. In a recent study, published by Bakhmet et al. (2009), long-term exposure of oil pollution to blue mussels (*M. edulis* L.) caused changes of Hr.

Possible reasons were offered for the long-lasting decrease of the Hr of mussels during the exposure to different toxic polluters. Valves closure accompanied with blocking neuromuscular transduction was suggested by Kholodkevich et al. (2009) and stimulation of inhibitory cholinergic nerves of the heart (Curtis et al. 2001).

In our opinion, decrease of the Hr in action of dispersed diesel oil and SD-25 could be the low oxygen consumption when the mussel valves are closed and also the impact of hazardous compounds of SD-25. However, spontaneous Hr recovery observed in the addition of the lowest dose of SD-25 indicates that, in spite of the presence the toxicants, mussels overcome the stress that leads to conclusion that SD-25 poses mechanism of action that does not affect neurophysiologic pathways.

Associated with oil, SD-25 caused a longer recovery time to stress than separately. After dispersion, oil was able to reach mussel tissues, and despite low concentration, it was possible to contribute in resulting reaction of the mussel's heart.

Long-term fluctuations of the Hr in the action of 200 µl/l of SD-25 can be prescribed to insufficient washout of chemical due to great the quantity of foam. Thus, the baseline Hr value was achieved after the period required for water filtration by mussels.

2.5 Conclusions

We cannot argue that the direct influence of diesel oil is not dangerous for seashells, based on the absence of cardiac activity response within 2 h of exposure. However, oil slicks present a serious problem due to their mechanical impact on the entire ecosystem.

Dispersed diesel oil is more hazardous to organisms inhabiting the water column due to its solubility in seawater.

Due to a significant response in cardiac activity of the Mediterranean mussels (*M. galloprovincialis* L.) in the delivery of the 2 µl/l of SD-25, this could be the evidence for high toxicity of oil slick dispersant. Furthermore, the usage of SD-25 and similar substances needs to be reduced.

The fast response of the mussels Hr to the deterioration of environmental conditions, results obtained by IR light-based technology, may become an important tool for testing the impact of hazardous substances that are present in the port areas.

Acknowledgments This chapter is part of the ongoing TEN ECOPORT project supported by the South East Europe Transnational Cooperation Programme, EU funded and part of the project Kotor (complex research of the ecosystem of the coastal sea of Montenegro), supported by the Ministry of Science, Montenegro. Also, authors are grateful to Prof. SV Kholodkevich from SRCES RAS, St. Petersburg, Russia, and EPA Montenegro for providing experimental equipment.

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Chapter 3
Assessing the Impact of Port Bourgas on Air Quality During Different Seasons

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Abstract Bulk cargo handling operations is one of the major factors that may cause undesirable effect to the air quality of urban and port areas in Bourgas. The air quality monitoring of the port of Bourgas is needed to deliver reliable data for air pollution assessment in the area of the port, as well as for better insight of the impact of the port activities on the air quality of the city. Unfortunately, there is no information for the bulk cargo or open source events. There is no record on what type and amount of material, what size of the pile and duration of exposure to wind existed. Therefore, in this dispersion study of the particulate matter with diameter size smaller than 10 micrometers (PM10), we use as source a pile of arbitrary size and emission rate that give concentrations close to those observed in the centre of the city by the air quality authorities at wind speed of 5 ms^{-1}. The United States Environmental Protection Agency (US EPA) AERMOD (**A**ir Disp**ER**sion **MOD**el) system is used here to illustrate the dispersion pattern and to show applicability for future use by the port authorities. The results showed that the central part of Bourgas might be polluted by port activities at southern winds, but those have low frequency. The easterly and southeasterly winds, which appear more often, bring the eventual pollutants from the port towards the lake "Bourgasko ezero" and the district "Pobeda." Comparing monitoring data from the port and from different parts of the city, we revealed no difference in winter months, but higher concentrations at the port in the transition months April and September.

3.1 Introduction

Bourgas is a regional and municipal centre, as well as the fourth largest town in Bulgaria, with a population of about 200,000 inhabitants (in 2012). The largest refinery on the Balkan Peninsula, Lukoil, is situated close to the city. The city is built on a complex coastline in a large and deep bay. Three big lakes bring additional

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Fig. 3.1 The port of Bourgas. PM10 monitoring is performed at site *2*. The hypothetic open area source used for AERMOD dispersion calculations is north of site *3*

complexity to the terrain and meteorological conditions. The air quality of the city is defined by the emissions due to the operation of the refinery, several power stations and industrial sites, the port and the traffic, on the one hand, and by the meteorological conditions on the other hand (AQR 2004; Assessment 2002; Kirova et al. 2013; Batchvarova et al. 2008; Kirova-Galabova et al. 2012). Situated at the Black Sea coast, the city is characterized by breeze circulation from March to October. During July, typically, more than 95 % of the days are characterized by breeze circulation (or winds from northeast, east and southeast).

The port of Bourgas with its oil terminal "Rosenets" forms the biggest Bulgarian industrial port area. After the new expansion, the plan is to develop a modern and highly diversified port, fully answering the challenges of the new cargo trends. Still, in some cases, coal, sulphur, or other bulk materials are stored in open space in the port area before being distributed to final destinations.

In this study, we analyse the PM10 data from the monitoring site of the port and several sites in the city for the years 2012 and 2013. We also model the PM10 dispersion from an open source at the port with hypothetical emission, as no measurements are taken for this purpose. We relate all results with the specific meteorological conditions in this coastal area, including the breeze circulation. Figure 3.1 shows the area of the port, where site 2 denotes PM10 monitoring site and the area north of site 3 is used for the hypothetic open PM10 source.

3.2 Data Analysis

The monitoring programme at the port presently includes three sampling sites of water quality measurements (sites 1, 3, and 4) and one (site 2) for air quality measurements, as presented in Fig. 6.1 (Chap. 6). The atmospheric air quality sampling site is located in the area of an existing workshop for repair and storage of stock of Bulgarian Ports Infrastructure Company and is representative for the impact of the old and new bulk cargo terminals in northwest direction. The location of

Fig. 3.2 A Google map of Bourgas showing the location of the PM10 monitoring stations of the regional inspectorate of the Ministry of Environment and Waters

the air quality monitoring stations of the regional inspectorate of the Ministry of Environment and Waters is shown in Fig. 3.2.

Tables 3.1, 3.2, 3.3, and 3.4 list mean, minimal, and maximal PM10 concentrations at the port monitoring site built by ECOPORT 8 (Marinski et al. 2012) and three monitoring sites of the Regional Inspectorate of the Ministry of Environment and Waters: "OPSIS" in the centre of the city, Meden Rudnik, and Dolno Ezerovo (Fig. 3.2). On a monthly basis, the PM10 pollution at the port is higher compared to the centre of the city and some of the districts to the south and to the east of it. During the winter months, the PM10 concentration is higher than the state health norm of 50 μg m^{-3} at the port and at Dolno Ezerovo. Comparing the monthly mean PM10

Table 3.1 Monthly averaged concentrations of PM10 in μg m^{-3} and observed minimal and maximal daily averaged PM10 concentrations at the monitoring site of the port during the period January–September 2013. The state norm for daily averaged PM10 concentration is 50 μg m^{-3}

2013	January	February	March	April	May	June	July	August	September
Mean	63.17	50.33	48.36	51.20	35.32	48.91	54.20	50.16	52.73
Min	37.70	25.87	20.09	39.14	29.45	42.53	47.91	49.48	38.99
Max	102.15	73.04	66.70	60.83	72.14	52.29	61.93	71.13	56.46

Table 3.2 Monthly averaged concentrations of PM10 in μg m^{-3} and observed minimal and maximal daily averaged PM10 concentrations at the monitoring site OPSIS in the city centre during the period January–September 2013. The state norm for daily averaged PM10 concentration is 50 μg m^{-3}

2013	January	February	March	April	May	June	July	August	September
Mean	44.82	37.97	35.83	31.10	35.00	24.76	29.56	30.39	29.42
Min	14	4	15	11	11.53	15.4	13.1	11.8	17.7
Max	114	112	117	61	165.1	43.2	88.7	51.1	45.3

Table 3.3 Monthly averaged concentrations of PM10 in μg m^{-3} and observed minimal and maximal daily averaged PM10 concentrations at the monitoring site Meden Rudnik during the period January–September 2013. The state norm for daily averaged PM10 concentration is 50 μg m^{-3}

2013	January	February	March	April	May	June	July	August	September
Mean	47.10	30.78	24.90	25.78	21.95	14.94	17.17	17.86	10.58
Min	18.23	8.81	10.86	10.63	4.73	7.63	5.81	0.49	0
Max	104.42	77.61	40.56	58.71	78.86	47.31	33.88	37.56	21.73

Table 3.4 Monthly averaged concentrations of PM10 in μg m^{-3} and observed minimal and maximal daily averaged PM10 concentrations at the monitoring site Dolno Ezerovo during the period January–September 2013. The state norm for daily averaged PM10 concentration is 50 μg m^{-3}

2013	January	February	March	April	May	June	July	August	September
Mean	76.97	53.31	42.32	37.79	34.83	26.63	26.04	38.34	27.22
Min	29.28	18.53	18.36	12.17	13.74	10.23	11.80	14.80	8.18
Max	169.23	148.94	83.51	77.77	97.13	51.86	38.49	70.13	50.94

concentrations from the four monitoring stations for the period January–September 2013 reveals distinct seasonal minimum in summer and maximum in winter months at all stations, as well as weaker seasonal variability at the port station. The maximal monthly concentrations at all stations are observed in January, and from those highest is the level at Dolno Ezerovo, followed by the port, Meden Rudnik, and the station in the centre.

It can be noted that in winter the diurnal mean PM10 concentrations at all stations show similar values and variation as seen in Fig. 3.3 for February and March 2013, suggesting that the port is in the same air mass as the city. This is supported by the wind direction climate in the area Fig. 3.4, which is from the westerly sector in winter. In spring and autumn, Fig. 3.5, the PM10 concentrations at the port are higher, pointing that local conditions are more important.

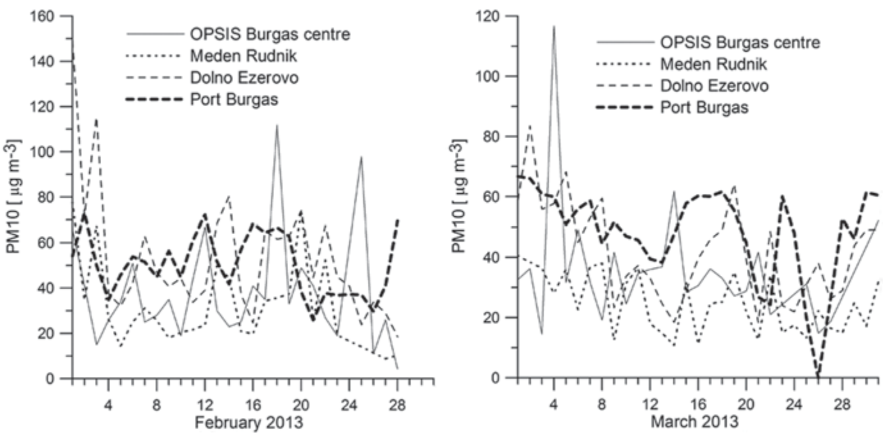

Fig. 3.3 Comparison of PM10 concentrations at port Bourgas sampling station and three monitoring sites of the regional centre of the Ministry of Environment and Waters during winter months

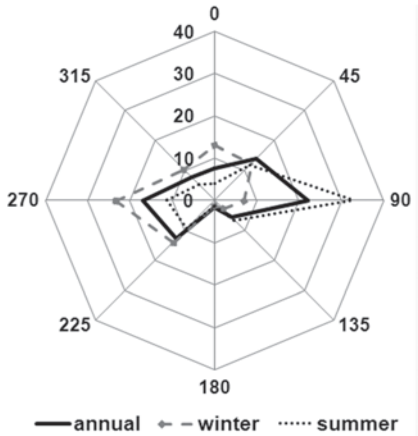

Fig. 3.4 Wind rose at the meteorological site. The frequency of observed cases is noted radially

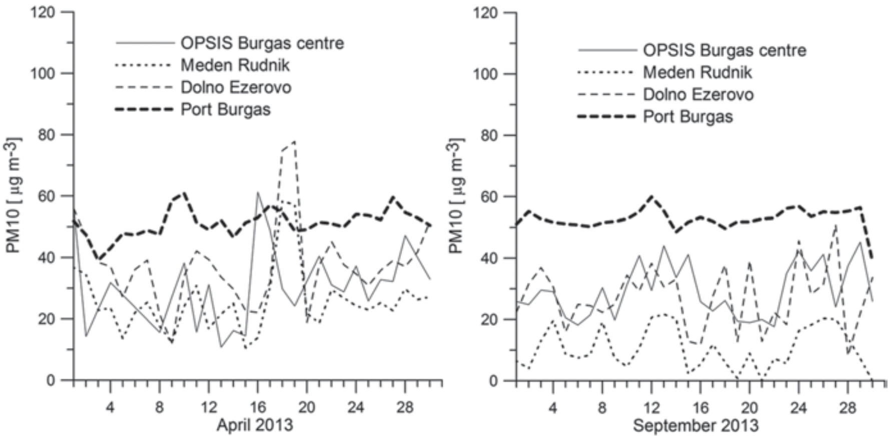

Fig. 3.5 Comparison of PM10 concentrations at Port Bourgas sampling station and three monitoring sites of the regional centre of the Ministry of Environment and Waters during spring and autumn months

3.3 Local Scale Dispersion Modelling

The AERMOD atmospheric dispersion modelling system is used in this study to calculate the dispersion of PM10 from eventual open area source in the port, mainly for wind from the sea (east, southeast and south directions). AERMOD is an integrated system that includes three modules (Brode 2006): A steady-state dispersion model designed for short-range (up to 50 km) dispersion of air pollutant emissions from stationary industrial sources; An **AER**mod **MET**eorological preprocessor (AERMET) that accepts surface meteorological data to obtain the dispersion parameters, such as atmospheric turbulence characteristics, mixing heights, friction velocity, Monin-Obukov length and surface heat flux; An **AERM**od Terr**A**in **P**reprocessor (AERMAP) whose main purpose is to provide a physical relationship between

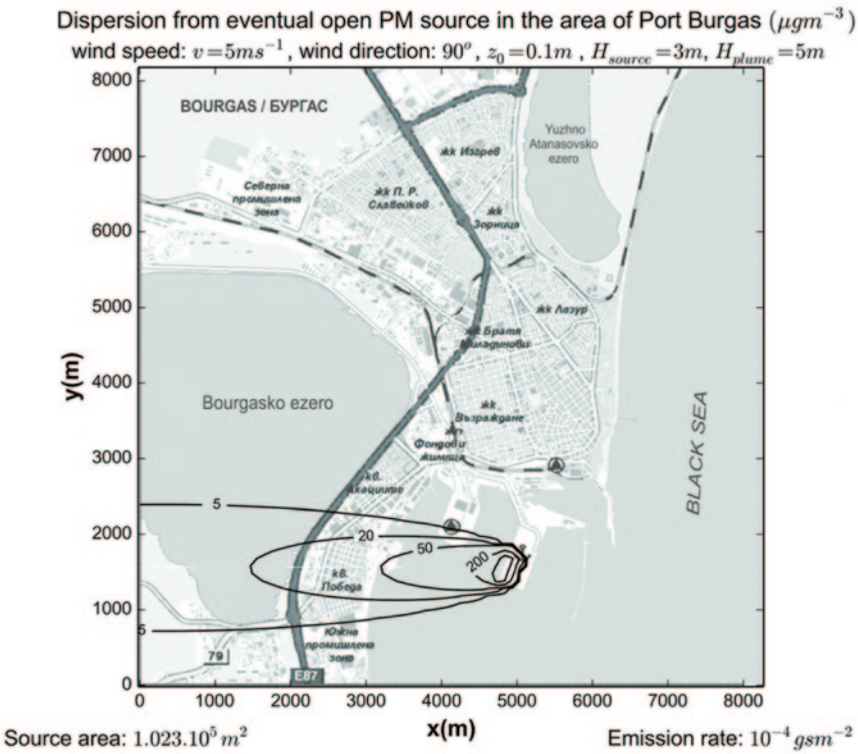

Fig. 3.6 Example for the dispersion pattern of an open area PM source with arbitrary emission rate at the port under easterly wind of 5 m s^{-1} speed

terrain features and the behaviour of air pollution plumes. Here, only the dispersion model is used prescribing wind directions east, souatheast, and south in order to assess the impact of open source emission in the port area on the city of Bourgas.

The open area source of PM10 (typically coal) is described as a rectangular area of about 230 m × 450 m emitting 10^{-4} g s^{-1} m^{-2}. The intensity is arbitrary given in order to illustrate the dispersion process. Further monitoring is needed at the port close to an open source in order to assess the emission accurately. It has to be noted that such sources are acting for limited time as the coal is transported to final destinations, and, thus, such sources are highly irregular.

AERMOD calculations were performed with wind speed 3 m s^{-1} and 5 m s^{-1} based on typical values from climate studies. The wind directions used are east, south, and southeast. Westerly and northerly winds blow away the plume over the sea and are not discussed here. Easterly winds are observed often (Fig. 3.4) because of sea breeze circulation in the warm seasons. Southerly winds are rarely observed. The wind measurements are performed at the coast north of the port.

Dispersion patterns at wind speed of 5 m s^{-1} are illustrated in Figs. 3.6, 3.7, and 3.8. Such a wind speed is characteristic for a fully developed sea breeze. More

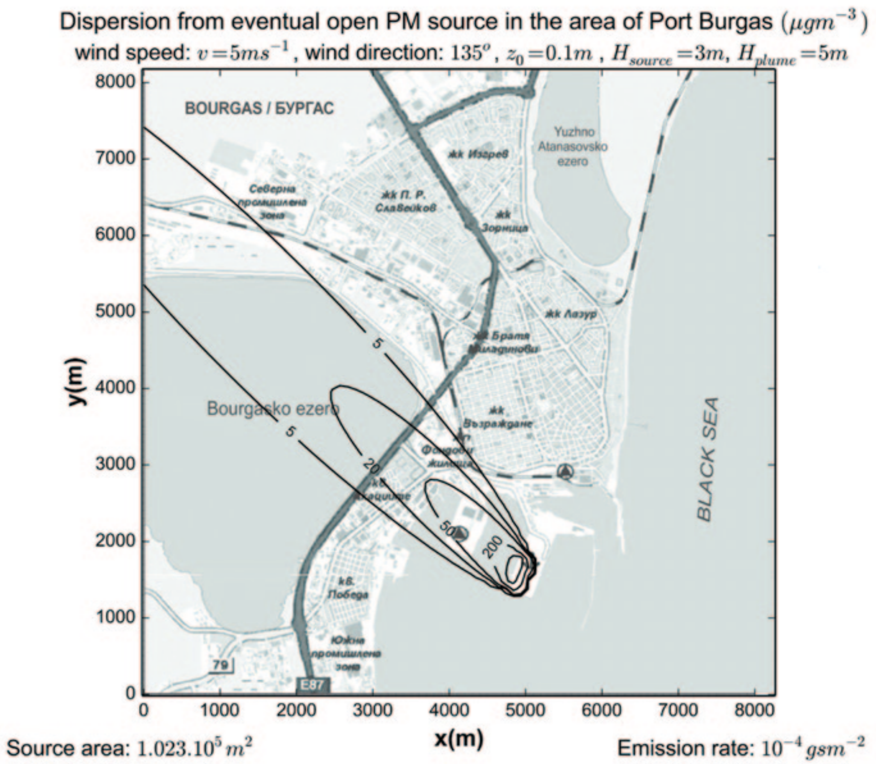

Fig. 3.7 Example for the dispersion pattern of an open area PM source with arbitrary emission rate at the port under southeasterly wind of 5 m s^{-1} speed

often, though, the wind speed is lower and the concentrations are higher as shown in Fig. 3.9.

It has to be noted that at easterly winds (most common in summer during days) the city centre area is not affected by the plume, but other areas, such as the district "Pobeda" are affected (Figs. 3.2 and 3.6). The plume under southeasterly winds does not affect the centre of Bourgas as well (Fig. 3.7) but travels above the lake "Burgasko Ezero" and does not reach any of the monitoring stations.

Under southerly winds the centre of Bourgas is affected by emissions at the port (Fig. 3.8), but such wind directions are very rare (Fig. 3.4). For this wind direction, in addition to speed 5 m s^{-1}, calculations are made with the speed 3 m s^{-1}, which is observed more often. At the wind speed 5 m s^{-1}, the concentrations in the centre of Bourgas are of the order of 30–50 μg m^{-3}, which corresponds to the level of observed concentrations shown in Figs. 3.3 and 3.5 for the station OPSIS. At wind speed 3 m s^{-1}, the concentrations in the centre of Bourgas are higher (Fig. 3.9), of the order of 70–90 μg m^{-3}.

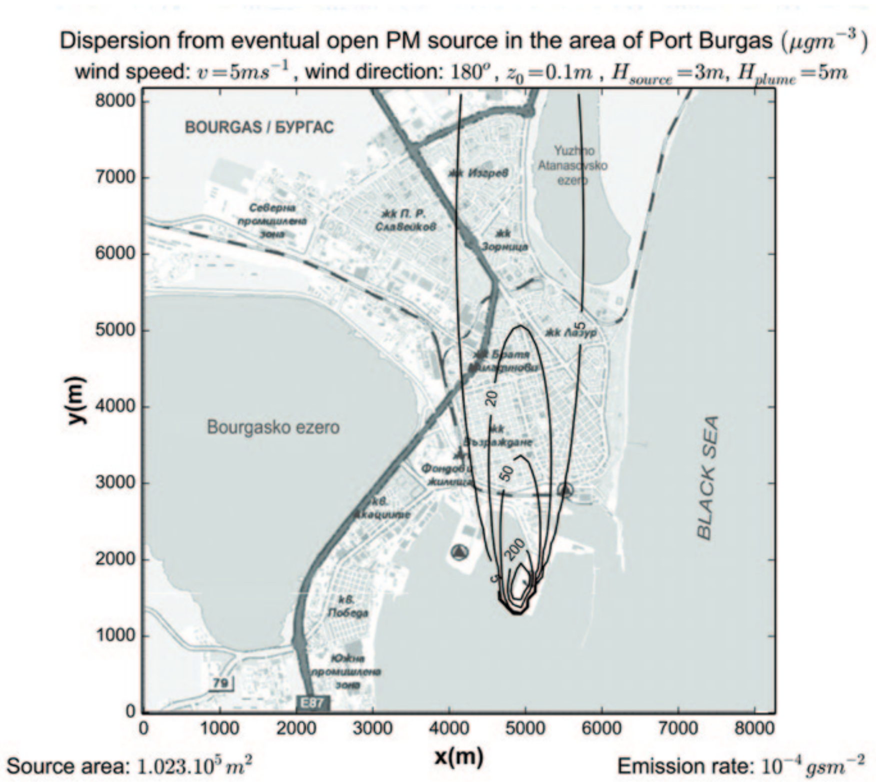

Fig. 3.8 Example for the dispersion pattern of an open area PM source with arbitrary emission rate at the port under southerly wind of 5 m s^{-1} speed

3.4 Conclusions and Discussion

The impact of emission sources of the port on the city centre of Bourgas is assessed based on 2-year PM10 concentrations monitoring data at the port of Bourgas, climatological information in the station of National Institute of Meteorology and Hydrology (NIMH), air quality monitoring of the Ministry of Environment and Waters, and AERMOD modelling exercise with arbitrary source. It is concluded that most often the meteorological situation is favourable and the port does not affect the air quality in the city centre.

Further monitoring of air quality is required in order to accumulate information for the concentration levels at different meteorological conditions. The lack of PM10 source information (how often and what amounts of different materials are deposited openly at the port) make real time modeling inapplicable presently. Still, it is shown that regulatory models, like AERMOD, can be useful tools for port administration as part of air quality managing systems.

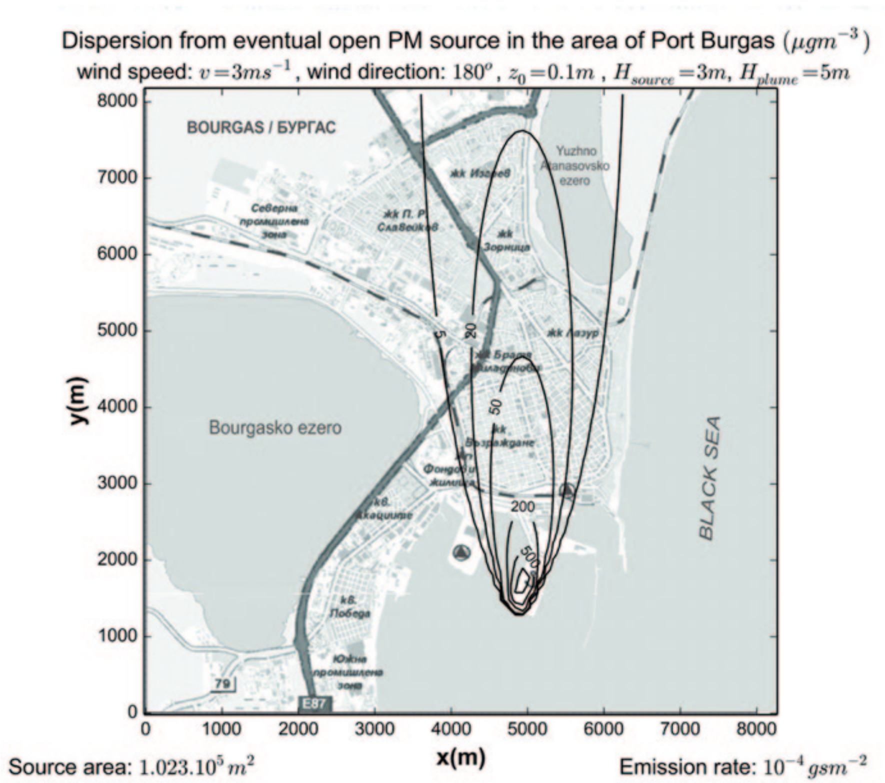

Fig. 3.9 Example for the dispersion pattern of an open area PM source with arbitrary emission rate at the port under southerly wind of 3 m s^{-1} speed

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Chapter 4
Application of Zero Liquid Discharge Water Treatment Units for Wastewater Reclamation: Possible Application in Marine Ports

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Abstract In the present chapter, we investigated the operation of a water treatment plant for wastewater reuse and production of demineralised water. The plant consisted of coagulation with iron salts, lime softening, and powdered activated carbon unit, followed by multimedia filtration and ultrafiltration. The water was then treated with reverse osmosis and finally with ion exchange, consisted of cation, anion, and mixed bed exchange resins. Inlet water had total organic carbon (TOC) concentration of 10–12 mg/L, turbidity of 10–15 nephelometric turbidity units (NTU) and conductivity of 3500–4500 μS/cm. Treated water had TOC of less than 0.2 mg/L, turbidity of 0.1 NTU and conductivity of 0.055 μS/cm. The plant was operating under zero liquid discharge conditions for the treatment of any liquid waste generated within the plant. This treatment process could find applications in ports in water short areas, where wastewater reuse could serve as a viable alternative to conventional water sources and improve the environmental sustainability of the ports.

4.1 Introduction

Marine ports are major centres of economic activity but also major sources of pollution. Ships with engines running on the dirtiest fuel available, thousands of diesel truck visits per day, other polluting equipment, and activities at marine ports cause an array of environmental problems that can seriously affect local communities and the environment (Bailey et al. 2004).

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Port operations can cause significant damage to water quality and subsequently to marine life and ecosystems, as well as human health. These effects may include bacterial and viral contamination of commercial fish and shellfish, oxygen depletion of water, and bioaccumulation of certain toxins in fish. Major water quality concerns at ports include wastewater and leaking of toxic substances from ships, storm-water runoff, and dredging (Bailey et al. 2004).

The treatment of wastewater created in ports, or by the ships entering the ports is therefore essential for protecting the local environment. Consequently, there is a need for implementation of advanced water treatment technologies, in particular, in water short areas such as in South East Europe. The problem is identified in cities like Igoumenitsa in Greece, making the cost of water extremely expensive for business consumption. Igoumenitsa Port Authority, as the only water provider to the ships within the port, is obliged to sell it extremely expensive, resulting in very low consumption, leading to lower company revenues and dissatisfied customers.

Zero liquid discharge (ZLD) is a process that is beneficial to industrial and municipal organizations as well as the environment because no effluent, or discharge, is left over. ZLD systems employ the most advanced wastewater treatment technologies to purify and recycle all the wastewater produced within the plant (Veolia water treatment 2013).

Wastewater reclamation systems provide numerous economic and environmental advantages for plant managers. First, water is recycled and reused, saving on the cost and treatment of raw water. In addition, in ZLD units, all water is reclaimed; thus, no effluent is discharged from the plant, avoiding the cost of environmental impact. The technology is particularly appropriate in water-short areas.

In this chapter, we present the application of such wastewater treatment plant at full scale, which was operating under ZLD conditions. The study took place in wastewater treatment plant in the city of Modugno (BA), in South Italy. The plant was treating municipal wastewater received after biological treatment and was producing ultra-pure demineralised water, to be used in a power plant mainly for use in the production of steam but also covering all the water needs of the plant.

4.2 Materials and Methods

4.2.1 Description of Treatment Plant

The wastewater treatment plant was receiving municipal wastewater, already treated by biological treatment in the main wastewater treatment plant of the city of Bari, in South Italy.

The chemical characteristics of the incoming wastewater are shown in Table 4.1. The raw water had conductivity values of around 4000 μS/cm and total organic carbon (TOC) concentrations of approximately 10 mg/L. Based on the incoming water quality, the treatment train was decided in order to obtain finally ultra-pure water. The treatment plant comprised coagulation with iron salts, lime softening and use of powdered activated carbon. The water was then filtered through multimedia filter,

Table 4.1 Chemical characteristics of the incoming wastewater, after biological treatment at the municipal wastewater treatment plant of the city of Bari, South Italy

Chemical parameter	Incoming wastewater	Service water RO outlet	Demineralised water
pH	7–8	7–8	5–6
Conductivity µS/cm	3500–4500 µS/cm	2–10	0.055
TOC mg/L	10–12 mg/L	0.1–0.3	<0.2
Hardness (total) mg/L	600–800 mg/L	0	0
Turbidity (NTU)	10–15 NTU	<0.1	<0.1

RO reverse osmosis, *TOC* total organic carbon, *NTU* nephelometric turbidity units

followed by ultrafiltration before passing through reverse osmosis membranes for the main reduction of organic carbon concentration, heavy metals and silicate. Final treatment of the water consisted of ion exchange for achieving the goal of demineralised water production, which had a final conductivity of 0.055 µS/cm and TOC of less than 200 µg/L (Table 4.1). A schematic representation of the plant is shown in Fig. 4.1. The maximum treatment capacity was designed to be 40 m^3/h and the maximum incoming flow was around 80 m^3/h.

The waste generated by the wastewater treatment plant was further treated, so that the liquid discharge of the plant would be eliminated. Evaporation and crystallization were applied for concentrating the liquid waste, generated by the regenera-

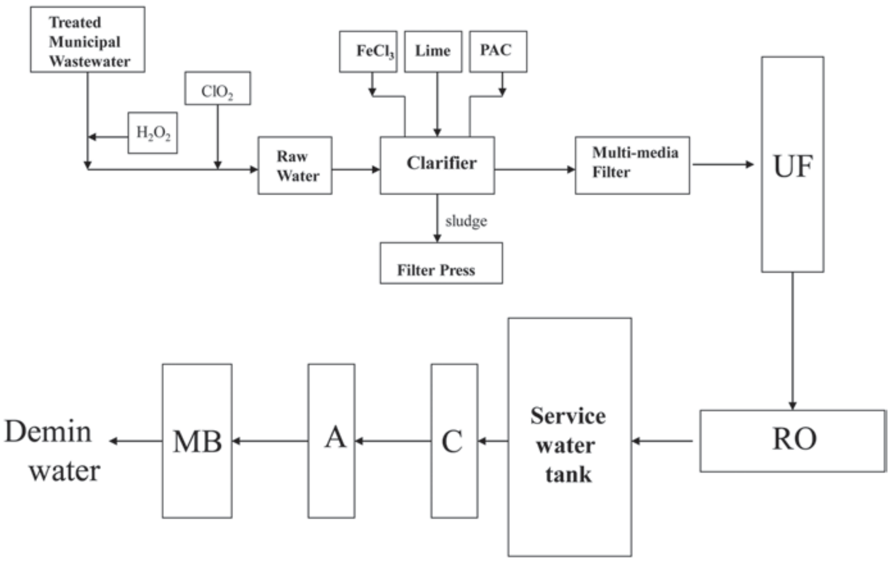

Fig. 4.1 Simplified schematic representation of the examined wastewater treatment plant. The plant consisted of two twin units operating in parallel. The incoming water flow to the clarifier was around 20 m^3/h. Important dimensions: clarifier: 100 m^3, UF water tank: 30 m^3, service water tank: 1000 m^3. *UF* ultrafiltration, *RO* reverse osmosis, *C* cationic exchanger, *A* Anionic exchanger, *MB* mixed bed (anionic and cationic exchanger)

tion of the ion exchangers and the backwashing of membranes and filter presses for dewatering the sludge from the coagulation unit.

4.2.2 Analytical Determinations

pH and conductivity were measured with online instruments from Endress and Hauser. Iron and phosphate were measured with the respective photometric methods (Katsoyiannis et al. 2013) based on standard methods. Silica was also measured with silicomolybdate method, taking into consideration possible interferences from phosphate (Govett 1961). TOC was measured with online TOC meters. Size exclusion chromatography was employed for the determination of the natural organic matter fractions. Turbidity was measured with mobile turbidity meters and after ultrafiltration with on line turbidity meter. Traces of ions were measured with ion chromatography.

4.3 Results and Discussion

4.3.1 Removal of Turbidity

One of the major quality parameters in wastewater treatment is turbidity. The removal of turbidity was mainly taking place by ultrafiltration, as it is well established that coagulation and following microfiltration or ultrafiltration diminishes significantly turbidity (Katsoyiannis et al. 2013; Laine et al. 2000). Initial values were mostly in the range of 10–15 nephelometric turbidity units (NTU). During the coagulation-flocculation step, turbidity removal was around 60 %, which was increased to 80 % after the pH adjustment, taking place at the outlet of the clarifier. Filtration of water through the multimedia filter was reducing the turbidity to values below 1 NTU and further reduction was taking place at the ultrafiltration stage (Laine et al. 2000). After the ultrafiltration step, the water had values below 0.1 NTU.

4.3.2 Removal of Iron, Silicate, and Phosphate

Iron removal was taking place after the multimedia filtration by removing the iron particles from water, while phosphate was removed during the coagulation step with ferric chloride, as it is well demonstrated that phosphate removal by iron oxides is a very efficient process (Katsoyiannis and Zouboulis 2006). On the contrary, silicate was persistent to coagulation, to lime softening and to the use of powdered activated carbon. Around 40 % silicate removal was taking place in the clarifier because of the addition of lime, due to the formation of calcium silicates, which are insoluble in water (Sheikholeslami and Bright 2002). The rest of silicate was finally removed by RO. Silicate concentration after the RO treatment step was below

Table 4.2 Typical concentrations of TOC, humic substances, and neutrals after each treatment stage; results obtained by size exclusion chromatography

Treatment	TOC (mg/L)	Humic substances (mg/L)	Neutrals (mg/L)
Incoming water	10.7	2.9	3.76
Clarifier outlet	5.6	1.4	2.14
UF outlet	5.5	1.4	2.14
RO outlet	0.2	–	0.187

TOC total organic carbon, *UF* ultrafiltration, *RO* reverse osmosis

20 μg/L and remained practically unchanged during the anion exchange process (Sheikholeslami and Bright 2002).

4.3.3 Removal of Total Organic Carbon

Total organic carbon is a very significant parameter in wastewater treatment plants (Katsoyiannis and Samara 2007) and was therefore further investigated by the application of size exclusion chromatography. TOC removal was taking place mainly by the application of powdered activated carbon and by reverse osmosis. Almost 50% TOC removal was taking place during the coagulation-lime softening step including the use of powdered activated carbon (Matilainen et al. 2002). The rest was removed by the reverse osmosis. TOC in the RO outlet was around 0.2 mg/L. Table 4.2 shows the results obtained by size exclusion chromatography with emphasis to humic substances and neutrals.

Table 4.2 shows that almost all TOC exiting from the reverse osmosis unit is in the form of neutrals, which is also to be expected, according to studies showing that Natural Organic Matter (NOM) removal by RO depends on the charge and molecular weight (Drewes et al. 2003).

4.3.4 Production of Demineralised Water

Further treatment of the water after the reverse osmosis treatment stage was performed by ion exchange, in order to receive the end product of the plant, which was demineralised water, for use in the production of steam in the thermal power plants. To achieve the very challenging specifications for demineralised water quality (i.e., conductivity of 0.055 μS/cm), the water was treated firstly by cation exchange and afterwards by anion exchange. The final treatment was performed by a mixed bed of anion and cation exchange resins. The results of the treatment are shown in Table 4.3 with emphasis on concentrations of trace elements such as sodium, potassium, calcium, etc.

Table 4.3 Ion concentrations in the demineralised water

Sample	Cl	Na	NH_3	K	Mg	Ca
RO outlet (ppb)	162	635	3	23	1	36
Demin outlet (ppb)	4	2	0	8	0	4

The results show the very low concentrations of trace elements in the final water, which result in the low conductivity of ultra-pure water of 0.055 μS/cm.

4.4 Conclusions

The present article described the operation of a wastewater treatment plant for production of demineralised water. Initial values of conductivity and TOC were 3500–4500 μS/cm and 10–12 mg/L, respectively, and final concentrations were 0.055 μS/cm and 0.2 mg/L, respectively. The treatment reduced also turbidity to levels below 0.1 NTU, and trace element concentrations were at low ppb levels, i.e., sodium concentration was 2 and Cl was 4 ppb. The cost of the treated water was in the range of € 1–2/m^3 of water produced, which is considered as satisfactory and could be further reduced if no ZLD units should be applied. The present technology could be applied in ports or in ships for production of service water or even for drinking water, which will dramatically reduce the cost of water for the port and the customers. Depending on the incoming water quality, some modifications of the treatment train would be needed.

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Chapter 5
Physical-Chemical Parameters and Assessment of Pollution Through Bioindicators of Narta Lagoon

Petrit Kotori, Luan Hasanaj and Sonila Kane

Abstract Coastal lagoons are the most fragile ecosystems, with an increasing pressure from anthropogenic inputs (urban and agricultural sewages, industrial wastes, etc). These ecosystems are widely distributed along Mediterranean coasts. Narta Lagoon represents an important wetland ecosystem. It is located in the northwestern part of Vlora city separated by the Adriatic Sea through a narrow belt of land and communicates to sea by two channels. The aims of this study were: (a) the determination of some physical-chemical parameters of Narta Lagoon water, (b) identification of recent benthonic foraminifera, (c) observation of different damages of their fragile shells, and (d) the possible correlation of these damages to variations of water physical-chemical parameters.

For this purpose, some water samples (to assess some physical-chemical parameters and nutrients) and surface sediments were taken for benthonic foraminifera at the same time and stations, as mentioned above.

5.1 Introduction

Coastal lagoons are particularly important but especially vulnerable among coastal habitats (Gonenc and Wolflin 2005). They perform a range of ecosystem services of socioeconomic value to coastal communities, including shoreline stabilization, sediment and nutrient retention, high primary and secondary production, fisheries resources, habitat and food resources for terrestrial, aquatic and marine fauna, coastal water quality buffering, biomass and biodiversity reservation, and recreation and tourism amenities (Costanza et al. 1997; Gedan et al. 2011). The water pollution is the result of releasing of fluid toxic substances, urban and industrial remains, or accidental discharges. The water organisms absorb and accumulate these components more than their concentrations in aquatic environment (Nixon et al. 1994).

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Benthic foraminifera are increasingly used as environmental bioindicators of pollution in coastal and marginal marine settings. Because of their high sensitivity to environmental conditions, they are increasingly used for ecological and paleoecological studies all over the world (Samir 2000; Samir et al. 2003). Numerous studies have shown that the distribution of benthic foraminiferal assemblages can be related to several environmental and sedimentological conditions. The response of foraminifera to the changed environmental conditions is reflected in the variation in abundance and morphology of the test. The foraminiferal test has high preservation potential, thus, making these microorganisms one of the most useful proxies for the long- as well as short-term temporal variation in the amount and type of toxins in all kinds of marine environments, especially the near-shore coastal areas. Their community structure provides useful information on the general characteristics of the environment quality and more species are sensitive to specific environmental parameters (Alve 1991; Alve 1995; Coccioni 2000; Samir 2000; Debenay et al. 2001; Coccioni et al. 2003; Coccioni et al. 2005). This study discusses the environmental situation of Narta Lagoon one of the largest lagoons in Albania, located in the northwestern part of Vlora city, Adriatic Sea, with geographical coordinates: 40°32′ N latitude, 19°28′ E longitude. For this purpose, one expedition was conducted in September 2013 for sampling water samples and surface sediments for benthonic foraminifera (water and surface sediment samples were collected at same time and stations). Water samples were analyzed for physical-chemical parameters (pH, temperature, total suspended matter (TSS), dissolved oxygen (DO), biological oxygen demand (BOD), etc.) and nutrients (nitrites, nitrates, and phosphates). Surface sediments were observed for possible damages of benthonic foraminifera.

5.2 Materials and Methods

This study was carried out to determine some physical-chemical parameters (pH, T, redox, potential DO, BOD) and nutrients in water samples of Narta Lagoon and to give possible correlation between damaged fragile shells of foraminifera and these physical-chemical parameters. For these purposes, water samples and surface sediments for benthonic foraminifera were collected (at same time and places) according to a network of four sampling points in Narta Lagoon shown in Fig. 5.1.

Sample stations were chosen in order to do a better evaluation of Narta Lagoon possible polluting sources and human impact. Sample collection, transport and conservation was done according to standard methods recommended (American Public Health Association, APHA). Water samples were analysed in the laboratory of "Environmental Centre" of Vlora University. Water samples were collected in 1.5 L polyethylene terephthalate (PET) bottles and were transported during the same day to the laboratory by refrigerated containers under the temperature of 40 °C (Table 5.1).

Physical-chemical parameters of water were determined immediately after the samples were taken to the laboratory. pH and redox potential, were measured with a

Fig. 5.1 Network of sampling points in Narta Lagoon

Table 5.1 Sampling stations

Sample station	Latitude (decimal degrees)	Longitude (decimal degrees)
St. 1	40°30′14.01″ N	190°27′32.60″ E
St. 2	40°30′32.60″ N	190°25′25.07″ E
St. 3	40°31′ 02.78″ N	190°24′14.76″ E
St. 4	40°30′ 58.44″ N	190°23′47.11″ E

pH meter (Model pHS-3BW). Then, the water was filtered (glass filter of 0.42 µm pore size) with the aim to separate all the inert materials that can indicate in the results and stored at −200 °C until nutrient analysis. TSS was determined by pouring 1 L volume of water through a pre-weighed filter of 0.42 µm pore size, then weighing the filter again after drying it at 1050 °C for 2 h to remove all water dissolved oxygen, and BOD were determined using the Winkler method.

Nitrogen (NO_2–N, NO_3–N, and NH_4–N) and phosphates (PO_4–P) in water were measured by using an UV-VIS spectrophotometer (model UV 2400 PC), following the standard methods recommended by APHA/AWWA/WPCF (1995).

To analyze microfauna sediment (benthonic foraminifera), samples (mud, silt) were taken in the uppermost part of lagoon bottom. Each sample (about 100 g sediment), after being washed, dried, and passed through a 63 micron sieve, and after the picking up of foraminifera, was identified under a stereomicroscope.

5.3 Results and Discussion

The results of chemical-physical parameters of Narta Lagoon are shown in diagrams of Fig. 5.2, and the statistical data of physical-chemical parameters obtained through descriptive statistics are shown in Table 5.2.

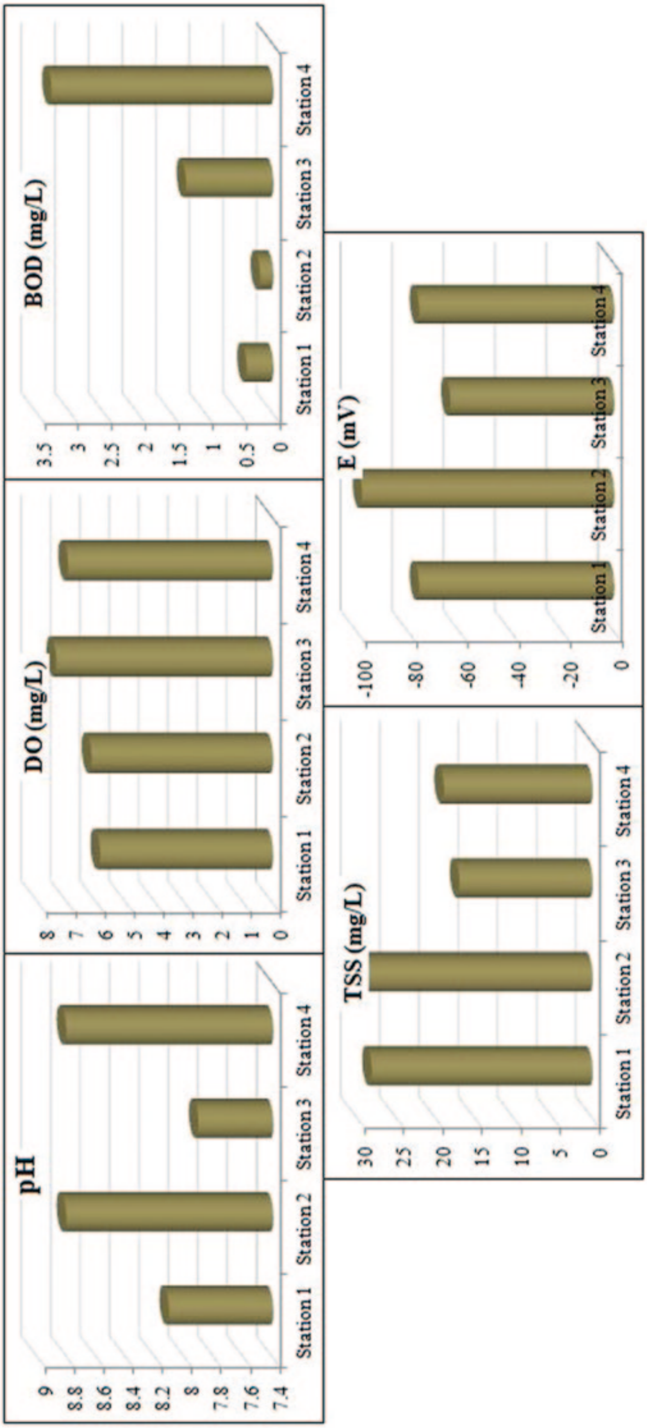

Fig. 5.2 The results of physical-chemical parameters of Narta Lagoon

Table 5.2 Statistical data of physical-chemical parameters

Statistical parameters	pH	E (mV)	TSS (mg/L)	DO (mg/L)	BOD (mg/L)
Mean	8.41	−78.5	23.3	6.625	1.3
Median	8.46	−76	23.6	6.6	0.85
Minimum	7.91	−98.2	17	5.9	0.2
Maximum	8.81	−63.8	29	7.4	3.3

TSS total suspended matter

As it can be seen, pH values resulted within normal levels for natural waters in Narta Lagoon. Higher levels of pH were found in station 2 (near Dampa) and lower level resulted in station 3 (Ura e Manastirit) of Narta Lagoon. Redox potential values fluctuated between a minimum of −98.2 mV at station 2 and a maximum of −63.8 mV at station 3. TSS resulted in high levels especially in stations 1 and 2 due to the small depth (0.3–1.0 m) of the Narta Lagoon.

Dissolved oxygen is one of the main chemical factors necessary for good water quality and can be considered as an indicator of healthy water. Changes in the dissolved oxygen levels in water can be caused by aquatic vegetation and temperature. When aquatic vegetation photosynthesize, dissolved oxygen levels in water increase, while levels can be decreased when the same vegetation respire, which uses up oxygen and produces CO_2.

Cold water can absorb more oxygen, producing higher values, while warm water produces lower values (when measured as mg/L). In samples studied, lower levels of dissolved oxygen were measured in stations 1 and 2 due to urban wastes.

The results of nitrite, nitrate, and phosphate content in water of Narta Lagoon are shown in diagrams of Fig. 5.3 and the descriptive statistical data of nutrients are given in Table 5.3.

Nitrates concentrations vary between 0.023 and 0.0202 mg/L. Higher levels were found in stations 2 and 3. This might be due to discharges of sewage water, agricultural and livestock wastes, or organic loads. Lower levels were found in station 4. As we can see nitrites ($N–NO_2^-$) resulted in higher content in station 1 and in other stations nitrites resulted in very low content (lower than the detection limit of spectrophotometer).

Phosphates resulted in higher level in station 1 of Narta Lagoon. The reasons for having higher values of phosphorus content in this station are urban discharges (sewage, phosphate fertilizers, and detergents).

