Japan International Cooperation Agency (JICA)
Ministry of Environment and Water Management, Romania

Final Report

The Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore in Romania

Volume 3

Annexes

August 2007

ECOH CORPORATION

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
MINISTRY OF ENVIRONMENT AND WATER MANAGEMENT, ROMANIA

FINAL REPORT

THE STUDY ON
PROTECTION AND REHABILITATION OF
THE SOUTHERN ROMANIAN BLACK SEA SHORE IN ROMANIA

VOLUME 3
ANNEXES

AUGUST 2007

ECOH CORPORATION

FOREWORD

In response to a request made by the Government of Romania, the Government of Japan decided to conduct the Study on Protection and Rehabilitation on the Southern Romanian Black Sea Shore and entrusted the project to the Japan International Cooperation Agency (JICA).

JICA sent to Romania a study team headed by Dr. Yoshimi GODA of ECOH CORPORATION between May 2005 and March 2007.

The team held discussions with the officials concerned of the Government of Romania and conducted field studies in the targeted area in the Study. The team prepared present report upon the final modification.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Romania for their close cooperation extended to the team.

August, 2007

Ariyuki MATSUMOTO
Vice-President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Ariyuki MATSUMOTO
Vice President
Japan International Cooperation Agency

Dear Mr. Matsumoto,

It is my great pleasure to submit herewith the Final Report of “the Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore in Romania”.

The study team composed of ECOH CORPORATION conducted surveys in Romania over the period between May 2005 and March 2007 according to the contract with the Japan International Cooperation Agency (JICA).

The study team compiled this report, which proposes an overall coastal protection plan aimed for 2020, and feasibility study on the coastal protection and rehabilitation plan of Mamaia Sud and Eforie Nord, including an operation and management plan, a monitoring plan and an institutional framework, through consultation with officials of the Government of Romania and other authorities concerned.

On behalf of the study team, I would like to express my sincere appreciation to the Government of Romania and other authorities for their diligent cooperation and assistance and for the heartfelt hospitality, which they extended to the study team during our stay in Romania.

I am also very grateful to the Japan International Cooperation Agency, the Ministry of Foreign Affairs of Japan, the Ministry of Land, Infrastructure and Transport of Japan and the Embassy of Japan in Romania for giving us valuable suggestions and assistance during the course of the study

Yours faithfully,

August, 2007

Yoshimi GODA
Team Leader,
The Study on Protection and
Rehabilitation of the Southern Romanian
Black Sea Shore in Romania

PREFACE

In response to the request of the Government of Romania, the Government of Japan has decided to conduct the Study on Protection and Rehabilitation of the Southern Romanian Black Sea Shore (hereinafter referred to as “the Study”), in accordance with the relevant laws and regulations in force in Japan.

Accordingly, Japan International Cooperation Agency (hereinafter referred to as “JICA”), the official agency responsible for implementation of the technical cooperation program of the Government of Japan, has undertaken the Study in cooperation with the authorities concerned of Romania based on the Scope of the Study agreed upon by the both governments on July 30, 2004, which is attached to the present report in Annex J in Volume 3. JICA awarded ECOH CORPORATION the contract for the execution of the Study in March 2005, and the latter has formed a team of seven experts (hereinafter referred to as “the Team”) and dispatched the Team to Romania for six occasions, intermittently since May 2005. The composition of the Team and the information on the Study mission are given in Annex J.

This final report describes the accomplishment of the basic study in the Phase I, the formulation of coastal protection plan in the Phase II, and the feasibility study on the coastal protection and rehabilitation project at Mamaia Sud and Eforie Nord in the Phase II of the Study, which have been executed by the Team during the period of March 2005 to September 2006. The report is comprised of three volumes. Volume 1 presents the main results of the basic study and the coastal protection plan for the whole study area. Volume 2 describes the outcome of the feasibility study on the Mamaia and Eforie Project, while Volume 3 is compilation of Annexes that contain detailed information and data.

Volumes 1 and 2 are provided with their own Executive Summaries for quick references to the contents of the main bodies of the report.

ACKNOWLEDGMENT

The Study has been made possible through the cooperation and collaboration of many people in Romania. The Team first expresses its sincere thanks to all the Romanian counterparts, the names of which are listed in Annex J.3. They have earnestly assisted the activities of the Team and brought the Study to its completion.

Secondly, the Team acknowledges the excellent works under subcontracts executed by the staff of the National Institute of Marine Geology and Geo-ecology (GeoEcoMar), the National Institute for Marine Research and Development "Grigore Antipa," IPTANA S.A., and INSERT S.R.L., even though the Team refrains itself from listing the names of individual persons involved.

Thirdly, the Team was given invaluable information and data through interviews with the National Agency for Mineral Resources, the River Administration of the Lower Danube Galati, the Administration of Navigable Canal S.H., the National Company Maritime Ports Administration S.A., the Danube Delta Biosphere Reserve Authority, the Delegation of the European Commission in Romania, the Office of the International Bank for Reconstruction and Development, and others.

Last but not least, the Team would like to express its appreciation to Professor Virgil Breaban and his staff at "Ovidius" University of Constanța, who offered the first guidance on coastal problems in Romania in August 2004, assisted the field survey on the willingness-to-pay (WTP), and arranged the use of the university's auditorium for the JICA Symposium in June 2006 and March 2007 in Constanța.

Yoshimi GODA, Prof.
Team Leader of the Study Team

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ANNEX A:

AERIAL AND ONSHORE VIEWS OF STUDY AREA

Annex A: Aerial and Onshore Views of Study Area

A.1 Aerial Photographs of Coastline

The Team visited the whole coastal area under study by boarding a helicopter and taking photographs of the coastline. The helicopter cruised at a distance of 500 m from the shore at the altitude of 300 m. Because the views taken from the air are very effective in visualizing the coastal characteristics, they are compiled and listed in this Annex. The sector numbers I to VII and the sub-sector numbers such as I-1 are those defined in Table 5.2.1 of Volume 1. The numbers to jetties etc. such as I-B-1 and II-J-3 are the same as those appearing in **5.4** of Volume 1.

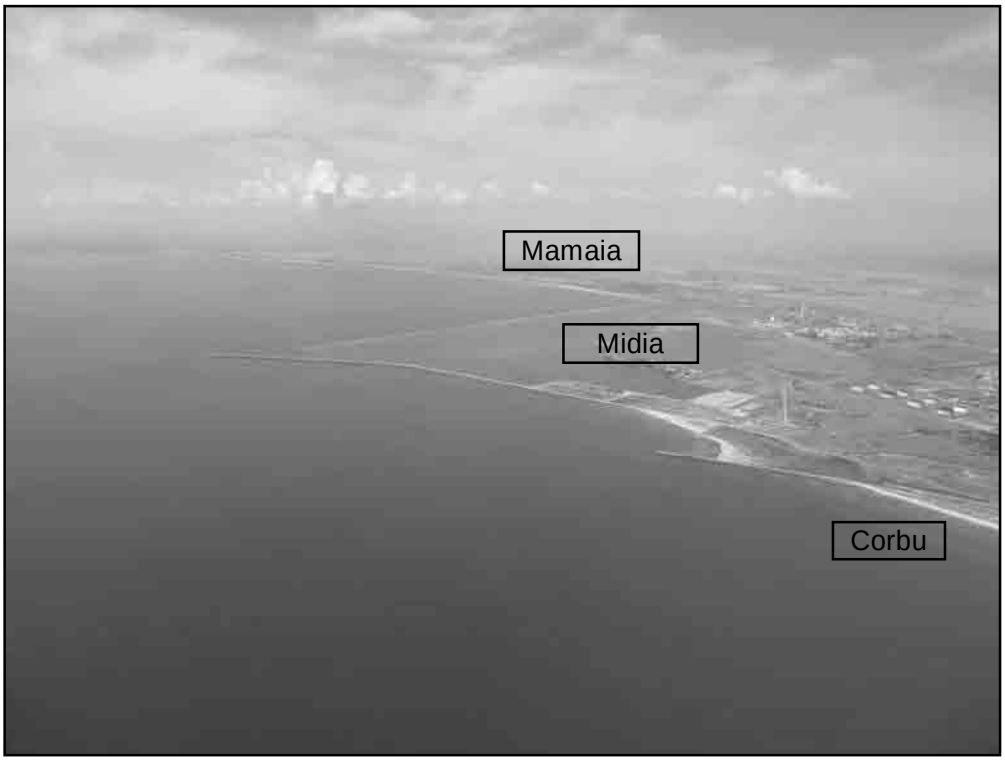
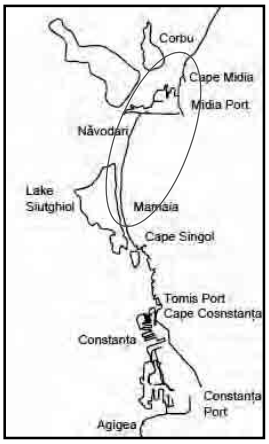


Photo 0-1
Over View from
Midia Port to
Mamaia



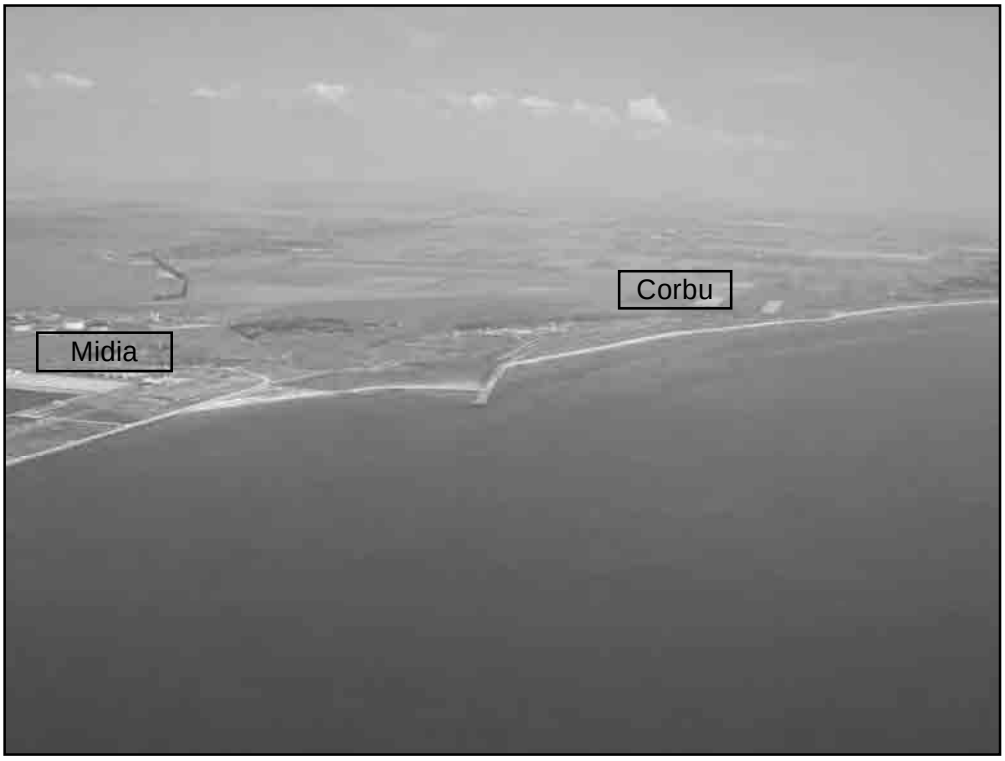
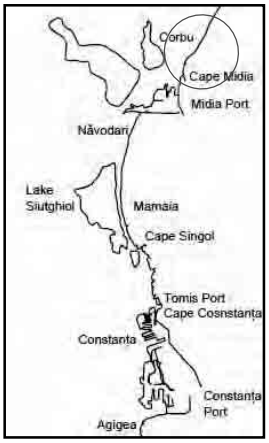
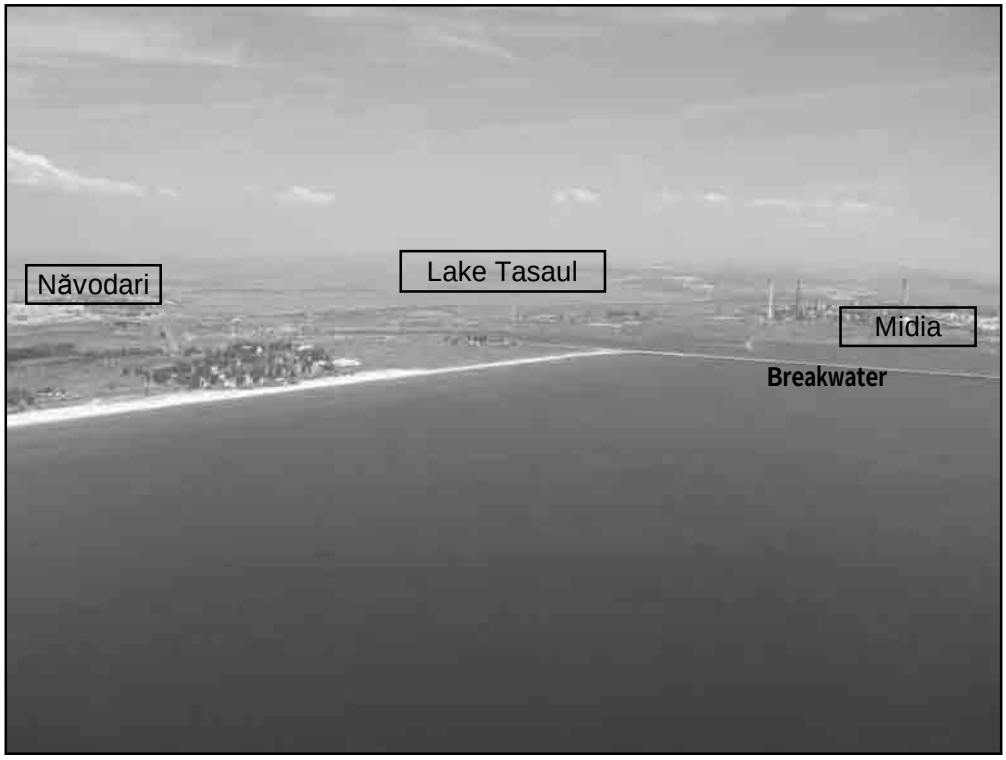


Photo 0-2
North of Midia Port
Corbu





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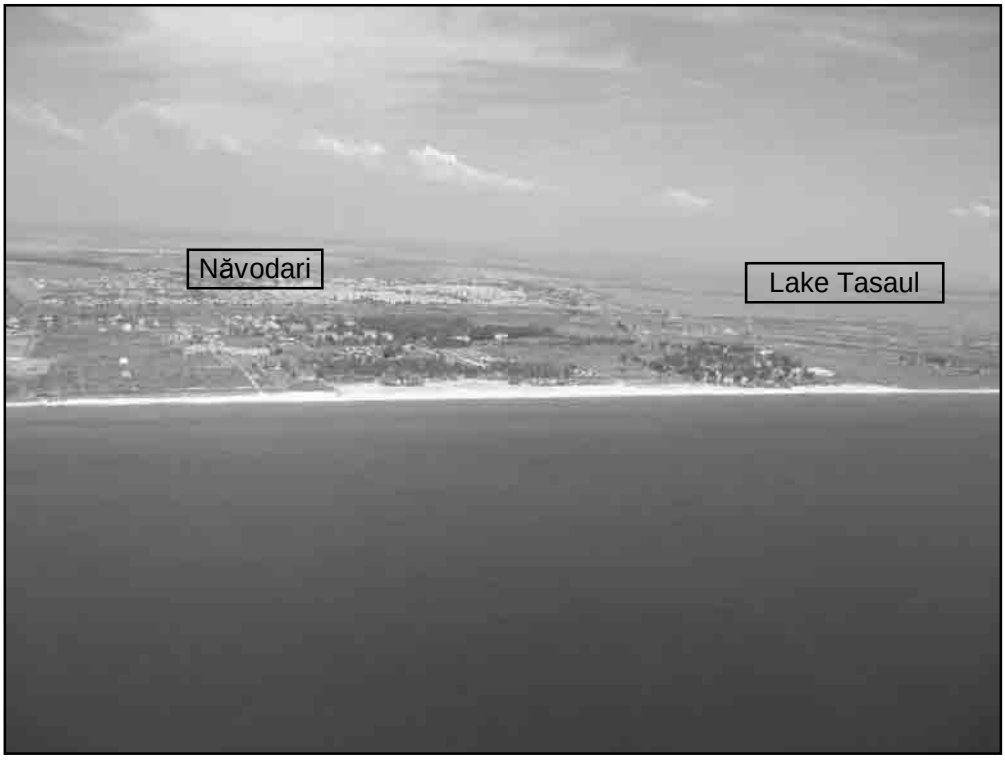
Sector: Ⅰ-1
Năvodari North (1)



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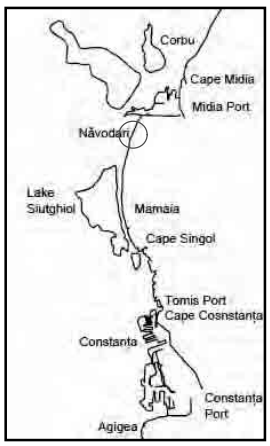
Năvodari North (2)



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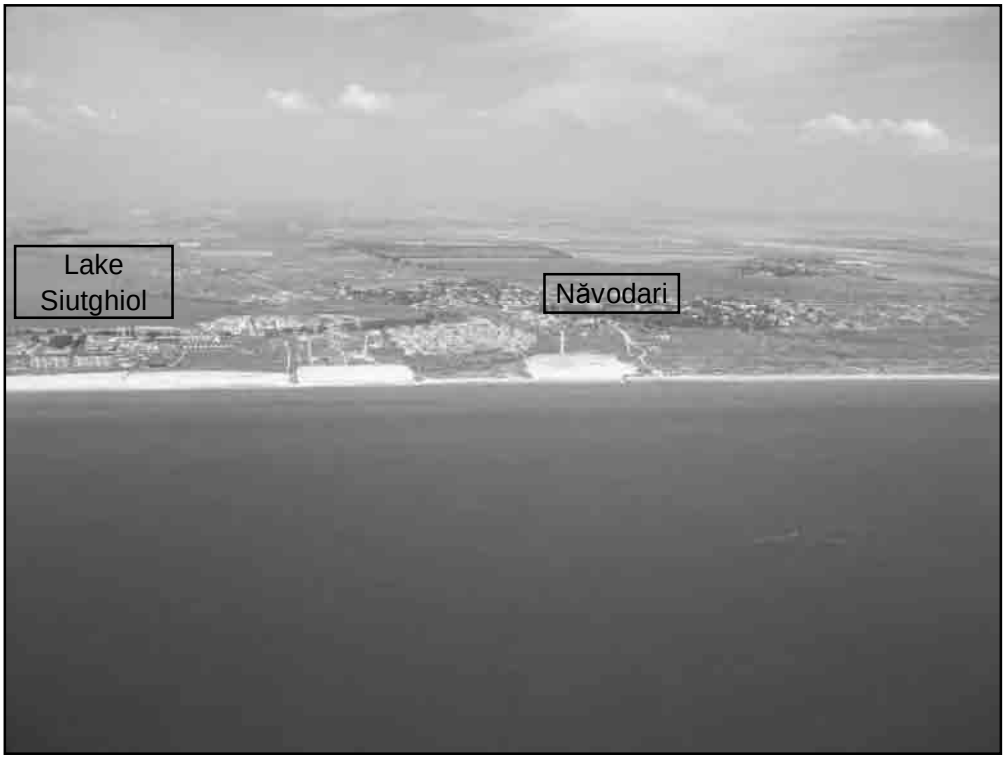
Sector: Ⅰ-2
Năvodari South (1)

Photo Ⅰ-4
Sector: Ⅰ-2
Năvodari South (2)



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Sector: Ⅰ-2
Năvodari South (3)

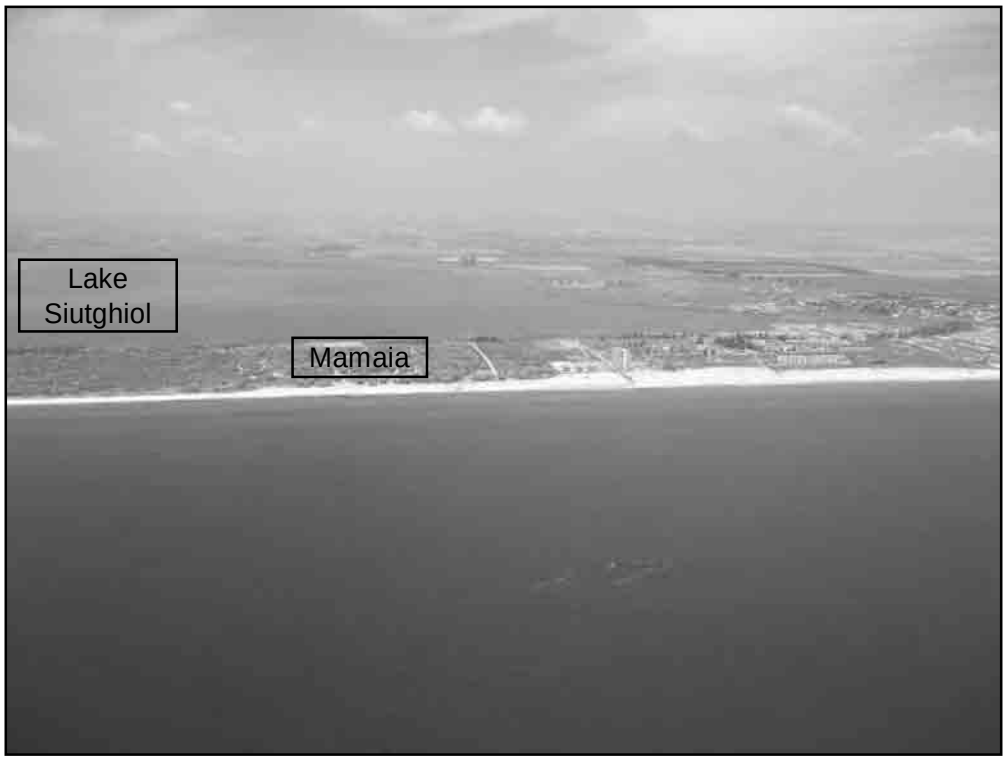


Photo Ⅰ-6
Sector: Ⅰ-3
Mamaia North (1)

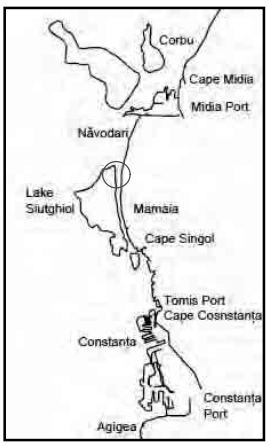
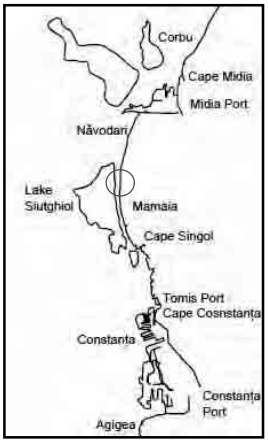


Photo Ⅰ-7
Sector: Ⅰ-3
Mamaia North (2)



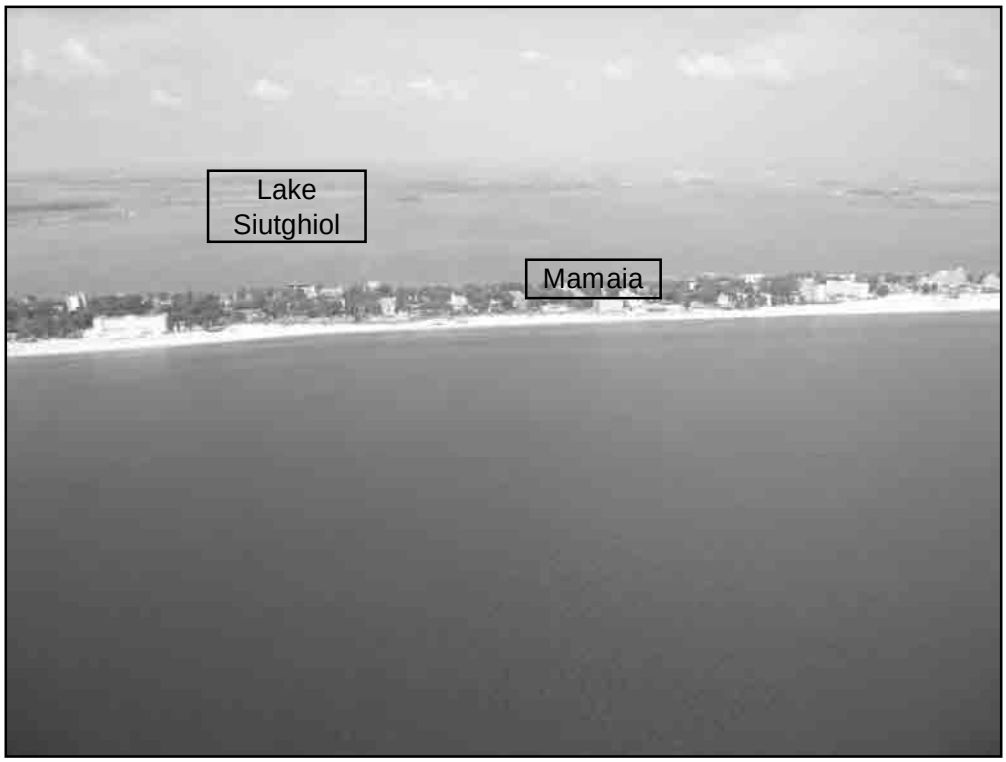
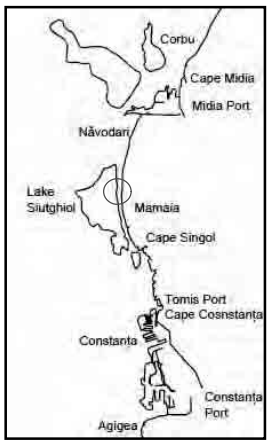


Photo Ⅰ-8
Sector: Ⅰ-3
Mamaia North (3)



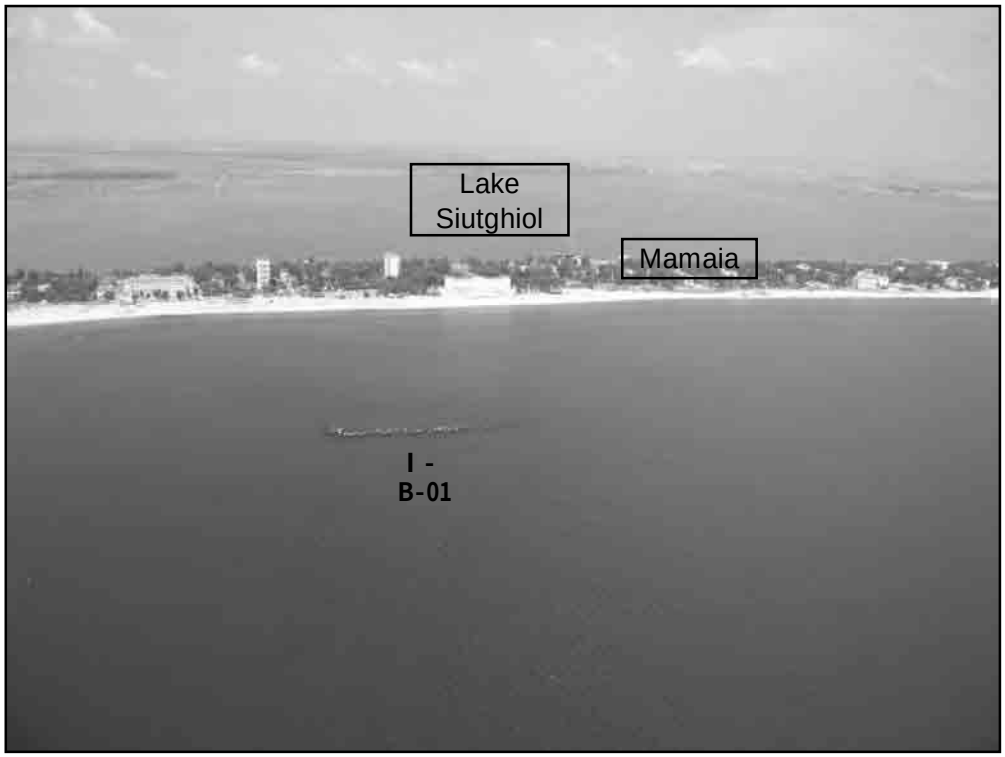
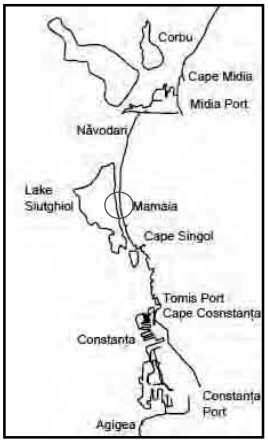


Photo I -9
Sector: I -4
Mamaia Center (1)



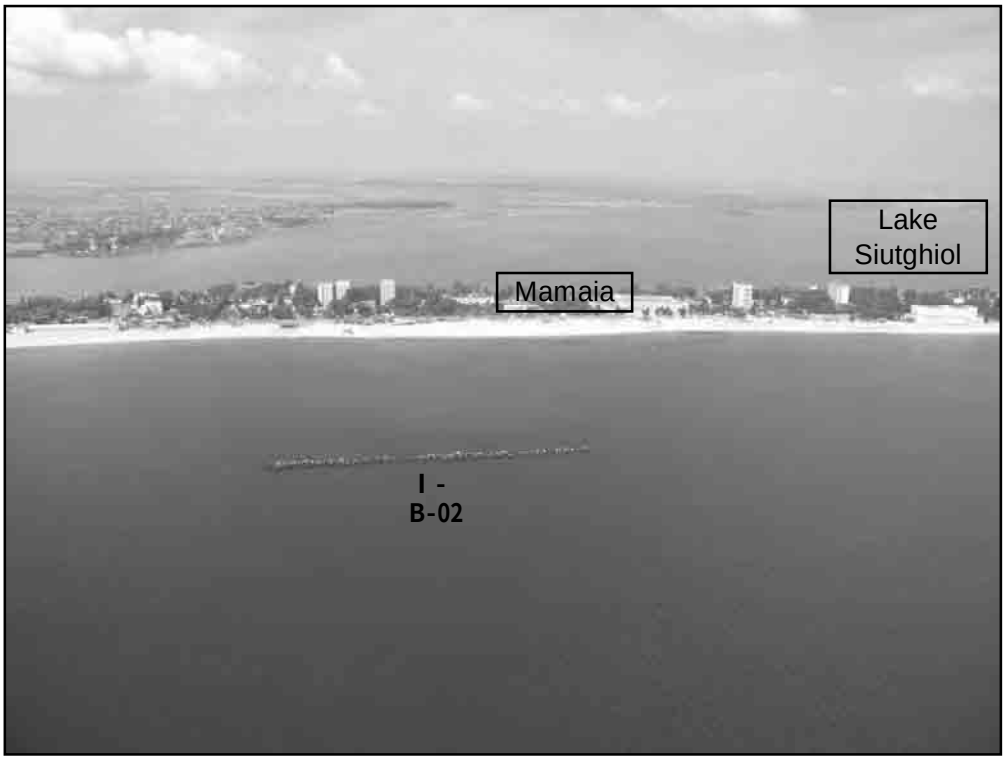
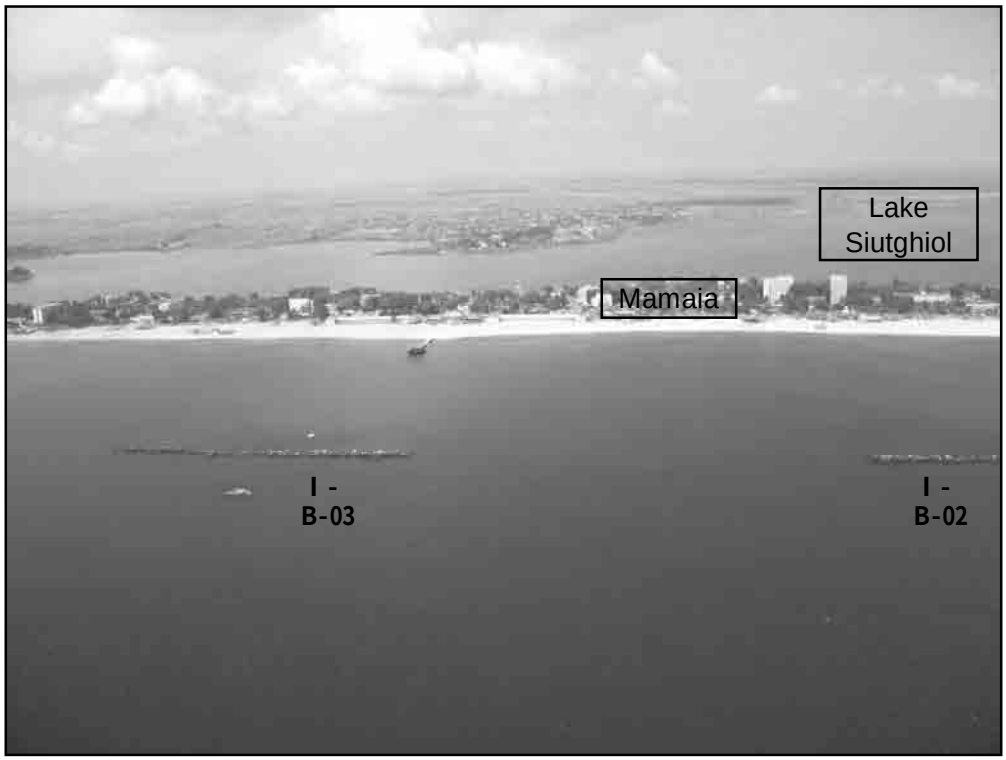


Photo I -10
Sector: I -4
Mamaia Center (2)



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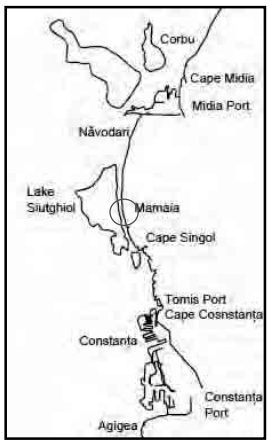
Sector: I -4
Mamaia Center (3)



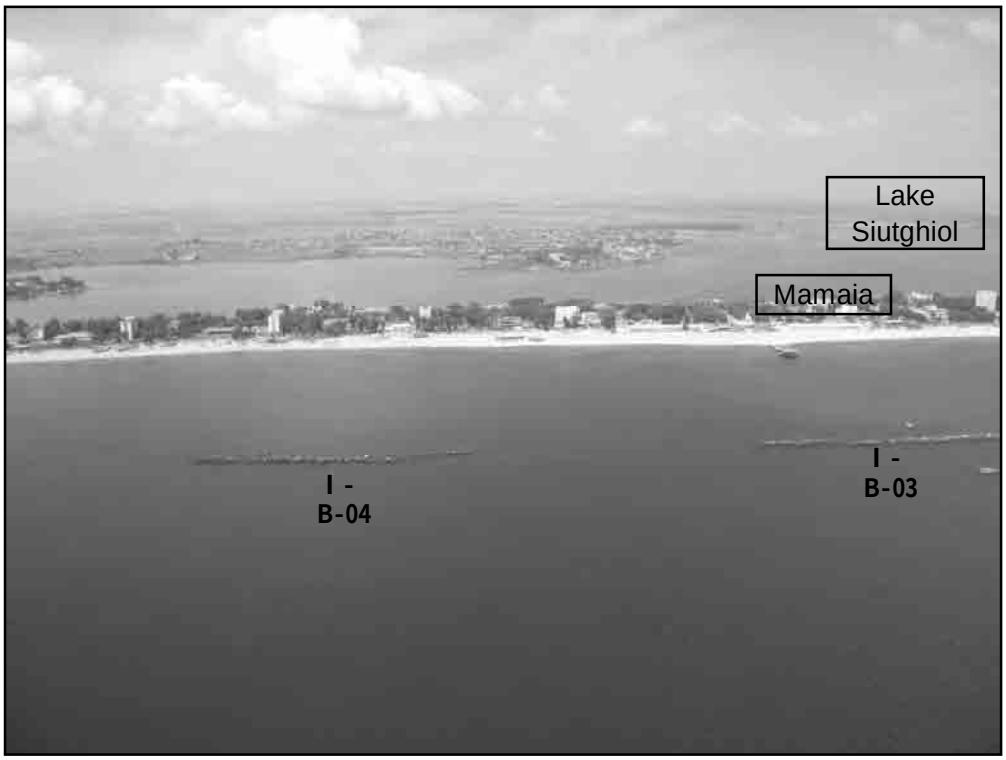
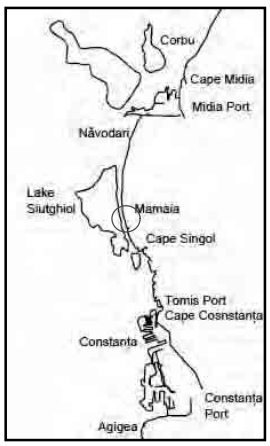
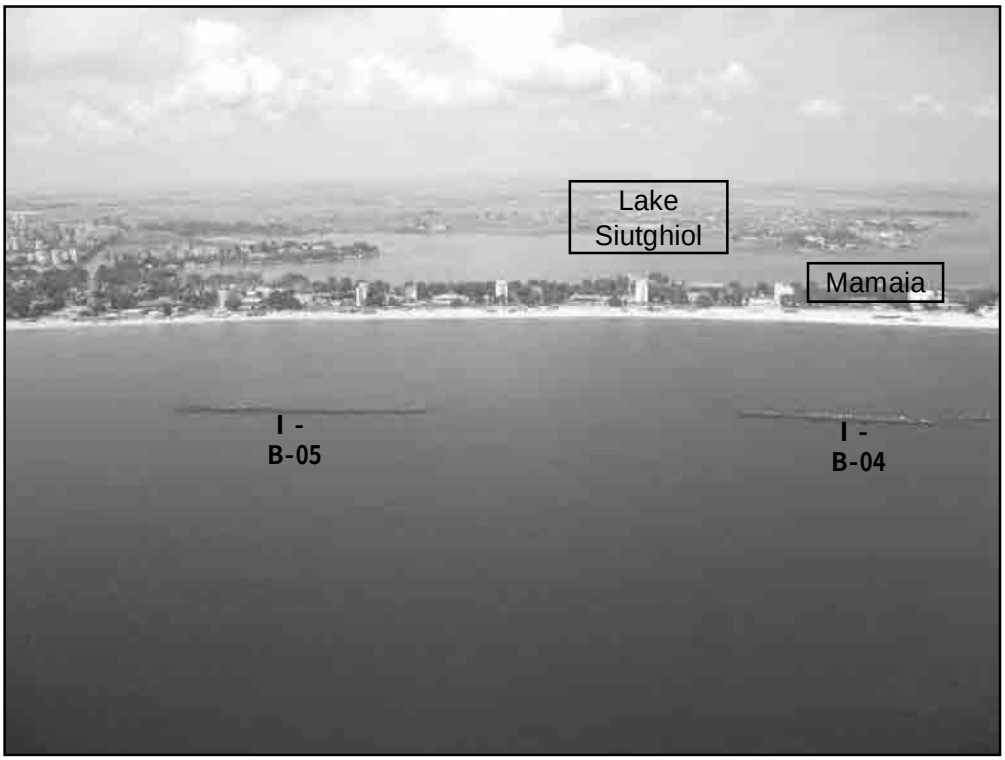


Photo I -12
Sector: I -5
Mamaia South (1)





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Sector: I -5
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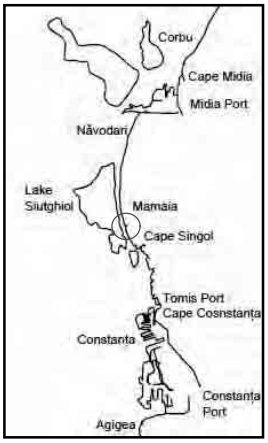

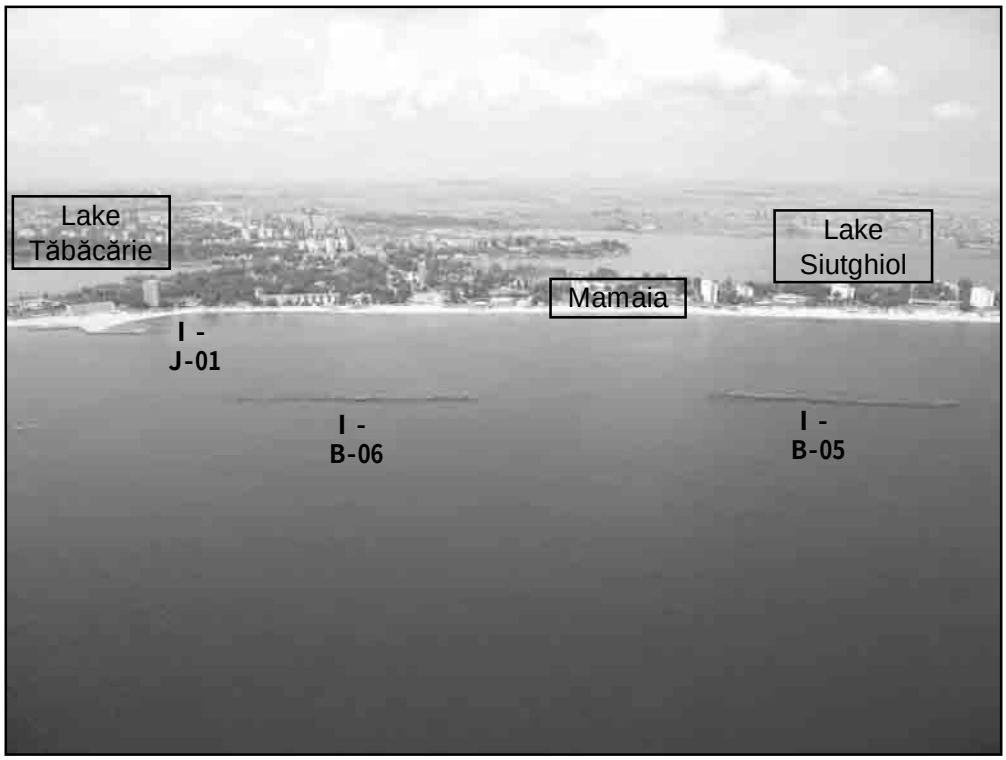

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Sector: I -5
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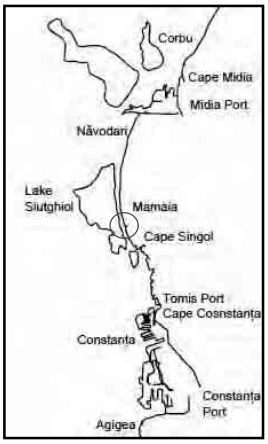

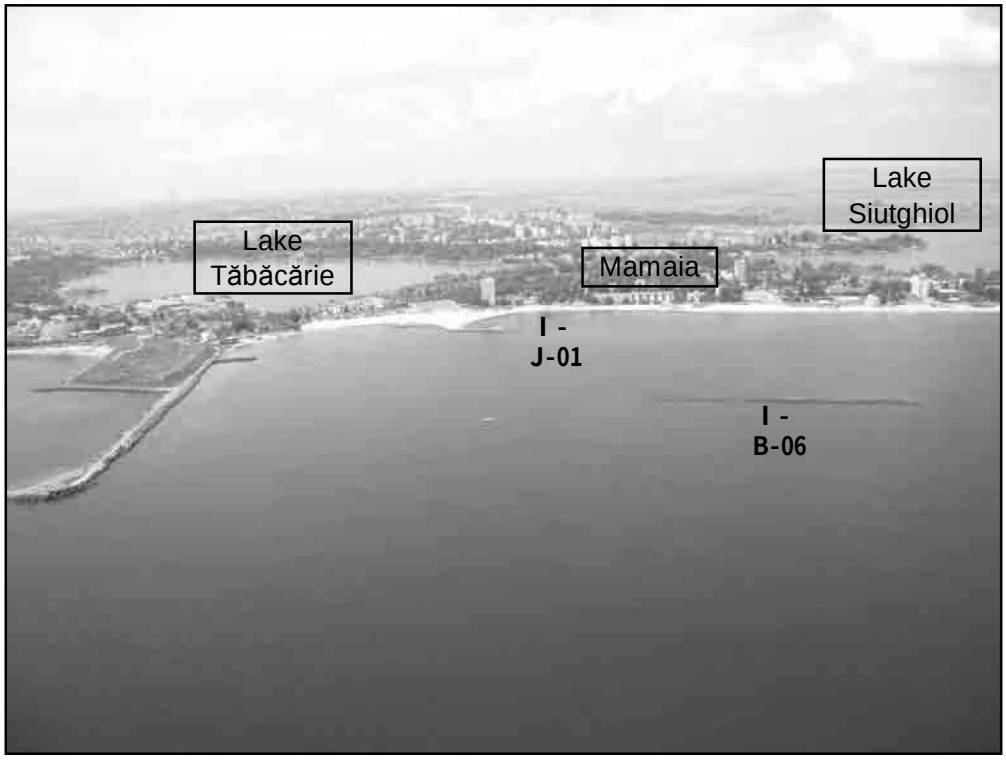

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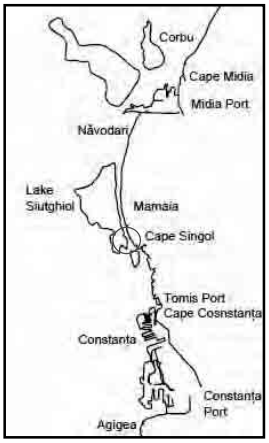