During last decades benthonic foraminifera are used as environmental bioindicators of lagoons, ports, bays, etc. (Alve 1991; Alve 1995; Buosi et al. 2010). This is because foraminifera possess such features like: (1) short cycle life, (2) abundant in the sea and coastal ecosystems, (3) they have quick response to environmental changes, and (4) some of their species are characteristic for special ecosystems, etc. (25, 26). Foraminifera assemblages consist of four genera and five species: *Ammonia tepida, A. parkinsionana, A. gr. beccarii, Nonion depressulum, N.* sp, *Haynesina*

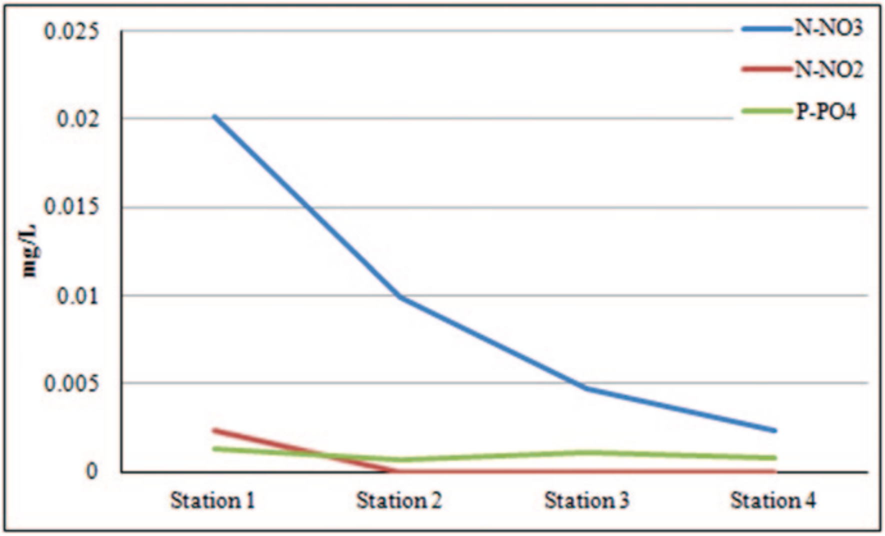

Fig. 5.3 The results of nitrates, nitrites, and phosphates

Table 5.3 Statistical data of nitrates, nitrites, and phosphates

Statistical parameters	$N–NO_3$ (mg/L)	$N–NO_2$ (mg/L)	$P–PO_4$ (mg/L)
Mean	0.009275	0.000579	0.000979
Median	0.0073	0	0.00095
Minimum	0.0023	0	0.0007
Maximum	0.0202	0.002317	0.001315

germanica, Quinqueloculina sp. as well as Ostracods, Microgastropods, and small Bivalvia. Although the study is not statistically encountered, microfauna shows that individuals of *A. tepida* and Ostracods are most abundant.

Up to 200 individuals were picked from sample residues. About 10 % of population (tests) resulted damaged or deformed. Dilution and deformed shells observed, were due to their damage. They were more stressed in the last three chambers, between sutures and apertures. Damages are observed also in some Ostracods and Microgastropods. Stations 1 and 2 represent the most damaged microfauna (Fig. 5.4).

Fig. 5.4 Damaged benthic foraminifera

5.4 Conclusions

pH, TSS, and nutrients determined in water samples collected in Narta Lagoon resulted in higher levels (DO and BOD in lower level) in stations 1 and 2 due to urban and industrial discharges near these stations (station 1 is positioned near Narta channel and station Narta 2 is positioned near the landfill of wasted deposits from industrial activities).

From above data, we can say that there exists a good correlation between variations of physical-chemical parameters and damaged foraminifera in stations 1 and 2. Based on the results of physical-chemical parameters and the study of foraminifera, Narta Lagoon represents a polluted ecosystem especially in its southern part due to artificial human interventions (urban, industrial, agricultural discharges) In the future, we think to extend the study not only in Narta Lagoon but in Karavasta and Patok lagoons as well.

Acknowledgments Thanks to the community and the local government area of Narta Lagoon, who expressed interest and readiness in conducting this study.

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Chapter 6
Water Quality Assessment of the Bourgas Port Waters

Zvezdimira Tsvetanova, Magdalena Korsachka and Jordan Marinski

Abstract The aim of environmental monitoring of the port of Bourgas is to deliver reliable data for pollution assessment of the port water body and to support the development of a program for environmental risk management. The present study attempts to assess the quality of the Bourgas port waters summarizing the water monitoring data and calculating the integrated trophic state index (TRIX).

6.1 Introduction

TEN ECOPORT and ECOPORT 8 projects involve Mediterranean and Black Sea ports in South East Europe and aim to improve the quality of ports management placing the prevention of pollution and preservation of natural resources in port areas and nearby coastal zones as pivotal to the maritime system. The port of Bourgas is a key-hub on Trans Border Corridor 8 and for that reason it was chosen as a pilot site for water monitoring in the ECOPORT 8 project. It covers the East Terminal, Bulk Cargoes Terminal, Terminal 2A, West Terminal, and the Oil Terminal. The estimation of ecological potential of port Bourgas waters is quite difficult because of the inland origin of Black Sea water contamination and the presence of the Oil Terminal belonging to “Lukoil” refinery. At the same time, anthropogenic eutrophication of the costal Black Sea region has been identified as a key problem, and summer is pointed as a vulnerable season for its origination (Kolarov et al. 2010; Kolarova and Medinets 2012; Moncheva et al. 2002). In Bulgaria, sea water quality in port aquatories is not subject to any legislative regulation. Only the quality of coastal waters is governed by the Regulation No 8 (2001).

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Environmental monitoring of the port of Bourgas aims to deliver reliable data for characterization of the port water body, pollution risk assessment, and development of a program for environmental risk management. The main goals of the present study were to summarize the port water monitoring data and to assess the quality of the Bourgas port waters. The present study was an attempt to apply the integrated trophic state index (TRIX) for scaling the eutrophication of port waters and to select relevant indicators of ecological water quality.

6.2 Materials and Methods

The water quality data were collected using the automatic monitoring system built in the frame of the ECOPORT 8 project. The monitoring network includes three water monitoring stations located in the port area (Fig. 6.1).

Sampling station 1 was selected to cover the impact of loading–unloading activities at the old bulk cargo terminal, inflows of city storm water sewage, and untreated waste water from service port buildings. Station 3 monitored the impact originating from liquid cargos operations (mostly oil products) and a storm water inflow from bulk cargo Terminal 2A as well. Station 4 monitored the aquatory adjacent to the Container Terminal, the most actively operating port unit, and the impact of fish village and Vaja Lake inflow as well. The monitoring process started in March 2012.

EUREKA Manta 2 Multiprobe incorporating multiple sensors in one instrument was used for triple daily measurement of pH, water temperature, dissolved oxygen and oxygen saturation, turbidity, conductivity, and salt content. Chlorophyll a, blue-green algae cells, and crude oil were measured by fluorometric sensors (Turner designs). SYSTEA Micromac C analyzer for measurement of ammonia, nitrites, nitrates, and phosphates was used. Specific servicing software for remote control of the equipment and real-time database transfer and accumulation was applied.

On the base of monitoring data, the TRIX, proposed by Vollenweider et al. (1998), was calculated for the classification of the eutrophication level of marine port waters. The index is given by the equation:

$$\text{TRIX} = \left(\text{LOG}\ \left[Chl * aD\%O * N * P\right] - \left[-1.5\right]\right)/1.2,$$

where *Chl* is chlorophyll a in µg/L, *aD%O* is oxygen as an absolute deviation from saturation $aD\%O = [\text{abs}|100 - \%\text{O}|]$ in %, *N* is dissolved inorganic nitrogen as N–($NH_4 + NO_3 + NO_2$) in µg/L, and *P* is dissolved inorganic phosphorus as P–PO_4 in µg/L.

Numerically TRIX is scaled from 0 to 10 defining four trophic categories: <4—low trophic level, 4–5—moderate level, 5–6—high level, and >6—very high eutrophication level (Caruso et al. 2010; Giovanardi and Vollenweider 2004; Vollenweider et al. 1998). The molar *N*:*P* ratio is calculated as well.

Fig. 6.1 View of the port of Bourgas and location of the water monitoring stations: *1*—in Terminal East (old harbour), *2*—for air monitoring, *3*—in port waters between Terminal 2A and new breakwater, *4*—in port waters near the Container Terminal and private fish port, *5*—a reference point

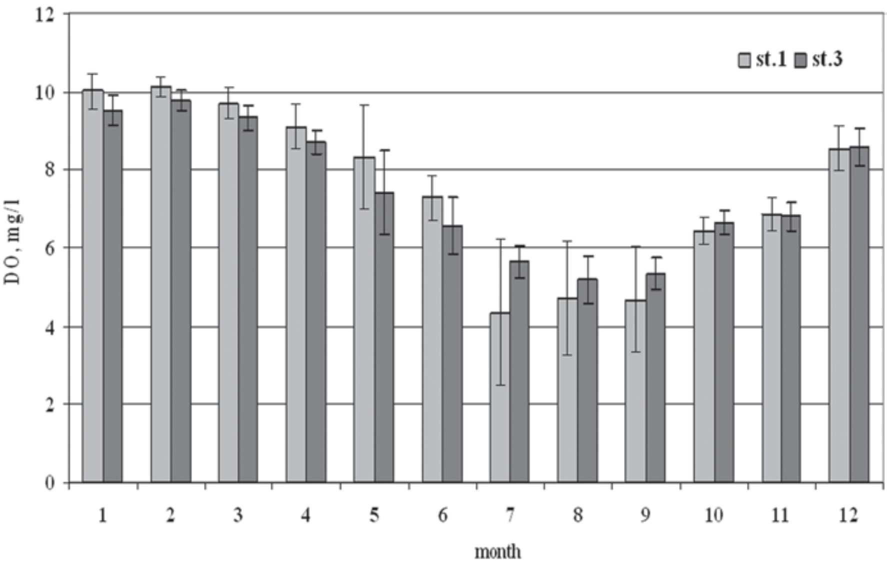

Fig. 6.2 Monthly average values of dissolved oxygen (DO), measured in stations 1 and 3

6.3 Discussion

The pollution and eutrophication of the Bourgas Bay were well documented, but a few data are available for the port water body (Kolarov et al. 2010). The port water was under human impact as a result of port activities, the close proximity of the town of Bourgas, and the industrial zone along the beach. Analyzing data, the impact of Vaja Lake and Mandra Lake water on the port basins' water in the corresponding monitoring points should also be taken into consideration because of the discharges of treated waste waters from the Bourgas city waste water treatment plant (WWTP) and untreated sewage waters of Aitos and Kameno towns into Vaja Lake.

Water monitoring performed in the main port basins demonstrated seasonal changes of water temperature and effect of lake water inflow as well. The pH values of port waters changed slightly. Turbidity (measured as nephelometric turbidity unit (NTU), equal to 1 mg/L dissolved Si) was influenced by port activities, season, and water mass exchange with open sea, having the highest values registered in summer. The salinity of sea water was low (17.3 ‰). From May to August, it was lower in station 3 (13.3 ‰) than station 1, due to the lake water impact, while in September it increased to 18.0 ‰ influenced by open sea currents.

Variation of dissolved oxygen (DO) content in the port waters correlated with water temperature and water pollution. The DO values were lowest during the summer, as a result of oxygen consumption and intensified mineralization of organic pollutants (Fig. 6.2).

The nutrients, measured as $N–NO_2$, $N–NO_3$, $N–NH_4$ and $P–PO_4$, characterize biological processes. The nitrite nitrogen values were in the range from 0.005 to 1.41 μg/L. Nitrate nitrogen varied from 7.0 to 70.4 mg/L (with the highest monthly

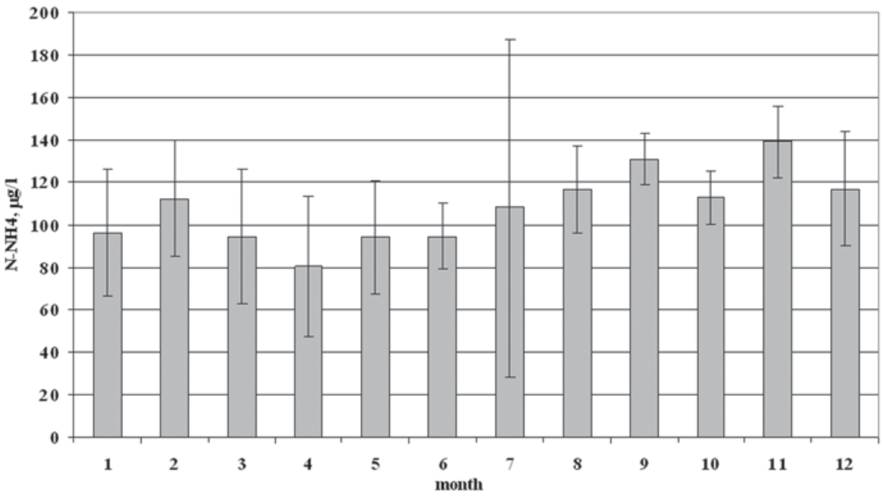

Fig. 6.3 Temporal distribution of ammonium nitrogen ($N–NH_4$), measured in station 4

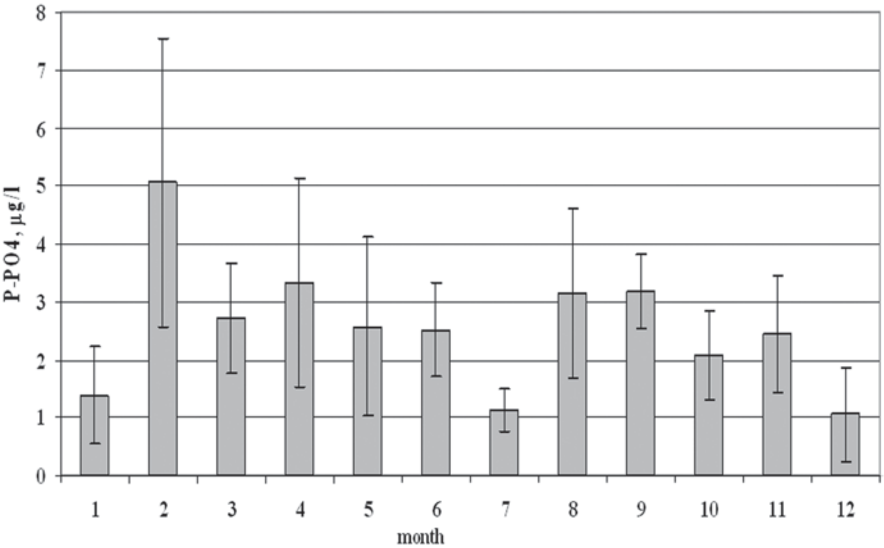

Fig. 6.4 Temporal distribution of phosphorus ($P–PO_4$) in the port water, measured in station 4

average value in February and the lowest ones during the summer). Ammonium nitrogen (Fig. 6.3) showed seasonal distribution and the lowest monthly values were in spring (the minimum in April). The highest values were registered in August, September, and November. The monthly average $N–NH_4$ values did not agree with the limit of 0.1 mg/L according to the Regulation No 8 (2001), and most daily values exceed it. The deviations could be explained with the impact of the nutrient polluted waters from Mandra and Vaja lakes on the port aquatory. Phosphates content of the port waters (Fig. 6.4) was permanently low, varying from 1.1 to 5.1 µg $P–PO_4$/L.

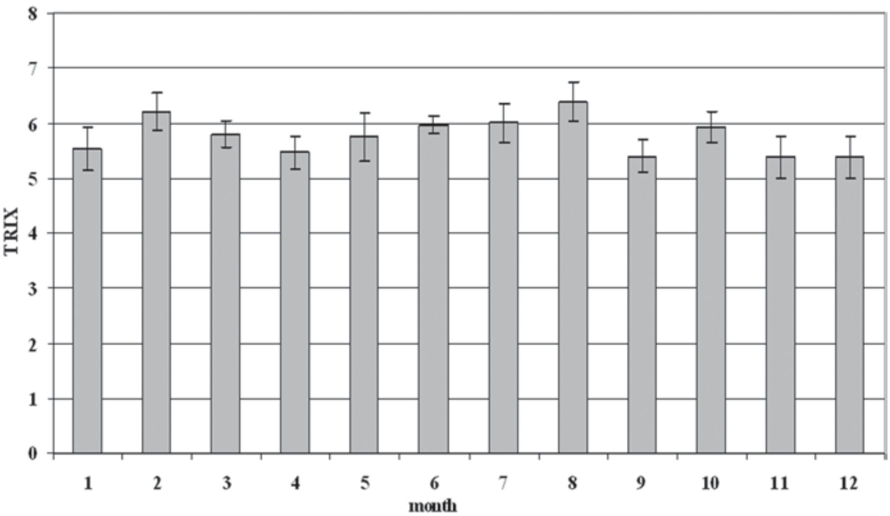

Fig. 6.5 Monthly average values of the trophic state index (TRIX) of the Bourgas port water

The multimetric TRIX can be a useful means in the classification of ecological status of port waters, especially when complemented with *N*:*P* ratio or other addition information. The values of the TRIX of the Bourgas port water (Fig. 6.5) were in the range from 5.4 to 6.4. The average annual value of 5.8 ± 0.3 according to the classification of Vollenweider et al. (1998) corresponds to the category of high eutrophic water. Seasonal dynamics of the TRIX showed the lowest values of 5.4 or 5.5 found in April and from September to January. Nutrient pollution during active summer tourist season probably was a reason for increasing index, as the highest TRIX value of 6.4, characterizing very high eutrophication, was found in August. However, the opposite seasonal variations of the trophic index, characterizing with decreasing summer values, have been pointed out for the coastal waters of the northern Bulgarian coast (Moncheva et al. 2002). The obtained data for the port waters conform to the TRIX data for the western Black Sea coastal water, showing similar TRIX values (Kolarova and Medinets 2012).

The TRIX was in agreement with the information inherent to the individual nutrients. The obtained data for low dissolved oxygen content and daily $N–NH_4$ values exceeding the threshold were indicative for the eutrophic potential of the port water. Values of water quality indicators that exceeded the thresholds were detected at places with discharges of treated waste water from urban treatment plant and from industrial facilities to the port area. This showed that port activities cannot be regarded as a major polluter of the port.

Phytoplankton growth is generally considered to be limited by one of the major nutrients and the ratio between dissolved inorganic nitrogen and phosphorus (*N*:*P*) available for primary production is an indicative number of potential nutrient limitation. If the molar *N*:*P* ratio deviates from 16, primary production is limited either by nitrogen ($N{:}P < 16$) or by phosphorus ($N{:}P > 16$). Our results determined that

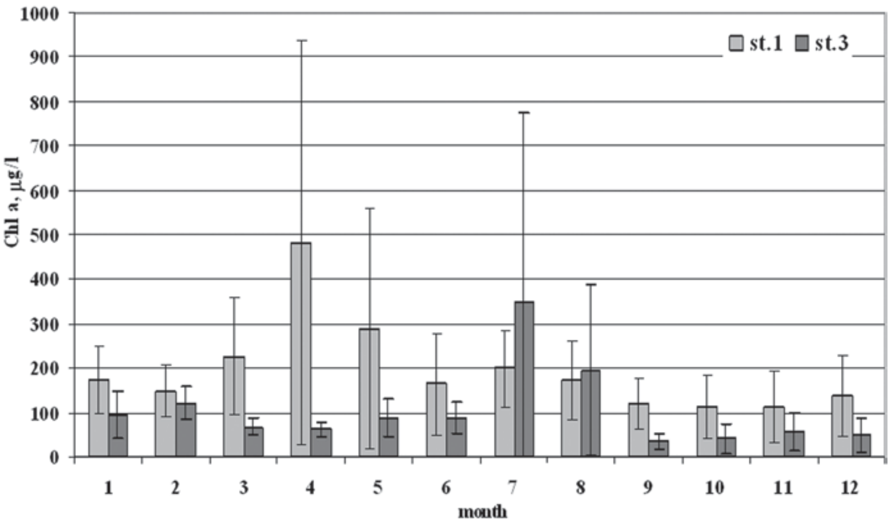

Fig. 6.6 Temporal distribution of the chlorophyll a monthly average values, measured in the Bourgas port waters

the monthly values of *N*:*P* ratio were in the range from 61 to 137, and nitrogen-impacted port waters were moving towards phosphorous limitation. The highest *N*:*P* ratio was found in March, September, and October, while the lowest values in winter months.

Chlorophyll values of the port waters were low (Fig. 6.6). Usually, chlorophyll content measured in station 1 was higher than in station 3, related to the urban-treated wastewater discharges and higher plankton productivity. On the contrary, in July and August the chlorophyll values were higher in point 3, attributed mainly to Vaja Lake water, having significant phytoplankton growth.

From the ecological point of view, the petroleum hydrocarbons parameter is an important one, giving account to entirely anthropogenic influence. Petroleum hydrocarbons were the main pollutants of the port waters in both monitoring stations (Fig. 6.7), although they were below the normative value of 0.15 mg/L.

The oil product values measured in station 3 were higher than in station 1, that is, in relation to the liquid fuel uploading. The highest values were registered in February.

6.4 Conclusions

On the basis of the data from the automated water monitoring stations, the ecological condition of the seawaters at the separate aquatories of the port of Bourgas was assessed. The quality of port waters was influenced by the port activities and by other point and nonpoint pollution sources (lake water inflow, waste water discharges, etc.). In the aquatory of Terminal East (station 1), the deviations could be due to the

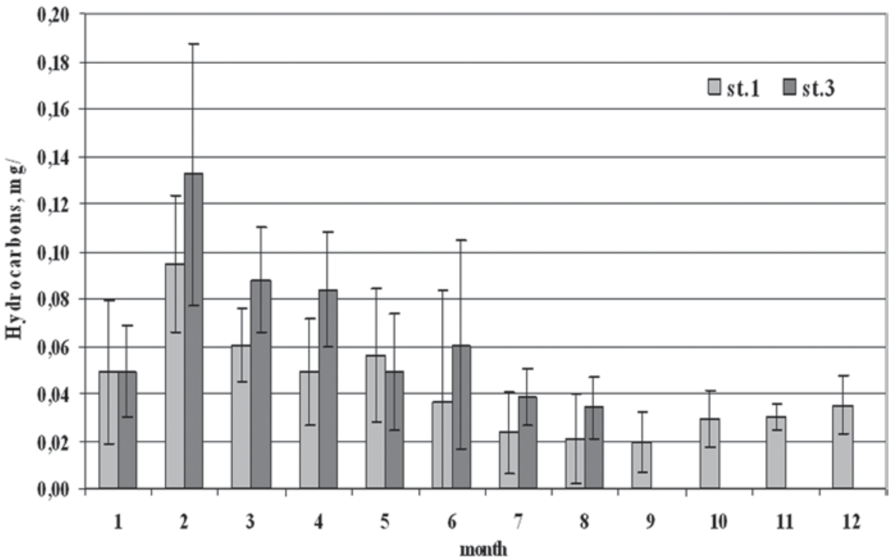

Fig. 6.7 Temporal distribution of the monthly average values of petroleum hydrocarbons, measured in the Bourgas port waters

untreated domestic waste waters. In the aquatory near the Container Terminal (station 4), water quality was strongly influenced by the Vaja Lake and the discharge of the urban treated waste waters, whose impacts were beyond the capabilities of the port management, while the increased content of oil products could be directly related to the port activity (liquid fuel uploading).

The automated water monitoring network could supply the information needed for a quality assessment of the port waters and for an identification of the main ecological problems. On the basis of these data, the port authorities could assess pollution sources leading to environment disturbance and undertake appropriate measures for their elimination.

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Chapter 7
Assessment of Soft-Bottom Communities and Ecological Quality Status Surrounding Constanta and Mangalia Ports (Black Sea)

Adrian Teaca, Tatiana Begun and Mihaela Muresan

Abstract Managing coastal development requires a set of tools to adequately detect ecosystem and sediments degradation. Benthic indicators are often used to detect or assess disturbances, but while they may be very sensitive to the impact itself, the question is whether they can be used as a complementary tool for port managers to improve the environmental policy. The chapter is focused on environmental assessment of influence of Constanta and Mangalia ports' activities on the macrobenthic diversity and population structure. Using the diversity and ecological quality indices as tools for quantifying the Good Environmental Status of the area situated in the proximity of the ports, our main results revealed a positive correlation between shifts occurred in macrobenthic population structure and distance to ports aquatorium. It showed also notably different temporal trends, indicating the high sensitivity to environmental pressures.

7.1 Introduction

Coastal areas are the most dynamic but also the most populated areas of the world. Natural and anthropogenic impacts, poor planning and management of conflictive activities have a major influence on the resident biota and productivity of coastal aquatic systems, which in turn, affect directly the global biodiversity and the whole ecosystem health (Halpern et al. 2007). As well as natural fluctuations in abiotic parameters, the input of nutrients, organic matter and pollutants related to anthropogenic activities can further modify coastal environmental conditions, sometimes to a greater extent, and produce changes in the biota different to those derived from natural variability alone (Venturini et al. 2004). Seaports are major hub of economic activities, connecting sea routes with the hinterland via rail, road and inland waterway. At the same time, they are hubs of environmental issues, resulting from its diversified operations involving vessels, machines, vehicles and industries

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(ESPO-ITMMA 2007). Within the TEN ECOPORT an inventory of Critical Environmental Issues was performed for nine ports involved in the project (TEN ECOPORT 2014). This activity aims to provide the mapping of all the specific critical issues within each port area and the surrounding cities involved. Anyway, the critical issues data collection can be a time-consuming task. A straightforward method to obtain valuable and quick information is to use specific indicators to assess the impact of cumulative pollution sources. Among such indicators many of them were designed to assess the quality of sediments using the macrobenthic communities as sensitive barometers of environmental conditions.

7.2 Methods

7.2.1 Study Area

The metropolitan Romanian coastal zone in particular, holds Constanta, a 0.5 million city. Its harbours are one of the most important in Black Sea with a relevant economical importance for the south-east region of the Europe. The Port of Constanta is located on the Western coast of the Black Sea, at 179 NM from the Bosphorus Strait and 85 NM from the Sulina Branch, through which the Danube flows into the sea and is the biggest from all three ports situated on the Romanian Black Sea coast. It is both a maritime and a river port and has a handling capacity of over 100 million t per year and 156 berths, of which 140 berths are operational. Important cargo quantities are carried by river, between Constanta and Central and Eastern European countries. The Port of Mangalia is situated in the southern part of Constanta port, close to the border with Bulgaria. Main activities within the Mangalia port are related to cargo traffic of: chemicals, fertilizers, bitumen. The intense activity resulted from performed operations related to loading/unloading, ships traffic and industry is heavily reflected in the quality of water, sediments and air within and in the ports area neighborhood (http://www.portofconstantza.com).

Because the sediments have a lower degree of variability compared with the water column, they are mirroring the quality of environment. Those with finer texture tend to accumulate higher concentrations of heavy metals (Nicolaev et al. 2012) and other pollutants than the coarse sediments. Around ports area the sediments consist mainly of silt, and secondary of clay and small quantities of sand, being known under generic name of 'clayey silt', while in the stations from Constanta (CT01 and CT02) and Mangalia area (MA05, MA06 and MA09), the sediments fall into silty sand and sandy silt categories, the percentage of sand being higher (Secrieru et al. 2011).

7.2.2 Sampling and Analysis

During several national and international cruises carried out in 2009, 2010, 2011 and 2012, 24 quantitative macrozoobenthos samples were collected surrounding

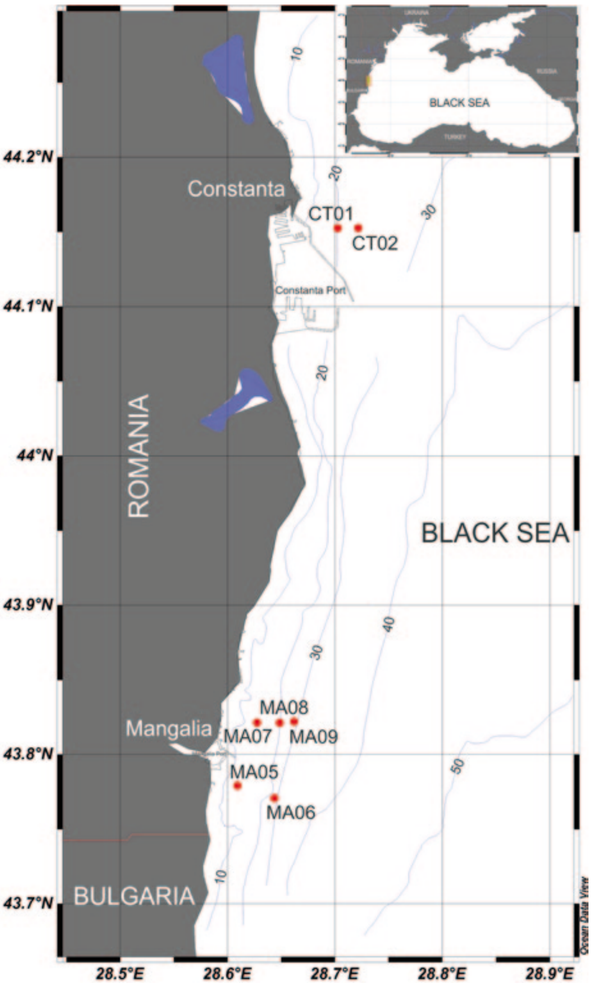

Fig. 7.1 Map of sampling stations carried out between 2009–2012 in the vicinity of Constanta and Mangalia Ports from Romanian Black Sea coast

Constanta and Mangalia port, between 15–30 m depths (Fig. 7.1) using a Van Veen-type grab (0.14 m^2), on board of R/V 'Mare Nigrum'. The samples were washed using 1.0 and 0.5 mm sieves. The biomass of bivalves was calculated as wet visceral tissues after removing the shell.

The structure of the macrobenthic community was analyzed in terms of species composition, density, dominance, frequency, diversity and biomass. The diversity was calculated by the Shannon-Wiener diversity index (H') on a log 2 base. The AZTI Marine Biotic Index, AMBI (Borja et al. 2000), and the multivariate AMBI, M-AMBI (Muxika et al. 2007) were calculated using the freeware program available on http://www.azti.es. Multivariate analysis (Bray-Curtis similarity) was performed with fourth square-root transformed data using PRIMER package programme version 5.2.4 (Clarke and Warwick 2001). Furthermore, SIMPER analysis was performed to identify the percentage contribution of each species to the overall similarity (dissimilarity) within each of the groups identified from the cluster analysis.

7.3 Results and Discussion

A total of 88 taxa belonging to 16 systematic groups were found in the assemblages (Annelida—36, Mollusca—26, Crustacea—17, others—9). The mean abundance of the macrozoobenthic populations was 4878 ind/m^2 and 45.5 g/m^2 as biomass. Polychaeta had the highest number of species (28) and individuals (Average density: 3216 ind/m^2). The maximum biodiversity (73 species) occurred in the Mangalia area. Most of the macrozoobenthic fauna were deposit feeders, except the bivalve, amphipods, the barnacle *Amphibalanus improvisus*, and few carnivorous polychaetes belonging to families Nereididae and Nephtyidae, and Nemertini. Although, the ecological setting as well as water depth in the two areas were similar (varying from 15 to 30 m) macrofauna showed important variation in composition and abundance. In the Constanta area the macrozoobenthic abundance ranged from 67 to 11,220 ind/m^2, while in the Mangalia from 340 to 5900 ind/m^2. Biomass (wet wt.) also showed great variability between the stations and ranged from 0.2 to 332.3 g/m^2 (Constanta) and 1.3–44.5 g/m^2 (Mangalia) respectively. The higher biomass was largely due to the occurrence of bigger sized mollusks, accounting to 76 % of the macrofaunal biomass at Constanta, and 43 % at Mangalia.

Polychaetes were numerically dominant accounting for 66 % of the total macrofauna. Dominance of polychaete worms was as expected for harbour area and compares well with other harbour studies (Guerra-García and García-Gómez 2004; Ingole et al. 2009; Mandal and Harkantra 2013).

Bray-Curtis similarity (hierarchical clustering) followed by an ordination through multidimensional scaling (MDS) categorized the samples into two groups (17–19 m and 26–27 m sites, respectively) in Constanta area. Group I (seven samples) represented the site CT01 (depth 17–19 m) situated at 3.2 km away from the port, and group II (four samples) were the site CT02 (depth 26–27 m) at 5 km away from the port. The average similarities of these two groups were 35.37 % and 22.79 %. The community data was subjected to SIMPER analysis to find the species, which contributed to the similarity within each group. Accordingly, Group I was dominated by *Spio decoratus* (61.5 %), *Heteromastus filiformis* (15.6 %), *Lentidium mediterraneum* (7.4 %); Group II—Oligochaeta (50.1 %), *Melinna palmata* (25.5 %), *H. filiformis* (9 %).

In Mangalia area—there were detected three groups: group I (five samples, depth 14–17 m) situated at 2.8 km away from the port, group II (two samples in marine protected area) at 5.8 km away from the port, and group III (six samples, depth 23–30 m) at 4.3 km away from the port. The average similarities within these three groups were 24.13 %, 49.6 % and 19.97 %. SIMPER analysis showed that Oligochaeta contributed with 68.6 %, *H. filiformis*—19.9 %, *Nephtys hombergii*—6.1 % in group I, *Amphibalanus improvisus*—45.5 %, *H. filiformis*—13.4 %, *Prionospio*

Table 7.1 SIMPER analysis based on group obtained from cluster and MDS ordination showing the species that contributed to the differences among the groups in Constanta area

Average dissimilarity = 82.57	Group I	Group II			
Species	Average abundance	Average abundance	Average dissimilarity	Percentage contribution	Cumulative percentage
Spio decoratus	3703.7	1038.96	27.54	33.35	33.35
Oligochaeta indet	71.53	1978.76	17.74	21.49	54.84
Melinna palmata	138.13	852.48	7.60	9.21	64.04
Heteromastus filiformis	658.60	494.32	6.90	8.36	72.40
Capitella spp.	489.63	304.88	4.37	5.30	77.70
Lentidium mediterraneum	430.43	236.8	4.10	4.96	82.66
Polydora cornuta	155.4	167.24	1.93	2.33	84.99
Abra prismatica	0.00	185.00	1.73	2.09	87.09
Prionospio multibranchiata	131.97	71.04	1.25	1.52	88.61
Nephtys hombergii	11.10	116.92	1.15	1.39	89.99

multibranchiata–7.2 % in group II and *H. filiformis*—22.8 %, *Dipolydora quadrilobata*—15.1 %, *Aricidea claudiae*—14.2 % in group III. The species, which resulted in the dissimilarity in the two area surrounding harbours, are listed in Tables 7.1 and 7.2. Dominant polychaets species are largely opportunistic and proliferate in sediments with high organic enrichment (Glémarec and Hily 1981). Further, Spionidae and Capitellidae contributed to 30 % of the total macrozoobenthic populations.

The sediments within and around port area are historically affected by pollution with heavy metals, contaminants and organic matter. However, the levels of the heavy metals in marine sediments in 2011 remained in the trend values of the period 2007–2010. In terms of spatial distribution, the values of copper, nickel, and chromium showed significant increased accumulations in Constanta south port area, compared to neighboring area. High concentration of total petroleum hydrocarbons was recorded in 2011 around Constanta port. Still, the pollution level was significantly lower compared to 2010, following the continuous decreasing trend of the past 5 years. The level of PAHs instead indicated a significantly higher level of pollution compared to 2010. Significant concentrations for the priority hazardous organic contaminants were recorded at 5 m in the south Constanta and Mangalia area. Similarly, the organochlorine pesticides, especially aldrin, reached higher concentrations in the south of Constanta (5 m) in 2011. However, compared to the period 2006–2010, the values followed the downward tendency observed in the past years (Nicolaev et al. 2012).

The three benthic indices for the macrozoobenthic communities provided a broad picture of the Ecological Quality Status of ecosystem in the surrounding Constanta and Mangalia ports. Major differences in faunal composition of polluted and non-polluted sites are at the outset noticed in abundance and in presence/absence of families (Gray et al. 1990). Diversity indices such as the Shannon-Wiener index

Table 7.2 SIMPER analysis based on group obtained from cluster and MDS ordination showing the species that contributed to the differences among the groups in Mangalia area

Average dissimilarity = 83.57	Group I	Group III			
Species	Average abundance	Average abundance	Average dissimilarity	Percentage contribution	Cumulative percentage
Oligochaeta indet	2406.48	289.66	26.67	31.91	31.91
Heteromastus filiformis	395.16	661.77	9.38	11.23	43.14
Polydora cornuta	7.40	729.43	7.97	9.54	52.68
Aricidea claudiae	28.12	291.77	6.83	8.18	60.85
Prionospio multibranchiata	26.64	553.94	6.78	8.12	68.97
Alitta succinea	1.48	426.03	5.13	6.14	75.11
Dipolydora quadrilobata	28.12	253.71	4.32	5.17	80.28
Phoronis euxinicola	0.00	178.66	2.73	3.26	83.54
Nephtys hombergii	87.32	89.86	2.25	2.69	86.23
Spio decoratus	37.00	69.77	1.26	1.51	87.74
Melinna palmata	109.52	9.51	1.07	1.28	89.02
Streblospio gynobranchiata	127.28	0.00	1.03	1.24	90.26
Average dissimilarity = 86.79	Group I	Group II			
Amphibalanus improvisus	0.00	1739.00	28.38	32.7	32.7
Oligochaeta indet	2406.48	111.00	24.64	28.39	61.09
Heteromastus filiformis	395.16	510.60	4.95	5.7	66.79
Spio decoratus	37.00	296.00	4.54	5.23	72.02
Prionospio multibranchiata	26.64	273.80	4.15	4.79	76.8
Melita palmata	0.00	214.60	3.50	4.04	80.84
Protodrilus flavocapitatus	0.00	111.00	1.81	2.09	82.93
Nephtys hombergii	87.32	0.00	1.74	2.01	84.94
Cephalotrix sp	0.00	66.60	1.09	1.25	86.19
Diogenes pugilator	1.48	66.60	1.06	1.22	87.41
Streblospio gynobranchiata	127.28	0.00	1.01	1.17	88.58
Melinna palmata	109.52	0.00	0.97	1.11	89.69
Conopeum seurati	0.00	51.8	0.85	0.97	90.67

(H') and the AMBI and M-AMBI are common tools for measuring such community changes in benthic ecology and are also widely used for the assessment of the ecological quality status (Kröncke and Reiss 2010). In the present study, H' and the AMBI and M-AMBI revealed good environmental quality in the surrounding Constanta and Mangalia ports. Still, the effect of pollution was found for a small number of situations. In the case of the station MA05 in 2010 and 2011, surrounding Mangalia port, the low number of species associated with Poor and Moderate EcoQs as resulted from H' calculation and Bad and Poor EcoQ according to M-AMBI could be an indication of an ecological perturbation in this area (Fig. 7.2).

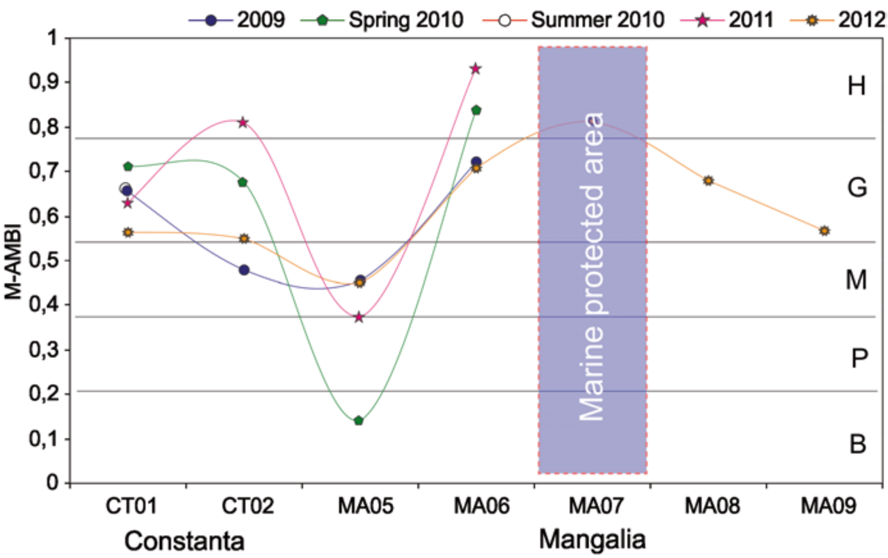

Fig. 7.2 Evolution of M-AMBI values, during the studied period, at each sampling station. Key: *H* high quality, *G* good quality, *M* moderate quality, *P* poor quality, *B* bad quality

The trend towards the deterioration of the EcoQ in the adjacent zone of Mangalia port (station MA05) is evidenced by changes in the ecological species groups, i.e. the absence of species of group I and II, together with an increase in group III, IV and V (*H. filiformis*, *Spio decoratus,* Oligochaeta). In this study, polychaets and oligochaets dominated in the closest stations of Mangalia port (MA05), where the intensity of harbour activities is obviously major. The polychaets *H. filiformis*—indicator of organic pollution, *N. hombergii* and *S. decoratus*—tolerant to pollution with organic substances was found in most stations and most abundant in MA05 station. Also, in this station was found the first presence of *Streblospio gynobranchiata*, a new polychaete species at the Romanian coast of the Black Sea. The average density and biomass of *S. gynobranchiata* were 636.4 ind/m^2 and 0.19 g wwt/m^2, respectively. This species is indicator of organic pollution.

7.4 Conclusions

According to the present study results, the quality of ecosystem surrounding Constanta and Mangalia harbours is quite good, except the area in front of Mangalia Port (station MA05), where a bad ecological status (poor) was recorded in 2010 and 2012, as the indices M-AMBI showed. Findings made during this study should form an important baseline for future monitoring of this area, since no previous record on macrofauna communities is available for this region. Keeping in mind the goal of the TEN ECOPORT project to put the right instruments in hand of port managers to help ports to accede at the status of environmental certified port, our study renders a good example of reliable tool for assessing the impact of port activities and for further decision making.

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Chapter 8
Application of Hydrodynamic, Pollution Drift and Wave Models as Tools for Better Environmental Management of Ports

Vasko Galabov, Anna Kortcheva, Elisaveta Peneva, Georgi Kortchev, Marieta Dimitrova and Jordan Marinski

Abstract Numerical modelling provides additional information useful for implementation of the sustainable model for environmental-friendly development of the port networks. This chapter presents an improved modelling approach using better interconnections between the components of the system. The input data has been produced by the usage of an operational hydrodynamic model for the areas in the vicinity of ports, which makes the system applicable in case of extreme situations. This provides the decision makers with examples of worst-case scenarios of pollution drifts during extreme cases like combinations of strong winds, high waves and storm surges.

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8.1 Introduction

Providing information about the vulnerability in case of storm weather and oceanographic conditions is essential for the proper environmental management of ports. One of the major problems along the coast is the insufficient data sets of measurements. Numerical modelling provides additional information useful for implementation of the sustainable model for environment-friendly development of the port networks. Ports are vulnerable to severe meteorological and oceanographic conditions that may affect their operability and may increase the environmental risks due to increasing probability for disasters in ports and in the coastal areas. The capabilities to monitor such conditions are limited and therefore the numerical modelling is the primary tool to assess and predict such extreme situations. The study of these extreme situations is important for efficient environmental management of port areas. The output of such 2D and 3D hydrodynamic, pollution drift and wave models in case of severe weather may be used by the port authorities to improve the preparedness and awareness in case of extreme hydro-meteorological events (extreme winds, waves and storm surge sea level rise) by means of proper forecasts. In our previous study (Galabov et al. 2012a, 2013), we evaluated the risk of oil pollution for the Port of Bourgas in case of ship accident under normal meteorological conditions using climatic data for the sea currents. This chapter presents an improved modelling approach using better interconnections between the components of the system and hydrodynamic model data as an input to the system. The input data has been produced by the usage of an operational atmospheric and hydrodynamic models for the areas in the vicinity of ports, which makes the system applicable in case of extreme situations, because it provides the decision makers with examples of worst case scenarios of pollution drifts during extreme cases of combinations of strong winds, extreme waves and storm surge.

8.2 The Modelling System

The meteorological and oceanographic conditions in case of extremes may increase significantly the probability for the occurrence of accidents not only in open waters, but also in harbours, ports and in the coastal area outside the ports. Some notable examples of accidents with oil pollution, caused by extreme weather and sea hazards that are further worsened by the weather conditions include the Prestige accident in 2002, the Erika Accident in 1999 and more recently the Kerch Strait disaster (Matishov et al. 2013). The studies (Daniel et al. 2004) of such accidents confirmed that proper numerical simulation of the winds, sea waves and currents are crucial not only prior to the accident, but also during the liquidation of consequences.

Based on the knowledge gathered during such cases and the practices in other countries, we implemented the modelling system consisting of the following four components:

- *A hydrodynamic 3D model* for the Bay of Bourgas and the Bay of Varna with high spatial resolution nested within a lower resolution hydrodynamic model for the entire Black Sea. The coarser resolution model for the entire Black Sea is the NEMO model (Nucleus for European Modelling of the Ocean; Madec 2006). The model to represent adequately the Black Sea hydrodynamics has to permit eddy resolving resolution. It also has to provide a good representation of the vertical processes in order to represent adequately the stratification, the permanent picnocline and the existence of a layer of cold intermediate water persisting during the summer. It also has to represent the fresh water inflow in the northern part of the western Black Sea shelf and the Bosporus plume of Mediterranean saline water. The NEMO model is such a model—a primitive equation model—adapted not only to global, but also to regional scales. The setup of the model for the entire Black Sea is with a spatial resolution of 1/27 by 1/36° in zonal and meridional directions (about 3 km horizontal resolution) and 31 vertical levels. It is initialized by the monthly mean temperature and salinity 3D fields. The atmospheric forcing comes from the operational model of the European Centre for Medium Range Forecasts (ECMWF): the output is every 6 h with 0.25° resolution, including information about the air pressure, temperature, humidity and wind on the sea surface, as well as cloud cover. In order to ensure the fresh water fluxes budget vs. evaporation, the ECMWF precipitation is used and also the river runoff of 40 rivers along the Black Sea coast. The runoff is balanced by the Bosporus Straits transport, which is treated in the same way as rivers. The areas of the bays of Varna and Bourgas are resolved with a horizontal resolution of 20" (approximately 500 m) using a nested GETM model (General Estuary Transport Model; Bruchard and Bolding 2011) due to the fact that it is more adapted for such shallow water areas and includes the flooding and drying mechanism. The NEMO model was integrated for 2012 and the results represent adequately the seasonal variation in the Black Sea circulation. The dominating Rim current is evident, enhancing the speed in winter. Around Cape Kaliakra the current accelerates throughout the year (Fig. 8.1).

The implementation of NEMO and GETM for the port areas provides a state of art information for the sea currents, temperature, salinity and other hydro physical fields in terms of climatic seasonal means and actual values during extreme sea storms. The model output serves as an input to the wave model and the pollution drift model. Example of the output of the model is presented in Fig. 8.1 for the currents during the extreme storm of February 2012 and the variation of the current speed for a selected point (location of a ship accident that is mentioned later in the chapter). The atmospheric forcing that is used in the frame of the present study is the operational model of the European Centre for Medium Range Forecasts (ECMWF) for the entire system when we are evaluating potential pollution scenarios or the operational regional model of NIMH-BAS which is an implementation of the ALADIN Model—for more details see Bogatchev (2008), for operational forecasts.

- *A sea wave model* implemented for the western part of the Black Sea is SWAN (simulating waves nearshore; Booij et al. 1999). The SWAN model provides

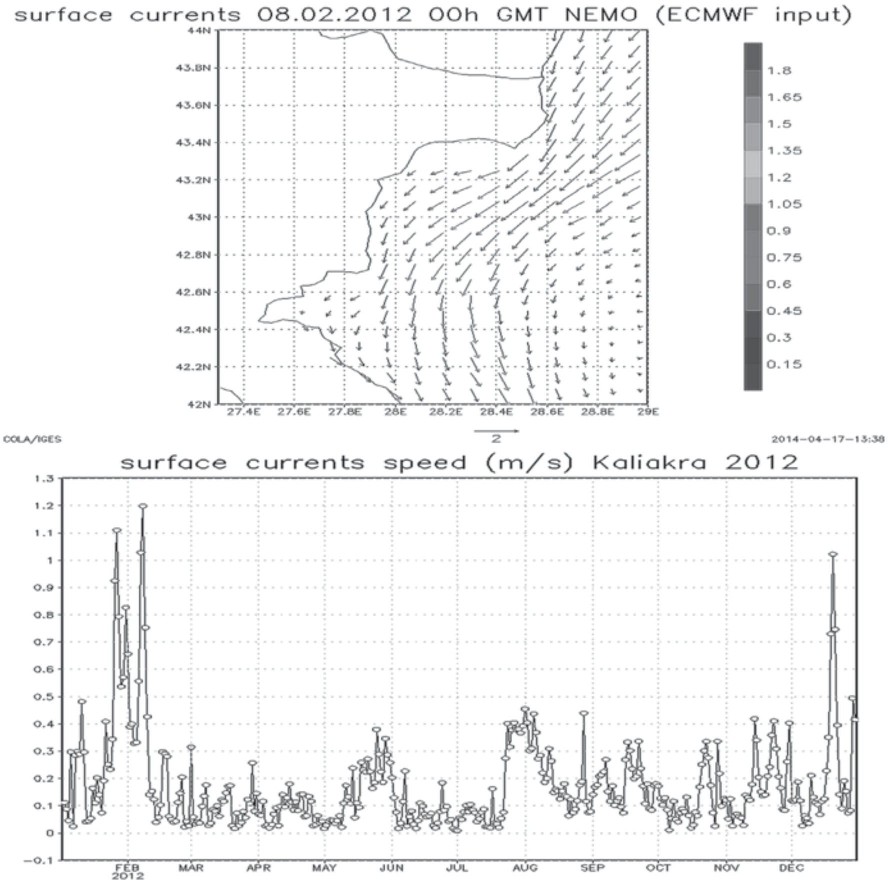

Fig. 8.1 The NEMO hydrodynamic model: *the upper graphic*—the surface currents during the storm of 06–08 February 2012 around the Bulgarian coast; *down*—the current speed variation during 2012 for a point close to Kaliakra Cape—notice the significant difference of the current speed from the mean seasonal value

forecast of significant wave height and direction for the whole area and time series for the wave heights at the entrance of three ports: Bourgas, Varna and Constanta (Fig. 8.2—the upper three graphics).The model has been validated and calibrated for the open sea, using satellite data and coastal locations, using the observations in the coastal stations of NIMH-BAS (Galabov et al. 2012b). SWAN is also used for similar systems providing sea state information for the needs of ports like the systems presented in Rusu and Guedes Soares (2011, 2012). The operational SWAN implementation is based on SWAN version 40.91. The horizontal resolution is 1/30°. Also for the Bays of Bourgas and Varna a nested implementations are available with a horizontal resolution of 1/180° (approximately 3 km).