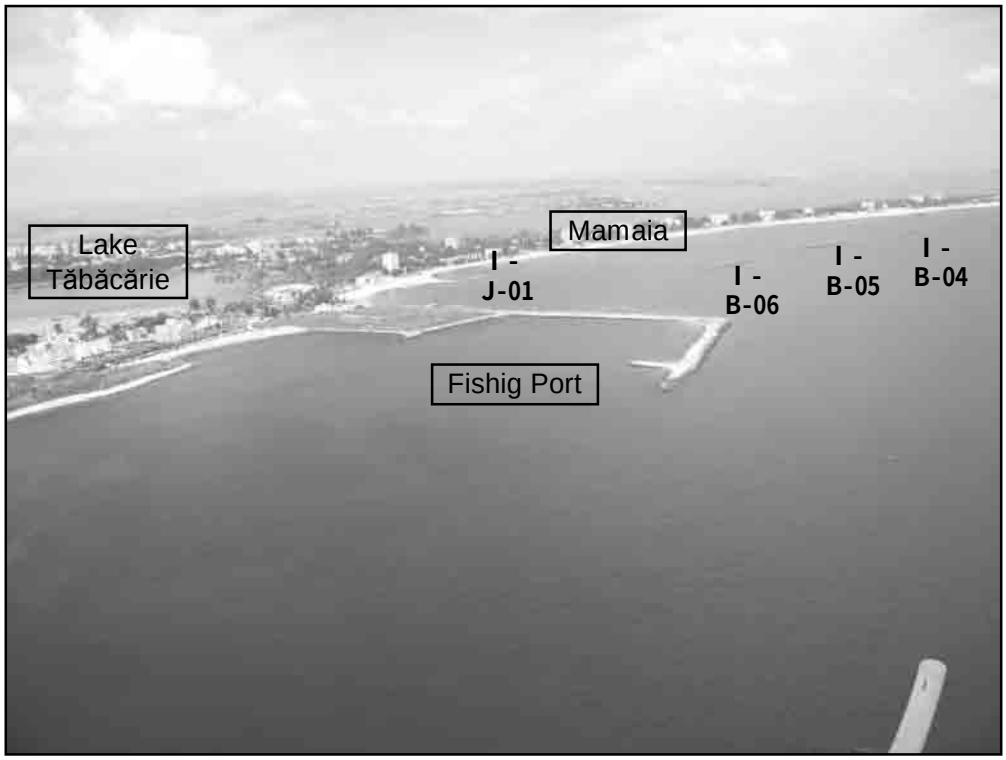

Photo I -16
Sector: I -6
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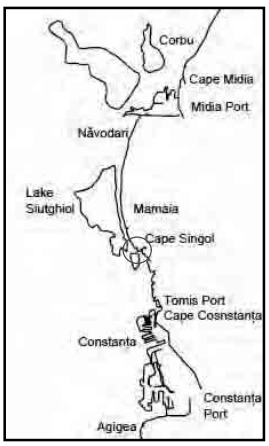

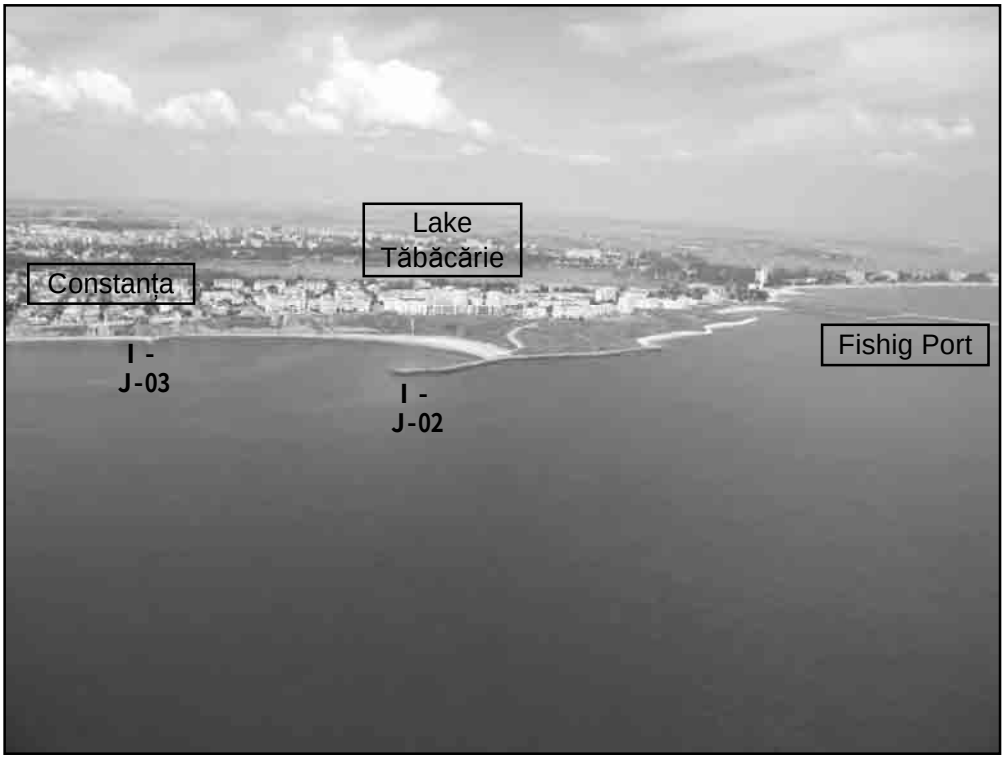

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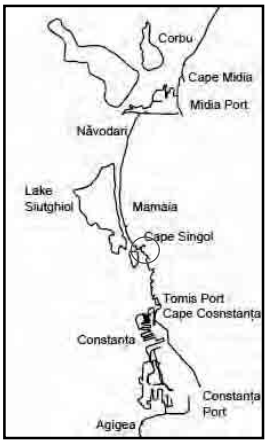

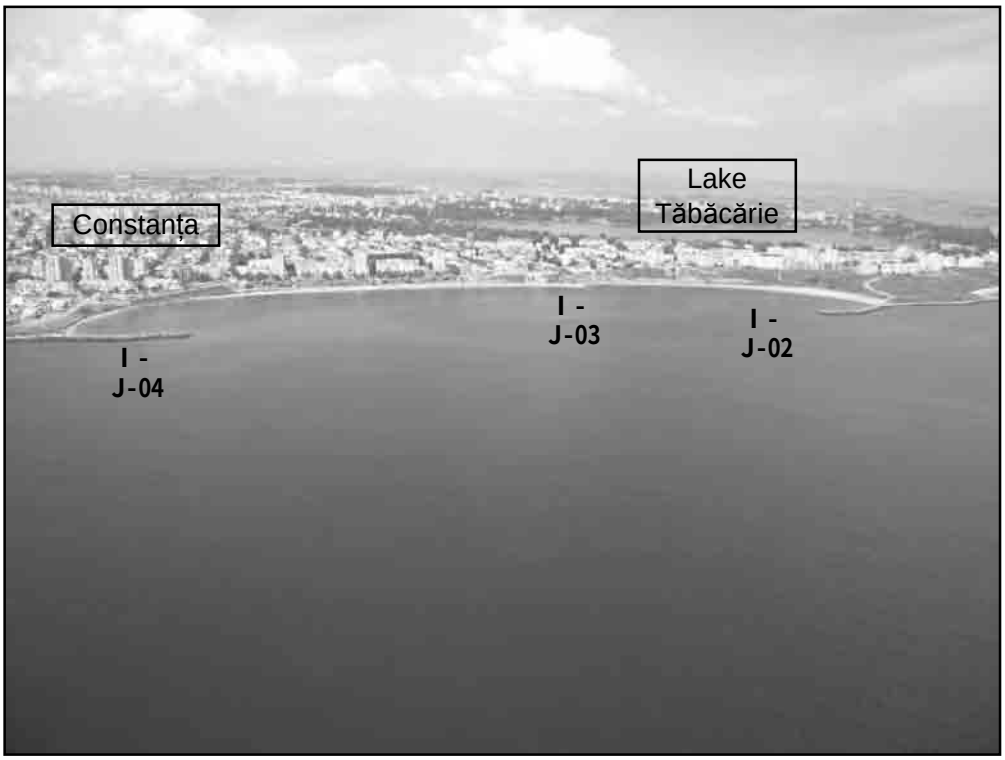

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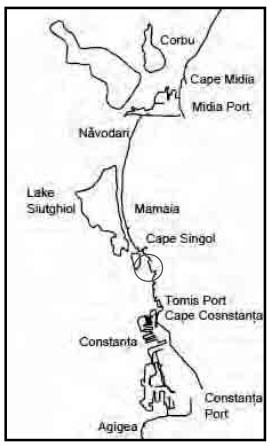

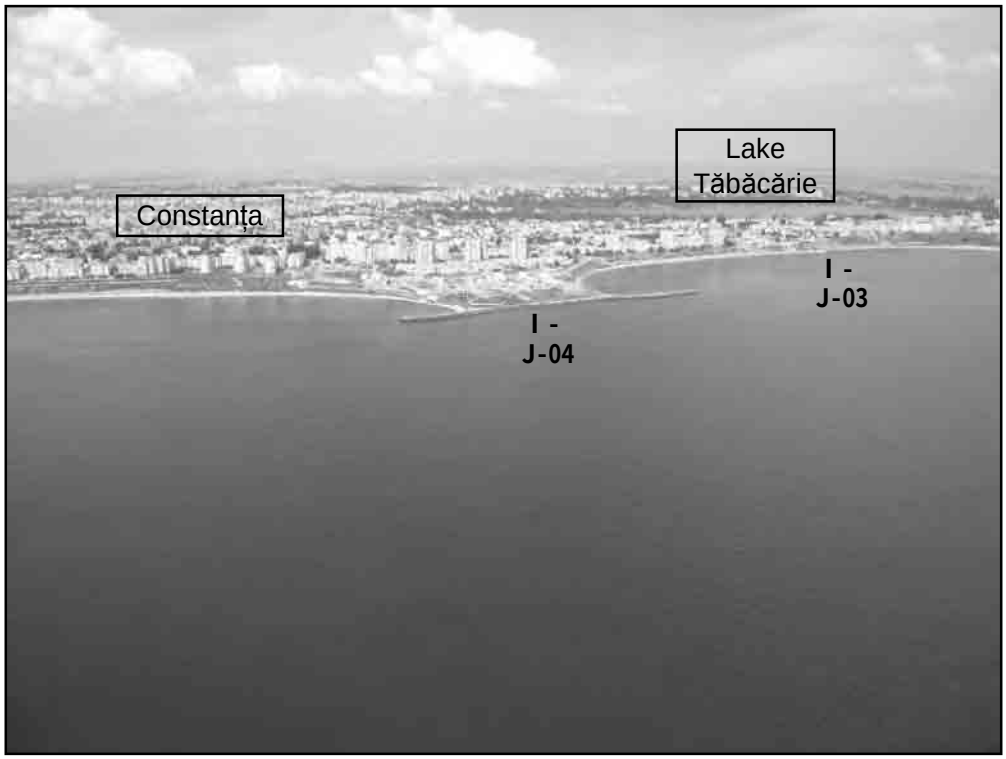

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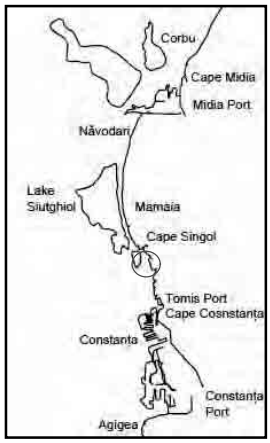


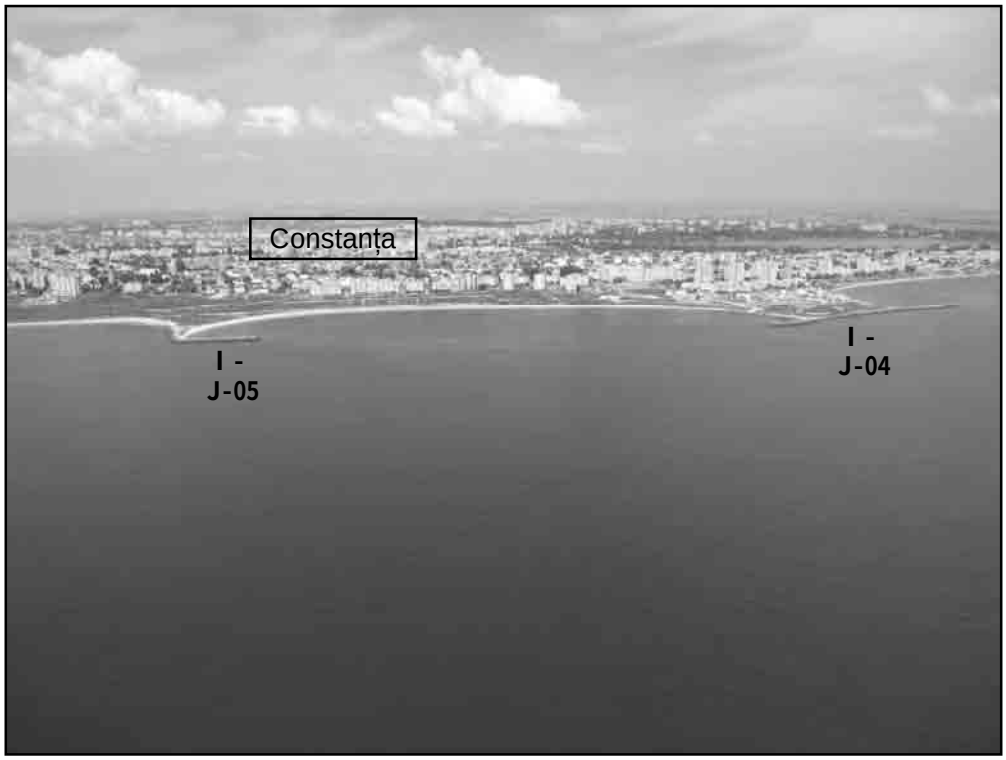
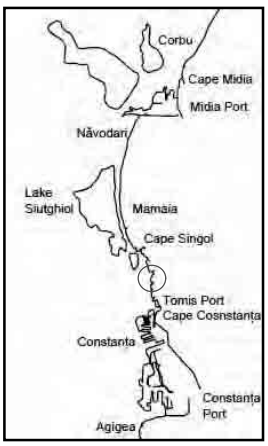


Photo I -20
Sector: I -7
Tomis South (1)



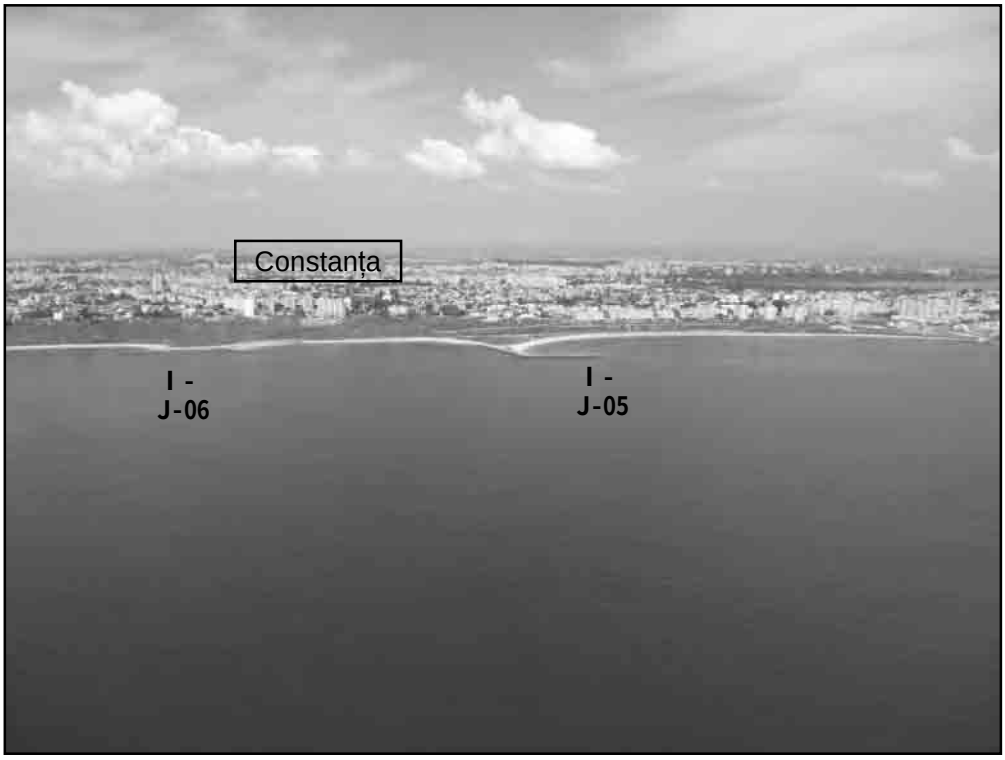


Photo I -21
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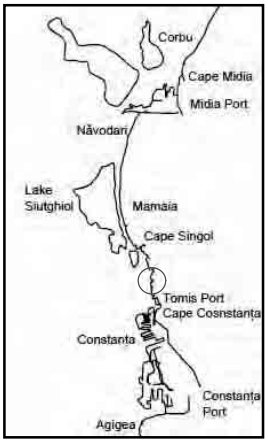

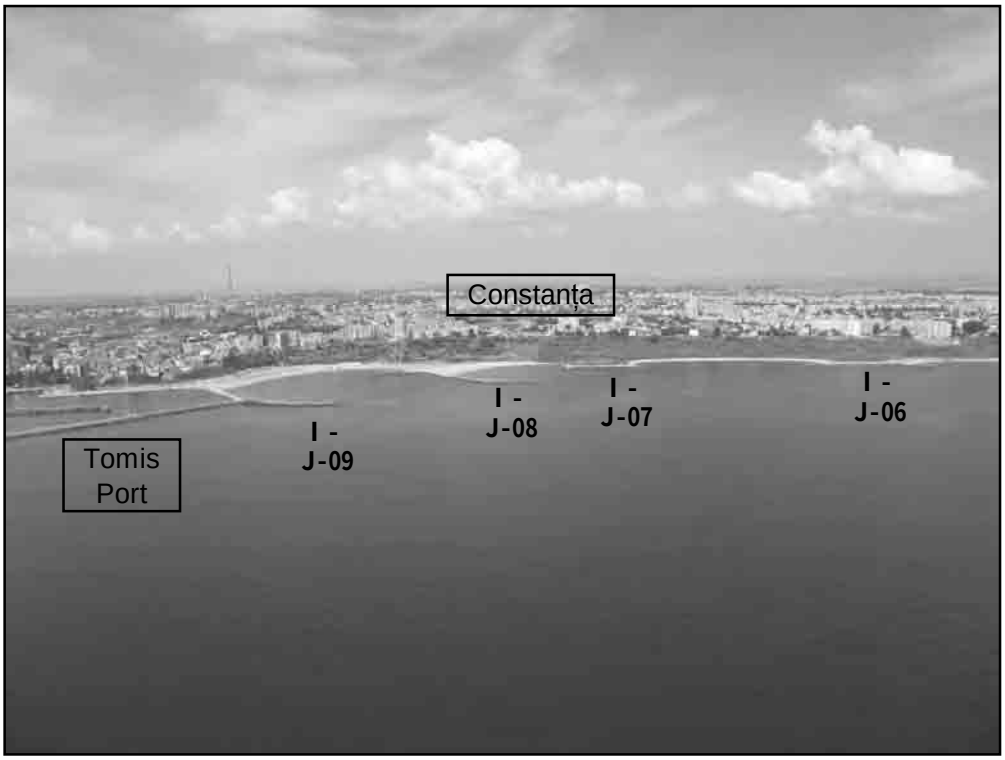

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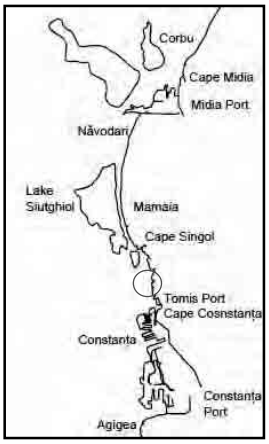


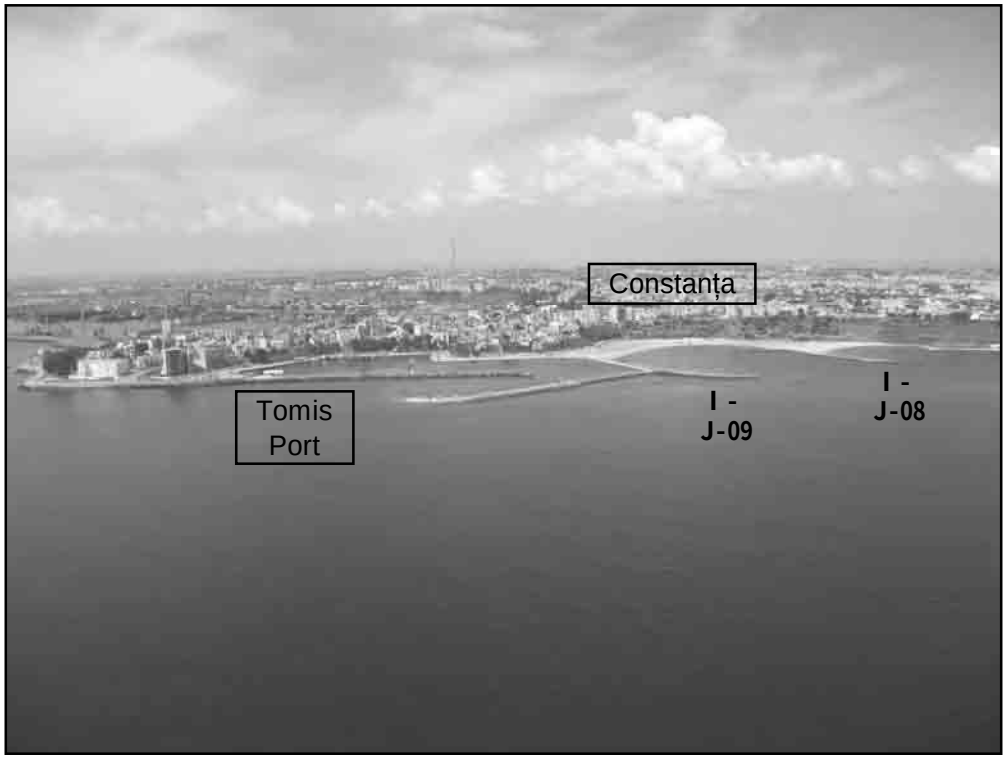
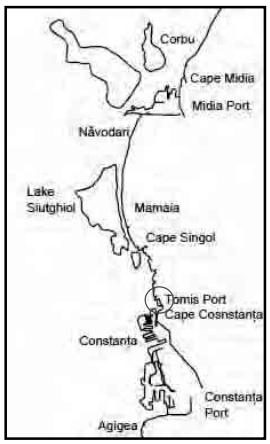


Photo I -23
Sector: I -7
Tomis South (4)



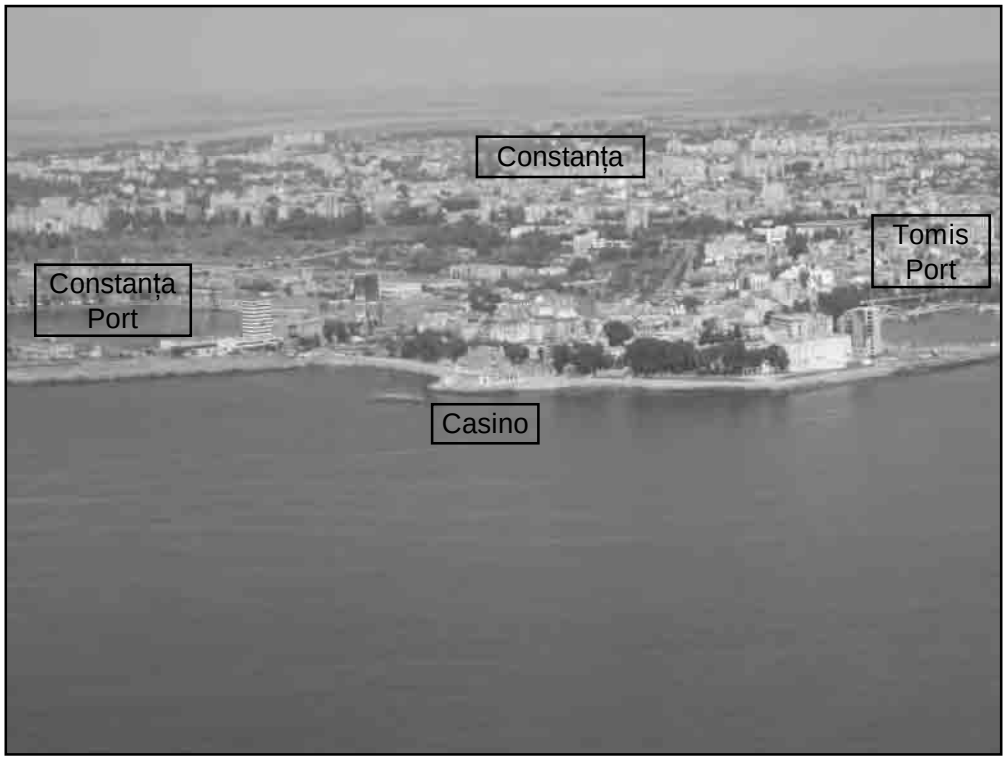
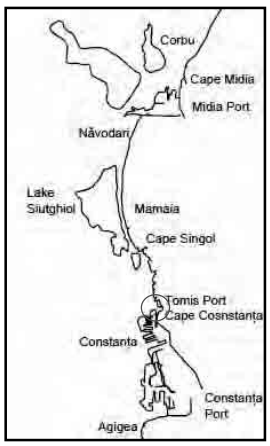


Photo I -24
Casino Area adjacent to Constanț a Port



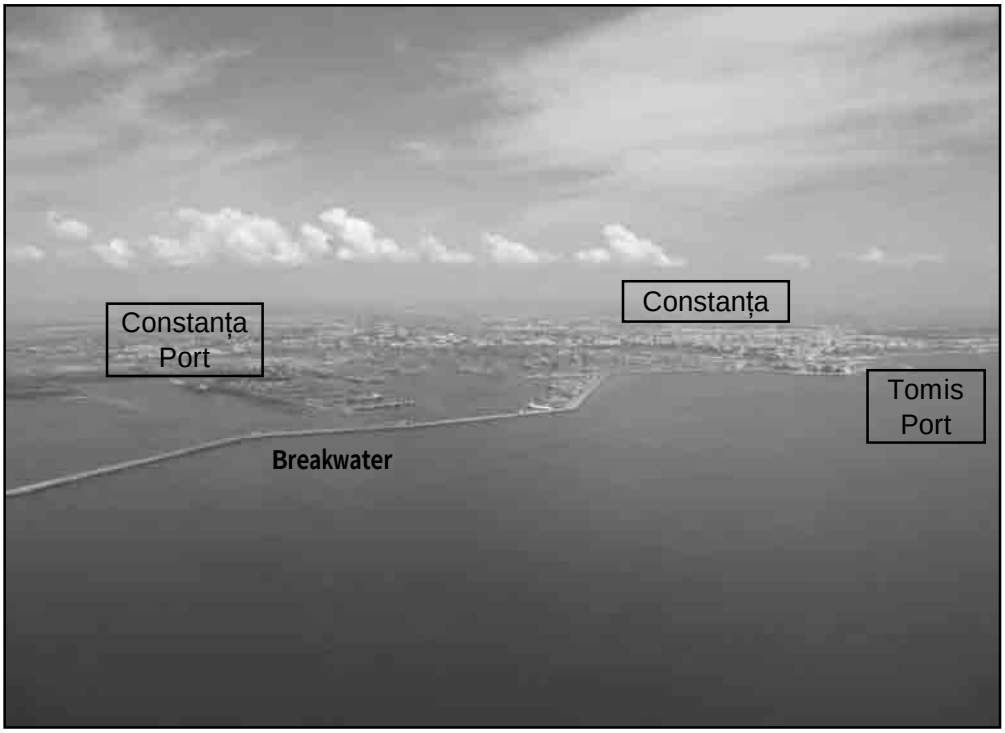


Photo I -25
Constanța Port
(North Port)

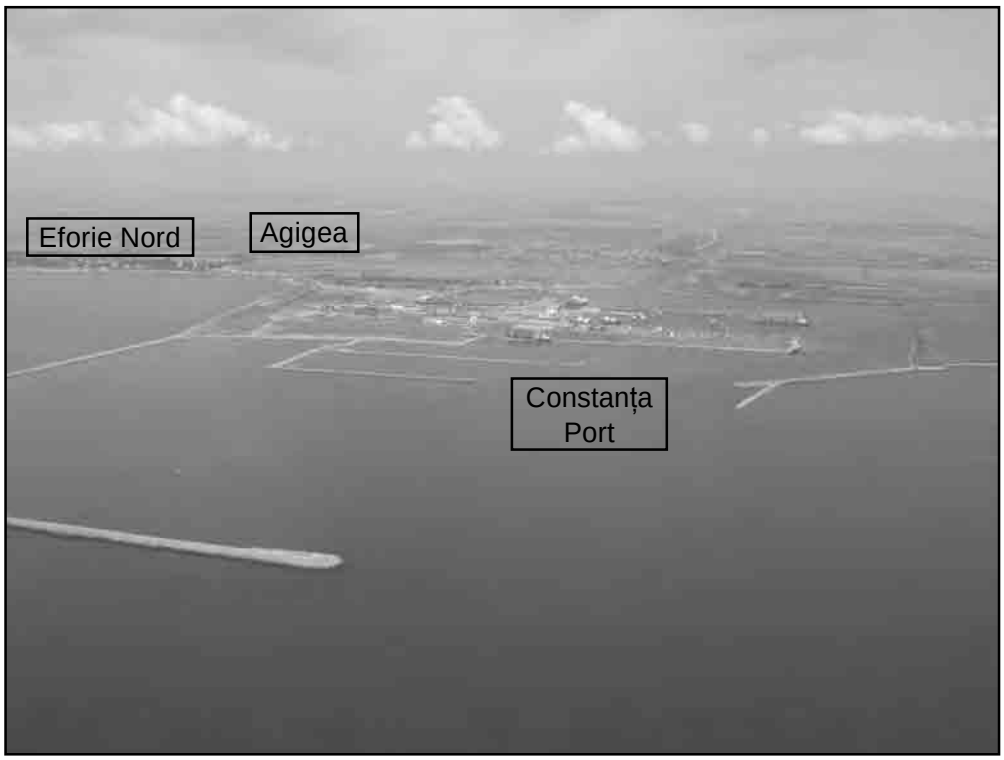
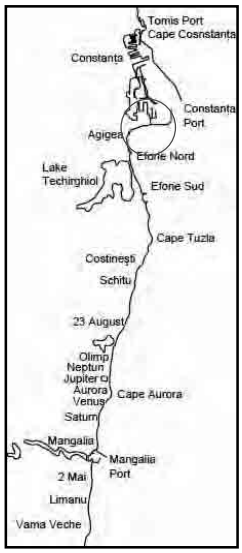


Photo **II**-1
Constanța Port
(South Port)



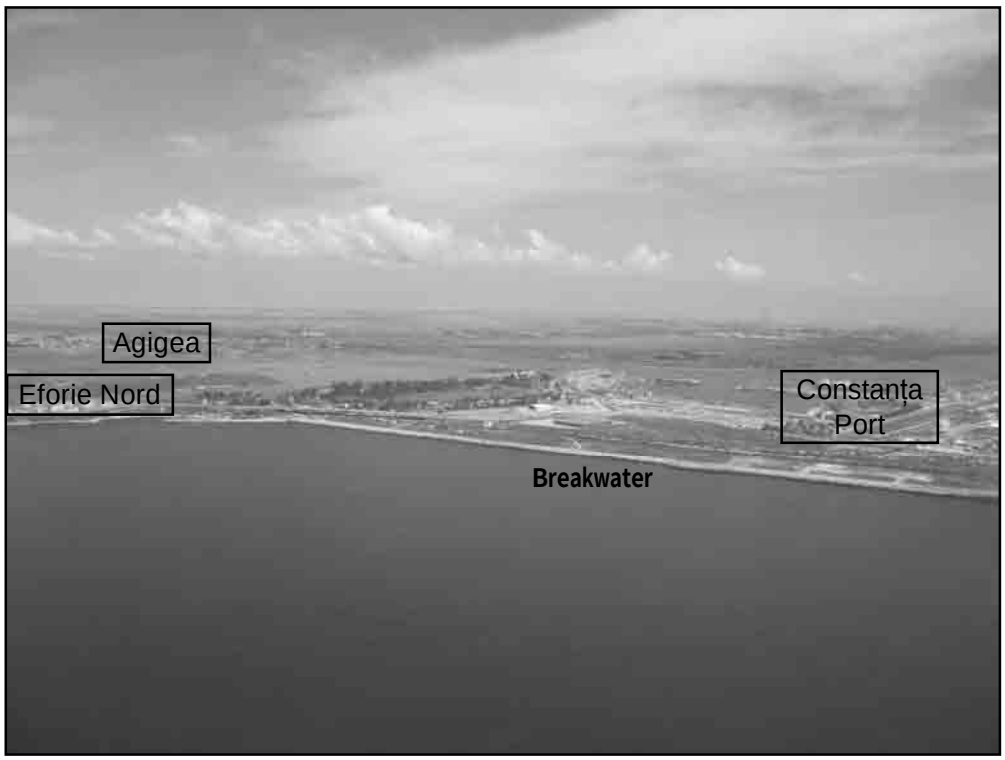


Photo **II**-2
Sector: **II**-1
Eforie Nord (1)

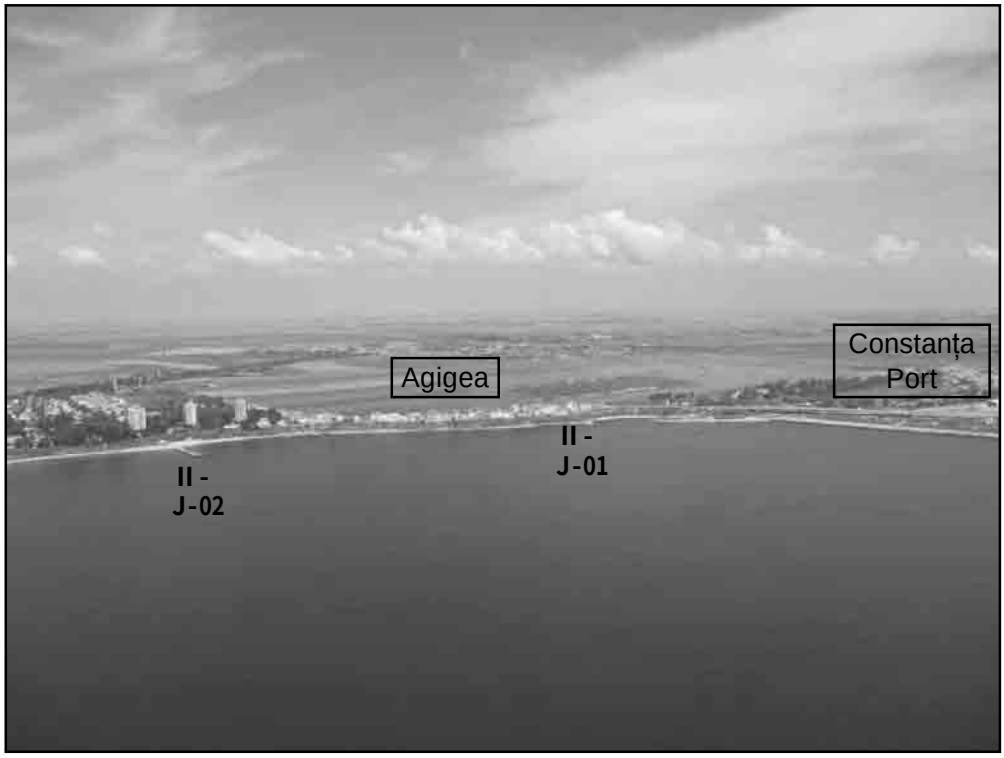
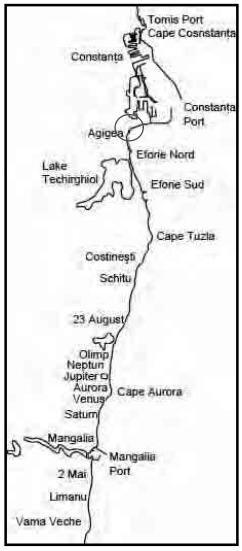


Photo II-3
Sector: II-1
Eforie Nord (2)



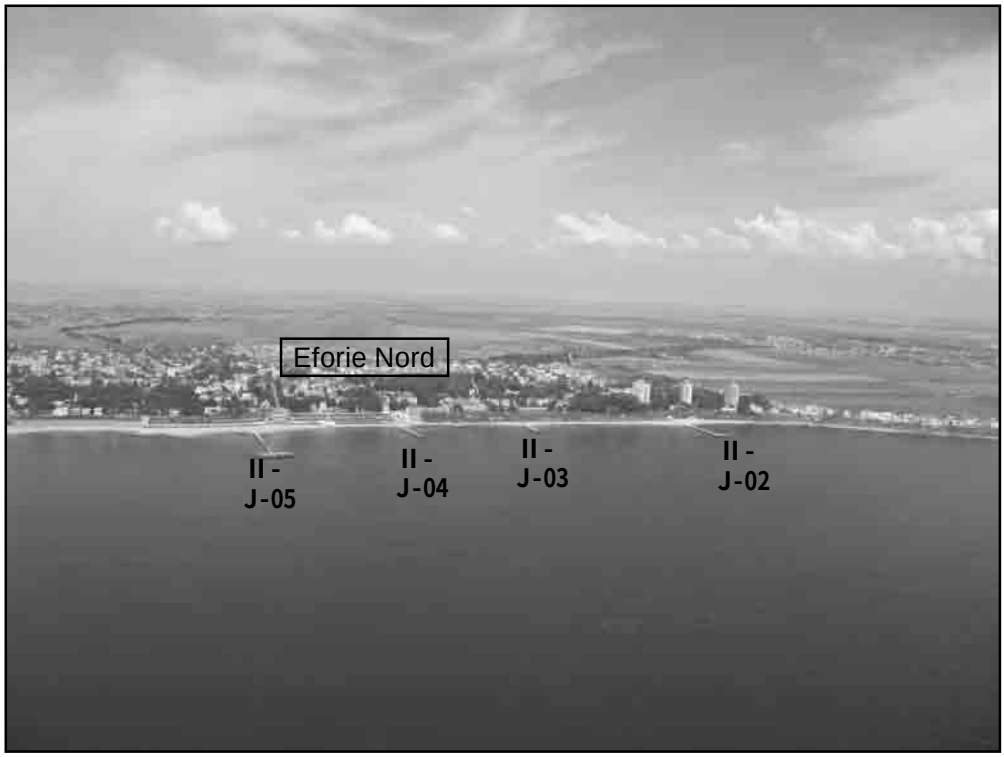
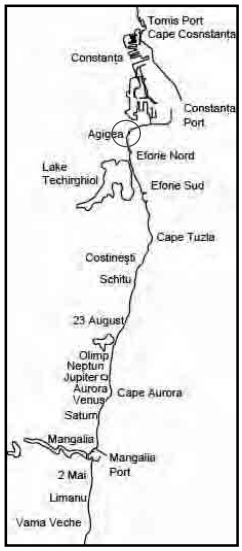


Photo II-4
Sector: II-1
Eforie Nord (3)



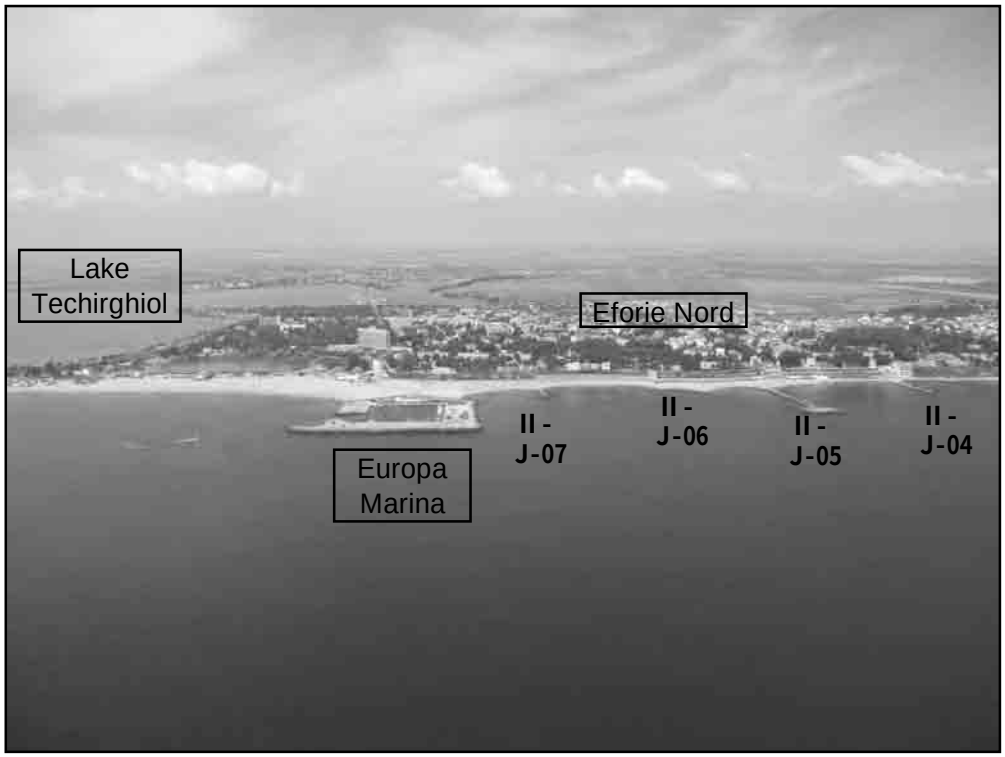
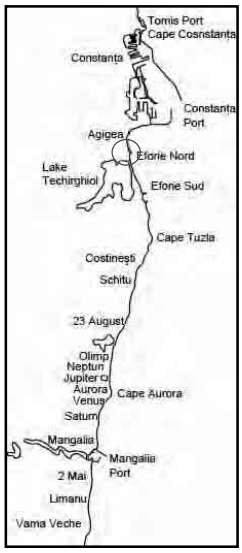


Photo II-5
Sector: II-1
Eforie Nord (4)



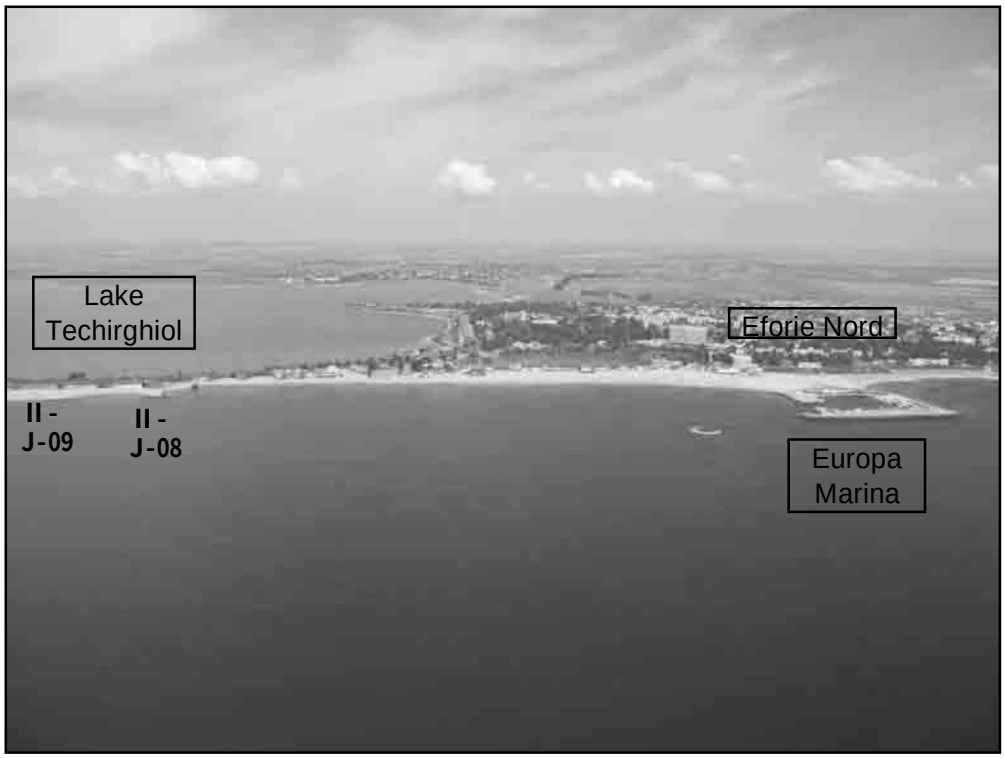
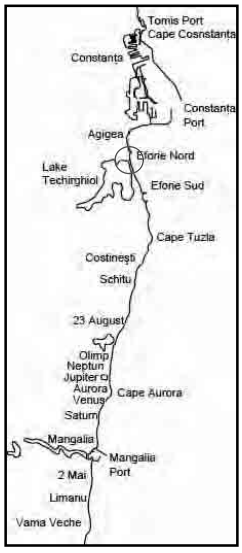


Photo II-6
Sector: II-1
Eforie Nord (5)



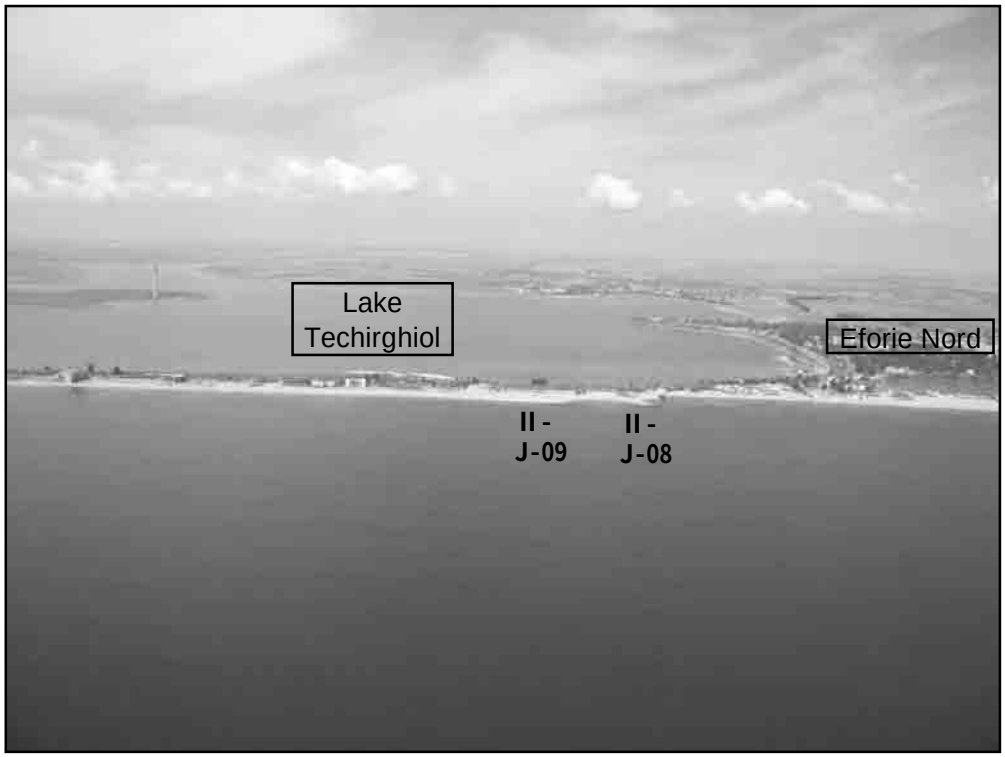
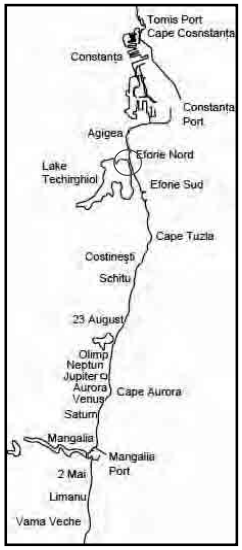


Photo II-7
Sector: II-2
Eforie Middle (1)



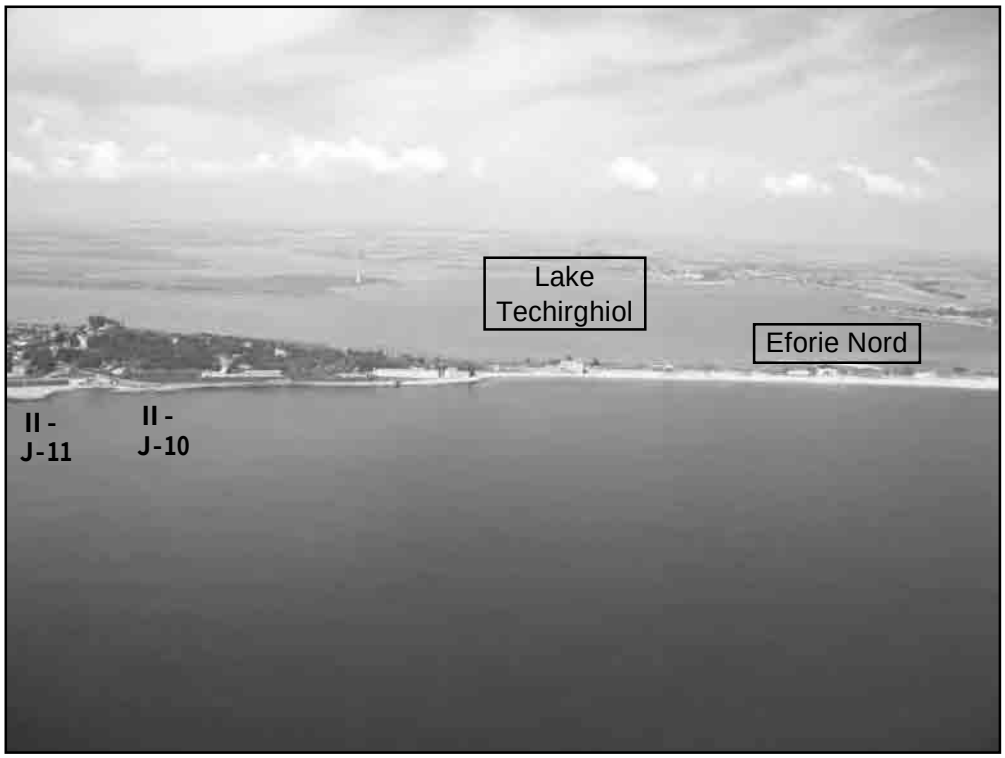
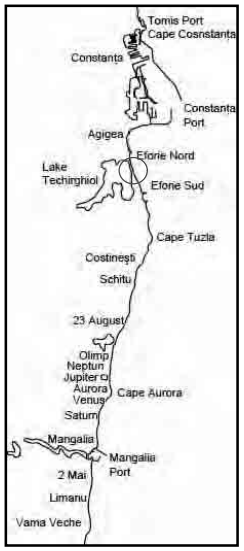


Photo II-8
Sector: II-2
Eforie Middle (2)



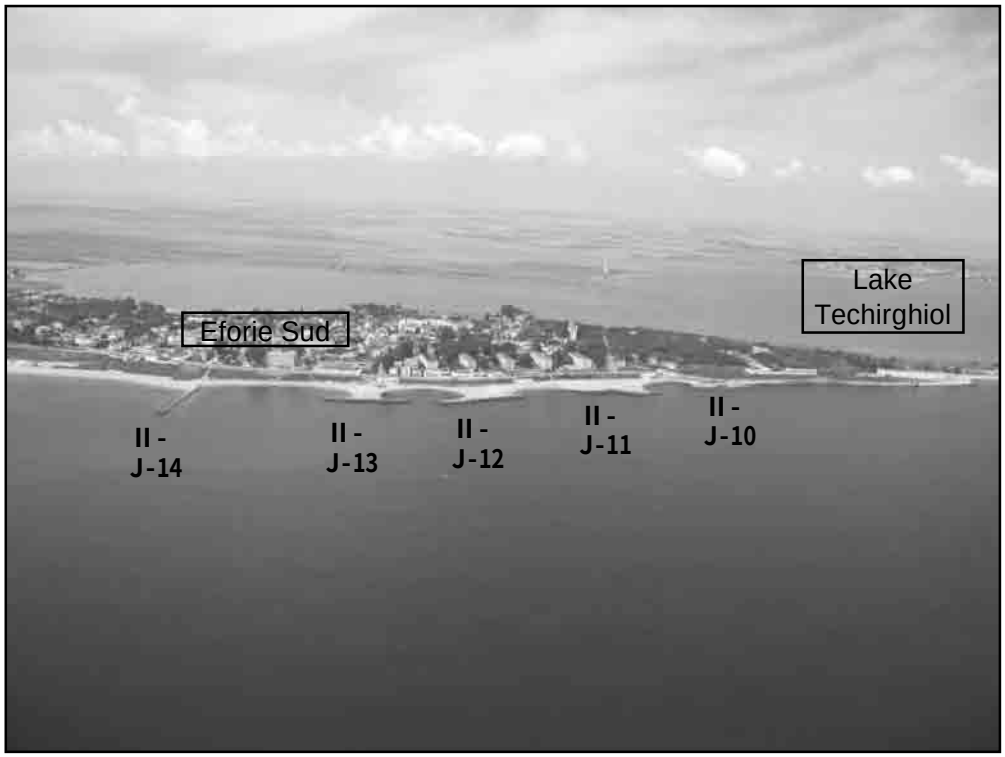
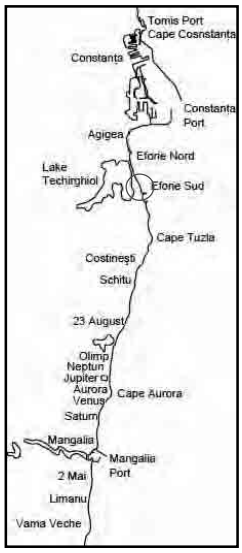


Photo II-9
Sector: II-3
Eforie Sud (1)



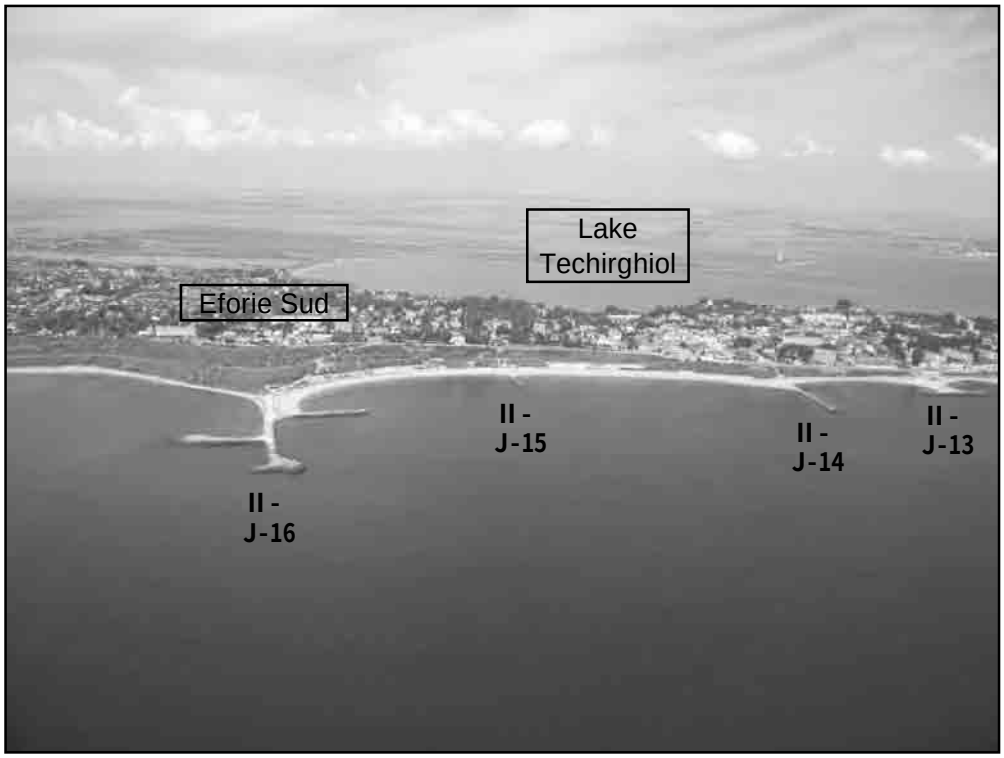
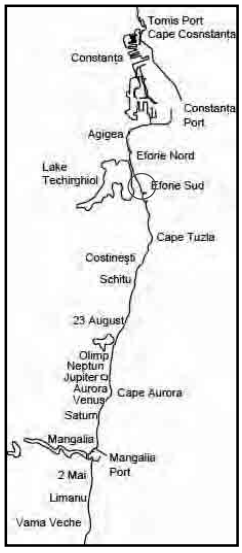


Photo II-10
Sector: II-3
Eforie Sud (2)



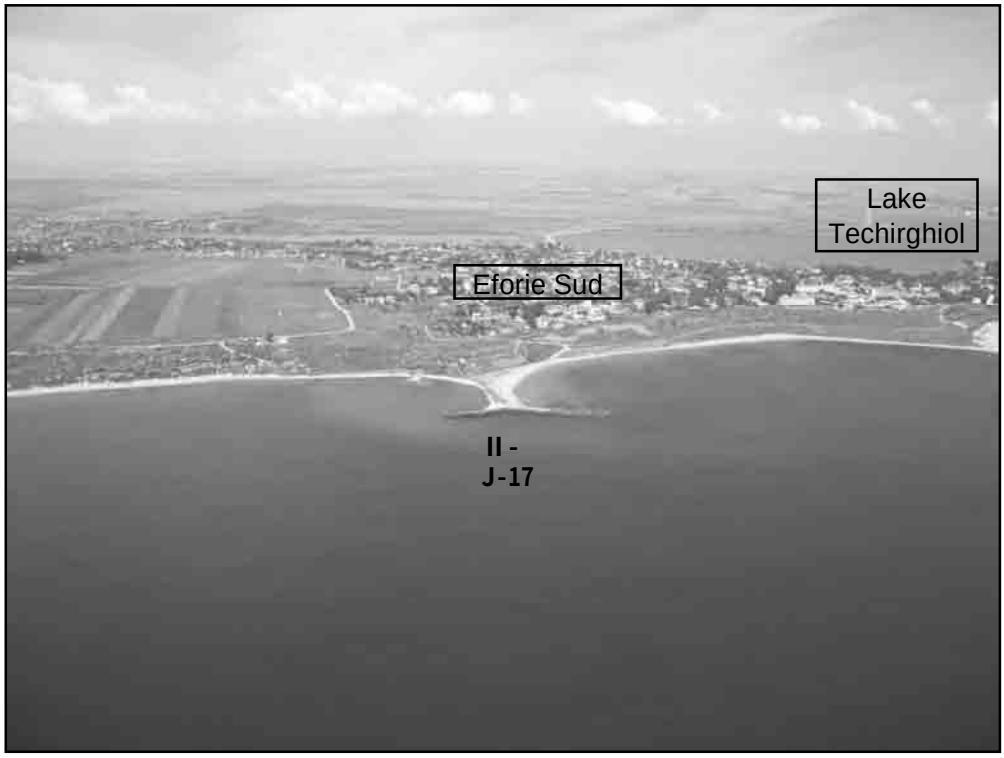


Photo II-11
Sector: II-3
Eforie Sud (3)

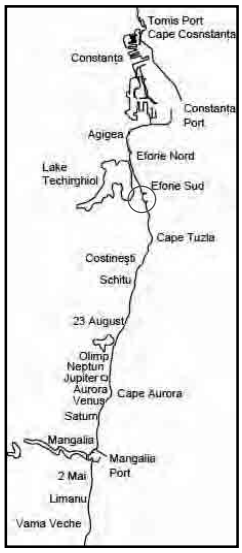


Photo **III**-1
Sector: **III**-1
Tuzla North (1)

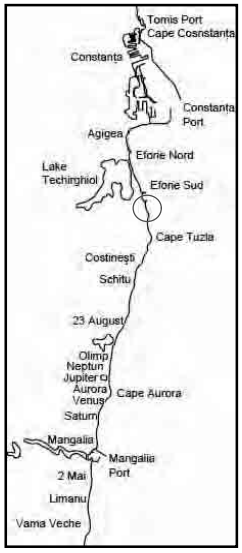


Photo **III**-2
Sector: **III**-1
Tuzla North (2)

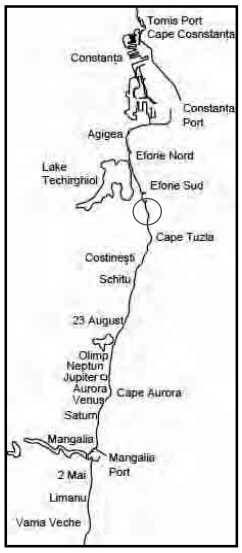


Photo **III**-3
Sector: **III**-1
Tuzla North (3)

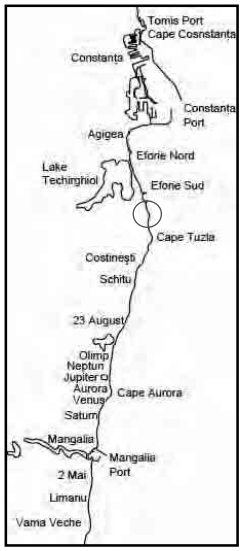


Photo **III**-4
Sector: **III**-1
Tuzla North (4)

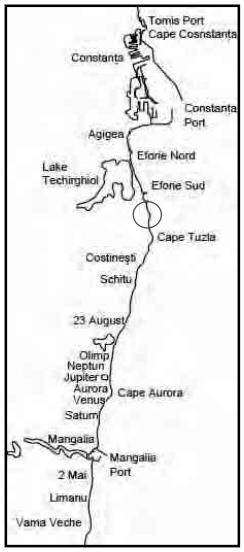


Photo **III**-5
Sector: **III**-1
Tuzla North (5)

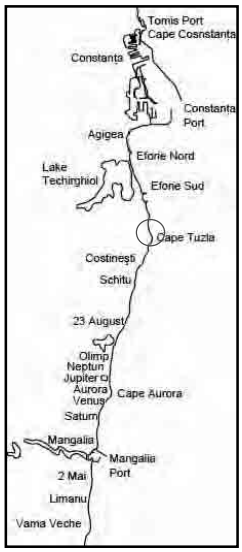


Photo **III**-6
Sector: **III**-2
Tuzla South (1)

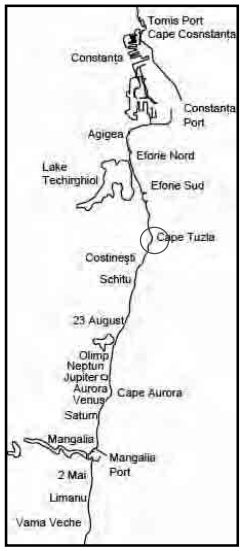


Photo **III**-7
Sector: **III**-2
Tuzla South (2)

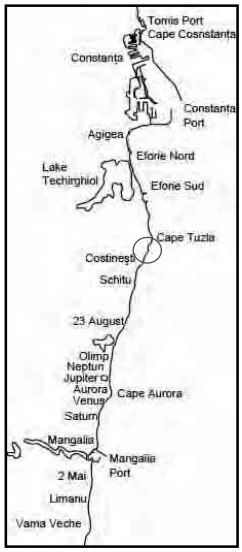


Photo **III**-8
Sector: **III**-2
Tuzla South (3)

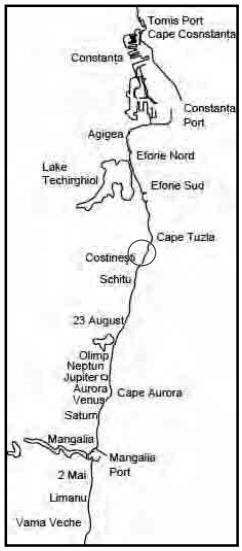


Photo **III**-9
Sector: **III**-2
Tuzla South (4)

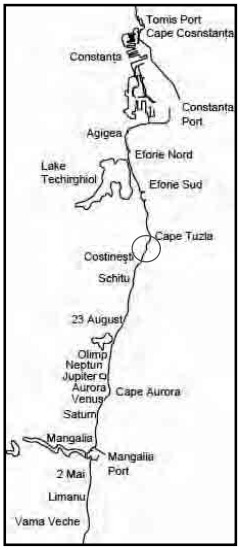


Photo **IV**-1
Sector: **IV**-0
Costineşti (1)

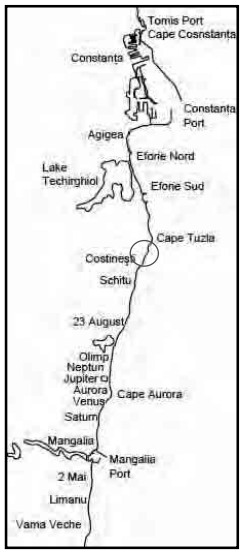


Photo **IV**-2
Sector: **IV**-0
Costineşti (2)

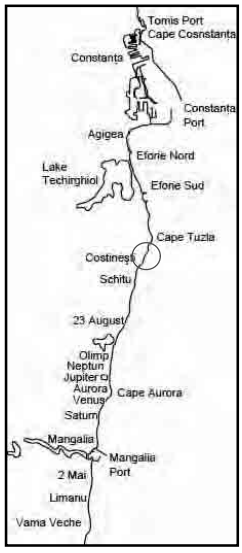


Photo **IV**-3
Sector: **IV**-0
Costineşti (3)

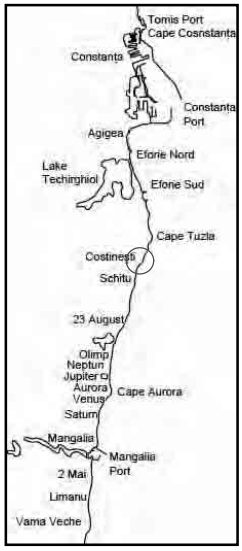


Photo **IV**-4
Sector: **IV**-0
Costineşti (4)

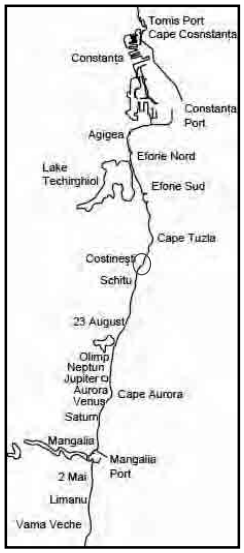


Photo **V**-1
Sector: **V**-1
Schitu (1)

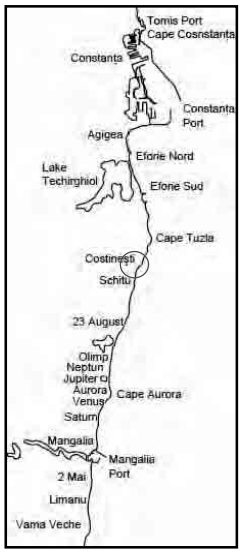


Photo **V**-2
Sector: **V**-1
Schitu (2)

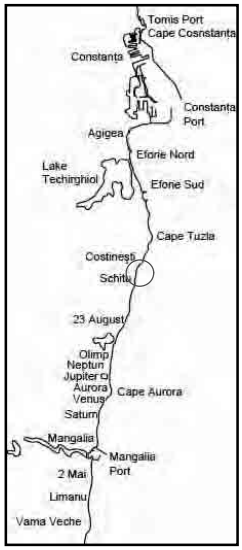


Photo V-3
Sector: V-1
Schitu (3)

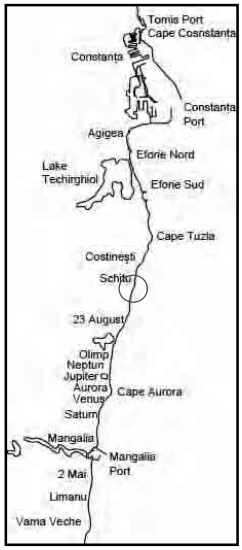


Photo V-4
Sector: V-1
Schitu (4)

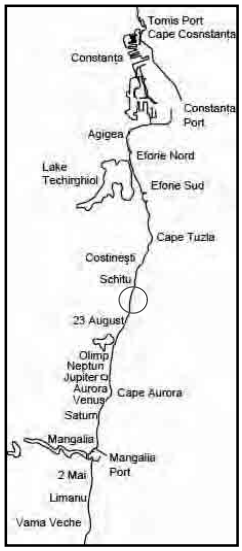


Photo V-5
Sector: V-1
Schitu (5)

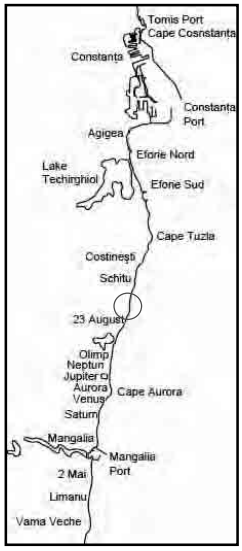


Photo V-6
Sector: V-1
Schitu (6)

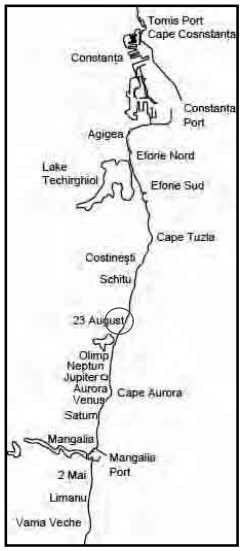
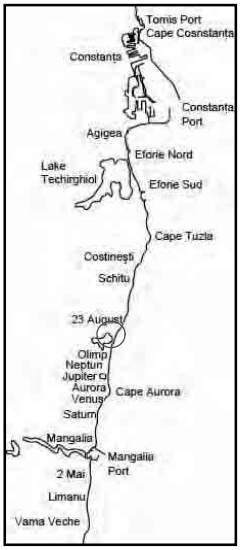


Photo **V**-7
Sector: **V**-1
Schitu (7)



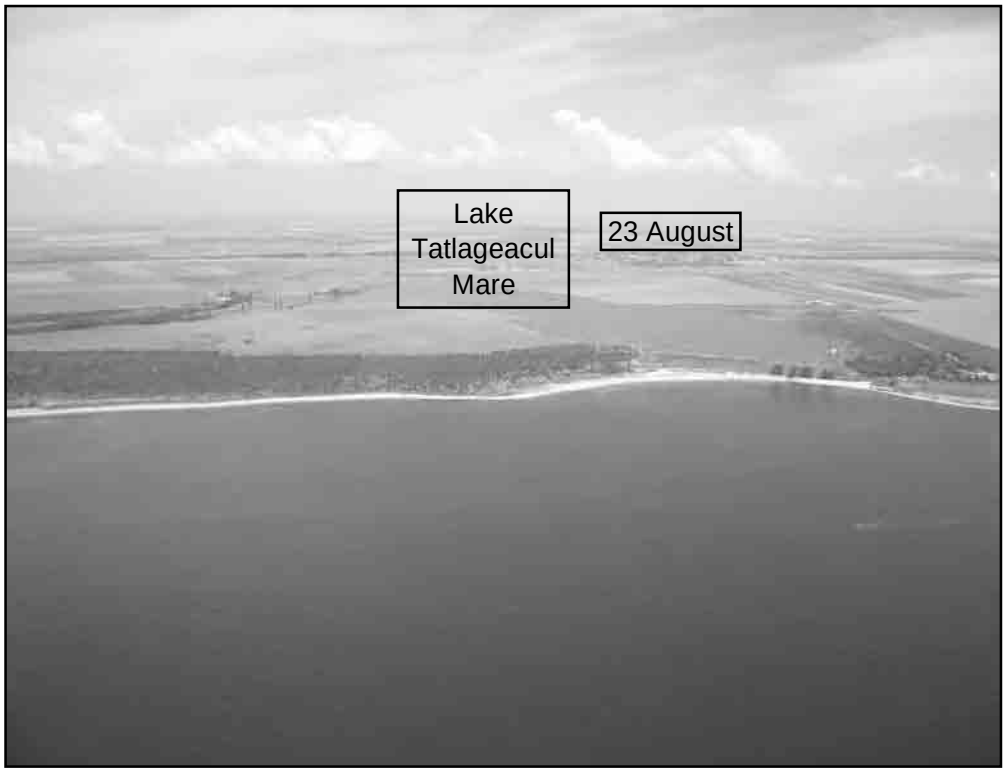


Photo **VI**-1
Sector: **VI**-1
Olimp-Venus (1)

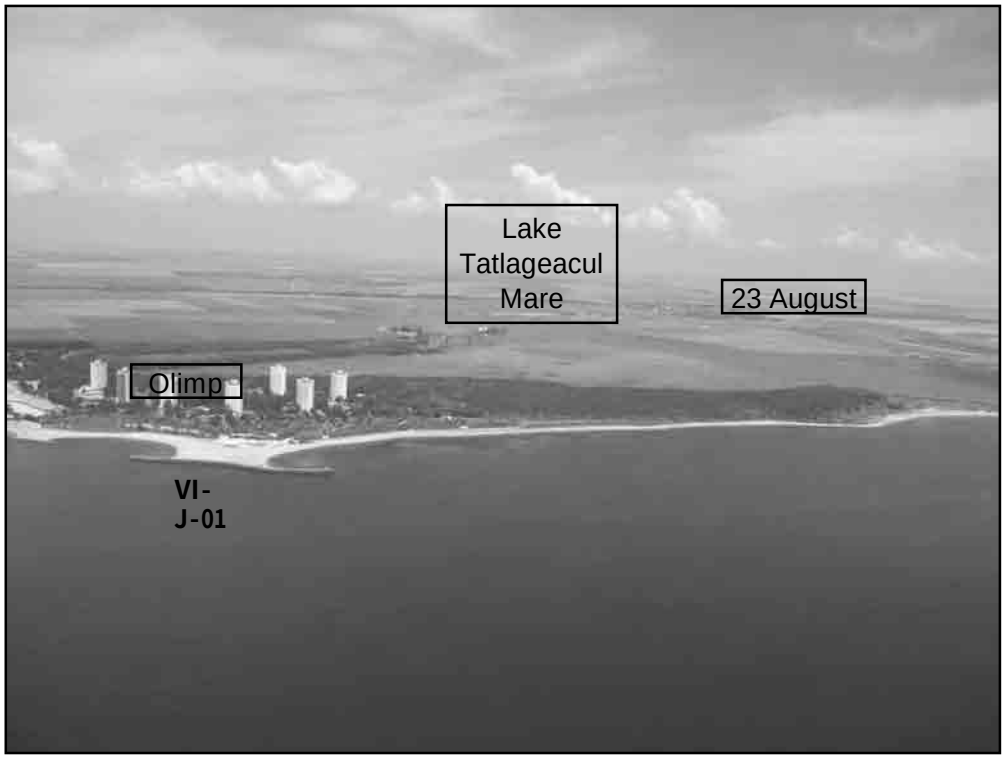


Photo **VI**-2
Sector: **VI**-1
Olimp-Venus (2)

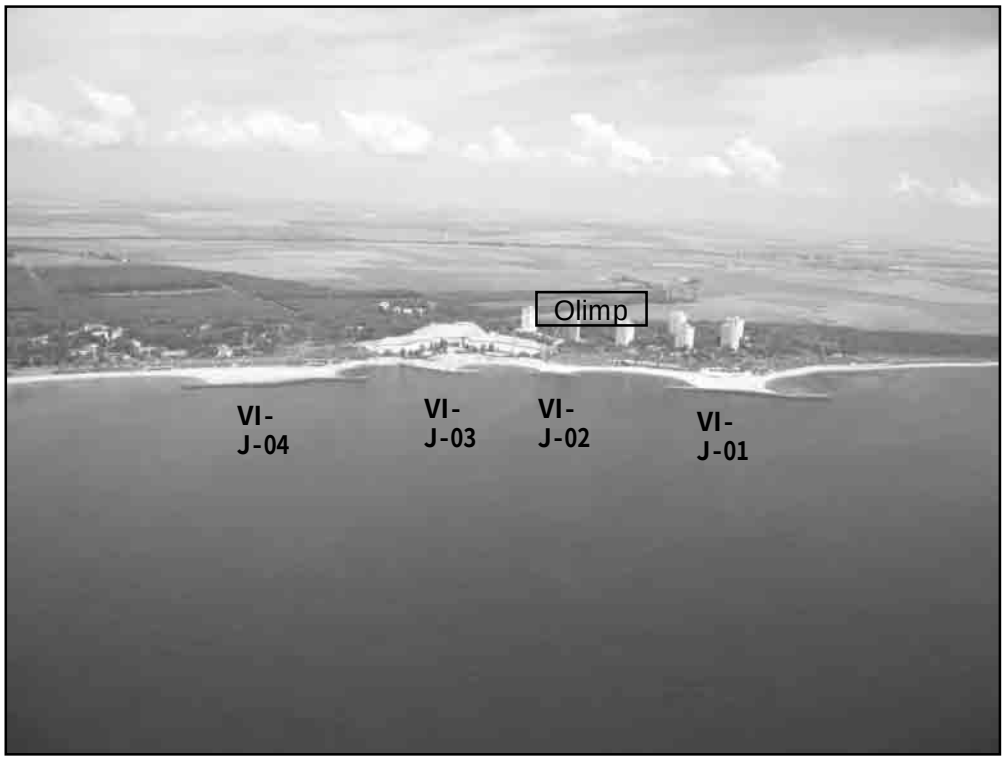


Photo **VI**-3
Sector: **VI**-1
Olimp-Venus (3)

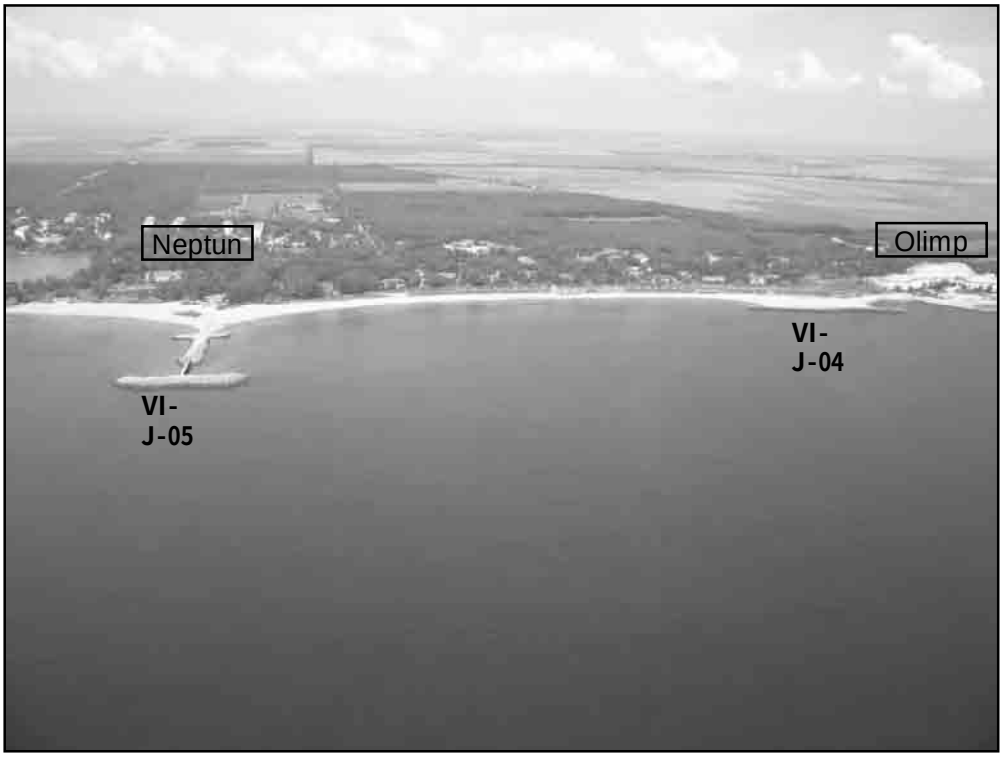
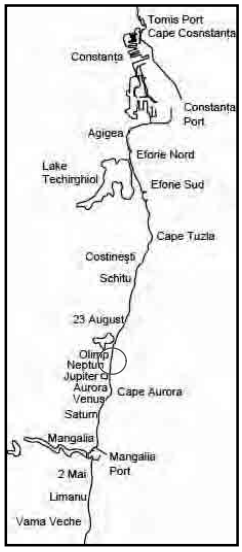


Photo **VI**-4
Sector: **VI**-1
Olimp-Venus (4)



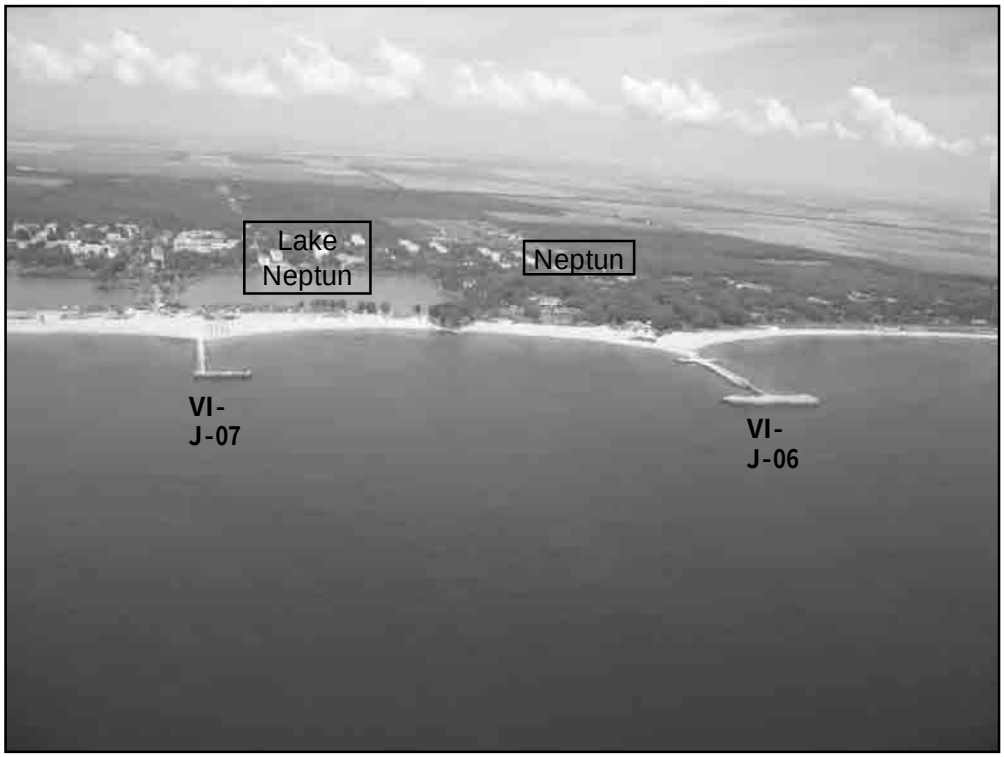


Photo **VI**-5
Sector: **VI**-1
Olimp-Venus (5)

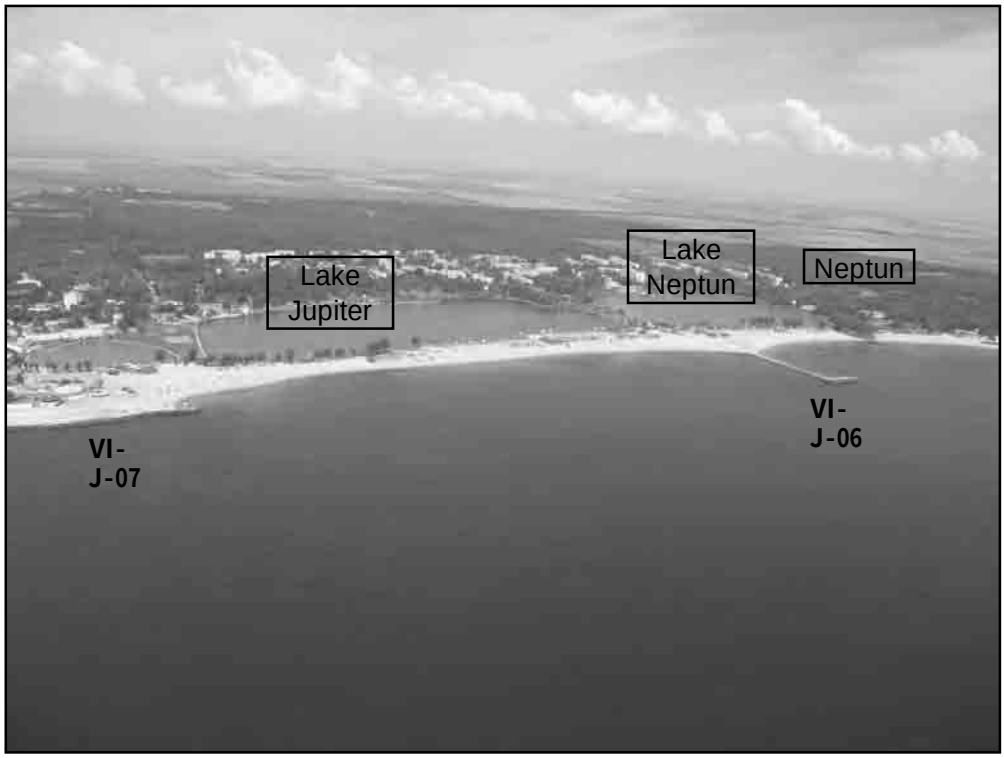


Photo **VI**-6
Sector: **VI**-1
Olimp-Venus (6)

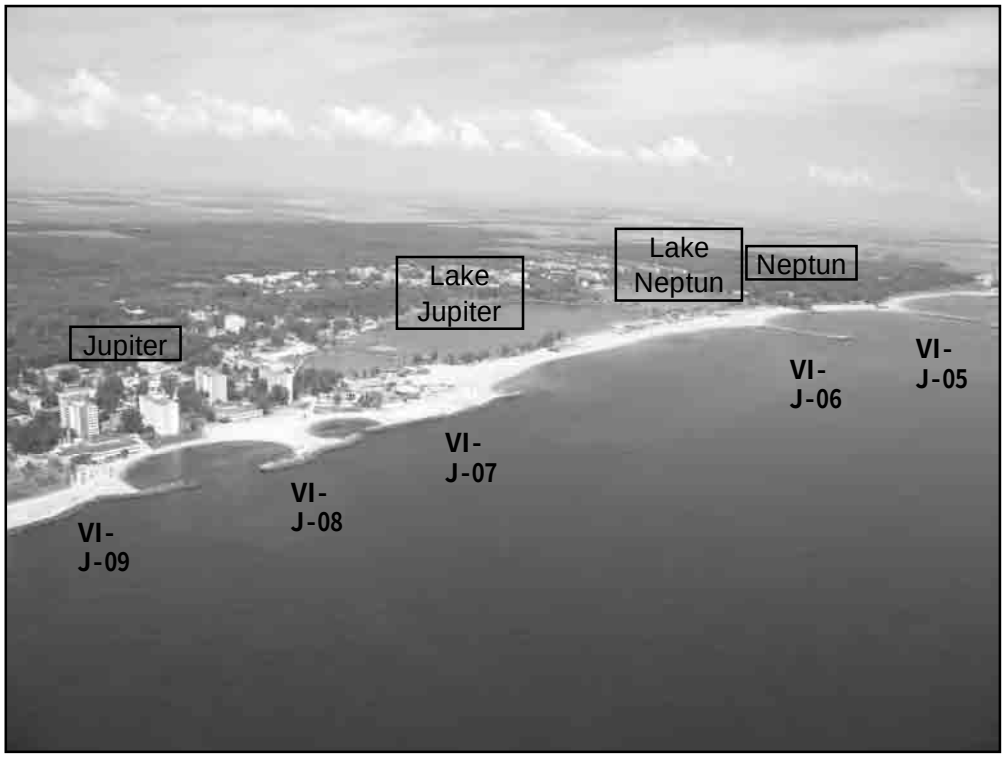
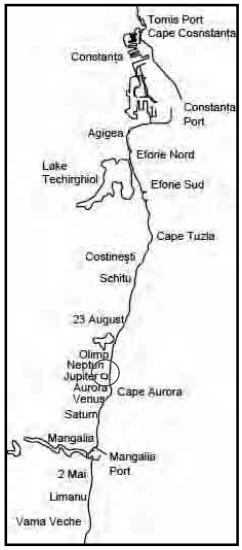


Photo **VI**-7
Sector: **VI**-1
Olimp-Venus (7)



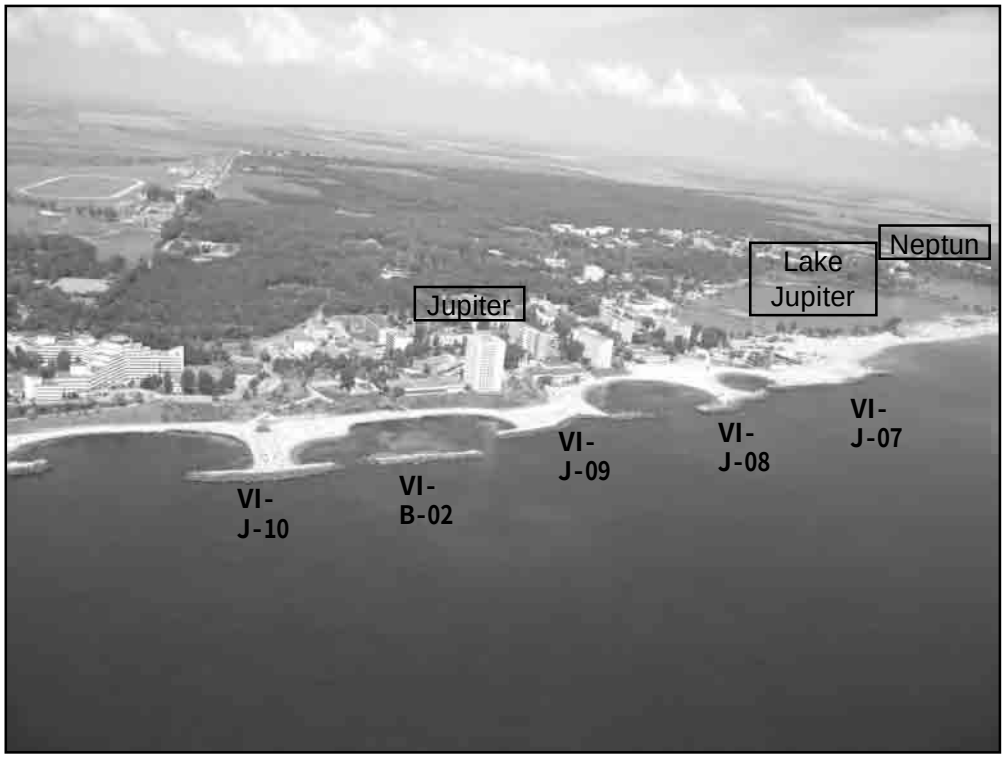
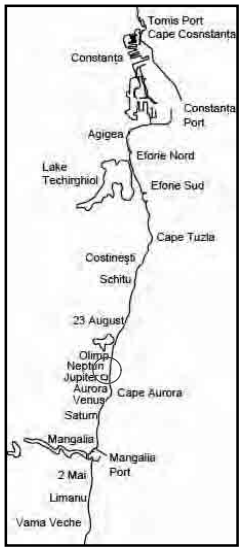