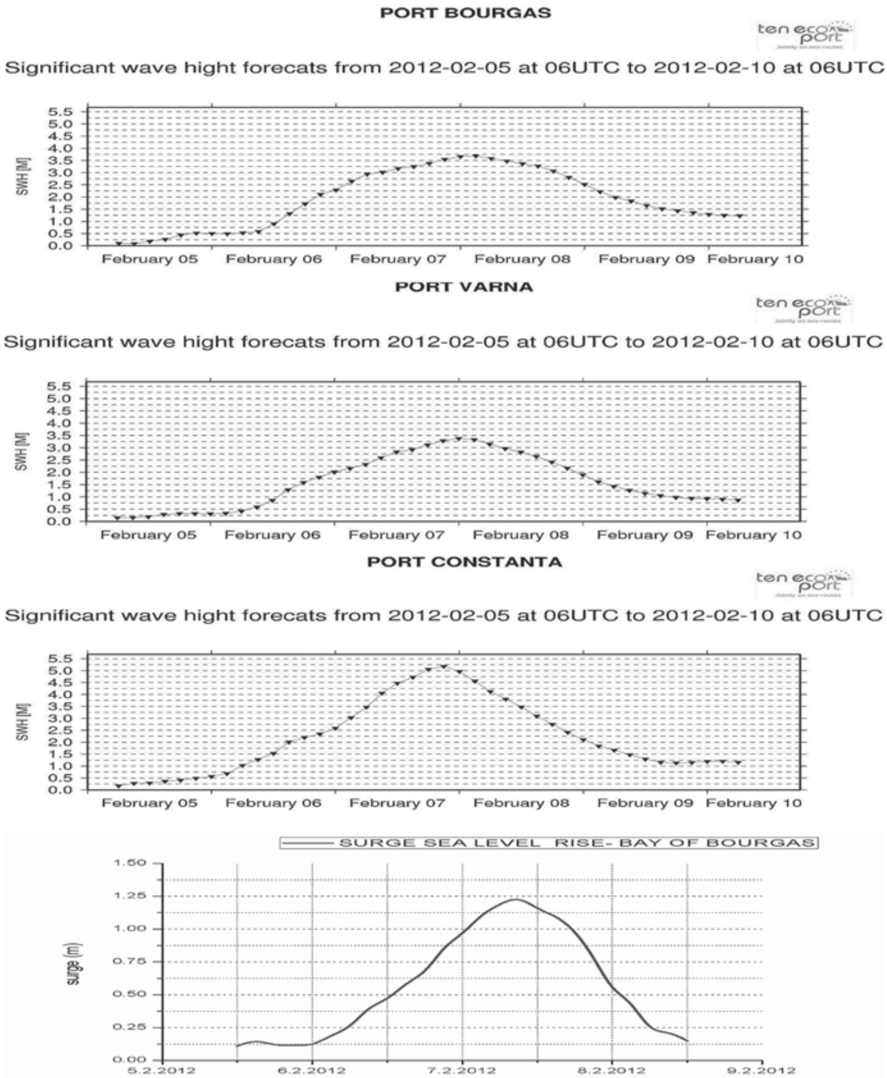

Fig. 8.2 The storm of 06–08 February 2012: the first three graphs represent the forecast of the significant wave height at the entrance of the ports of Constanta, Varna and Bourgas. The last graph represents the storm surge forecast for the area of the port of Bourgas and the town of Bourgas

- *A storm surge model* implemented for the Black Sea by Mungov and Daniel (2000). The modification to the model consists in the interconnection (one way coupling) between the storm surge and the wave model. In order to account properly the air–sea interaction we use the sea state parameters and wave radiation stress in the storm surge model. An example of the model time series output for the area port of Bourgas is shown in Fig. 8.2 (the last graph). Together with the previous two graphs, these are examples of an extreme weather and sea situation, causing significant damages around the Bulgarian coast.

- *The MOTHY model* (Daniel 1996). The model simulates the evolution of oil spills and other floating pollutant spills. In our previous research (Galabov et al. 2012a, 2013) we evaluated the vulnerability of the Bourgas port to oil pollution under different typical weather conditions by using MOTHY and the model was used as a standalone model, while in the present study we are using the information from the wave model and the hydrodynamic model (in the previous work we used climatic currents while here we use a nonstationary time evolving currents from the hydrodynamic model). The variation of the surface currents speeds in Fig. 8.1 shows that a significant difference between the mean seasonal current speeds especially under stormy conditions may lead to significant changes in the numerical simulations of the drift pollution under such conditions. The standalone version of the MOTHY system for the Bulgarian coast takes into account the differences in the wind driven currents by the usage of two dimensional depth integrated circulation model (the OCEAN2D component of the system) but it does not take into account that difference of the thermohaline circulation under such conditions are also expected. Another advantage of the approach with the usage of three dimensional hydrodynamic model is that it explicitly resolves the stratification and the mixed layer depth, while the two dimensional model requires a preliminary setup of the mixed layer depth of the Black Sea as a single parameter or as two dimensional matrix. By the usage of three dimensional hydrodynamic model a new mean seasonal currents are also produced which may also be used in the future studies (like risk analysis and real accidents).

Two examples of pollution drift are presented in Fig. 8.3. The source location is the actual location of a sunken ship that may cause pollution if the heavy bunker fuel that is still in the ship leaks in the water. NIMH-BAS providing the Bulgarian authorities (the Maritime Administration) with numerous simulations of the behaviour of a possible spill under different meteorological (different wind speeds from different directions) and oceanographic conditions (presence or absence of an anticyclonic eddy). The left part of Fig. 8.3 shows the behaviour of the spill in calm weather using the mean seasonal currents. The right part of Fig. 8.3 also presents a simulation for calm weather but for a situation when the Kaliakra anticyclonic eddy is not present but the circulation is cyclonic. As it may be seen, the simulation with the mean seasonal currents suggests that there is a significant risk for a pollution of the area of Constanta (including the Constanta port) while the simulation without the presence of the anticyclonic eddy leads to a significantly lower risk for a pollution of Constanta (and the Romanian coast in general).

The pollution drift model in the present version of the model system uses not only information from the atmospheric and the hydrodynamic model, but also from the wave model. Two different approaches were tested to calculate the wind drag coefficient Cd. First approach is by the usage of the friction velocity from the model (computed explicitly when the Janssen's parameterization (Janssen 1991) of the wind input is used) and the second using the wave steepness, following the results of Guan and Xie (2004). Explicit calculation of the drag coefficient is expected to

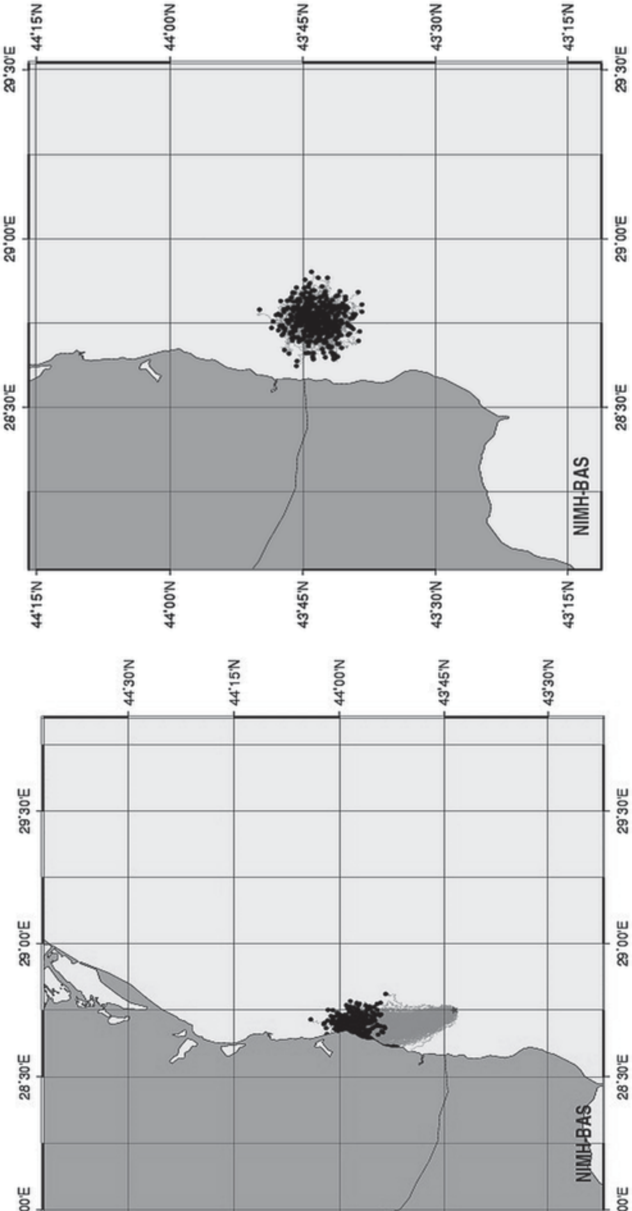

Fig. 8.3 MOTHY model simulations in calm weather conditions for the location of a ship that sunk during February 2014 (a potential source of oil pollution). *Left*—the movement of the spill when the Kaliakra anticyclonic eddy is present. *Right*—the same simulation when the eddy is not present (the thermohaline circulation is cyclonic)

improve the calculation of the surface currents for strong wind conditions for which the drag coefficient deviates from the linear approximations. SWAN wave model also provides to MOTHY the components of the wave radiation stress. MOTHY takes into account the Stokes drift. While usually the most widely used pollution drift models do not take into account the Stokes drift, to use it is justified because thereby the prediction of the spills behaviour in shallow water depend also on the Stokes drift.

8.3 Conclusions

In order to provide fast predictions of potential impacts for different environmental scenarios information about the vulnerability in case of typical and extreme weather and oceanographic conditions to the South East European ports of western Black Sea area a modelling system has been implemented. The system consists of interconnected modules based on input information from the state-of-art ocean model and possible usage of various atmospheric models. The applications of modelling system produce the following results:

1. The sea wave model implemented for the western part of the Black Sea (SWAN) provides forecast of significant wave height and direction at the entrance of three ports: Bourgas, Varna and Constanta which are included in TEN ECOPORT project. The model has been validated and calibrated using satellite data and the observations in the coastal stations of NIMH-BAS.
2. The MOTHY model was implemented for numerous simulations of the behaviour of oil spills caused by sunken ship if the heavy bunker fuel leaks in the water under different meteorological (different wind speeds from different directions) and oceanographic conditions (presence or absence of an anticyclone eddy). The simulation with the mean seasonal currents suggests that there is a significant risk for a pollution of the coast area of Constanta (including the Constanta port) and the Romanian Black Sea coast in general.

Acknowledgments This work was made possible thanks to a research grant provided by South East Europe Transnational Cooperation Programme within 'Transnational enhancement of ECOPORT 8 network'—TEN ECOPORT project (SEE/D/0189/2.2/X).

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Chapter 9
Design of Wave Energy Distribution for the Harbour and Coast Protection

Idlir Lami and Stavri Lami

Abstract In this study, we present wave climate analysis at specific location points in deep water of Adriatic Sea and refracted waves distribution in Porto-Romano coastal area in order to determine the wave energy distribution. The analysis of wave energy distribution for this coastal area and the design of wave refraction plans are the first step to find effective solutions for coast and harbour protection. The results from wave climate analysis show us that the most extreme waves are generated from south directions at Adriatic Albanian coast. The analysis of refraction plans for Porto-Romano coastal area illustrates gaining of the maximum wave at Porto-Romano harbour from the south-west direction.

9.1 Introduction

Along the Albanian coastline, having a total length of about 446 km, we can distinguish the Ionian littoral, with a length of about 172 km, where the dominant (80 %) is rocky high coast, and the Adriatic littoral, with a length of about 274 km, where on the contrary the dominant (74 %) is low-land coast (about 35 % by sandy beach and 39 % by river mouth deposits or marshlands). The coastal protection is important because of intensive erosion processes in low-land coast in the Adriatic littoral are identified.

Wind blowing over the surface of the Adriatic and Ionian Sea transfer energy to the water surface in the form of wind-generated waves. The analysis of wave energy distribution in this coastal area and development of wave refraction plans are the first step to find effective solutions for coast and harbour protection.

In this chapter, wave climate analysis at a specific location point (40.75°N and 19°E) in deep water of Adriatic Sea and refracted waves distribution in Porto-Romano coastal area are presented. In this location, because of suitable depth and

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shoreline configuration of the northern coast of the Durres Bay, a new commercial oil port is constructed.

9.2 Analysis of Wave Climate in Deep Water of Adriatic Albanian Coast

Waves are the dominant active phenomenon in the coastal zone. It is important to have a means to quantify wind-generated waves for use in various engineering analyses and designing coastal structures. It is also important to be able to predict these waves for a given wind condition, both wave hind casts for historic wind conditions and wave forecasts for predicted impending wind conditions.

It is desirable to select a single wave height and period to represent a spectrum of wind waves for use in various engineering problems. The most commonly used representative is significant wave height, which is the average height of the highest one-third of the waves. The significant wave height and period as well as the resulting spectrum of wind-generated waves depend primarily on the distance over which the wind blows (known as the fetch length), the wind speed and the duration of the wind.

Thus, the maximum length of geographical fetch at a specific location point (40.75°N and 19°E), in deep water of Adriatic Sea, is about 1150 km from south direction and about 700 km from north-west direction, the respective length of effective fetch are about 680 and 315 km (Fig. 9.1) (Petrillo et al. 2008).

The data of wave climate in this specific point, by model of Argoss (Dutch Company), are presented in Table 9.1, from 1992 to 2004 (13 years) (Petrillo et al. 2008).

The extreme probability of wind occurrence (2.6%), predicted from wind conditions data, for the extreme wind speed (>22 node) coincide with south direction,

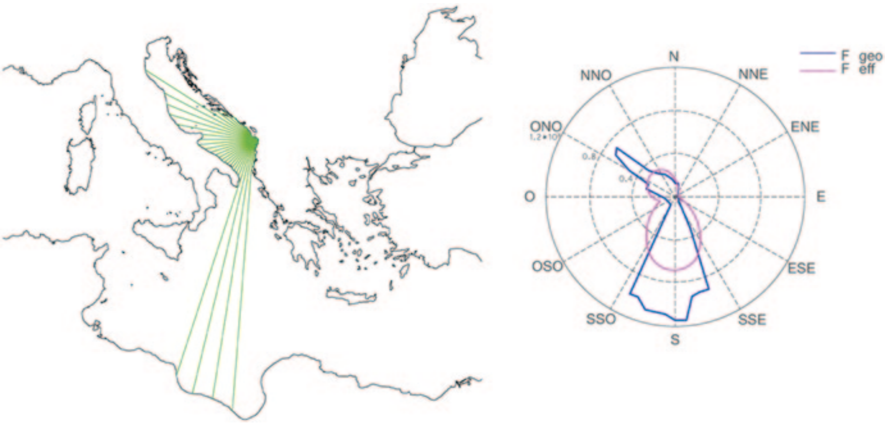

Fig. 9.1 Extension of geographical and effective fetch from a specific point in deep water of Adriatic Sea

Table 9.1 Wave measurements in deep water

Date/Time	Significant wave height Hs	Peak period Tp	Spectral mean period T-1,0 T-1,0	Principal wave direction	Wind speed	Wind direction
[MMDDYY hh:mm]	[m]	[s]	[s]	[degr]	[m/s]	[degr]
09/01/1992 0.00	0.2	4.9	4.7	302	2.8	160
09/01/1992 3.00	0.2	4.9	4.7	300	2.8	152
09/01/1992 6.00	0.2	4.9	4.7	255	2.8	144
09/01/1992 9.00	0.1	4.9	4.9	214	3.4	166
09/01/1992 12.00	0.5	3.6	3.1	184	4.0	184

Table 9.2 The extreme wave height and peak period in given deep water point, predicted from this data by probability distribution of Gumbel function, for various directions and return periods

Wave Direction	Wave significant height H_S (m)				Wave peak period T_P (s)			
	Return periods (years)							
	50	25	20	10	50	25	20	10
N	4.43	3.95	3.8	3.3	9.5	8.97	8.79	8.2
NNE	2.81	2.54	2.46	2.18	7.56	7.19	7.07	6.66
SSE	4.04	3.63	3.49	3.07	9.06	8.59	8.43	7.91
S	6.92	6.47	6.32	5.86	11.87	11.47	11.34	10.92
SSW	5.5	4.99	4.82	4.3	10.57	10.07	9.91	9.36
WSW	4.52	3.99	3.82	3.28	9.59	9.01	8.81	8.16
W	5	4.41	4.22	3.61	10.09	9.47	9.26	8.57
WNW	4.94	4.47	4.32	3.84	10.03	9.54	9.37	8.84

which is direction of maximum effective fetch. The extreme wave heights and peak periods in given deep water point for various directions and return periods are shown in Table 9.2.

Thus, by the wave climate at given specific point in deep water of Adriatic Albanian coast, the most extreme waves are generated from south direction.

9.3 Design of Refracted Wave Distribution in Porto Romano Coastal Area

Consider the design of a protective breakwater for a small marina that is located on the open coast. A typical design concern would be to predict wave conditions at interior points in the marina for a given deep water design wave height, period and direction (Lami 2002).

Wave refraction occurs in transitional and shallow water depths because wave celerity decreases with decreasing water depths to cause the portion of the wave crest that is in shallower water to propagate forward at a slower speed than the portion that is in deeper water. The result is a bending of the wave crests so that they approach the orientation of the bottom contours. Wave orthogonal, to remain normal to the wave crest, will also bend so that orthogonal that are parallel in deep water may converge or diverge as wave refraction occurs. This convergence or divergence of wave orthogonal will cause local increases or decreases in wave energy and consequently wave height (Lami 2003).

Design of wave energy distribution plans in this condition is realised by means of mathematical model, which is based on numerical solutions of two fundamental differential equations (Lepetit 1964). These equations, represented as geometric (quantitative) and energetic (qualitative) aspects, are:
the differential equation of wave orthogonal or wave direction

$$\frac{d\alpha_i}{dt} = \frac{\partial C_i}{\partial x_i}\sin\alpha_i - \frac{\partial C_i}{\partial y_i}\cos\alpha_i, \tag{9.1}$$

and the differential equation of wave front distribution

$$\frac{d^2\beta_i}{dt^2} + p(t)\frac{d\beta_i}{dt} + q(t)\beta_i = 0, \tag{9.2}$$

where: α_i—the angle between the tangent of wave orthogonal and the ox axis,
C_i—the wave celerity,
$\beta_i = b_i/b_0$—the coefficient of wave front distribution between two adjacent orthogonal from deep water to a refracted wave point, and

$$\left\{ p(t) = -\left(\frac{\partial C_i}{\partial x_i}\cos\alpha_i + \frac{\partial C_i}{\partial y_i}\sin\alpha_i\right) \right. \tag{9.3}$$

$$\left\{ q(t) = C_i\frac{\partial^2 C_i}{\partial x_i^2}\sin^2\alpha_i - 2C_i\frac{\partial^2 C_i}{\partial x_i\,\partial y_i}\sin\alpha_i\cos\alpha_i + C_i\frac{\partial^2 C_i}{\partial y_i^2}\cos^2\alpha_i \right. \tag{9.4}$$

where $K_r = \beta_i^{-1/2}$ is the wave refraction coefficient.

For solving these differential equations, the numerical methods of Euler, Adams and Runge–Kutta are used.

The basic equations of finite differences by Runge–Kutta method are:

$$\begin{cases} x_{i+1} = x_i + \left(C_i + C_{i+1}\right)\dfrac{\Delta t}{2}\cos\left(\alpha_i + \Delta\alpha_i/2\right) \\ y_{i+1} = y_i + \left(C_i + C_{i+1}\right)\dfrac{\Delta t}{2}\sin\left(\alpha_i + \Delta\alpha_i/2\right) \\ \alpha_{i+1} = \alpha_i + \Delta\alpha_i/2 \end{cases} \tag{9.5}$$

$$\begin{cases} \frac{d^2\beta_i}{dt^2} = \left(\beta_{i-1} - 2\beta_i + \beta_{i+1}\right) / \Delta t^2 \\ \frac{d\beta_i}{dt} = \left(\beta_{i+1} - \beta_{i-1}\right) / 2\Delta t \\ \beta_{i+1} = \frac{\left(p_i \Delta t - 2\right)\beta_{i-1} + \left(4 - 2q_i \Delta t^2\right)\beta_i}{p_i \Delta t + 2} \end{cases} \tag{9.6}$$

The wave climate in deep water (direction angle, wave height and period) and the bathymetrical relief of coastal area are the basic data for this numerical model.

According to the climatic data during several years in Durres station, the results show that the south-western, western and north-western winds are predominant.

Wave heights and respective periods in deep water of Porto-Romano coastal area are predicted by the analysis of this climatic data and their respective effective fetch, and by means of an analytical method.

The application of numerical model for the design of refracted wave distribution plans for three predominant wind direction (SW, W and NW) is realised on the strength of initial data: wave climatic in deep water and the bathymetric relief of Porto-Romano coastal area (Table 9.3, only SW direction).

The results of refracted wave distribution plan at SW direction of wind are presented in Fig. 9.2 and Tables 9.3 and 9.4.

9.4 Conclusions

- Analysis of wave energy distribution is important to find effective solutions for the protected harbours and shore in each coastal area.
- Wave climate in deep water and the bathymetrical relief of coastal area are the basic data for realised plans and analysis of wave energy distribution by numerical model.
- The analysis of refraction plans for Porto-Romano coastal area illustrates gaining of the maximum wave at Porto-Romano harbour from the south-west direction.
- For wave monitoring in deep water, it is necessary to install maritime stations on characteristic area along Albanian coast.

Table 9.3 The data of numerical model program for wave energy distribution

Coastal area								Porto Romano					
Wave direction in deep water								SW					
Wave period in deep water								$T=9.4$ s					
Wave height in deep water								$H=5.54$ m					
Direction angle of front wave in deep water with ox								$A_o=0°$					
Scale of maritime map								1: 50,000					
Dimension of unity square								$A=500$ m					
Number of vertical unity								$M=14$					
Number of horizontal unity								$N=28$					
Position of primary point								$X_o=1$, $Y_o=1$					
90	89	88	87	86	85	83	82	80	79	78	77	76	75
87	86	86	85	85	84	82	80	79	77	76	74	72	71
85	85	85	85	85	83	81	79	77	75	73	71	69	67
84	84	84	83	83	82	80	78	75	72	69	67	65	63
84	84	83	82	81	80	78	76	73	70	67	64	61	58
83	82	80	80	79	78	76	74	70	67	63	60	56	53
81	79	77	77	77	73	70	66	63	60	57	54	51	48
79	77	74	73	75	67	64	61	58	56	53	50	47	44
77	74	71	68	65	62	59	56	53	50	46	44	42	40
70	72	69	66	63	60	57	54	51	48	44	40	38	35
73	70	68	64	60	56	53	50	46	43	40	37	35	32
72	69	66	62	59	55	52	48	45	42	38	35	32	29
62	60	58	56	57	50	48	47	43	41	38	33	30	27
58	57	52	50	45	40	43	46	40	37	34	31	28	25
55	53	51	49	40	38	35	35	35	32	29	26	24	22
51	48	45	40	37	36	35	32	29	26	24	23	20	20
48	44	40	37	34	32	30	27	25	23	23	22	20	18
42	38	36	34	30	26	21	24	24	23	22	21	19	15
40	36	34	31	27	26	26	24	23	22	20	13	13	14
37	35	32	28	27	25	24	23	22	21	17	10	10	8
34	32	29	27	26	24	21	21	19	18	13	11	5	0
31	29	27	25	24	23	21	20	16	11	8	8	2	0
27	26	24	23	23	22	20	18	14	11	10	4	0	0
26	23	22	21	21	20	19	14	10	8	3	0	0	0
21	21	20	12	10	10	10	11	8	4	0	0	0	0
19	15	11	6	3	5	10	11	8	4	0	0	0	0
10	5	1	2	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0

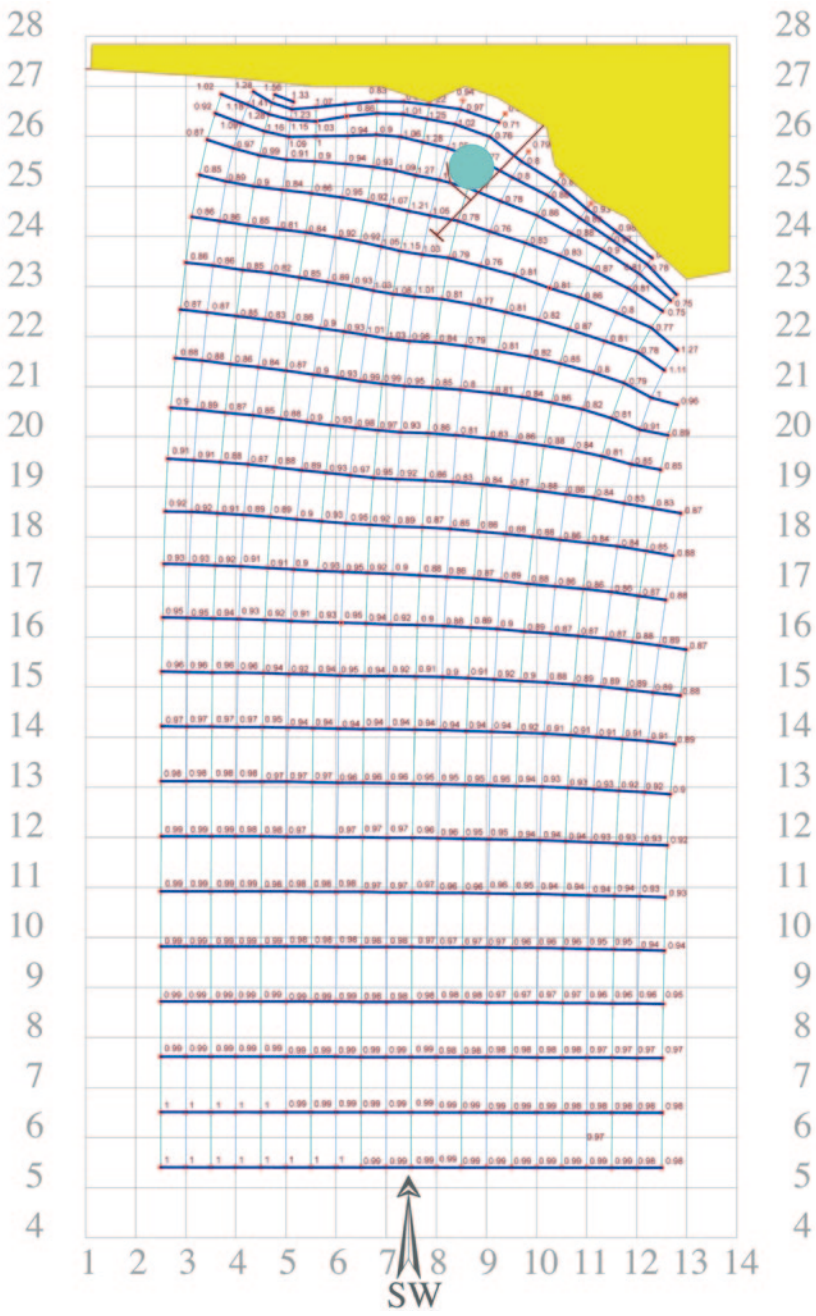

Fig. 9.2 Plan of wave refraction in the 'Porto-Romano' coastal area from S-W direction

Table 9.4 Results of numerical model

Orthogonal Nr. 13								
Nr	*t*	*X*	*Y*	FL	BE	WL	VL	EL
3	38	7.50	2.10	80.90	1.00	1.00	1.00	14.66
4	75	7.50	3.21	79.79	1.00	1.00	1.00	14.66
5	113	7.50	4.31	78.38	1.00	1.00	1.00	14.66
6	150	7.50	5.41	76.18	1.00	0.99	0.99	14.66
7	188	7.50	6.51	71.41	1.00	0.99	0.99	14.65
8	226	7.50	7.61	64.62	1.00	0.99	0.99	14.62
9	263	7.51	8.71	58.92	1.00	0.98	0.98	14.58
10	301	7.51	9.81	55.85	1.00	0.98	0.97	14.55
…	…	…	…	…	…	…	…	…
27	940	8.85	25.54	6.82	1.75	1.02	0.77	7.64
28	978	9.07	25.99	4.67	2.01	1.08	0.76	6.19
29	1015	9.25	26.28	2.72	2.34	1.08	0.71	3.62
30	1053	9.37	26.45	1.74	2.65	1.08	0.66	2.32

t the time of wave front (s), *X* and *Y* predicted position of the points of orthogonal (A m), *FL* the water depth in the points of orthogonal (m), *BE* the coefficient of wave front distribution between two adjacent orthogonal from deep water to refracted wave point of orthogonal, *WL* the shoaling coefficient at points of orthogonal, *VL* the relative height of refracted wave at points of orthogonal, *EL* the wave front celerity at points of orthogonal (m/s)

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Part II
Monitoring

Chapter 10
Multi-Compartment Water Quality Assessment of Port Burgas and Burgas Bay

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Abstract The study employs the biogeochemical budget methodology of multi-compartment LOICZ model to the complex system of Burgas port and Burgas bay. Main model input data are turbidity and concentrations of phosphorous, nitrogen, and chlorophyll-a. Two distinct seasonal periods are considered in the study—low precipitation (September–November) and high precipitation (December–April). Internal nutrient fluxes are estimated and their dependence on nutrient load is discussed. The results show that system varies between autotrophy and heterotrophy during the year due to rainfall regimes, human activities in the basin, and the associated runoff and phosphorus loads or releases from sediments.

10.1 Introduction

Port Burgas, situated in the Burgas bay, is an important hub of the transborder Pan-European transport corridor 8. The existing terminals of the port Burgas are in process of reconstruction and even the new ones are expected to be built. However, the potential adverse effects of the port operation embrace a range of environmental issues like air and water pollution, contamination of sediments, loss of bottom biota, coast erosion, waste discharges, oil spillage, leaking of hazardous materials, etc. (Karagyozov et al. 2004; Peris-Mora et al. 2005). The effective management of such

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systems among the others requires an improved scientific understanding of ecological responses to changes in nutrient inputs.

ECOPORT8 and TEN ECOPORT projects aim to better quality of Southeast European ports placing the prevention of pollution and preservation of natural resources in port areas and nearby coastal zones. Apart of the other measures, the mathematical modelling was identified as a reliable tool for recognition; the interplay of the main factors affecting seaport aquatic systems that could be used for better port ecological management.

A single-box application of LOICZ model (Gordon et al. 1996) for Burgas bay is presented in (Marinov et al. 2014). Although the main input sources and fluxes into/out of the port area were estimated, some open questions are still present. These include: To what extent the single-box model estimates the nutrient fluxes into/out the port area? What is the water quality into the different zones of the port Burgas? How nutrients and turbidity contribute to the overall ecosystem development?

To answer the above open questions a multi-compartment LOICZ model (LOICZ 2010) is developed in this study. The majority of input data, needed for model run, are provided by measurements performed in the aquatorium of the Burgas port and Burgas bay. A short model description and the details about the model set up, followed by a discussion of the obtained results, are presented in the next sections.

10.2 Study Area and Methods

Study area consists of "small" Burgas bay, including port Burgas, with a surface of 9.8×10^6 m^2 and mean depth 9 m. The water exchange with the coastal Lakes Mandra and Vaya (Fig. 10.1) is low and it is intensified in rainy conditions. The average annual precipitation is 590 mm while the evaporation is 675.9 mm. In terms of water balance, the small Burgas bay can be classified as weakly stratified positive estuary (Valle-Levinson 2010). Monitoring data are collected at four sampling stations close to the port terminals and one outside of the bay considered as a reference one in the model (Fig. 10.1; ECOPORT 8 project 2012; TEN ECOPORT project 2013). The monitoring involves surface water observations taken approximately three times per month, from the beginning of September 2011 till the end of April 2012.

Study area is divided into three compartments as shown in Fig. 10.1. The division allows computing the transport, net production rates, regional processes within the system (e.g., patterns of productivity and denitrification with regard to nutrient transports), and to isolate regions with high-abiotic activity. Such information could be used to assess how nutrient load reduction/amplification affects water quality, productivity, and net biogeochemical fluxes through particular areas.

Multi-compartment LOICZ model is applied assuming that the bay is well mixed vertically and at steady state. However, in the case study of the Burgas bay the salt budget cannot be accurately assessed as the salinity gradient is too small which could induce errors in the computed exchange rates (LOICZ 2010). Thus, instead of salinity budget our procedure involves suspended particulate matter (SPM).

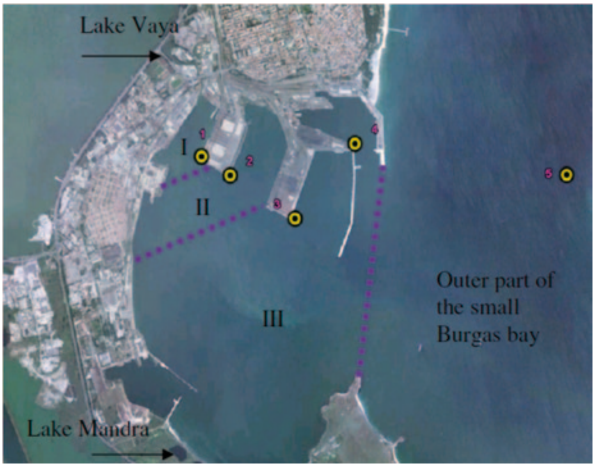

Fig. 10.1 Map of the study area, model compartments, adjacent coastal zone, and sampling points

The model calculations follow several steps: (1) budgets of conservative materials like water and SPM; (2) budgets of nonconservative materials such as dissolved inorganic carbon (*DIC*), nitrogen (*DIN*), and phosphorous (*DIP*); and (3) stoichiometric linkages. Two time periods are examined: with low (September 2011–November 2011) and with high (December 2011–April 2012) precipitation.

The water and SPM balances for the compartment $i+1$ in the multi-compartment scheme are described by the following relations:

$$Qr_{i+1} = Qr_i + Qf_{i+1} \tag{10.1}$$

$$0 = Qf_{i+1}Sf_{i+1} + Qr_{i+1}S_{i+1} - Qr_iS_i + E_{i,i+1}(S_i - S_{i+1}) + E_{i+1,i+2}(S_{i+2} - S_{i+1}) \tag{10.2}$$

where Qf_{i+1} is the freshwater input directly into the box, estimated as a difference between evaporation and freshwater inflows for each compartment; Sf_i is SPM in the freshwater input; S_i and S_{i+2} are the concentration of SPM in the landward and seaward boxes; $E_{i,i+1}$and $E_{i+1,i+2}$ are the diffusive exchanges with the landward box and with the seaward box, respectively. Equation 10.1 allows to calculate the residual flux Qr_i leaving each compartment, while Eq. 10.2 is used to find the flow across the compartment's boundary ($E_{i,i+1}$), used afterwards for the calculation of nonconservative compounds. In particular, the balances for the first box are:

$$Qr_1 = Qf_i \tag{10.3}$$

$$E_{0,1} = (Qf_1Sf_1 + Qr_1(S_1 + S_2)/2)/(S_2 - S_1) \tag{10.4}$$

The equations for nutrients are similar to those for SPM balance (Eqs. 10.2 and 10.4), where SPM is replaced with the water quality component (*DIN* or *DIP*) and also a net source/sink term (*ΔDIN* or *ΔDIP*) is added.

LOICZ model is designed to describe the role of ecosystem-level metabolism as a net source or sink of *P*, *N*, and especially *C*, so the interest is firstly to specify the difference between primary production and respiration. This difference is often called “net ecosystem metabolism” (NEM). Accepting the Redfield ratio as a representative, the model describes the organic metabolism as assimilation of forms of nitrogen (ammonium, nitrate, and nitrite) and phosphorous to support primary production (p). On the contrary, all nitrogen released during respiration (r) is immediately converted to ammonium, nitrate, and nitrite. The difference between these two biological process rates ($p-r$) is a measure of NEM. The nitrogen cycle is more complicated than the phosphorus and carbon cycles because of the side reactions of “denitrification” and “nitrogen fixation.” These side reactions also consume or produce the measured forms of nitrogen.

10.3 Discussion

Water and SPM budgets are counted first in order to estimate the water exchange between different compartments. Principally, the studied system displays a net positive water balance since the total freshwater input from rivers/lakes and rain exceeds water loss by evaporation during both periods. Additionally, model results show that the water exchange with the seaward parts of the bay is the dominant renewal process for the each compartment. The average period of time that a specified unit of water spends in a particular reservoir is called the residence time. The steady-state residence time, tr_i, is given by the ratio of water volume of the compartment, V_i, and daily volumetric rate of water input/output, $(|Qr_i| + E_{i,i+1})$ (Pritchard 1969).

Water residence times for the both periods are given in Table 10.1. For comparisons, calculations based on the single-box model (Marinov et al. 2014) are also presented. During high season, the residence time of seaward compartment, $tr_3 = 25\,\text{days}$, is very close to the single-box residence time. The third compartment, that is largest one, represents to a greater extent the water renewal of the entire bay. Note that the residence time depends inversely on $E_{i,i+1}$, which is calculated in the case of single box using salt budget, while in the present study it is estimated on the base of SPM budget. The water renewal process in the landward and middle

Table 10.1 Volume and residence time for the three compartments (I, II, and III) and for the whole study area based on single-box model. (Marinov et al. 2014)

	Period	Box I	Box II	Box III	Single-box model
Volume $V_i \times 10^6\ \text{m}^3$	N.A.	4.5	20.2	63.6	88.2
Residence time tr_i day	High	1	8	25	23
	Low	8	28	26	32

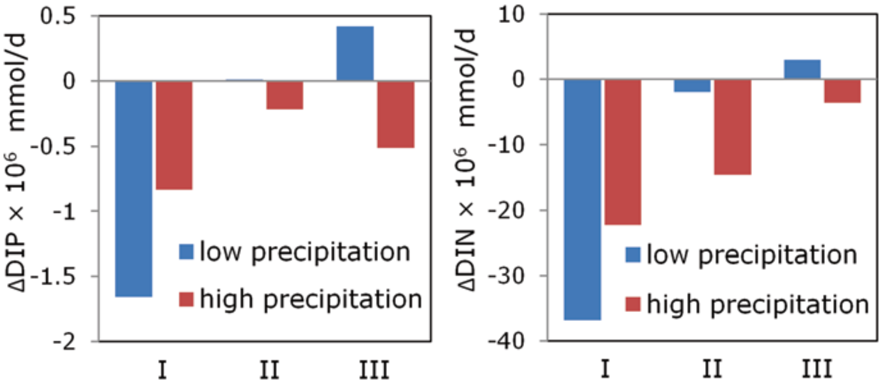

Fig. 10.2 Residuals of dissolved inorganic nitrogen (*ΔDIN*) and phosphorus (*ΔDIP*) in the three model compartments (I, II, and III) for both seasons in million mmol/d

compartments shows clear seasonal pattern. However, the seaward compartment is less susceptible to variation in precipitation than the other compartments.

The main input of nutrients in the study area is due to the industrial and domestic wastewaters. The treated wastewater enters the small Burgas bay through the discharges of Lake Vaya through a narrow connection. Another point source of nutrients is Lake Mandra connected with the seaward compartment (Fig. 10.1). Model input values of *DIN* and *DIP* in the runoff and precipitation are given in Marinov et al. (2014). The essential plant nutrients elements *C*, *N*, and *P* can be consumed and/or produced in the system, thus, in their budgets there will be residual elements (*ΔDIC*, *ΔDIN*, or *ΔDIP*) which are not balanced. The residual values are a measure of the net internal fluxes and should be interpreted as a function of the internal system dynamics.

The calculated *ΔDIN* and *ΔDIP* for the compartments during both seasons are presented in Fig. 10.2. Note that *ΔDIP* and *ΔDIN* are always negative in I and II meaning that there the ecosystem works as a sink of *DIP* and *DIN*. In contrast, III is a source in a low-precipitation season. In I the consumption of nutrients rises in low-precipitation season due to relatively long residence time, despite of lower runoff of nutrients. Obviously, the amount of nutrients is enough to keep high levels of primary production. The II experiences elevated *DIN* and *DIP* consumption in high-precipitation season even though water renewal period is 3.5 times shorter than in low-precipitation season. This compartment lacks a point source of nutrients and receives them from the landward or seaward compartment where the concentration of nutrients is lifted up during high-precipitation season. The seaward compartment is a producer/consumer of nutrients in low- or high-precipitation season. This result coincides with the findings of single-box model, although the residuals are greater in Marinov et al. (2014).

The model also involves the developing of stoichiometric linkages among non-conservative budgets. Assuming that plankton is likely to dominate the net metabolism with the Redfield *C*:*N*:*P* ratio 106:16:1, the LOICZ can evaluate NEM

Table 10.2 Stoichiometric calculations for II and III compartments and for the whole study area based on single-box model. (Marinov et al. 2014)

	Period	Box II	Box III	Single-box model
NEM (mmol/m^2d)	High	9.8	8.0	13.85
	Low	−0.36	−6.55	−4.03
Nfix.-Denitr. (mmol/m^2d)	High	−4.59	0.68	−0.55
	Low	−0.82	−0.56	32

and Nfix.-Denitr., which is estimated as a difference between calculated ΔDIN and expected $\Delta DIN = 16\Delta DIP$.

LOICZ approach could not be successfully applied for small turbid systems like the first compartment of our study area. Thus, results for NEM and Nfix.-Denitr. are reported here only for II and III in Table 10.2 where the results of the single-box model (Marinov et al. 2014) are also presented. The estimated values of NEM are positive during high-precipitation period, demonstrating a net production of organic matter and an autotrophic state. Obviously, NEM in II is higher than that of III because II receives nutrient-rich water from Lake Vaya that spent only a day on average in I. In both compartments, NEM is lower than NEM of single box. The last is expected since the first compartment has been excluded from the NEM calculations. During winter-spring the small bay receives a huge amount of *DIN* from the point sources leading to production amplification. It appears that NEM is controlled more by the balance between inputs of *DIN* and total organic nitrogen. The estimated value of NEM is negative during low-precipitation period, showing a net mineralization of organic matter and a heterotrophic state. Moreover, negative NEM is an indicator that the system is likely a source of carbon dioxide and *DIP* release to the water column, probably from bottom sediments. The seaward compartment exhibits stronger respiration than the middle one though production prevails in II during growth season. Further model development is needed so that NEM estimation requires an accurate determination not only of the contribution of DIP fluxes, but also of the oxygen flux.

According to Swaney et al. (2011) the difference between nitrogen fixation and denitrification should be generally close to zero (with a dominance of denitrification). High-negative values of Nfix.-Denitr. (−4.6 mmol/m^2d) are estimated for II due to high-negative values of ΔDIN. Large inputs of *DIN* from the lakes lead to ΔDIN exceptionally negative in comparison with expecting ΔDIN indicating that an important sink of *DIN* is missing or some flux estimations are incorrect. In view of the fact that high-precipitation season includes period of algal growth phase, a significant role may be played by algae as a nitrogen storage. On the contrary, nitrogen fixation prevails for III in the same period, indicative of *DIN* source in this area.

In summary, the multi-compartment model shows that the denitrification overwhelms nitrogen fixation in low-precipitation period, while the single-box model shows that fixation prevails. Fixation is a source of *DIN*, while denitrification represents a sink of *DIN* and takes place in the water column under low-oxygen conditions, resulting from high rates of organic degradation that depletes oxygen content. Thus, we can conclude that estimations based on the multi-compartment model better represent the system pointing out that in the low-precipitation period the water quality of port area is low.

10.4 Conclusions

Multi-compartment LOICZ model computation of nutrient transport provides interpretive framework to examine possible causes and mechanisms underlying water quality, thus being useful tool for management related research. The results point out that even complex water quality patterns in variable coastal port areas can be better understood when detailed data are available for analysis.

Multi-compartment LOICZ model results for the small Burgas bay, including the aquatorium of port Burgas, allow concluding that the water renewal in landward and middle compartments is subject to clear seasonal pattern. In winter-spring period 1 day is required to replace the port water of the landward compartment by the fluxes of fresh or marine water (8 days for the middle zone), while it takes 8 days in summer-autumn (28 for the middle). The seaward compartment is not strongly influenced by the season change.

Port Burgas area receives a rich supply of nutrients from land-based sources leading to decrease in water quality, particularly in periods with high temperature and low precipitation. In high-precipitation season there is a clear relationship between nutrient loading from terrestrial sources and nitrogen metabolism. Phosphorous metabolism does not show such a relation since indicative phosphorous release from bottom sediments or load from another indeterminate source. One could suggest that nutrient loads to the system associated with terrestrial sources are the likely reason for the declining tendency in the water quality of this area, although the possibility still remains that other unidentified and uncontrolled factors can govern the system dynamic.

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Chapter 11
Application of an Environmental Monitoring Strategy in the Port of Bari

Mario Mega, Annunziata Attolico and Elvira Armenio

Abstract Since 1974, the master plan of the port of Bari established the port expansion works. The planned works started in the 1990s but, unfortunately, shortly after the start, the yard was closed due to the failure of one contracting company. After many years, the completion of the abovementioned works has been resumed, adapted, and updated to the new laws and regulation. Thereby the important works foreseen in the port master plan will be finally completed and new docks and yards will be available for port functions. Due to the complexity of the planned works, it has been necessary to draw up an extensive monitoring plan on the environmental components. This chapter intends to describe the monitoring strategy planned to control accurately the state of the environmental components during the different work phases in order to avoid any possible environmental pollution. The main steps of the monitoring strategy are reported as the preliminary observations on *Posidonia oceanica.*

11.1 The Port Expansion Project

The main works of the port expansion project consist of the filling of Marisabella's area, the widening of Pizzoli Pier, and dredging activities (Fig. 11.1). The dredged materials will also be used in the main works planned.

Taking into account the manoeuvring space, the new filled-in area of Marisabella will allow to moor a vessel of 150 m in length, with a depth of 12.0 m mooring. The expansion of the Pizzoli Pier, with 12.0 m mooring depth, will allow the berthing of ships 300 m in length. The overall length of the new quays will be about 1000 m. Although the area is protected by breakwaters, no commercial function is carried out in that area. From the point of view of an overall efficiency of the basin, it is a negative condition.

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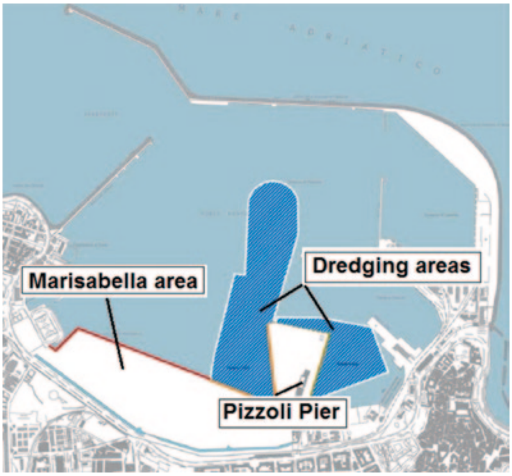

Fig. 11.1 Port of Bari: map of the main port expansion project works

The port expansion project has been planned to pursue a sustainable port development intended as the ability to characterize environmental performance through appropriate monitoring and mapping procedures (Wooldridge et al. 1999; Darbra et al. 2004; Corsini et al. 2007).

11.2 Main Objectives of the Monitoring Strategy on Aquatic, Sediment, and Biota Components

Due to the complexity of the project, an extensive environmental monitor strategy has been defined to assess the state of water, air, noise, and marine ecosystem in order to avoid any adverse effects to the environment and preparing also the eventually adoption of mitigation measures (Freimann and Walther 2001; Darbra et al. 2004; Trozzi and Vaccaro 2000). The strategy adopted is aimed to control the possible effects on aquatic, sediment, and biota components.

The main objective of the monitoring strategy on aquatic component is aimed to get information about the fluctuations of chemical, physical, microbiological and ecotoxicological parameters involved in the diffusion and dispersion process of suspended solids.

The monitoring strategy will help to evaluate the extent of potential effects of dredging activities and the progress of spatial and temporal sediment suspended in order to act promptly on working methodologies, applying ap-propriate mitigation measures, whenever unacceptable environmental effects are encountered.

The aim of the monitoring strategy to the sediment component is intended to verify the eventual occurrence of diffusion and dispersion processes of suspended solids in the investigated area. Accurate study of the fluctuations of the chemical, physical, microbiological, and ecotoxicological properties of the surface sediments has been planned for this purpose.

Benthic organisms and aquatic sensitive biocenosis are located in the inner and coastal areas outside the port of Bari. The purpose of the monitoring strategy on biota component is intended to control, in the long-term time, the possibility of occurrence of bioaccumulation phenomena in the marine organisms tissues (mussels native if present), consequently to the possible dispersion of suspended solid fraction due to dredging activities (ICRAM 2008).

11.3 The Monitoring Phases

Four different monitoring phases have been identified to control the state of the environments: ante-operam, work in progress, post-operam, and operational. The ante-operam phase includes the monitoring actions that have the end up before work beginning. The target of monitoring ante-operam is to verify the state exposed and the beginning situation for comparison with the following phases. The work in progress phase is the time between the beginning of the yard and the end of construction, in particular during dredging activities and backflow in tank. The post-operam phase occurs after the completion of the construction activities. It lasts 12 months. The operational phase is the time of use, during the normal operating activities of the port of Bari. It lasts 6 months (ICRAM 2008).