Photo **VI**-8
Sector: **VI**-1
Olimp-Venus (8)



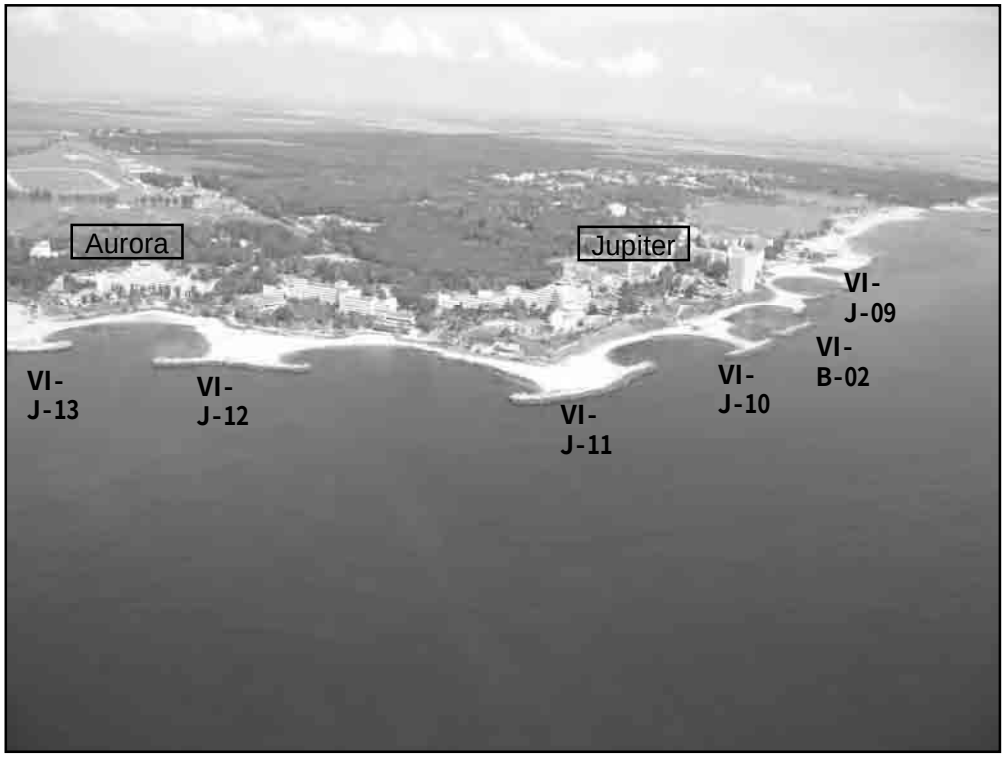
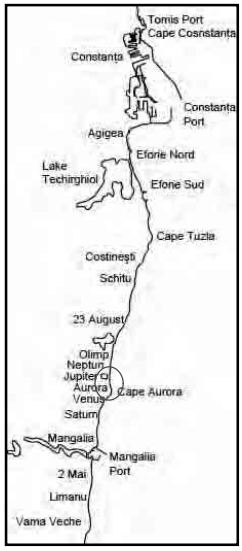


Photo **VI**-9
Sector: **VI**-1
Olimp-Venus (9)



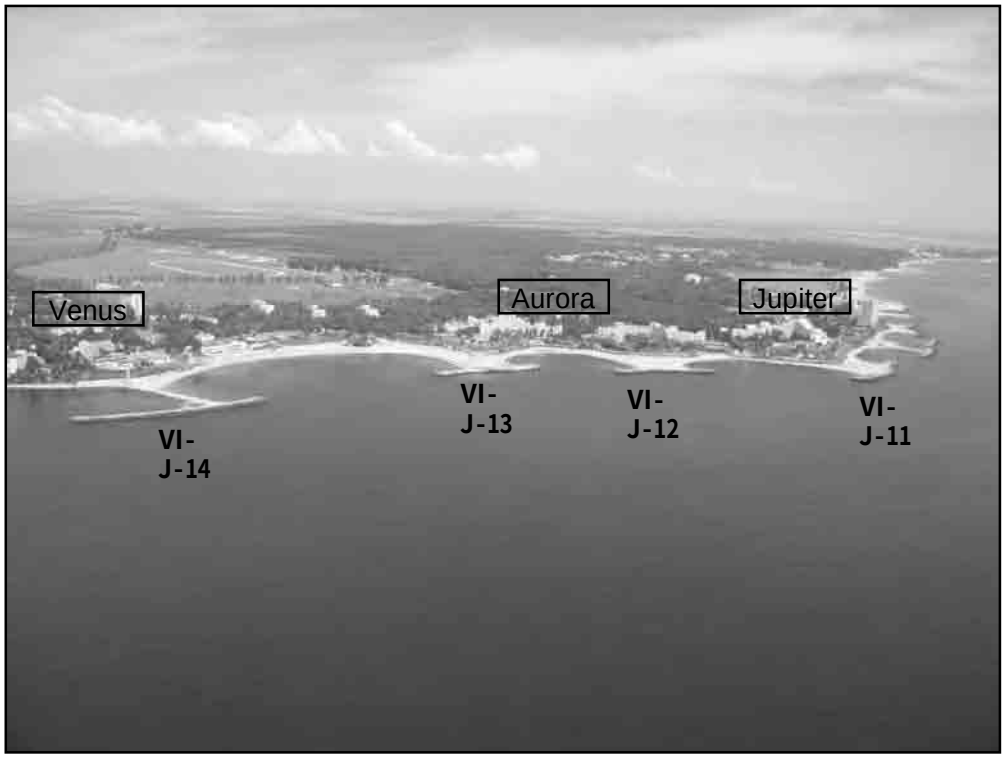
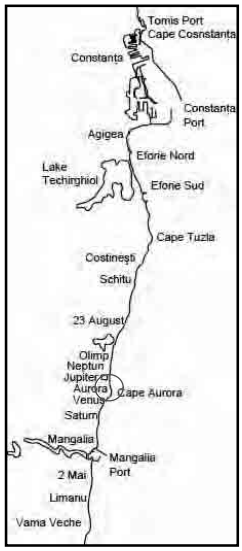


Photo **VI**-10
Sector: **VI**-1
Olimp-Venus (10)



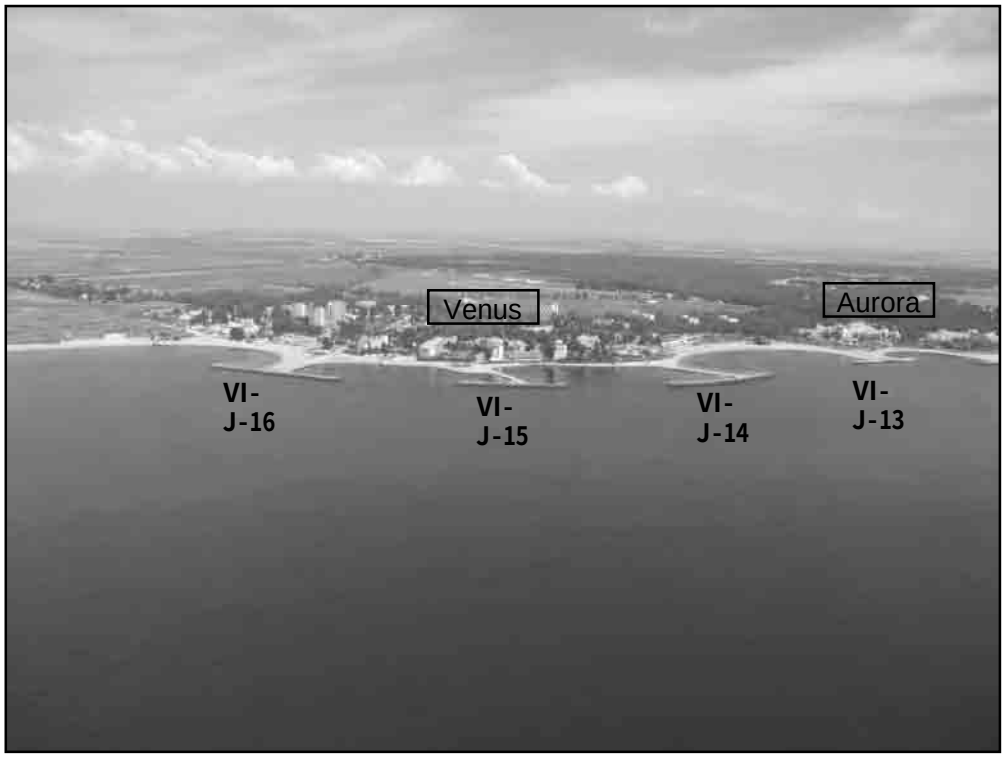
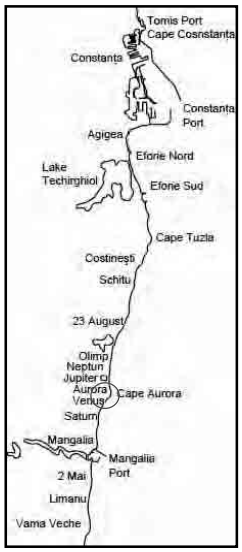


Photo **VI**-11
Sector: **VI**-1
Olimp-Venus (11)



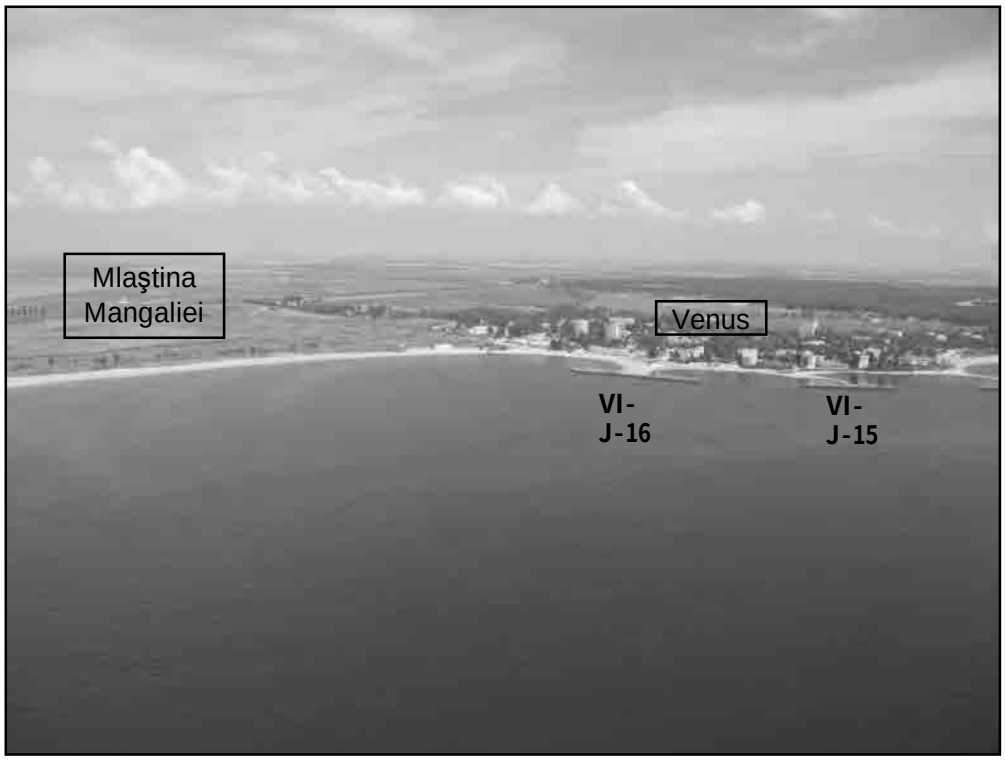
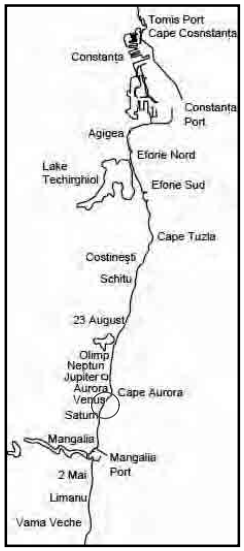


Photo **VI**-12
Sector: **VI**-2
Balta Mangalia (1)



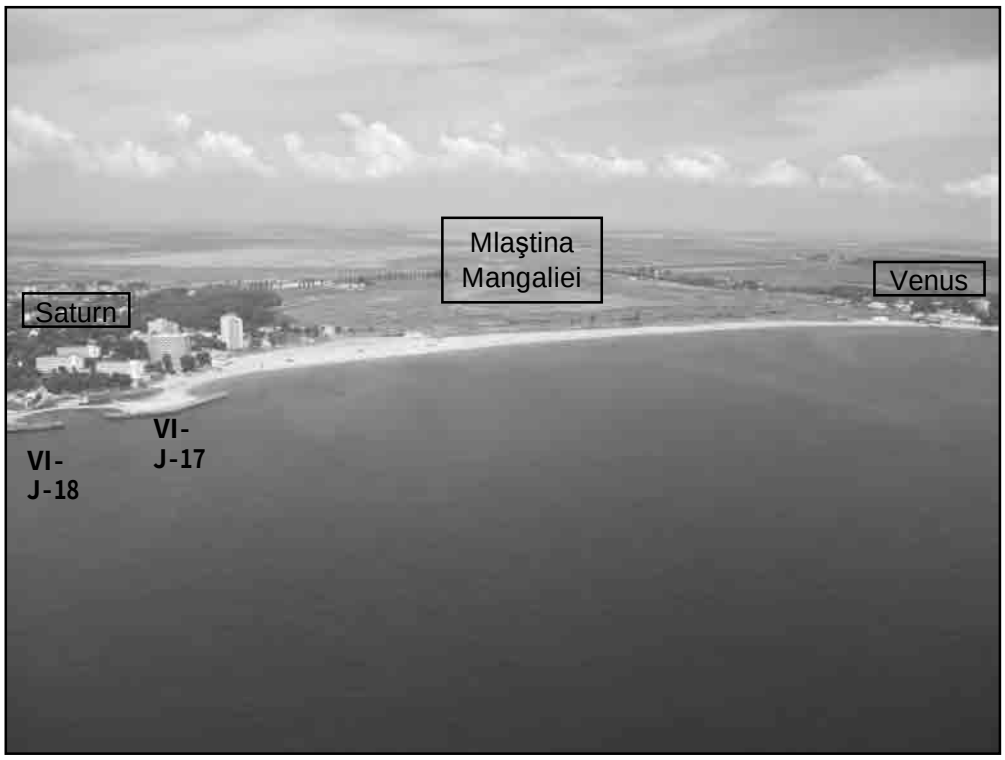
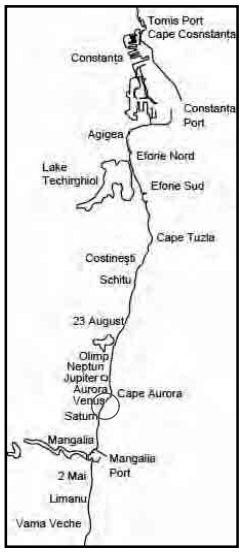


Photo **VI**-13
Sector: **VI**-2
Balta Mangalia (2)



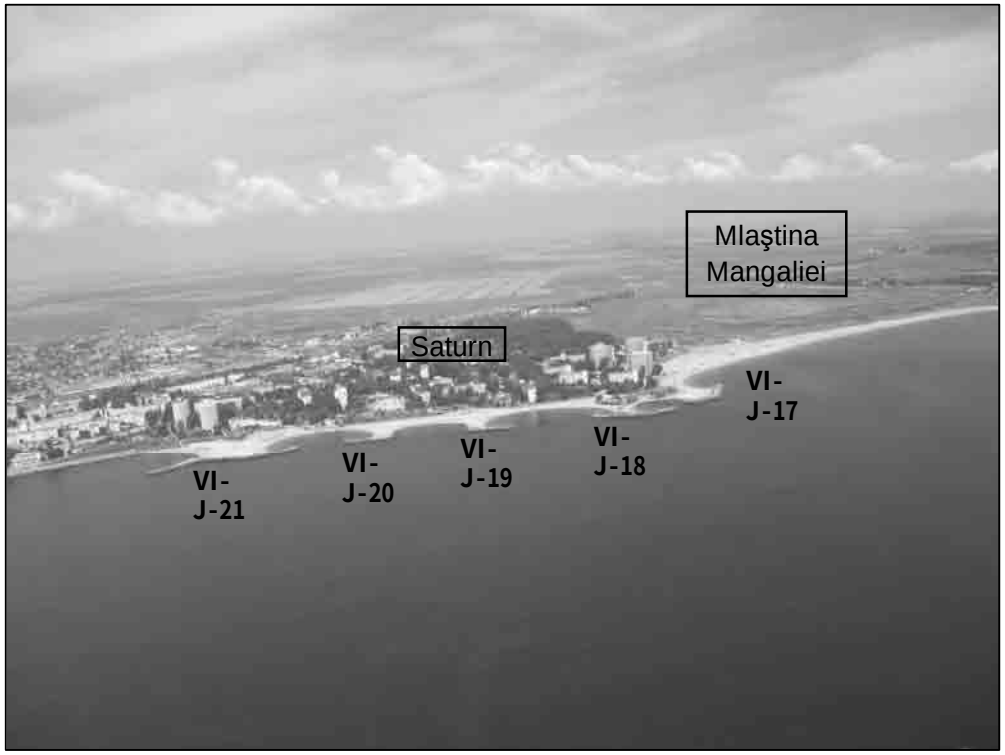


Photo **VI**-14
Sector: **VI**-3
Saturn-Mangalia (1)

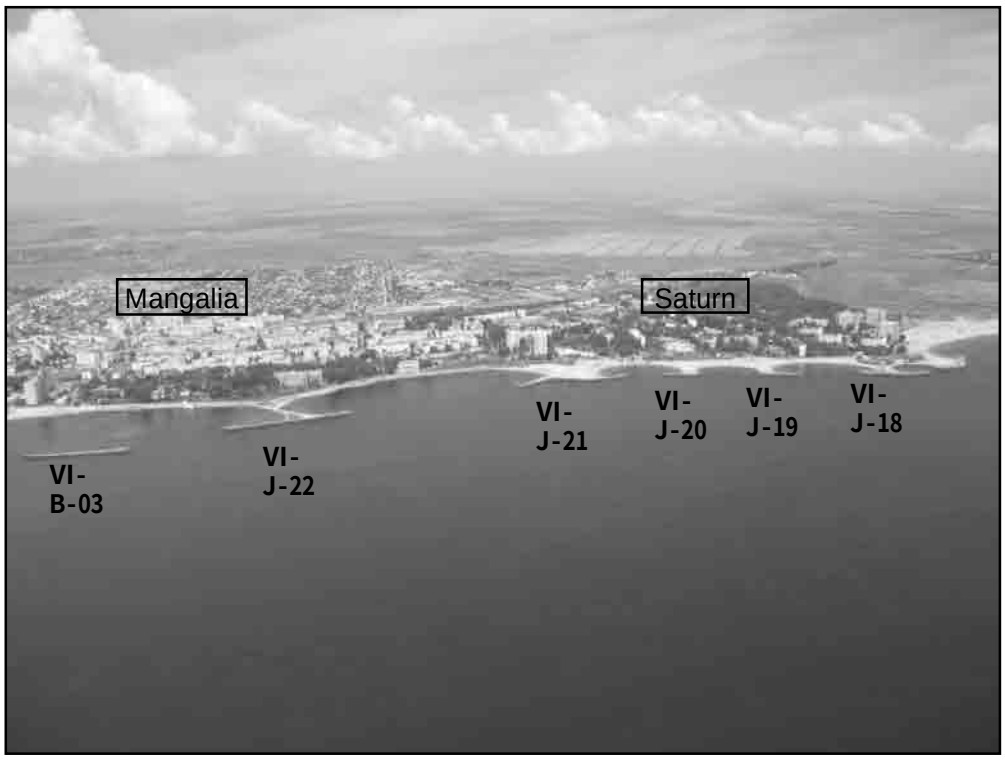
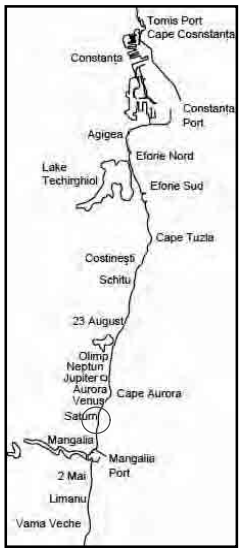


Photo **VI**-15
Sector: **VI**-3
Saturn-Mangalia (2)



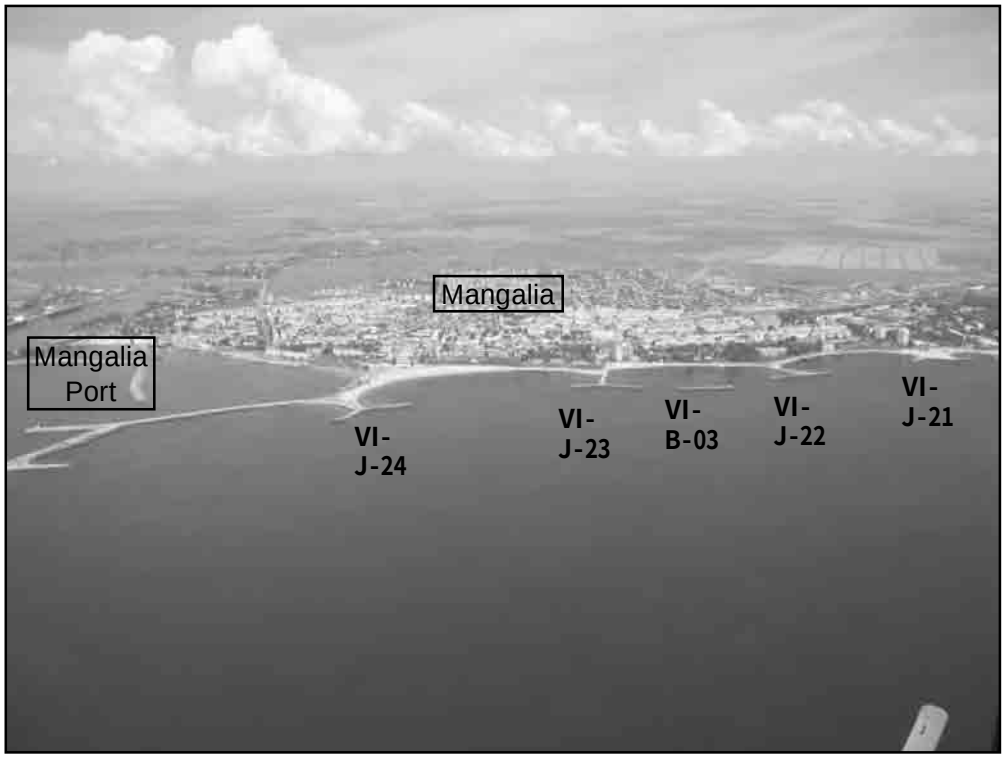
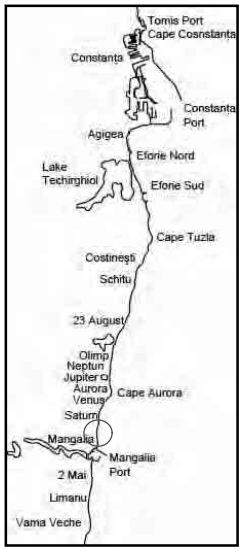


Photo **VI**-16
Sector: **VI**-3
Saturn-Mangalia (2)



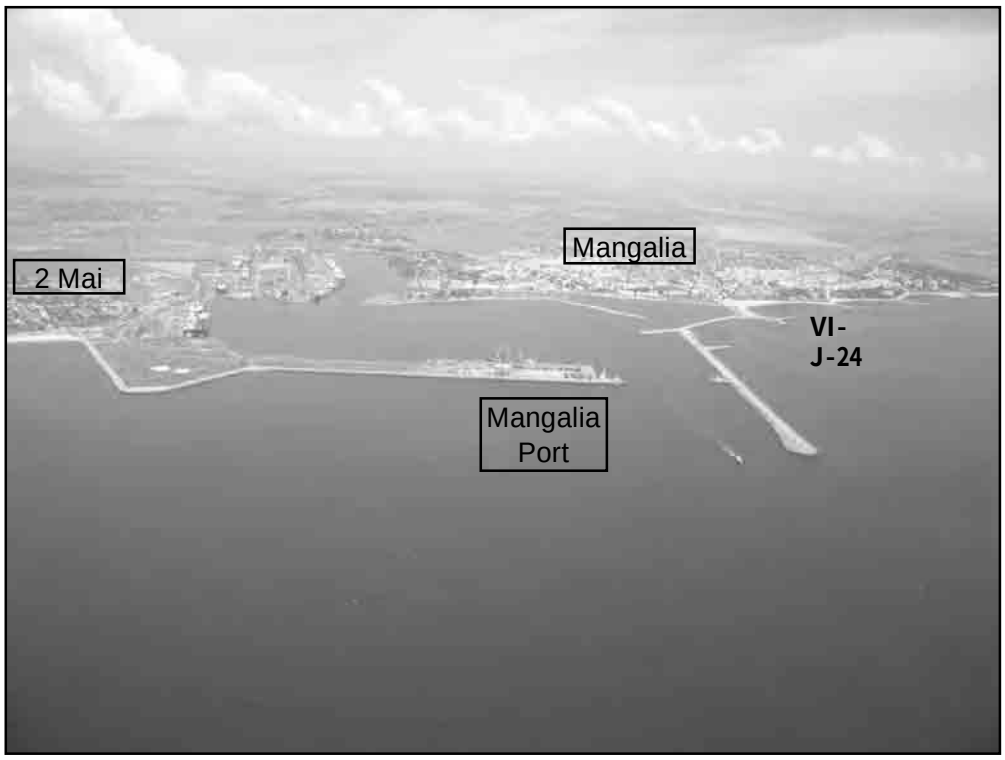


Photo **VI**-17
Sector: Mangalia Port

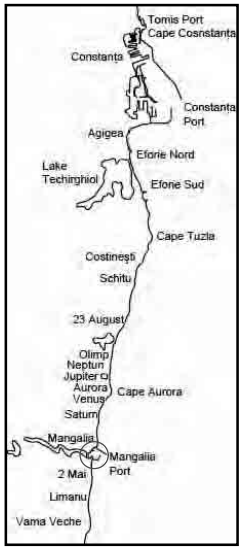


Photo **VII**-1
Sector: **VII**-1
2 Mai (1)

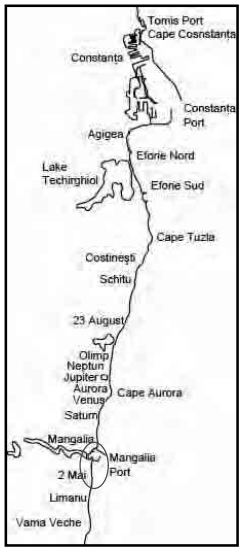


Photo **VII**-2
Sector: **VII**-1
2 Mai (2)

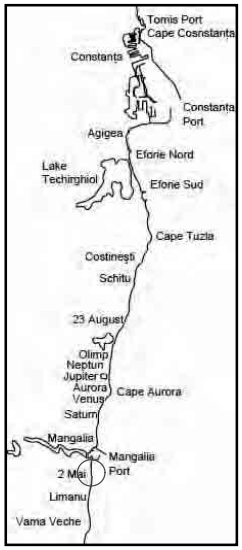


Photo **VII**-3
Sector: **VII**-2
Limanu (1)

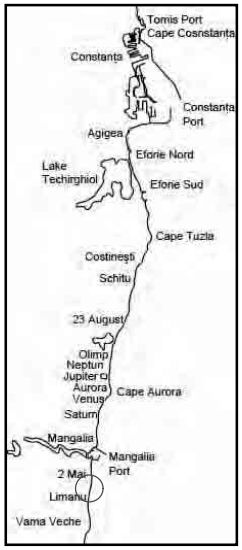


Photo **VII**-4
Sector: **VII**-2
Limanu (2)

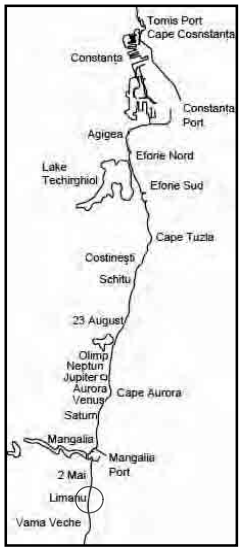


Photo **VII**-5
Sector: **VII**-3
Vama Veche (1)

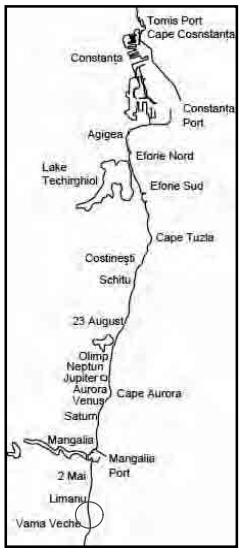


Photo **VII**-6
Sector: **VII**-3
Vama Veche (2)

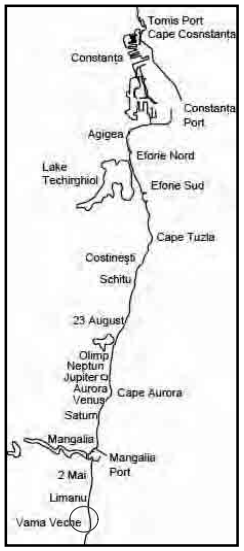


Photo **VII**-7
South of
Vama Veche
with Burugarian

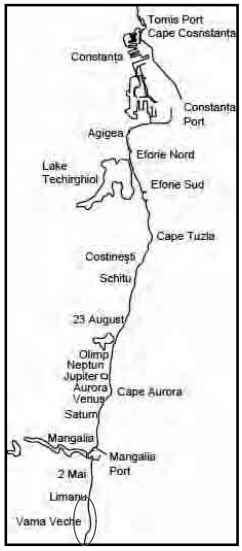
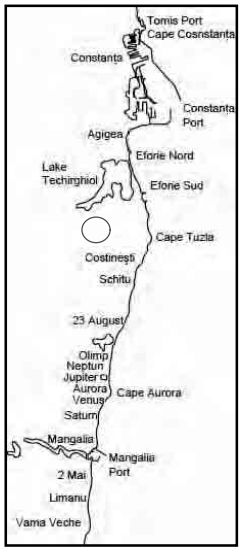


Photo **VII**-8
Helicopter
for Aerial Survey



A.2 Photographs of Beach Utilization

The Team visited all the beaches in August to inspect the state of beach utilization during the summer season. The density of beach visitors was roughly counted by visual inspection as listed in Table A.1. Selected photographs of beach utilization are listed in the following pages.

Table A.2.1: Survey of beach visitor density along the Southern Romanian Black Sea Shore

Survey Date： 10 August 2005, 09:00 to 16.55
Weather: very fine, slight breeze, cool temperature (26ºC?)
Investigators: Y. Goda, Y. Ochi, K. Kuroki, and Y. Ito

Sector No.	Sector Name	Visitor density per area	Visitor density per length
I-1	Năvodori North	-	0.01 person / m
I-2	Năvodori South	-	0.1 person / m
I-3	Mamaia North	-	1.5 person / m
I-4	Mamaia Center	-	1.0 person / m
I-5	Mamaia South	0.5 person / m^2	-
I-6	Tomis North	-	1.0 person / m
I-7	Tomis South	-	1.0 person / m
II-1	Eforie Nord	0.3 person / m^2	-
II-2	Eforie Middle	-	0.2 person / m
II-3	Eforie Sud	0.2 person / m^2	-
III-1	Tuzla North	-	-
III-2	Tuzla South	-	-
IV-0	Costineşti	0.3 person / m^2	-
V-0	Schitu	-	-
VI-1	Neptun Large	0.05 person / m^2	-
VI-2	Venus	-	0.1 person / m
VI-3	Saturn	-	0.3 person / m
VII-1	2 Mai	0.1 person / m^2	-
VII-2	Vama Veche	0.2 person / m^2	-

Note: Tourist density is based on casual observation and rather inaccurate. It is for the purpose of comparison between beaches.

Photo I-1
Sector: I-5
Mamaia South

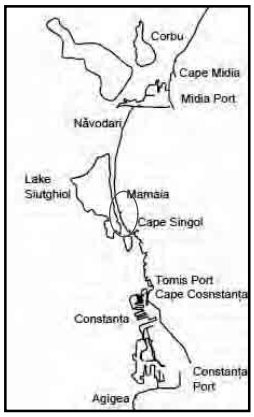


Photo I-2
Sector: I-5
Mamaia South

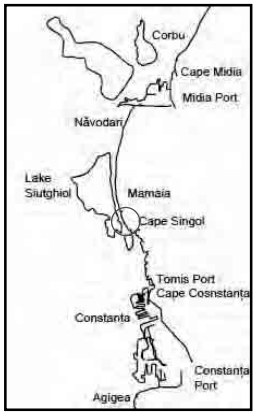


Photo I-3
Sector: I-4
Mamaia Center

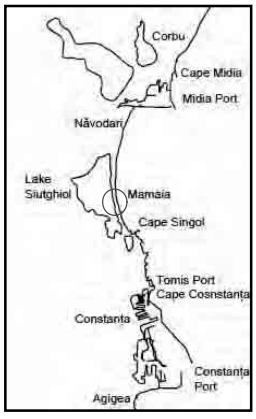


Photo Ⅰ-4
Sector: Ⅰ-4
Mamaia Center

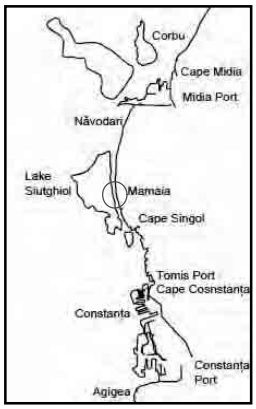


Photo Ⅰ-5
Sector: Ⅰ-2
Năvodari South

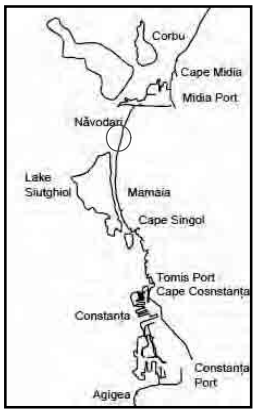


Photo Ⅰ-6
Sector: Ⅰ-2
Năvodari South

Photo I-7
Sector: I-6
Tomis North

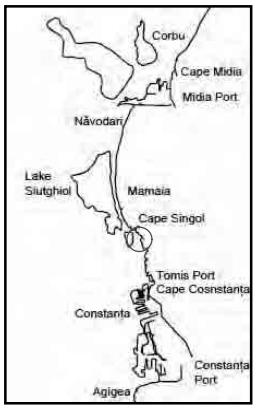


Photo I-8
Sector: I-6
Tomis North

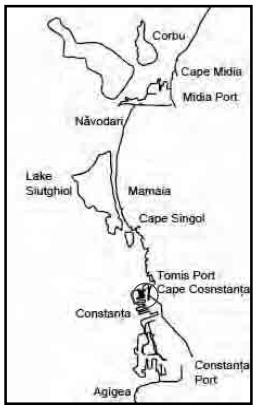


Photo I-9
Sector: I-6
Tomis North

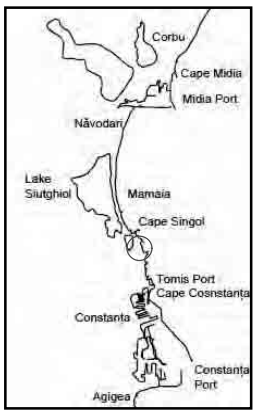


Photo I-10
Sector: I-6
Tomis North

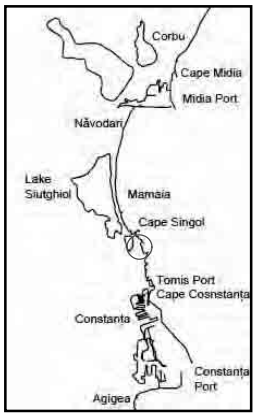


Photo I-11
Sector: I-7
Tomis South

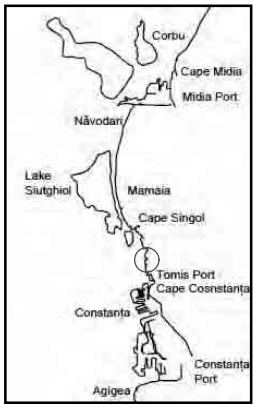


Photo I-12
Sector: I-7
Tomis South

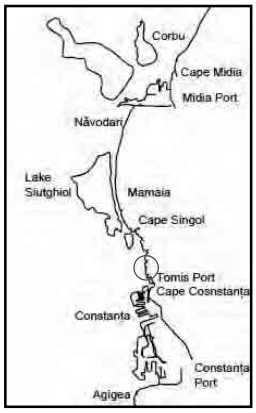


Photo II-1
Sector: II-1
Eforie Nord

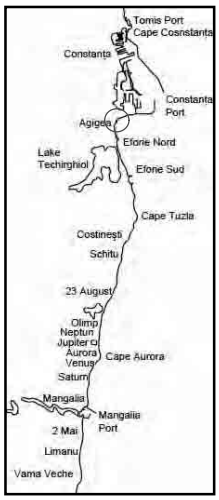


Photo II-2
Sector: II-1
Eforie Nord

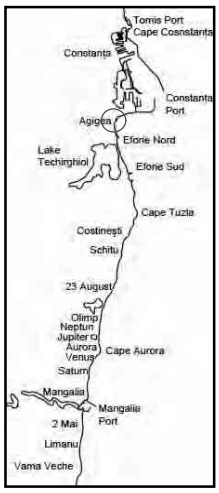


Photo II-3
Sector: II-1
Eforie Nord

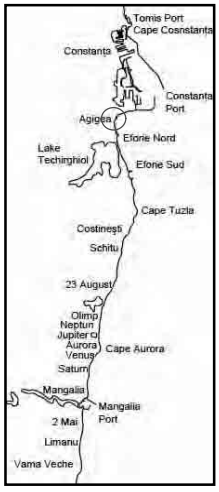


Photo **II**-4
Sector: **II**-1
Eforie Nord

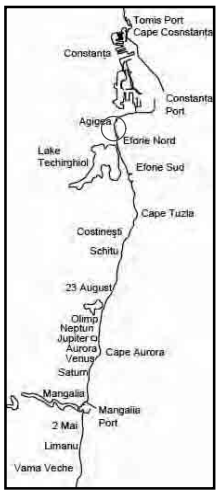


Photo **II**-5
Sector: **II**-2
Eforie Middle

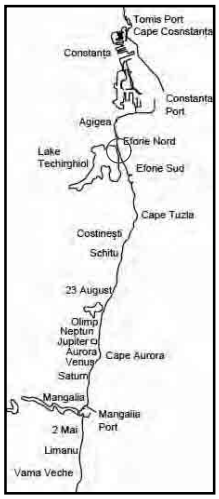


Photo **II**-6
Sector: **II**-2
Eforie Middle

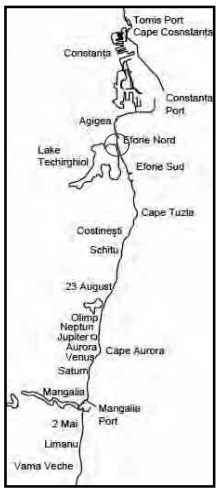


Photo **II**-7
Sector: **II**-3
Eforie Sud

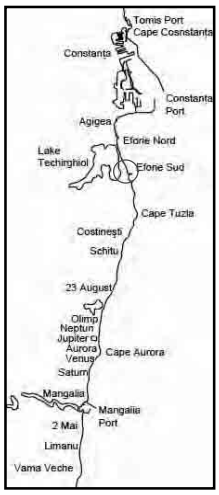


Photo **II**-8
Sector: **II**-3
Eforie Sud

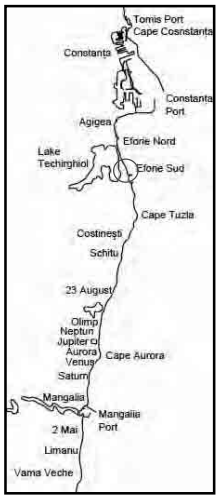


Photo **II**-9
Sector: **II**-3
Eforie Sud

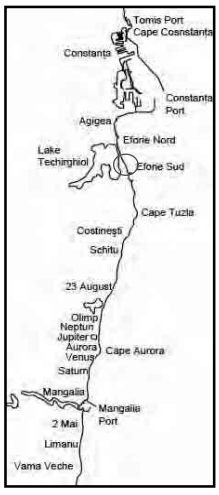


Photo **IV**-1
Sector: **IV**-0
Costineşti

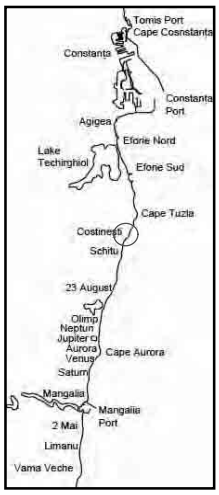


Photo **IV**-2
Sector: **IV**-0
Costineşti

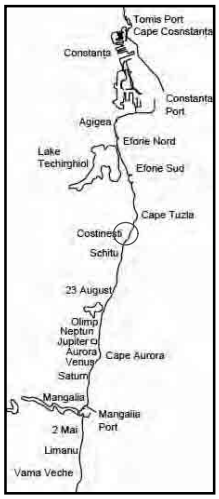


Photo **IV**-3
Sector: **IV**-0
Costineşti

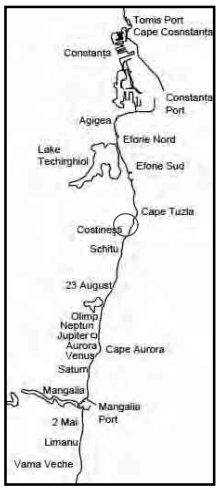


Photo **VI**-1
Sector: **VI**-1
Olimp-Venus

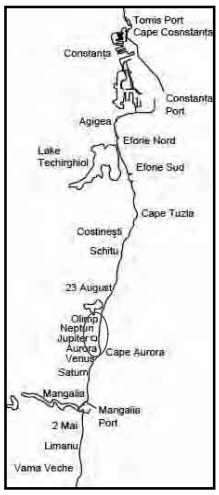


Photo **VI**-2
Sector: **VI**-1
Olimp-Venus

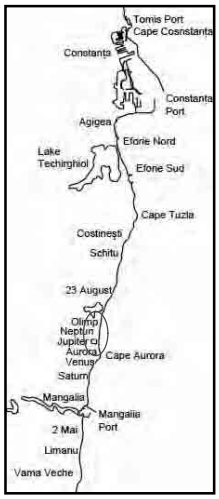


Photo **VI**-3
Sector: **VI**-1
Olimp-Venus

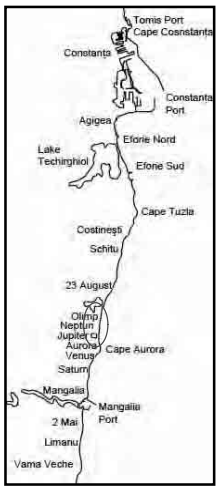


Photo **VI**-4
Sector: **VI**-1
Olimp-Venus

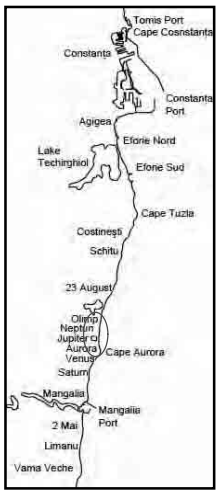


Photo **VI**-5
Sector: **VI**-3
Mangalia

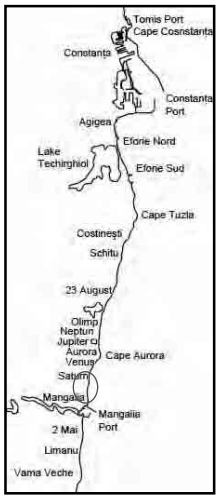
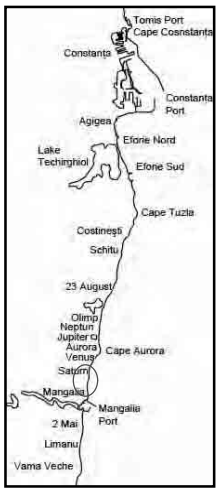


Photo **VI**-6
Sector: **VI**-3
Mangalia



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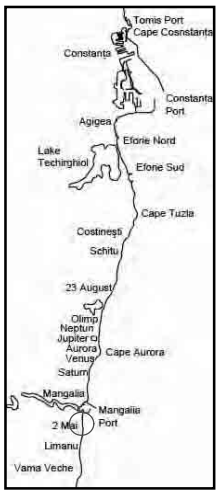

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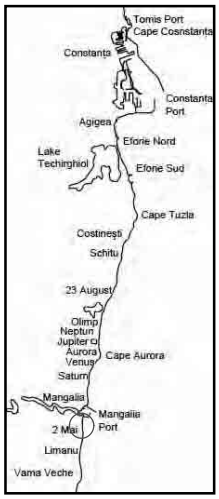

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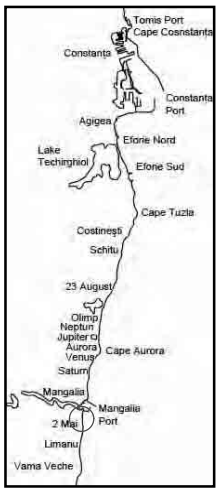

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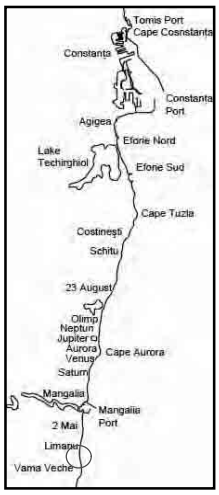

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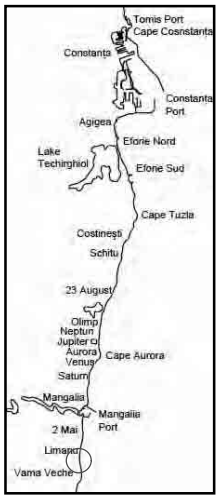

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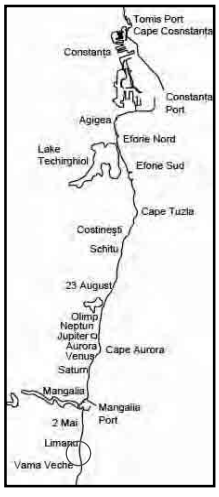

ANNEX B:

LEGAL FRAMEWORK AND PUBLIC FINANCE MANAGEMENT IN ROMANIA

Annex B: Legal Framework and Public Finance Management in Romania

B.1 Legal Aspects of Environmental Protection

(1) Accession to EU

As previously mentioned, Romania established the diplomatic ties with the European Union (EU) right after the collapse of the Berlin walls and the emergence of democratic regime in 1990. Following the signing of the Trade and Cooperation Agreement (1990) and the Association Agreement (so-called a Europe Agreement) in 1993 that envisaged the Romania's membership of EU in the days that come, Romania submitted the application for membership in 1995. Accession negotiation has taken place since 2000 together with Bulgaria, and the 25 EU member states agreed for Romania and Bulgaria to join the Union on the 1st of January 2007, with the Accession Treaty signed in April 2005. Ratification of the Treaty already took place in Romania whereas processing in other EU member states in progress.