For each phase the monitoring plan provides for the verification, in the short as well as long period; the absence of environmental impacts on water, air, sediment, and biota (Corsini et al. 2007; Stavrakouli and Wooldridge 2004).

In addition, to achieve the objectives of the monitoring strategy, two different observation scales have been defined: an acquisition of short-term information, allowing for the timely intervention of environmental protection and an acquisition of information in the medium to long term, for the evaluation of the possible effects over time induced by the succession of different phases of the work involved.

The work activities have been planned also at system scale and event scale: the system scale includes specific activities, named to the scale of the entire system, designed to control the long-term alterations on the matrices of interest, to be carried out on a regular basis, both in the inland areas than in the surrounding areas and outside the port of Bari; the event scale consists of additional specific activities planned for short-term changes verification in the matrices of interest, to be carried out during the operations of removal, transport, and filling basin with dredged material and only in the inland areas at the port of Bari (ICRAM 2008).

11.4 Implementation of the Monitoring Strategy and Boundary Conditions Adopted

The environmental monitoring strategy planned for the port expansion works consists of the following main steps:

- Elaboration and updating of a correlation curve between the turbidity measured in real time by the multiparameter probe and the relative concentration of solids in suspension

- Real-time survey of the variation of the chemical–physical characteristics of the water column (in particular of turbidity) in the area around the dredging work
- Regular verification of the actual concentrations of solids in suspension associated with turbidity values measured
- Ecotoxicological control, on selected water samples collected and analyzed as described above, and the specific turbidity measured
- Regular monitoring of sediment spill from the port area and sediment resedimentation mobilized during the dredging activities
- Qualitative and quantitative analysis of the changes induced in the biotic component, due to any dispersions of fine sediment out of the port basin
- Spatial and temporal analysis of *Posidonia*, and
- Acoustic disturbance analysis to marine organisms due to dredging activities

The boundary conditions considered for the monitoring strategy include wind, waves and current data to characterize the hydrodynamic field of the area, civil and industrial drains inside the port area and surrounding areas, physical, chemical, microbiological, and ecotoxicological characteristics of water column, data related to maritime traffic (location of the berths, average drafts of ships, average ship's speeds in port incoming and outgoing, daily number of ships' entrance, etc.), and the presence of buried war devices.

11.5 The Ante-Operam Phase

The ante-operam phase is a preliminary investigation aimed to get a correct interpretation of the processes taking place during the port expansion works in order to acquire information on the natural variability of the area's characteristics and properly calibrate the monitoring activities provided for in the later stages. In particular, the preliminary investigation is intended to control, in all the components being monitored, the presence of contaminants and to identify the possible effects encountered during the port sediments handling activities caused by anthropogenic nature or industries factors (e.g., sediments resuspension due to port traffic, presence of civil drains, etc.). The analysis to perform and frequency to adopt for the campaigns of investigation of the ante-operam phase are listed in Table 11.1.

11.5.1 Monitoring Stations Used for the Ante-Operam Phase

In order to control the state of water, sediment, and marine ecosystem in the ante-operam phase, several monitoring stations have been used. In particular, fixed monitoring stations have been localized at the mouth of the port of Bari, inside the port area and off the coast of port. The stations have been equipped with acoustic current profiler and waves self-recording mode.

Mobile monitoring stations have been localized outside the port area. In addition, one station has been localized at the discharge point of Marisabella, and further monitoring stations have been placed inside the port and at the outflow point

Table 11.1 List of analysis to perform in ante-operam phase

Component	Analysis	Frequency
Water column	Chemical, physical, microbiological, and ecotoxicological analysis. Evaluation of phytoplankton component	n. 2 campaigns of investigation
Sediment	Chemical, physical, microbiological, and ecotoxicological analysis	n. 2 campaigns of investigation
Biota	Monitoring of Posidonia. Monitoring of macrozoobenthos. Tests of bioaccumulation of mussels	n. 1 survey campaign n. 2 investigation campaigns, properly spaced in relation to the start up of dredging activities

of the filling basin of Marisabella area. Moreover, mobile monitoring stations have been localized in correspondence of the areas to be dredged.

The monitoring of air and noise will be carried out by means of n. 2 mobile labs localized inside the port to monitor the air component and n. 5 monitoring station localized outside the port area to monitor the noise component. For air and noise components, the ante-operam phase requires an evaluation period of at least 30 days to be performed only one time.

11.6 Preliminary Observations on *Posidonia oceanica*

At present, the monitoring activities of the ante-operam phase are still ongoing and only the investigations on *Posidonia oceanica (L.) Delile* have been concluded allowing to acquire relevant information on the quality of *Posidonia* meadow.

The monitoring of the margins of *Posidonia* meadows was already delimited in 2007. The purpose of this investigation has been to gather additional and updated morpho-ecological data (shoot density and percentage cover) for a comparison between the current situation and the analysis performed in 2007. The ante-operam investigation on *Posidonia* represents a starting point that will also be useful for a comparison with monitoring activities planned for the subsequent phases of work.

The *Balisage* (Corsini et al. 2007; Trozzi and Vaccaro 2000) technique has been adopted to identify, in the medium and long term, any dynamics of the *Posidonia* prairies as a response to the same environmental stress of *Posidonia* prairies. The *Posidonia oceanica* meadows investigated are localized at southeast and northwest of the port of Bari. In both the areas, situations of disturbance have been occurred. In particular, the *Posidona* meadow located south of the port basin shows bioecological characteristics that seem to indicate a stable state of preservation. The *Posidonia* meadow located at the north of the port is extremely impacted and it shows an advanced state of regression. Such degradations are probably caused by the phenomena of anthropic disturbances in the northwest coastline of the port.

The urban waste found along the north coastline of Bari can determine a progressive deterioration of water quality, increasing the turbidity and significantly reducing the extension of an existing *Posidonia* meadow.

11.7 Conclusions

The expansion works in the port of Bari will allow to get new areas useful to reorganize the various port functions, to increase the efficiency of the freight management, to improve the safety of the work areas and especially the quality of services offered to ferries and cruises ship passengers. To pursue the goal of sustainable port development an extensive environmental monitoring strategy has been planned to ensure appropriate control of environmental components. Different monitoring phases have been identified to monitor, on a regular basis, the environmental components. Fixed and mobile stations will be used to investigate the environmental matrices both in inland areas than in the surrounding and outside areas of the port of Bari. The monitoring phases will be carried out with different temporal and spatial levels of detail.

The ante-operam investigations of *Posidonia* meadow have shown a regression state. In such a situation, the future monitoring of *Posidonia* meadows planned for the next phases is essential in order to check if and how the port expansion works can produce any further negative effects and contribute to the regression process already in place in the surveyed areas, and particularly in the north of the port. The environmental monitoring strategy established for the port of Bari is proving to be an accurate control of the environmental components during the port expansion works.

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Chapter 12
The Black Sea Security System—A New Early Warning and Environmental Monitoring System

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Abstract A new environmental monitoring and early warning system was realized in the western Black Sea through a Romanian–Bulgarian cooperation program. The system consists in five offshore observatories and a coastal gauge; each offshore observatory includes three modules—surface, mid-water and bottom. The system, unique in the Black Sea area, is able to collect long-term data for several key environmental parameters (e.g., dissolved oxygen, chlorophyll *a*, water pressure, etc.) and to launch an early warning for tsunami-like geohazards and/or extreme storm waves.

12.1 Introduction

The Black Sea, a semi-enclosed basin with a high regional seismicity, has a relatively high potential for tsunami-type hazards. Based on the tsunami-type events that occurred in the Black Sea during the last 120 years (1868–1997), the recurrence time for a tsunami was estimated at 20 years (Pelinovsky 1999). From the 22 major events known in the Black Sea, nine were produced in the twentieth century (Yalçiner et al. 2004). Considering only these events, the authors concluded that the actual recurrence period for the tsunamis in the Black Sea seems to be of only 11 years.

The last tsunami-like event occurred in 2007 on the Bulgarian coast and was attributed to a possible gravitational marine slide (Papadopoulos et al. 2011). Its intensity was estimated at 4–5 on the Papadopoulos–Imamura scale and no major

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damages were recorded but small fishing boats were thrown on the beaches of Kavarna and Balchik.

In these conditions, the tsunami-type hazard may represent an important threat for the western Black Sea coast (Oaie et al. 2006).

Scientists from different Black Sea countries discussed the necessity and possibility to implement a tsunami early warning system (Dotsenko and Eremeev 2008; Oaie et al. 2006).

On the other hand, starting from 1973, the Black Sea was for two decades in a critical ecological situation and from the early 1990 is in a slow recovery process (Mee et al. 2005).

The recovery is slow, with many ups and downs, and subject to many uncertainties, mostly due to the lack of long term, systematic data.

Both conditions require a long term, systematic monitoring.

This chapter presents the newly established Black Sea Security System (BSSS), the result of the MARINEGEOHAZARD project, a cross-border Romanian–Bulgarian cooperation, conceived as a solution for long-term environmental monitoring and for prevention/mitigation of the marine geohazards (e.g., earthquakes, active faults, and submarine landslide) effects, with risk for the Black Sea coastal area.

12.2 The Black Sea Security System

The BSSS consists in five offshore moored observatories (Fig. 12.1), three in Romanian waters (EUXRo01, EUXRo02, and EUXRo03) and two in Bulgarian waters (EUXBg04 and EUXBg05), supplemented by a coastal measuring station (CG) located in Mangalia area (Romania) at 15 m water depth, close to the Romanian–Bulgarian border (Fig. 12.1, Table 12.1).

Each of the offshore observatories consists in three main units (Fig. 12.2):

- Surface relay buoy (SRB)
- Instrumented mooring line (IML), and
- Underwater tsunami module (UTM)

The coastal gauge is limited to the SRB.

The SRBs of the observatories EUXRo01, EUXRo03, CG, and EUXBg05 are equipped with a weather station which continuously measuring the following parameters: wind speed and direction, temperature, pressure, and relative humidity (Table 12.2). The instrument also integrates a heading sensor, which allows the automatic correction of the wind direction for the buoy rotation.

The SRB of each observatory is also equipped with an environmental monitoring instrument pack, mounted on the buoy pole at 5 m water depth. The instrument pack includes a Doppler current meter, classic CTD sensors (conductivity, temperature, and pressure/depth) and sensors for measuring dissolved oxygen concentration, turbidity and chlorophyll *a* concentration (Table 12.2).

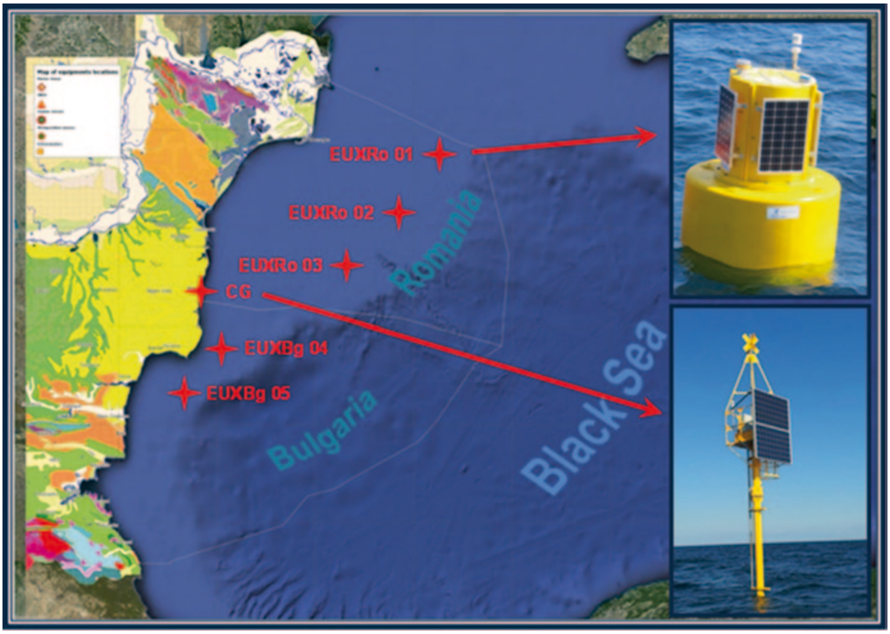

Fig. 12.1 Locations of the BSSS's observatories

Table 12.1 Coordinates and water depths of the BSSS's moored observatories

Station	Latitude	Longitude	Water depth (m)
EUXRo01	44°42.357′ N	30°46.700′ E	79.3
EUXRo02	44°19.070′ N	30°24.812′ E	90.3
EUXRo03	43°58.748′ N	29°56.186′ E	72.1
Coastal gauge (CG)	43°48.131′N	28°36.149′ E	15
EUXBg04	43°25.510′ N	28°46.980′ E	76
EUXBg05	43°08.000′ N	28°27.180′ E	77

Auxiliary equipments of the SRBs include a communication box with GPS receiver, radio link allowing full control of the buoy from a nearby ship, iridium bilateral link with antenna for satellite data transmission to the terrestrial data centres from Romania (Constanta) and Bulgaria (Varna) and reprogramming of the sensors, active and passive radar reflectors, IALA signalling light and four solar panel for recharging the batteries.

A second instrument pack is mounted on the mooring line of each observatory, at 20 m above the bottom of the sea. This pack consists in a Doppler current meter and classic CTD sensors (Table 12.2).

The tsunamis underwater module, located on the sea bottom, is equipped with a high-resolution pressure sensor and temperature sensor, mounted in titanium housing with pressure port at sea.

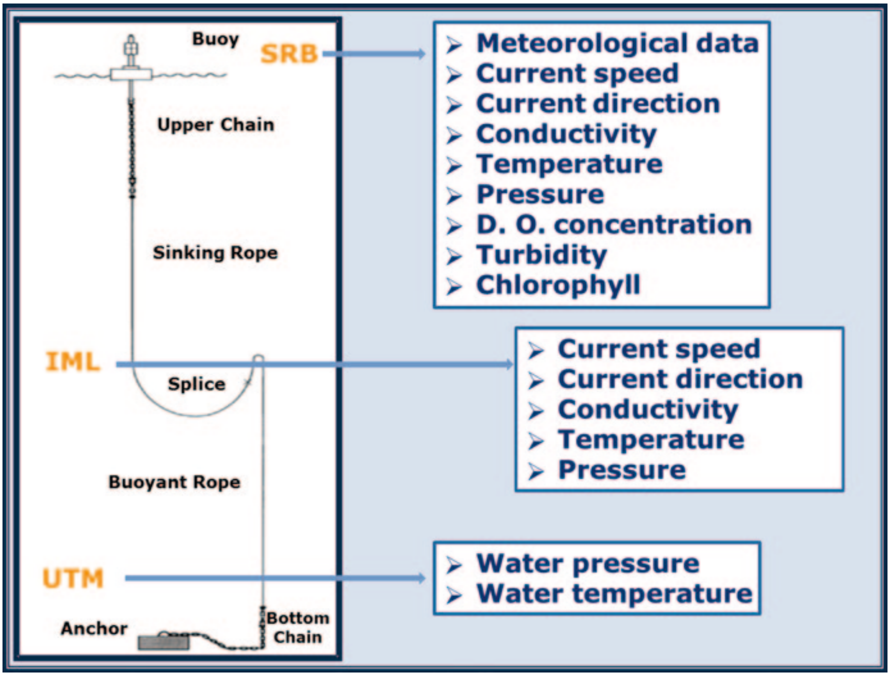

Fig. 12.2 Design of the offshore observatories

Each underwater instrument pack has an acoustic communication system for transmitting the data to the SRB. From SRB, the data are retransmitted via satellite iridium bilateral link to the two interlinked data centres.

The SRB and IML instrument packages are switched on every hour and data are acquired, stored in the mass memory and transmitted to the coordination centres, together with the weather data averaged for 1 h.

The UTM has two operative data acquisition and transmission modes—the *Normal* mode and the *Alert* mode.

In normal mode, the instrument acquires, logs, and processes every 15 s the pressure data to detect events over the normal tide signal. The acquired data, averaged for 15 min, are transmitted to the coordination centres every hour.

In *Alarm* mode, the system operates similarly but transmits for 3-h-alarm messages composed of 5 min raw pressure samples spaced at 15 s interval. The *Alarm* mode is switched on at a user programmed pressure threshold, set for now to correspond to a 50 cm height tsunami wave.

The BSSS work conjointly with a complementary coastal network of seismic monitoring (CNSM), realized in the framework of the same project and the tsunami analysis tool (TAT), a specialized software developed by the Joint Research Centre (JRC) in Ispra, Italy (Annunziato 2007; Annunziato et al. 2009).

The CNSM includes water level, radar tide gauge and pressure sensors, seismometers and accelerometers and a communication system.

Table 12.2 Characteristics of the observatories sensors

Sensor type	Manufacturer	Parameter	Range	Accuracy	Observatory/ Module
All-in-one weather sensor	Climatronics	Wind speed (w.s.)	0–50 m/s	± 0.5 m/s	EuxRo01/SRB
		Wind direction	0–360°	± 5°@w.s. + 2.2 m/s	EuxRo03/SRB
		Temperature	-40 to + 50 °C	± 0.2 °C	EuxBg05/SRB
		Relative humidity	0–100 %	± 3 %	CG
		Pressure	600–1100 hPa	± 0.35 hPa@25 °C	
		Compass	–	± 2°	
Z pulse Doppler current sensor	Aanderaa	Current speed	0–300 cm/s	± 0.15 cm/s	All/SRB@IML
		Current direction	0–360°magnetic	± 5° for 0–15°tilt	
		Tilt	0–45°	± 1.5°	
AADI optode 4835	Aanderaa	Oxygen concentration	0–500 µM	< 8 µM	All/SRB
		Air saturation	0–150 %	< 5 %	
AADI 4880/4880R	Aanderaa	Temperature	− 4–36 °C	± 0.03 °C	All/SRB@IML
AADI 4319B	Aanderaa	Conductivity	0–75 mS/cm	± 0.0018 S/m	All/SRB@IML
		Temperature	− 5–40 °C	± 0.1 °C	
AADI 4112B	Aanderaa	Turbidity	0–500 FTU	200 mV/FTU[a]	All/SRB
AADI 4646C	Aanderaa	Pressure	0–3100 kPa,≈300 m	± 0.04 % FSO[b]	All/SRB@IML
		Temperature	0–36°C	± 0.2 °C	
CYCLOPS–7	Turner design	Chlorophyll *in vivo*	0–500 µg/l	MDL = 0.025 µg/l	All/SRB
Digiquartz absolute pressure transducers series 4000, model 46 K-101	Paroscientific	Internal temperature Water pressure	-4–35°C 0–414.4 MPa	0.07 °C 0.01 %	UTM

[a] Sensitivity
[b] *FSO* full scale output

When an underwater earthquake occurs in the Black Sea, the initial data of the earthquake (coordinates and magnitude), supplied either by the international observation systems or by the CNSM, are fed into the TAT, which analyses the data and calculates the probability of a tsunami event. If a tsunami event is possible, the software elaborates, using a precalculated scenarios database, a model of the tsunami propagation, with arrival time and tsunami height in the entire propagation area.

If the propagation model predicts a tsunami threat for the Romanian–Bulgarian coast of the Black Sea, a preliminary tsunami warning may be issued.

The final confirmation of a tsunami event is obtained by comparing the water pressure data received from the UTM and automatically fed into TAT with the data obtained in the simulation. If the event is confirmed, a warning is transmitted to the local Inspectorates for Emergency Situations, the data centres are linked to. The warning can be issued with a maximum of 15 min before the impact of the tsunamis waves on the shore.

At the same time the collected environmental data, allow to monitor at least some quality parameters of the marine water and, over long-time periods, constitute a valuable fund, extremely valuable for modelling marine environmental processes.

The system was completed and became operational in June 2013. Future plans foresee the inclusion of the system in the IOC NEAMTWS. For now, the data are internationally shared on the basis of bilateral agreements, such an agreement being already signed with the JRC, Ispra, Italy.

12.3 Conclusions

The BSSS represents the first major initiative addressing in an integrated and co-ordinated manner the establishment of a geohazard early-warning system for the Black Sea. The BSSS is functional from June 2013 and has proved itself as a valuable tool for early warning for marine geohazards, extreme meteo events, and collecting long-term environmental data, useful for continuously monitoring the marine water quality in near real time while the time growing database will provide much needed long-term data.

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Chapter 13
Environmental Assessment in Durrës Port Based on Pollution Indicators

Tania Floqi, Jorgaq Kaçani, Ilo Bodi, Rajmonda Gjata and Redi Kodra

Abstract Durrës Port is the largest port in Albania, where different activities are carried out. This chapter presents the evaluation of pollution indicators such as water, air and noise level. Environmental assessment performed in Durrës Port according to ISO 14001 and Environmental Management System, EMAS 2010. The parameters measured to assess water quality are: temperature, salinity, conductivity, N-NO_2, P-PO_4, Fe and Ni and microbiological parameters. The air quality measured parameters are: total solid particle (TSP), particle matters (PM10), SO_2, NO_2, CO, total hydrocarbons (THC) and the noise level. The results obtained and the evaluation of indicators are used as a database of an innovative methodology, like eco-mapping.

13.1 Introduction

Durrës is the oldest city and port of Albania. While part of the Roman Empire approximately in 146 BC, the Romans built the Road Egnatia, which passed across the Dyrracium, as a connection between Rome and Bizant. The Durrës port, located in the south of the Adriatic Sea and in the north of Durrës bay, is the main gate connecting Albania with Europe. The port ensures a safe mooring of the ships, covering 90 % of the marine commercial international activities of the country, trading, passenger traffic, shipyard and fishing fleets, as well as 85 % of the national import–export activities, mainly mineral export, Cr, cement, scrap, other cargo, bulk food, etc. The cargo handling of chemicals, hazardous materials, dry and liquid bulk, fertilizers, grain, coal, etc. impact the port environment and the nearby coastal area. Durrës port activities have been growing every year due to infrastructure improvement and investment.

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Potentially all activities carried out in the Durrës port area are subject to an environmental assessment and to be considered in the building of the corresponding environmental indicators.

13.2 Materials and Methods

The methodology used to assess the quality of water, air and land territory is according to European and international standard methods. Environmental assessment was performed according to international standard ISO 14001 and the environmental management system EMAS 2010.

The study area includes the port environment, the water of aquatorium, air and the inland port territory. The parameters measured to assess the quality of the water are: temperature, salinity, conductivity, $N–NO_2−$, $P–PO_4−$, Fe and Ni and microbiological parameters (APHA 1998; AFNOR 1994). Considering the above-mentioned activities and situation in the Durrës port, the heavy metals in the sediments of water basin are measured too (Chapman and Anderson 2005; Hoellert et al. 2002).

At first we had to identify the best locations for the station sampling location and so we took into consideration the activity typology of the portal zone, ship traffic, the intensity and the frequency of activities impacts and the interference impact of

Fig. 13.1 Water sampling stations

the nearby activities. The same consideration is taken into account for the sampling in air. The parameters measured to assess the quality of air are: total solid particle (TSP), particle matters (PM10) SO_2, NO_2, CO, total hydrocarbons (THC) (Decision of Council of Ministers No. 435, 2002; Law No. 8897 2002; EEA n.d.; Lewis 1998). In order to define the location of the noise monitoring sampling stations, we took into account the distance from the populated areas, the activity during days and nights and the level and typology of noise pollution (Magrini 2005; Papa 2007).

Figures 13.1 and 13.2 present the sampling stations. Noise stations are located in the same place as air sampling stations.

Eco-map is a simplifying methodology to be used by all the stakeholders and interested parts, in which are shown the environmental critical points in water, air and land, indicated by the legend explaining the source and the type of pollution. For each environmental issue one eco-map (in total 10 eco-maps) was performed. The Durrës Port eco-map is concluded with the completion of a form which contains information about the possible action to be set for solving or managing the emerged issues (Heinz-Werner 2002).

Fig. 13.2 Air and noise sampling stations

13.3 Results and Discussion

The above-mentioned parameters were monitored during the TEN ECOPORT project period (2010–2012). The values of pollution indicators were measured and elaborated; the results are shown in the tables and charts. The results were used to perform the eco-maps for every environmental issue. The parameters measured to assess the quality of the water are the ones mentioned in the above section.

In this chapter, the values of pH, temperature, salinity and conductivity are not shown, because they are within the limit values of the European standard. In the Durrës Port aquatorium, which covers a surface of about 0.67 km^2, until a couple of years ago, waste water from 137 channels of inland territory used to be discharged. Recently, inland area septic tanks have been established, and a private company regularly collects the waste water that is treated in a waste water treatment plant near Kavaja, 15 km away. In the quay of passengers, One year ago, during ferry terminal reconstruction, it was established a biological waste water treatment plant with a capacity of 350 i.e (inhabitant equivalent).

All these interventions have improved the water quality. The values of content of the chemical parameters in the water of port aquatorium are within the EU Standard of Third A3 Category of surface water, only nutrients exceed the EU Standard values in two points, as shown in Table 13.1 and Fig. 13.3. Taking into account also that microbiological parameters exceed the standard values many times (see Table 13.2 and Fig. 13.4), more pollution parameters, such as BOD, COD, etc., should be monitored (Magrini 2005).

Table 13.1 Chemical parameters in port aquatorium

Point of sampling					
Parameters monitored (mg/l)	Point 1	Point 2	Point 3	Point 4	EU standard
	Quay 4	Quay 11	Quay of entrance	Quay 9	
$N–NO_2$	0.15	0.012	0.01	0.206	<0.05
$P–PO_4$	0.32	0.05	0.05	0.35	0.3
Fe	0.05	0.05	0.05	0.03	2
Ni	0.08	0.09	–	–	–

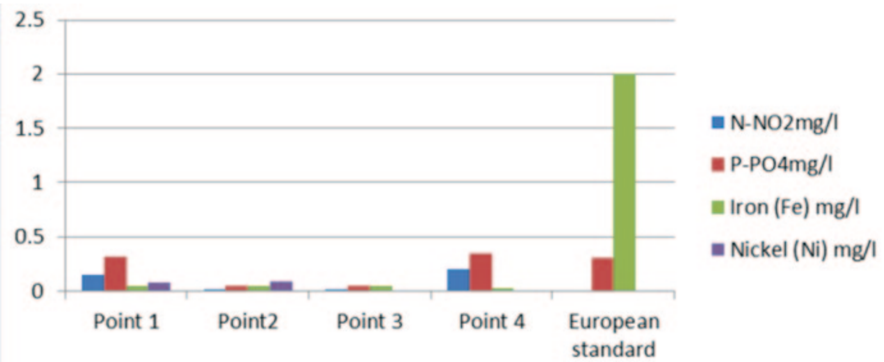

Fig. 13.3 Chemical parameters in Port aquatorium

Table 13.2 Microbiological parameters values, expressed in MPN

No	Microbiological index	Values	EU standard/A3 category
1	Coliforms total	120,000	100,000
2	Coliforms faecal	100,000	40,000
3	Streptococ faecal	80,000	NA

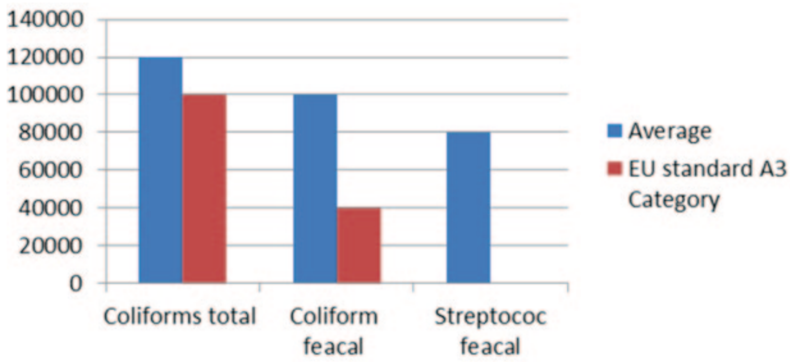

Fig. 13.4 Microbiological parameters

Table 13.3 Subsurface sediment sampling result

Parameter (mg/kg)	Sample 1 (0–1 m)	Sample 2 (1–2.2 m)	Sample 3 (0–1 m)	Sample 3 (0–1.2 m)	Sample 4 (0–1.2 m)	Sample 5 (0–1.2 m)
Hg	0.173	0.102	0.178	0.176	0.202	0.242
Pb	68.6	28.4	65.4	69.9	25.7	35
Cu	29.42	26.94	46.27	38.91	27.79	25.91
Zn	93.2	84.84	130.18	107	75.39	72.84
Cd	0.273	0.207	0.314	0.327	0.288	0.293
Cr	246	269.3	304	302.3	246.3	203.2
Ni	235	238	294.6	303	273	220.3
Mn	744.7	672.6	717.4	796.2	764.5	750.6
As	22.4	26	24.7	24.6	26.5	17.6
Fe	30.2	29.89	35.08	37.19	35.35	31.16
P	0.53	0.47	0.93	0.81	0.7	0.56

Based on the analyses displayed on the Table 13.3, it can be concluded that there is a distinction between the samples collected near the sediment surface (0–1 and 0–1.2 m) and samples collected at the depth (1–2.2 m). The basin is relatively polluted from activities affecting the seabed; nevertheless the pollution is still in lower, compared to other Mediterranean ports and harbours.

Regarding air pollution assessment, in Table 13.4 and Fig. 13.5 the average values of the parameters measured are presented. TSPs exceed the limit values of European

Table 13.4 Average values of air pollution parameters

Air parameter	TSP (mg/l)	PM 10 (μg/m³)	NO_2 (μg/m³)	SO_2 (μg/m³)	CO (mg/m³)	THC (mg/m³)
Average value 120	120	45	54	35	2700	1300
EU standard	–	50	40	20	5000	250
Albanian standard	80	70	60	60	6000	300

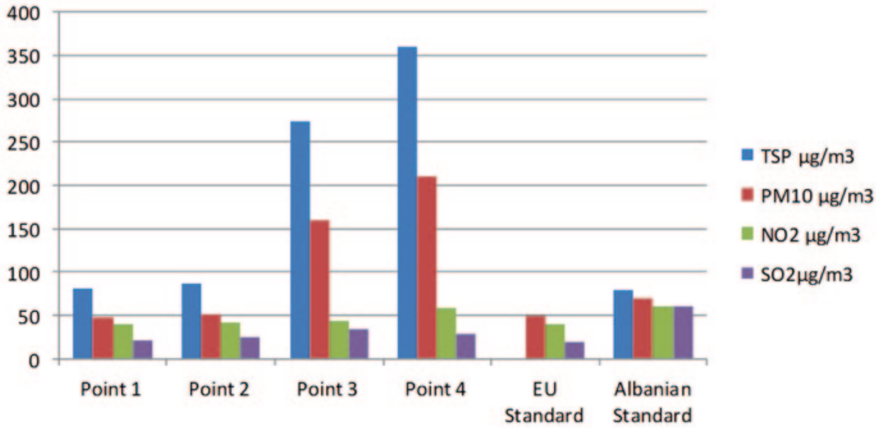

Fig. 13.5 Average values of air pollution parameters

Table 13.5 CO and total hydrocarbons (THC) values

Point of monitoring	CO (μg/m³)	THC (μg/m³)
Point 1	2500	130
Point 2	2700	145
Point 3	4400	370
Point 4	3500	530
EU standard	5000	250
Albanian standard	6000	300

and domestic standards; additionally, nitrogen dioxide exceeds the EU standard. PM10, SO_2, NO_2, values are presented in Tables 13.3, 13.4 and 13.5 (Heinz-Werner 2002).

Noise level, with its potential impact on population and fauna, measured higher than 65 dB, which is the Albanian standard for urban spaces, in all station.

To perform the eco-maps of the Durrës Port have been used: the monitoring data; inventory of practices and problems; on-site environmental review; collection of information on the current situation using photos.

13.4 Conclusions

Regarding water quality, the high values of microbiological parameters measured exceed the European Standard on surface water, A3 category.

The values of some chemical-measured parameters are within the EU Standard; some exceed the limit values, and the other sensible parameters on water quality are not monitored yet.

The reasons of aquatorium water pollution are untreated first flush water (which contains bulk materials), fishing fleet and shipyard located within the port aquatorium and accidental releases during loading/unloading operations.

In port critical points (stevedoring of dry bulk goods into/from ships) high air concentration of TSP and some gases (SO_2, NO_2) are encountered (Figs. 13.5 and 13.6). In some occasions has been noted smog formation, especially during the days of low pressure and high relative humidity.

The reasons of air pollution are improper hermetization (closure) of emission points in the quays; operation of other bulk materials handling such as mineral scrap, cement, coal, grain, etc and maintenance of port territory roads; motor vehicles, etc.

During the daytime, the noise average levels are much higher than the limit value for urban spaces. Considering the distance from the source of the noise to the nearest urban buildings, one has to admit that the sea port activities are also influencing the noise perception in nearby buildings.

Creation of local networks by Durrës Port involving all local stakeholders guarantees the realistic information and provides timely solutions. Mapping the critical issues of Durrës Port ensures achievability of concrete results for a common action plan aimed at creating feasible processes to protect the port area and surrounding ecosystem.

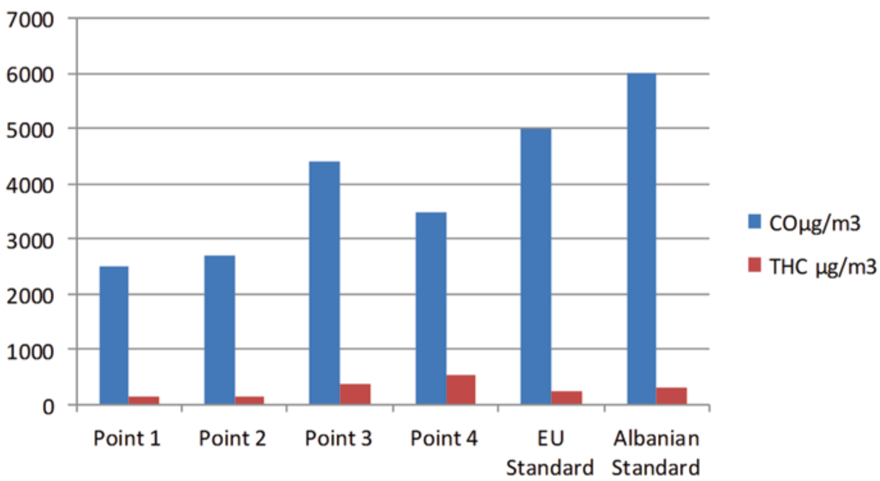

Fig. 13.6 CO and total hydrocarbons (THC) values

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Chapter 14
Coastal Marine Environment Monitoring Using Satellite Data Derived from MODIS Instrument

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Abstract The quality of marine environment has a vital importance for the sustainable future of the Earth. On the other hand, the human activities, the sea commerce and transportation, affect significantly the marine environment especially in coastal areas, port areas, and the sea corridors. These induced activities impose contiguous and accurate methods for marine environment monitoring. Nowadays, modern satellite instruments gather data and the relative products derived from them can be used as an alternative, robust, and accurate way to monitor many basic marine parameters such as chlorophyll, sea surface temperature (SST), euphotic depth, dissolved organic matter and examine their long-term (climatic) tendencies. This study comprises an effort to assess the accuracy of satellite products, comparing them with relative ground-based measurements and it also focuses on provision of satellite-based mean variations on monthly basis regarding two important marine parameters (Chlorophyll-a and SST). In this study, available measurements of two different ports are used, i.e., the port of Bar in Montenegro and the port of Burgas in Bulgaria, which are partners of Transnational ENhancement of ECOPORT8 network (TEN ECOPORT) project.

14.1 Introduction

The quality of marine environment affects importantly the quality of natural life in many direct and indirect ways. It is essential and for this reason many physical parameters and indices are used to monitor changes and tendencies in different spatial and time scales. Additionally, estuaries and coastal waters (especially when they are

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located nearby cities and/or port areas) can be considered as the most highly vulnerable marine areas (Urquhart et al. 2013).

Nowadays, the satellite remote sensing of the marine environment provides unique information and large datasets of a wide variety of parameters in many different spatiotemporal scales even in areas (such as sea areas), where in-situ measurements are sparse and difficult or almost impossible to perform. But, it is possible to monitor many sea areas and calculate variations of their basic physical parameters using satellite produced datasets. In this study, we examine sea surface temperature (SST) and Chlorophyll-a concentration using such data.

More specifically, the SST is considered as an important factor that affects the physical, chemical, and biological characteristics of the sea. The SST is highly dependent on the solar energy, the dynamics of the sea water, the precipitation, and the season.

The other parameter, Chlorophyll-a, is the main indicator of eutrophication and high concentration, which indicates increasing organic production. Chlorophyll is the green pigment located in chloroplasts and thylakoids and it has an important role in the process of the photosynthesis.

There are two basic scopes of this study. Firstly, we assess the accuracy of selected satellite derived products about SST and Chlorophyll-a comparing them with available relative datasets from the ground-based stations of the ports of Bar and Burgas. A second basic scope is to calculate mean monthly variations of the examined marine parameters using satellite-based datasets for a period between the years 2000 and 2012 for both SST and Chlorophyll-a because it is well known that the long-term interannual variability of basic physical parameters is of crucial importance in climatic studies (e.g., Mesias et al. 2007; Rivas 2010).

14.2 Data and Methodology

14.2.1 Ground-based Measurements

Quality checked datasets of SST and Chlorophyll-a on a monthly basis are available thanks to the Institute of Marine Biology, University of Montenegro (BIOKOTOR) and Port Authority of Burgas, partners of TEN ECOPORT project.

More specifically, BIOKOTOR in collaboration with the Port Authority of Bar (Montenegro) provided monthly data from May 2011 to February 2012. These data were selected from two different stations, one inside the marine of the port of Bar and the other one mile outside the port; every month and their mean value is considered representative on monthly basis for each one of the examined parameters. The second dataset of ground-based measurements at the area of Port Authority of Burgas is coming from three different stations (their mean monthly values) for the period between February and December of 2012.

14.2.2 Satellite Data

For the needs of the study we collected and used satellite products about SST and Chlorophyll-a. The original satellite datasets came from NASA's MODerate resolution Imaging Spectroradiometer (MODIS) instrument on board of Terra and Aqua satellite platforms and they are widely used in a great variety of studies (e.g., Shang et al. 2011; Urquhart et al. 2013; Li et al. 2013; Brewin et al. 2013). We preprocessed the initial data so that to be on monthly basis in the spatial analysis of 9 km at 11 μm (day and night) in degrees of Celsius (°C) for SST and for Chlorophyll-a estimations (in mg/m^3) at 4 km spatial resolution.

14.2.3 Accuracy Assessment of Satellite Data Using Ground-based Measurements

To compare the two different types of data, the first important procedure is to identify the accurate spatial and temporal correlation between the two main types of data (satellite and ground based) so that to conclude about the accuracy of the satellite datasets. Both types of data are spatiotemporally correlated and the results of these correlations are provided in Fig. 14.1.

It is mentioned that the available measurements are coming from two ground-based stations in the port of Bar where both stations are inside the pixel dimensions of satellite data (9 km for SST estimations and 4 km for Chlorophyll-a). For this reason, the pixel values of the satellite data are correlated with the mean values of the relative ground-based measurements. In the case of the port of Burgas, the data come from three ground-based stations with valid measurements and their mean values are correlated with the relative satellite ones. The validation period for the port of Burgas is from February to December 2012 and for the port of Bar is from May 2011 to February 2012. It is mentioned that both the monthly values of SST and Chlorophyll-a satellite are satisfactorily correlated with the ground-based ones (Fig. 14.1). The correlation is higher in the case of SST monthly values than in chlorophyll concentration. It is concluded that the range of values for SST has the same order of magnitude in both the port areas but for the Chlorophyll-a concentration there is almost one order of magnitude higher in the port of Burgas relatively to the port of Bar. Table 14.1 presents that the correlation coefficient (R^2) for the SST is higher for Burgas compared to the relative value at the port of Bar but both of them can be characterized satisfactory enough. The mean absolute error (MAE) is calculated at about 1.8 °C in both the port areas. The root-mean-square error (RMSE) is also below 1 °C (about 0.5 °C) amplifying the conclusion about the satisfactory correlation among satellite and ground-based monthly SST values.

Regarding Chlorophyll-a, the correlation coefficients (R^2) are lower than the case of SST. For Burgas port, the correlation coefficient is significantly higher

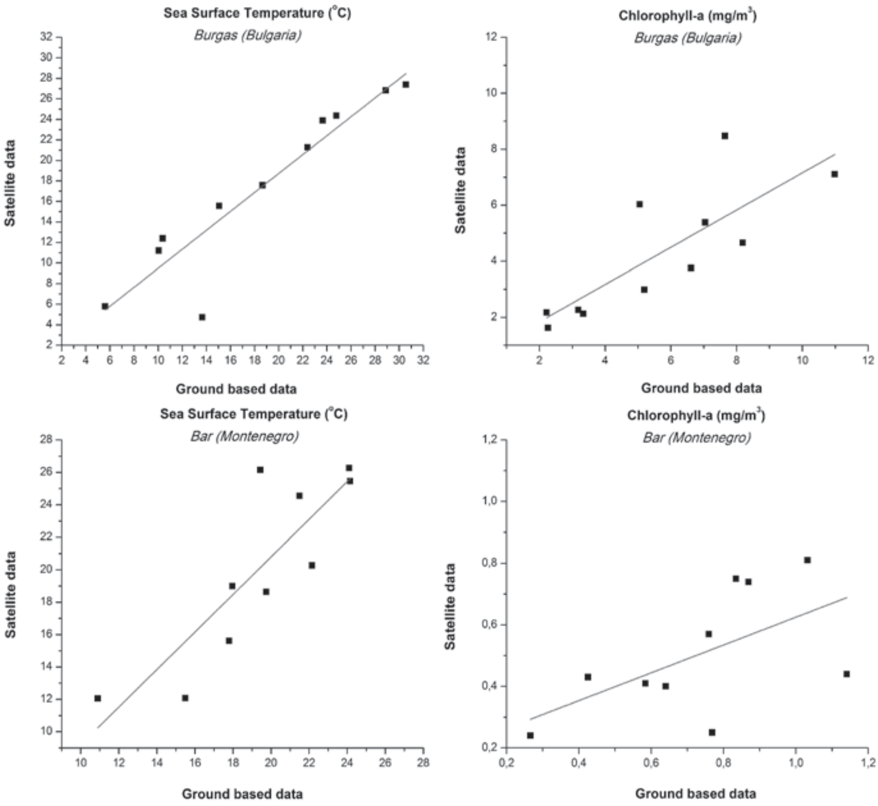

Fig. 14.1 Comparisons between satellite estimations and ground-based measurements in two port areas (the port of Burgas, Bulgaria, and the port of Bar, Montenegro)

Table 14.1 Basic statistics regarding the correlation between monthly satellite values and ground-based measurements for SST and Chlorophyll-a in both the examined ports

Location	Parameter	Adjusted R^2	MAE	ME	RMSE
Burgas (Bulgaria)	Chlorophyll-a	0.61	7.42	6.19	2.24
	SST	0.86	1.89	1.59	0.57
Bar (Montenegro)	Chlorophyll-a	0.26	0.71	0.71	0.22
	SST	0.69	1.85	0.28	0.59

than the port of Bar (Table 14.1). It is also noted that the MAE is slightly below 2 mg/m^3 in both the ports but the RMSE is higher for the port of Burgas, which means larger monthly deviations of ground-based monthly values in comparison with the relative satellite based.

14.3 Mean Monthly Variations

Considering the satisfactory accuracy of satellite data for SST and Chlorophyll-a, there are used monthly time series (from 2000 to 2012) to produce the mean monthly variations. Figure 14.2 concludes that the SST follows strictly the well-known-monthly changes of the incident solar radiation.

The same order of magnitude variations at the port of Burgas was also found in the study of Ginzburg et al. 2004, who used AVHRR satellite data to reveal interannual variations of SST for the whole Black Sea. It can also be noticed (Fig. 14.2) that there is a significantly smaller minimum for the SST in the case of Burgas port in comparison to the port area of Bar and the minimum temperature for the both ports is reached at the same month (February). There are higher mean monthly variations in the case of the port of Burgas than the relative variations in the port of Bar (Fig. 14.2). Regarding Chlorophyll-a, it is noted that there is a small decrease in mean concentration levels of Chlorophyll-a during summer and the first month of

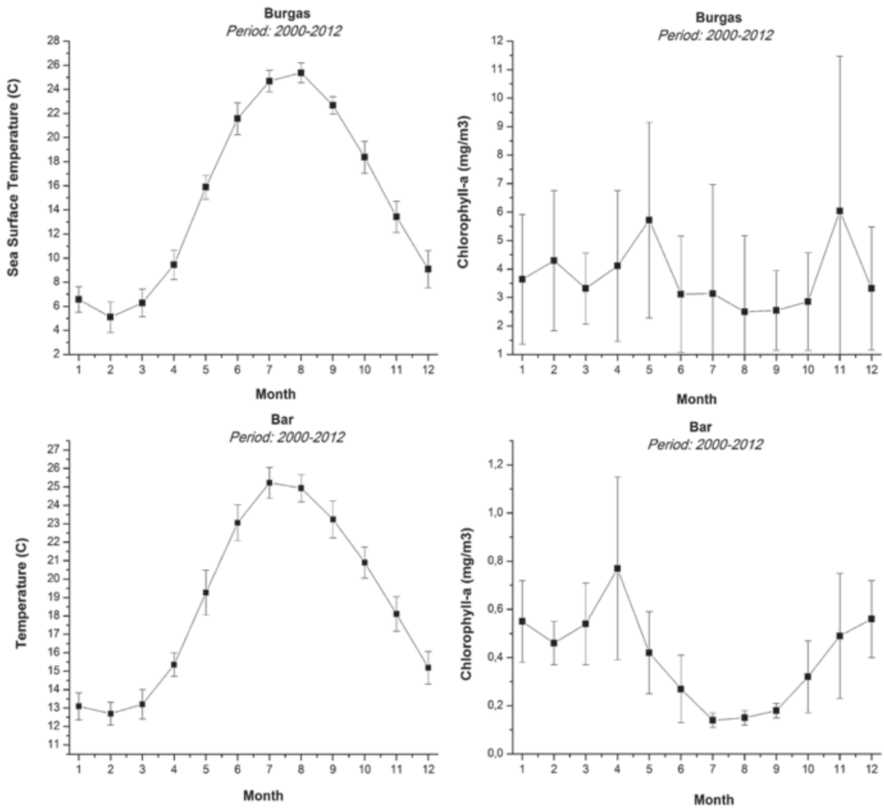

Fig. 14.2 Mean monthly variations for the period from 2000 to 2012 for the SST and Chlorophyll-a in the port areas of Bar (Montenegro) and Burgas (Bulgaria) using MODIS satellite datasets

autumn. It is also seen (Fig. 14.2) that the mean monthly Chlorophyll-a values are one order of magnitude higher for the port of Burgas relatively to the port of Bar.

It is important to mention the almost opposite monthly behavior of the two examined parameters. More specifically, in summer, the SST has the higher values annually but the concentration levels of the Chlorophyll-a are lower annually in the same season. Similar results have been found for other regions (e.g., Van De Poll et al. 2013) but it is mentioned that the type of the relationship between these two parameters is not always the same and affected importantly by local features of an area (Katara et al. 2008). The correlation coefficient (R^2) of these two parameters is 0.286 for Burgas and 0.76 for Bar, depicting a notable negative correlation although the small number of samples.

The statistical significance of the monthly differences (in the median values) for the two examined parameters is also tested. The analysis of variance (ANOVA) (Kruskal–Wallis test) hypothesis tests is implemented and the p-values (confidence interval: 99 %) and the results are provided in Table 14.2.

It is concluded that all the median monthly values in both of the examined parameters and ports are statistically different at a confidence level of 99 %. This conclusion indicates that there are important monthly variations of the examined parameters that can be owe to the changes of physical conditions (e.g., solar radiation) but also to the port traffic or sediments.

14.4 Conclusions

Firstly, this study is an effort to evaluate the accuracy of satellite-based products regarding two basic marine parameters (the SST and the Chlorophyll-a) using ground-based measurements for two case study areas (the port of Bar in Montenegro and the port of Burgas in Bulgaria). At a second stage, this study aims to provide the mean monthly variations of the examined parameters for a 13-year period (2000–2012) in the two study areas.

The main findings of this study are that the values of the statistical parameters (Table 14.1) regarding the correlation between monthly satellite estimations and ground-based measurements provide an overall satisfactory correlation for both the examined parameters (SST and Chlorophyll-a). This conclusion can be used as a robust argument that satellite products are characterized by enough accuracy to provide—at least—information about spatial and temporal tendencies and variations of these parameters.

Using the satellite-based data products, mean monthly variations of the SST and Chlorophyll-a are calculated and presented (Fig. 14.2). All the monthly differences are checked regarding their statistical significance using ANOVA nonparametric test and it is concluded that all the mean monthly values (in both of the parameters) are statistically different at 99 % confidence level.

It is also concluded an almost opposite monthly variation between chlorophyll and SST for both the port areas. More specifically, during the summer season the

Table 14.2 Results of ANOVA regarding the median values of the monthly satellite-derived datasets for the SST and Chlorophyll-a in the ports of Bar and Burgas

Location	Parameter	ANOVA (*p*-value)
Burgas (Bulgaria)	Chlorophyll-a	0.000
	SST	0.000
Bar (Montenegro)	Chlorophyll-a	0.000
	SST	0.000

SST reaches its maximum values annually but in the same season the Chlorophyll-a concentration is in their lowest levels for both of the port sea areas.

In the near future, we intend to analyze—for other subareas in the Mediterranean basin—spatiotemporal variations of the same parameters in order to identify how their spatial distribution can be affected by seasonality and large-scale circulations. We will also investigate the reasons of any interannual changes, the type, the intensity, and the nature of possible relationships among parameters that define the quality of the marine environment like SST and chlorophyll.

Acknowledgements The authors would like to thank the Institute of Marine Biology, University of Montenegro (BIOKOTOR), and the Port Authority of Burgas for providing measurements and data. This study is supported by the "Transnational ENhancement of ECOPORT8 network" (TEN ECOPORT) project with code SEE/D/0189/2.2/X, cofinanced by the European Union within the South East Europe Transnational Cooperation Programme.

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Part III
Sustainable Management System

Chapter 15
Guidelines for Elaboration Management Action Plan for Ecologically Sustainable Development and Management of SEE Seaports of Trans-European Transport Networks

Jordan Marinski, Dimitar Marinov, Tatiana Branca, Matilda Mali, Tania Floqi, Chrysostomos Stylios and Leonardo Damiani

Abstract Sea transport is considered globally as one of the most environmentally harmless forms of transport. For this reason the ports' activities are a subject to special precautions to ensure that they support the sustainable and environment friendly development of sea conditions. The work presents, first, the main features of the common model (CM) for improved seaports' ecology, and second, it elucidates the guidelines about the preparation of Managing Action Plans (MAP) for South-East Europe (SEE) harbors. Also, the work describes the general structure of MAP and gives a list of tangible instructions and recommendations streaming the elaboration of MAP for an improved management of SEE seaports of TEN-T.

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15.1 Introduction

Nearly half of the global population resides in coastal areas. The dramatic increase of human pressure on the environment, being concentrated along the coasts, leads to degradation of coastal systems and destruction of habitats in the coastal zone (Wooldridge 2004). Although sea transport may be considered as one of the most environmentally harmless forms of transport, the type and magnitude of activities at ports should be subject to special precautions to ensure that they support the sustainable and environment friendly development sea conditions.

For example, ISO Standard 14001 (EN ISO 14001 2004) and the Environmental Management Auditing Scheme (EMAS 2001) claim the implementation of *Environmental Management System* (EMS) and nowadays it is considered as a prerequisite in the certification process. In particular the seaports sustainable development depends on the application of well-defined environmental management instruments considering social, economic, legal, technical, and environmental imperatives (Ondiviela et al. 2012). However, even though the seaports from *South-East Europe* (SEE) have systems (or elements of such systems) for environmental management, only few meet the international standards for certification (Marinski et al. 2012).

In order to improve the eco-performance of SEE seaports and implementation of EMS, especially in ports, the TEN ECOPORT project (http://www.tenecoport.eu/) has developed a *common model* (CM) and *Guidelines* able to yield a long-term *Management Action Plan* (MAP), as a core element of the ecologically and sustainable development and management of ports of TEN-T networks within SEE area. The CM consists of management and preparative/executive cycles and it identifies the main actors responsible for the improvement of port ecology, namely port decision makers, port environmental office, port operators, stakeholders and research institutions, and the important steps to be followed in the process of construction of MAP (Marinski et al. 2014).

This work aims, first, to remind in short the main features of the CM, and second, to elucidate the guidelines about the MAP preparation for ports. In addition it describes the MAP's structure and gives a list of tangible instructions and recommendations streaming the elaboration of MAP for an improved management of SEE seaports of TEN-T.

15.2 Common Model Basic Features

Capitalizing on the results of ECOPORT 8 project, TEN ECOPORT project has taken further steps towards an improvement of the environmental quality of the SEE ports (Damiani et al. 2013; Floqi et al. 2013). The practical way to achieve this goal is to apply the approach, procedure, and tools of the CM for SEE ports (Marinski et al. 2014). Apparently, the CM has to be built on sound principles, and has to rely on innovative methods and models for environmental protection.

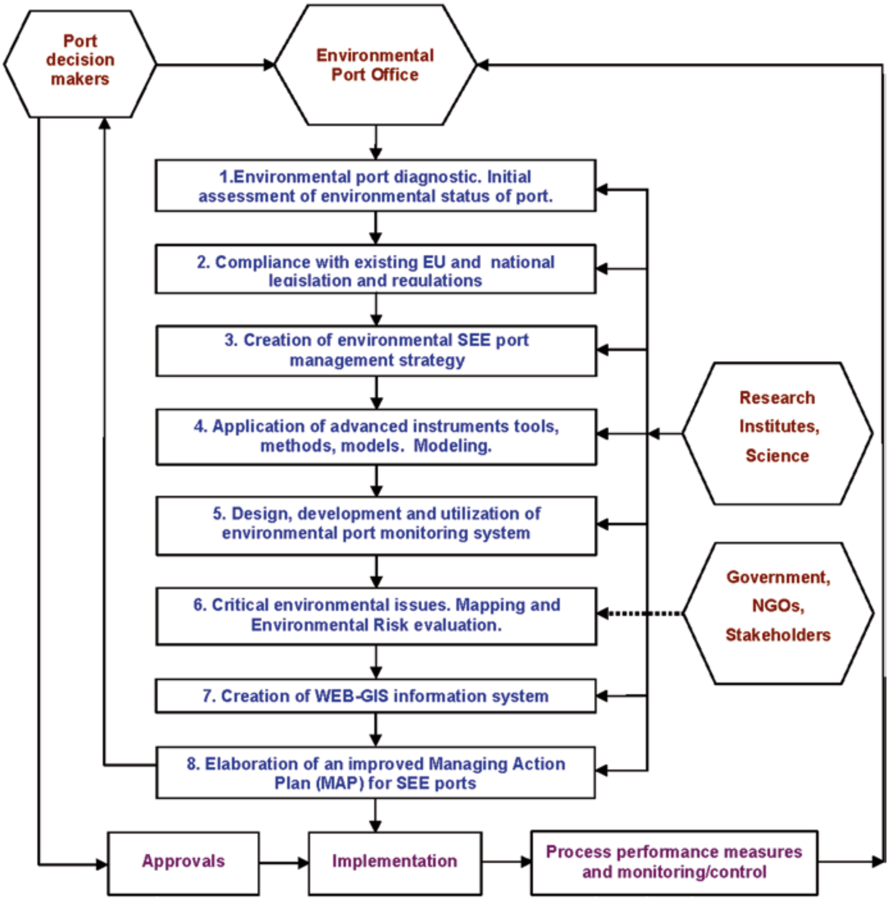

Fig. 15.1 Schematic view of management and preparative cycles, consecutive steps, and major actors of common model (CM) for ecologically sustainable development and management of South-East Europe (SEE) ports of TEN-T

Principally, any model should be a conceptual scheme that describes a given complex system such as seaports. The port systems could comprise multiple views such as planning, analysis, design, implementation, deployment, structure, behavior, input data, and output data. Thus, the model is required to describe and represent all multiple features of the considered system. Therefore, the CM for ecological and sustainable port development and management takes the form of a procedure, steps or guidelines that are schematically presented in Fig. 15.1.

The CM procedure has to be initiated by the port decision makers with the creation of a relevant port environmental office. The environmental office in ports should perform the eight consecutive steps of the preparative (internal) cycle of the CM (see Fig. 15.1): an initial assessment of port environmental status, to harmonize measures with the existing EU and national low, to create an environmental management strategy, to guarantee the application of advanced methods, models, and tools for better port management, including utilization of a monitoring system to observe the port environment, to map the critical environmental issues in the port area through a WebGIS information system, and based on the results to elaborate a MAP for an improved port ecology. Thereafter, the MAP has to be approved by the port government body before being implemented, which is followed by an institutional monitoring and control.

It is important to note that the elaboration and more importantly the implementation of MAP cannot be efficient without the involvement of port operators and stakeholders, since without an active collaboration and agreement with them, the port authorities alone will be not able to guarantee and perform an effective environmental management of SEE ports.

In addition, the CM illustrates the supporting role of research institutes and innovative science in all steps of the CM and the important influence of national governments, NGOs, and all interested parties, in particular when identifying and mapping the port critical environmental issues and environmental risk evaluation.

The management cycle of the CM is a continuous process of planning, implementation, control, review, and improvement of actions undertaken to meet the port's environmental obligations.

Integrating environmental management with other processes can improve financial quality and environmental performance of the SEE ports. In most cases this provides an answer to legal requirements, controls port sustainability, identifies significant environmental aspects or prevents and assesses air and water quality degradation.

To this end it is expected that the procedure and steps of the CM would help to resolve the decision difficulties related to ISO14001 as the CM suggests a realistic and constructive planning that is able to meet the needs of decision makers and management authorities of the SEE ports.

15.3 Guidelines for Management Action Plan Elaboration

Specifically, the building of a MAP for environmentally friendly and sustainable SEE ports development, according to TEN ECOPORT, has to follow the guidelines, instructions, and recommendations given below:

Cover Page of the MAP The cover page should include the following information: title, who prepared the document, date, approval body, who is responsible for the MAP implementation, etc.

Structure Chart of the MAP The structure chart is simply a table of content of the MAP.

Definitions of Terms Used in the MAP This part should give a short description and specification of all terms (technical, financial, etc.) used in the MAP.

Introduction The introduction has to specify the general context of the MAP. It must be short and concise. It has to be considered that the MAP could be related at least to one or more critical environmental issues specific to the ports.

The key environmental aspects to be considered at ports according to TEN ECO-PORT are:

- Emissions to air (including gases, solid particles and energy, dust)
- Discharges to water (waste waters, accidental releases during loading/unloading operations)
- Releases to soil due essentially to industrial activities
- Releases to marine sediments and activities affecting the seabed (such as dredging)
- Noise, with its potential impact on population and fauna
- Waste generation and dredging disposal
- Loss/degradation of terrestrial habitats
- Changes in marine ecosystems
- Odors
- Resource consumption
- Port development (land and sea occupation).

Reasons for MAP Elaboration When explaining the reasons it has to be kept in mind that the MAP:

- Helps port authorities to get awareness of the complex environmental context in which they operate and their impacting activities
- Provides a useful, practical and an easy way for guiding future implementation actions taken for obtaining a sustainable, economic, social, and environmental development at national and trans-national level, and stimulating the competitiveness in the context of EMS certification

Objectives of the MAP The MAP has to highlight the legislative context that permits ports to promote an environmental management drawn to the adoption of the best available practices for the solving environmental problems

The MAP should weigh the effectiveness of monitoring plans proposed for the assessment of port activities and environmental impacts.

It should also draw the main steps/actions and best available practices in order to reduce the environmental impact and support its continuous improvement of environmental performance in port areas.

Another important objective is to assess the framework for environmental management system implemented in your port.

The objectives do not have to be general but strictly and concretely related to the environmental problem(s) that is the subject of the MAP. The principal aim is to define reference actions to prevent the pollution of water, air, ground, and preserve all natural resources in port areas and nearby coastal zones.

Legal Framework (Local, Regional, EU, International) for MAP Development and Implementation

- When preparing the MAP, one should clarify and comply with: Existing environmental laws, regulations, policies, and guidelines
- Existing environmental agreements/new environmental laws and regulations
- New agreement established (or to establish) among key actors

A Short Description of the Port in Relation to the MAP This section should describe the port's activities, operators, stakeholders, critical environmental issues, ecological needs, etc. related to the MAP.

In addition, the port description has to use relevant and available information for your port arising from sources as specified in the steps of the CM:

- Previous port environmental assessments
- Eco-mapping and other evaluation tools
- Monitoring data and results from EMS, and
- Application of modeling tools and methods

Institutional Organization Chart for Map Implementation The MAP framework should include the following information for port authorities:

- Internal staff and resources:

  a) Human resources to be involved
  b) Internal financial resources
  c) Internal services and facilities already available
  d) Training needs

- External staff and resources:

  a) External and internal Operators within ports (companies, polluters, institutions, public, private, and national)
  b) External financial resources
  c) External services and facilities already available

Activities and Actions Activities and actions planned in the MAP should also be specified using the Round Table results by:

- Verification of the data and results achieved by round table
- Procedures established
- Procedure implemented
- Processing information and data storage

Facilities Chosen, etc. In the MAP should be described actions and activities planned for resolving problems related to environmental issues after the definition of environmental objectives.

Moreover, one has to explain what practically has been or will be done in the port and the timing of the implementation of actions by giving details about procedures, documentation, processing of information, data storage, prices, etc.

Tasks and Responsibilities of Key Actors The MAP should explain who will or is doing what, per action proposed.

It is important to identify precisely all those responsible both in the internal staff and among the port's operators involved as well as to decide on the procedures established and implemented.

Information and Communication System (Info-Management) The main information to be disseminated should be described in the MAP.

15.4 Conclusions

The CM, developed in the framework of TEN ECOPORT project, generalizes and extends the comprehensive ECOPORT8 project results for the SEE ports. The proposed CM for SEE ports is fully harmonized with legislation and regulations nowadays and it could overcome the decision traps related to ISO 14001.

The present guidelines for MAP development, supporting the CM, will help the overall decision-making process as they are streaming and always resulting in a feasible and constructive planning able to meet needs of management port authorities. In this way will be made possible an improved environmental performance of the SEE seaports and the facilitation of the preparation of concrete MAP.

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Chapter 16
Eco-Mapping as an Integrated Approach in Environmental Protection in Ports and Adjacent Urbanized Areas

Vania Ioncheva, Irina Faitondzieva, Kremena Nedyalkova, Venzeslav Krastev and Jordan Marinski

Abstract This study illustrates how ecological mapping and land-use planning can become an effective instrument for environmental protection of Bourgas port. Eco-mapping aims to identify quickly and clearly the problems of environmental protection within the port and to provide the mapping of all the specific critical issues in the port area and surrounding cities involved. This approach is an easy way to document and track environmental improvements. The application of eco-mapping is laid down in the managing action plan of development of environmental management of Bourgas port. The graphic representation of environmental requirements and their manifestation in specific territory planning and architectural and construction measures, as a part of a general plan or detailed territory planning of the port, would guarantee sustainability of the environment, both regarding the port territory itself and the urban environment they belong to or border.

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16.1 Introduction

Over the past 20 years ecologists have reported environmental degradation in port areas and coastal zones. The development of ecological research as adverse to complicated ecological situations has entailed the creation and use of eco-mapping (Kotelnikova and Kotova 1994) and land-use planning (Panchev 2006), as a means of the cognition and prevention of deterioration of urban areas and coastal zones.

Eco-mapping is a practical, visual and easy-to-use tool, which helps port authorities to map the threat and the risk of environmental pollution in port areas and in the adjacent urban areas. This approach is a step-by-step simple process to gather useful information on environmental issues, which are the basis of environmental documentation for the port company to immediately react to define and prioritize problems to improve environmental protection within the port via the Environmental Action Plan. The results of eco-mapping provide smart and helpful assistance for local public managers and gives a fast snapshot of the practice of environmental management registered in the current situation.

The eco-mapping consists of:

a. The port's map or port's general plan (master plan) serves as a basis for all the port's territory and aquatory, which allows us to analyse the port situation and the localization of main activities in ship berthing areas and cargo spaces.
b. The environmental monitoring for detecting in advance the set of critical points, indicated by environmental pollution caused by port activities and planning and implementing anti-pollution measures and activities envisaged and included in the environmental protection programme.
c. The monitoring data collects current information on the condition of main parameters—determining sea water quality, atmospheric air and any possible impact on them by port activities. Such approach will allow initiating corrections in the technological operations for environmental protection and will support port management.

The aim of this study is to illustrate how ecological mapping can become an effective instrument in the sustainable planning and construction of ports, integrating ecological investigation and strategies for environmental protection by means of land-use planning.

16.2 Ecological Mapping of Bourgas Port

The Bourgas Port is one of the most important international ports on the western Black Sea coast. The modern port management requires a consistent set of databases covering all spatially required information and incorporating appropriate model for their analysis and identification of the resources and emission status of environment and opportunities for tabular and graphical presentation of results. A dynamic powerful Geographic Information System (GIS) is used for the identification of critical points of the port for the aim of eco-mapping and WebGIS. The *Arc*

Table 16.1 Legend for the critical points and symbols inserted in the map

No.	Notification and explanation	Symbol
1.	Red for pollution from ground[a]	
2.	Light blue for pollution from water[a]	
3.	Blue for WATE[b]	
4.	Brown for SOIL AND STORAGE[b]	
5.	Grey for AIR, ODOURS, DUST AND NOISE[b]	
6.	Yellow for ENERGY/CONSUMPTIONS[b]	
7.	Green for WASTE[b]	

[a] The colour of the circle's upper part indicates the source of pollution
[b] The colour of the circle's lower part indicates the issue

GIS 9.3 is the most known GIS system, which enables us to involve, view, edit and analyse geographic data, to find and understand the relationship among geographic features and symbolize data in a wide variety of ways, to create charts and reports and to create maps that integrate data in a wide variety of formats, including shape files, coverage, tables, computer-aided drafting (CAD) drawings, images and grids.

For the creation of the port of Bourgas eco-mapping a legend for the critical points has been inserted in the maps (Table 16.1):

The critical points of pollution are positioned in maps for each environmental issue. A form per each symbol is completed (it will be inserted in the WebGIS in order to give information when the symbol is clicked).

The main step of eco-mapping is recommended to be a diagnostic review of the current environmental situation in the port by ecological maps identifying

Fig. 16.1 Map in local WebGIS of the port of Bourgas with four automatic monitoring stations

significant impacts. The environmentally significant impacts in port are connected with water pollution, air pollution, soil pollution, prevention and reduction of waste or prevention of environmental accidents. All environmental information during the monitoring and observation can be transformed in graphic representation as a visual, simple and practical instrument to analyse, resolve and manage environmental problems. A spatial graphic system is made ready for collecting, analysing and including in European networks the main statistic data as a part of GIS for the management of ports. The critical points of significant impacts are positioned in each map (Chunmiao and Bennett 1995) (for water pollution and air pollution). Per each symbol of critical points must be completed a form (it will be inserted in the WebGIS in order to give information when the symbol is clicked).

Considering the environmental situation in the port of Bourgas four critical points with significant environmental impacts have been selected (Fig. 16.1). On the basis of the performed investigations during the performance of the ECOPORT 8 activities (www.ecoport8.eu), three sampling stations (p. 1, 3 and 4) for automatic seawater monitoring and one sampling station (p. 2) for atmospheric air monitoring have been installed at critical points, which were determined and indicated by their coordinates.

The maximum range of controlled parameters is measured in sampling station 4, Table 16.2 where for illustration are shown only data from 3 different days during 1 month. The main loading–unloading operations of the port of Bourgas are concentrated here, in the West Terminal, where it is expected to have considerable impact on the port sea waters. In these internal basins, where station 4 is located, water quality was strongly influenced by the discharge of urban treated waste waters, the impacts of which were beyond the capabilities of the port management, while the increased content of oil products could be directly related to the port activity (liquid fuel uploading).

Table 16.2 Critical point 4—port of Bourgas

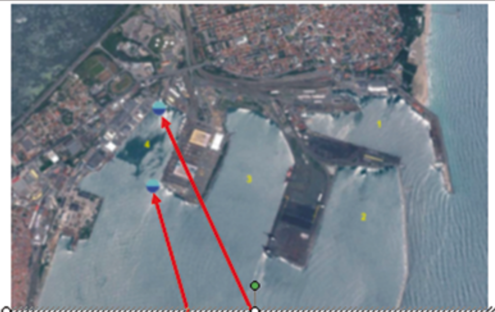
No	Parameter	Units	Value and limit of the parameter according to regulation		Date 06.09.2011	Date 15.09.2011	Date 25.09.2011
1	Temperature	°C	–	–	29.5	22.5	19.5
2	Transparency	n	2	10	–	2	–
3	Turbidity	FTU	–	–	2.55	2.81	2.09
4	pH	–	6.5	9	8.25	8.23	8.4
5	Ammonia nitrogen	Mg/dm^3	0.1	0	0.141	0.039	0.092
6	Nitrite nitrogen	Mg/dm^3	0.03	0	0.006	0.002	–
7	Nitrate nitrogen	Mg/dm^3	1.5	0	0.311	0.398	–
8	Phosphorus (total)	Mg/dm^3	0.1	0	–	0.08	–
9	Phosphorus (total as PO4)	Mg/dm^3	–	–	0.026	–	–
10	Phosphates	Mg/dm^3	–	–	–	–	0.027
11	Dissolved oxygen	Mg/dm^3	6.2	20	6.74	6.49	9.76
12	BOD5	Mg/dm^3	6	0	–	1.73	–
13	Extractable substances	Mg/dm^3	0.15	0	–	0.29	–
14	Iron	Mg/dm^3	0.1	0	–	0.111	–
15	Cadmium	Mg/dm^3	0.005	0	–	0.002	–
16	Cromium (Cr total)	Mg/dm^3	0.1	0	–	0.021	–
17	Lead	Mg/dm^3	0.01	0	–	0.01	–
18	Copper	Mg/dm^3	0.03	0	–	0.006	–
19	Conductivity	μS/cm	–	–	25,200	33,300	29,100
20	Dissolved substances	Mg/dm^3	–	–	–	18,644	17,350
21	Coliforms (total)	Cfu/cm^3	200	0	–	1260	–
22	Faecal coliforms	Cfu/cm^3	1000	0	–	930	–
23	Chlorophyll "A"	Mg/dm^3	3	0	–	0.468	–
24	Salinity	%	–	–	–	16	17.6

Observed environmental parameters are different for every critical point. All the information for every critical point is visualized in the project by hotlink options in ArcMap. This allows an analysis of the trend of various pollutants at different times in comparison with the limit values in accordance with national regulations.

The eco-map form for critical point 4 is presented in Fig. 16.2.

General features

Country	BULGARIA
Region/City	BURGAS
Geographical coordinates	42°28'58.2"N, 27°27'25.2"E 42°29'20.7"N, 27°27'24.2"E
Managing Authority	- Executive Agency Maritime Administration; - Bulgarian Ports Infrastructure Company - Port of Burgas PLC, BMF Port Burgas PLC - Port operators



Port layout shows monitoring point 4 of the automatic monitoring system and discharge of urban sewage

ISSUE: Inflow of polluted water in the aquatorium 4.

ENVIRONMENTAL PROBLEM:
Water Pollution

CAUSES/SOURCES:
Inflow of polluted water in the aquatorium 4 of the inflow of lake Vaya and discharge of urban sewage.

SURFACE EFFECTED:
Sea water

OPERATING ORGANIZATIONS IN THIS AREA (stakeholders):
- Port operator

DATA:

Monitoring data	Data quality	Source
1. Determination of pH; 2. Measuring the temperature in C^0; 3. Measurement of dissolved oxygen (O_2); 4. Determination of turbidity; 5. Determination of the specific conductivity; 6. Determination of salt content; 7. Determination of chlorophyll; 8. Determining the speed and direction of flow of water; 9. Blue-green algae; 10. Oil contents of 11. Measurement of seawater / maximum - Ammonia nitrogen; - Nitrite nitrogen; - Nitrate nitrogen; - Phosphates.	☐ Precise ✓ Fairly good ☐ Guessing	☐ Invoice ✓ Measure ☐ Other…

ENVIRONMENTAL OBJECTIVE:	**Stakeholders to involve**

Fig. 16.2 Eco-map form for critical point 4

16.3 Discussion

Looking for additional instruments to existing legislation, a revised and improved program is suggested for the environmental protection of "TEN ECOPORT" ports to include modern land-use planning related specifically to the environmental parameters of the port where its ecological infrastructure and operation are visualized and displayed on map materials. In this way, modern concepts on territory planning as an approach applied to ports will become an added operative instrument for environmental protection. Moreover, it is quite reasonable for this approach to assume a statutory form by becoming a requirement to section “Environment” of ports’ general (master) plans, also including specific ecologic plans and drawings. After approbation in the TEN ECOPORT project, this requirement can be considered as a prospective amendment to legislation in the sphere of environment.

The graphic representation of environmental requirements and their manifestation in specific territory planning and architectural and construction measures as part of a general plan or detailed territory planning of the port would guarantee sustainability of the environment, both regarding the port territory itself and the urban environment they belong to or border. This is due to the mandatory character of the graphically measurable parameters of the measures planned and in view of the mandatory and irrevocable character of the approved territory planning and architectural–constructive plans. Working out ecological maps of port territories would be a step forward after the obligatory environmental impact assessments, which, however, do not require final graphic representations of findings and recommendations. The ecological port maps with graphic representation of port’s ecological infrastructure and its functioning should reflect the dislocation and functioning of the port’s system for environmental management and control: location of stations for the processing of bilge water from ships and vessels, storage stations for preliminary disposal and treatment of hard waste, waste management plan operations in graphic form, system for port monitoring and operational plans related to port waters and channel dragging.

16.4 Conclusions

Eco-mapping as an environmental approach is implemented in the preparation of managing action plan of Bourgas port. The graphic representation of environmental requirements and their manifestation in specific territory land-use planning and construction measures as a part of master plan would be guarantee sustainability of the environment in the port territory. This approach should be considered as an element of the common strategy for environmental protection in SEE ports and harbour areas and intents to become a useful element for the establishing of a Common Intelligent Sustainable Model of Sea Corridors.

Acknowledgments This paper was made possible thanks to a research grant provided by South East Europe Transnational Cooperation Programme within “Transnational enhancement of ECOPORT 8 network” (TEN ECOPORT) with code SEE/D/0189/2.2/X.

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Chapter 17
Process Performance Measures and Monitoring/ Control for a Sustainable Management of South East Europe Ports' Areas

Tatiana Branca, Matilda Mali, Jordan Marinski, Dimitar Marinov, Tania Floqi and Leonardo Damiani

Abstract In the framework of the activities of the TEN ECOPORT project, carried out with a "closed chain" approach, the Environmental Management System (EMS) and its additional instruments, already individuated and implemented in the previous experience of ECOPORT 8, become effective through the enforcement of a managing action plan (MAP) which needs to be periodically checked to ensure that the quality system continues to meet the requirements of the standards and to permit a continual improvement. With the aim of checking the effectiveness of the EMS chosen within Southeast Europe (SEE) ports, the process performance measures and monitoring (PPMM) and its control system (CS), based on a closed chain used to explicit causes and effects related to a particular situation, were applied in order to recognize the bottlenecks on which it is necessary to intervene with priority with the aim of achieving an effective sustainable management of SEE Ports.

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17.1 Introduction

The TEN ECOPORT project ("Transnational ENhancement of ECOPORT8 Network"), funded by the SEE Transnational Cooperation Programme, was born with the intention to overcome all the environmental management weaknesses that emerged in the previous experience of ECOPORT 8 project ("Environmental Management of Transborder Corridor ports"), which also had been funded by the SEE Programme. In the ECOPORT 8 project, eight ports (Port Authority of Levante in Italy, Durres Port Authority in Albania, Bulgarian Port Infrastructure Company—Bourgas and Varna Ports—in Bulgaria, Port of Bar Holding Company in Montenegro, Port of Constanta in Romania, Port Authority of Igoumenitsa S.A., and Port Authority of Patras S.A. in Greece), were involved in a research led by the scientific institutions of their related countries (Polytechnic University of Bari and Universus CSEI, Italy; Polytechnic University of Tirana, Albania; National Institute of Meteorology and Hydrology, Bulgaria; BIOKOTOR, Montenegro; GeoEcoMar, Romania; and Patras Science Park, Greece) in building common ecological and safeguarding policies with shared methodologies. The ECOPORT 8 activities started with a comprehensive context analysis of the current state of environmental protection in the port areas of Corridor8, as well as an environmental diagnostic of each port, in which the main environmental issues were also addressed. This context analysis was extended to the whole legislation addressed to ports areas and coastal zones, which includes international conventions, EU directives, national laws, and regulations as well as the instruments adopted for port planning.

A SWOT analysis was then used as a basis to formulate a successful strategic "improvement program of the eco performance" for the whole port areas, comprehensive of an environmental management system (EMS) specific to the SEE sea ports, and additional tools like environmental risk analysis (ERA); environmental land use plans (LUP), which makes efficient use of space after the environmental impact assessment (EIA); and integrated coastal zone management (ICZM), specified for harbors' needs and proposed to define policy guidelines, allowing a strategic environmental approach in accordance with the requirements of international and European standards for certification of ports. Listed below are the common environmental objectives and principal measures for improvement of the eco-performance of the PAN-EU Corridor8 port areas proposed by ECOPORT 8:

1. Compliance with environmental EU and national legislation and regulations
2. Elaboration and Implementation of an EMS specific for SEE ports in order to achieve environmental objectives and targets that can meet the requirements according ISO 14001(4) and SEE area ports environmental policy
3. Assessment and managing of an ERA typical for SEE ports' conditions
4. Application of an ICZM, approach and tools for achieving environmental goals in the SEE area ports
5. Environmental preventive measures including ones based on LUP
6. Environmental monitoring, based on performance indicators in order to measure progress in environmental port practices

7. To strengthen the administrative capacity for environmental requirements implementation and enforcement
8. To improve SEE ports communication policy and practice
9. Efficient use of the financial and material resources for ensuring sustainable port development/environmentally sound ports' operation (ECOPORT 8 project 2012)

Before acting to obtain these environmental objectives or their specifications in each area, an environmental monitoring was necessary. It was made in two pilot ports in order to define the "white," the starting point on which set the EMS trigger. This environmental parameters' monitoring phase, lasting 6 months in each port, allowed for the obtainment of the assessment of the current environmental status of the port waters, air, soil, and other main issues and the identification of significant environmental impacts from port activities and ships in ports. The situation of the SEE ports involved is very heterogeneous in the dimension of infrastructure and specialization of terminals: some of them have an industrial vocation and are more suitable to operate as rail nodes (the medium–large ones), while others (the medium–small ports) have a more passenger and commercial orientation and can operate mainly as road transit points. These differences confirm that each step of the EMS must be specified so adapted to a complex reality like it is the one of an harbour, and the same steps must be verified time by time, action by action, process by process in its effectiveness. Harbors are the receptors as well as the emitters of impacts if related to their surrounding city areas; therefore, these topics involve not only strictly ports' operations but also the environment of the urban system of which most of the SEE ports are a part. In ports almost all the elements can be associated with environmental impact: waste water, emissions of gas or particles into the atmosphere, noise, soil contamination, dredging, waste production, accidental releases into water or air, etc. Often, and almost always in SEE ports, near the harbor area or within it there are industrial plants, fisheries, storage of hazardous materials, or other activities which can further raise environmental impacts. Therefore many different processes must be submitted to a specific EMS. Also, there is a lack of clarity on the environmental responsibilities of the different services involved in port activities. Without a framework to include the specific environmental variables inherent to port operation, it is difficult to explain to governments, users, or other audiences the scope and extent of port activity in relation to the environment. Defining reference actions to prevent the pollution of sea water, air, ground, and preserve all natural resources in port areas and nearby coastal zones, through close cooperation of port authorities, port operators, and scientific institutions are extremely important. The main lesson learned in Ecoport8 is actually that port authorities, alone, cannot ensure a sustainable development if unable to involve all the different actors operating or affecting the harbors' areas. In the long term, however, port authorities have to act as the "smart" institution that governs the implementation of new organizational forms (Chlomoudis and Pallis 2004) and lead the rest of stakeholders in this smart management making decisions and agreeing policies easily implementable. Therefore, in the next experience of TEN ECOPORT (enlarging the Partnership with Brindisi Port Authority in Italy, the Romanian Naval Authority in Romania, Dubrovnik Port Authority in Croatia—added country, and the Technological Research Center of Epirus in Greece) Ecoport8's outcomes were capitalized, trying to overcome the difficulties met before through an active involvement of all key actors operating in harbors' areas. Each of the ports analyzed has a system for environmental management, but none of them meets the international standards for certification in respect of environment protection ISO 14000 or EMAS (EN ISO 14001-2004; EN ISO 14004-2004; EMAS-2010) (Marinski et al. 2012). The EMS and its additional instruments individuated and implemented in ECOPORT 8, then become effective in TEN ECOPORT through the enforcement of a managing action plan (MAP) and after an eco-mapping of all critical points of pollution within port areas. The MAP needs to be periodically checked too, therefore has been established a management cycle for SEE harbors with particular attention to the weakest link: measurement. It undermines the reliability of the entire management system and makes it unstable. In the absence of a suitable measuring system then the organization is not aware of their own managerial shortcomings and sinks in an "unaware inefficiency" (US Environmental Protection Agency 2003). That is why measures are made after choosing an adequate system of Indicators, with the intentions of letting them become tools to evaluate the status of the environment in a port, as consequent status of applied environmental policies. Indicators, most of all, must be chosen in order to be then available for decision making, giving quantitative and qualitative results related to the environmental actions applied. The process performance measures and monitoring (PPMM) and its control system (CS) as part of a general common model for sustainable development, is based on the closed-chain approach and defines the possible internal or external constraints that restrain the achievement of the results' sustainability, it permits to put matters on environmental objectives and actions and allow port authorities to really take advantages from environmental management's benefits.

17.2 Process Performance Measures and Monitoring/Control System for South East Europe Ports' Areas: TEN ECOPORT Pilot Ports Case Study

There are two steps to ensure the sustainable development of the sea corridors: first, working on sustainability of the process—applying common policies which can create same opportunities in all the involved countries and not affecting the concurrency among ports, and secondly verifying the quality of processes' results. This second step is harder to achieve than the first one because of the difficulty in defining the link between implemented processes and the expected results. This consideration makes it necessary to follow up the process step by step, monitoring intermediate results and identifying the critical points in order to modify, over time, the implemented programs through a closed chain approach (Damiani et al. 2013). ISO Standards and others do not give specific indication on "how" to make less polluting all the processes (industrial or not) which take place within a har-

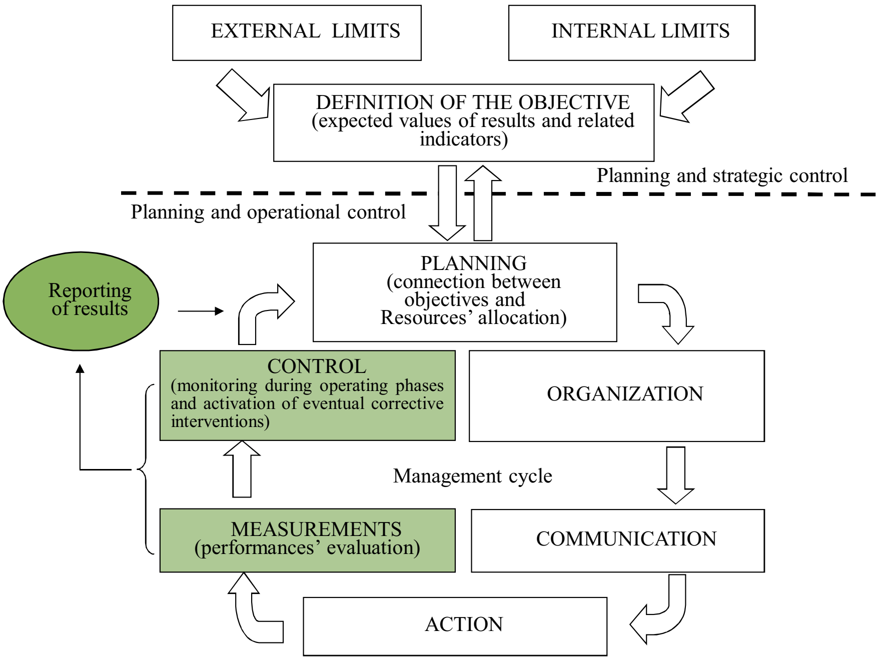

Fig. 17.1 Port managing cycle for SEE ports

bor; thus port managers have to find out by themselves the contraprocesses and environmental actions to apply against any risk of pollution. The implementation of environmental actions require the quantification of objectives and goals as well as the effort and commitment by all ports' actors involved in these processes for continuous improvement of them. Quantification is not only needed during an initial analysis but also, as an intrinsic element for the EMSs which are based on the continuous improvement philosophy, the quantitative "check" of the improvements is necessary to assure valuable results. To verify the quality of processes' results, a well-integrated system of PPMM and a CS, within a management cycle structured like in Fig. 17.1, are needed. Measurement, or performance evaluation, is the phase of the cycle most interesting in this context, but because the instruments on which it is based (indicators, detection systems, etc.) are still very limited, it appears still limited too. The first objective in this phase is actually to define the best indicators that can permit to measure the efficiencies of processes, therefore to evaluate them. The consequent monitoring, evaluation, and control, if the measurement is limited, become difficult; that is why the choice of indicators is crucial to measure the process performance.

Performance, or efficiency, is the level in which a sustainable process implemented within the port area is achieving the environmental objectives as planned results comparable to targets and standards. Process measures look at "upstream" factors, such as the amount of paint used per unit of product or the number of employees trained on a topic (US Environmental Protection Agency 2003).

Performance indicators (PIs) help to evaluate and measure the success of the overall EMS program, while key characteristic indicators (KIs) measure progress against EMS objectives for specific significant environmental aspects. In TEN ECOPORT activities, firstly ports were studied, in order to outline the scope of the system of indicators within the port area. All the activities carried out within the SEE ports were analyzed, making (i) the identification of port activities and processes; (ii) the identification of environmental issues affected by each activity–process; (iii) the evaluation of their level of significance; (iv) the evaluation of their impact. TEN ECOPORT pilot ports, Bari and Durres, as medium realities with mostly passenger and commercial vocation, decided to focus thus their MAP on a specific issue: they chose waste. Examples of EMS results performance indicators for this issue are:

- Number of active action already implemented in compliances with regulation
- Number of environmental objective and targets met
- Kilograms of hazardous waste generated per unit of production
- Percentage of employees completing environmental training
- Percentage of solid waste recycled/reused
- Number of products that have a recycling program, etc.

The results shown by these environmental performance indicators will become the basis for planning future actions within the ports and for documenting continuous improvement. As key characteristic indicators related to potential environmental impact of waste, instead, can be chosen among others:

- Quantity of urban and dangerous waste creation
- Quantity and type of ship generated waste and cargo residues
- Quantity of separate collection waste
- Quantity of scrap from building and repair of vessels
- Quantity of scrap from civil works
- Quantity of general organic waste from the handling of bulk solids
- Nonorganic waste: types in port services
- Dangerous waste, etc.

The common action plan implemented by the two ports has as main objectives to improve the availability and the use of port reception facilities, to improve the port waste management system by promoting the practices of separate collection according to the type of categories, and moreover to reduce the illegal discharges of waste into the sea, trying to monitor and avoid any discharges along the whole route in the Adriatic and not only in the two ports' area. Durres and Bari started coordinated activities to define common protocols and procedures for the management of ship-generated waste in order to monitor the process from a port to another and the other way round. Before setting the plan, types of ships and ordinary traffic and ship-generated waste and cargo residues were analyzed in order first to verify if the waste reception facilities are suitable for the expected quantity of waste. A first process' check, based on a defined performance indicator, was already available in the assessing phase: choosing as indicator the state of implementation of international conventions (Marpol73/78) and European Directive (2000/59/CE concerning

Table 17.1 Environmental measurement indicators form

Environmental issue	Objective	Indicator	Date checked	Result	Corrective actions
Waste	Transposition of EU Directive 2009/59/CE	State of implementation	2014	Implemented (in Italy and Albania)	Compliance with regulations
Waste	Transposition of MARPOL 73/78	State of implementation	2014	Implemented (in Italy and Albania)	Compliance with regulations

the collection facilities for ship-generated waste and cargo residues in the port area) in the two countries, resulted that Italian Legislative Decree 24th June 2003 n. 182 then replaced with the Legislative Decree 152/2006 (Environmental Code), adopted by the Italian Government in April 2006 in order to reorganize the national environmental legislation, transposed the EU Directive 2000/59/CE, while Marine Administration in Durres has issued the Order No. 25, Dated 05 August 2013, on "Establishment of the Collection Plants for the Ship-Generated Waste and Cargo Residues at Ports of Republic of Albania and their Management and Collection Plan" to implement the obligations of the same EU Directive and the ones of the MARPOL Convention 73/78. In particular, the Directive 2008/98 of the European Parliament and of the Council of 19 November 2008, which sets down the fundamental principles and rules for definition and management of waste, was incorporated into the Italian legal framework by Part IV of the Environmental Code. Moreover, Albanian Government has approved Decision No. 480, dated 25 July 2012 "On the Approval of National Emergency Plan of Response to Marine Pollution in the Republic of Albania" and in order to ensure legal requirements and international standards—MARPOL 73/78, Durres Port Authority has contracted private operator "Cleaning Marine Ltd" for carrying out the aquarium cleaning service at Port of Durres. Results of this first PPMM are summarized in the Table 17.1, an example of a simplified environmental measurement indicators form compiled using as indicator the state of directives and conventions implementation regarding ship-generated waste and cargo residues.

Even if the most important regulations result implemented in both countries, evident is the need of both port authorities to remark in their plan that all the actions must be done in compliance with them, so to set environmental actions always able to really satisfy the requirements of those standards. Along with the actions, types of monitoring, and measurements needed to ensure that the collection of separate generated waste is complying with applicable legal requirements were chosen, and were looked for those processes of collection to be periodically evaluated in compliance with legal requirements. Many indicators forms, using different indicators, are used to monitor those processes. During the next phase of the project, the effectiveness of these chosen processes will be verified through the control system, in order to permit to evaluate precisely the ongoing of the actions taken for the EMS now in place: in the comparison among "actions planned" and "actual state" will be identified the "deviations," founding causes and effects, developing options, and

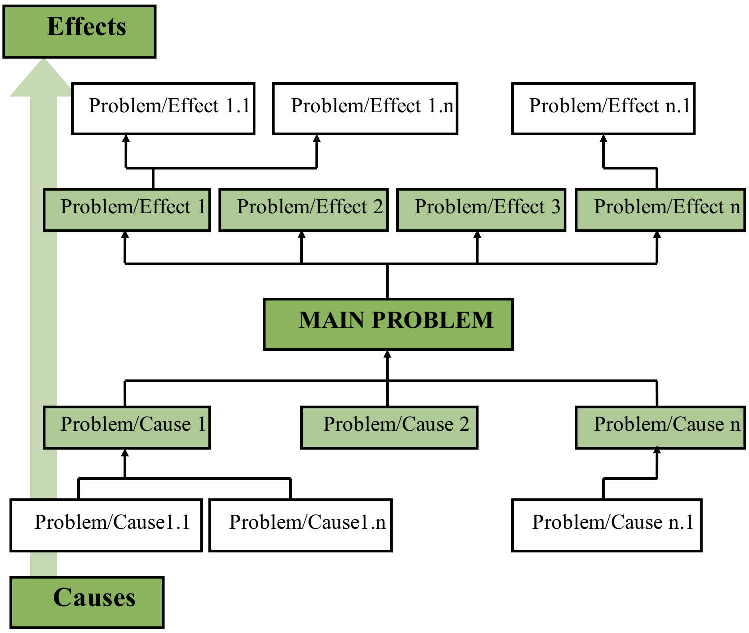

Fig. 17.2 Problem analysis for the CS of TEN ECOPORT

if necessary updating the plan, which must be continuously improved through this check. Corrective actions are useless if not integrated with a careful control to verify if they have been really done and if their implementations leads to the expected effects. With the purpose to avoid useless actions therefore TEN ECOPORT strategy propose to its working groups, (the ones formed in the Port Authorities involving all key actors called to perform the EMS), a tree of problems' analysis characterized by simplicity and intuitiveness, that make it a useful tool for the groups coordination, because it permit to build the net of problems effecting a determined situation, through the collecting of different points of view of the different participants at the working groups in ports. Thus to avoid the choice of any ineffective action" working groups in ports.

The TEN ECOPORT tree of problems, as showed in Fig. 17.2, forecasts three steps:

1. Identification of the main problem: the problem most deeply felt by all actors involved in the group, selective enough to lead more quickly to the identification of its main causes and effects related.
2. The direct causes of the main problem are reported immediately below the latter, and one by one, these causes are branched out into more specifics.
3. Above the main problem are listed its direct effects, which one by one can be declined in even more general effects.

When the group is sure of having considered all causes and effects of the chain, the tree is completed. All problems will be in this way ordered on the basis of the cause/effect relation, which will permit to recognize problems' hierarchy. Each problem could be considered completely solved just when all problems/causes listed below will be solved. More results of this phase could be given after the end of the project (September 2014).

17.3 Conclusions

All the components to perform a PPMM and SC have been shown, inserted in a general MC as tool of an EMS which in that way results continuously monitored, process by process, in its effectiveness. In order to verify the efficiency of the processes proposed are needed also: the tracking over the time of the performances, the measurement in improvement of pollution prevention, and, of course, the right calibration of the equipment for the monitoring. The pilot port case study demonstrate that these tools let to have always available information which permit to evaluate precisely the ongoing of the actions taken for the EMS implemented and let managers understand how an "ECO" Systems, means both "ECO-logical" and "ECO-nomics" when indicators are used to reduce not only the risks, but also the costs by a sustainable management. Through the indicators it is easier to quantify the benefits of an EMS, listed in terms of market opportunity, development, positive image, self-improvement, liability, and responsibility of the port authorities. Once established the priorities, it is easier to find practical solutions and to ask functional organizations to deliver effective polices which include the environmental protection. Moreover, if monitored and verified time by time, these policies will result really efficient for the expected results' achievement, otherwise the control system allow to detect useless actions and change them, in order to apply more effective ones whenever it is needed.

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Chapter 18
Sustainable Coastal Management: Case Studies

Anna Trono and Gabriella Trombino

Abstract One of the main issues in Europe in the field of environmental protection is the need to develop political decision-making systems that can support the complex mechanisms guiding the development and implementation of European policies while considering both the interests of stakeholders and social conflicts. Resolving the environmental problems of European coasts and seas requires a political response that takes account of all strategic sectors linked to water, nature, pollution, fishing, climate change and regional planning. Historically these have been considered separate policy domains, but with the adoption of the Marine Strategy Framework Directive (MSFD) in 2008, an integrated response is being pursued. This management approach considers the entire ecosystem and aims to achieve good environmental status for a number of specific environmental aspects.

Integrated coastal zone management relies on complex and elaborate measures proposed by stakeholders, and on the active involvement of local people in identifying sustainability objectives via information dissemination and consensus. This requires monitoring, regulation and good governance. Public participation in environmental decision-making in Europe was made a legal requirement by the European Union's (EU) Water Framework directive. This study presents the results of direct research conducted in the Puglia and Calabria regions in Italy.

18.1 Premise

Economic and social systems exert strong influence on environmental processes and ecological systems, causing ever greater irreversible damage to the ecosystem and human health. On a global scale, the past few years have seen environmental and

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social problems grow to the point that anthropic pressure on coastal resources may in many cases exceed the carrying capacity of the marine environment (Pagnotta and Barbiero 2003).

Thousands of toxic chemical substances now pollute European seas, damaging the marine ecosystem and potentially human health (Depledge et al. 2013).

As a ‘closed’ sea, having very limited water renewal capacity, the Mediterranean suffers from excessive fishing, high-localised concentrations of nutrients (derived from waste, fertilisers, etc.) and other pollutants and intense pressure on the coasts arising from human activities including agriculture, fishing, tourism and transport (Tsimillis and Pithara 1995; Benoit and Comeau 2005; EEA 2006, 2007).

After a presentation of public intervention policies designed to contain and/or resolve problems of coastal pollution, this study considers the role of stakeholders in a new policy of sustainable environmental management and their possible involvement in policy-making, in line with the recommendations of the Aarhus Convention in 1998, subsequently enshrined in the European Union’s (EU) Water Framework Directive in 2000. Particular attention is paid to case studies in Italy.

18.2 New Coastal Pollution Management Policies

The Europe-wide shift in water policy is marked by the 2000/60/EU Water Framework Directive (WFD). This Directive opens up the possibility on a European scale of changing the planning process by developing sustainable strategies that provide a much more integrated and strategic (riverbasin) approach to European water policy, explicitly recognising the interdependencies of ground, surface and coastal waters (Trombino et al. 2007). Moreover, the WFD introduced two key elements in water policy:

- The concept of ‘good’ and non-deteriorating ‘status’ for surface, underground and coastal waters
- Hydrological planning on a riverbasin scale of pollution-control measures as the best way to reduce impacts in coastal areas (Kallis and Butler 2001).

The increased complexity of the ‘Program of Measures’ is related to the adoption (in the context of the WFD) of an integrated approach that combines principles of ecology, economics and sociology (Giupponi et al. 2002). The evaluation of possible strategies under this new perspective has generated much debate in Europe and in May 2001, Member states, Norway and the European Commission agreed on a Common Implementation Strategy (CIS). This aims to provide support for the implementation of the WFD by developing a common understanding and coherent guidance on its key elements. Member states have promoted initiatives aimed at protecting both inland and coastal waters in order to prevent and to reduce pollution, to promote sustainable water use, and to protect the aquatic environment. Specifically, the WFD aims to preserve water resources by fixing quality objectives for all water bodies. At a European level, the WFD requires all countries to achieve specific water quality objectives (WQOs). However, it is not clear how these WQOs should be achieved.

As mentioned in a European report (European Commission Report 2014)

> The marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive.

To meet these needs, on 17th June 2008 the European Parliament and the Council of the European Union enacted the Marine Strategy Framework Directive 2008/56/EC (MSFD). The MSFD was transposed into Italian national legislation, as required for all member states, by Legislative Decree n. 190 of 13th October 2010.

The MSFD's main objective is to establish a framework for all member states to take the necessary measures to achieve and/or maintain good environmental status (GES) in the marine environment by 2020.

18.3 New Players in Sustainable Environmental Management Policy: Governance and Stakeholders

The attention paid by legislators to environmental issues and the growing environmental awareness are encouraging, but they are not sufficient to ensure sustainable management of the coastal environment.