With the above in view, the European Council has taken a close look at the country's performance in the light of the EU requirements for accession in (i) political, (ii) economic, and (iii) EU legal orders (*Acquis Communautaire*). In this light, EU submitted the latest monitoring and evaluation report as of 30 September 2005 that assessed Romania's preparedness for membership in terms of political and economic evolution as well as legislation and implementation[1]. In general, the Report assessed in favour of Romania in the light of all of these three segments, while saying that "Romania continues to meet political, economic requirements" and "the country made a significant progress in aligning its legislation with EU *Acquis*". In connection with Chapter 22 (Environment), the Report assesses in favour of the country, based on the government's implementation of Strategic Environment Assessment (SEA) and Environment Impact Assessment (EIA)-related legislations. Nonetheless, industrial pollution control, along with the structure and mechanism for participation in the EU structural fund, anti-corruption activities, and a high-level food safety, was taken up as one of the most serious issues requiring immediate actions from the country[2].

While the country is assessed positively for the progress achieved in terms of transposition as well as implementation and enforcement of environment-related measures, no particular development in integration of environment policies into other policies could be reported. The inter-ministerial committee being set up for the coordination and approval of inter-sectoral policies and strategies met only once since the second last monitoring in October 2003. Further, the Report stressed the urgent needs for the enhancement of institutional capacity of the administrative bodies at the central, regional and local levels in the application and enforcement of environment-related acts.

[1] Reference: The European Commission, *Romania 2005 Comprehensive Monitoring Report*, October 2005, p.63
[2] In this connection, transport, anti-trust enforcement report, free meovement of persons in the EU contries are classified satisfactory, while state aid control, customs rules, and proper financial controls being assessed somewhat weak requiring further effort. (source: *Ibid*., p.4)

(2) Romanian Legal Framework in Relation with EU

Environment protection constitutes part of the legal orders (*Acquis Communautaire*) and is defined in *Chapter 22* of the *Position Paper of 2000*, with the outline view in the following[3].

The overall objective of the community environment policy, in line with the integration of the issue into other community policies, preventive actions, the polluter-pays-principle, environmental damage at source and shared responsibility, is to promote sustainable development and protect environment for present and future generation. The *Aquis* comprises over 200 legal acts with seemingly lesser attention to coastal protection included in nature protection, while covering other areas of horizontal legislation, water and air pollution, management of waste and chemicals, biotechnology, industrial pollution and risk management, noise and radiation protection. Romania is to implement *acquis communautaire* in the field of environmental protection until the date of accession, with the exception of the EU legal acts in the following:

Air quality:

- Council Directive No.94/63/EC on the control of volatile organic compound (VOC) emissions resulting from the storage of petrol and its distribution from terminals to service stations; Romania requests a transition period of 3 years, until 2010.

Waste Management:

- Council Directive No.94/62/EC on packaging and packaging waste; Romania requests a transition period of 3 years, until 2010.
- Council Directive No.99/31/EC on the landfill of waste; Romania requests a transition period of 10 years, until 2017.
- Council Directive No.2000/76/EC on incineration of waste; Romania requests a transition period of 3 years, until 2010.

Water quality:

- Council Directive No.91/271/EEC concerning urban wastewater treatment; Romania requests a transition period of 15 years, until 2022.
- Council Directive No.98/83/EC on the quality of water intended for human consumption; Romania requests a transition period of 15 years, until 2022.
- Council Directive No.76/464/EEC on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community (and the 7 Daughter Directives); Romania requests a transition period of 8 years, until 2015.
- Council Directive No.91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources; Romania requests a transition period of 7 years, until 2014.

Industrial pollution control and risk management:

- Council Directive No.96/61/EC concerning integrated pollution prevention and control (IPPC); Romania requests a transition period of 8 years, until 2015.

[3] Reference: The Commission of the European Communities, *2004 Regfular Report on Romania's Progress towards Accession*, October 2004, pp.117-120

- Council Directive No.1999/13/EC on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations (VOC); Romania requests a transition period of 8 years, until 2015
- Council Directive No.88/609/EEC on the limitation of emissions of certain pollutants into the air from large combustion plants (LCP); Romania requests a transition period of 5 years, until 2012

B.2 Legislative Procedures Stipulated in the Constitution

(1) Legislative acts

According to the Constitution, the following institution in Romania can formulate and adopt legislative acts:

1. Parliament passes constitutional, organic, and ordinary laws.
2. Organic laws shall regulate:
   (1) the electoral system;
   (2) the organization and functioning of political parties;
   (3) the organization and holding of a referendum;
   (4) the organization of the Government and the Supreme Council of National Defense;
   (5) the states of siege and emergency;
   (6) criminal offences, penalties and the execution thereof;
   (7) granting of amnesty or collective pardon;
   (8) the organization and functioning of the Superior Council of the Magistracy, the courts, the Public Ministry and the Court of Audit;
   (9) the status of civil servants;
   (10) contentious business falling within the competence of administrative courts;
   (11) the general legal status of property and inheritance;
   (12) general rules covering labor relations, trade unions and social security;
   (13) the general organization of education;
   (14) general statutory rules of religious cults;
   (15) the organization of local administration, of the territory, as well as general rules on local autonomy;
   (16) ways and means to establish the exclusive economic zone; and
   (17) other fields, for which the Constitution provides the enactment of organic laws.

(2) Legislative initiative

Article 73

1. The legislative initiative lies with the Government, Deputies, Senators, as well as no fewer than 250,000 citizens having the right to vote. The citizens exercising the right to legislative initiative must belong to at least one quarter of the country's counties, while in each of these counties or the Municipality of Bucharest at least 10,000 signatures should be registered in the support of this initiative.
2. A legislative initiative of the citizens may not touch on matters concerning taxation, international affairs, amnesty or pardon.

3. The Government shall exercise its legislative initiative by introducing bills in one of the Chambers.
4. Deputies, Senators and citizens exercising the right of legislative initiative may present proposals only in the form required for a bill.
5. Legislative proposals shall be first submitted for being passed to the Chamber before which they were read.

(3) Passing of bills and resolutions

Article 74

1. Organic laws and resolutions concerning the Standing Orders of the Chambers shall be passed by the majority vote of the members of each Chamber.
2. Ordinary laws and resolutions shall be passed by the majority vote of the members present in each Chamber.
3. On request by the Government or on its own initiative, Parliament may pass bills or legislative proposals under an emergency procedure, established in accordance with the Standing Orders of each Chamber.

(4) Sending of bills and legislative proposals from one Chamber to the other

Article 75

Bills or legislative proposals passed by one Chamber shall be sent to other Parliament Chamber. If the bill or legislative proposal is rejected in the latter, it shall be sent back, for a new debate, to the Chamber that had passed it. A second rejection is final.

(5) Mediation

Article 76

1. If one of the Chambers has passed a bill or legislative proposal, in a different wording from that approved by the other Chamber, the Presidents of both Chambers shall initiate a mediation procedure, by a parity Committee.
2. In case no agreement has been reached in the Committee, or one Chamber has not approved the Mediation Committee report, the texts in conflict shall be submitted for debate to the Chamber of Deputies and the Senate, assembled in a joint session, that shall adopt the final text by a majority vote, as provided under Article 74, paragraphs (1) or (2).

(6) Promulgation of laws

Article 77

1. A law shall be submitted for promulgation to the President of Romania. Promulgation shall be given within twenty days after receipt of the law.
2. Before promulgation, the President of Romania may return the law to Parliament for reconsideration, and he may do so only once.
3. In case the President has requested that the law be reconsidered or a review has been asked for as to its conformity with the Constitution, promulgation shall be made

within ten days from receiving the law passed after its reconsideration, or the decision of the Constitutional Court confirming its constitutionality.

(7) Coming into force of laws

Article 78

Laws shall be published in the Official Gazette of Romania and come into force on the day of publication or the date provided in its text.

(8) Legislative Council

Article 79

1. The Legislative Council shall be an advisory expert body of Parliament that initiates draft normative acts for the purpose of a systematic unification and coordination of the whole body of laws. It shall keep the official record of the legislation of Romania.
2. The setting up, organization and functioning of the Legislative Council shall be regulated by an organic law

(9) Acts of the Government

Article 107

1. The Government shall adopt Decisions and Statutory Orders.
2. Decisions shall be issued to organize the execution of laws.
3. Statutory orders shall be issued under a special enabling law, within the limits and in conformity with the provisions thereof.
4. Decisions and statutory orders adopted by the Government shall be signed by the Prime Minister, countersigned by the Ministers who are bound to act to carry them into execution, and shall be published in the Official Gazette of Romania. Non-publishing entails non-existence of a decision or statutory order. Decisions of a military character shall be conveyed only to the institutions concerned.

B.3 Governance – Public Financial Management

As noted by the World Bank, there is considerably an empirical evidence of a strong causal relationship between better governance and better development outcomes[4]. Governance with the financial accountability framework as an important element in a country relates closely with the capacity of government to manage scarce resources and implementing sound development policy and projects. With this in view, this section overviews the policy issues in connection with governance of the Romanian government, while taking into account the prospective coastal protection projects of the southern Romanian Black Sea shore.

As previously noted in **2.2.1**, Romania underwent a punishing economic recession during the 1990s, with the last 3 years of 1997-1999 in particular, despite of successive economic stabilization reform programs[5]. By and large, this low economic profile was attributed to a

[4] The World Bank, *Romania Country Financial Accountability Assessment*, December 2003, p.iii
[5] Real GDP growth rates stood at -6.1 percent, -4.8 percent, and -1.2 percent in the descending order of 1997 through 1999.

failure to undertake structural reforms, and even in the years that posted positive growth rates, the economy suffered from macro-disequilibrium in high inflation and deficits in trade balance and current accounts. The country's economic performance was significantly improved in mid-2000 and the following four years to date, due largely to robust export drive heading mainly to the EU market. Despite of the global economic downturn in 2001-2002, strong domestic activities in the agriculture and construction sectors, and domestic consumption kept the economy afloat at 5.7 percent, 4.9 percent, and 8.3 percent (estimated) in the order of 2002, 2003, and 2004[6]. In October 2003, IMF Board approved Romania's completion of the 2001 standby agreement in the face of the country's successive macro-management of the economy, notably, progress in privatization, deficit reduction, and the curbing of inflation[7]. This is the first time that Romania successfully concluded the IMF standby agreements since 1989 political incidence[8]. IMF standby agreements and its thriving conclusion in 2003 did help providing the economic environment and confidence that was conducive to invite direct foreign investment (DFI) from EU countries and the US[9].

In the light of the above, the Government embarked on the bold economic reform agenda that aims at keeping the country on the right track to sustainable growth by way of redefining the role and function of the state in the economic activities and public financial management[10]. The major policy issues thereof included

(i) ensuring the sustainability of economic recovery in place thus far,
(ii) strengthening budget management, and
(iii) comprehensive development framework with the social sectors in view.

A set of specific measures discussed amongst the World Bank and the Government of Romania are summarized in Table B.3.1.

In the meantime, the sources of public finance at the local government level primarily include the property tax and income taxes. The full amount (100%) of the former is retained at local governments, whereas the latter being shared between the central and local governments with 36.5 percent, 25 percent, and 38.5 percent for local councils, county councils, and the central government, in that order. In addition, an equalization grant is provided by the central government such that funding disparities among local governments is alleviated to the extent possible[11]. The issue is the redefinition of public expenditure by the central and local governments in education and social assistance in particular. While local councils have broad authority and discretion to determine the quality, quantity and costs of public services they

[6] Source: UNDP, Romania Country Profile, http://www.undp.ro/profile_romania.php
[7] Average inflation rates per annum over the periods of 1970-1979, 1990-2000 and of 2001-2003 are 0.8 percent, 100.5 percent and 29.7 percent, respectively.
[8] IMF executive board further approved a 24-month standby agreement of US$367 million in July 2004 while counting on the country's financial accountability and sustainability of the current economic recovery.
[9] In connection with Governance and financial accountability, some observation states that the recent high profile of micro-management of the economy have done little to address Romania's wide spread poverty, red-tape, and corruption. (Nationmaster.com, Romania Profile, http://www.nationmaster.com./country/ro/economy)
[10] The World Bank, *Building Institutions for Public Expenditure Management: Reforms, Efficiency and Equity*, August 2002 Following the Public Expenditure and Institutions Review of 2002 as noted immediately above, the Bank and the government are now preparing another PEIR that is supposed to be drafted out in a short while.
[11] The World Bank, *A Public Expenditure and Institutional Review*, August 2002, p. xiv

provide, financial burden of quality service delivery on local councils are heavy. With this in view, the World Bank discusses that the national programs inclusive of education and social assistance are to be borne out by the central government in lieu of the local councils.

Table B.3.1: Specific measures for economic reform

Issues	Measures
1. Ensuring Sustainability of Economic Recovery	(1) Lowering the general government deficits, inclusive of quasi-fiscal deficits[12], by half of one percent of GDP; (2) Reducing the losses of the energy sector by 1.7 percent of GDP; and (3) Making visible progress on bank and enterprise privatization in a bid to reduce the public sector involvement in the economy and improve business climate:
2. Strengthening Budget Management	(1) Improving Treasury accounting information, curbing the practices of exceeding budget ceilings by accumulating payment arrears by way of establishing a central monitoring system for payables and issuing monthly reports on payment arrears; (2) Subjecting foreign financed public investment to full budgetary scrutiny through controlling inflow of assistance funds by the Central bank and the Ministry of Public Finance; and (3) Increasing accountability in the management of off-budgetary funds by special funds such as the Energy Department Fund:
3. Social Sector Development	(1) Reengineering the health and pension funds to put on a financially sound basis by reducing the high payroll taxes and broadening tax bases[13], removing non-essential expenditure such as non-insurance related benefits (e.g., two-year maternity leaves and etc.) (2) Increasing funding for primary health care, health promotion, and prevention, and greater control over hospital expenditures and change in payment method for family doctors, especially in rural areas; (3) Reconstructing the present system of financing of education by realigning weights of fiscal burden of local councils[14]; and (4) Improving the allocation criteria for earmarked transfers to local councils under the minimum income guarantee (MIG) program for equitable redistribution of public funds[15]:

Payroll taxes are currently levied to employers at around 60 percent of gross wages, thereby leading to tax evasion (under-the-table payments) and reduction of formal sector employment to around 60 percent of the labor force[16].

B.4 Institutional Framework – Game Players of the Sector

By the Governmental Decision (GD) no.17/2001, the Ministry of Environment and Water Management (MoEWM) has since 2003 been responsible, as the line ministry, for the overall

[12] Defined as the Government deficits accrued to the deficits of state owned enterprises, tax arrears, and tax evasion.
[13] Reference as noted in the 5th paragraph of the report herewith.
[14] Reference as noted in the 4th paragraph of the report herewith.
[15] Reference as noted in the 4th paragraph of the report herewith.
[16] *Ibid.*, August 2002, p. xiii

aspects of environmental protection and development, with the following activities: (i) policy-making for water and environmental protection at the central level, (ii) devising strategies and specific regulations, (iii) implementing Government strategy in the concerned areas, and (iv) accomplishing its role as a state authority for the synthesis, co-ordination and control in these fields. Minister is assisted by Secretaries of State and a General Secretary, with each of the office being responsible for the following areas (Fig. B.4.1):

- Environmental Protection,
- Water Management,
- European Integration, and
- Secretary General (general administration and partnership with the Parliament)

Faced with EU accession now being scheduled on the 1st January 2007, all of the policy issues in connection with the preparatory process for European integration has been given a priority. In this respect, the Secretary of State for European Integration coordinates the activities of national legislation to expedite processing of drafting, promoting and controlling the implementation of the new legislation in compliance with the environment-related *acquis communautaire*. Directorate with specific responsibilities for waste and hazardous chemicals management was established in consideration of the complexity of the issue. The Public Relation Directorate has been established in order to develop dialogues between the governmental structure in the field of environmental protection and civil society, as well as for providing a realistic view on the role and activity of the MoEWM and its subordinate units. In conformity with the GD no.352/2001 amending the GD no.17/2001, the Unit for the Coordination of the Implementation of the Structural Pre-accession Instrument ISPA was established under the direct coordination of the Secretary of State for European Integration and Minister.

The Environmental Protection Inspectorates (EPI) is, in accordance with the GD no.17/2001 as well as then Order no.92/2001 of the Minister of Waters and Environmental Protection, responsible for the enforcement, monitoring, and implementation of the legislation at the county level. EPI was established through the reorganization of the Environmental Protection Agency (EPA), each of which has a Unit for capacity development for policy planning and implementation in line with the domestic legislation and EU legal framework. Furthermore, in order to decentralize decision-making process within the legally stipulated administrative system, Department of Nature Protection and Protected Areas and Department of Waste and Hazardous Chemicals Management have been set up in each of EPIs. The Department for Integrated Monitoring of Environment Factors and the Department for Ecological Control and Monitoring of Environment Investments have been also established.

In the field of water management, this activity is developed in an integrated manner (quantity-quality, ground-surface) on hydrographical basins. At the level of each hydrographical basin (or in some cases groups of hydrographical basins), the Basin Department for Water Management is responsible for the effective management of water resources, in consistent with the EU Water Framework Directive (WFD) and the basin planning programs. In accordance with the requirements of WFD, the GD no.1212/2000 was approved for the establishment of the Basin Committees in a bid to harmonize responsibilities and activities amongst the stakeholders concerning environment protection. The committees comprise representatives of MoEWM, the Ministry of Health and Family (MoHF), the local public administration, the National Administration “Apele Romane” (ANAR), the National Authority for Consumers’ Protection, and the non-governmental organisations (NGOs). Some

of the major responsibilities are, among others, to (i) advise schemes for water management for each river basin, (ii) approve the classification into a water quality category of river waters within the basin, and (iii) analyse and recommend financing priorities to the central and local public administration.

By the Water Law no.107/1996, the National Administration "Romania Waters" (ANAR) with its river 11 basin branches was set up in 1996 to (i) integrate water management, (ii) operate of water management structures, and (iii) implement national water strategy and policy on behalf of the ministry.

In order to put into practice the priority projects on environment protection, and to accelerate the process of implementing and enforcing the new legislation, the Law no.73/2000 concerning the Environment Fund has been adopted. In order to ensure the Fund functioning, the Government Emergence Ordinance (GEO) no.93/2001 has also been adopted to amend the above-mentioned law. After the adoption of the law for the approval of the GEO no.93/2001, the institutional structure of the Fund Administration was established and approved by the Government Decision (GD).

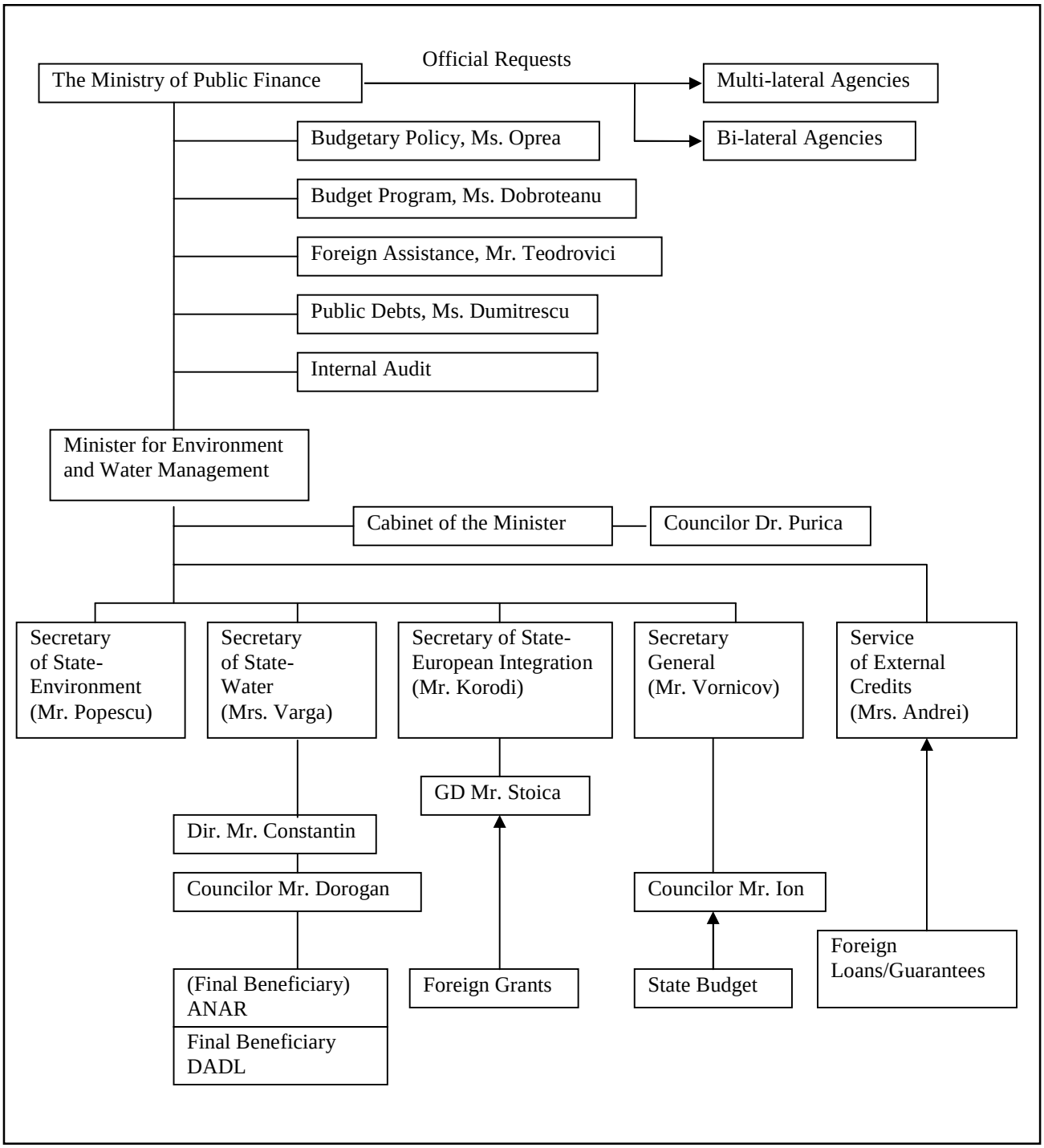

Fig. B.4.1: Organizational framework of MoEWM for policy planning, coordination, and implementation as of December 2005

ANNEX C:

INTEGRATED COASTAL ZONE MANAGEMENT

IN ROMANIA

Annex C: Integrated Coastal Zone Management in Romania

C.1 Legal Framework of ICZM in Romania

The legal framework of the integrated coastal zone management (ICZM) in Romania is the Emergence Ordinance no. 202/2002, modified and added by Law no. 280/2003. It is in compliance with the Recommendation of the European Parliament and of the Council of 30 May 2002 concerning the implementation of Integrated Coastal Zone Management in Europe. A brief description of the EO no. 202/2002 (hereinafter referred to as "EO") is given below in chapter-wise with a special reference to the Study.

Chapter I General Orders (ten articles)**:**

The scope and objectives of EO are described. The general and specific principles of ICZM are listed. Cited as sectoral activities are agriculture, forestry, fishing and aquaculture, energy, industry including activity of mineral resources extraction, transport, waste management, water management, telecommunications, tourism, town and country planning or land use, regional development. The coastal zone is defined only in qualitative manner and no method of delimitation is given (**Art. 9**).

Chapter II System of Public Proprietary Use of Coastal Zone (eleven sections with 30 articles)**:**

Section 1 states free use of the coastal zone and free and access to the shore by the public in principle. The scope for exclusive use of the coastal zone is explained with the public authority's functioning for it. **Article 16** states delimitation of a zone of land along the coast with the width of 50 to 150 m measured from the most advanced point of the sea, where any type of permanent, temporary, or transportable construction is forbidden. However, exceptions may be made for the construction indispensable for security or public service, provided that the authorization is given by the relevant central public authorities.

Sections 2 to 11 describe regulations concerning the activities of agriculture, military, electrical energy production and natural resources exploitation, fishing and marine aquaculture, forestry, industry, tourism, transport, and management of water and refuses. **Article 35** in Section 9 for transport activities states that the authorization of new road construction in the littoral zone of about 50 to 150 m wide parallel to the shoreline is forbidden. Exception is a promenade with the width not exceeding 6 m.

Chapter III Interdictions and Restriction (eleven articles)**:**

Article 40 forbids any type of construction in the delimitated zone with risk of sliding, flooding, and erosions except those for measures of risk elimination. Various types of work executions are cited as forbidden or regulated from the viewpoint of environmental protection. This includes the extraction of sand, gravel and rocks from the shore (**Art. 43**), but maintenance dredging of navigation channels is excluded. The central public authority for environment protection and water management has the responsibility to issue general and specific regulations for the public proprietary protection and sustainable utilization of the coastal zone, which should cover project execution regarding the protection, utilization,

facility improvement and coastal zone conservations (**Art. 42**).

Articles 46 to **48** direct the central public authority for environment protection and water management to take charge of rehabilitating the coastal zone affected by erosion or flooding.

Chapter IV Integrated Coastal Zone Management (five sections with ten articles)**:**

Sections 1 and 2 dictate conservation and protection of coastal parks, reservations, and damp areas[1]. Section 3 deals with integrated control and monitoring system. Then **Article 56** in Section 4 orders the central public authority for environment protection and water management to elaborate the integrated administration plan for the coastal zone in collaboration with other relevant central authorities. The plan should be approved through the Government decision. Section 5 deals with city planning and territorial improvement plan

Chapter V Coastal Zone Management – Economical and Financial Mechanisms – (one article)**:**

Article 61 states that the financial investment necessary for coastal protection against erosion etc. should be assured from the state budget, the internal and/or external credits guaranteed by the Government, from the Environment Fund and other sources.

Chapter VI Responsibilities and Duties (four sections with eight articles)**:**

In this chapter, responsibilities and duties of the central public authority for environment protection and water management, the territorial public authority for environment protection, and the local authority of water management are listed. Responsibilities and duties of other central public authorities are also listed. Section 4 establishes the National Committee of the Coastal Zone (**Art. 68**). It lists the numbers and institutions from which the committee members are to be selected, designates the National Institute of Marine Research and Development as the permanent technical secretariat, and specifies the responsibility of the committee.

Chapter VII Public Access to Information and Their Decision (four articles)**:**

This chapter assures the public's free access to the information related to ICZM and encourages the public to make comments or proposals to the measures to be taken by public authorities.

Chapter VIII Control Activities on Integrated Coastal Zone Management (three articles)**:**

This chapter describes how to control the activities related to the integrated coastal zone management. Some persons will be assigned the control responsibility and the central and local public authorities must assure support to the persons in charge of control. However, no specific descriptions are given for the procedure of assigning persons with the control rights.

Chapter IX Contraventions and Infractions (seven articles)**:**

Acts that constitute contraventions are listed in **Arts. 77** with the amounts of penalty, and

[1] Damp zone is defined as slope extension, swamps, turf moor, by natural or artificial waters, permanently or temporarily, where the water is musty, fluently, sweetie, salty or briny.

those for infractions are listed in **Art. 80** with the length of imprisonment and in **Art. 81** with the amounts of penalty or the length of imprisonment.

Chapter X Final Dispositions (five articles)**:**

This chapter provides the central public authorities concerning ICZM with disposition to issue norms, normative and orders with compulsory characters. The last **Article 87** stipulates that this EO enters in force after 60 days from the date of its publication in the Romanian Official Monitor, Part 1.

EO is quite comprehensive and wide in scope as well as ambitious, but it is not in all aspects internally consistent as observed by the Dutch consultants.[2] As of December 2004, the Ministry of Environment and Water Management is discussing with Apele Romane on the necessary amendments to EO. A modified version of EO will be reviewed in the next meeting of the National Committee of the Coastal Zone.

C.2 Romanian National Committee of the Coastal Zone

C.2.1 General

The Government of Romania has issued the Emergency Ordinance nr. 202 concerning the integrated management of coastal zone on 18 December 2002. Based on the Article nr. 68 of this Ordinance, the government made a decision Nr. 1015 for establishment of the National Committee of the Coastal Zone (hereinafter referred to as "NCCZ") on 25 June 2004, which was published in the Official Gazette no. 619 / 8 July 2004.

NCCZ is composed of 37 members as stipulated in the Emergency Ordinance nr. 202/2002 and carries out its activity under the Central Public Authority for Environment Protection and Water Management (hereinafter referred to as "MoEWM). The Chairperson of NCCZ is appointed by MoEWM, and currently Mrs. Secretary of State Ana Lucia Varga is the Chairperson.

C.2.2 First Meeting of NCCZ

The first meeting of NCCZ was held on 19 April 2005 in Constanța. Two Deputy Chairpersons were elected at this meeting. Setup of several working groups was approved. One working group is given the assignment of making recommendation for the definition of the limit of coastal zone. The members of the Permanent Technical Secretariat, which is located at the National Institute for Marine Research and Development "Griogore Antipa," were designated.

C.2.3 Second Meeting of NCCZ

The second meeting of NCCZ was held on 22 June 2005 in Constanța. Several projects related to the coastal zone management were presented and discussed with participation of 48 persons. The first discussion was made on the financial basis of the Permanent Technical

[2] Hakoning Nederland BV: Outline Strategy for the integrated management of the Romanian Coastal Zone Toward Implementation, Nov/Dec 2004, **7.3.1**.

Secretariat, which has been supported by a part of research projects by MoEWM. Several opinions were raised for more sound financial support and strong organizational structures, but no definite conclusions were reached.

Next, proposals of setting-up several working groups were made by the Permanent Technical Secretariat. The attendees were requested to send their comments on the proposals within 7 days to the Permanent Technical Secretariat.

Presentations were made of the Environmental Conditions of Constanța in 2004 by the Environmental Protection Agency in Constanța, the Study on protection and rehabilitation of the southern Romanian Black Sea shore financed by JICA, the 2 Mai – Vama Veche Marine Reservation by NIMRD, and the Coastal Road project by the Constanța City Hall.

C.2.4 Third Meeting of NCCZ

The third meeting of NCCZ was held on 17 August 2005. Six working groups were established with the following subjects:

WG 1: Coastal zone delimitation, urbanism and land facilities;
WG 2: Coastal zone management against coastal degradation by marine erosion, land slides and other accidents;
WG 3: Drawing up the technical and juridical documents in the coastal zone;
WG 4: Drawing up policies, strategies and action plans for ICZM;
WG 5: Integral control and environment monitoring in the coastal zone;
WG 6: Information and communication.

The members of NCZM were asked to nominate the experts for these working groups at the end of the meeting. However, due to urgency of amendment works of EO, all the working group activities are suspended.

Then presentation of a few projects was made for discussion and possible approval. Among them, the urban zone planning (UZP) of the coastal zone of the Black Sea by Constanța City Hall brought out heated discussions, because the UZP proposal includes construction of a highway along the shore from Tomis to Mamaia while the Emergency Ordinance no.202/2002 on ICZM prohibits any construction within the land zone of 50 to 100 m wide from the shoreline. There is an exception clause in EO **Art. 16** (2) such that exceptions may be made for the constructions indispensable to security or public services on the basis of an impact study. NCCZ approved the UZP under the condition that it will obtain the notification of exception from the Ministry of Environment and Water Management and Ministry of Transport, Construction and Tourism.

ANNEX D:

PHYSICAL AND ENVIRONMENTAL CONDITIONS

Annex D: Physical and Environmental Conditions

D.1 Geological and Geomorphological Conditions of Study Area[1]

D.1.1 Paleogeography of the Southern Romanian Black Sea Shore

The study area is situated at the eastern edge of the Dobrogea area, which constitutes the eastern part of the Moesian Platform (a large structural unit of Carpathian shelf). The Dobrogea area consists of the South Dobrogea Platform, the Central Dobrogea Massis, and the North Dobrogea Orogene. South and Central Dobrogea are divided by the Capidava – Ovidiu Fault line, which passes through Lake Siutghiol. Thus the study area belongs to South Dobrogea.

South Dobrogea has been subject to several periods of uplift and erosion, followed by those of deposition and subsidence since the Palaeozoic (some 540 to 250 million years ago).[2] When it was submerged, shallow marine environment prevailed and carbonate deposition took place. The process yielded deposits of several limestone layers, the uppermost of which is that of the Sarmatian age. The period of the formation of the Sarmatian was about 13 to 6.5 million years ago.

After the deposition of Sarmatian limestone layer, South Dobrogea became an emerged land and was covered by thick layers of continental sediments (clay, loess, etc.). Deposition of continental sediments by winds continued during the cold climate of glacier ages throughout the Quaternary (since 1.8 million years ago to the present) to the thickness of several tens of meters. The lower deposition is red clay, the middle one is loess deposit, and the upper one is recent (several tens of thousand years) loessoid deposit.

At the sea cliff outcrop, one can easily observe the basement of limestone up to the elevation of one meter or so overlain by multiple layers of loess and red clay, especially at headlands. South Dobrogea is a slowly undulating tableland with the elevation varying from a few meters to some 40 m. Where a high plateau meets the sea, it is cut by a high cliff with visible limestone outcrop at its base. Where the tableland of low elevation meets the sea, sandy beaches appear with the limestone layer going down deep below the ground, as verified by borings at the barrier beach of Mamaia.

D.1.2 Chronological Sea Level Change of the Black Sea

The Black Sea is a large inland sea surrounded by the Eurasian Continent and the Asian Minor and is connected to the Sea of Marmara with a narrow channel of the Bosporus Strait. It is a consensus among geologists that the global ocean surface level was at the level of –140

[1] The major source of information to this section is the subcontract report of GeoEcoMar, which is attached to the present report as a digital file of L.8.

[2] Ion, J., Iordan, M. Mãrunteanu, M. and Sededi, A.: Palaeogeography of Dobrogea based on lithofacies maps of the Moesian cover, *GEO-ECO-MARINA*, 5-6/2000-2001, pp. 73-90.

to –120 m around 18 to 20 kyr BP (twenty thousand years [kyr] before present [BP]), when the last glacier age was at its peak. The ocean level rose steadily at the rate of about 1 cm per year to the level of +3 to +5m around 4 to 5 kyr BP, then made a few oscillations, fell to the present level around 0.5 kyr BP and stayed at that level ever since. The rise of the sea level from around 20 kyr BP is called the Flandrian or Neoeuxinian transgression. However, there were sea level fluctuations of similar amplitudes before that, in correspondence to global glaciations and deglaciations.

Compared with the change of ocean surface level, the surface level of the Black Sea seems to have experienced much wider variations, probably because it is more susceptible to climatic changes on land owing to its land-locked environment. By referring to several authors[3,4,5,6,7], the chronological sea level change of the Black Sea may be summarized as listed in Table C.1.1, even though there remain many arguments on the sea levels and their dates of occurrence.

Table D.1.1: Chronological sea level change of the Black Sea

Year	Sea level (m)	Name of transgression or regression	Reference
1.0 kyr BP	–1 m to –2 m		Olteanu[3)]
1.5 kyr BP	+1 m to +3 m	Nymphaean or Istrian transgression	Olteanu[3)]
2.5 kyr BP	–2 m to –3 m		Ciorbea[3)]
3.5 kyr BP	–5 m to –8 m	Phanagorian regression	Olteanu[4)]
4.0 –5.0 kyr BP	+3 m to +5 m	Neolithic transgression	Olteanu[4)]
7.2 kyr BP	–18 m		Görel et al.[5)]
11.7 kyr BP	+ 0 m (?)		Panin[6)]
18 kyr BP	–140 m		Ryan et al.[7)]

The rate of sea level rise between the period between 18 kyr BP and 12 kyr BP was about 2.3 cm per year, which was much larger than the rate of 1 cm per year of the sea level rise of the global ocean. The speed of rise and fall of the Black Sea level since around 7 kyr BP is of the order of 1 cm per year at most, which could have been occurred by climatic changes. It should be stated here that the sea level changes relative to the present level include the tectonic change of the ground also, although the quantitative assessment of the latter speed is hard to make.

With a rapid rise of the Black Sea level during the late Neoeuxinian (about 20 to 10 kyr BP), the Black Sea level became higher than the Aegean at a certain point, and there was a fresh-water outflow from the Black Sea to the Aegean through the Bosporus-Dardanelles straits with the rate of about 190 km^3/year.

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[3] Olteanu, R.: Black Sea transgressions during the late Holocene, *GEO-ECO-MARINA*、9-10/2003-2004, pp. 31-35.

[4] Ciorbea, Valentin: ”Portul Constanța de La Antichitate La Mileniul III”

[5]. Görur, N. et al.: Is the abrupt drowning of the Black Sea shelf at 7159 yr BP a myth? Marine Geology, **176**, 2001, pp. 65-73.

[6] Panin, N.: On the geomorphologic and geological evolution of the River Danube – Black Sea interaction zone, *GEO-ECO-MARINA*, 2/1997, pp. 31-45

[7] Ryan, W.B.F. et al.: An abrupt drowning of the Black Sea Shelf at 7.5 kyr BP, *GEO-ECO-MARINA*, 2/1997, pp. 115-125.

The Phanagorian regression corresponds to the ages when Hellenic people started to build colonies along the Black Sea shore. The present port city of Constanța began its activity as a port named Tomo or Tomis in the seventh century B.C. Archaeological explorations have found many artifacts in the sea in front of the present Casino building. It is believed that the harbor of Tomis was well protected by natural breakwaters of emerged reefs, which were submerged by the rising sea and/or sunk below the sea through the actions of abrasions by waves, currents, ices, etc.

There is another theory on the evolution of the Black Sea level. According to Ryan et al.[6], a more dramatic change took place in around 7.5 kyr BP. Being separated by the isthmus of Bosporus, the Black Sea was a huge inland lake with the surface level of –156 m. However, as the rising sea level of the Sea of Marmara rose above the lowest point of the isthmus of Bosporus, the seawater suddenly began to flow into the basin of Black Sea with an enormous flow rate of 50 to 100 km^3/day (600,000 to 1,200,000 m^3/s). Ryan et al.[6] estimate that the shoreline must have advanced inland with the speed of 1 to 2 km per day: The Black Sea must have been filled up within one year. Though quite attractive itself, the theory has met many arguments and evidences against it and the mainstream of geologists does not seem to support it.

The rise of the Black Sea level in the past was not a monotonous one, but repetitions of rise and stop processes. While the sea level lingered at some elevation, wave-cut terraces and barrier beaches are formed around the shoreline at that time. Evidences of wave-cut terraces in the Surozhian phase (40 to 25 kyr BP) are found below the seabed at about –14 m, –22 m, –28 m, and –38 m of the southern Romanian coast. Several stages of relic barrier beaches that were formed during the late Neoeuxinian have also been identified at the depth –23 m to –42m. During the Neolithic transgression around 4 kyr BP, “Old Black Sea” terrace was formed along the coastal land at the elevation of 3 to 5 m.

D.1.3 Formation of Sandy Beaches along the Northern Romanian Black Sea Shore

The Romanian Black Sea shore is generally divided into the northern and southern units. The northern unit extends from Sulina to Cape Midia and the southern unit is from Cape Midia via Constanța to Vama Veche. However, in the present report, the southern unit is further divided into the northern and southern sectors. The beaches of Năvodari and Mamaia are included into the northern sector and the southern sector is defined from Cape Singol to Vama Veche, because of the difference in the origin of sediment supply.

Almost the whole length of the northern unit is occupied by beaches with terrigeneous gray sand of fine to very fine grain size, which apparently represents sediment from the Danube; it used to transport a huge amount of sediment toward the Black Sea. The situation is same for the northern sector of the southern unit. With this supply of sediment, sand spits extended southwestward year after year and formed littoral barriers at the entrances of the lakes of Razim, Sinoie, and Siutghiol, which were originally the embayments but later became land-locked lakes. The Hellenistic colonial port of Histria was developed at the western shore of Sinoie Bay in the seventh century BC and prospered for many centuries with calling of ships sailing along the Black Sea. However, the port stopped to function in the 3rd to 4th century B.C. owing to sand deposition and Histria was isolated from the other Hellenistic colonies[8]. It would have been the result of the closure of the entrance channel of Sinoie Bay

[8] Mihail Şerbănescu: DOBRGEA, Publisher Romart Design, Constanța, 2005.

by the growth of sand spit around there. Histria nevertheless continued to prosper until it desertion around 650 AD.

The town of Ovidiu, which is located at the western bank of Siutghiol Lake, prospered as a port town in the Hellenistic and Roman ages, together with Tomis (present Constanța) and Histria. That means that the littoral barrier of the present Mamaia Beach was not completed yet and trading ships could enter the Bay of Siutghiol from the Black Sea. The closure of Siutghiol Lake would have been around the first century A.D.

A further evidence of enormous amount of sediment supply from the Danube can be found on the backshore of Corbu Beach at the north of Cape Midia. At the distance of some 130 m from the present shoreline, there are two German pillboxes half buried in the sand. They must have been built in the early 1940s as the watch stations at the coastline. Therefore, the shoreline must have advanced at the mean rate of 2 m per year over the period of 60 years; the advance rate might have been larger in the 1940s to the 1960s than in the later period because of the decrease of sediment supply from the Danube in the recent years.

The supply of sediment from the Danube decreased drastically in recent years, however. This has caused severe erosion of beaches along the northern sector except for the area in the shadow zone of the Sulina jetties. Decrease of sediment supply to the coast has often been attributed to the construction of the Iron Gate Dams I and II. In addition, a large number of dams were built after World War II in the tributaries of the Danube that flow down the Carpathian. These dams must have cut down the supply of sand to almost null and contributed greatly to the beach erosion of the northern sector of the Romanian Black Sea shore.

D.1.4 Formation of Sandy Beaches along the Southern Romanian Black Sea Shore

Along the study area of the Romanian Black Sea shore, there are eight natural sandy beaches: Năvodari–Mamaia, Eforie Nord–Sud, Costineşti, Olimp, Neptune–Jupiter, Saturn, 2 Mai, and Vama Veche. Except for the last two beaches, they are all located in front of some sorts of lakes (or marshes), large or small. Behind the lakes, the land of low elevation is stretched over. These lakes are listed with their surface areas and depths in Table D.1.1.