It is important to inform, to flag up inefficiencies and suggest measures to make up for lost time and focus attention. The strategic assessment of existing plans and programmes and the drawing up of fundamental guidelines for regional organisation clearly make an important contribution to the prediction of future environmental scenarios, but they are not sufficient to guarantee sustainable environmental planning and management. Considering that the latter take place on a local level, they need to be implemented in collaboration with all the local economic and social stakeholders, while respecting the principle of sustainability. Those responsible for planning need to follow a model of sustainable development that also respects and takes account of the needs and values of various groups of people. The norms and values of a given society are also the expression of the behaviours of the common people, and it is among the latter that intervention is required because behaviours both reflect and condition the perception of rules and respect for them. Obviously, success cannot be guaranteed, but knowing people's behaviour helps to identify roles, functions and responsibilities, and thus to achieve lasting and sustainable results (Özhan 2002; Reeves 2005).

To the difficulties of attributing a single agreed meaning to the concept of environmental sustainability (Turner et al. 2003), the uncertainty about what is meant by *environmental management* may be added, which began to be spoken of in the 1970s as a form of problem-solving designed to provide assistance to local government technicians.

Essential elements in the process of environmental management are *governance* and *stakeholders* (Beato 1999; Collentine et al. 2002). In the case of the former, reference is made to models of interaction in which the coherence and effectiveness of the government in regional processes does not depend on political-administrative activity alone, but also and above all, on horizontal and vertical coordination among a plurality of institutional and social players as well as on their capacity to share objectives, negotiate agreements and cooperate in order to achieve them (Freeman 2010).

In the management process it is necessary to consider three participatory moments for stakeholders that translate into the following steps:

- To legitimize the decisions that are taken, by making the decision-making process more *transparent*.
- To increase the *knowledge* base for making decisions by making use of local, non-professional knowledge.
- To develop new management *alternatives* rather than just accepting or rejecting those offered by experts.

The adoption of guided strategies clashes with the unpredictable dynamics of the changes that form the backdrop to the work (such as climate change), and there is a tension between the need to conserve and protect and the demands for innovation and development (Trono 2010).

Experience worldwide shows a range of different benefits that may be gained through participatory approaches, from 'getting more people involved' to 'achieving greater democracy' (Quattrone 2010, p. 170).

Participation needs to *involve* people not just in the delivery of specific, externally determined measures, but also in terms of design and planning (Selman 2004). The need remains, however, to first *educate* the community to respect the environment in order to ensure sustainable development (Tinacci Mossello 2014).

18.4 Coastal Pollution in the Puglia Region in Italy

All sectors of the Mediterranean Sea are affected by serious pollution. Of the southern Italian regions, the environmental situation in *Puglia*, which has coasts on the Adriatic and Ionian Seas, is critical.

The coastal strip of the Salento peninsula, the terminal sub-region of Puglia, increasingly behaves like a separate system in terms of the speed of its growth and the decreasing returns on its resources. While the depletion is currently unevenly distributed, there is a dangerous tendency towards generalisation. In addition, the whole of the Salento is affected by anthropic pressure from urbanisation, tourism, agriculture, industry and maritime transport, but the processes of pollution are most frequently seen to act in combination near the coast. An important role is played in these processes by the big industrial complexes of Brindisi and Taranto, whose impact on the environment, society, economy and landscape is dramatic. Ilva in Taranto and Enipower in Brindisi are among the biggest names on the 'black list' compiled by the EU as part of its register of pollutant emissions (Trono et al. 2009).

Ilva alone produces 70 % of Italy's and 10 % of Europe's carbon monoxide emissions from industrial activities. The air quality parameter values measured by stations in the area of Taranto, managed by Arpa Puglia, show that limits for several pollutants are persistently exceeded in locations close to the industrial zone and ILVA, with directional features and spikes that show a clear correlation with emissions of industrial origin. The epidemiological health data available for the population of the area at risk in Taranto show dramatically higher values than the region as a whole. The period 1997–2010 saw tumours increase by 10–11 %, again with a higher incidence than the regional as a whole.

In second position, in terms of damage to the environment and health is *Brindisi*, one of the most polluted areas in Europe, cited by the World Health Organisation as being at high environmental risk, where toxic fumes are responsible for the high number of children born with birth defects between 2001 and 2008, at rates about 18 % above the European average. The area is characterised by the presence of a large industrial estate that is highly destabilising from the environmental point of view, considering the disastrous effects of the fossil-fuel burning Cerano power station and its associated power lines, in addition to the chemicals plant, a 'monument' to environmental destruction with grave consequences for human health (Trono et al. 2009).

To the complex and multifaceted risks arising from the presence of large industrial plants may be added the dangers linked to various forms of human activity in the region, such as the production and management/disposal of special and urban waste.

Indeed, the Salento has numerous contaminated sites linked to decommissioned industrial plants, unauthorised rubbish dumps and the uncontrolled dumping of waste in rural areas. Small and medium-sized industrial companies (which were the pride of Puglia's regional economy in the 1990s although many of them have now closed) have had a severe impact on the environment: special waste has frequently been disposed of illegally, polluting the groundwater with inevitable consequences for the marine ecosystem. In addition to waters discharged directly into the ground or the sea, there is pollution arising from urban and agricultural activities, tourism and maritime transport.

Tourism also has a considerable impact on the coasts of the Salento (Trono 2005; Petrosillo et al. 2006). Mainly oriented to the beach resorts, it is highly seasonal. In the decade 2000–2010 it grew rapidly, accounting for half of tourism development in the Italian Mezzogiorno. For decades, demand has mainly been from the local and regional population. It has favoured the construction of holiday homes along the coast, exacerbating coastal erosion. The erosion index values of the main beaches range from 0 (Cesine) to 29 (Alimini), with most values between 7 and 14 (Associazion Verdi Ambiente e Società 2007, p. 45). Particularly serious is the situation of Casalabate (within the municipal boundary of Lecce; Trono 2009a, b, 2012; Elliott et al. 2010, 2014).

In an attempt to resolve the problems of coastal erosion, Puglia Regional Administration adopted a regional strategic plan, for which funding was allocated, to tackle the hydrogeological situation. As for coastal erosion, the local administration has made small compensation payments to the owners of lidos and sought to replenish the beaches with river sand.

18.5 Environmental Issues in the Coastal Zone (CZ) of Calabria

The CZ of Calabria has distinctive features and problems related to fragile and important habitats subject to anthropogenic pressures. Numerous marine reserves, Natura 2000 areas, Sites of Community Importance (SCIs) and Special Protection Areas (SPAs) are seriously threatened.

The entire coastal belt is subject to the following problems:

- Presence of sites contaminated by highly-toxic chemicals or radioactive materials
- Degradation of quality status (EQS) due to the lack of efficient waste water treatments plants (WWTPs)
- Coastal erosion

Big industrial centres near coastal areas have seriously damaged the quality of ecosystems, as in the case of Crotone. In this area the most significant environmental impact is attributable to three main sources, i.e. the decommissioned industrial sites of Pertusola, Fosfotec and Agricoltura (Barone et al. 2010). These were in operation from the 1920s to the 1990s. This area is included in the list of remediation sites of national interest set out in Decree 468/2001, encompassing an area of approximately 530 ha of land and 1452 ha of sea (including 132 ha in the port area), due to the high level of contamination, mainly by heavy metals, which affects both the soil and the groundwater (Barone et al. 2010).

There are numerous cases of pollution as the direct result of criminal activity, attributed to the so-called 'ecomafia', such as that of the ship 'Jolly Red' found mysteriously beached on the shores of Amantea in 1990. It caused chemical contamination with significant impact on both ecosystems and human health. In 2010, with the proliferation of tumours in the area, core samples were taken from the bottom of the River Oliva in the municipalities of Amantea, San Pietro in Amantea and Serra d' Aiello. It is estimated that 2000 t of industrial sludges containing cesium-137, beryllium, cobalt, copper, tin, mercury, zinc, manganese and vanadium were dumped into the River Oliva near Valle del Signore. It should be pointed out that near the town of Amantea is the 'Scogli dell' ISCA' Marine Park, which is protected due to the presence of an extensive and fragile Posidonia bed.

It is easy to see that the presence of chemical pollutants buried in the area near the coast is a very important determinant but no one has sought to relate the two.

The degradation of water qualitative status (WQS) due to the lack or inefficiency of WWTPs is the most common cause of the so-called 'Mare Sporco' (dirty sea) phenomenon, which results in 'Bad Qualitative Status' in many areas of high tourism potential, such as the city of Paola. The European Commission has begun infringement proceedings against Italy concerning the implementation of the Urban Waste Water Directive. The Calabria region is included in the list of areas requiring 'Urgent Intervention' drawn up by the Interministerial Committee for Economic Planning (CIPE).

Lastly, coastal erosion is linked to anthropic factors acting on the watershed level and in the coastal areas. The alteration of the shore line and the removal of sediments from rivers have a deep impact on the coastline. Concerning this problem, in 2013 the Basin Authority launched joint measures aimed at identifying the main problems on the basis of scientific data and preparing a master plan.

18.6 Case Studies

Among the case studies mentioned in the previous paragraphs the most important in terms of both urgency and extent are those related to industrial sites. Case studies should be performed in accordance with a multidisciplinary and integrated approach such as the driver-pressure-state-impact-response (DPSIR) framework. This paragraph will present only the driver-pressure (DP) analysis. The DPSIR approach, formerly developed by the Organisation for Economic Cooperation and Development (OECD; 1993) in pressure-state-response (PSR) form, is used to highlight the relationships between human activity and environmental degradation. It is based on the concept of causality: human activities exert pressures on the environment and change the quality and quantity of natural resources. Society responds to these changes through environmental, general and sector-specific policies, the latter forming a feedback loop to pressures through human activities (OECD 1993; EEA 1999).

Assessment of current pollution problems in the marine environment in relation to the social and economic drivers encompasses the following steps:

- Identification of the main contaminant categories included in available reports by the main agencies (United Nations Environment Programme (UNEP), European Environment Agency (EEA), regions, provinces, municipalities, etc.)
- Evaluation of data availability and data quality
- Identification of main driver categories responsible for chemical pollution in coastal case studies
- Assessment of pressures and their relative importance for marine pollution

The critical environmental issues potentially affecting the coasts can be analyzed by reconstructing the principle of causality. In accordance with the requirements set out in the regulations mentioned in the previous sections, a DP analysis was carried out and potential pressures on marine ecosystems were identified.

In Table 18.1, the emissions are divided into:

- Direct emissions
- Indirect emissions including atmospheric deposition

Starting from Table 18.1, it is possible to identify the biogeochemical cycle of each chemical pollutant, evaluating its impact and developing plausible socioeconomic scenarios (Trombino et al. 2005).

A decision support system (DSS) could be developed and used to choose cost effective strategies for each case study, defining both short-term and long-term strategies.

Table 18.1 DP analysis for case studies

Types of pressure	Drivers	Indicators
Direct emissions into waters (coastal and marine)	Industry	Industrial production/waste discharges Industrial production/accidental discharges
	Population and tourism	Urban waste treatment/waste discharges Lifestyle
	Transport	Maritime traffic/accidental discharges
	Energy	Energy production/waste discharges
	Legislation	Laws and regulations
Indirect emission into waters (through rivers and groundwater)	Industry	Industrial production/waste discharges Industrial production/accidental discharges
	Population and tourism	Urban traffic/urban run-off Urban waste treatment/waste discharges Lifestyle
	Agriculture	Agricultural production/use of pesticides and herbicides Agricultural production/use of fertilizers Livestock production/waste discharges
	Legislation	Laws and regulations
Atmospheric deposition	Industry	Industrial production/air emissions
	Population and tourism	Urban traffic/air emissions Lifestyle
	Agriculture	Agricultural production/use of pesticides and herbicides
	Transport	Land and maritime traffic/air emissions
	Environment	Volcanoes/degassing, eruptions fires/burning vegetation

18.7 Conclusions

The irresponsible use of natural resources is compounded by certain ignorance and an inability to weigh the risks of certain actions and manage the consequences, but an important role is also played by the limited information and the lack of any attempt to raise awareness among the local communities.

New models of modern environmental governance need to be developed using research-based tools and methods with a view to sustainable planning of the coastal environment. In order to succeed, the management and the responses to change driven by human activities need to be ‘ecologically sustainable; technologically feasible; economically viable; socially desirable/tolerable; legally permissible; administratively achievable; politically expedient; ethically defensible (morally correct); culturally inclusive; effectively communicable’ (Elliott 2013, p. 2).

The coastal management tools adopted should meet all of these criteria, working on a number of levels, i.e. involving citizens and institutions on a local, national and international level. Above all, the management should be sustainable, taking account of the following points of interest: recovery/respect for historical heritage; marine and coastal ecosystem functions that are threatened with extinction; the legal and administrative framework; economic prosperity and provision of social services; climate change.

Unfortunately, local organisations frequently seem to be distracted and absent. It is thus important to fully involve the local community, who need to be educated and made more aware and responsible (using deterrents where appropriate) regarding waste management and respect for the environment.

It is essential to achieve a balance between the needs of the environment and the power exerted by economic interests, which are frequently intertwined with those of politicians and their associates. Political action is fundamental, considering that environmental and pollution control measures depend on political goodwill in order to be effective, and we must make sure that external interests—of varying degrees of legality—do not restrict their field of operation. All this requires the sensitivity of stakeholders and public attention to environmental and ecological issues.

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Chapter 19
The Evaluation of Integrated Planning and Management Initiatives of Coastal Areas for Sustainable Development: The Case of Albania

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Abstract The environmentally sustainable development is becoming one of the basic goals for the interventions carried out in the Adriatic and Ionian areas in Albania. Integrated planning and management of these coastal areas are becoming the biggest tools in the implementation of sustainable development. The need for these tools has become a priority for Albania in all the programmes launched to point environmental degradation in the region. This chapter identifies these initiatives, outlines the lessons learned from these initiatives and identifies constrains at a regional level. The results of this chapter help to inform future promoters of other initiatives. This study also reports examples of integrated coastal management (ICM) initiatives that the Albanian government has undertaken and the outputs from these initiatives that promote sustainable development.

19.1 Introduction

There are a number of initiatives in the Mediterranean region which are focused on the achievement of sustainable development in coastal areas. These initiatives range from the national programmes and projects to bilateral and multilateral actions (METAP 1998). Since the year 1994 the international donor community and the nations bordering the Mediterranean are underlying the nature of environmental problems in the region and help to develop strategies at both national and regional levels to combat these problems (Atkins 2004). The majority of these projects and programmes are in the form of background studies and they focus on the management of Mediterranean coastal areas. In the last 20 years, Albania has suffered from problems of urbanization and industrialization especially in Durres city, which is the second largest city after the capital. Pollution is increasing from industries growing around the highway of this city. The urbanization and the rapid growth of tourism in Albania has brought social changes. The integrated coastal management initiatives are a priority in all the environmental projects that are being implemented. The latest European Union (EU) recommendation on integrated coastal zone management

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(ICZM) outlined the need for administrative bodies and legislation for sustainable development (Chapman 2005). But despite the variety of national programmes with partnership with other EU countries this initiatives remain voluntary from the government and society stakeholders. This chapter presents an analysis of the ICM initiatives in Albania through examining the process and how this process is contributing to sustainable development.

19.2 Methodology

The research used the approach of grounded theory. This aims to develop a framework of the processes and mechanisms that are used as ICM initiatives. This theory is a qualitative research method which uses the process of grouping together data and facts to explain the phenomena under study. The process used for the analysis of the integrated coastal and management areas initiatives was developed in two phases. In the first phase, the specific documentation for these initiatives in the region was analysed. In the second phase, a questionnaire was developed for the relevant authorities, public institutions and experts in this field. After these two phases, a framework was developed to identify the important dimensions in which the case study of Albania could be analysed and evaluated. The questionnaires had the objective to identify the national programmes for the evaluation of integrated coastal area management initiatives in the form of investment projects, the projects carried out from the Durres Port that helped to improve the sea water quality and the programmes that helped for the creation of the coastal area management policies. The feasibility dimension involved a detailed analysis which is explained below. The successes and the weakness of the programmes were identified. A distinction is done between components that are a result of a macrosituation or originate from the situation itself. The integration dimension is concerned with the level of participation of the Albanian government, the correlations between different sectors and administrative levels.

19.3 Analysis and Evaluation

In the region 15 interventions were identified. The projects were located in rural and urban areas. The nature of the projects were as follows: five of them had to do with pollution issues, four with biodiversity, four with tourism development and two with aspects of integrated management of coastal zones. Many of the objectives of the projects had to do with the improvement of Durres Port and the improvement of water quality. They were focused on the strength of the Albanian institutions and the building of capacities. The aforementioned are monitored during the TEN ECOPORT project period. Furthermore, much institutional information was analysed. Albania has started to create a legal context for coastal management.

The laws and regulations in Albania exist for these kinds of issues. An office that deals with these issues exists. The sources of finance come from the international community. Albanian institutions are not active in generating activities that are related to the coastal zone management. It is the international support that is offering assistance for these kinds of issues. The interventions that are made cover many objectives. They cover tourism development, coastal land development, water resources, biodiversity protection and pollution. All the initiatives start with many policies and objectives but at the end they do not give the expected results. These programmes do not propose instruments for an environmental education and do not propose regulatory, legal and economic policies. The interventions are oriented on the ground and involve practical levels. At the second phase, information from the institutions was analysed. Starting in 2013 Albania has started create a legal context for coastal zone management. Still we cannot draw conclusions about how effective these regulations are and how they should be implemented. One office exists for these kinds of issues. Albania is not able to find financial resources internally. The interventions that were identified supported the implementation of national coastal area management plans by increasing institutional capacity. Different cost-benefit mechanisms were proposed for sustainable development and different indicators were developed for the adaption of tools and techniques. The intervention aimed also to appropriate arrangements through institutions and governmental bodies and stakeholders. It was identified that many problems related to the treatment of water, especially the industrial waste waters, exist but this requires great investment. Interventions with this priority should be given in the future.

19.4 Conclusions

- ICAM initiatives in Albania are being used only for managerial purposes; the EU donors should also build mechanisms to generate results.
- Focus has been on the development of tourism in the last 10 years and not to the administrative human activities.
- Coastal management features in Albania focus mainly on the plans for the use of the land and on the strategies for the environment.
- Albania is developing an ICM from the existing policies and procedures in the coastal zone from 2012.
- The lack of a definitive property law in Albania leads to land-use conflicts in the last 10 years and for these reasons is not included in the management policies.
- For the biogeographic characteristics more coast initiatives are being undertaken in cooperation with the Italian government
- The Albanian government should find mechanisms to involve stakeholders in the planning and managing the coast.
- The creation of the appropriate jurisdiction, specific agencies will be suitable to reduce the bureaucracies and will lead to effective knowledge management.

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Part IV
Port Processes

Chapter 20
Evidence-Based Monitoring for Sustainable Development of Port and Chain Operations

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Abstract The aim of this chapter is to set the context of the evolution of the environmental management of port authority operations to the point where credible functional organization of their liabilities and responsibilities requires cognizance of their role in the logistic chain. Having established the role and status of the port in this integrated approach, the research focuses on the environmental performance indicators (EPIs) that may be monitored and reported as evidence of compliance and sustainable development.

The port sector has strived to ensure compliance with environmental legislation, protection of the habitats and ecosystems of the port area, and to deliver continuous improvement of overall environmental quality. The apparent dichotomy of view between the challenges of the commercial imperative and the environmental protection is, in fact, part of the same objective if sustainable development is to be achieved.

The port sector and its associated research partners have recognized for some time that it is essential to monitor progress of both the quality of environmental management and quality of the environment itself in order to identify trends, forewarn of problems, and to deliver unambiguous evidence of progress toward declared targets.

The chapter demonstrates the selection criteria, application and trends of selected EPIs, and summarizes the options for a more integrated approach to the

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environmental management of port and shipping operations bearing in mind the ubiquity of biological and ecological considerations for all aspects of the chain.

20.1 Introduction

Environmental issues play a vital role in the management of ports and the logistics chain. Port activities and services have impacts on water, sediment as well as air and soil, thus affecting both the marine and the terrestrial environment (Stojanovic et al. 2006). It is well known that worldwide environmental awareness is high and environmental laws and regulations, within the context of sustainability, are numerous and rapidly increasing in number and complexity. Effective environmental management is essential if stakeholders are to continue their support for port operations. Within this context, port authorities, as well as transport operators active in the logistic chain, are obliged to comply with these new institutional and legal frameworks, demonstrating continuous improvement as well as compliance per se.

It is now recognized that sustainable transport requires the development and implementation of environmental management systems (EMS) for purposes of compliance, cost and risk reduction. In addition, policy and management options rely heavily on substantive evidence from science-based quantified measures acquired through monitoring and reporting. Environmental performance indicators (EPIs) are fundamental components of a system supporting the effectiveness and success of an EMS, since EPIs provide evidence on how the port is performing and a science-based methodology to apply improvements and long-term strategies.

Important contributions to the establishment and recognition of EPIs have been made by the European Comission (EC) co-funded project Port Performance Indicators: Selection and Measurement (PPRISM; http://www.pprism.espo.be) and the EC project Clean Baltic Sea Shipping (http://www.clean-baltic-sea-shipping.com). The significant advances initiated by the American Association of Port Authorities with the Global Environment and Technology Foundation (http://www.getf.org) supporting up to ten public seaport authorities to develop and implement EMSs highlight the importance of EPIs in the day-to-day operation of this global sector. As a result of these and other initiatives, a significant number of European ports, as well as others in Oceania, North and Latin America, have implemented EMSs and have achieved internationally recognized accreditation, such as the Port Environmental Review System (PERS; Darbra et al. 2004a) and ISO 14001.

Many studies have highlighted that EPIs are often particular to individual ports as well as having a sector-wide applicability. This may be viewed as an apparent contradiction which needs further investigation by studying the wide range of port types in terms of their statutory duties, governance, operations and activities, liabilities and responsibilities. There is concern among academics and transport operators that, as environmental awareness is increasing throughout society, different worldwide approaches addressing environmental concerns result in an “uneven playing field” as far as the maritime industry is concerned, with differentiated costs and anticipated environmental results, influencing the competition between ports and companies operating in the logistic chain (Michail and Wooldridge 2008).

20.2 Policy to Practice

EPIs concern an organization's impacts on living and nonliving natural systems, including ecosystems, land, air, and water. EPIs can show clearly how the organization is performing and provide a firm basis for future targets and improvements. The main criteria used in selecting the appropriate indicators are environmental relevance, international comparability, and applicability of the information provided by the indicator (Wooldridge et al. 1999).

Nowadays, the burgeoning growth and impact of environmental directives and associated legislation is largely increasing while renewable energy and Carbon Footprint are becoming issues of priority for ports. In addition, ports have to demonstrate compliance and continuous improvement with substantive evidence from science-based quantified measures. A substantive number of European Sea Ports Organization (ESPO) ports have achieved recognized standards of EMS for purposes of compliance, cost, and risk reduction. This can be largely attributed to the long standing cooperation between ESPO and EcoPorts, the sector's most significant environmental initiative over the last 15 years. In this context, a growing number of ports are actively implementing appropriate standards such as PERS and ISO 14001.

In the recent research project PPRISM, referenced above, an initial list of 125 potential EPIs was reduced to 12 proposed indicators (PPRISM 2011). This followed assessment feedback, discussions, and advice from members of the ESPO Sustainable Development Committee and 289 port and marine professionals. The final proposal (see Table 20.1) identifies three quantitative measures, namely

Table 20.1 List of proposed indicators for port environmental management. (PPRISM 2011)

Operational indicators
Carbon footprint
Waste management
Water consumption
Management indicators
Environmental management system
Monitoring programme
Inventory of significant environmental aspects
Environmental policy
ESPO code of practice
Inventory of environmental legislation
Objectives and targets
Environmental training
Environmental report

carbon footprint, waste management, and water consumption; and nine qualitative measures of a port authority's capability to deliver effective environmental protection and sustainability through appropriate EMS.

20.3 Managing the Chain

It may be argued that the battle for hearts and minds in terms of the status of the environmental imperative and the aim of sustainable development has largely been won, and that the challenge now is to develop processes and methodologies that will actually deliver practicable and cost effective implementation of appropriate policies (Wooldridge et al. 2003). International legislation, government and company policies, and wide-ranging stakeholder pressure related to climate change, carbon emissions and energy use continue to drive the agenda along with the established objectives of compliance, and cost and risk reduction.

There can be no doubt as to the influence of burgeoning legislation in requiring profound changes in the functional organization of both individual companies and the chains within which they operate as they strive, not only to comply with such legislation, but to be seen to comply through demonstrably transparent reporting of performance and evidence of the credibility of their control systems. The whole task of environmental management has evolved from site-specific, localised concerns to a more integrated overview where the interests of employees and local communities must incorporate area and regional perspectives, and even be set within the context of the complex that is the global logistic chain. Environmental programmes have developed through a wide range of initiatives ranging from proactive actions by individual companies and industries, input from government departments and non-governmental organizations, and networked enterprise by sectors of the transport chain.

As a major node in the transport chain, the port sector has an exemplary record over the last 15 years of delivering appropriate tools and methodologies through collaborative research and development projects predicated on the free exchange of knowledge and experience throughout the sector. The development of preliminary tools (Self Diagnosis Methodology; Darbra et al. 2004b), the specification of a standard for a certificated review system (Port Environmental Review System), the adoption of the ESPO's Code of Practice, and the publishing of sector, benchmark performance indicators (ESPO Review) all demonstrate the positive actions of such bodies as the EcoPorts Foundation (EPF) and ESPO. The value of the exchange of experience and information between port authorities and the contribution from a wide range of other professional associations, academic institutions and consultancy companies confirm the port sector's credentials to deliver compliance with environmental legislation through voluntary, self-regulation.

The development of a systems approach is reflected in recent European Directives and the policies associated with them (Wooldridge et al. 1998). There is widening agreement that the benefits of collaboration, cooperation, and integration throughout the chain are optimized in terms of costs and environment impact if public and private companies in ports and transport no longer seek optimization only for their own organization. If these organizations cooperate closely in a goods transport network or logistic chain approach, these effects are mutually enhanced. For example, cost reductions of up to 40 % per container and CO_2 reductions of up to 80 % per container are reported. Additional benefits include improved security, greater transparency of performance and better communication of knowledge and experience between participants. Here, the significant role of information flow and technology can combine to reduce errors and increase efficiency throughout the chain—subject to collaboration.

The stimulus of legislation in Europe can be seen in the effect of such provisions as the General Food Law that aims at food safety in the whole transport chain from seeds in the land to final product in the retail shops. It requires each link in a chain to know the transport and product details of each link before and after its own position. The necessity of a chain approach is witnessed also by the requirement for digital documentation and 24/7 transparency of the condition of the food in the chain. Similarly, the Environmental Liability Directive (2004) makes each participant in a chain liable for its environmental effects. In the case of port authorities, this can pose a high financial risk as they are required to take immediate action in the event of incidents and accidents that may be complex because of the range of operators and tenants within the port area. Environmental performance and risk assessment are factored into insurance premiums and so again, the benefits of cooperation within the chain may yield financial advantage to mutual satisfaction. Customs laws such as the Green Lane with the authorized economic operator (AEO) approach also encourage integration of effort and organization. The requirement for all links in the transport chain to deliver certain minimum qualities of transparency and management with appropriate IT and electronic information is a strong incentive for a chain approach where it also brings financial advantages.

In the White Paper "Environmental Transport Policy for 2010: time to decide," the European Commission again draws attention to the major environmental impact of goods transport in terms of CO_2 and energy use. It announces new policies aimed at addressing the balance of further growth in transport with the need to deal with the potential negative environmental impacts of such developments. In these new policies, the EC also chooses a logistic chain and logistic networks approach. A key role is identified for seaports and inland ports in organizing hinterland logistics. A number of seaports already see sustainable hinterland transport connections as a key driver of their business opportunities. Several ports are already active in investing in inland hubs and new connections by environmentally friendly transport modes, such as inland barges, trains and short sea shipping. New models of public and private cooperation are developing and some of the larger ports are active investors in their hinterland infrastructure, port area and logistic networks.

Once the concept of environmental management of the logistic chain is accepted by key players, then an iterative process of development and implementation is required in order to deliver the common aims and objectives. The established protocol of initially raising awareness of the potential and benefits followed by the establishment of a database of shared knowledge, experience and best practice through networked communication can launch a programme of collaboration based on phased development at a selected pace of development. The system evolves further through monitoring and review procedures—a typical approach adopted for both quality and risk management systems. The experience of the EPF in implementing the PERS system demonstrates the benefits of a step-by-step approach that draws on existing levels of information and capability and so allays the concerns of potential participants that the cost and complexity of such environmental management programmes is too much. The fact that 50 port authorities are now certificated under the scheme after independent review by Lloyd's Register is a strong endorsement of both the approach and the sector's ability to deliver credible self-regulation.

This sequential approach has been adopted by the StratMoS project (http://www.Stratmos.no) the core aim of which is to promote and facilitate shift of cargo from road to sea-based intermodal transport, and improve accessibility within the North Sea Region by supporting the implementation of Motorway of the Sea (MoS) and related transport networks in an integrated logistic chain. The project comprises 29 partners, covering the North Sea Region from Flanders in the south to Finnmark in Norway in the north. The Murmansk, Arkhangelsk and Nenets regions in Russia are associated partners. The partners are public entities, associations and private companies. Within the project, a new logistic concept is being developed to integrate all relevant parties including terminals in seaports and inland ports, industrial estates on waterways, inland shipping companies, trucking companies and shippers in a dedicated, chain-based system for a sustainable hinterland transport system. Similar tools to SDM and PERS are currently being developed for the logistic chain by ECO SLC.

When an auditor inspects the environmental credentials of a company or sector for purposes of certification of standard of environmental management, their key request is often "show me the evidence." An effective response is to prepare a dashboard of key performance indicators (KPIs). A dashboard is an easy-to-read (virtual) textual or graphical representation of a limited number of performance indicators that summarizes data relating to the monitoring of trends of significant aspects, delivers key information to a wide range of stakeholders, and enables users to interpret and understand sector performance at-a-glance. The information is directly linked to policy objectives. The EC project PPRISM (pprism@espo.be) identified a set of accessible and feasible port performance indicators to be implemented at EU level in order to measure and assess the impact of the European Port System on society, environment and economy. In concept, the "dashboard" will demonstrate details of selected KPIs that will be of value to a wide range of stakeholders. The research project Port Observatory for Performance Indicator Analysis (PORTOPIA; http://www.portopia.eu/) is currently compiling relevant data and demonstration technology.

Sustainability is here to stay as a key driver in policies of governments and companies. Managing the transport of goods in a sustainable fashion is a high priority now and for the future in an attempt to limit CO_2 production and energy use for transport (Wooldridge et al. 2008). It is expected that a collaborative, systems approach will deliver the best results and that evidence of compliance and indication of progress toward continuous improvement of environmental quality will be essential requirements. Research-based results suggest that the sectors and chain have the capability to deliver effective management systems.

20.4 Conclusions

This research has shown that it is timely and topical to identify, select, monitor, and report KPIs to assist in the management of port and shipping environmental management. It has been shown that the shipping and port industry are ready and willing to develop further the culture of science-based monitoring and to apply appropriate techniques to assist in controlling maritime pollution. However, it must be kept in mind that these KPIs must be practicable, cost- and time-effective, and capable of transparent and unambiguous interpretation in order to be incorporated in the management of these enterprises.

The indicators presented here are also based on physical and biogeochemical parameters that can be monitored and be effective components of the environmental management system, since science-based evidence is of increasing importance in demonstrating compliance, achieving standards, forewarning of problems and prevention and reduction of risks. The port sector in Europe is well-placed in terms of culture, data, information, and networking to develop further the notion of an observatory and dashboard to demonstrate the results from selected KPIs.

Finally, the port sector's declared policy of voluntary self-regulation will be supported by this research as it seems to have a significant impact on the development of port strategy in terms of environmental management policy options.

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Chapter 21
The Progressive Regulation of the Passage of Large Cruise Ships in Venice: The Decision-Making Proceedings Between Law and Stakeholder Pressure

Marco Casagrande

L'enfer est plein de bonnes volontés et désirs
St. Bernard of Clairvaux

Abstract We all tend to examine the legal rules applying to the sea, the coast and the seaports without worrying about how those rules are adopted. The importance of the decision-making proceedings is highlighted by the case of the passage of large cruise ships in Venice, an issue so delicate under many respects that it is requiring a progressive regulation. The observation of how the rules are being tentatively adopted raises some interesting questions. In the contemporary globalized world, which should be the level and the latitude of stakeholder consultation? And which is the relationship between stakeholder consultation and decision-making?

21.1 Venice from the Deck of a Cruise Ship

"Gondolas and canals. Romance and intrigue. Venice has it all. But to view this magical place from the deck of a cruise ship is a special and unique experience," writes Sherry Laskin (2003) on Cruise Maven, her cruise travel webzine (www.cruisemaven.com). The article is complete with a photograph of St. Mark Square taken from a deck. Indeed if you reach Venice by cruise ship, you will pass just in front of the famous square before entering the Giudecca Channel and reaching the Maritime Station, from where you can take a tour of the city.

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Sh. Laskin (2003) dutifully adds that “conservation groups are trying to ban the behemoths, citing erosion and pollution as the two main reasons.” The possibility of an accident is also cited, especially after the Costa Concordia disaster (BBC 2013).

But there are also less practical, more idealistic reasons. The cruise ships traveling within Venice are perceived by some as the embodiment of mass tourism, which is accused of depopulating and even slowly destroying Venice. For example, this is the position expressed by the Venice branch of the NGO Italia Nostra in a statement by Vice-President Paolo Lanapoppi (2013).

According to the local Accountants’ Bar, 14.5 million people visited Venice in 2012. According to the Historical Series published by the Statistics and Research Service of the Municipality (Servizio Statistica e Ricerca—Comune di Venezia 2013), the population of the city sank from 174,808 in 1951 to 58,991 in 2011, although it is questionable that this is due to tourism.

The opposition to cruise ships in Venice is far from unanimous, however. To defend their passage, the Cruise Venice Committee was established. The committee represents mainly the business sector, but a sizable pro-ships movement exists in the public, too.

The more compelling argument in a country still engulfed in a deep crisis is probably the economic one. The cruise ships pour large amounts of money in the city in terms of port fees, port services and tourists disembarking and visiting the city.

But this is not the only factor.

The perception of danger—it is contended—is emotional and instinctual rather than founded. Every cruise ship traveling within Venice is towed by local towing ships and assisted in its pilotage by two local pilots, a higher standard than usual. In Italian waters, safety is in the hands of the Maritime Authority, a role which is attributed to the navy, a military corps used to apply strict rules and standards without tempering them with any economical or commercial consideration. Moreover, the Venice Lagoon has a sand seabed which would largely mitigate the consequence of any accident.

The pollution issue was addressed, too. In 2013 the Municipality of Venice, the Venice Port Authority, the Venice Harbormaster’s Office and the cruise companies concluded the Blue Flag II agreement, obliging the cruise ships to use only green fuel while traveling within the Lagoon (Portavoce—Città di Venezia 2013).

Finally, the cruise ships do not follow the current route just for the view: it is simply the only possible route. The Venice Lagoon has an incredibly low depth (Portolando 2006) and the Giudecca Channel is the only safe route for large ships. Therefore, overzealous advocates of maritime safety could actually be putting the passengers of cruise ships in danger.

21.2 The Costa Concordia Disaster and the Clini-Passera Decree

The 2012 Costa Concordia disaster prompted the Italian Government to finally take a stand in the controversy with the enactment of the Clini-Passera Decree[1], also known as the "no bow Decree."[2]

The Decree is an administrative act, not a legislative one or even a regulation. It was enacted pursuant to article 83 of the Navigation Code[3], according to which "the Minister of Transportation and of Navigation can limit or forbid the passage and the stop of merchant ships in the territorial sea for reasons of public security and of safety of the navigation and, with the consent of the Minister of the Environment, also for the protection of the marine environment, identifying the zones covered by the prohibition."[4]

On a first look, the Decree seems to express a clear-cut orientation by stating: "The use of the St. Mark Channel and of the Giudecca Channel is forbidden to ships transporting goods and passengers having a gross tonnage over 40,000 tons."[5]

However, that would have meant forbidding the entire Lagoon to cruise ships, since the Giudecca Channel is the only route they can follow. Therefore, a transitional clause in the Decree stipulates that the prohibition will become binding only "as soon as alternative safe navigation routes are available as identified by the Maritime Authority by its decision. Pending such availability the Maritime Authority, in agreement with the Magistrate for Venetian Waters[6] and the Port Authority, will adopt measures aimed at mitigating the risks deriving from the transitional regime pursuing the highest level of protection of the Lagoon environment."[7]

[1] Decree of 2 March 2012, published in the Official Journal of the Italian Republic n. 56 of 7 March 2012. The Decree was enacted by the Minister of the Infrastructures and of Transportation (Mr Corrado Clini) with the consent of the Minister of the Environment, for the Protection of Territory and of the Sea (Mr Corrado Passera).

[2] In Italian nautical language an "inchino" (bow) is a maneuver at a very short distance from the coast. A bow, which is considered a demonstration of ability by the pilot of the ship, was probably the ultimate cause of the Costa Concordia disaster.

[3] Enacted by Royal Decree n. 327 of 30 March 1942, published in the Official Journal of the Kingdom of Italy n. 93 of 18 April 1942.

[4] All the translations are unofficial translations by the author.

[5] Art. 2, par. 1, lett. b), n. 1.

[6] Established by the most serene Republic of Venice, the Magistrate for Venetian Waters is a public entity existing in Venice only. It is tasked with vigilating over the waters of the Lagoon as well as the land works serving them. It was reestablished with the Law n. 257 of 5 May 1907, published in the Official Journal of the Kingdom of Italy n. 122 of 24 May 1907.

[7] Art. 3.

21.3 Administrative Proceedings and Stakeholders' Involvement: The Italian Practice

Apparently, the transitional clause of the Clini-Passera Decree delineates a very simple and quick administrative proceeding (especially, one may add, by Italian standards[8]). An alternative in the Venice Lagoon is identified with a decision of the Maritime Authority, id est the Venice Harbormaster's Office; with the entry into force of that decision, cruise ships over 40,000 t are forbidden from using the Giudecca Channel.

This appearance of simplicity is deceptive, however. In line with international and European standards, the Italian administrative law obliges the civil service to involve stakeholders in decision-making proceedings[9].

But the Italian administrative practice tends to transform the right to be consulted into a veto power, and thus into a share of the decision-making power. This is due to formal as well as material reasons[10].

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[8] OECD 2010, p. 84: "Excessive administrative burdens stemming from bureaucratic methods are one of the first reasons for the competitive disadvantage of Italy within the European context and in the entire OECD area." The European Commission has estimated that the administrative costs burdening Italian enterprises amount to 4.6 % of GDP.

[9] See Law n. 241 of 7 August 1990, published in the Official Journal of the Italian Republic n. 192 of 18 August 1990, also known as "Law on Civil Service," "Law on the Transparence of the Civil Service," or "Law on Administrative Proceedings". Art. 7, par. 1 states: "Unless there are impeditive reasons deriving from a particular need for celerity, the start of a proceeding is communicated… to the subjects on which the final decision will bear direct effects and to the subjects which are legally entitled to intervene in the proceeding. Unless there are the said impeditive reasons, whenever a proceeding can cause any prejudice to known or easily identifiable subjects, the Administration must equally inform those subject of the start of the proceeding". Art. 9 adds: "Any subject which is the bearer of public or private interests, as well as the bearers of collective interests organized in associations or committees, which can suffer a prejudice as a consequence of the proceeding, are entitled to intervene in the proceeding." All of these subjects are entitled to "access the records of the proceeding" and to "file written pleas and documents which must be evaluated by the Administration as long as they are relevant for the proceeding" (art. 10).

[10] While this article is primarily focused on administrative law, one can't help but outline the features which, in the formal and material constitutions once or currently existing in Italy, favored a horizontal/contractual conception of power rather than a vertical/hierarchical one. The Italian State was born in 1861 from the annexion of the Peninsula by Piedmont-Sardinia. The annexed territories, in particular the Central and Southern ones, had been ruled for centuries by States which had tried to preserve the ancient feudal law, in which the public authority was allocated by a contract between the Crown and the notables rather than hierarchically by the law. The Italian Government tried forcefully to reverse this trend, among the other things enacting the famous Unification Law or Lanza Law (Law n. 2248 of 20 March 1865, published in the Official Journal of the Kingdom of Italy of 27 April 1865). However, the transition was too brusque, and thus largely unsuccessful: thus only in 1923, under the fascist regime, a unified Italian Supreme Court was established, replacing five different High Courts sitting in Turin, Florence, Rome, Naples and Palermo. The fascist regime itself was nominally based on the corporative law, which claimed to be a codification of the social contract between the different classes, in contrast with the rigid hierarchy that is usually associated with that political ideology. After the fall of fascism, the current Italian Constitution was drafted to encourage the development of consensus rather than of strong hierarchical

First of all, in Italy the concurrence of a decision-making power by different authorities on the very same issue is the rule rather than the exception, so much that a legal tool called "Conference of Services" was introduced to speed up decisional proceedings[11]. However, in an implicit recognition that even authorities without a decision-making power on the issue will usually interfere with the final decision, the law allows the conference to be established "whenever it is expedient to make a contextual examination of different public interests involved in an administrative proceeding."[12]

Moreover, the Italian administrative justice system will induce the decision maker to ensure that nearly everyone involved agrees with its decision. In fact, the Italian administrative justice system is often described as "impugnatorio," which could be translated as "annulment-centered." This means that typically your request to the Administrative Court will be to quash the decision adopted by the public authority[13]. Since the Italian administrative law is extremely complicated[14], and the public administration is required not only to respect it, but also to act pursuant to it[15], you will often obtain your annulment[16]. Under some conditions the annul-

authorities. Formally, the executive power was vested in a strictly collegial Cabinet, with the Prime Minister as a primus inter pares. Materially, a proportional electoral system was adopted, forcing any Government to ensure the support of a broad coalition of political parties.

[11] The Conference of Services is regulated by articles 14–14-quinquies of Law 241/1990. The Conference is essentially a formal meeting of the public Authorities involved in a given issue. The decision-making power of the Authorities invited to attend is thus transferred to the Conference which will adopt a unified decision after a majority vote. However, some privileged Authorities (such as, for example, Health Authorities) yield a veto power which, if exercised, will force the presiding authority to submit the issue to the Cabinet. The Conference must be established whenever there are concurrent decision-making powers on the same issue.

[12] Art. 14, par. 1 of Law 241/1990.

[13] This configuration, which has its roots in the nineteenth century, should guarantee the separation of powers, in particular the separation between executive-administrative and jurisdictional power, safeguarding the so-called "administration reserve." Therefore, an Administrative Court cannot order the Public Administration to take a given stance, it can only annul its decision thus indirectly forcing it to take a new one. While this was tempered by the more recent jurisprudence and legislation, the traditional framework is still strong both in the positive law and in the judicial culture and practice.

[14] A Ministry of Simplification exists in Italy. It is tasked with trying to make legislation and administrative practices less complex. A former Ministry for Legal Simplification, now absorbed in the Prime Minister's Office, claims the adoption of at least five "law-cutting laws" and the abrogation of 7000 laws. Data retrieved from Unità per la Semplificazione e la qualità della Regolazione—Governo italiano 2014.

[15] This means that it is not enough for the Public Administration not to violate the law: it must prove that it acted only pursuing the aims of the norms it applies.

[16] According to statistics published by the Venice Administrative Court, a little less than one request in three is granted: see Tribunale Amministrativo Regionale per il Veneto 2011. However, if your request is not granted, you can still appeal to the State Council (the Italian Supreme Administrative Court). Moreover, the same decision can be challenged more than once, and the proceedings on a given issue will usually involve more than one decision. Finally, if you lose you will bear no consequences but the payment of legal taxes and expenses; but this is not a problem if the challenger is another public Authority using public money.

ment will entail an obligation for the decision-making authority to indemnify the subject who challenged the decision, and the officers adopting such decision could be held responsible and subject to disciplinary or accounting proceedings. Finally, the appointments and promotions of involved officers will themselves depend on proceedings involving different authorities[17].

From all this descends that the decision-making authority will try its best to build the broadest consensus possible over its decision.

This approach can look commendable, but it has two seriously negative sides:

a. When no consensus is reached, which happens more often than not, the decision is postponed indefinitely.
b. The legal rules attributing the decision-making power to a given authority are de facto ignored, thus weakening the rule of law and making decisional proceedings more informal and less transparent.

There is little doubt, therefore, that the Italian administrative practice should be evaluated negatively. At best, it can be recognized that—in rare and exceptional cases—it can lead to shared and supported decisions.

Now it remains to be seen if the case of the large cruise ships in Venice was one of this exceptions. Indeed, taking into account the delicateness of the issue and of the balance of interests involved, this could be one of those rare cases in which the Italian cautious and nearly diplomacy-based approach proves rewarding.

21.4 The Italian Practice and the Venice Case

As said before, the Clini-Passera Decree attributes to the Maritime Authority the ultimate power to identify the alternative route that the large cruise ships will have to follow in the Venice Lagoon. The Maritime Authority in Venice is the Maritime Director (Harbormaster) of Venice, who is an officer of the Harbormaster's Offices Corps—Coast Guard. The Corps administratively is a branch of the Italian Navy,

[17] For example, pursuant to the Italian Port Law (Law n. 84 of 28 January 1994, published in the Official Journal of the Italian Republic n. 28 of 4 February 1994), the President of a Port Authority is appointed "by Decree of the Minister of Transport, with the consent of the interested Region, choosing between three experts with the highest proven professional qualifications in the sectors of transport economics and port economics proposed by the Province, the Municipalities and the Chambers of Commerce… if in 30 days the consent of the interested Regions is not obtained, the Minister of Transport shall appoint a candidate chosen between three nominee of the President of the Regional Government, taking into account the suggestions of local Governments and Chambers of Commerce. If the President of the Regional Government does not designate his nominees in thirty days from the ministerial request, the Minister shall ask the Prime Minister to submit the issue to the Cabinet, which will decide by a motivated decision" (art. 8). The Port Authority Secretary General is appointed by the Port Committee with the advice and consent of the Port Authority President (art. 10). The Port Committee, in turn, includes representatives of the Harbormaster's Office, the Customs, the Public Works Office, the Region, the Province, the Municipalities, the Chambers of Commerce, the shipowners, the factory owners, the terminal operators, the dock workers, the couriers, the agents and the land transport companies (art. 9).

but functionally it answers to the Ministry of Transport, the Ministry of Environment, the Ministry of Agriculture or other Ministries according to the specific function fulfilled (safety of navigation, marine environment protection, fishery control, etc.).

After the Costa Concordia disaster, the option chosen by the Ministers was clearly signaling the will to reach a quick, clear-cut decision: only one decision-maker, belonging to the Military Administration.

However, coherently with Italian practice this trend soon changed with the involvement of the "Venice Super-Committee," id est the Committee for the Safeguard of Venice. Established by the special legislation for the safeguard of the city[18], the Super-Committee is supposed to coordinate and direct exclusively the fulfillment by the various authorities of the various functions attributed to them by the special legislation, which in no way regulates navigation, but is essentially a landscape and urban planning instrument. However, since the super-committee conveniently includes the most influential authorities at the national and local level[19], it was instead involved in the follow-up to the Clini-Passera Decree.

Predictably, the proceedings slowed down without reaching any decision, not even the very preliminary one on where to excavate the new channel to be used by large cruise ships[20]. The Clini-Passera Decree was enacted at the beginning of 2012.

In the night between 7 and 8 May 2013 the Italian ship Jolly Nero, despite being towed by two towing vessels, hit the pilots' tower of the port of Genoa, killing nine people and adding further pressure on the authorities.

On 5 December 2013, the Maritime Director of Venice, acting on orders by the Ministry of Transport, unilaterally ruled that "the Contorta-Sant'Angelo Channel, a ramification of the Malamocco Channel, as represented in the enclosed chart, which, on the basis of the project documents currently drafted, has the technical-nautical characteristics required to reach the necessary level of safety and ensure the compatibility with the exigencies of commercial navigation in the port of Venice, is hereby identified as the practicable route in alternative to the forbidden ones for ships having a gross ton of more than 40,000 G.T., id est the St. Mark Channel and the Giudecca Channel."[21] This decision automatically triggered the Clini-Passera

[18] Law n. 171 of 16 April 1973, published in the Official Journal of the Italian Republic n. 117 of 8 May 1973; Law n. 798 of 29 November 1984, published in the Official Journal of the Italian Republic n. 332 of 3 December 1984.

[19] After various modifications, the Committee is currently composed by the Prime Minister's Office (acting as Presidency), the Ministry of Transport, the Ministry of Environment, the Ministry of Culture, the Ministry of Education, the Veneto Region, the Province of Venice, the Municipality of Venice, the Municipality of Chioggia, the Municipality of Cavallino-Treporti and other two Municipalities of the Lagoon. The Magistrate for Venetian Waters acts as secretary.

[20] After that, obviously, the channel will have to be projected, then the project will need all the required clearances and finally the channel will have to be excavated and tried. Only then the Clini-Passera Decree will produce its full effects.

[21] Harbormaster's Office Decree n. 472 of 5 December 2013. The motivation of the Decree quotes a "dispatch" from the Minister of Transport "inviting" the Harbormaster's Office to adopt the act. Since it is a Military Administration, the Office regards similar directives as strictly binding.

Decree prohibitions, despite the obvious fact that the new route had been "identified" on paper only, and was not ready yet. Predictably, therefore, the decision was challenged in the Venice Administrative Court, which promptly suspended it[22]. However, the interested cruise companies announced that they will respect the limits set by the Harbormaster's Office anyway (Vitucci 2014a), therefore, until the Administrative Court issues its final judgment, the Maritime Authority decision will stand as a soft law instrument.

However, the Maritime Authority decision is itself provisional, since it appears that an alternative route different than the Contorta-Sant'Angelo Channel could be chosen. The stakeholders are still heatedly discussing on which authority should take the final decision. The Clini-Passera Decree, as said above, attributes the decision-making power to the Maritime Authority, but the Municipality of Venice still insists that the "Venice Super-Committee" is instead competent (Vitucci 2014b).

21.5 A Balance: Too Many Decision-Makers, Not Enough Stakeholders

At the end of the third paragraph of this article, I presented some aspects of the Italian decision-making practice which are at odds with the rule of law, particularly in light of their disregard for the legal allocation of competencies. I also added that the Venice case, due to its extreme delicateness, could be a rare example of fitness of the Italian claudo pede approach. In the end, however, the examination of its practical results does not appear to allow even this consolation.

Indeed the Italian over-inclusive practice led to unacceptably long proceedings, which in turn produced—as a reaction—sudden episodes of rushed decision-making, in disregard with the rule of law and throwing away the cooperation between stakeholders so carefully and painfully built in the previous stages. Summing it up, it is a schizophrenic build-and-destroy method that not only deviates from legal standards, but does not even meet any criterion of expediency or common sense.

[22] Order n. 178 of 17 March 2014, case n. 146/2014, Venezia Terminal Passeggeri s.p.a. v. Ministry of Transport, Prime Minister's Office, Ministry of Environment, Harbormaster's Office, Venice Port Authority, Magistrate for Venetian Waters and Ministry of Defense, with the intervention ad opponendum of the Municipality of Venice. In the motivation of the Order the Court states: "The said limitations [to the passage of ships within Venice], while being officially disposed pursuant to Interministerial Decree n. 79/2012 [the Clini-Passera Decree], are established in absence of the specific condition required for their adoption, since the effects of the prohibition to pass in the St. Mark Channel and in the Giudecca Channel for ships carrying goods or passengers exceeding a gross tonnage of 40,000 tons (see art. 2, par. 1, lett. b) of the aforementioned Decree 79/2012) is thereby expressly subordinated to the availability of alternative safe navigation routes, as identified by the Maritime Authority by its decision (see art. 3, par. 1 of the aforementioned Decree, which no concrete guideline can indeed be found). The measures under scrutiny are therefore contrary to the specific principle of graduation established by Decree n. 79/2012."

It does not even reach its basic objective of getting the broadest picture possible of the stakeholders' positions and interests: in fact, the Venice case has received indeed a very narrow and limited consideration. It is considered essentially a problem of the city as an urban community represented by the municipality, as a seaport represented by the Maritime and Port Authority and as a world heritage site represented by the central Government[23].

Instead the problem involves, at least, the whole Venetian region, whose hinterland enterprises supply the cruise ships using the Venice port: and, in fact, the regional and provincial administration took part in the decision-making proceedings. However, other obvious stakeholders like the cruise companies and the port operators were involved at a far less institutional level, raising legitimate doubts about the real weight given to their contributions and ignoring the principle of impartiality of the public administration[24].

Moreover, it is equally obvious that the Venice port is part of the Adriatic cluster, of the European ports network and of the world maritime transport market; and yet no North Adriatic port, no European Institution or Agency and no international commercial body took any substantial part in the decision-making proceedings. Unfortunately, one may add, since the Italian administrative law and practice would gain some benefit from the adaptation to at least some principles of lex mercatoria, which is more attentive to transparency and legal clearness and to the protection of the investor: in this case, foreign investors like terminal operators, essential for Venice to be part of the world market.

In conclusion, administrative proceedings having an impact far exceeding their local context should receive EU-wide publicity, in analogy with major public procurement procedures. A wider basin of stakeholders will be only healthy and beneficial, as long as it is clearly established who the decision-maker is. The Venice case suggests that a broader outlook is not necessarily confusing, but on the contrary can make clearer where the decision-making authority should be allocated.

In fact, a more open approach is also a comparative approach, and everywhere in the world maritime navigation is regulated and managed by dedicated Maritime Authorities, while seaports are regulated and managed by dedicated Port Authorities, for obvious reasons. Navigation and seaports are highly specialized and technical sectors, as well as cultural communities.

Seaports, in particular, have a recognized specificity (ESPO 2013). That is why they are usually managed by local Port Authorities and why Maritime Authori-

[23] Venice and its Lagoon are included in the UNESCO World Heritage List: see UNESCO 2014. UNESCO maintains a permanent Office in Venice, and it petitioned the Italian Government for limitation to the passage of large ships in Venice and in the Lagoon: see UNRIC—Centro Regionale di Informazioni delle Nazioni Unite 2014. However, in the decision-making process the Italian central Government played a more visible role than UNESCO in protecting the Venetian cultural heritage, in the framework of its exclusive competence to maintain foreign relations (art. 117, par. 2, lett. a) of the Italian Constitution) and protect the cultural heritage (art. 117, par. 2, lett. s) of the Italian Constitution).

[24] Pursuant to art. 97, par. 2 of the Italian Constitution "the public offices are organized according to the legal norms, so to ensure a good and impartial public administration."

ties, when interfacing with ports, do so by means of a dedicated liaison organ, the Harbormaster's Office. Unsurprisingly, this is exactly where the decision-making power was allocated by the applicable Italian law, id est the Clini-Passera Decree. A strict adherence to the norms without interferences or distortions would have been enough to reach a solution perfectly in line with international standards, practices and principles, as well as with common sense and expediency.

One could reply that, if seaports have their specificity, Venice has its uniqueness, which makes this case different from any ordinary regulatory issue. However, the recognition of the appropriate competences to a public entity—in this case the Maritime and Port Authority—does not mean that it should become sovereign and independent. If superior interests become relevant which are not properly protected by the ordinarily competent Authority, a superior one will be entitled to intervene. In 2006, the Congress of the USA lobbied the United Arab Emirates public terminal operator Dubai Ports World into renouncing to its right to operate several terminals in US ports on grounds of security. It was a controversial and much criticized stance, taken by the Congress against the executive branch of the Government of the USA, but it proves that the specificity of the port and maritime sectors does not make them self-contained.

In the case of Venice, it would be ungenerous to rule out that the Maritime and Port Authority, if left free to act according to the law, would have had the sensitivity to protect their own city of Venice; and indeed, in more than one occasion the maritime and port stakeholders were wise enough to unilaterally shelter the city by adopting soft law rules where an opaque—if perhaps well-intentioned—application of the law had failed.

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Chapter 22
The Strategic Role of Port Community Systems for enhancing Business Operations and Productivity: The Case of the Port Authority of Igoumenitsa

Konstantinos Grinias, Eleftherios Iakovou, Dimitrios Vlachos, Arrianos Gkikas, George Tsoukos and Apostolos Bizakis

Abstract The implementation of "single window" IT systems in port management is a widely accepted practice that is being met with an ever-increasing popularity worldwide. This work is motivated by the results of an Adriatic Port Community (APC) project, in which Igoumenitsa Port Authority, along with two other ports, designed and developed a number of modules toward a single window IT system. The project represents a first effort toward the implementation of a full scale IT system and started with the analysis of each port's procedures and unique characteristics. Moreover, the ports' processes and critical issues were identified through interviews with their stakeholders using appropriately designed questionnaires.

In this manuscript we describe the design and implementation of a Port Community System (PCS) in Igoumenitsa and demonstrate its interoperability with respective systems in ports of the Adriatic for the creation of a "single window." The central theme in this effort is the improvement of the provided value-added services to the customers of the port. Moreover, the system was designed for an easy adoption of European directives and regulations in the maritime sector, as well as for a more efficient movement of goods and passengers through the respective ports.

The design of the PCS was based on a service-oriented architecture (SOA), integrating all the benefits during the development phase and enabling the possibilities to meet future needs. Finally, modern practices were used to ensure

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interoperability (web services, XML) and communication with external systems and the single window.

The developed PCS includes applications for the effective management of the arrival and departure of ships, customs clearance of imported/exported goods, reservation of parking spaces within the port area, as well as a solution for complete visibility of port's operations.

22.1 Introduction

Optimum performance in operations of a port can be significantly enhanced by introducing information and communication technologies (ICT) for improved organization of port operations, particularly through smart Port Community Systems (PCS), capable of improving interconnection among the various stakeholders and port management. The e-Maritime initiative of the EU, aims to further promote the use of advanced ICT in the field of maritime transport. The initiative takes into account the fact that several systems have been developed in the last years in different European ports.

Since each port has its own characteristics, exchange of data between them is practically impossible. Therefore, the limited interoperability of these systems should be addressed to drastically reduce the need of introducing the same data in different systems across Europe.

The European Commission has also expressed its preference in the development of technologies based on "single window" methodologies. Therefore, port operational processes such as, management of clearing manifests and inspections by port authorities or exchanging docking information between the ship and the harbor master, etc. are encouraged to be performed by "integrated single window IT systems."

The chapter examines the implementation of a PCS in a Greek port, namely the Port of Igoumenitsa and the interoperability of the system with corresponding systems in Adriatic ports (Venice–Italy, Ploce–Croatia) for the creation of a "single window" system to provide value added services to the port's stakeholders.

The work was carried out under the project "APC—Adriatic Port Community" (APC)[1] and funded through the IPA Adriatic 2007–2013 Programme.

22.2 Methodology

The methodology used was based on the principles of Rational Unified Process (RUP)[2], a configurable method of software development (software development process) which provides a set of defined procedures (best practices) to define and

[1] http://www.apcwindow.eu/en/project. Accessed 30 Sep 2014.

[2] http://www-01.ibm.com/software/rational/rup/. Accessed 30 Sep 2014.

manage tasks and responsibilities throughout the entire cycle and all phases of a software development project.

According to RUP, the first phase involves the recording and representation of business processes in a specific port. For this purpose we used notation for modeling business processes (BPMN—business process modeling notation; Fig. 22.1).

The design of the PCS was based on Service Oriented Architecture (SOA), integrating all the benefits during the development phase and enabling the possibilities to meet future needs.

The architecture of the system meets the needs of a port with increased demands on reliability, integration with existing systems, communication with external users such as passengers, regular communication with clients such as shipping agents, security, maintenance of national and international rules and regulations, future extensions, etc. The system features modular design and all communications between applications are conducted through Web Service interfaces and through shared access to the database.

The use of standards included in the solution is imperative for the seamless integration of the subsystems and their collaboration with other future or existing systems. More precisely, the standards followed are:

- Open GIS for the management and exchange of spatial data
- XML/SOAP & WSDL to exchange other data
- Open Database Connectivity (ODBC) to interface with the database system.

These ensure easy and simplified interconnection of the various subsystems with any external system logic in an open architecture, further enabling the future expansion of the platform (Fig. 22.2).

22.3 The Developed PCS

According to the user requirements, the final system (Fig. 22.3) provides the capabilities listed below.

- *Ships Arrival and Departure Management*: For compliance with international and European regulations concerning information about the arrival and departure, as well as the coordination and management of available moorings from "Igoumenitsa Port Authority S.A." (OLIG) side. For this purpose, the following applications were further delivered:
  - Berth management system
    The *Berth management system* is an integrated information system that supports the entire process of ship berthing. The system receives messages from the ship arrival announcement through the *electronic document management system* using Web Service interfaces.
  - Electronic document management system

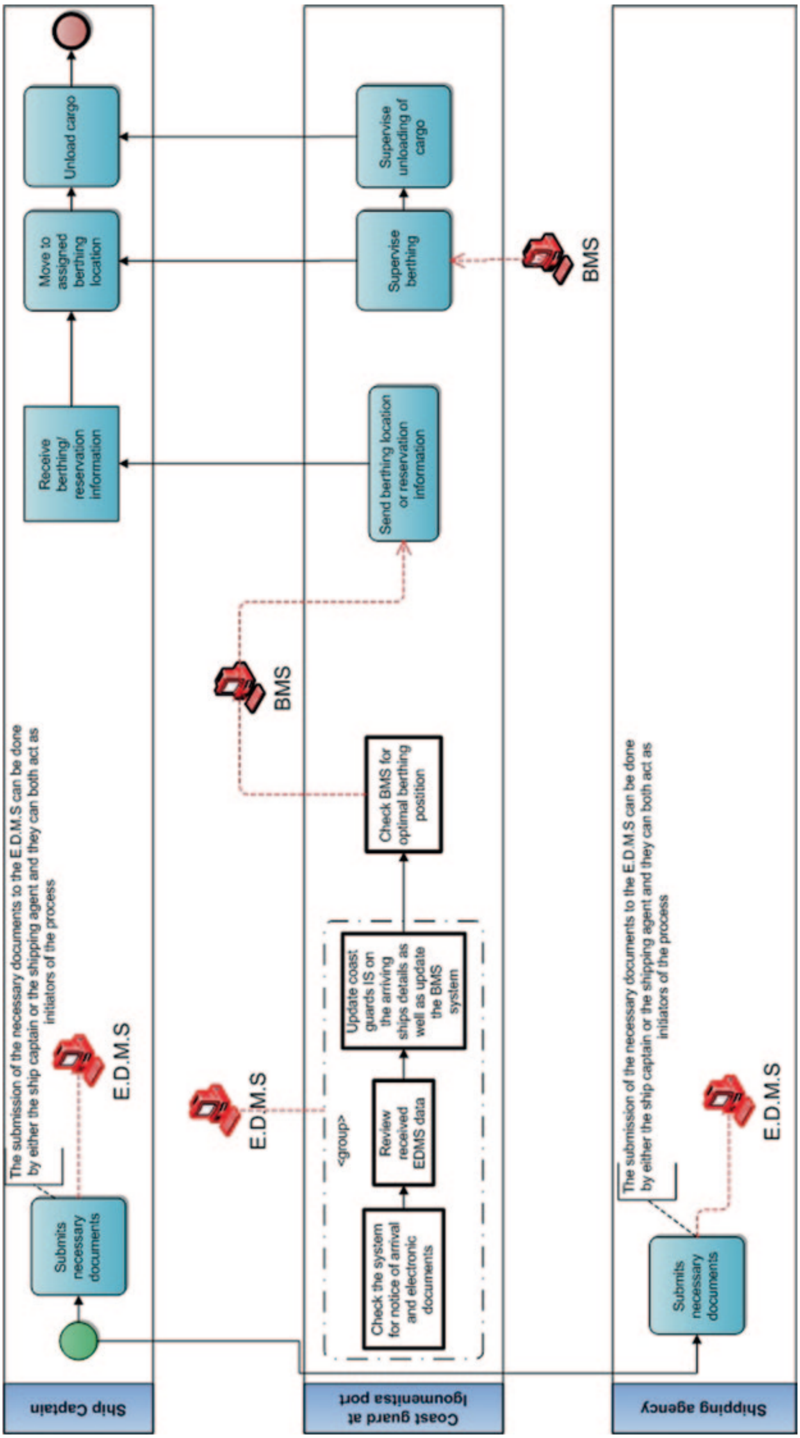

Fig. 22.1 Business process modeling using business process modeling notation (BPMN)

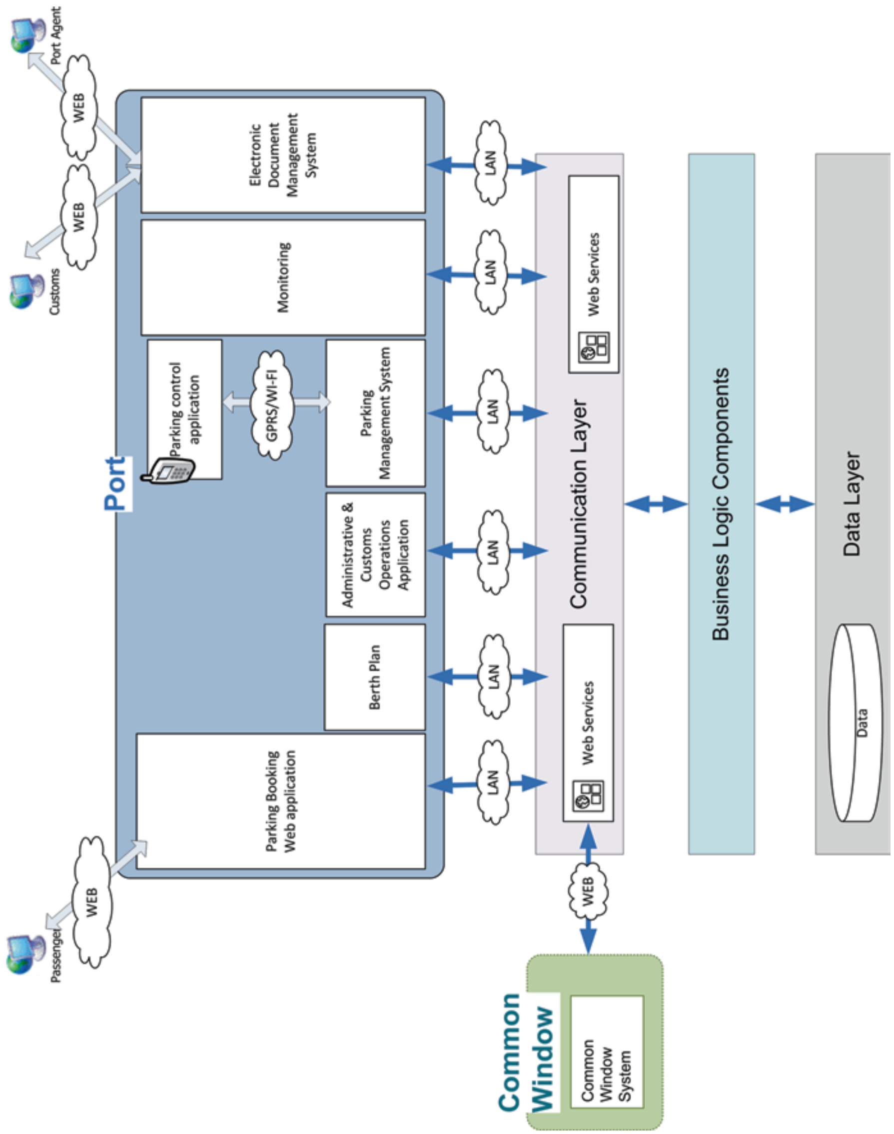

Fig. 22.2 Overall architecture

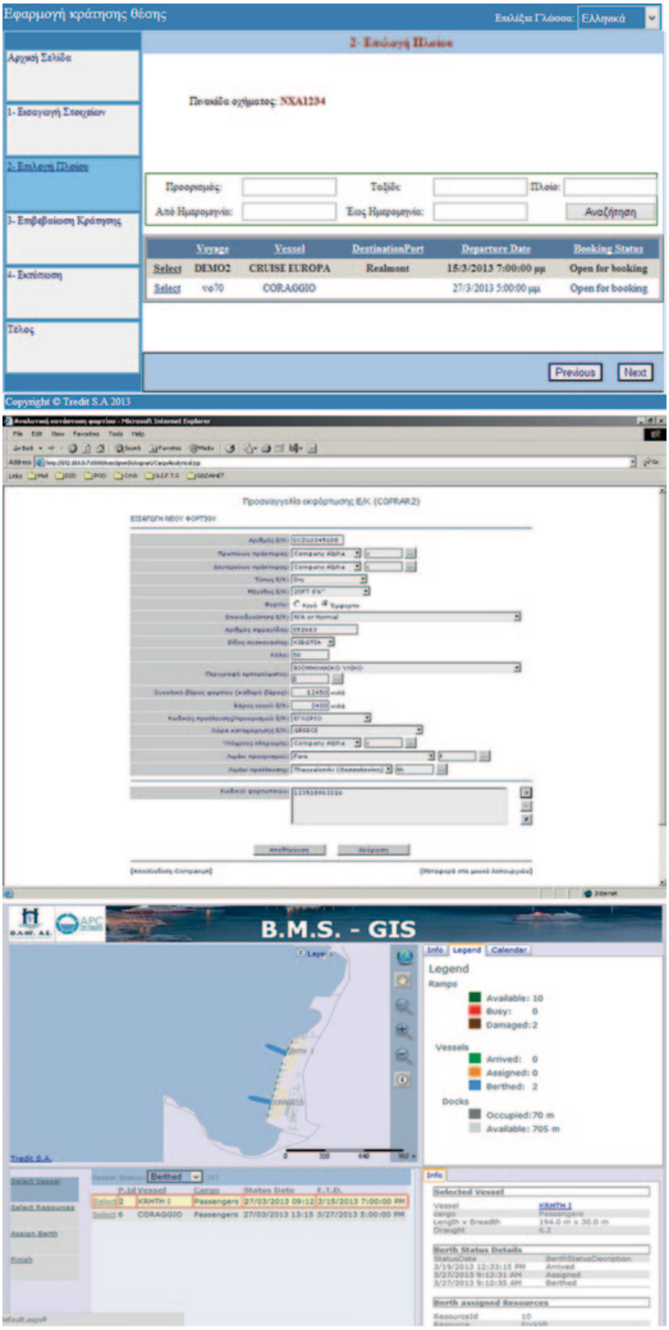

Fig. 22.3 The developed Port Community System (PCS)

It is the main application of the whole system. Both harbor and external users have access to the system. Users depending on their rights have access to corresponding electronic documents or part of them. The application supports the ability to fill in web forms of messages, supporting XML or EDI messages.

- *Custom operations management*: improves computerization and communication with customs authorities.

The following application was delivered:

  - *Administrative and customs operations application*, which interfaces to the electronic document management system mentioned above.

- *Parking management system*: enables the efficient management of available space inside the port and provides value-added services to its customers.
  The following applications were delivered:

  - Parking position management system
    The user is able to choose a berthing position or make use of the one proposed by the system (through historical records). The berth position can be communicated to other applications via a respective Web Service. Using this information the *parking position management system* is capable of providing to vehicles the best parking space close to the berthing position of the ship.
  - Parking booking web application
    External users (drivers) use the *parking booking web application* to reserve parking space for the vehicle through an online application.

Finally, a tool in order to monitor the activities and processes related to vessel and cargo operations was provided, in order to offer an improved view of the flow of operational and historical information.

Furthermore, the developed system, which includes the above-mentioned individual applications, is connected (via appropriate interfaces) with the common window of the Project APC.

22.4 Port Operations Monitoring Tool

The monitoring tool provides two main options and overall viewing possibilities: (i) vessel view and (ii) cargo view.

These two different views are actually providing an overview of the current status of the vessel or cargo with regards to the general process to be followed (Fig. 22.4).

In this way, all information regarding a specific vessel (or cargo) can be provided in a single reference application (part of the local port community system).

The update on the information can be provided with two different ways:

1. Information on the status of the vessel will be updated by exchange of information with Electronic Document Management System and Berth Management System

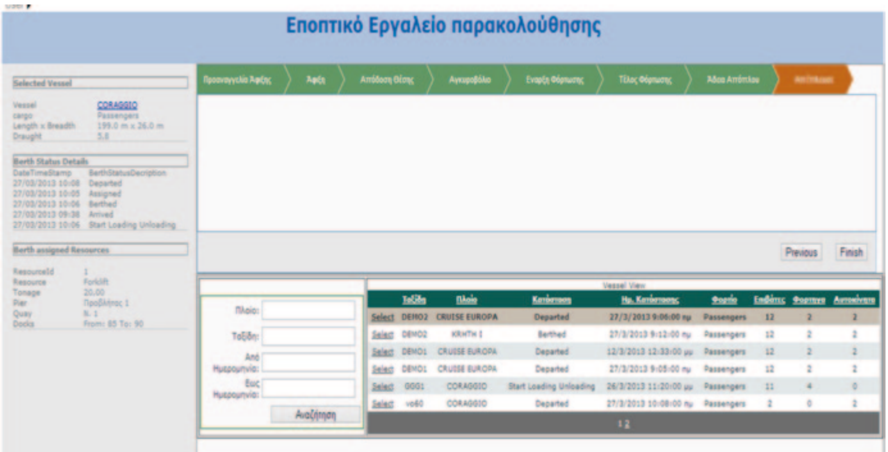

Fig. 22.4 The monitoring tool allowing control over port operations

2. Direct input from a user (e.g., custom's operator) can be permitted on the monitoring tool to update the status of the vessel (e.g., that the vessel is allowed to depart since all the necessary documents are provided).

22.5 Interface with the Common Window's Adriatic Port Community

The project required the development of interfaces between the local system of OLIG and the APC global window (or common window), in order to exchange messages and information.

The system is able to process online requests from the common window of APC. These demands relate to the sending of data from the port of Igoumenitsa to other Adriatic ports via the common window platform implemented within the APC project.

The interface is based on web services (server) and a suitable communication protocol WSDL to determine the need and form of data (according to the specifications of common window) as it is presented in Fig. 22.5.