Table D.1.2: Lakes behind sandy beaches in the study area

Name	Surface area (km^2)	Maximum depth (m)	Mean depth (m)	Beach in front of lake
Siutghiol	19.6	17.05	4.52	Năvodari–Mamaia
Tăbăcărie	0.96	16.15	2.08	
Techirghiol	12.3	9.75	3.40	Eforie Nord–Sud
Costineşti	0.07	0.35	0.26	Costineşti
Tătlăgeac	1.4	2.5	1.57	Olimp
Neptune–Jupiter	-	-	-	Neptune–Jupiter
Hagieni	0.52	2.5	1.15	Saturn
Mangalia	2.61	13.0	6.02	

Note: The data of surface area and depth are taken from a report by AQUAPROIECT S.A.[9]

[9] "Studiu privind urmărirea în timp a eroziunilor plajelor şi falezelor în corelatie cu parametrie furtunilor de litoralul Românesc al Mării Negre," Contract Nr. 3511, 1998.

Lakes Siutghiol, Techirghiol and Mangalia have their origins in the Jurassic Period as carst depressions of limestone. For a long period of time, they were embayment of the Black Sea. In recent times (a few thousand years ago), littoral barriers gradually grew at the bay mouths of Siutghiol, Techirghiol, and Mangalia, transforming them into land-locked lakes. Although Mangalia Lake is open to the Black Sea nowadays, it was also a land-locked lake in the early half of the 20th century. Since 1960, a port development project took place by cutting channels to the sea, dredging a harbor basin, and constructing breakwaters and other facilities.

While Siutghiol is a freshwater lake, Techirghiol Lake is a very salty lake with the salinity of over 50 per mill. The former has many submarine springs that provide a sufficient amount of freshwater, but the latter is devoid of such freshwater springs. A large amount of evaporation exceeding precipitation in this area caused to change Techirghiol into a lake of brine water. The major cause of salinity increase seems to be the decrease of the lake water volume by deposition of fine sediment on the lake bottom, which was brought down by rainwater. The mean water depth must have been around 10 m when the lake was open to the Black Sea with the salinity around 18 per mill. Before the 1970s, the water level of Techirghiol Lake was lower than the Black Sea by 1.5 m, and the salinity was about 70 per mill. A large irrigation project in this area in the late 1970s raised the groundwater table considerably and the groundwater began to penetrate into the lake. Nowadays the lake water level is about the same as the surface level of the Black Sea.[10]

Lake Neptune–Jupiter is a recent creation through artificial supply of water by boring works over the former marsh called Comorova, having been separated from the sea by a littoral barrier and covered with overgrown reeds.

Between the sandy beaches, the land gains the altitude and a long stretch of sea cliff continues over several kilometers. Therefore, the beaches of the southern sector are not classified as pocket beaches between the narrow spaces of headlands, but they are regarded as barrier beaches developed on sand spits.

D.1.5 Origin of Beach Sand in the Southern Romanian Black Sea Shore

The sediment that formed the littoral barrier of Lake Siutghiol is the terrigenous sediment of the Danube without doubt. Questions remain as to the origin of sediment that created barrier beaches south of Cape Singol. While the sand along Năvodari Beach is very fine and of gray color, the sand along Eforie Nord and other beaches are fine to medium in grain size and of brown color.

As will be discussed in Annex E.2, sand samples taken along the southern sector contain a large content of calcium carbonate and only a small amount of silicides. On the other hand, sand samples at Năvodari Beach and the riverbed of the Danube around Călărăşi indicate large amount of silicides with little calcium carbonate. This fact clearly establishes the fact that the sand of the southern sector has come from the source other than the Danube.

It has been well acknowledged that the majority of beach sand at the southern sector is composed of fragments of bivalve shells. Any visitor to the southern coast of Romania will be

[10] This paragraph is based on personal communication with Prof. Nicolaev Panin on 30 May 2005.

surprised to see large deposits of shells along the shoreline for many kilometers. In addition, there are a certain amount of calcareous clasts (rock fragments), which are supposed to have come from Sarmatian limestone. The ratio of clasts to shell fragments is said to increase toward the south and exceeds 1.0 at the southernmost area.

Photo D.1.1: Eroded limestone at the foot of the cliff at the south of Hotel Horum at Southern Costineşti

Photo D.1.2: Eroded limestone at the foot of the cliff at the south of Eforie Sud

Photo D.1.3: Eroded limestone at Agigea

One probable source of the calcareous clasts is the limestone at the base of sea cliff, which has been abraded by wave actions, impacts of colliding ice, etc. Because the limestone is a soft rock, it is easily eroded and ground into small pieces. The basement rises above the sea level up to the elevation 4 m such as at the south of Cape Turcului. The exposed limestone is always abraded and eroded intensively as shown in Photos D.1.1 to D.1.3.

Although no quantitative estimation on the amount of abraded limestone at the feet of eroded sea cliffs has yet been made, it can be deducted that the abraded limestone became clasts and supplemented shell fragments for supplying beach sand of the southern sector over many thousand years.

D.2 Wind Statistics

D.2.1 ECMWF Hindcast Wind data

Statistical data on wind speed and direction have been derived from the archive data of wind forecast by the European Center for Medium Range Weather Forecast (hereinafter referred to as ECMWF) at the location at 44ºN and 29ºE and they are summarized for throughout the year and every season, respectively as listed in Tables D.2.1 to D.2.5. Figure D.2.1 shows a wind rose of the ECMWF hindcast data for the whole year and the four seasons. Table D.2.1 has been listed in **3.2.3** as Table 3.2.3 of Volume 1.

Table D.2.1: Yearly wind direction and frequency in Black Sea off Constanța

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-2.0	126	143	140	143	122	113	144	134	106	140	139	147	141	150	135	144	2167
(%)	0.9	1.0	1.0	1.0	0.8	0.8	1.0	0.9	0.7	1.0	0.9	1.0	1.0	1.0	0.9	1.0	14.8
2.0-4.0	235	230	225	197	195	189	149	177	222	257	247	217	170	171	174	228	3283
(%)	1.6	1.6	1.5	1.3	1.3	1.3	1.0	1.2	1.5	1.8	1.7	1.5	1.2	1.2	1.2	1.6	22.4
4.0-6.0	264	253	217	203	183	157	178	245	307	328	307	284	142	121	131	280	3600
(%)	1.8	1.7	1.5	1.4	1.2	1.1	1.2	1.7	2.1	2.2	2.1	1.9	1.0	0.8	0.9	1.9	24.5
6.0-8.0	201	235	161	140	134	104	113	198	278	299	260	135	87	55	74	97	2571
(%)	1.4	1.6	1.1	1.0	0.9	0.7	0.8	1.3	1.9	2.0	1.8	0.9	0.6	0.4	0.5	0.7	17.5
8.0-10.0	116	135	104	77	64	61	62	155	245	240	149	65	33	17	26	34	1583
(%)	0.8	0.9	0.7	0.5	0.4	0.4	0.4	1.1	1.7	1.6	1.0	0.4	0.2	0.1	0.2	0.2	10.8
10.0-12.0	30	55	38	25	34	13	26	76	183	145	114	34	16	7	5	6	807
(%)	0.2	0.4	0.3	0.2	0.2	0.1	0.2	0.5	1.2	1.0	0.8	0.2	0.1	0.0	0.0	0.0	5.5
12.0-14.0	14	25	17	11	20	5	11	42	81	78	74	17	5	2	3	2	407
(%)	0.1	0.2	0.1	0.1	0.1	0.0	0.1	0.3	0.6	0.5	0.5	0.1	0.0	0.0	0.0	0.0	2.8
14.0-16.0	4	6	2	5	5	3	1	11	33	44	40	12	2	0	0	0	168
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.1	0.0	0.0	0.0	0.0	1.1
16.0-18.0	0	4	0	1	2	1	2	4	10	16	22	4	1	0	0	0	67
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.5
18.0-20.0	0	0	0	0	0	0	1	0	1	3	7	4	2	0	0	0	18
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	990	1086	904	802	759	646	687	1042	1466	1550	1359	919	599	523	548	791	14671
(%)	6.7	7.4	6.2	5.5	5.2	4.4	4.7	7.1	10.0	10.6	9.3	6.3	4.1	3.6	3.7	5.4	100.0

Source: ECMWF 1991-2002

Table D.2.2: Wind direction and frequency in the spring season (March to May) in Black Sea off Constanța

Direction / Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-2.0	47	45	42	38	41	34	43	35	28	31	37	42	37	43	42	51	636
(%)	1.3	1.2	1.1	1.0	1.1	0.9	1.2	0.9	0.8	0.8	1.0	1.1	1.0	1.2	1.1	1.4	17.2
2.0-4.0	86	74	71	55	47	44	31	35	48	60	67	56	45	40	52	71	882
(%)	2.3	2.0	1.9	1.5	1.3	1.2	0.8	0.9	1.3	1.6	1.8	1.5	1.2	1.1	1.4	1.9	23.9
4.0-6.0	84	85	58	42	29	38	41	50	61	71	58	78	50	33	42	73	893
(%)	2.3	2.3	1.6	1.1	0.8	1.0	1.1	1.4	1.7	1.9	1.6	2.1	1.4	0.9	1.1	2.0	24.2
6.0-8.0	71	65	47	42	22	18	14	36	61	55	69	24	20	21	27	48	640
(%)	1.9	1.8	1.3	1.1	0.6	0.5	0.4	1.0	1.7	1.5	1.9	0.7	0.5	0.6	0.7	1.3	17.4
8.0-10.0	32	32	22	14	12	6	9	25	44	57	44	17	12	8	9	17	360
(%)	0.9	0.9	0.6	0.4	0.3	0.2	0.2	0.7	1.2	1.5	1.2	0.5	0.3	0.2	0.2	0.5	9.8
10.0-12.0	7	14	7	3	4	0	5	14	25	30	32	6	0	1	1	2	151
(%)	0.2	0.4	0.2	0.1	0.1	0.0	0.1	0.4	0.7	0.8	0.9	0.2	0.0	0.0	0.0	0.1	4.1
12.0-14.0	4	9	3	2	1	0	2	11	8	21	25	1	0	0	1	1	89
(%)	0.1	0.2	0.1	0.1	0.0	0.0	0.1	0.3	0.2	0.6	0.7	0.0	0.0	0.0	0.0	0.0	2.4
14.0-16.0	0	1	1	0	0	0	1	4	4	7	9	2	0	0	0	0	29
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.8
16.0-18.0	0	0	0	0	0	0	0	1	4	2	0	0	0	0	0	0	7
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
18.0-20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	331	325	251	196	156	140	146	211	283	334	341	226	164	146	174	263	3687
(%)	9.0	8.8	6.8	5.3	4.2	3.8	4.0	5.7	7.7	9.1	9.2	6.1	4.4	4.0	4.7	7.1	100.0

Source: ECMWF 1991-2002

Table D.2.3: Wind direction and frequency in the summer season (June to August) in Black Sea off Constanța

Direction / Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-2.0	29	40	38	41	33	38	37	47	35	61	65	49	55	59	44	47	718
(%)	0.8	1.1	1.0	1.1	0.9	1.0	1.0	1.3	1.0	1.7	1.8	1.3	1.5	1.6	1.2	1.3	19.5
2.0-4.0	71	60	52	41	43	38	44	62	94	106	105	85	67	71	54	74	1067
(%)	1.9	1.6	1.4	1.1	1.2	1.0	1.2	1.7	2.6	2.9	2.9	2.3	1.8	1.9	1.5	2.0	29.0
4.0-6.0	67	43	27	31	30	24	32	71	106	147	112	103	43	39	44	96	1015
(%)	1.8	1.2	0.7	0.8	0.8	0.7	0.9	1.9	2.9	4.0	3.0	2.8	1.2	1.1	1.2	2.6	27.6
6.0-8.0	49	31	10	8	19	8	21	40	61	93	75	32	14	18	20	24	523
(%)	1.3	0.8	0.3	0.2	0.5	0.2	0.6	1.1	1.7	2.5	2.0	0.9	0.4	0.5	0.5	0.7	14.2
8.0-10.0	24	9	1	2	8	6	13	31	47	42	25	11	2	3	6	10	240
(%)	0.7	0.2	0.0	0.1	0.2	0.2	0.4	0.8	1.3	1.1	0.7	0.3	0.1	0.1	0.2	0.3	6.5
10.0-12.0	3	1	0	1	3	3	2	17	29	9	10	3	0	0	1	0	82
(%)	0.1	0.0	0.0	0.0	0.1	0.1	0.1	0.5	0.8	0.2	0.3	0.1	0.0	0.0	0.0	0.0	2.2
12.0-14.0	1	0	0	2	4	0	0	4	6	6	2	0	0	0	0	0	25
(%)	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.2	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.7
14.0-16.0	0	0	0	0	0	3	0	0	2	0	0	0	0	0	0	0	5
(%)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
16.0-18.0	0	0	0	0	2	1	0	1	1	0	0	0	0	0	0	0	5
(%)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
18.0-20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	244	184	128	126	142	121	149	273	381	464	394	283	181	190	169	251	3680
(%)	6.6	5.0	3.5	3.4	3.9	3.3	4.0	7.4	10.4	12.6	10.7	7.7	4.9	5.2	4.6	6.8	100.0

Table D.2.4: Wind direction and frequency in the autumn season (September to November) in Black Sea off Constanța

Direction / Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-2.0	27	38	25	36	28	23	27	34	22	32	22	34	33	32	32	31	476
(%)	0.7	1.0	0.7	1.0	0.8	0.6	0.7	0.9	0.6	0.9	0.6	0.9	0.9	0.9	0.9	0.8	13.0
2.0-4.0	61	62	53	53	47	50	41	34	35	53	41	47	38	54	46	57	772
(%)	1.7	1.7	1.4	1.4	1.3	1.4	1.1	0.9	1.0	1.4	1.1	1.3	1.0	1.5	1.3	1.6	21.0
4.0-6.0	79	69	57	48	41	37	43	60	58	51	101	68	42	42	32	82	910
(%)	2.1	1.9	1.6	1.3	1.1	1.0	1.2	1.6	1.6	1.4	2.7	1.9	1.1	1.1	0.9	2.2	24.8
6.0-8.0	54	61	23	25	30	23	37	53	63	63	68	63	35	13	25	14	650
(%)	1.5	1.7	0.6	0.7	0.8	0.6	1.0	1.4	1.7	1.7	1.9	1.7	1.0	0.4	0.7	0.4	17.7
8.0-10.0	30	31	22	15	19	21	13	48	56	59	46	24	15	3	9	3	414
(%)	0.8	0.8	0.6	0.4	0.5	0.6	0.4	1.3	1.5	1.6	1.3	0.7	0.4	0.1	0.2	0.1	11.3
10.0-12.0	7	16	7	6	10	7	13	25	51	52	37	15	10	2	3	2	263
(%)	0.2	0.4	0.2	0.2	0.3	0.2	0.4	0.7	1.4	1.4	1.0	0.4	0.3	0.1	0.1	0.1	7.2
12.0-14.0	2	5	5	2	5	1	6	12	24	22	22	11	4	2	1	0	124
(%)	0.1	0.1	0.1	0.1	0.1	0.0	0.2	0.3	0.7	0.6	0.6	0.3	0.1	0.1	0.0	0.0	3.4
14.0-16.0	0	0	0	1	2	0	0	6	9	9	10	7	2	0	0	0	46
(%)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.2	0.3	0.2	0.1	0.0	0.0	0.0	1.3
16.0-18.0	0	0	0	0	0	0	2	0	2	2	5	3	1	0	0	0	15
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.4
18.0-20.0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	0	5
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.1
Total	260	282	192	186	182	162	182	272	320	343	352	275	182	148	148	189	3675
(%)	7.1	7.7	5.2	5.1	5.0	4.4	5.0	7.4	8.7	9.3	9.6	7.5	5.0	4.0	4.0	5.1	100.0

Source: ECMWF 1991-2002

Table D.2.5: Wind direction and frequency in the winter season (December to February) in Black Sea off Constanța

Direction / Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-2.0	23	20	35	28	20	18	37	18	21	16	15	22	16	16	17	15	337
(%)	0.6	0.6	1.0	0.8	0.6	0.5	1.0	0.5	0.6	0.4	0.4	0.6	0.4	0.4	0.5	0.4	9.3
2.0-4.0	17	34	49	48	58	57	33	46	45	38	34	29	20	6	22	26	562
(%)	0.5	0.9	1.4	1.3	1.6	1.6	0.9	1.3	1.2	1.0	0.9	0.8	0.6	0.2	0.6	0.7	15.5
4.0-6.0	34	56	75	82	83	58	62	64	82	59	36	35	7	7	13	29	782
(%)	0.9	1.5	2.1	2.3	2.3	1.6	1.7	1.8	2.3	1.6	1.0	1.0	0.2	0.2	0.4	0.8	21.5
6.0-8.0	27	78	81	65	63	55	41	69	93	88	48	16	18	3	2	11	758
(%)	0.7	2.1	2.2	1.8	1.7	1.5	1.1	1.9	2.6	2.4	1.3	0.4	0.5	0.1	0.1	0.3	20.9
8.0-10.0	30	63	59	46	25	28	27	51	98	82	34	13	4	3	2	4	569
(%)	0.8	1.7	1.6	1.3	0.7	0.8	0.7	1.4	2.7	2.3	0.9	0.4	0.1	0.1	0.1	0.1	15.7
10.0-12.0	13	24	24	15	17	3	6	20	78	54	35	10	6	4	0	2	311
(%)	0.4	0.7	0.7	0.4	0.5	0.1	0.2	0.6	2.1	1.5	1.0	0.3	0.2	0.1	0.0	0.1	8.6
12.0-14.0	7	11	9	5	10	4	3	15	43	29	25	5	1	0	1	1	169
(%)	0.2	0.3	0.2	0.1	0.3	0.1	0.1	0.4	1.2	0.8	0.7	0.1	0.0	0.0	0.0	0.0	4.7
14.0-16.0	4	5	1	4	3	0	0	1	18	28	21	3	0	0	0	0	88
(%)	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0	0.5	0.8	0.6	0.1	0.0	0.0	0.0	0.0	2.4
16.0-18.0	0	4	0	1	0	0	0	2	3	12	17	1	0	0	0	0	40
(%)	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3	0.5	0.0	0.0	0.0	0.0	0.0	1.1
18.0-20.0	0	0	0	0	0	0	1	0	1	3	7	1	0	0	0	0	13
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.4
Total	155	295	333	294	279	223	210	286	482	409	272	135	72	39	57	88	3629
(%)	4.3	8.1	9.2	8.1	7.7	6.1	5.8	7.9	13.3	11.3	7.5	3.7	2.0	1.1	1.6	2.4	100.0

Source: ECMWF 1991-2002

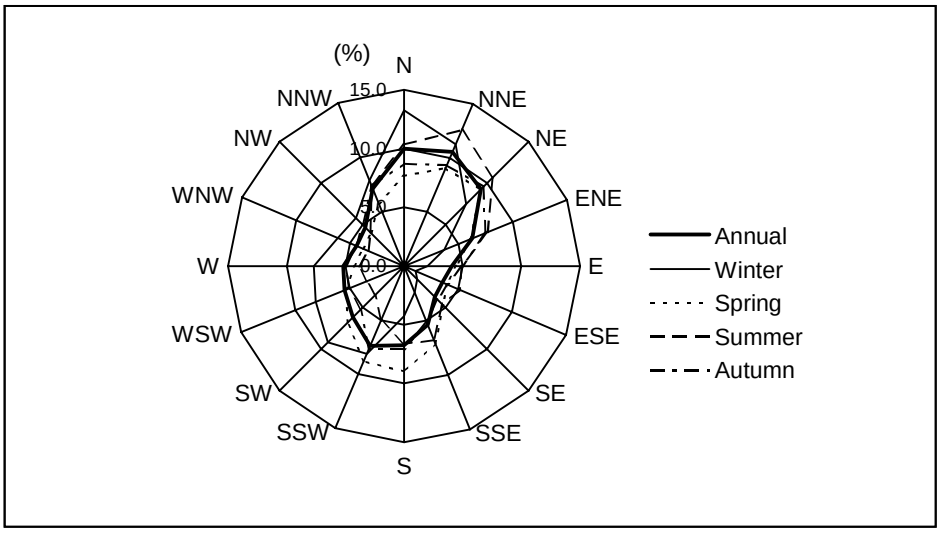


Fig. D.2.1: Directional distribution of wind frequency (in percentage) in Black Sea off Constanța

D.2.2 Ground Observation Wind data

Statistical data on wind speed and direction observed at the Constanța Meteorological Station are summarized for throughout the year and every season, respectively as listed in Tables D.2.6 to D.2.10. Table D.2.6 has been listed in **3.2.3** as Table 3.2.4 of Volume 1.

Table D.2.6: Yearly wind direction and frequency observed at Constanța meteorological station

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-0.5 Calm (%)																	3850 13.6
0.5-2.0	230	194	36	175	263	250	31	99	117	47	17	91	99	83	22	164	1918
(%)	0.8	0.7	0.1	0.6	0.9	0.9	0.1	0.3	0.4	0.2	0.1	0.3	0.3	0.3	0.1	0.6	6.8
2.0-4.0	1111	704	132	750	1189	1066	148	638	658	238	103	567	487	398	114	879	9182
(%)	3.9	2.5	0.5	2.6	4.2	3.8	0.5	2.2	2.3	0.8	0.4	2.0	1.7	1.4	0.4	3.1	32.4
4.0-6.0	888	394	64	393	734	743	119	575	714	275	108	575	340	205	74	696	6897
(%)	3.1	1.4	0.2	1.4	2.6	2.6	0.4	2.0	2.5	1.0	0.4	2.0	1.2	0.7	0.3	2.5	24.3
6.0-8.0	353	166	19	125	296	264	42	242	512	219	80	384	165	72	24	234	3197
(%)	1.2	0.6	0.1	0.4	1.0	0.9	0.1	0.9	1.8	0.8	0.3	1.4	0.6	0.3	0.1	0.8	11.3
8.0-10.0	91	46	6	30	84	79	13	92	305	123	45	205	63	28	4	50	1264
(%)	0.3	0.2	0.0	0.1	0.3	0.3	0.0	0.3	1.1	0.4	0.2	0.7	0.2	0.1	0.0	0.2	4.5
10.0-12.0	47	21	2	19	71	74	11	70	375	224	67	276	78	37	4	22	1398
(%)	0.2	0.1	0.0	0.1	0.3	0.3	0.0	0.2	1.3	0.8	0.2	1.0	0.3	0.1	0.0	0.1	4.9
12.0-14.0	3	4	0	3	15	13	2	9	106	92	26	98	24	13	0	2	410
(%)	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.4	0.3	0.1	0.3	0.1	0.0	0.0	0.0	1.4
14.0-16.0	1	0	0	1	4	3	0	3	46	29	10	39	13	4	0	2	155
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.5
16.0-18.0	0	0	0	0	1	1	0	3	16	8	4	19	4	0	0	0	56
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
18.0-20.0	0	0	0	0	0	0	0	0	5	1	1	6	2	1	0	0	16
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
>=20.0	2	4	0	1	1	1	0	1	10	2	0	0	0	0	0	1	23
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	2726	1533	259	1497	2658	2494	366	1732	2864	1258	461	2260	1275	841	242	2050	28366
(%)	9.6	5.4	0.9	5.3	9.4	8.8	1.3	6.1	10.1	4.4	1.6	8.0	4.5	3.0	0.9	7.2	100.0

Source: National Meteorological Administration 1995-2004

Table D.2.7: Wind direction and frequency in the spring season (March to May) at Constanța

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-0.5																	860
Calm (%)																	12.0
0.5-2.0	72	52	7	33	41	35	5	19	26	12	5	24	30	21	6	48	436
(%)	1.0	0.7	0.1	0.5	0.6	0.5	0.1	0.3	0.4	0.2	0.1	0.3	0.4	0.3	0.1	0.7	6.1
2.0-4.0	353	205	35	188	240	182	26	134	145	60	29	175	163	128	37	295	2395
(%)	4.9	2.9	0.5	2.6	3.4	2.5	0.4	1.9	2.0	0.8	0.4	2.4	2.3	1.8	0.5	4.1	33.5
4.0-6.0	288	125	19	105	152	156	25	110	159	67	29	170	98	64	24	232	1823
(%)	4.0	1.7	0.3	1.5	2.1	2.2	0.3	1.5	2.2	0.9	0.4	2.4	1.4	0.9	0.3	3.2	25.5
6.0-8.0	137	65	6	31	60	44	10	54	92	35	20	121	45	14	8	88	830
(%)	1.9	0.9	0.1	0.4	0.8	0.6	0.1	0.8	1.3	0.5	0.3	1.7	0.6	0.2	0.1	1.2	11.6
8.0-10.0	30	17	2	8	17	19	3	15	48	29	13	62	18	5	1	16	303
(%)	0.4	0.2	0.0	0.1	0.2	0.3	0.0	0.2	0.7	0.4	0.2	0.9	0.3	0.1	0.0	0.2	4.2
10.0-12.0	16	11	1	8	20	18	2	14	71	42	18	94	24	11	1	4	355
(%)	0.2	0.2	0.0	0.1	0.3	0.3	0.0	0.2	1.0	0.6	0.3	1.3	0.3	0.2	0.0	0.1	5.0
12.0-14.0	1	2	0	1	7	6	1	3	26	13	6	28	6	2	0	0	102
(%)	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.4	0.2	0.1	0.4	0.1	0.0	0.0	0.0	1.4
14.0-16.0	0	0	0	1	1	1	0	0	8	5	2	9	2	1	0	0	30
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.4
16.0-18.0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	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	0.0	0.0	0.0	0.0	0.0
18.0-20.0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	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	0.0	0.0	0.0	0.0	0.0
>=20.0	2	2	0	0	0	0	0	0	1	0	0	0	0	0	0	1	6
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	899	479	70	375	539	462	72	349	576	263	122	684	387	246	77	684	7144
(%)	12.6	6.7	1.0	5.2	7.5	6.5	1.0	4.9	8.1	3.7	1.7	9.6	5.4	3.4	1.1	9.6	100.0

Source: National Meteorological Administration 1995-2004

Table D.2.8: Wind direction and frequency in the summer season (June to August) at Constanța

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-0.5																	1275
Calm (%)																	17.3
0.5-2.0	78	64	13	65	72	60	8	25	27	12	5	34	43	45	10	63	624
(%)	1.1	0.9	0.2	0.9	1.0	0.8	0.1	0.3	0.4	0.2	0.1	0.5	0.6	0.6	0.1	0.9	8.5
2.0-4.0	303	177	31	165	249	225	35	166	174	70	33	188	190	161	44	301	2512
(%)	4.1	2.4	0.4	2.2	3.4	3.1	0.5	2.3	2.4	0.9	0.4	2.6	2.6	2.2	0.6	4.1	34.1
4.0-6.0	267	99	15	73	115	127	24	141	196	78	35	184	119	77	27	249	1826
(%)	3.6	1.3	0.2	1.0	1.6	1.7	0.3	1.9	2.7	1.1	0.5	2.5	1.6	1.0	0.4	3.4	24.8
6.0-8.0	89	37	2	14	38	39	8	62	118	59	21	89	37	16	6	57	692
(%)	1.2	0.5	0.0	0.2	0.5	0.5	0.1	0.8	1.6	0.8	0.3	1.2	0.5	0.2	0.1	0.8	9.4
8.0-10.0	23	7	0	2	13	14	4	30	59	17	7	37	10	5	1	15	244
(%)	0.3	0.1	0.0	0.0	0.2	0.2	0.1	0.4	0.8	0.2	0.1	0.5	0.1	0.1	0.0	0.2	3.3
10.0-12.0	10	2	0	1	8	15	3	13	49	29	8	28	6	1	0	5	178
(%)	0.1	0.0	0.0	0.0	0.1	0.2	0.0	0.2	0.7	0.4	0.1	0.4	0.1	0.0	0.0	0.1	2.4
12.0-14.0	1	0	0	0	3	3	0	0	3	1	0	1	0	0	0	2	14
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
14.0-16.0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	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	0.0	0.0	0.0	0.0	0.0
16.0-18.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18.0-20.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
>=20.0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	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	0.0	0.0	0.0	0.0	0.0
Total	771	386	61	321	500	484	82	437	626	266	109	561	405	305	88	692	7369
(%)	10.5	5.2	0.8	4.4	6.8	6.6	1.1	5.9	8.5	3.6	1.5	7.6	5.5	4.1	1.2	9.4	100.0

Source: National Meteorological Administration 1995-2004

Table D.2.9: Wind direction and frequency in the autumn season (September to November) at Constanţa

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-0.5 Calm (%)																	1097 14.7
0.5-2.0	56	51	9	39	74	88	10	23	28	12	4	18	17	13	4	38	484
(%)	0.8	0.7	0.1	0.5	1.0	1.2	0.1	0.3	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.5	6.5
2.0-4.0	303	189	33	197	309	314	41	143	143	43	20	111	89	78	25	205	2243
(%)	4.1	2.5	0.4	2.6	4.2	4.2	0.6	1.9	1.9	0.6	0.3	1.5	1.2	1.0	0.3	2.8	30.1
4.0-6.0	234	108	13	87	186	205	34	158	155	65	24	131	84	45	17	159	1705
(%)	3.1	1.5	0.2	1.2	2.5	2.8	0.5	2.1	2.1	0.9	0.3	1.8	1.1	0.6	0.2	2.1	22.9
6.0-8.0	92	41	4	27	69	67	11	65	151	69	21	92	55	27	7	70	868
(%)	1.2	0.6	0.1	0.4	0.9	0.9	0.1	0.9	2.0	0.9	0.3	1.2	0.7	0.4	0.1	0.9	11.7
8.0-10.0	24	14	2	7	20	18	3	24	108	39	12	55	23	13	2	15	379
(%)	0.3	0.2	0.0	0.1	0.3	0.2	0.0	0.3	1.5	0.5	0.2	0.7	0.3	0.2	0.0	0.2	5.1
10.0-12.0	13	5	0	4	23	19	3	27	125	82	21	76	29	22	3	8	460
(%)	0.2	0.1	0.0	0.1	0.3	0.3	0.0	0.4	1.7	1.1	0.3	1.0	0.4	0.3	0.0	0.1	6.2
12.0-14.0	1	2	0	0	2	2	1	5	31	32	9	33	11	8	0	0	137
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.4	0.1	0.4	0.1	0.1	0.0	0.0	1.8
14.0-16.0	1	0	0	0	1	1	0	2	7	5	3	13	4	1	0	2	40
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.2	0.1	0.0	0.0	0.0	0.5
16.0-18.0	0	0	0	0	0	0	0	2	4	3	1	5	2	0	0	0	17
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2
18.0-20.0	0	0	0	0	0	0	0	0	0	1	1	4	1	0	0	0	7
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.1
>=20.0	0	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	4
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	724	411	61	361	684	715	103	450	752	352	116	538	315	207	58	497	7441
(%)	9.7	5.5	0.8	4.9	9.2	9.6	1.4	6.0	10.1	4.7	1.6	7.2	4.2	2.8	0.8	6.7	100.0

Source: National Meteorological Administration 1995-2004

Table D.2.10: Wind direction and frequency form December to February at Constanţa

Direction Speed(m/s)	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	Total
0.0-0.5 Calm (%)																	618 9.6
0.5-2.0	24	27	7	38	76	67	8	32	36	11	3	15	9	4	2	15	374
(%)	0.4	0.4	0.1	0.6	1.2	1.0	0.1	0.5	0.6	0.2	0.0	0.2	0.1	0.1	0.0	0.2	5.8
2.0-4.0	152	133	33	200	391	345	46	195	196	65	21	93	45	31	8	78	2032
(%)	2.4	2.1	0.5	3.1	6.1	5.4	0.7	3.0	3.1	1.0	0.3	1.5	0.7	0.5	0.1	1.2	31.7
4.0-6.0	99	62	17	128	281	255	36	166	204	65	20	90	39	19	6	56	1543
(%)	1.5	1.0	0.3	2.0	4.4	4.0	0.6	2.6	3.2	1.0	0.3	1.4	0.6	0.3	0.1	0.9	24.1
6.0-8.0	35	23	7	53	129	114	13	61	151	56	18	82	28	15	3	19	807
(%)	0.5	0.4	0.1	0.8	2.0	1.8	0.2	1.0	2.4	0.9	0.3	1.3	0.4	0.2	0.0	0.3	12.6
8.0-10.0	14	8	2	13	34	28	3	23	90	38	13	51	12	5	0	4	338
(%)	0.2	0.1	0.0	0.2	0.5	0.4	0.0	0.4	1.4	0.6	0.2	0.8	0.2	0.1	0.0	0.1	5.3
10.0-12.0	8	3	1	6	20	22	3	16	130	71	20	78	19	3	0	5	405
(%)	0.1	0.0	0.0	0.1	0.3	0.3	0.0	0.2	2.0	1.1	0.3	1.2	0.3	0.0	0.0	0.1	6.3
12.0-14.0	0	0	0	2	3	2	0	1	46	46	11	36	7	3	0	0	157
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.7	0.2	0.6	0.1	0.0	0.0	0.0	2.4
14.0-16.0	0	0	0	0	1	0	0	1	31	19	5	17	7	2	0	0	83
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.3	0.1	0.3	0.1	0.0	0.0	0.0	1.3
16.0-18.0	0	0	0	0	0	0	0	1	12	5	3	14	2	0	0	0	37
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.6
18.0-20.0	0	0	0	0	0	0	0	0	5	0	0	1	0	1	0	0	7
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
>=20.0	0	1	0	0	0	0	0	0	9	1	0	0	0	0	0	0	11
(%)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Total	332	257	67	440	935	833	109	496	910	377	114	477	168	83	19	177	6412
(%)	5.2	4.0	1.0	6.9	14.6	13.0	1.7	7.7	14.2	5.9	1.8	7.4	2.6	1.3	0.3	2.8	100.0

Source: National Meteorological Administration 1995-2004

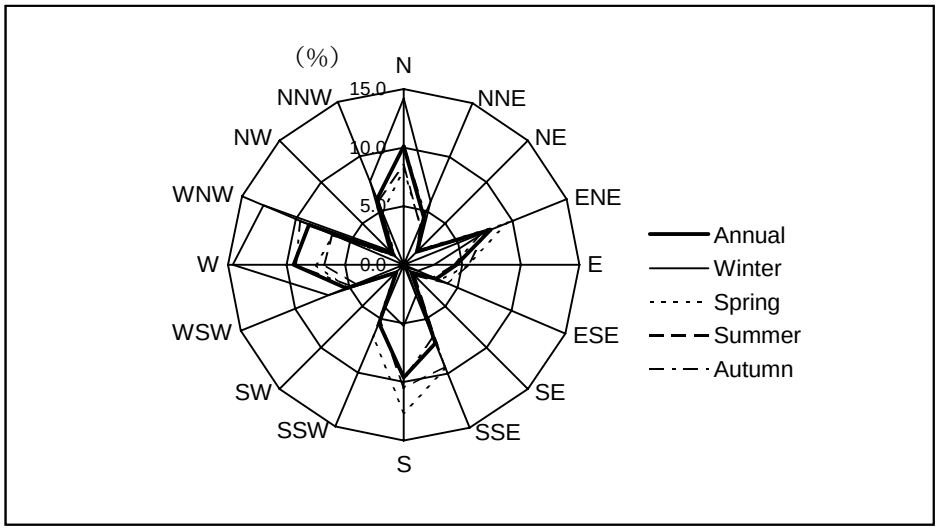


Fig. D.2.2: Directional distribution of wind frequency observed at Constanța Meteorological Station

Figure D.2.2 shows the wind rose for the whole year and the four seasons. The wind rose has an odd shape with few winds coming from the directions of NE, SE, SW, and NW; an officer of the Romanian Meteorological Administration (MRA) explained it to the Study team that it was caused by the wind shield effects of buildings in the vicinity of the observation station where many constructions has been taken place in the last 15 years. However, it seems that the original wind data of MRA have been compiled in the system of 30 degree divisions for wind direction and the data was converted subjectively into the 16-point bearing system.

Another peculiarity in the wind data observed at the Constanța Meteorological Station is appearance of a few strong winds of speed greater than 20 m/s. There are 19 such cases and some of them record the wind speed of 32, 40, 42, and 50 m/s. They appear singularly without being accompanied by other observations in excess of 20 m/s. Because MRA did not provide the time series data or original wind records, it has not been possible to examine the cause of such outlying wind speed.

D.2.3 Wind Data in Meteorological Year Book

Further wind data are available in the Meteorological Year Book, as advised by the National Institute of Marine Geology and Geo-ecology. Their exact data sources have not been confirmed yet, but they are supposed to be a part of meteorological measurements by the National Agency of Meteorology. The direction-wise frequency distribution of wind speeds at Constanța and Mangalia in the period of 1981 – 1999 are listed in Tables D.2.11 and D 2.12 for additional information, although the wind data are somewhat different from that of Table 3.2.4 for the period of 1995 – 2004. Furthermore, Table D.2.2.13 lists the offshore wind speed with the return period of 100 years at the Romanian coast.

D.3 Water Level

D.3.1 Water Level Records and Filtered Tide Records

As described in **3.3**, the water level records in the Ports of Constanța and Mangalia are

characterized by presence of irregular fluctuation, the amplitude of which is much larger than the astronomical tide. Thus, a weighted smoothing filter has been applied to the original records to separate them into the low and high frequency components. The filter is applied for 120 data points in the both side with the objective of killing 24-hour tide components. Figures D.3.1 and D.3.2 present two examples of the original water level records and the filtered tide records in the both ports. Figures D.3.1 is the case of September 2000 and Fig. D.3.2 is the case of February 2001. The upper panel shows the original record (thin line) and the low frequency component (thick line), and the lower panel shows the filtered tide records. In the case of February 2001, the mean water level changed by more than 50 cm in three days in both Constanța and Mangalia simultaneously.

Table D.2.11: The multiannual average of winds direction frequencies (%) for speed classes during the 1981-1999 period at Constanța

Speed, m/s	Wind directions								Annual
	N	NE	E	SE	S	SV	V	NV	
0-1	0.451	0.191	0.462	0.331	1.249	0.746	1.936	0.280	5.646
1-3	2.797	1.581	3.279	2.585	5.449	2.669	8.734	2.057	29.151
3-5	3.360	2.034	2.247	2.182	4.508	1.461	6.200	1.995	23.987
5-10	8.579	3.248	1.966	1.208	3.265	0.741	4.205	1.732	24.944
10-13	1.026	0.393	0.133	0.017	0.024	0.003	0.104	0.037	1.737
13-15	0.418	0.119	0.042	0.010	–	–	0.017	0.011	0.617
15-17	0.205	0.051	0.024	–	–	–	0.006	0.003	0.289
17-22	0.131	0.017	0.010	–	–	–	0.003	–	0.161
22-28	0.028	–	–	–	–	–	–	–	0.028
>28	0.007	–	–	–	–	–	–	0.004	0.011
Annual	17.002	7.634	8.163	6.333	14.495	5.62	21.205	6.119	86.571
Av. speed	6.35	5.64	4.07	3.70	3.75	3.05	3.60	4.24	4.41
Calm=									13.429
Total=									100.00
Average of speed annual duration (%)									
0	1	3	5	10	13	15	17	22	28
86.57	80.92	51.77	27.79	2.84	1.11	0.49	0.20	0.04	0.01

Table D.2.12: Multi-annual average of winds direction frequencies (%) for speed classes during the 1984-1999 period at Mangalia

Speed, m/s	Wind directions								Annual
	N	NE	E	SE	S	SV	V	NV	
0-1	0.219	0.103	0.147	0.189	0.269	0.090	0.799	0.104	1.92
1-3	3.871	1.855	2.804	3.031	2.885	0.722	12.872	2.229	30.269
3-5	4.260	1.936	1.818	3.438	2.276	0.442	8.324	2.137	24.631
5-10	6.567	2.655	1.902	4.586	2.084	0.203	4.195	1.132	23.324
10-13	0.457	0.167	0.159	0.069	0.022	0.004	0.060	0.013	0.951
13-15	0.128	0.112	0.043	0.018	–	–	0.009	–	0.31
15-17	0.069	0.047	0.030	–	–	–	0.004	–	0.15
17-22	0.026	–	0.004	0.004	–	–	–	–	0.034
22-28	–	–	–	–	–	–	–	–	–
>28	–	–	–	–	–	–	–	–	–
Annual	15.597	6.875	6.907	11.335	7.536	1.461	26.263	5.615	81.589
Av. speed	5.31	5.19	4.37	4.89	4.10	3.30	3.49	3.86	4.33
Calm=									18.411
Total=									100.00
Average of speed annual duration (%)									
0	1	3	5	10	13	15	17	22	28
81.59	79.67	49.40	24.77	1.44	0.49	0.18	0.04	0.00	0.00

Table D.2.13: Offshore wind speeds (m/s) with centennial repetability at the Romanian coast

N	NE	E	SE	S	SV	V	NV
32.7	31.8	23.9	23.4	26.7	22.2	26.7	31.9

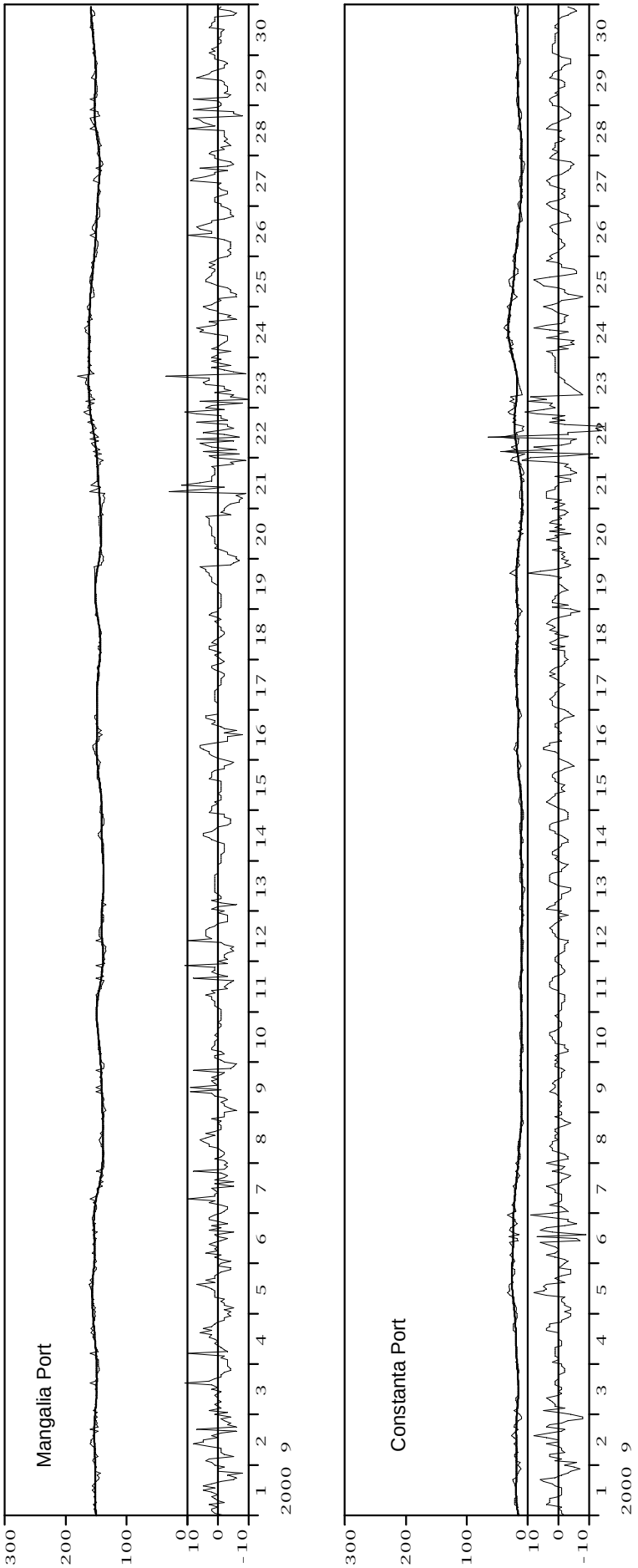


Fig. D.3.1: Original sea level records and filtered tide records of September 2000 in Mangalia and Constanta

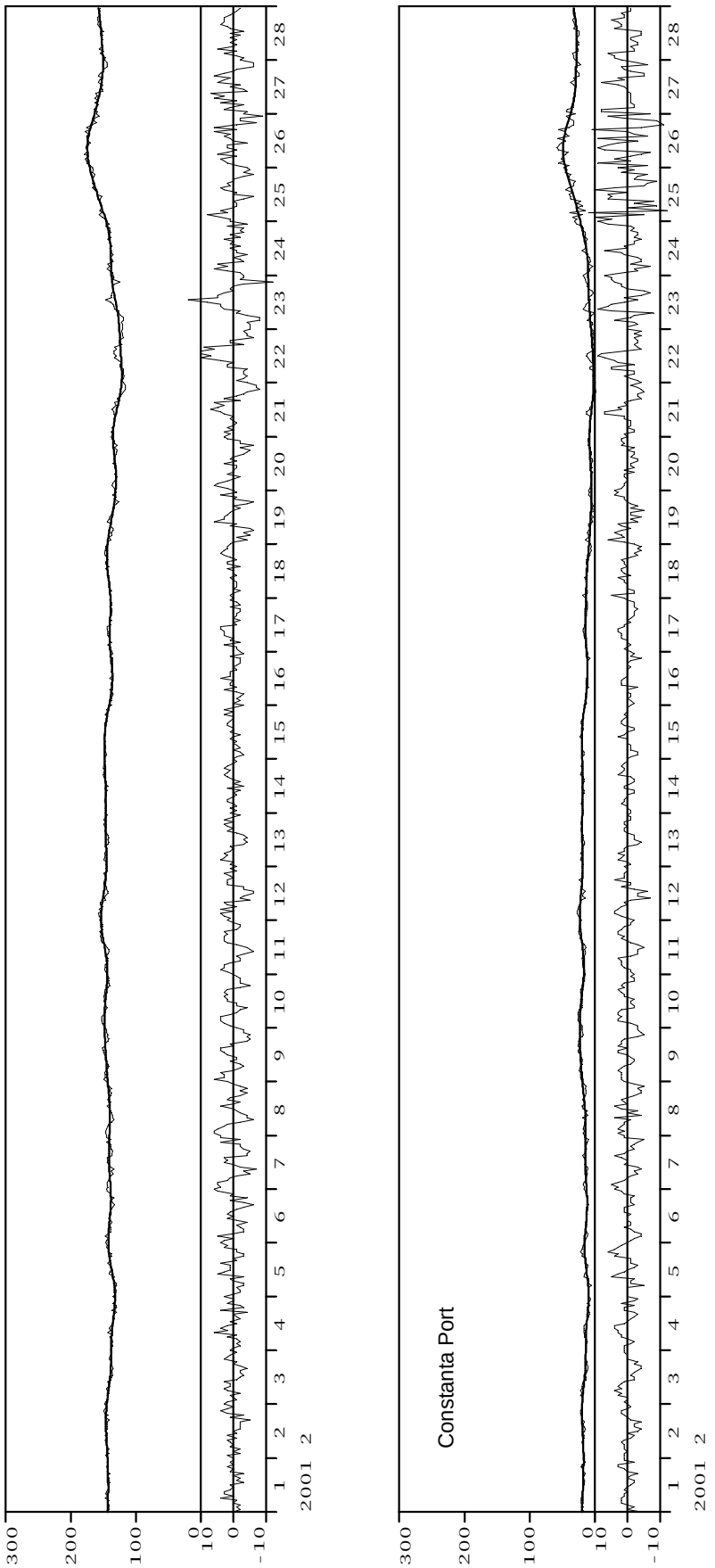
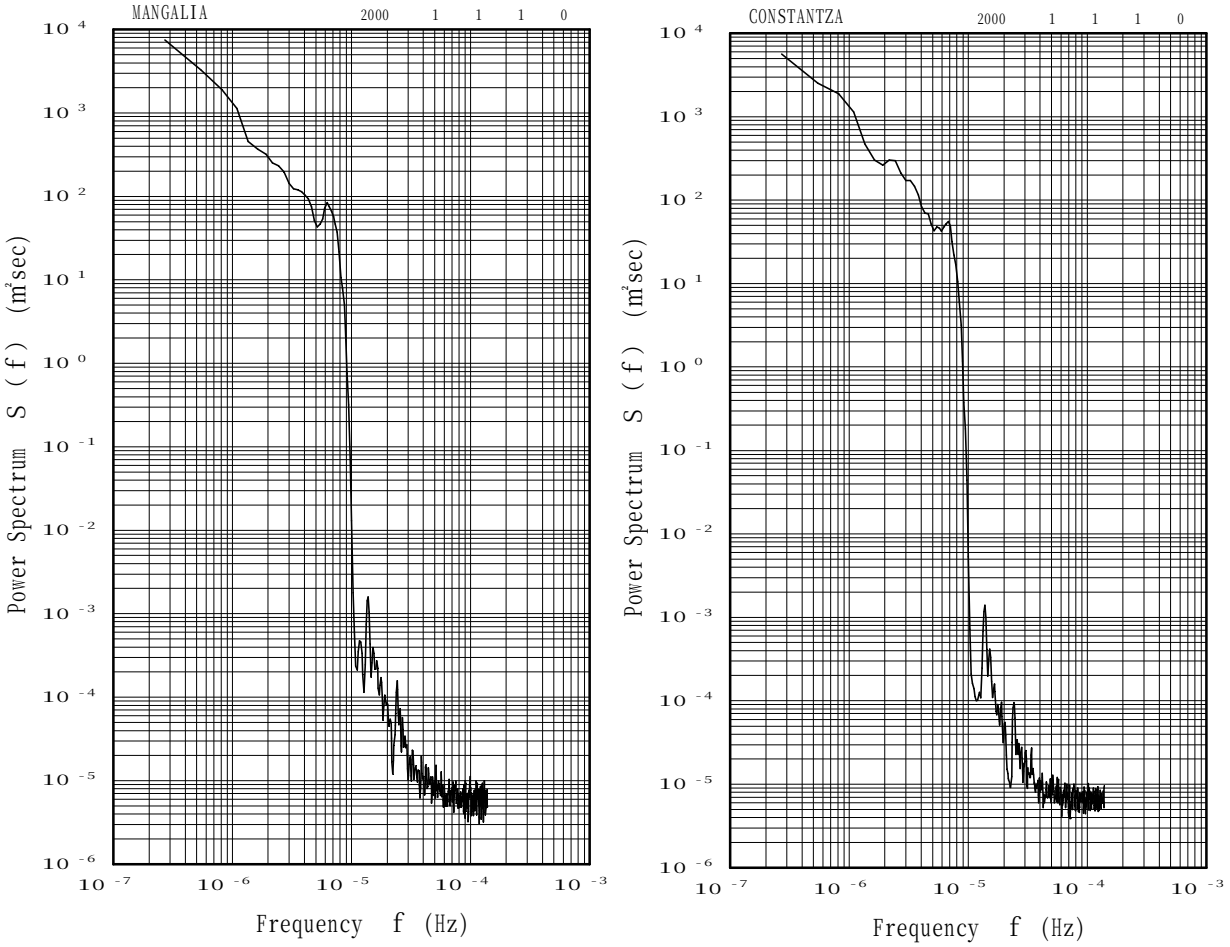


Fig. D.3.2: Original sea level records and filtered tide records of February 2001 in Mangalia and Constanța

D.3.2 Slowly Varying Mean Water Level

The low frequency component, or slowly varying mean water level, varies almost simultaneously at the both ports. The cross correlation analysis reveals that the low frequency component of Mangalia is 1 to 2 hours ahead of Constanța.