22.6 Conclusions

The system developed for the Igoumenitsa Port Authority covers various activities relating to the operations within the port area. The system is providing the means for more efficient and productive operation. It also leads to critical improvements

```
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      <out_1_0_Departure>false</out_1_0_Departure>
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      <out_1_1_ShipType>N/A</out_1_1_ShipType>
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Fig. 22.5 Specifications of the interface to common window

in relation to the “time of services” offered by the port, environmental issues and safety of port operations.

The evaluation from external stakeholders was positive in terms of the overall functionality provided by the system. The full-scale installation of the system is considered vital, since it leads to improved information exchange between all the port’s stakeholders, forming the basis for the provision of quality services.

The usage of standards (e.g., XML structures) provides the means for easy adoption of the system and enhances the development of the system in full scale. Finally, this chapter presents the potential of using such methodologies for integrated development of information systems in ports to ensure efficient operations.

Chapter 23
Greener Port Performance Through ICT

Georgia Ayfantopoulou, George Tsoukos, Alexander Stathacopoulos, Apostolos Bizakis and Eliza Gagatsi

Abstract Container terminal efficiency and integration into the supply chain are determinants for the effectiveness of the entire distribution system. In order for the terminals to operate effectively, terminal operators use information and communication technology (ICT) solutions supporting processes that are related to container-handling and supply chain management. The scope of this chapter is to present an ICT solution aiming to support ports in improving performance and reducing emissions. The chapter reports on the results of the ENVIROPORT Project, funded in the context of the cooperation framework for research and technology between Greece and China for 2012–2014, which addresses issues related to the efficiency and optimization of container terminal operations and use of available resources to develop ICT for more efficient and environmental port operation.

23.1 Introduction

Container terminal efficiency and integration into the supply chain are determinants for the effectiveness of the entire distribution system. In order for the terminals to operate effectively, terminal operators use information and communication technology (ICT) solutions supporting processes that are related to container-handling and supply chain management.

At the same time, local communities are placing more and more pressure on the ports to perform more environmentally and meet their social responsibilities. One of the major environmental impacts generated by ports is air pollution. The sources of the emissions in terms of ship types are port activity based (Lam and Notteboom 2012). With the majority of the port emissions originating from the vessels, the

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emissions of the container-handling equipment (CHE) and port operations comprise a very large portion of the emissions. Indicative of the role of ports in the local environment is the case of the Port of Long Beach, in California, which is responsible for the generation of 10 % of the emissions of the region. Approximately one quarter of those emissions are generated by the CHE and the trucks in the port (Port of Long Beach 2007). The scope of this chapter is to present an ICT solution aiming to support ports in improving performance and reducing emissions. The chapter reports on the results of the ENVIROPORT Project, funded in the context of the cooperation framework for research and technology between Greece and China for 2012–2014, which addresses issues related to the efficiency and optimization of container terminal operations and use of available resources to develop ICT for more efficient and environmental port operation.

23.2 ICT Developments for Green Ports

Many ICT solutions have been developed and updated over the past decades focusing on improving port efficiency. These have been developed originally to improve efficiency and meet the increasing demand at ports without their physical expansion, a fact that makes them in some cases even more important due to expansion restrictions and constraints (Le Griffin and Murphy 2006). The latest systems reveal a trend towards automation of yard operations for increasing the terminal throughput and decreasing ship turnaround time (Bish et al. 2001) and truck turn time (CyberLogitec 2012). The increased operations' efficiency has an inherent environmental efficiency increase for the ports through more efficient use of the polluting handling equipment, less idling time for trucks at ports (both at the gates and in the terminal), and reduced electrical consumption.

The developments in terminal operating systems (TOSs) have shown that automation of yard operations (planning, stacking, and transport) increase terminal throughput and decrease ship turnaround time at the terminal (Bish et al. 2001). The adoption of automation technologies in operation process by terminals gives them the opportunity to maximize visibility into the data, resulting in real-time operations, business intelligence, and general increase of productivity. Abajo (2009) states that automation in container terminal operation systems is focused on four key processes. These are technologies for loading systems; automated horizontal transportation; equipment tracking technologies; and monitoring systems.

Furthermore, increased efficiency at port container terminals from gate appointment systems (GASs) can affect the overall port area. Appointment systems, gate operating systems, and extended operation hours can help reduce congestion at the port gates and improve the air quality in the port and the surrounding areas. Just like with the TOS, automation is of importance for improving gate system performance. The majority of the systems today are starting to implement automatic driver and container identification through the use of new technologies.

The system developed in the scope of the ENVIROPORT project addresses efficiency and optimization in container terminal operation and the use of available

Category	Specific Requirement	Priority
TOS integration with Fleet Management	Display straddle carrier position on yard map	HIGH
	Optimize ad-hoc container movements	HIGH
	Equipment configuration	MEDIUM
	Service oriented dispatching	MEDIUM
	Use Straddle carrier fuel consumption	HIGH
	Equipment productivity and utilization reports	HIGH
Advanced Gate Appointment System	Web based application	HIGH
	Registration of new user	HIGH
	Personalised access	HIGH
	Personalised content	HIGH
	Uploading of container lists	HIGH
	Provision of booking windows	HIGH
	Possibility for slot allocation	HIGH
	Configurable distribution of booking windows	MEDIUM
	Communication of events	MEDIUM
	Management of existing bookings	HIGH
	Unique Identification per booking	HIGH
	Payment capabilities	MEDIUM
	Auction System for slots	MEDIUM
	Interfaces to existing systems - Interoperability	HIGH
	Integration to TOS	HIGH
	Integration to traffic management systems – Cooperative Systems	LOW

Fig. 23.1 Overall architecture of the systems to be developed

resources taking into account the environmental aspect of those operations. The new system architecture, presented in Fig. 23.1, does so by investigating the joint use and exploitation of available ICT systems currently applied in the sector. ICT systems like TOS and fleet management solutions are currently being deployed in different solutions, while their joint use is not established.

The main objectives of the system presented in this chapter are to:

a. Optimize the port terminal operations in the yard by efficiently integrating TOS with intelligent transportation systems (ITS).
b. Enable environmental intelligence in container-handling procedures by taking into account energy-saving potentials.

23.3 User and System Requirements

In order to develop this system for pilot application in the Port of Ningbo, China, the requirements of the port were investigated, and the Port of Ningbo provided this information along with the priority level for each requirement. User and system requirements are two important factors considered that determine the specifications of any ICT solution. In this particular case, the user requirements are related to the

TOS and the GAS and can be categorized to both functional and nonfunctional. A classification of the functional requirements based on their priority is presented in the table of Fig. 23.2.

The nonfunctional requirements fall into six main categories: *usability*, *reliability*, *performance*, *supportability*, *design*, and *interface* requirements. *Usability requirements* regard the overall usability of the system and include help option requirements. *Reliability* regards the system stability and the requirements and scenarios for the system recovery. *Performance* regards system availability and performance. *Supportability* regards the system extensibility and whether it is for further extensions or for internationalization and requirements about system testing and troubleshooting. *Design* includes system specifications and/or constraints. Finally, *interface requirements* refer to the system's capabilities for connectivity with external systems.

The use case technique was used to capture the functional requirements of the system, to describe the interaction between the primary actors, i.e., the initiators of the interaction and the system itself, represented as a sequence of simple steps and to gather usage requirements for the software design. The primary goals of the use case analysis are designing a system from the user's perspective, communicating system behavior in the user's terms, and specifying all externally visible behaviors. The secondary goals are to communicate system requirements, how the system is to be used, the roles the user plays in the system, what the system does in response to the user's stimulus, what the user receives from the system, and what value the customer or user will receive from the system.

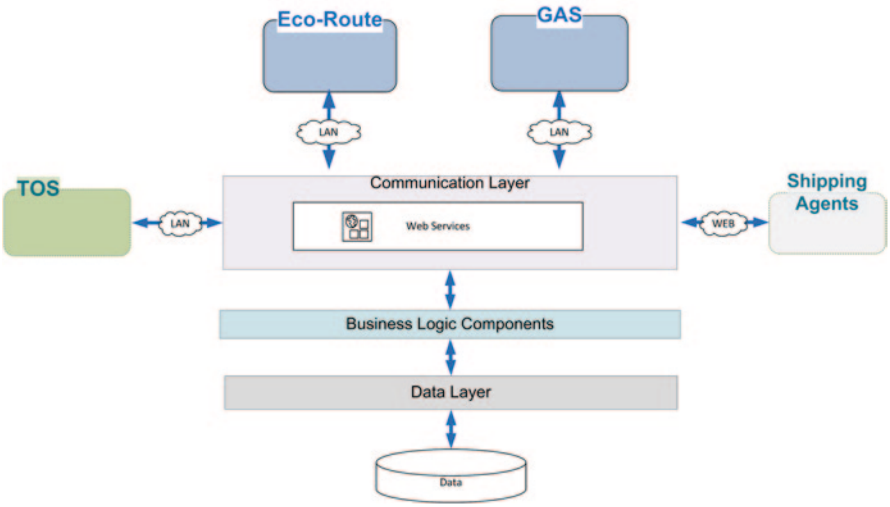

Fig. 23.2 Prioritization of functional requirements

23.4 System Architecture

Based on the abovementioned findings from the project State-of-the-Art report and the user requirements, the ENVIROPORT solution was developed. The terminal (yard) planning of a TOS constitutes the basis for an effective operation of terminals in terms of required resources, expected cargo/units to be handled, and available yard positions. In particular, yard planning is a mandatory prerequisite for the efficient and effective disposition of the containers particularly during the import phase. The TOS provides significant information for the monitoring of cargo/units. Information related to the physical status of the cargo or entry/exit to/from a terminal is usually provided from the terminal nodes.

For the needed developments regarding the TOS, the first step can be the development of the yard management module and the installation of a fleet management system for the monitoring of the cranes, straddle carriers and other equipment within the terminal, and the preparation of a plan for the positioning of containers within the terminal. The fleet management module may select the straddle carrier to move a container based either on a simple list of vehicles, on a list of available carriers, or by selecting the nearest available carrier to the crane handling the container.

The chosen solution—namely eco-route—is designed as a stand-alone module that is interoperable with the existing TOSs and provides the required functionality.

With regard to the GAS, this is a functionality of the gate operation system, which operates above the system and allows the truck driver to make a booking for delivery or pick up of a container at the terminal at a specific time slot. This automatic prenotification, in conjunction with the gate control system will allow the truck to enter the terminal at the selected time slot and drop off/collect the container faster and in a more efficient manner.

The automatic control of the container movements from the landside is carried out through the integrated entry/exit control module for containers, vehicles, and drivers entering through the land gates of the container terminal.

At the gate, the operator provides each driver a printed message regarding the exact position/slot within the parking area. This information is also made available to the yard management for the collection/delivery of the containers to/from the stowage area. Entry/exit control is ideal for minimizing vehicles waiting time and congestion at terminals and exercising a high degree of security on inbound/outbound flows of containers, vehicles, and drivers.

At the same time, similar functionalities (Yard Planning and Monitoring, Gate Control modules) have been identified in other TOS developments. The above clearly indicates that any development should not be focused on a specific TOS, but should follow an approach that would allow the possibility for future integration in other available TOSs. However, within the scope of the project, a specific TOS (namely FRETIS-IFT currently in operation in the Port of Thessaloniki container terminal) was used as a basis both for designing and for testing purposes in order to have the possibility for real-life testing of the final outcome.

The two subsystems (eco-route and GAS) are independent modules that can interface existing TOS solutions with the use of a certain set of web services. The systems to be developed do not cover the communication layer and other business layers, since all those may well be in place through other solutions. On the other hand, the two systems developed, largely depend on existing information and their interactions with other systems.

23.4.1 Advanced GAS Architecture

The advanced GAS that was developed within the project consists of different submodules as shown in Fig. 23.3.

The *user management* submodule is responsible for user creation/registration and holds all information regarding the individual users that have access to the system. The users can be both administration and end users.

The *booking configurator* submodule is responsible for all configuration actions and keeps track of relevant data. It is a crucial part of the GAS solution since it is the basis upon which the system behavior will be built. More specifically the configuration refers to:

- The available booking windows.
- The distribution of time slots within each booking window, determining the desired allocation of time slots throughout the working hours of the terminal gates.
- User-related configurations.

Finally, the *dynamic controller* is responsible for assigning time slots to each requester. The component gets the current configuration from the booking configurator and

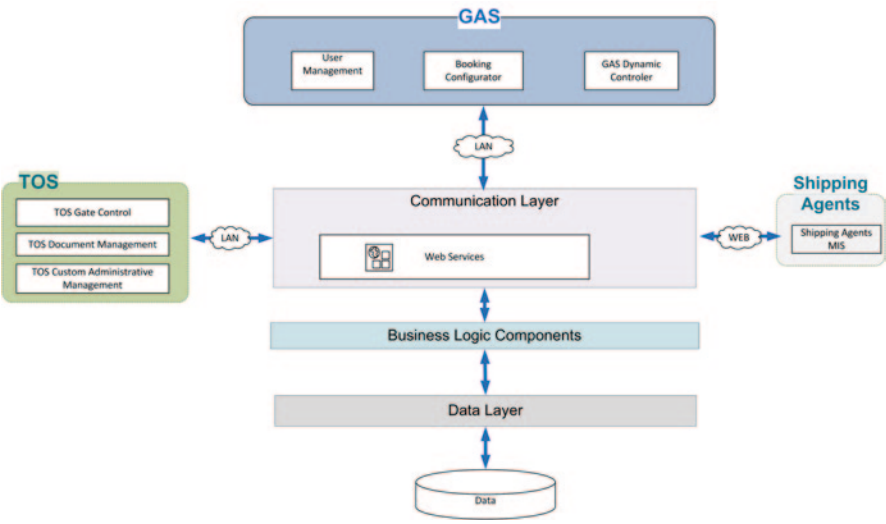

Fig. 23.3 Submodules of advanced GAS

interfaces existing modules of TOS (gate control, etc.) in order to determine the best available time slot (or alternatives) to be suggested.

The above-described submodules of the advanced GAS system are interconnected and exchange information while at the same time they use common persistency mechanism (common database) to store and retrieve the specific data.

23.4.2 Eco-route System Architecture

The eco-route system that was developed within the ENVIROPORT project consists of different submodules. Figure 23.4 shows the interactions of the eco-route with both the fleet management and the TOS. The interaction and exchange of data is also performed through a communication layer, which can take the form of available web services or other means of interfacing that enables interoperability and easy integration with third-party applications.

Eco-route is based on certain configuration in order to be used for environmentally friendly container movement optimization.

The container terminal user/planner will be able to configure the available yard using the *yard configurator* subsystem, the available CHE using the *CHE configurator* subsystem and the optimization rules using the *optimization rules* subsystem.

The *Yard configurator* defines the existing yard map and all available routes that the container handler equipment may use to transfer containers within the terminal.

CHE parameters may be specified by configuring the *CHE configurator*. The parameters that can be set include the CHE type, the allowed map areas, the average fuel consumption, the average speed, and the lifting capability.

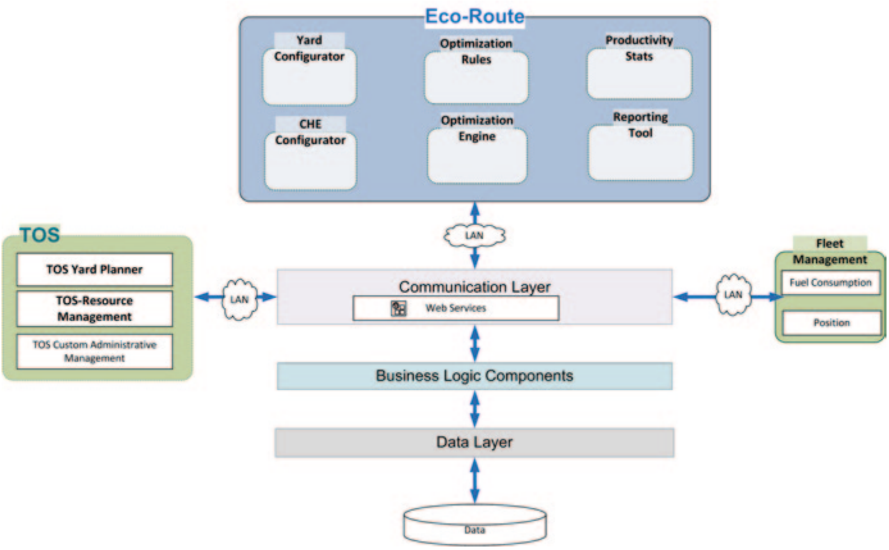

Fig. 23.4 Submodules of eco-route

The *rules (optimization rules) engine* optimizes the container movements using four criteria: CHE's proximity to the container movement position, CHE's consumption and respective emissions (e.g., GHG emissions), productivity of the CHE, and the user-defined prioritization of the above.

Finally, the *statistics* submodules take care of any relevant data collection regarding consumption (CHE) and implements the specific interface to Fleet management, while the *reporting tool* is used to report on the suggested CHE. In that way, the output of the system can take the form of an indication to the end user (yard planner) regarding the optimal and other alternative suggested CHE to be used for a specific container movement within the yard or a direct input to TOS yard planner system regarding the optimal CHE to be used.

The above results in a highly configurable system since it allows for full flexibility based on user needs and terminal setup (yard characteristics and type of CHE), user-defined weights on available selection criteria, and flexible use of output (suggested CHE to be used): either view only or direct use in own TOS.

23.5 Conclusions

The importance of sustainability in port areas is reflected in the aim of the port authorities, as stated in the ESPO Green Guide (ESPO 2012) to "continuously work towards improving their environmental performance." Over the years the environmental priorities of the ports have changed. Today, the environmental performance of a container terminal is almost as important as its operational performance. It is for this reason that new technologies and solutions are constantly being sought, which will help ports increase efficiency without adversely affecting the environment.

The ENVIROPORT project aims at achieving this by developing a system, which integrates the TOS with the fleet management solution as well as an advanced GAS.

The expected results of the project are threefold:

a. Integration and pilot usage of ICT in container terminal operations with a clear goal to increase optimization in operations taking into account environmental efficiency and energy savings. This will be performed by:
    1. Integration of TOS with ITS (fleet management system)
    2. Advanced GAS
    3. Integration of the above two to currently deployed TOS systems
b. Research and identification of relative KPIs in order to validate the approach and create a set of measurable results regarding environmental efficiency in port operations, assisting in that way in recent efforts for "greener" ports.
c. Exploitation plans both on developed systems level as well as for research organizations and participating industrial companies.

The proposal will also demonstrate, evaluate, and test the effectiveness of the final solutions—integration to existing TOS—in order to verify their contributions towards green ports.

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Part V
Historical Ports

Chapter 24
Assessment and Development of Historical Ports

Mariella De Fino, Fabio Fatiguso and Giambattista De Tommasi

Abstract The increasing spatial and functional disconnection between port and city areas, resulting from the evolution of naval production and transport in post-industrial times, has modified the port–city relationships, whereas the port was typically the founding settlement of the ancient town, the pole of the urban framework, as well as the commercial and cultural intersection of a variety of ethnic groups and social classes. Such a disconnection has caused several critical issues within the ports at different scales, in terms of conservation of structures and infrastructures with historical and architectural value, connotation of public access spaces for tourists and visitors and quality of connection and interface zones with the urban settlement. The present contribution focuses on the protection of the built historical heritage, the safeguard of the landscape and the conservation of the cultural identity within the overall sustainable development of ports. Specifically, an assessment methodology is developed and applied on TEN ECOPORT (SEE Transnational Cooperation Programme) pilot cases on the basis of indicators and sub-indicators, as decision-making support for the definition of problems and potentialities and the proposal of strategies for requalification and refurbishment.

24.1 Introduction

The industrial transformation of most ports throughout the nineteenth century has required spatial–functional rearrangement and technical–technological improvement, according to modern standards of management of activities and flows and movement of means and goods. The overall impact of such a process on the port–city relationships has concerned several aspects at different scales, which are mutually dependent (Cappola and Garzonio 2013; Marshall 2004; Martínez et al. 2013; Zazzara et al. 2012). Among them are:

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- Conservation of historical structures, that might be functionally obsolete, both for port dynamics and logistics—docks, piers, lighthouses, industrial plants, naval yards, facility areas—and for relative defense, administration and accommodation activities—towers, blockhouses, fortifications, customhouses, convents, houses for pilgrims
- Connotation of public access spaces for tourists and visitors, where over-lapping either/or interference with higher safety and control areas and lack of surfaces and functions might occur
- Quality of connection and interface zones with the urban settlement, eventually featured by residual spaces

Those aspects should be considered as relevant critical issues within the sustainable development of port areas. In fact, such a development should go beyond the legitimate goals of risk protection for environment, human health, and biodiversity and find further challenges in the safeguard of the landscape, the protection of the historical built heritage and the preservation of the cultural identity. However, since "*conservation*" of architectural and environmental heritage must be "*integrated*", namely "*achieved by application of sensitive restoration techniques and correct choice of appropriate functions*"—European Charter of the Architectural Heritage (1975)—sustainable development strategies of port areas should take into account both requalification and reuse measures, in order to enhance protection from surrounding aggressive conditions, as well as suitable functional destinations for public fruition.

24.2 Research Goals and Methodology

Within the research activities of TEN ECOPORT project, funded under the SEE Transnational Cooperation Programme, an assessment methodology is developed to support the identification of problems and potentialities for the development of historical ports, in order to address the proposal of requalification and reuse strategies. In detail, the study is applied to all the project pilot cases, namely Bar(Montenegro), Bari (Italy), Barletta (Italy), Brindisi (Italy), Burgas (Bulgaria), Constance (Romania), Dubrovnik (Croatia), Durrës (Albania), Monopoli (Italy) and Patras (Greece). It comprises:

- Survey: collection and elaboration of data by survey forms
- Analysis: definition of reference scenarios by a system of indicators and identification of critical issues by a system of sub-indicators
- Diagnosis: assessment of strengths, weaknesses, opportunities and threads (SWOT)

Herein, the collection and elaboration of data and the definition of reference scenarios is discussed for all the pilot cases, whereas the identification of critical issues and the SWOT assessment is shortly presented for the port of Brindisi, which is particularly representative of a variety of challenging aspects.

24.3 Data Collection and Elaboration

According to the described methodology, three survey forms are proposed for documenting the present state of TEN ECOPORT pilot cases.

Specifically, the first survey form, “General,” concerns a general overview of the port areas. A map is provided, where a series of data is located, including: functional areas (mercantile, commercial and touristic areas, historical centre); historical open spaces (e.g., docks, piers, service areas, shipyards); historical buildings (e.g., customhouses, lighthouses, towers, shelter houses).

Thus, the second survey form, “Spaces” is replicated for each historical open space that is referred to in “General”. Here, along with historical/current pictures and drawings, the required data includes: year of construction; total surface; original and present functional use; scheduled area (yes/no).

Finally, the third survey form, “Buildings” is replicated for each historical building that is referred to in “General.” Here, along with historical/current pictures and drawings, the required data includes: year of construction; number of floors; gross building surface and volume; original and present functional use; present functional use and property (private/public/mixed); scheduled building (yes/no); typology (masonry/framework/mixed/other) and materials of vertical structures (stone/brick/concrete/wood/other); typology (vault/flat ceiling) and materials of roofs (pitched roof/flat roof); present state of conservation (poor/fair/good/very good).

24.4 Definition of Reference Scenarios

Based on the survey documentation, and particularly on the “General” forms, all the pilot cases are assessed against a system of indicators, in order to define some reference scenarios, showing specific features. In detail, the indicators are selected to take into account the three levels of aspects/scales, which were discussed in the introduction: historical and architectural heritage, public access spaces, and the port–city system (Table 24.1). Specifically, the assessment by indicators of all TEN ECOPORT sites addresses the definition of two reference scenarios (Fig. 24.1):

- Within the first scenario, including Bar, Barletta, Burgas, and Dubrovnik, where at least one “low” score is achieved, the port is generally neither located near the ancient town nor is featured by relevant historical architectures. As a consequence, main critical issues arise from the environmental relationship with the modern urban settlement, with potential social and economic impact, in terms of safety and fruition, attractiveness for commercial and touristic operators and connection with activities and interests of the local community.
- Within the second scenario, including Bari, Brindisi, Constance, Durrës, Monopoli, and Patras, where no “low” score is achieved, the port–city relationship, beyond environmental, social and economic implications, has cultural relevance, due to the proximity, in some cases continuity, with the ancient town, also resulting in the presence of historical structures and infrastructures.

Table 24.1 Indicators and scores

Indicators	Description	Assessment
I_1. *Relevance of built heritage*	Presence of structures and infrastructures with historical-architectural features and with value of industrial archaeology	High
	Presence of structures and infrastructures with value of industrial archaeology	Medium
	Absence of structures and infrastructures with historical-architectural features and with value of industrial archaeology	Low
I_2.*Separation of functional areas*	Suitable separation of port functional areas	High
	Partial separation/overlapping of port functional areas	Medium
	Substantial overlapping of port functional areas	Low
I_3. *Spatial port–city connection*	Spatial integration among port, city and ancient town	High
	Spatial closeness among port, city and ancient town	Medium
	Dislocation of port in extra-urban and peri-urban areas	Low

Although both scenarios are challenging and interesting, from scientific and technical perspectives, the latter is further developed and herein presented for the port of Brindisi. In detail, before going through the following phases of analysis and assessment, according to the described methodology, a general overview of the case study, in terms of morphology and architectural/environmental sites, is shortly illustrated below.

The port of Brindisi (Fig. 24.2) has undergone a significant improvement in modern times, with increasing levels of maritime traffic and commerce, particularly due to well-established relationships with the East Coast of the Adriatic Sea. Nevertheless, it has always been strictly connected with the historical evolution of the city, resulting in strong relations among urban settlement, historical centre and port area, as well as in the widespread presence of structures and infrastructures with historical and architectural value.

The port of Brindisi is a natural basin, composed of different areas:

- The outer port is delimited by the mainland on the south side, Padagne islands on the east side, Sant'Andrea island and Costa Morena pier on the west side, and Punta Riso dam on the north side. In this basin, industrial activities are mainly carried out, also connected with the close Petrochemical Pole.
- The middle port is delimited by Bocche di Puglia dam on the north side, Pigonati canal on the west side and Costa Morea pier on the south side. In this basin, commercial and touristic activities mainly take place. Particularly, touristic port Marina di Brindisi is next to Bocca di Puglia dam, the east side of Costa Morena pier, facing the outer port, currently houses general cargo activities, while in the

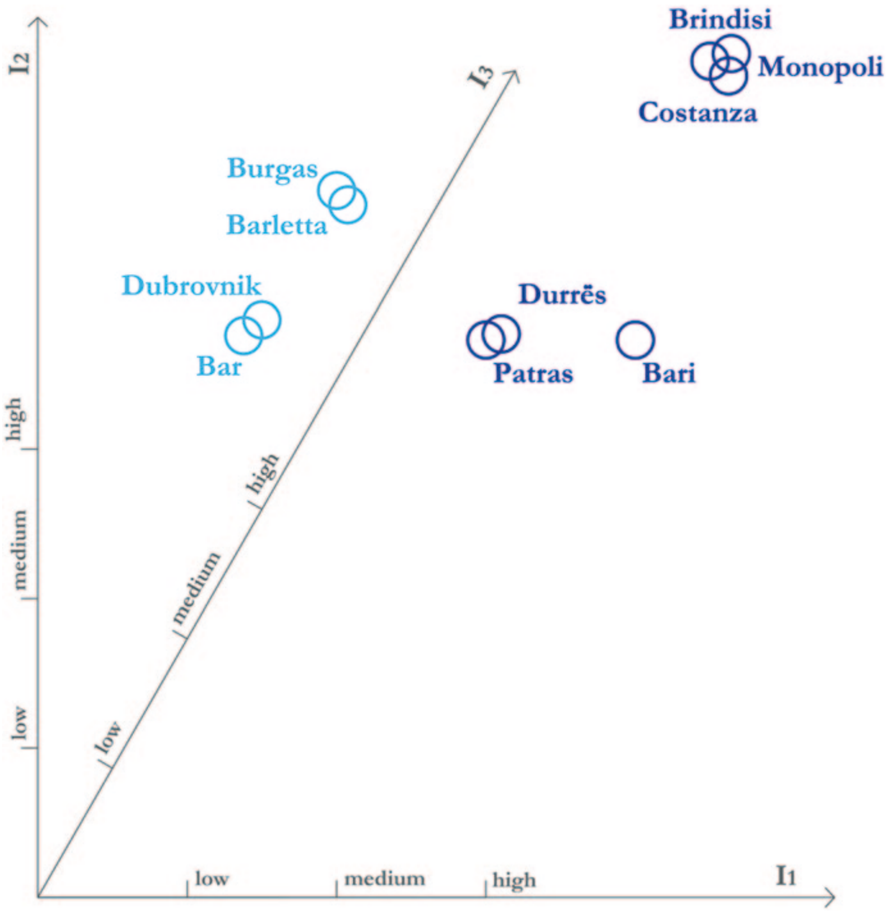

Fig. 24.1 Reference scenarios

west side of Costa Morena pier, all the ferries from and to Greece/Albania/Croatia and all the cruise boats sail.

- The inner port is composed of two bays, namely the east bay, "Seno di Levante", used for transport of goods and passengers and the west bay, "Seno di Ponente", partially used as military port. Both the bays surround the old town of Brindisi on the north and east sides.

The main architectural/environmental sites might be summarized as follows:

- Punta delle Terrare area is an archeological site, dating back to the Bronze Age, between the XV and XIII centuries B.C., as testified by some findings of the 60's, including the remains of masonry structures and huts, plates, and arms.
- The Swabia Castle, also called the "Mainland Castle," was built by Frederick II in 1233.

Fig. 24.2 Morphology of the port of Brindisi: Pedagne islands (*1*), Sant'Andrea island (*2*), Costa Morena pier (*3*), Punta Riso dam (*4*), Petrochemical pole (*5*), Bocche di Puglia dam (*6*), Pigonati canal (*7*), Touristic harbor (*8*), Passengers and cruise harbor (*9*), Sea Fort pier (*10*), Sant'Apollinaire dock (*11*), Sciabiche dock (*12*), Carbonifera dock (*13*), Customhouse dock (*14*), Capo Bianco dam (*15*), Punta delle Terrare (*16*), Swabia Castle (*17*), Aragonese Castle (*18*), Sea fort (*19*), Pedagne lighthouse (*20*), Punta Riso lighthouse (*21*), Arsenal (*22*), Montecatini warehouse (*23*), Naval boarding school (*24*), Monument to the sailor (*25*), Maritime station (*26*), Naval League and harbor (*27*)

- The Aragonese Castle, also called the "Sea Castle," was built under Alfonso II of Aragon, between 1445 and 148, on Sant'Andrea Island, for improving the protection of Brindisi against possible invasions by Turks and Venetians.
- The Sea Fort, also called the "Hornwork" was built by Philip II of Austria close to the Aragonese Castle, between 1558 and 1604.
- The lighthouses on Pedagne Island, Sea Fort pier, and Punta di Riso dam were discovered between 1861 and 1890.
- The Military Arsenal was built between 1913 and 1918.
- The Montecatini warehouse was built in 1929.
- The Naval Boarding School and the Monument to the Sailor were discovered in 1933.
- The Maritime Station was designed by Architect Rapisardi in 1936–1940.
- The Naval League and close harbor were built in 1960.

24.5 Identification of Critical Issues

According to the described methodology, a set of subindicators is developed and assessed, in order to consider more specific and relevant critical issues toward requalification and reuse of historical ports. Similarly to the indicators, the subindicators are selected to take into account three levels of aspects/scales: historical and architectural heritage, public access spaces and port–city system. In detail:

- I_1 historical and architectural heritage: $I_{1.1}$ state of conservation; $I_{1.2}$ functional use; $I_{1.3}$ recent, ongoing and scheduled restoration/reuse programs; $I_{1.4}$ owning/managing stakeholders
- I_2 public access areas: $I_{2.1}$ flows of tourists and passengers; $I_{2.2}$ equipment of areas for tourists and passengers; $I_{2.3}$ inner port connections by land and by sea; $I_{2.4}$ spatial and functional connections of public areas with architectural/environmental sites
- I_3 city–port system: $I_{3.1}$ connections with airport/train station/highways; $I_{3.2}$ social and cultural events; $I_{3.3}$ environmental and landscape quality of the waterfronts; $I_{3.4}$ environmental and landscape quality of port industrial sites

As far as the port of Brindisi is concerned, the aforementioned themes are examined through the survey documentation, particularly the “Spaces” and “Buildings” forms, as well as through the analysis of institutional sources, research of bibliographic and archivist records and direct investigation of site conditions.

24.6 SWOT Assessment

The subindicators help define the aspects that might result in strengths/weaknesses inside the system and opportunities/threats from the outside (Table 24.2).

In general, it might be observed that the assessment of current state of conservation ($I_{1.1}$) and use ($I_{1.2}$) of the architectural heritage, along with the quality of the waterfronts ($I_{1.2}$) provides with an outline of the inner technical potential (weaknesses versus strengths) that the site shows with regard to preservation measures, whereas the consideration of recent, ongoing, and scheduled programs ($I_{1.3}$), and owning/managing stakeholders ($I_{1.4}$) is related to the outer political and economic capability (opportunities versus threats) to make those measures feasible. Similarly, the assessment of the equipment in areas for tourists and passengers ($I_{2.2}$), the routes within the port ($I_{2.3}$) and toward the city ($I_{3.1}$), as well as the spatial and functional connections of public areas with architectural/environmental sites ($I_{2.4}$) concerns the inner inclination of the settlement (weaknesses versus strengths) toward enhancement strategies for a network of poles, rather than for isolated spots. Those strategies might deal with the outer environmental, social, and cultural context (opportunities versus threats) due to flows of tourists and passengers ($I_{2.1}$), events that actually attract citizens and visitors ($I_{3.2}$) and overall quality of the close modern port and relative industrial plants ($I_{3.4}$).

Table 24.2 SWOT assessment

Strengths	Weaknesses
Good proximity of port, train station, airport, and highway—$I_{3.1}$ Good proximity between architectural sites and public access areas for tourists and visitors (touristic harbor close to Aragonese Castle and Sea Fort, passengers and cruise harbor close to Punta delle Terrare site and Montecatini warehouse, Naval League harbor close to Naval Boarding school, Arsenal and Swabia Castle)—$I_{2.4}$ Good equipment within the touristic harbors (Marina di Brindisi and Naval League harbors)—$I_{2.2}$.	Several abandoned and decayed sites (Punta delle Terrare, Montecatini warehouse, Naval Boarding School)—$I_{1.1}$ Several buildings not open to the public, as they were unused (Montecatini warehouse, Naval Boarding School), used for reserved functions (Military Navy headquarter in the Swabia Castle and the arsenal, Port Authority headquarters in the Maritime Station) or accessible with restrictions (the Aragonese Castle can be visited in certain days under booking)—$I_{1.2}$ Limited equipment within the passengers and cruise harbor (Costa Morena pier)—$I_{2.2.}$ Limited inner sea connections—$I_{2.3}$ Poor quality of most waterfront areas (Carbonifera, Sciabiche, Sant'Apollinaire, Customhouse docks)—$I_{3.3}$
Opportunities	**Threats**
Increasing flow of tourists and visitors in the airport toward the surroundings—$I_{2.1}$ Strong relationships among city, citizens, port and sea (sail competitions, and religious/civil events regularly take place in the west bay)—$I_{3.2}$ Imminent dismissing of relevant areas and buildings (the Arsenal and the Swabia Castle by the Military Navy)—$I_{1.4}$	Different authorities owning either/or managing the properties (Port Authority, Military Navy, Municipality of Brindisi, …)—$I_{1.4}$ Fragmented requalification programs, which are neither coordinated and integrated nor fully implemented—$I_{1.3}$ Industrial settlements at high emissions and consumptions (production firms, …)—$I_{3.4}$ Decreasing flows of tourists and visitors in the port—$I_{2.1}$

24.7 Conclusions

The interest toward critical issues regarding conservation of historical and architectural heritage, connotation of public access spaces for tourists and visitors, and quality of urban connection and interface zones is strategic for the integrated and coordinated improvement of port systems and facilities. Particularly, inner and outer aspects, at technical, environmental, and management levels, should be taken into account in order to achieve the port sustainable development, where the preservation of materials, construction techniques and technologies, the regeneration of landscapes and the selection of suitable uses trigger the functional and spatial integration between port and city, the cultural and social connection between people and places and, thus, the overall effort for risk protection of natural and anthropical environment and human health within the site.

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Chapter 25
Transformations of the Relationship of the City of Patras and its Port from 1828 to Today

Panagiota P. Karamesini

Abstract Despite the changes that have occurred in the economic and social structures, the concurrence of the city of Patras and its port is reflected even today in the urban fabric. The main objective of the paper is the investigation of the interrelations between the port and the city of Patras from the first Voulgari's city plan in 1828, which defined its future role in close connection with the city centre, until today, where a major transformation is taking place: the construction and operation of the New Patras Port. The New Patras Port is located in close connection to the old industrial area of Patras, which attracted the industrial activity of the city since the late nineteenth century until 1990, when it presented the first signs of deindustrialisation. The transfer of the greater part of port activities is a springboard to change for this part of the modern history of the city in terms of sustainable development.

25.1 Introduction

This chapter aims to study the transformations of the relationship of the city of Patras and its port from 1828 until today. The issue is approached through the study of the urban planning legislation and plans drawn up in different periods, and a parallel investigation of the region, namely the specific social, political and economic relations that developed within this and shaped it. Correspondingly, we attempt to integrate these into the wider historical and political context, as the nature of state intervention in the area depends directly on the current political situation. In this way, we try to explore issues relating to what the basic intentions in the design of the city and its port are.

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The methodology used in this work is the parallel study of the institutionalized state intervention in the city of Patras and the projects that followed across various periods, in combination with the study of the specific social, economic and political conditions in the area.

The data were derived from a literature study and a search of sources. The literature mainly concerns historical, urban planning, demographic and sociological studies. Despite the fragmentary nature of these studies, this chapter attempts to combine them, to reveal the city's development in relation to its port. The search of sources focused on the collection and study of legislation, decrees, plans, aerial photographs from different periods, master plans and studies prepared for Patras and its port.

25.2 1828–1870. The Formation of the New State and the Creation of a New City

A top priority for the newly established Greek state was the reformation of its urban centres, since these cities would serve in the transformation of the country. These urban centres would gather all administrative, productive and political functions. (Kaukoula 2002, p. 4)

In this context, in 1828, the engineer Stamatis Voulgaris was assigned a project to reform the old city of Patras; he, however, proposed a plan that concerned both the reform of the old city and its expansion in the western plain between the hill of the fortress and the sea. This first plan for Patras accumulates all the characteristics of the first plans drawn under I. Kapodistrias, and thus is regarded as the most complete. As shown in the plan (Fig. 25.1), this expressed an innovative concept of spatial organization, drawing on the urban tradition of the West (Kaukoula 2002, p. 14). A grid plan was used for both the old and the new city, to support economic functionality and aesthetic rationalization. The pre-existing fabric was ignored, but some main roads were kept. Although Voulgaris' plan did not provide for building along the coastline to the port, pressures were exerted early on for its development.

The street plans of the lower and upper city were approved in 1866 and 1867 (Greek Governmental Gazette No 29/16-8-1866 & No 30/12-5-1867). It should be noted that larger properties appear on the coastal road, due to the desired image of the city from the port.

We note that priority is given to creating markets, in parallel with the creation of private commercial premises. These functions are sited mainly around squares, but also in the port, which has abundant storage areas (Despoiniadou 1999). On the contrary, public works in Patras, such as the creation of squares, sewers and pavements, and the construction of the port (Fig. 25.2)—conducted mainly by the municipality

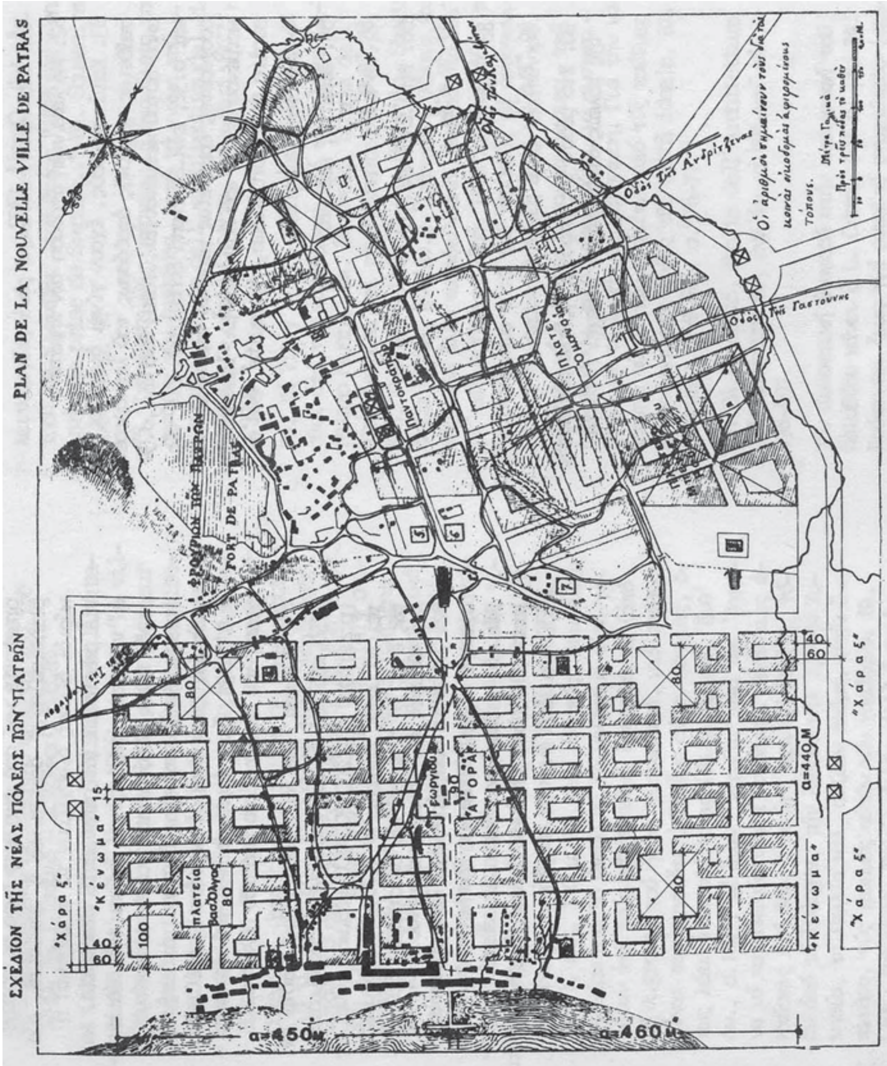

Fig. 25.1 Stamatis Voulgaris plan for Patras. (Giannopoulou Papadatou 1991, p. 25)

through the taxation on imported and exported goods it imposed—progressed very slowly (Triantafillou 1995, p. 1443).

At the same time, the Law on the classification of estates was issued on 21.06.1837 (Greek Governmental Gazette, Series A, No 25/10-7-1837), making a reference for the first time to the concept of the foreshore and its legal status as a public domain.

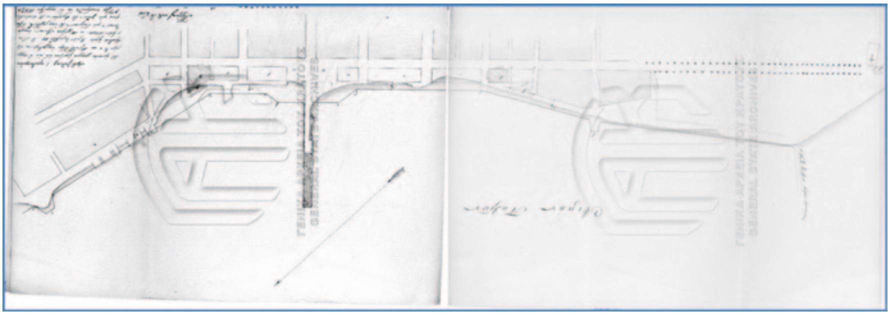

Fig. 25.2 Design of Patras port and the suggested projects in 1854. (http://www.gak.gr)

25.3 1870–1910. The Consolidation of the Characteristics of Patras

The main pillars of policy in this period aimed at reorganizing the state, strengthening the army and implementing major public works.

The port and the raisin trade form the centre of Patras' activities. Major public works were also implemented in Patras during this time, such as the gasworks to illuminate the city, large-scale port projects, while, in 1878, a stone lighthouse, which became a symbol of the city for many decades, was built at the pier of Agiou Nikolaou Street. A railway line connecting Patras with Athens was opened in 1887, with a station at Agios Dionysios, as was a second line, connecting Patras with Pyrgos, with a station at Agios Andreas. Tellingly, these stations were not linked to each other, while there was fierce opposition to the creation of a connecting line, mainly by merchants (Triantafillou 1995, p. 1843).

As of the late nineteenth century, the export of raisins started declining, due to changes in international trade. It appears that the role of the city became gradually less important, faced with the strong competition and development of Athens and Piraeus. From this point on, the Port mainly served as a centre for the departure of immigrants.

The need to create demand for the oversupply of raisins shifted the attention of industry captains to the already emerging winemaking and distilling industry. The craft and industrial units accumulated along the coastal road to the south of the city, thanks to its privileged proximity to the train station of Agios Andreas and the port but also because of the existence of the water required for the industry. At the same time, the city plan continued expanding southwards, to the district of Agios Andreas, and northwards.

25.4 1910–1940. The Interwar Period

Greece's main feature in this period in the field of urban planning was the development of a common framework for its urban planning policy, by including the development of urban centres in a single scheme. The laws enacted set the basis for the technical and financial control of the built environment.

At the same time, emergency Law 2344/1940 (Greek Governmental Gazette, Series A, No 154/18-5-1940) defined the concepts of the foreshore and the beach and specified the procedures for the demarcation of Port zones, to clarify the surfaces covered by the Port Authorities, ensure the existence of a management body, facilitate works and avoid the encroachment of public land, as well as to improve the resources of the Port Authorities. This was preceded by the Royal Decree of 14/01/1939 (Greek Governmental Gazette, Series A, No 24/19-1-1939 1939), which codified the provisions on municipal port funds.

The population of Patras increased during this period. Almost 30 % of the population was internal migrants and 10 % refugees from Asia Minor. The export of raisins continued the downward trend that had begun in the previous period, while its position in production was gradually taken over by crafts and industry. The port of Patras was now mostly an immigration station, as evidenced by Law 3964/1929 (Greek Governmental Gazette, Series A, No 55/16-2-1929) on the ratification of the Convention on the International Regime of Maritime Ports.

The so-called old plan of Patras was completed in 1929, with a series of extensions from 1923 to 1929, occupying an area of 400 ha. These extensions concerned the addition of series of building blocks on the pre-existing axes, without providing any new communal spaces (Giannopoulou Papadatou 1991, p. 47). Many of these extensions concerned refugee settlements. Tellingly, no comprehensive plan was created for the city of Patras in this period either, as public interest focused on Piraeus and Athens, where the majority of refugees accumulated. The joining of the railway line between the stations of Agios Dionysios, and Agios Andreas, just before the war, launched the separation of the city from its waters, in conjunction with the commercial and other port activities already established there (Triantafillou 1995, p. 1843). At the same time, more and more industries accumulate in the southern coastal line.

In 1930, the Patras Port Committee implemented new port projects, including the dredging of the basin, the construction of a new pier in Astingos Street, the widening of the pier of Agiou Nikolaou Street and new platforms.

25.5 1940–1975. The Reconstruction Period

Greece came out of the Second World War ruined and divided. The effective period of reconstruction began after 1950. The following upsurge in construction was based on a system of land exchanges and was strengthened by the new urban framework, changing the image of the Greek cities and especially their centres. Infrastructure projects were created, universities, hospitals and factories were established and new tourist complexes were constructed. The main feature of this period was a large wave of both external and internal migrants to the large urban centres, mainly Athens.

In this context, in Patras, the accumulation of industries and crafts along the coast in the southwest part of the city intensifies, thus forming in essence an industrial area, where large industrial units flourish, leading to arbitrary constructions by workers in the eastern regions bordering this.

In addition to acting as a commercial hub, the port also developed as a tourist centre that served passengers going to nearby tourist destinations, in line with the development of tourism promoted in this period.

The 1700-m joining part of the railway track built just before the war intensified the separation of the central area of the city from the sea, while a new passenger station in the central part of the port, was constructed in 1954.

New port facilities were constructed to manage the growing passenger traffic. In 1970–1971, the pier of Agiou Nikolaou Street was widened and a new pier was built in Astingos Street to the North. The construction of a platform to serve containers in the north pier and a 230 m breakwater extension started in 1972. During this period, the boundaries of the Onshore Port Zone expanded northwards and southwards, in the projection of the extension of the city plan (Greek Governmental Gazette, Series B, No 424/7-7-1968).

The principles of the modern movement pervade the proposals of contemporary architects and city planners. In the early 1960s, efforts were made for the preparation of regional development programs and urban master plans, which were drawn up by individuals on behalf of the state. These master plans acquired a regulatory framework only in 1972 and most of them were never implemented in practice.

An example of such a comprehensive design plan for the development of cities to face new conditions is the Master Plan prepared by G. Skiadaresis for Patras in 1967 (Skiadaresis et al. 1967). An essential element of this study was the examination and spatial arrangement of different uses and the shaping of the road network. Identifying the problems of the coastal zone, due to the collocation and interweaving of the different functions of the city centre, the port activities and the operation of the railway line, it proposed either the complete abolishment of the network, considering no longer entirely convenient, or its transfer eastwards, to bypass the centre. It also proposed that the port uses the pier of Agiou Nikolaou Street as a divider between the commercial and passenger port, thus defining its functions.

25.6 1974–2000. The New Era

A shift in the urban institutional framework was noted already in the 1970s. The key priorities are to protect the natural and built environment, as reflected in the Greek Constitution of 1975. To this end, laws were enacted introducing new methods and means for design, coupled with an effort for participatory processes and devolving powers to local authorities. Concerns emerged regarding the deterioration of cultural identity and architectural heritage, and efforts were made to promote the use of public transport and upgrade the city's aesthetics. Urban planning practice turns to the historic city centres and the showcasing of their cultural identity.

After 1975, Patras gradually undergoes changes, both in its production structures and in the social field, while the first signs of de-industrialization are evident, mainly in the southern coastal region. Major projects, such as the Rion-Antirrion Bridge and the city bypass, are constructed during this period.

In this framework, the first comprehensive urban plan for the city of Patras was created (Greek Governmental Gazette, Series D, No 1061/28-8-1986). Among others, it provided, for the showcasing and enhancement of the coastal front of the central region, the creation of green areas in the coastal region of Akti Dymeon, leisure facilities in the north and south port zone, and the abolishment of the existing railway.

Technological and economic changes in the transport market led to a nationwide change in the priorities for port activities and facilities. In this context, the Ministry of Urban planning commissioned a study to investigate the port's prospects and future needs and evaluate possible solutions for its extension and siting.

The dominant proposal that emerged from this preliminary study was that for the siting of the New Port in the southern coastal region of Patras, opposite the former industrial area. Then, in 1999, the Onshore Zone of the Patras Port was redefined to include the proposed projects (Greek Governmental Gazette, Series D, No 274/26-4-1999). In parallel, a study was conducted on the gradual transfer of the bulk of port activities from the old to the New Port. It highlighted the need to restore the communication of the city's historic centre with the marine environment and the area of the old port through a transformation of its character.

25.7 2001-Present. Building a New Relationship Between the City and the Port of Patras

This period is marked, at a national level, by the organization of the Olympic Games and, at a local level, by the city's nomination as European Capital of Culture, in an effort to promote the cultural heritage of Patras. The city bypass was already in use, while the New Port opened on 4 July 2011. Works were under way for the connection of the New Port with the city bypass through roads along the Glafkos River. Of the 12 km coastline of the Municipality of Patras, 6.7 km belong to the Port Authority of Patras (OLPA SA) and are mainly used to host port activities.

The main legislative acts of this period were Law 2932/2001 (Greek Governmental Gazette, Series A, No 145/27-6-2001), on the conversion of port funds to port authorities, and the almost simultaneous replacement of Law 2344/1940 by Law 2971/2001 'Foreshore and beaches' (Greek Governmental Gazette, Series A, No 285/19-12-2001), to classify the newly established port authorities as statutory management bodies, and define the concept and extent of the Onshore Port Zone. At the same time, programmatic plans are established for Ports, as part of the overall drafting of a National Port Policy for port development with modern infrastructure, to meet the needs and requirements for the safe servicing of passenger ships and cargo.

The Master Plan for Patras is revised (Fig. 25.3), taking into account the operation of the New Port and sets the basic directions for the development of the old

Fig. 25.3 The revised Patras master plan. (Greek Governmental Gazette, Series of Urban Planning Issues, No 358/30-12-2011)

industrial area in relation to this, foreseeing the impact it is expected to have on this area, which has extensive brownfield sites and remarkable empty shells from the recent industrial history of the city (Greek Governmental Gazette, Series of Urban Planning Issues, No 358/30-12-2011). The envisaged uses concern services and support facilities for the New Port, through the restoration and reuse of the empty shells. The new Port is designed to serve as an intermodal transit centre, in combination with the large traffic projects and its connection to the new railway line.

In the framework of showcasing the historic centre, the old port changes character, acquiring urban uses, oriented to tourism development and recreation.

25.8 Conclusions

The port of Patras developed in direct contact with the city's urban centre, and, based on the technological needs of the nineteenth century, served mainly to facilitate goods and passengers. The commercial nature of the Port of Patras and the momentum it developed in the last century and up to World War II was fuelled by the trade of produce from the rich hinterland and an economic structure based on agricultural and industrial production.

The gradual shift towards services and the subsequent de-industrialization of the 1980s contributed to the transformation of its key functions. In parallel, growing demands for infrastructure and security, coupled with technological developments

Fig. 25.4 The old and new Patras port and the city. (Figure designed by the author)

in the field of transport and navigation, led to the siting of the New Port in the south of the city.

Institutionalized planning usually followed the dictates of circumstances. In the first few decades of its operation and up to the early twentieth century, there are no clear boundaries between the port and the city. The first signs of saturation of the port area and an imperative need for the delineation and planning of its functions appear during the reconstruction of the state after World War II.

Today the operation of the new port enables the redefinition of the relationship of the old port with the city, in the context of showcasing its historic centre (Fig. 25.4). Simultaneously, a new dynamic relationship is born between the new port and the old industrial area of Patras, as provided in the new revised Master Plan of the City. For the first time, the uniform development of the city and its port is addressed through institutionalized urban planning tools. The future challenge for the city concerns the sustainable development of the old industrial area.

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Chapter 26
Ports Dubrovnik and Bar—Cooperation Opportunities for Development of Sustainable Cruise Tourism

Antun Asic and Deda Djelovic

Abstract Port cities, Dubrovnik and Bar, were created and their evolution has been connected to ports and shipping. Their location at the entrance of the Adriatic Sea presents potential for development of various shipping types. In modern history, ports Dubrovnik and Bar have developed in two different directions. Port of Dubrovnik's growth is based on passengers and particularly cruise passenger traffic, while Port of Bar developed mainly because of cargo traffic. Both cities and surroundings abound with rich historical heritage and natural beauty. Both of them are situated inside attractive East Mediterranean cruise region which integrates distinctive historical ports like Venice, Athens, or Istanbul. Inside wider East Mediterranean region lies the Adriatic region with significant potential for various segments and market niches of cruise tourism. More than 1 million cruise passengers visited Dubrovnik last year. At the same time, despite potentials and favorable location, Port of Bar has not developed cruise tourism. The objective of this work is to recognize the element how Port of Dubrovnik could assist Port of Bar in its efforts to develop sustainable environment-friendly cruise tourism.

26.1 Cruise Ports: General Characteristic

Cruise industry system is a mixture of water transport system, tourism travel, and leisure. Lekakou and Pallis (2004) defined cruising as leisure activity of passenger paying for sailing (and potentially, other on board services), which include at least one night on board the vessel with a capacity of at least 100 passengers. Ports are constitutive element of cruise tourism system. Croatian Bureau of Statistics (CBS) defined cruise voyage as leisure travel of several days according to predefined

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circular trip schedule. Both definitions include leisure or tourism as substantial element of cruising. Definition of tourism includes place or location as vital part of tourism system; therefore, ports as one of the constitutive elements of cruise tourism system must be touristic place or location. Cruise port may be divided in two types: ports of call and turn around ports or home ports.

According to the definition of touristic place by CBS, touristic place must fulfil the following elements: *attractiveness* (natural beauty, cultural—historic monuments, various cultural, entertainment, and sports events), *communication* (traffic connections), and *receptivity* (accommodation facilities with various services). Therefore, to become cruise ports, ports must fulfil these conditions. Port's industry in its nature is a derived activity of other industries, and also from tourism.

Despite the fact that in case of cruising, travel is the basis of tourism service, cruise ports industry is derived from touristic attractiveness of ports and surroundings and particularly for ports of call which must have tourist attractions.

Communication elements of cruise ports in relation to communication elements of touristic place are significantly different. All ports, as final point of sea passage, are connected with other sea ports, while their communications with hinterlands are limited with land, river, and air link. Land connectivity is vital for both types of cruise ports, but airline connectivity is required only for port with turnaround operations. Turnaround ports' hinterland in relation to land connectivity is limited to one day trip by car or train, but port hinterland in relation to airline connectivity is rather defined by network distance or number of direct flights from emitting market to nearby airport. Communicative elements of transit ports are mostly dependent on land transport systems, but in rare case on water or air transport. A specific factor of cruise ports is their geographic position in relation to other ports in the vicinity within its market niche. So, in megaship market niche, distance between ports may be larger allowing passenger to use various ship facilities, while on the small ships with limited facilities on board, the vessels distance between ports is smaller and passengers are more focused on ports of call touristic attractions.

Cruise port receptivity may be separated for those serving the ships and for those serving the cruise passenger. Receptive elements for ships are related to safe berths or anchorage in case of transit ports, acceptable cost level, and various ships services (e.g., bunkers, supplies). Receptive elements for passengers are more demanding and differ between turnaround ports and transit ports. Turnaround ports at least must provide passenger transfer, hotels accommodation, tour agency representative, and custom and border control. Essential receptive requirements for transit ports are limited to tour agency representative and cost competitiveness. Public safety and security and first aid service in both ports type are expected to be on high level. According to Lekakou and Pallis (2004), business opportunities of cruise operators are perceived in close correlation with the ports superstructure and infrastructure that support the cruisers' stay in port. Ports' development plans may extend port's limits and further enhance access during winter. Parallel to the development, the port authors recommend simultaneous development of tourist attractions of port hinterland.

26.2 Diseconomies of Cruise Tourism

Like every economic activity, cruise tourism has negative effects that can be classified into two groups:

- Effects on the natural environment
- Effects on cultural–sociological environment of destinations

Effects on natural environment may be classified by source:

- Ships cause
  - Discharge of harmful gases and particles in the environment created by the combustion of fossil fuels caused by navigation and energy production
  - Ballast water, which are negligible in the case of cruise ships as ballast changes are very rare
  - Antifouling paints
  - Waste generated due to regular operation and maintenance of the ship
- Passengers and crew cause
  - Packing materials
  - Food waste
  - Grey water
  - Sewage water

Combating the harmful effects on the natural environment is concerned within international IMO regulations, especially with the annexes of the MARPOL Convention. On the other hand, some regional communities such as the European Union, further elaborate regulations for individual regions such as the Baltic or Mediterranean. Port authorities built in at their documents applicable rules, preferentially applicable MARPOL rules. Control of application is subject of Port State Control inspections.

Effect on cultural–sociological environment of destination is characterized by negative influence of cruise passengers to local population and to other tourist. This effect is particularly prominent in smaller communities with concentrated tourism attractions and other developed forms of tourism.

26.3 Port of Dubrovnik

History of Dubrovnik harbor dates back to ancient times, when Greek sailors founded ports on the eastern coast of the Adriatic. Numerous authors wrote about history of Dubrovnik Port, among them are Beritic, Rubic and Nicetic. In recent history, after development of steamships, port in old city has been replaced with Port of Gruz. Its former orientation of a country landscape was replaced with port's features introducing steamships from the middle of nineteenth century and the railroad in the early twentieth century. During first development phase, Port of Gruz was freight

Table 26.1 Sea distance between Dubrovnik and other regional cruise ports

Distance from Dubrovnik to other cruise attractive ports in nautical miles)[a]	
Split	117
Venice	318
Ravenna	288
Bari	110
Corfu	201
Kotor	42
Bar	59
Sibenik	154
Zadar	155
Korcula	53
Hvar	106

[a] According to http://sea-distances.com/ and Google earth path measurement tool

and passenger port remained as such until the end of the twentieth century, when the port was developed exclusively as passenger port.

Tourism in Dubrovnik, as well on whole east Adriatic coastline, has developed by establishing steamship regular service line from mid-nineteenth century. Dubrovnik because of its attractiveness and uniqueness attracted guests from very emergence of tourism. First vessel with 153 passengers on "voyage of pleasure," as recorded in Harbormaster Office, arrived from Trieste in Dubrovnik Port on 10th August 1844 (Moravec 1955). From that time, Dubrovnik is unavoidable destination for cruise vessels.

Port of Dubrovnik is located on south part of Adriatic Sea. Distance from other cruise ports is favorable for various cruise vessels market niche (Table 26.1). Inside Adriatic–Ionian region, ports of Corfu, Venice, Ravenna, and Split are located at distance up to 320 nautical miles enabling port to port night sea passage for big cruise vessels. Shorter distance to attractive touristic ports, such as Kotor, Korcula, or Hvar are also available, enabling smaller cruise ships with slower speed daily or night port to port passage. These facts have enabled the positioning of various market niches in the Port of Dubrovnik.

The port's reception capacity corresponds to the reception capacities of main touristic attractions. Well sheltered port with excellent maritime characteristic has over 1200 m of quay with depth of 8.00–13.00 m. A large area alongside quay enables simple and fast passenger transfer from and to cruisers. Croatia accession to European Union and free movement of goods simplified port procedures.

In case of turnaround port, there is no specific cruise passenger terminal in Dubrovnik Port, but there is an adopted area which may be used for that purpose. Another important disadvantage for the employment of the Dubrovnik as turnaround port is still insufficient hotel capacity in 4 or 5 star hotels in peak season. Bunker facilities are limited as well as ship supply service. Well-structured relationship

Table 26.2 Cruise vessels and passengers at Dubrovnik for period 2008–2013. (Port Authority of Dubrovnik data)

Year	Vessels calls	Gross tonnage (GT)	Average GT	Total passengers capacity	Average passenger capacity	Passengers arrived
2008	700	30,626,527	43,752	965,708	1382	850,828
2009	628	29,625,056	47,174	938,072	1494	845,603
2010	705	31,892,699	45,238	1,025,113	1454	916,089
2011	681	36,126,521	53,049	1,096,582	1613	985,398
2012	654	35,097,399	53,666	1,065,326	1629	950,791
2013	692	39,505,279	57,089	1,181,278	1707	1,086,925
Total	4060	202,873,481	49,968	6,272,079	1546	5,635,634

with Dubrovnik airport allows integration of certain passenger functions which simplify passenger transit. All these facts show that Dubrovnik port is suitable for cruise transit but limited in service as turnaround cruise port. Master plan for port area planned cruise terminal building together with shopping mall and central bus station, as well as various amusement and business facilities.

Table 26.2 shows rising trends of passenger arrived and ship's size with variable trend of ships calls. During observed period, average grow rate of cruise passenger arrival was 5.21 % and ship size measured by GT was 5.71 %.

Various sizes of cruise ships arrived in Dubrovnik (Table 26.3) present diversity of market niches presented by ships size. Smaller ships are orientated to coastal cruising and in some occasion with element of adventure tourism, longer port stay, shorter sailing time between ports and more ports on route. Larger ships have a smaller number of ports, longer sailing time between ports, and shorter stay in ports.

Various national and international regulation are being used to minimize negative effects of cruising tourism on natural environment, as shown in the Table 26.4.

Table 26.3 Cruise vessels by GT arrived at Dubrovnik 2008–2013. (Port Authority of Dubrovnik data)

Vessels size as per GT	Vessels calls	GT	Passengers arrived
1–5000	984	2,347,925	120,756
5000–10,000	206	1,553,280	44,263
10,000–20,000	337	4,946,925	132,782
20,000–40,000	380	11,390,486	252,840
40,000–60,000	553	27,540,598	797,902
60,000–80,000	343	24,386,995	612,624
80,000–100,000	595	53,948,849	1,502,791
> 100,000	662	76,758,423	2,171,676
Total	4060	202,873,481	5,635,634

Table 26.4 Environmental protection rules applicable at Port of Dubrovnik

MARPOL annexes
Oily bilge water (Annex I)
Oily residues (sludge) (Annex I)
Oily tank washings (slops) (Annex I)
Dirty ballast water (Annex I)
Scale and sludge from tanker cleaning (Annex I)
Oily mixtures containing chemicals (Annex I)
Chemical/NLS (Annex II)
Sewage (Annex IV)
Ozone-depleting substances (Annex VI)
Exhaust gas-cleaning residues (Annex VI)
IMO MEPC 1/Circ.671 20 July 2009 guide to good practice for port reception facility providers and users
IMO MEPC 44/20 ANNEXES 2 Resolutions MEPC. 83(44) 13 March 2000 guidelines for ensuring the adequacy of port waste reception facilities
EU Directive
2000/59/EC
1999/32/EC as amended 2005/33/EC and 2012/33/EC

By applying the regulations to reduce the harmful effects of cruise ships further enables the sustainable development of cruise and other tourism industry in Dubrovnik.

Another aspect of the diseconomies of cruising is its effects on the sociocultural environment. Contemporary cruising tourism in Dubrovnik is characterized by increase of ships size and port reception facilities that enable concurrent stay in port and anchor up to 12,000 passengers. Such massive scale in the peak of tourism season can cause negative publicity of tourism as whole. Due to different reason of arrival in Dubrovnik, among tourist in hotels and passengers on board the cruise vessels, the daily rhythm of visiting tourist attractions is incompatible, except during bad weather condition for swimming and sunbathing.

Another effect on the sociocultural environment is shaping supply of tourism products, which due to the mass of passengers and the shortness of their stay in port does not strive to the quality and authenticity, but a quick sale and uniformity.

26.4 Port of Bar

The history of the Port of Bar passenger terminal is closely connected with the history of the port itself. The Port of Bar was founded in 1906 (Spin Consult and Pharos Port Consultancy BV 2010), when construction started following the design of Coen Caglia, the Italian expert in maritime construction, who had at that time designed the port for an annual turnover of 3 million t of cargo. After turbulent port

Table 26.5 Passenger traffic in the Port of Bar. (Port of Bar 2014)

Year	No. of passengers
2008	87,761
2009	73,443
2010	68,400
2011	60,142
2012	53,390
2013	43,561

history through twentieth century port's reconstruction was started in 1971 after finishing the port reached a capacity of 5 million t (this capacity is equal to the current overall port capacity).

When the passenger terminal became operational in 1965, a formerly state owned company called "Prekookeanska plovidba" from Bar inaugurated the first regular ferry line from Bar to the Italian Port of Bari. The same company, now called "Barska plovidba", has been successfully operating the same ferry line for the last 50 years. The ferry line from Bar to Bari operates throughout the year; whereas the ferry line from Bar to Ancona (Italy) is operational in the peak tourist season, from July till September.

The passenger terminal in the Port of Bar (Port of Bar—An Analysis of the Existing Situation 2009) is located in the most northern part of the port. Although it is officially classified as a passenger terminal, it is in fact a ferry terminal or a Ro-Pax terminal. The passenger terminal disposes of a total berth length of 430 m, distributed into five berths. Berths 54, 53, and 51 are most frequently used, while berth 52 is rarely used as the berthed vessels obstruct unhindered passage to the eastern basin of the passenger terminal, temporarily in use by the Montenegrin Navy. The depth of berths varies from 4.0 to 6.0 mts, enabling up to medium size vessels to be berthed at the passenger terminal.

Data on achieved passenger throughput for the period 2008–2013 are given in Table 26.5.

Shown data are related to the overall passengers throughput, with no share of "cruising passengers." Development of the Port of Bar in the past was dominantly oriented toward cargo handling and storing operations and although the Port has a favorable geographic position, specialized passenger terminal, and a lot of additional related potentials, cruising traffic had no participation in the overall port activities.

26.4.1 An Overview on Passenger Markets: Development and Prospects for the Port of Bar

Considerations given in this section of the paper take into account results of analyses done in Spin Consult and Pharos Port Consultancy BV (2010), Port of Bar—Long Term Development Plan (2009), Ministry of Sustainable Development and Tourism of Montenegro (2014), and Faculty of Maritime Studies Rijeka (2013).

In the current situation, passengers (all categories: “motorized passengers,” “passengers without their own wheels,” etc.) can only make use of the RoPax ferry lines Bar–Bari and Bar–Ancona, as there are no additional regular passenger lines or cruisers calling the Port of Bar. There are, however, different development opportunities at the passenger market that require attention, especially the cruise market, which is, as mentioned before, not utilized at all in the Port of Bar.

The eastern Adriatic has seen an immense rise of passenger cruise ship visits in the last decade, led by the “magnetic” attraction of its main destination Dubrovnik. A group of ports are profiting from the “rediscovery” of the Adriatic as a cruise destination, as well. Within Montenegro, Port of Kotor (primarily on gratitude of the attractive old town of Kotor), located deep inside the scenic Boka Kotorska fjord, has become a major destination in the recent years, receiving several cruise ships calls per week, mainly, during the summer season.

Results of initial analyses confirmed that the aforementioned developments at the cruise market provide some chances for the Port of Bar. Being situated in an interesting, beautiful, and unknown and undiscovered region, it is not unthinkable that Bar could start attracting some cruise calls. There are examples from other areas in Europe that the port of call in itself should not necessarily be a major attraction, as long as it can offer attractive day-long programs and logistical excellence in receiving, transporting, feeding, and bringing back large numbers of cruise passengers safely. With good nautical accessibility, available space on the land side and the vicinity of the interesting natural, historical, and cultural heritage (e.g., Old Town of Bar, Old Olive Tree, Lake of Skadar, etc.), the Port of Bar seems to have enough assets to more seriously consider the possibility of entering the cruise market.

Definitely, the first step would be to get a deeper understanding of the Adriatic and East-Med cruise market and consequently develop an attractive proposition for Bar as a port of call, joining forces with stakeholders in the national tourism industry.

Respecting basic features of the Port of Bar passengers terminal’s available infrastructure, in the first development phase, key orientation should be on small costal cruise ships (e.g., up to 200 passengers) with priority focus on the supply outside the cruise ships. As for the medium size and big cruise ships, options which have to be analysed on potential anchoring ships out of the port water area with tendering passengers to the terminal or improvement of the port terminal infrastructure (building new quay with bigger draft, etc.).

Analyses of potentials of the Port of Bar in the domain of cruise traffic have to take into account some experiences from the regional ports. For example, northern Adriatic ports Koper and Rovinj initially based development of their cruise traffic on cooperation with the Port of Venice (“redirecting” smaller cruise ships from the Port of Venice to Ports of Koper and Rovinj etc.).

The most rational option for the Port of Bar in the domain of cruise traffic development is establishing and implementing adequate cooperation model with the Port of Dubrovnik as the key cruise port of the region.

26.5 Cooperation Between Ports of Dubrovnik and Bar: Basic Directions

In general, cooperation of Adriatic ports should be developed in different domains. Certainly, one of the most important potential cooperation domains is cruising traffic. Concretizing previous general remarks, following basic directions of potential cooperation between Ports of Dubrovnik and Bar can be recognized: joint promotional activities (Websites, participation at fairs, conferences, etc.); exchange experience of environmental protection in the ports; port-related maritime safety issues; introducing joint itineraries which include the Port of Bar as a port of call; know-how transfer (adjusting management system in the Port of Bar to the relevant EU standards; improving implemented and introducing new operational procedures in the Port of Bar, etc.); joint participation in the international projects financially supported by the European Union, etc.

When the basic potential cooperation directions are considered, it is necessary to adequately take into consideration certain important influential elements: huge difference in domain of the cruise traffic development between ports of Dubrovnik and Bar; differences between national maritime and port policies; differences in national legislation; differences in the labor markets; etc.

Bases of cooperation between ports of Dubrovnik and Bar in the domain of cruise traffic: priority actions referred on the Port of Bar improving connections of the Port of Bar (strengthening cooperation) with the relevant local and national subjects in the domain of tourism; establishing partnerships with passengers road transporters in order to commonly create bases for supporting programs for cruise passengers which are to be developed; jointly with other relevant subjects, being focused on development of touristic destinations as bases for attracting cruise tourists (cruise ships) respecting existence of valuable natural, historical, and cultural assets; permanently keeping actual (in communication with national bodies in charge) urgent necessity of eliminating bottle necks in road connections of the port with its surrounding; initiating actions directed to introducing fast maritime connections between the Port of Bar and Budva and other nearby Montenegrin touristic centres in order to establish bases for development of additional efficient options of transferring cruise passengers from the Port of Bar; keeping actual, as well in the communication with the national bodies in charge, necessity of further development of the Airport of Tivat in order to establish bases for eventual future promotion of the Port of Bar as a Home Port for micro, small, and medium size cruise ships; establishing bases for cooperation with the Port of Kotor, currently the only cruise port in Montenegro, in order to avoid any potential misunderstanding related to entering the Port of Bar in the cruise market and promoting complementarity and expected benefits of having both ports involved in this market from the aspect of increasing attractiveness of the whole network of the cruising destinations; etc.

Environmental protection issues related to environmental protection have appeared as a group of the key priorities within the scope of activities directed toward development of cruising in the Port of Bar. Experiences of the Port of Dubrovnik

Table 26.6 Port of Bar applicable environmental protection regulations

Directive 2000/59/EC
Directive 2002/84/EC
Directive 2007/71/EC
Directive 2005/35/EC
Directive 2009/123/EC
Montenegrin law on ports
Montenegrin law on protection of sea from pollution from ships

in optimizing environmental protection system (its total adjustment to the relevant EU regulation) will be extremely valuable. Currently, the following national and international regulations have been implemented in the Port of Bar (Table 26.6).

Necessary investments in the Port of Bar the necessity of future expansion of the passenger terminal (Berth 55), in connection with the intention to develop cruise traffic in the Port of Bar, will depend on the draft of the vessels deployed and other relevant parameters. This major investment may be postponed if it proves possible to increase draft at the existing berths, at much lower costs. This option is worth an in-depth investigation, since the occupancy of the existing berths is very low and berth availability will not become an issue even in some high-growth scenarios. Intensified use and optimization of existing berths is the best way to accommodate growth in the short and medium term.

Otherwise, in the Detail Urban Plan for the Port area (Municipality of Bar—Port of Bar (2003) is foreseen extension of the Passenger terminal operational quay for 440 mts, with the water depth by new berths up to 10 mts.

26.6 Conclusions

Port of Dubrovnik and Port of Bar, despite difference in volume and type of present passenger traffic, due to their touristic attraction may find common interest for cooperation with goal to develop Port of Bar as a new cruise destination for specific cruise market niche. Their cooperation should not be directed only toward development of cruise port, but also toward environment-friendly cruise tourism development.

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