(a) Mangalia Port (b) Constanța Port

Fig. D.3.3: Power spectrum of low frequency component

Analysis has been made of power spectrum of the low frequency components of the water level records in Mangalia and Constanța. The results are shown in Fig. D.3.3. A sudden drop of spectral density at $f = 10^{-5}$ Hz reflects the effect of the smoothing filter applied to the water level records. The spectral density is decreasing almost in proportion to $f^{-1.5}$, but there is indication of some periodicity of 1.7 and 4.6 days. The cause of such low frequency components of the water level records in the Black Sea will be an interest subject of researches in the filed of physical oceanography.

D.4 Wave Climate

D.4.1 Seasonal Joint Distribution of Wave Height and Period Based on ECMWF Data

To supplement the wave climate data listed in Tables 3.4.1 and 3.4.2 of Volume 1, the joint distributions of
wave height, period and direction in summer and winter seasons are listed in Tables D.4.1 to D.4.4 in the following:

Table D.4.1: Joint distribution of wave height versus wave period in summer season based on ECMWF data (Apr.-Oct.)

Source ECMWF 1991-2002

Tm(s) / Hs(m)	0 -1	1 -2	2 -3	3 -4	4 -5	5 -6	6 -7	7 -8	8 -9	9 -10	10 -11	11 -12	12 -13	13 -14	14 -15	15 -	total
0 - 50			57 0.6	1238 13.9	1324 14.8	362 4.1	57 0.6	16 0.2	1 0.0								3055 34.2
50 - 100			29 0.3	727 8.1	1527 17.1	892 10.0	279 3.1	45 0.5	16 0.2	6 0.1	2 0.0	2 0.0					3555 39.8
100 - 150			1 0.0	22 0.2	494 5.5	550 6.2	281 3.1	60 0.7	5 0.1	2 0.0				1 0.0			1416 15.9
150 - 200				2 0.0	32 0.4	235 2.6	207 2.3	51 0.6	3 0.0								530 5.9
200 - 250					1 0.0	54 0.6	117 1.3	39 0.4	6 0.1								217 2.4
250 - 300						1 0.0	39 0.4	57 0.6	4 0.0								101 1.1
300 - 350							5 0.1	25 0.3	2 0.0								32 0.4
350 - 400								5 0.1	3 0.0	1 0.0							9 0.1
400 - 450									1 0.0	1 0.0							2 0.0
450 - 500								1 0.0	1 0.0	1 0.0							3 0.0
500 - 550										1 0.0	1 0.0						2 0.0
550 - 600										1 0.0	1 0.0						2 0.0
600 - 650																	
650 - 700																	
700 - 750																	
-750																	
total			87 1.0	2019 22.6	3378 37.9	2094 23.5	985 11.0	299 3.4	42 0.5	13 0.1	4 0.0	2 0.0		1 0.0			8924 100.0

Upper figures : Number of contents
Lower figures : Percentage of occurrence

Table D.4.2: Joint distribution of wave height versus wave period in winter season based on ECMWF data (Nov.-Mar.)

Source ECMWF 1991-2002

Hs(m) \ Tm(s)	0 -1	1 -2	2 -3	3 -4	4 -5	5 -6	6 -7	7 -8	8 -9	9 -10	10 -11	11 -12	12 -13	13 -14	14 -15	15 -	total
0 - 50			20 0.3	435 6.3	591 8.9	166 2.5	36 0.5	10 0.2	2 0.0	1 0.0							1261 18.9
50 - 100			17 0.3	545 8.2	968 14.5	592 8.9	167 2.5	31 0.5	5 0.1	3 0.0	1 0.0	1 0.0	1 0.0				2331 35.0
100 - 150				19 0.3	549 8.2	616 9.3	218 3.3	49 0.7	5 0.1	1 0.0		1 0.0					1458 21.9
150 - 200					47 0.7	419 6.3	240 3.6	42 0.6	9 0.1								757 11.4
200 - 250						76 1.1	216 3.2	61 0.9	7 0.1	1 0.0	1 0.0						362 5.4
250 - 300						3 0.0	104 1.6	72 1.1	13 0.2	2 0.0							194 2.9
300 - 350							14 0.2	80 1.2	23 0.3	2 0.0							119 1.8
350 - 400								36 0.5	34 0.5	5 0.1							75 1.1
400 - 450							1 0.0	6 0.1	28 0.4	6 0.1	1 0.0						42 0.6
450 - 500									17 0.3	11 0.2	2 0.0						30 0.5
500 - 550									5 0.1	6 0.1	2 0.0						13 0.2
550 - 600									1 0.0	4 0.1	1 0.0	1 0.0					7 0.1
600 - 650										3 0.0	2 0.0	1 0.0					6 0.1
650 - 700										1 0.0							1 0.0
700 - 750																	
750																	
total			37 0.6	999 15.0	2155 32.4	1872 28.1	996 15.0	387 5.8	149 2.2	46 0.7	10 0.2	4 0.1	1 0.0				6656 100.0

Upper figures : Number of contents
Lower figures : Percentage of occurrence

Table D.4.3: Joint distribution of wave height versus wave direction in summer season based on ECMWF data (Apr.-Oct.)

Source ECMWF 1991-2002

Hs(m) \ DIR	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	total
0 - 50	221 2.5	257 2.9	98 1.1	64 0.7	33 0.4	26 0.3	18 0.2	28 0.3	49 0.5	71 0.8	235 2.6	503 5.6	382 4.3	461 5.2	401 4.5	208 2.3	3055 34.2
50 - 100	263 2.9	323 3.6	117 1.3	46 0.5	48 0.5	41 0.5	14 0.2	33 0.4	62 0.7	112 1.3	239 2.6	475 5.3	511 5.7	530 5.9	473 5.3	277 3.1	3555 39.8
100 - 150	58 0.6	138 1.5	32 0.4	16 0.2	20 0.2	28 0.3	9 0.1	8 0.1	27 0.3	50 0.6	157 1.8	250 2.8	165 1.8	218 2.4	170 1.9	70 0.8	1416 15.9
150 - 200	6 0.1	38 0.4	20 0.2	10 0.1	1 0.0	6 0.1		6 0.1	4 0.0	39 0.4	85 1.0	122 1.4	56 0.6	77 0.9	48 0.5	12 0.1	530 5.9
200 - 250	5 0.1	11 0.1	12 0.1	2 0.0	7 0.1	2 0.0	2 0.0		3 0.0	10 0.1	34 0.4	60 0.7	35 0.4	25 0.3	8 0.1	1 0.0	217 2.4
250 - 300		1 0.0					2 0.0			5 0.1	8 0.1	43 0.5	30 0.3	10 0.1	2 0.0		101 1.1
300 - 350			2 0.0		1 0.0	1 0.0				1 0.0	5 0.1	11 0.1	8 0.1	2 0.0	1 0.0		32 0.4
350 - 400										1 0.0		5 0.1	2 0.0	1 0.0			9 0.1
400 - 450													2 0.0				2 0.0
450 - 500													1 0.0	2 0.0			3 0.0
500 - 550													1 0.0	1 0.0			2 0.0
550 - 600														2 0.0			2 0.0
600 - 650																	
650 - 700																	
700 - 750																	
750																	
total	553 6.2	768 8.6	281 3.1	138 1.5	110 1.2	104 1.2	45 0.5	75 0.8	145 1.6	289 3.2	754 8.4	1469 16.5	1193 13.4	1329 14.9	1103 12.4	568 6.4	8924 100.0

Upper figures : Number of contents
Lower figures : Percentage of occurrence

Table D.4.4: Joint distribution of wave height versus wave direction in winter season based on ECMWF data (Nov.-Mar.)

Source ECMWF 1991-2002

Hs(m) \ DIR	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	total
0 - 50	72 1.1	142 2.1	83 1.2	68 1.0	52 0.8	26 0.4	18 0.3	18 0.3	25 0.4	30 0.5	82 1.2	130 2.0	124 1.9	159 2.4	139 2.1	93 1.4	1261 18.9
50 - 100	106 1.6	273 4.1	191 2.9	173 2.6	96 1.4	86 1.3	65 1.0	45 0.7	63 0.9	87 1.3	210 3.2	292 4.4	214 3.2	213 3.2	125 1.9	92 1.4	2331 35.0
100 - 150	56 0.8	207 3.1	158 2.4	88 1.3	44 0.7	36 0.5	13 0.2	27 0.4	33 0.5	92 1.4	194 2.9	204 3.1	124 1.9	101 1.5	47 0.7	34 0.5	1458 21.9
150 - 200	14 0.2	80 1.2	101 1.5	25 0.4	14 0.2	8 0.1	3 0.0	5 0.1	22 0.3	60 0.9	161 2.4	132 2.0	65 1.0	41 0.6	16 0.2	10 0.2	757 11.4
200 - 250	5 0.1	33 0.5	33 0.5	5 0.1	10 0.2	1 0.0	1 0.0		6 0.1	18 0.3	86 1.3	97 1.5	26 0.4	34 0.5	5 0.1	2 0.0	362 5.4
250 - 300	3 0.0	17 0.3	17 0.3	1 0.0	3 0.0				2 0.0	10 0.2	41 0.6	55 0.8	26 0.4	16 0.2	2 0.0	1 0.0	194 2.9
300 - 350		5 0.1	6 0.1		1 0.0				1 0.0	2 0.0	18 0.3	44 0.7	35 0.5	7 0.1			119 1.8
350 - 400			2 0.0							1 0.0	12 0.2	34 0.5	21 0.3	5 0.1			75 1.1
400 - 450		1 0.0	2 0.0								7 0.1	17 0.3	12 0.2	3 0.0			42 0.6
450 - 500											5 0.1	15 0.2	8 0.1	2 0.0			30 0.5
500 - 550											3 0.0	4 0.1	3 0.0	3 0.0			13 0.2
550 - 600											2 0.0	2 0.0	2 0.0	1 0.0			7 0.1
600 - 650												4 0.1	2 0.0				6 0.1
650 - 700											1 0.0						1 0.0
700 - 750																	
750																	
total	256 3.8	758 11.4	593 8.9	360 5.4	220 3.3	157 2.4	100 1.5	95 1.4	152 2.3	300 4.5	822 12.3	1030 15.5	662 9.9	585 8.8	334 5.0	232 3.5	6656 100.0

Upper figures : Number of contents
Lower figures : Percentage of occurrence

D.4.2 Method of Analysis of NIMRD Data

The National Institute for Marine Research and Development (NIMRD) possesses the visual wave observation data at the water of 11 m deep off Tomis Tourist Port, and the full records of wave data were provided to the Study team through a subcontract work. The measurement location, observation methods etc. have been described in **3.4.1 (1)**. As mentioned there, the NIMRD data contained many occasions of downtime as listed with the entry of 99.99, which increased in number as the time elapsed. Also a number of measurement hours recorded as calm (zero values for wave height and period), which appeared often on Saturday and Sunday. Table D.4.5 lists the number of the entries with downtime and calm for the period of 1966 to 1989; the data from 1990 to 2004 was deleted from compilation because of too many downtimes and calm records.

If no downtime and calm are recorded, the number of entries varies from 84 (February) to 93 (January etc.). In principle, the winter months with the number of downtimes and calm records is less than around 35 are employed for the wave climate analysis, while the summer months are employed for the analysis with the number less than around 45. However the months that recorded the largest wave height in the whole observation period are also used in the analysis even though the number of downtimes and calm records exceeds the threshold values. The months selected for the analysis are shown with the number written in boldface letters, while the months not used for the analysis are shown with the number of erase-line italic letters.

Table D.4.6 lists the months selected for the analysis with the mark of "○", while the months not selected are marked with "×". The number of selected one for each month is listed at the second lowest row of the table. In total, 92 months are analyzed for the wave climate in front of Tomis Tourist Port. The mean downtime including the calm records is listed at the lowest

row. The overall downtime is 36%.

After compilation of the joint distribution of wave height and period, it was found that there are too many calm conditions compared with the ECMWF data. Thus the number of the entries of calm conditions was halved so that the percentage of the occurrence of waves smaller than 0.5 m in height would become almost the same as that of the ECMWF data.

Table D.4.5: Number of the entries of calm and downtime in respective months

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
1966	**12**	**13**	**19**	**28**	**34**	**36**	**34**	**29**	**30**	**24**	**22**	**31**	312
1967	**37**	**27**	**29**	**27**	**33**	**40**	**21**	**40**	**21**	**28**	**23**	**36**	362
1968	~~*43*~~	**18**	**25**	**37**	**47**	**27**	**40**	**45**	**30**	**35**	**8**	**19**	374
1969	**10**	**9**	**18**	~~*42*~~	~~*54*~~	**51**	~~*54*~~	~~*45*~~	**36**	**31**	~~*47*~~	**19**	416
1970	~~*42*~~	**26**	**36**	**34**	~~*78*~~	~~*58*~~	~~*58*~~	~~*53*~~	~~*42*~~	~~*37*~~	~~*52*~~	~~*56*~~	572
1971	~~*50*~~	~~*43*~~	~~*51*~~	~~*44*~~	**45**	~~*62*~~	~~*55*~~	~~*45*~~	~~*35*~~	~~*39*~~	~~*64*~~	~~*62*~~	595
1972	**26**	~~*56*~~	~~*56*~~	~~*52*~~	~~*61*~~	~~*56*~~	~~*56*~~	~~*52*~~	~~*34*~~	~~*39*~~	~~*65*~~	**42**	595
1973	**34**	~~*73*~~	~~*52*~~	~~*59*~~	~~*70*~~	~~*56*~~	~~*65*~~	~~*43*~~	**31**	~~*38*~~	~~*62*~~	~~*70*~~	653
1974	~~*43*~~	~~*40*~~	**37**	~~*49*~~	~~*74*~~	~~*55*~~	~~*66*~~	**27**	~~*54*~~	~~*50*~~	~~*58*~~	~~*67*~~	620
1975	~~*67*~~	~~*37*~~	~~*50*~~	~~*67*~~	~~*64*~~	~~*51*~~	**49**	~~*42*~~	~~*47*~~	~~*50*~~	~~*90*~~	~~*93*~~	707
1976	~~*87*~~	~~*87*~~	~~*93*~~	~~*90*~~	~~*79*~~	~~*57*~~	~~*55*~~	~~*63*~~	~~*54*~~	**20**	~~*49*~~	**39**	773
1977	~~*58*~~	~~*65*~~	~~*65*~~	~~*61*~~	~~*65*~~	~~*75*~~	~~*66*~~	~~*51*~~	**31**	~~*64*~~	~~*54*~~	~~*53*~~	708
1966-77	509	494	531	590	704	624	619	535	445	455	594	587	6687
Mean	42.4	41.2	44.3	49.2	58.7	52.0	51.6	44.6	37.1	37.9	49.5	48.9	557.3

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Sum
1978	~~*39*~~	~~*38*~~	~~*60*~~	~~*55*~~	**37**	~~*53*~~	~~*60*~~	**36**	~~*42*~~	**34**	~~*45*~~	~~*45*~~	544
1979	~~*50*~~	~~*56*~~	~~*93*~~	~~*90*~~	~~*87*~~	**47**	**49**	**38**	~~*63*~~	**22**	**26**	~~*43*~~	664
1980	~~*41*~~	~~*35*~~	**32**	~~*67*~~	**35**	**48**	~~*60*~~	**40**	**33**	~~*41*~~	~~*46*~~	~~*58*~~	536
1981	**31**	~~*45*~~	**44**	~~*41*~~	~~*71*~~	~~*62*~~	**44**	~~*56*~~	~~*35*~~	~~*44*~~	**55**	**38**	566
1982	~~*55*~~	**29**	~~*42*~~	**39**	~~*68*~~	**28**	~~*57*~~	~~*60*~~	~~*46*~~	**31**	~~*46*~~	**38**	539
1983	~~*63*~~	~~*34*~~	~~*53*~~	~~*54*~~	~~*81*~~	**42**	~~*50*~~	~~*52*~~	**29**	~~*47*~~	~~*43*~~	**60**	608
1984	~~*39*~~	**24**	**30**	**37**	~~*67*~~	~~*71*~~	~~*55*~~	~~*63*~~	~~*60*~~	~~*60*~~	**41**	~~*46*~~	593
1985	~~*56*~~	~~*84*~~	~~*64*~~	~~*61*~~	~~*62*~~	~~*68*~~	~~*71*~~	~~*48*~~	~~*54*~~	~~*39*~~	~~*53*~~	~~*85*~~	745
1986	~~*62*~~	**33**	~~*80*~~	~~*56*~~	~~*62*~~	~~*45*~~	**49**	~~*46*~~	~~*48*~~	~~*48*~~	**41**	~~*67*~~	637
1987	~~*66*~~	~~*58*~~	~~*58*~~	~~*51*~~	~~*71*~~	~~*64*~~	~~*50*~~	~~*56*~~	~~*34*~~	**21**	~~*56*~~	~~*58*~~	643
1988	~~*65*~~	~~*56*~~	~~*42*~~	**55**	~~*64*~~	~~*73*~~	~~*65*~~	~~*58*~~	~~*47*~~	**28**	~~*43*~~	~~*73*~~	669
1989	~~*91*~~	~~*61*~~	~~*52*~~	~~*63*~~	~~*71*~~	~~*77*~~	~~*62*~~	~~*71*~~	~~*72*~~	~~*70*~~	~~*59*~~	~~*70*~~	819
1978-89	658	553	650	669	776	678	672	624	563	485	554	681	7563
Mean	54.8	46.1	54.2	55.8	64.7	56.5	56.0	52.0	46.9	40.4	46.2	56.8	630.3

Note: Months with the entry numbers of boldface letters are employed for wave climate analysis, while months with the entry numbers of erased-line italic letters are deleted from the analysis.

Table D.4.6: Months selected for compilation of NIMRD wave data analysis

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1966	○	○	○	○	○	○	○	○	○	○	○	○
1967	○	○	○	○	○	○	○	○	○	○	○	○
1968	×	○	○	○	○	○	○	○	○	○	○	○
1969	○	○	○	×	×	○	×	×	○	○	×	○
1970	×	○	○	○	×	×	×	×	×	×	×	×
1971	×	×	×	×	○	×	×	×	×	×	×	×
1972	○	×	×	×	×	×	×	×	×	×	×	○
1973	○	×	×	×	×	×	×	×	○	×	×	×
1974	×	×	○	×	×	×	×	○	×	×	×	×
1975	×	×	×	×	×	×	○	×	×	×	×	×
1976	×	×	×	×	×	×	×	×	×	○	×	○
1977	×	×	×	×	×	×	×	×	○	×	×	×
1978	×	×	×	×	○	×	×	○	×	○	×	×
1979	×	×	×	×	×	○	○	○	×	○	○	×
1980	×	×	○	×	○	○	×	○	○	×	×	×
1981	○	×	○	×	×	×	○	×	×	×	○	○
1982	×	○	×	○	×	○	×	×	×	○	×	○
1983	×	×	×	×	×	○	×	×	○	×	×	○
1984	×	○	○	○	×	×	×	×	×	×	○	×
1985	×	×	×	×	×	×	×	×	×	×	×	×
1986	×	○	×	×	×	×	○	×	×	×	○	×
1987	×	×	×	○	×	×	×	×	×	○	×	×
1988	×	×	×	×	×	×	×	×	×	○	×	×
1989	×	×	×	×	×	×	×	×	×	×	×	×
Nos. of Months	6	8	9	7	6	8	7	7	8	10	7	9
Mean downtime	26.9%	26.6%	32.3%	40.2%	41.4%	44.3%	43.9%	39.2%	33.5%	29.5%	34.3%	40.5%

D.4.3 Seasonal Wave Climate of NIMRD Data

The joint distributions of wave height and period in the summer and winter seasons based on the NIMRD data are listed in Table D.4.7 and D.4.8, respectively, in the form of occurrence percentage. The joint distributions of wave height and wave direction in the summer and winter seasons based on the NIMRD data are listed in Table D.4.9 and D.4.10, respectively, in the form of occurrence percentage.

Table D.4.7: Joint distribution of wave height versus wave period in summer season (Apr.-Oct.) based on NIMRD data expressed in percentage of occurrence

H (m)	0 – 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	Total
0 - 0.5			7.43	14.69	6.62	3.19	0.56	0.04			32.53
0.5 - 1.0			2.44	18.21	15.11	5.33	1.58	0.07			42.74
1.0 - 1.5			0.04	2.39	7.79	3.83	1.52	0.25			15.81
1.5 - 2.0				0.23	1.47	2.66	0.91	0.20			5.48
2.0 - 2.5					0.39	0.91	0.74	0.15			2.19
2.5 - 3.0					0.11	0.05	0.25	0.16			0.56
3.0 - 3.5						0.05	0.16	0.11			0.31
3.5 - 4.0						0.07	0.00	0.21			0.28
4.0 - 4.5							0.06	0.03			0.09
4.5 - 5.0											0.00
5.0 - 5.5											0.00
5.5 - 6.0											0.00
6.0 - 6.5											0.00
Total	0	0	9.91	35.52	31.49	16.08	5.78	1.21	0.00	0.00	100.00

Table D.4.8: Joint distribution of wave height versus wave period in winter season (Nov.-Mar.) based on NIMRD data expressed in percentage of occurrence

H (m)	0 - 1	1 - 2	2 - 3	3 - 4	4 - 5	5 - 6	6 - 7	7 - 8	8 - 9	9 - 10	Total
0 - 0.5			3.66	8.18	3.60	2.77	0.67	0.13			19.01
0.5 - 1.0			0.82	12.46	12.04	7.34	3.10	0.42	0.13		36.30
1.0 - 1.5				2.23	8.25	6.61	3.07	0.34			20.50
1.5 - 2.0				0.36	2.29	6.02	2.19	0.33	0.05		11.23
2.0 - 2.5					0.60	2.97	2.17	0.78	0.07		6.60
2.5 - 3.0						0.83	1.04	0.98	0.07	0.02	2.94
3.0 - 3.5						0.26	0.80	0.50	0.07		1.63
3.5 - 4.0						0.09	0.14	0.40	0.04		0.66
4.0 - 4.5						0.05	0.09	0.32	0.05		0.51
4.5 - 5.0							0.09	0.23	0.03	0.05	0.39
5.0 - 5.5								0.09	0.04		0.13
5.5 - 6.0									0.05		0.05
6.0 - 6.5								0.04			0.04
Total	0	0	4.48	23.23	26.77	26.95	13.35	4.55	0.60	0.07	100.00

Table D.4.9: Joint distribution of wave height versus wave direction in summer season based on NIMRD data (Apr.-Oct.)

Wave Height	Wave Direction																Total
H (m)	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	
0 - 0.5			0.10		0.65	1.27	5.55	4.21	6.23	4.05	7.21	2.25	1.04				32.57
0.5 - 1.0					0.45	1.48	7.21	6.56	11.99	5.85	6.65	2.19	0.48				42.85
1.0 - 1.5					0.09	0.27	2.76	3.58	5.20	2.73	0.70	0.33	0.06				15.70
1.5 - 2.0						0.08	1.02	1.20	2.39	0.67	0.07						5.43
2.0 - 2.5							0.37	0.62	0.76	0.39							2.14
2.5 - 3.0							0.09	0.11	0.31								0.52
3.0 - 3.5								0.06	0.27								0.33
3.5 - 4.0						0.03		0.08	0.22								0.34
4.0 - 4.5									0.09								0.09
4.5 - 5.0									0.03								0.03
5.0 - 5.5																	0.00
5.5 - 6.0																	0.00
6.0 - 6.5																	0.00
Total			0.10		1.19	3.14	17.00	16.41	27.51	13.69	14.62	4.77	1.58				100.00

Table D.4.10: Joint distribution of wave height versus wave direction in winter season based on NIMRD data (Nov.-Mar.)

Wave Height	Wave Direction																
H (m)	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	Total
0 - 0.5					0.66	0.76	2.70	1.83	4.07	1.43	4.73	2.44	0.36				18.99
0.5 - 1.0			0.07		0.49	1.31	7.27	5.04	8.69	5.37	6.10	1.51	0.49				36.34
1.0 - 1.5			0.09		0.18	0.95	4.06	3.92	6.32	2.89	1.89	0.18					20.48
1.5 - 2.0						0.44	2.26	2.99	3.52	1.70	0.32						11.23
2.0 - 2.5						0.23	1.12	1.91	2.52	0.53	0.28						6.59
2.5 - 3.0							0.68	0.84	1.17	0.26							2.96
3.0 - 3.5							0.32	0.63	0.74								1.68
3.5 - 4.0							0.05	0.37	0.30								0.72
4.0 - 4.5								0.18	0.30								0.47
4.5 - 5.0							0.09	0.11	0.16								0.35
5.0 - 5.5								0.05	0.09								0.14
5.5 - 6.0									0.04								0.04
6.0 - 6.5									0.05								0.05
Total			0.16		1.33	3.69	18.55	17.87	27.96	12.18	13.33	4.13	0.85				100.03

D.5 Design Waves

D.5.1 Offshore Design Waves through Extreme Wave Analysis

As stated in **3.4** of Volume 1, extreme statistical analysis has been made on the ECMWF wave data. Extreme wave heights were selected by the Peaks-over-Threshold (POT) method with three threshold levels of 3.0, 3.5 m, and 4.0 m. Among the three thresholds, the extreme waves selected by the threshold level of 3.5 m yielded the most probable distribution function as judged by the MIR (minimum ratio of residual correlation coefficient) criterion. The distribution most fitted to the extreme wave data was the Weibull distribution with the shape parameter k = 1.4 as expressed below.

$$F(H < x) = 1 - \exp\left[-\left(\frac{x - 3.295}{1.257}\right)^{1.4}\right] \quad : \quad x \le 3.295 \tag{D.5.1}$$

The average number of extreme wave events per year is λ = 4.18. The data fitting to this distribution function is shown in Fig. D.5.1.

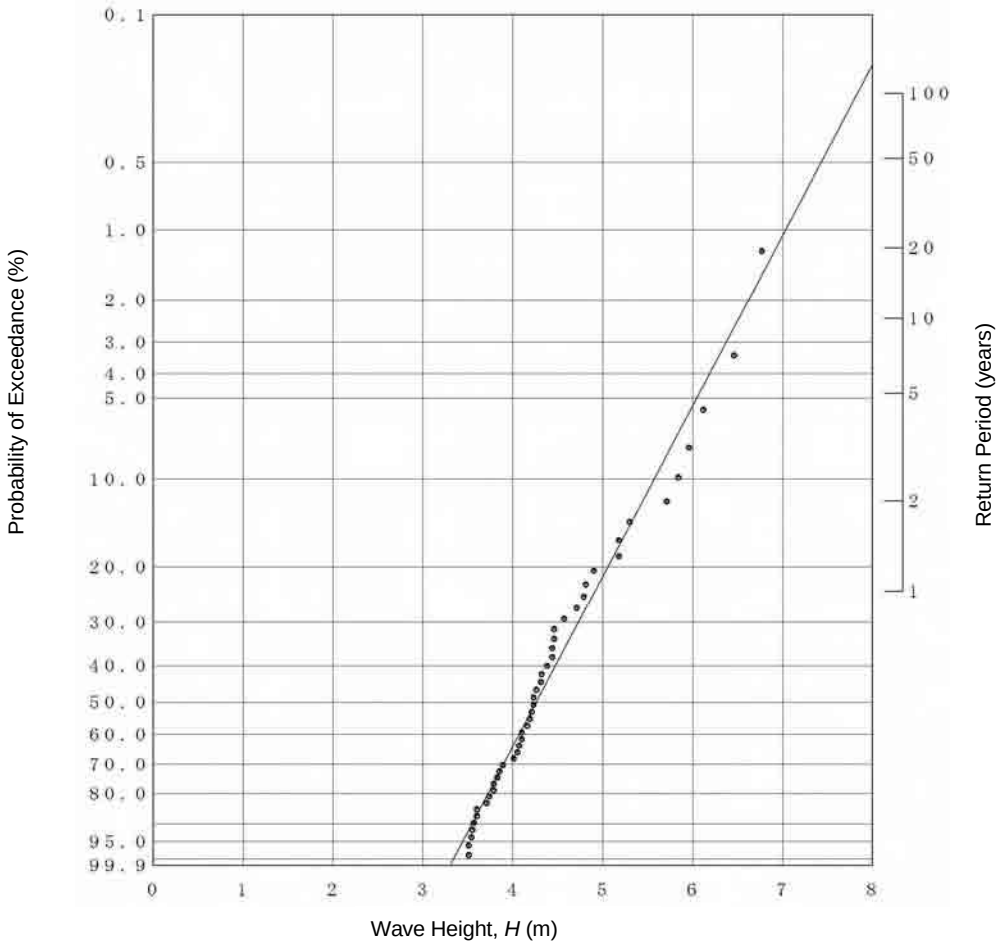


Fig. D.5.1: Fitting of Extreme wave data of ECMWF to the Weibull distribution with the shape parameter of k = 1.4

The wave heights corresponding to several return periods have been listed in Table 3.4.6 of Volume 1. The wave periods for these return heights are estimated from the joint distribution of the heights and periods of extreme waves, which is shown in Fig. D5.2. The curve marked with the formula of $T = 3.3H^{0.63}$ represents the empirical relationship based on Wilson's wave forecasting formulas for wind wave growth in the ocean.[11] The ECMWF data almost follow the empirical relationship between wave heights and periods.

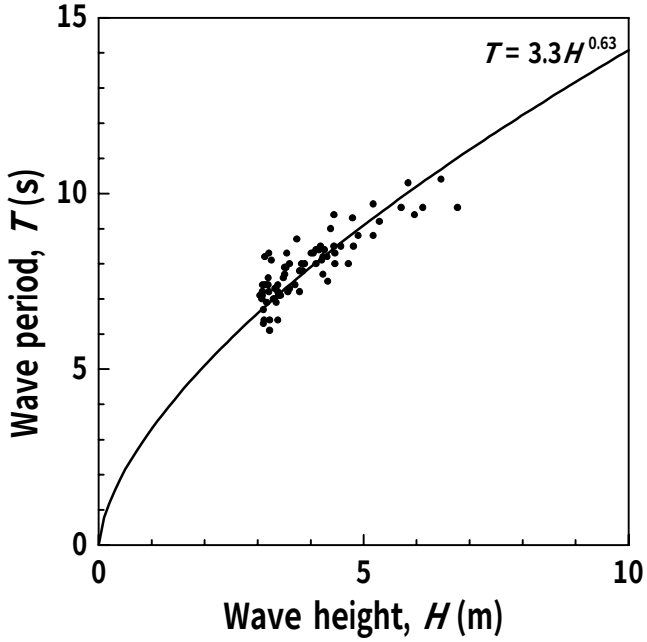


Fig. D.5.2: Joint distribution of extreme wave heights and periods

D.5.2 Design Wave Height in the Nearshore Water

The extreme statistical analysis presented in **D.5.1** refers to the waves in the offshore area, i.e. deepwater waves. The water depth is assumed to be greater than one-half wavelength so that wave propagation is not affected by the changes in water depth. In reality, offshore waves undergo various transformations as they approach to the shore: i.e., refraction, shoaling, breaking, and diffraction. Examples of wave transformations by refraction and shoaling have been shown in Figs. 4.5.2 and 3 for the northerly and southerly waves in **4.5.1** of Volume 1.

For structural design of shore protection facilities, wave decay by random breaking is the most important phenomenon. The change in the wave height due to breaking can be estimated by several numerical models. The PEGBIS (Parabolic Equation with Gradational Breaker Index for Spectral waves) model by Goda[12] is employed in the present study.

Four levels of offshore waves are examined for wave height variations in the nearshore water as listed in Table D.5.1. The first three waves correspond to the waves with the return period of 100, 10, and 1 years, respectively, and the last waves have the exceedance probability of

[11] Goda, Y. (2003): Revisiting Wilson's formulas for simplified wind-wave prediction, J. *Waterway, Port, Coastal, and Ocean Engineering*, ASCE, **129** (2), pp. 93-95.
[12] Goda, Y. (2004): A 2-D random wave transformation model with gradational breaker index, *Coastal Engineering Journal*, **46** (1), pp. 1-38.

about 2% (7 days per year). The wave periods have been assigned by the empirical formula of $T = 3.3H^{0.63}$. The parameter γ represents the spectral peak enhancement factor of the JONSWAP spectra employed and s_{max} is the directional spreading parameter. The values of γ and s_{max} have been subjectively assigned in consideration of the steepness characteristics of the wind waves listed here. Table D.5.1 also lists the significant wave height $H_{1/3}$ in shallow water with the depth ranging from h = 6 m to h = 2 m. The overall variations of wave heights are shown in Fig. D.5.3.

Table D.5.1: Design waves in the nearshore water

Waves with return period of	Offshore waves				Wave height in shallow water, $H_{1/3}$ (m)				
	H_0' (m)	$T_{1/3}$ (s)	γ	s_{max}	h = 6 m	h = 5 m	h = 4 m	h = 3 m	h = 2 m
100-year	7.83	11.0	3.3	25.0	4.02	3.50	2.96	2.40	1.82
10-years	6.52	10.2	2.5	20.0	3.79	3.31	2.79	2.25	1.69
1-year	5.00	9.1	1.8	15.0	3.58	3.11	2.62	2.11	1.56
2% exceedance probability	3.00	6.6	1.0	10.0	2.69	2.54	2.23	1.78	1.31

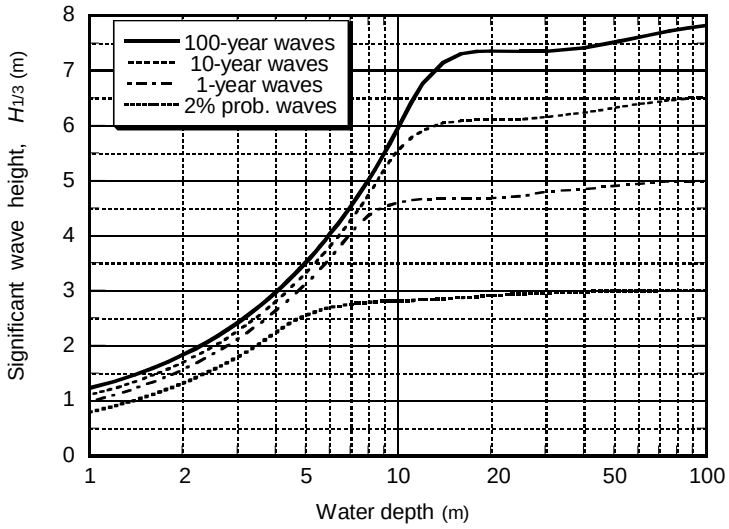


Fig. D.5.3: Variations of wave heights in shallow water

As exemplified in Table D.5.1 and Fig. D.5.3, the wave height in the nearshore water is mainly governed by the water depth regardless of the offshore wave height. Strictly speaking, the offshore wave heights in Table D.5.1 should be regarded as the equivalent deepwater wave height, that is the height corrected for the wave refraction and diffraction effects. However, these effects become negligible in shallow water because of the strong influence of wave breaking process. The differences of wave heights among the four levels of offshore waves are mainly induced by the differences in the wave period rather than the offshore height. The longer the period, the larger is the ratio of breaking wave height to the water depth.

For design of submerged breakwaters and jetties, the nearshore wave heights corresponding to the 100-year waves can be taken for the sake of structural safety, although the difference by using the waves of other return period is small. A caution should be taken to the water depth cited in Table D.5.1 and Fig. D.5.3. The water depth is that measured from the design water level, i.e., the summation of the depth in bathymetric chart and the rise of water level by meteorological phenomena and other reasons.

D.6 Present Conditions of Shore Sectors

The Team inspected the whole shore sectors of the study area by walking along the shoreline, while taking sediment samples and making simple topographic surveys. The following is the reports of shore inspections for the sub-sectors defined in **5.1** of Volume 1**.**

D.6.1 Năvodari North (Sub-Sectors I-1)

This sub-sector is a sandy beach of about 2 km long, stretching in the south of the base of the south breakwater of Midia Port. Figure D.6.1 shows the location of this sub-sector. At the distance of several hundred meters along the shoreline, a few low cross-shore ridges are built with shells to limit vehicle traffic. These ridges seem to serve as the boundaries of beach sectors for various resort facilities such as children's summer camps.

This beach sector is located in the shadow zone of the Midia breakwater, and thus has the tendency of accretion, for the southerly waves, by the direct northward longshore currents, and for the northerly waves, by the counter circulating currents in the lee of the sheltering breakwater. Although the beach must have lost new supply of sand by construction of the north breakwater of Midia Port, which have cut off the alongshore sediment transport from the Danube, the beach seems to have been stable because of the above accretionary tendency once it had reached to the equilibrium state.

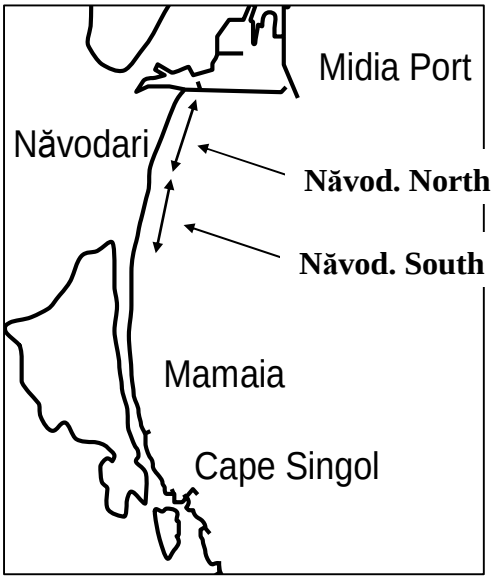


Fig. D.6.1: Location Map of Năvodari

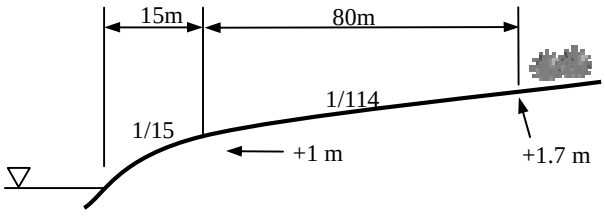


Fig. D.6.2: Beach Profile of Năvodari North

The foreshore slope is about 1/15 and the backshore has a gentle slope of 1/114. The beach width from the shoreline to the vegetation (wild olive etc.) is about 100 m. The characteristics of sand grains are as follows. The median grain size of sand is d_{50} = 0.21 mm, the density is ρ_s = 2.68, the sorting coefficient is S_0 = 1.88, and the skewness is S_k = 1.89.

D.6.2 Năvodari South (Sub-Sectors I-2)

This sub-sector is located at the north of Mamaia beach. There are several car-campsites, which are accessible from the highway (Mamaia–Năvodari Line), and private resort houses.

Beach of this sub-sector is wide and the backshore slope is generally mild. The shoreline is nearly straight and the distance to the highway is large compared with the Mamaia area. These features suggest the long-term accretionary tendency of the beach. A large distance of some 100 m from the seaward edge of the car campsite to the shoreline supports the estimate of accretionary tendency.

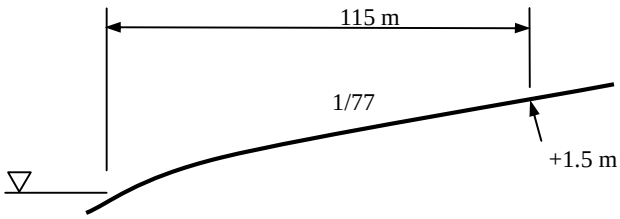


Fig. D.6.3: Beach profile of Năvodari South

This sub-sector is located in the shadow zone of the Midia breakwater, being same as the sub-sector I-1. Thus the beach is considered as a stable one in the long term, and sediment to the sub-sectors I-1 and I-2 must have been supplied from the sub-sectors I-3 to I-5, which are located outside the shadow zone of the Midia breakwater. However, the northward sediment transport is judged small because of a long elapse of time after the breakwater construction, and the beach maintains the equilibrium state nevertheless.

The backshore slope is almost the same as the natural slope, but caution should be taken for traces of machine grading on the surface.

D.6.3 Mamaia North (Sub-Sector I-3)

This sub-sector represents the northern part of Mamaia beach, the plan shape of which is shown in Fig. D.6.4.

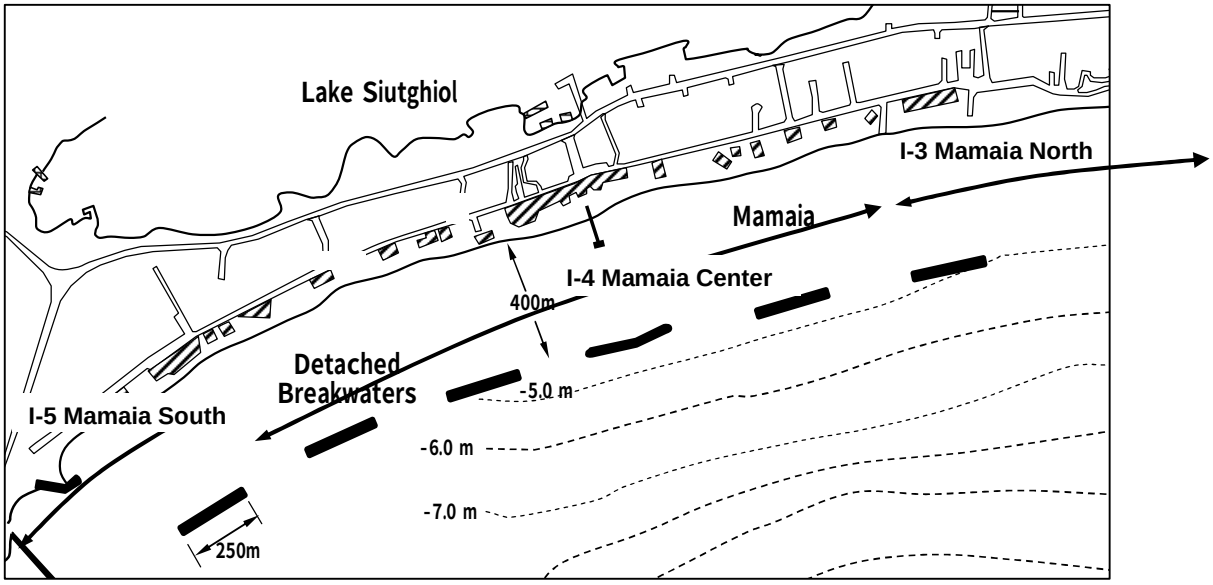


Fig. D.6.4: Map of Mamaia Beach

The beach width is 38 m, the foreshore slope is 1/6, and the backshore profile is 1/46 as shown in Fig. D.6.5. Beach surface has been graded by beach cleaners without large changes in beach slopes. The edge of the backshore was taken at the front of wild olive bush. Although the beach width is narrower than that of the sub-sector I-2, it is still sufficiently wide for the standpoint of beach users in the summer season.

Beach sediment is made of very fine and uniform sand grains with the median diameter of d_{50} = 0.18 mm and the sorting coefficient of S_0 = 1.25. The specific density of sand grains is ρ_s = 2.65, which is common with ordinary sand.

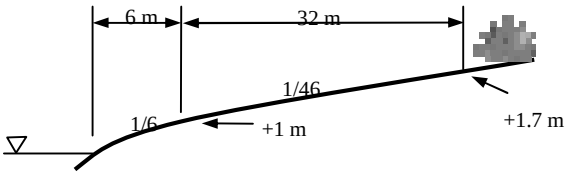


Fig. D.6.5: Beach profile of Mamaia North

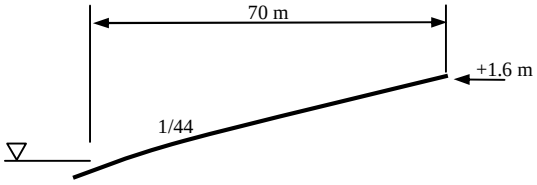


Fig. D.6.6: Beach profile of Mamaia Center

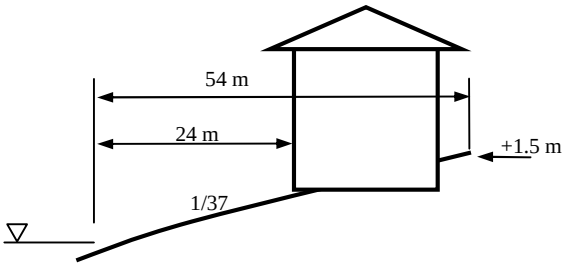


Fig. D.6.7: Beach profile of Mamaia South (1)

D.6.4 Mamaia Center (Sub-Sector I-4)

The foreshore and backshore are not separated because of the absence of a berm or beach scarp. Because this beach is visited by many people, beach seems to have often been graded by beach cleaners. The beach width from the shoreline to the bush in the back is about 70 m with the slope of 1/44.

Sand grains have the median diameter of d_{50} = 0.27 mm, the specific weight of ρ_s = 2.71, the sorting coefficient is S_0 = 1.88, and the skewness is S_k = 1.89.

D.6.5 Mamaia South (Sub-Sector I-5)

In this sub-sector, two locations were inspected. At the first visited site, many bars and restaurants are built on the backshore and a beach of only 24 m wide is opened

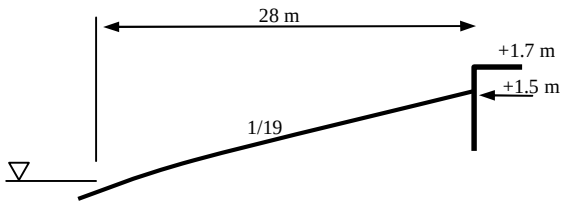


Fig. D.6.8: Beach profile of Mamaia South (2)

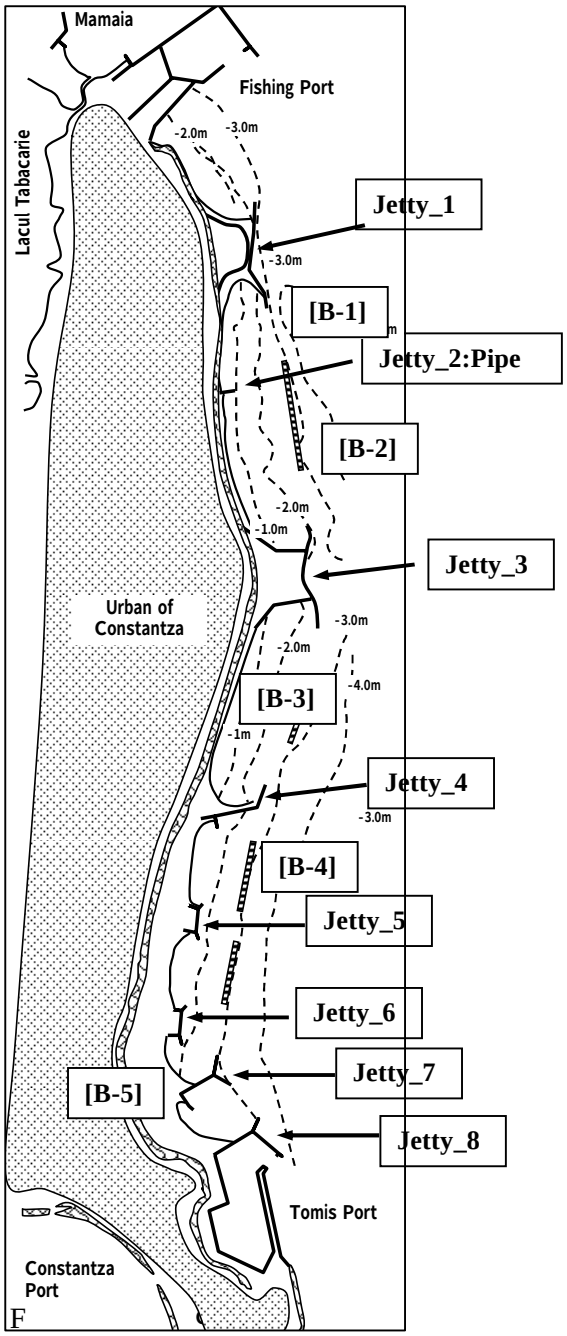


Fig. D.6.9: Map of Tomis North and Tomis South sub-sectors

to users out of the total beach width of 54 m. The overall beach slope is 1/37. The sediment sample at this beach was taken in front of a shop with conspicuous yellow-color roofs. At the north of this shop, a cross-shore fence of wire net is

installed; it is said to prevent invasion of gipsy people during the off-season. In the south of the fence at about several tens of meters, a low seawall built in the 1980s exists. No beach is present in front of the seawall and waves attack the seawall directly; stone blocks to protect the seawall are partly dislocated.

The second visited site was the south of Hotel Parc, which is the southern-most hotel of Mamaia beach, where the beach width was relatively narrow. The beach profile of this site is shown in Fig. D.6.8. The beach width from the shoreline to the stone block wall at the edge of highway is 28 m and the beach slope is 1/19.

One of the overall characteristics of the long and wide beach of Năvodari and Mamaia is a formation of multiple sand bars in the nearshore. Visual inspection from a helicopter indicated the most inner bar being located about 30 m away from the shore and the most outer bar at 200 to 300 m.

At the sub-sector I-4 “Mamaia Center” a pile-supported pier is jutted out for some 100 m. Its head is expanded to accommodate an observation deck and thus the pier has a certain degree of a headland function to protect a beach. Because of its piling structure, however, the beach protection function is minimal as judged from the shoreline shape around it.

Six detached breakwaters built at the distance of some 400 m from the shore, though they have subsided greatly, are exercising a certain accretionary function as evidenced by slight advance of the shoreline behind them compared with the area without the breakwaters. The shoreline change is typical of low-crested detached breakwaters located at a large distance from the shore.

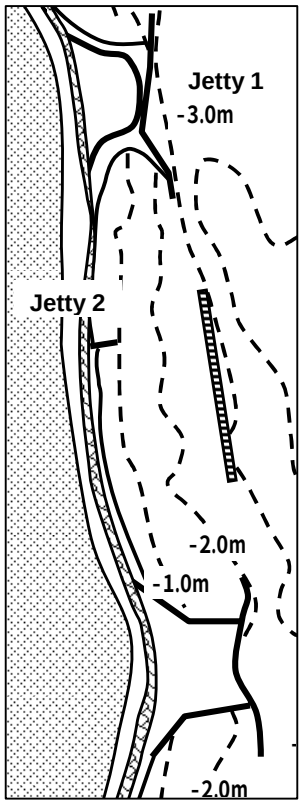


Fig. D.6.10: Plan Shape of B-1 and B-2 Sections

D.6.6 Tomis North and Tomis South (Sub-Sectors I-6 and I-7)

A detailed map of these sub-sectors is shown in Fig. D.6.9. Since this area is provided with eight jetties, which separate the shore into five distinctive beaches, description is made for these five beaches in the following.

[B-1 Section]

This section is located between the first Π-shaped Jetty 1 next to the fishing port and the second short Jetty 2. The Jetty 1 is built on a mound of some 300-kg rubble stones with 2-ton limestone blocks, and protected with stabilopods at the seaward side. The jetty maintains a good shape in general even though the head part of the southern wing shows a subsidence of its crest. Thus, the jetty functions well as the beach control structure.

The Jetty 2 is for discharge pipes of waste water from the top of the cliff. Pipes are installed in two layers: the upper pipe has the diameter of 20 cm and the lower pipe of 30 cm in diameter is embedded in concrete.

No sandy beach is found at the both sides of the Jetty 2, but the southern shoreline is advanced than the northern one. The difference in the shoreline position suggests a slightly northward sediment transport in late May.

The distance between the Jetty 1 and Jetty 2 is about 480 m. The shoreward side of the south wing of the Jetty 1 has some sediment deposition.

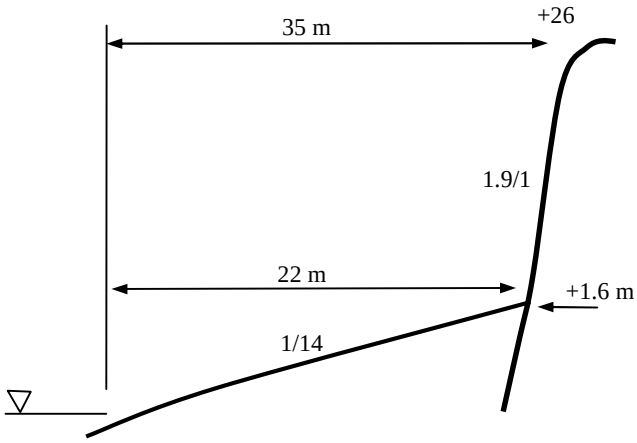


Fig. D.6.11: Beach profile of B-1 Section

The beach width at the middle of the B-1 Section is about 22 m and the beach slope is 1/14. Behind he beach, there exists a cliff with the crest elevation of about 26 m. On top of the cliff, many high-rising housings are built, which are susceptible of disaster by collapse when the beach is eroded by high waves and the cliff base is scoured.

[B-2 Section]

This section is located between the Jetty 2 and the Jetty 3. Sandy beach is narrow and there is a danger of disaster by cliff collapse.

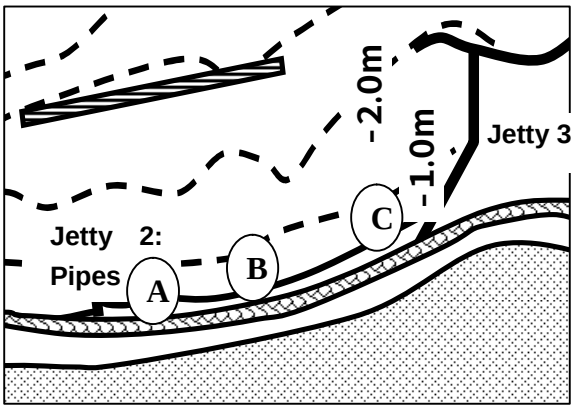


Fig. D.6.12: Map of B-2 Section

The zone of 190 m in the south of the Jetty 2 (marked “A” in Fig. D.6.12) is composed of a very narrow beach and a cliff in a manner same as the B-1 Section. The zone “B” has the area of about 100 m in the south of the zone “A.” A concrete seawall of about 3 m high is protecting the base of the cliff, but it is being attacked by wave actions and foundation rubbles are scattered by waves.

The zone “C” is located in the sheltered area of the north wing of the Jetty 3 and thus a beach has been developed; the erosional problem of beach and cliff is minimal. An interesting feature of this section is a reclamation work on top of the Jetty 3 and on-going construction of housing there.

A detached breakwater (submerged), which was indicated on the maps of shore protection facilities, could not be recognized during the inspection.

[B-3 Section]

This section is located between the Jetty 3 and the Jetty 4. Near the Jetty 4, beach made of mussel shells is developed. Sediment sampling was made at the foreshore at the linear distance of 540 m from the south wing of the Jetty 3.

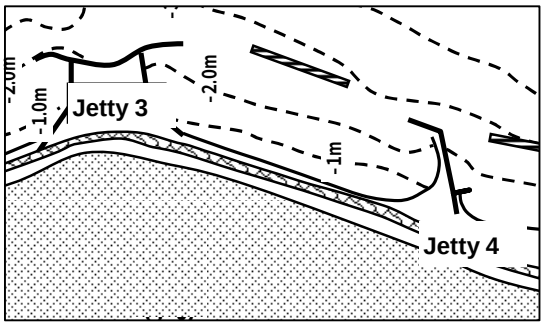


Fig. D.6.13: Map of B-3 Section

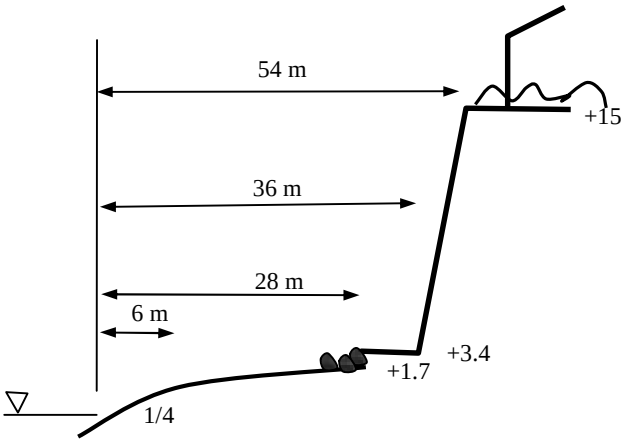


Fig. D.6.14: Beach profile of B-3 Section

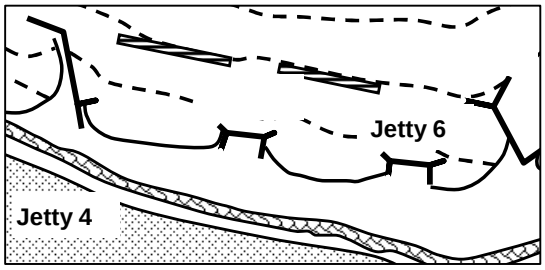


Fig. D.6.15: Map of B-3 Section

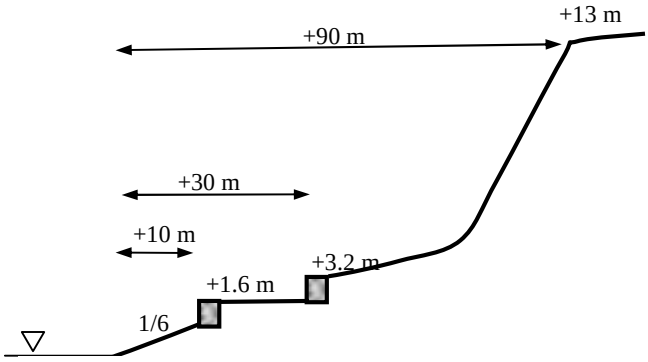


Fig. D.6.16: Beach profile between Jetty 4 and 5

According to a simple survey, the foreshore slope is steep on 1/4 and the backshore is nearly flat. The distance from the shoreline to the stone revetment is 28 m and a cliff with the slope of 1/1.6 rises after a flat promenade of several meters wide

[B-4 Section]

This section is located between the Jetty 4 and the Jetty 7; two small Π-shaped jetties 5 and 6 are arranged in this section. The maps of shore protection facilities depict two submerged, detached breakwaters. Some remnants of stabilopods were barely visible from a boat around the south end of the northern breakwater.

Near the Jetty 4, a beach made of mussel shells is formed. However, it is relatively narrow and the backshore from the middle to the southern part is protected with concrete blocks. The head of the Jetty 5 is protected with concrete cubes of 1.2-m size instead of stabilopods. Its south wing becomes submerged around the head by scattering of concrete blocks. the Jetty 4 and the Jetty 7, and incoming waves are attenuated by the submerged breakwaters to a certain degree. Thus the beach profiles in the B-4 section are judged as in the stable conditions. The offshore extensions of the Jetties 4 and 7 are relatively short and do not hinder the seaward view from the beaches. This aspect should be considered in the preparation of coastal protection plan.

The beach between the Jetty 5 and the Jetty 6 (the distance of 340 m apart) is a very beautiful pocket beach. Alongshore littoral transport within a broad B-4 section is well controlled by

the Jetty 4 and the Jetty 7, and incoming waves are attenuated by the submerged breakwaters to a certain degree. Thus the beach profiles in the B-4 section are judged as in the stable conditions. The offshore extensions of the Jetties 4 and 7 are relatively short and do not hinder the seaward view from the beaches. This aspect should be considered in the preparation of coastal protection plan.

[B-5 Section]

This section is located between the Jetty 7 and the Jetty 8, which is a wing structure of the north breakwater of Tomis Tourist Port, and thus it is the nearest to the Port. The distance between the bases of the Jetties 7 and 8 is 260 m and the opening width at their heads is 180 m. Outside the Jetty 8, the water quality was poor with quite bad smell. The beach has a wide backshore, the majority of which is not much utilized. This area may be well suited to beach sports such as soccer, volley balls, etc. The mean slope of the backshore is about 1/60 with much miler slope toward the landside. The foreshore is relatively mild with the slope of 1/17

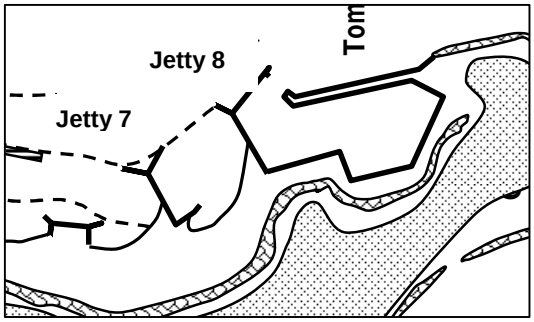


Fig. D.6.17: Map of B-5 section

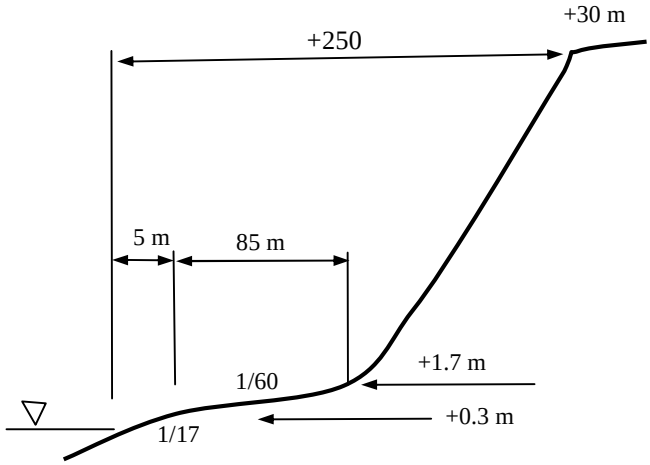


Fig. D.6.18: Beach profile of B-5 section

D.6.7 Agigea Area

This area is located at the northern part of the Sub-Sector II-1 “Eforie Nord.” It is adjacent to the south breakwater of Constanța Port. A fishing boat landing exists near the base of this breakwater as shown in Fig. D.6.18. A beach of coarse sand extends from the breakwater base to the Jetty 9 with the beach width of about 10 m.

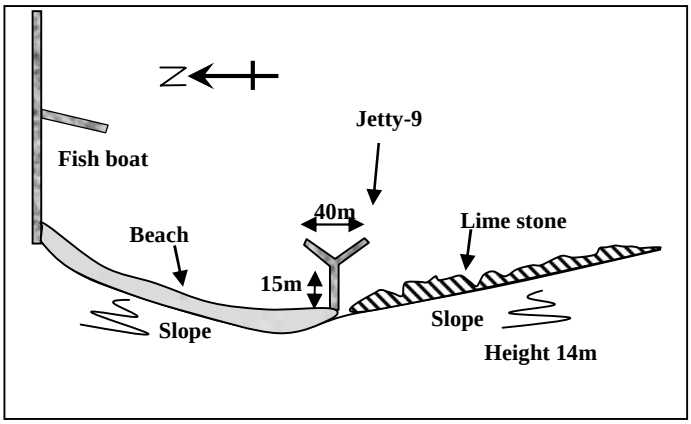


Fig. D.6.19: Map of Agigea area

The Jetty 9 has a shape of the letter “Y” with the trunk of about 15 m long and the two wings of about 40 m in total (by visual judgment). In the south of the Jetty 9, the limestone base is outcropped at the shoreline without sandy beach. The limestone base is extending toward Eforie Nord. Immediately behind the shoreline at the both sides of Jetty 9, there comes cliff with the crest elevation of about 14 m.

The shore sector of Eforie Nord is

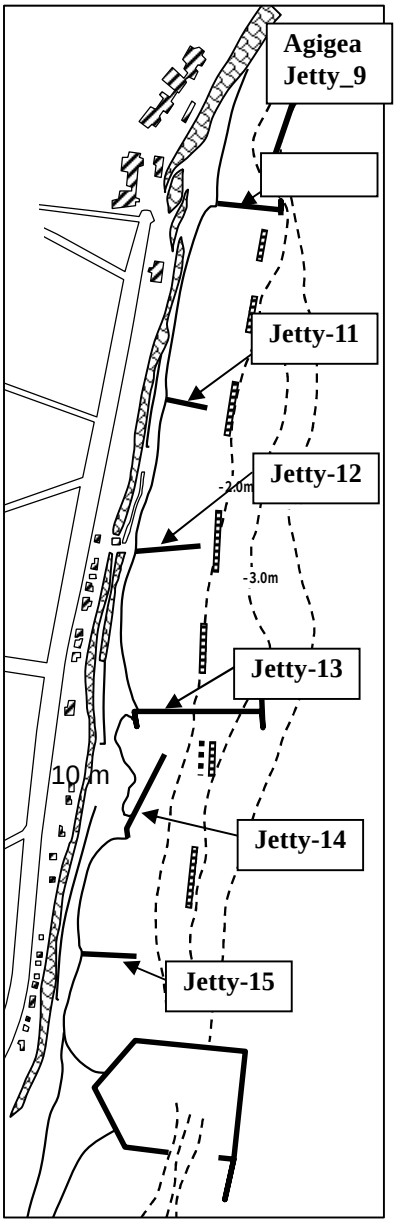


Fig. D.6.20: Map of Eforie Nord sub-sector

shown in Fig. D.6.20 with indication of the Jetties 10 to 15.

The Jetty 10 is jutted out in front of Hotel Medusa and two other hotels. The beach around this jetty is a kind of private beach because the access from land needs to go through the gates of the three tall hotel buildings, though entering by walking along the seawall is possible.

D.6.8 Eforie Nord (Sub-Sector II-1)

The shoreline positions around the Jetties 10, 11, and 12 are more advanced at the north sides than the south sides, suggesting the southward littoral transport in the spring season. Figure D.6.21 shows a sketch of beach around the Jetty 10.

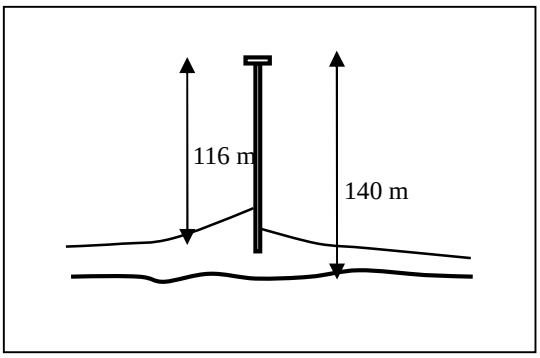


Fig. D.6.21: Sketch of shoreline around Jetty 10

The cliff protection in the area from the Jetty 10 to the Jetty 12 is almost the same. As sketched in Fig. D.6.22, the footing is protected by natural stones of about 1 ton, then a revetment of 2 to 3 m high is built by laying stone blocks, and the cliff surface of about 10 m high is covered by vegetation. However, there are a number of gully erosions, possibly by rainwater. The cliff is rather steep, and thus the danger of a large cliff sliding by heavy rainfall is great.

Discussion is given here with regard to the longitudinal section of a jetty, because many jetties constructed in the Eforie Sector seem not to have a sufficient function of shore protection. A jetty or groin is built for the purpose of controlling alongshore sediment transport. The longshore sediment transport rate is largest around the wave breaking depth and it becomes null at the threshold depth of sediment movement in the offshore. At the landward side, sedin Stone revetment s place up to the elevation of wave run-up. Therefore, a jetty is usually designed with three sections as shown in Fig. D.6.23: the landward horizontal section [1], the middle

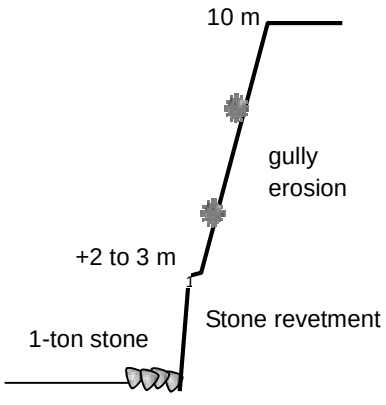


Fig. D.6.22: Cross-section of cliff

slanted section [2], and the seaward horizontal section [3]. The transition between the sections [2] and [3] is set at the shoreline position at the mean low water level. The elevation of the landward horizontal section is taken at the run-up height of storm waves. The gradient of the slanted section is set as equal to the equilibrium beach slope.

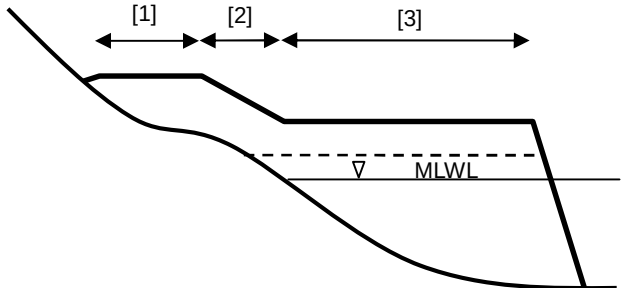


Fig. D.6.23: General longitudinal section of jetty

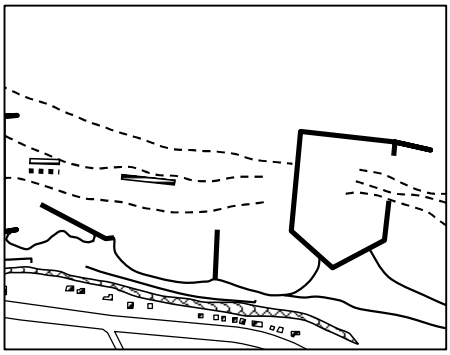


Fig. D.6.24: Tombolo behind the marina

In comparison with the normal design practice, most of jetties in the Eforie Sector have the crest elevations much lower than the above standard as indicated with the dashed line in Fig. D.6.23. The demerit of low crest could be compensated in the case of T-shaped jetty by means of a shore-parallel wing. However, the I-shaped jetties without the sections [1] and [2] cannot check the longshore sediment movement at the time of stormy high waves.

An interesting feature of the shore sector of Eforie Nord is the formation of tombolo behind the marina "Yacht Club Europa." The marina was constructed at the southern tip of the cliff extended to the sea in the 1980s. The entrance to the marina is located at the apex of the deformed pentagon shape, which is facing the shore with the distance of 105 m from the seawall. The marina with its breakwaters and dikes is functioning as a huge non-permeable jetty. The shoreline has advanced to reach the marina.

The shape of sandy beach attached to an offshore island or breakwater with the concave shoreline extending from there is a typical coastal topography called "tombolo." The sand attraction effect of the marina can be observed to extend over several hundred meters to the jetties at the sub-sector of Eforie Middle.

D.6.9 Eforie Middle (Sub-Sector II-2)

This sector is located between the sub-sectors Eforie Nord and Eforie Sud and is provided with only two short jetties around the center of this sector with the mutual distance of about 140 m. Although the maps of facilities list a number of submerged breakwaters as indicated in Fig. 6.2.25, they have been submerged greatly (or have not built to the full heights) and it is difficult to discern them.

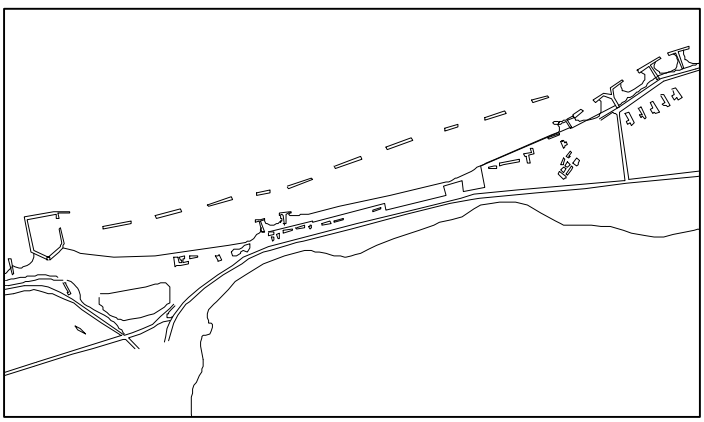


Fig. D.6.25: Map of Eforie Middle sub-sector

The beach is a typical barrier beach, which closed off Lake Techirghiol in

the time unknown. The salinity of the lake rose to the level of 70 per mill after closure as explained in Annex **D.1.4**.

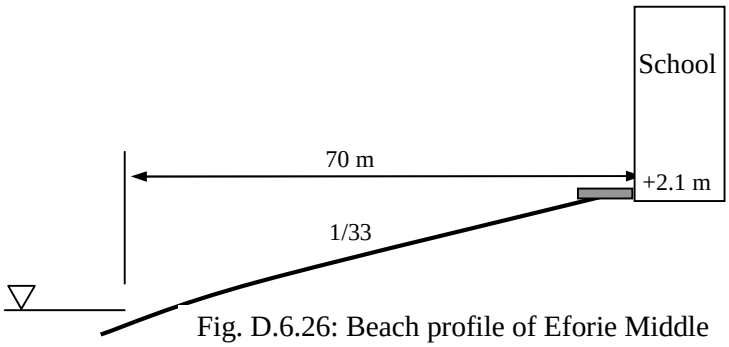


Fig. D.6.26: Beach profile of Eforie Middle

The beach around the jetties has the width of about 70 m and a mild slope of 1/33, which provide good conditions for beach users. There are several buildings, which are utilized as summer schools for children. Commercial facilities such as restraints and bars are not many. The beach in the north of the jetties is narrower than that shown in Fig. D.6.26: no immediate protection measures seem necessary.

D.6.10 Eforie Sud (Sub-Sector II-3)

Figure D.6.27 shows the general plan of the sub-sector of Eforie Sud. At the northern part of this sub-sector, there is a heavily-damaged seawall for a promenade below a sanatorium. Next to the seawall to the south, several small jetties have been built and they are also damaged.

The stretched portion of the seawall was used as the base of the promenade as shown in Fig. D.6.28. However, severe actions must have caused the collapse of this seawall in the following processes:i) collapse of the stone block revetment, ii) sucking out of the core material beneath the promenade, and iii) scouring at the foot of the cliff protection revetment.

The Jetty 10 had been built near the seawall, but it was almost destroyed without remnants of the original cross section around its head. The Jetties 11 to 13 were also built close to the foot of the cliff, where the promenade on the seawall similar as Fig. D.6.28 is present. Because narrow beaches remain in front of the seawall and waves do not attack the seawall, it has been saved from collapsing (see Fig. D.6.29).

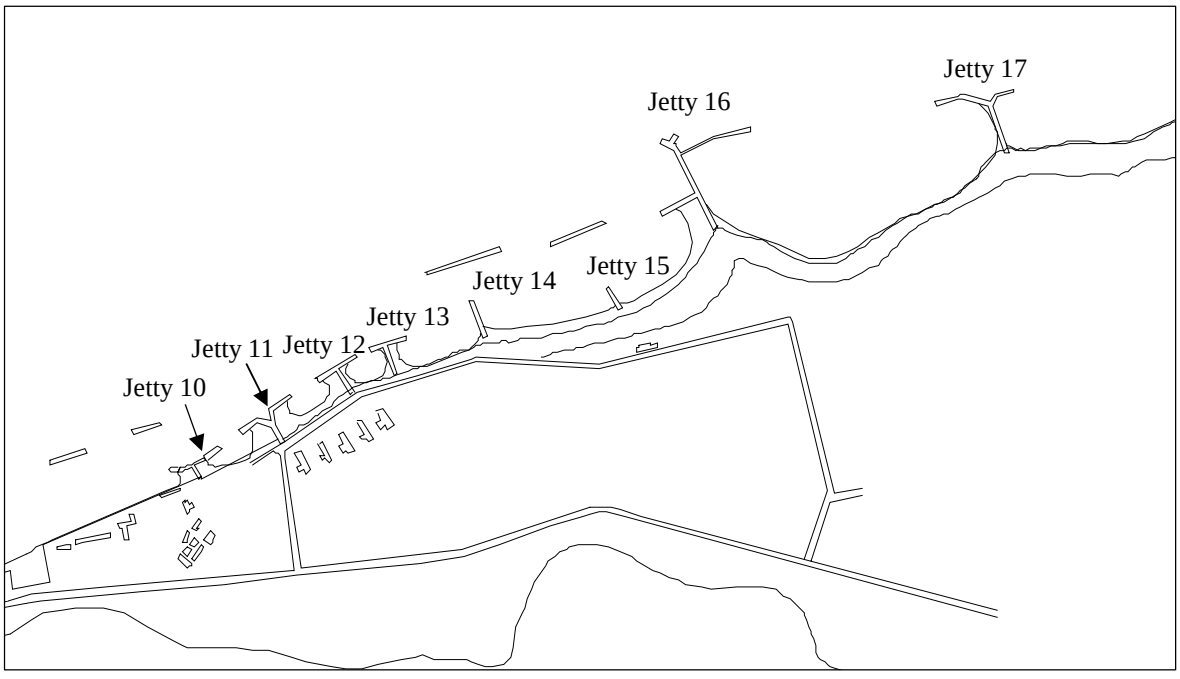


Fig. D.6.27: Map of Eforie Sud sub-sector

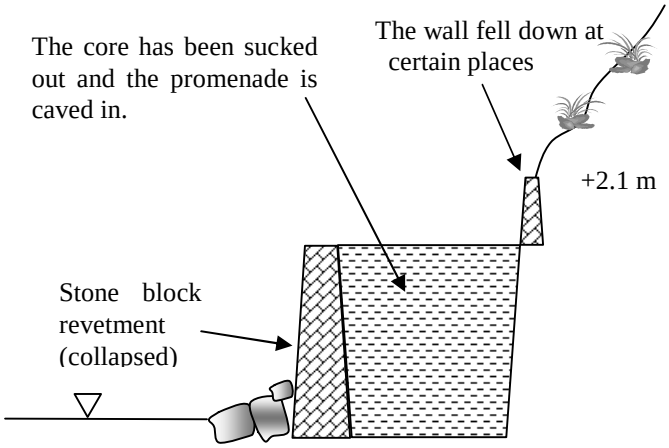


Fig. D.6.28: Cross-section around Jetty 10

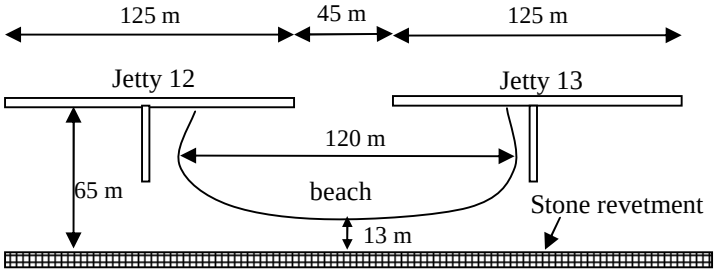


Fig. D.6.29: Plan shape around Jetties 12 & 13

The Jettis 10 to 13 were built with the narrowest distances in between in the sub-sector of Eforie Sud. The narrow openings between jetties have obstructed the exchange of water with the outside, and the area between the Jetties 10 and 13 the yields bad order owing to heaps of seaweed on beaches; the reconnaissance team had difficulty distinguishing the location of shoreline because of seaweed heaps.

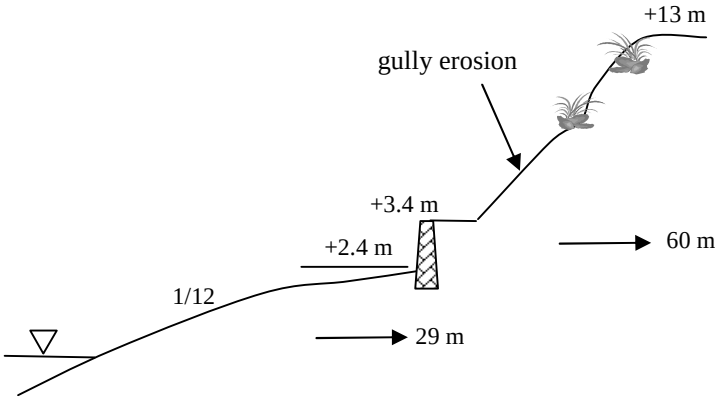


Fig. D.6.30: Profile of beach and cliff around Jetties 14 & 15

The area between the Jetty 14 and 15 is a beautiful beach with the width of 30 m at the narowest point. A promenade with the seaward revetment stretches behind the beach and it retains the original shape without damage because of the wide beach. A relatively mild slope of cliff rises above the promenade, but there are several trances of gully erosion and sliding, which seem to have been caused by rainwater.

The Jetty 16 is the largest one in the sub-sector of Eforie Sud with the cross-shore length of 280 m. Marine leasures such as scube diving are active, utilizing this jetty. The beach betwee the Jetties 15 and 16 is wide.

The shore between the Jetties 16 and 17 is a cliff coast; waves run up to the foot of the cliff. The jetty 17 seems to have been built as a fishing port facility and is provided with a winch for pulling up small fishing boats and other facilities.

The south shore of the Jetty 17 belongs to the Sector Tuzla. Just at the south side of the Jetty 17, an outlet of drainwater is discharging a large quantity of wastewater at the foot of the cliff. Further south of the discharge pipe, fishermen's huts are scattered on the slid-down slopes of the cliff with fishing boasts on the beach.

D.6.11 Tuzla North and South (Sub-Sectors III-1 and III-2)

The sub-sector of Tuzla North is a cliff coast of 4.2 km long with large-scale land slides having taken place over three quarters of the shoreline. The land slides have created broad mild slopes with the width of some 60 m. Bushes and trees cover thickly the surface of the slopes, and a number of fishermen's huts and bungalows have been built. Above the slopes, brown-colored scarps fringe the cliff; the height of the scarp is about one fifth of the total cliff height.

The large-scale land slides are the result of geotechnical instability due to the rise of ground water table, but the retreat of the base of the cliff by wave abrasion must have triggered the land slides.

The sub-sector of Tuzla South is also a cliff coast with the extension of 4.3 km. Cape Tuzla is employed in the Study as the boundary of the two sub-sectors. A large-scale land slide is observed only at the southern end of this sub-sector near the sub-sector of Costneşti. The mild slope is utilized as the base of fishing activity. For the rest of this sub-sector, steep slopes of soil with the angle of repose extend below the cliff and the slopes are covered with grasses. At the southernmost point of this sub-sector, an old Greek ship is aground on rocky seabed since around the 1950s. Beyond south of this sunken ship, the beach at the foot of the cliff begins to widen and the sector of Costneşti appears.

D.6.12 Costineşti (Sub-Sector IV-0)

This sub-sector is defined with the sunken ship at the north and a cape next to Hotel Horum at the south. It is characterized with a natural beach of about 100 m wide. The beach slope is about 1/40, which is comfortable for beach users. The beach as a whole is judged as quite stable.

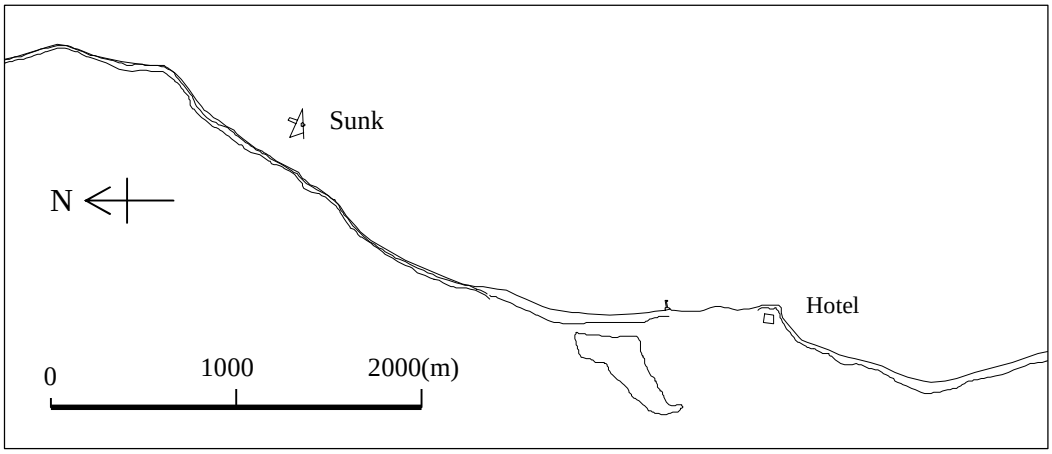


Fig. D.6.31: Map of Costineşti sub-sector

D.6.13 Schitu (Sub-Sector V-0)

This is a cliff coast of 4.3 km long, which has a feature similar with the shore sector of Tuzla South. There are some sandy beaches below the cliff, but they are utilized by a limited number of people because of poor access to the shore; they are functioning as a kind of private beaches.

D.6.14 Olimp–Venus (Sub-Sector VI-1)

This sub-sector includes five resort beach areas, which will be described separately.

[Olimp Resort Area]

This area is made of pocket beaches protected by four jetties as shown in Fig. D.6.32. The area is utilized as a private beach of Hotel Amfiteatru; the seaside entrance of the hotel leads to the Jetty J-03. The Jetty J-01 at the north end and the Jetty J-04 at the south end of this area have the length of about 100 m from the seaside revetment to the heads of the jetties. The Jetties J-02 has the length of 55m. The Jetty J-03 has a similar distance of projection to the sea because of its slant angle with the shore, though it has the extension of about 140 m.

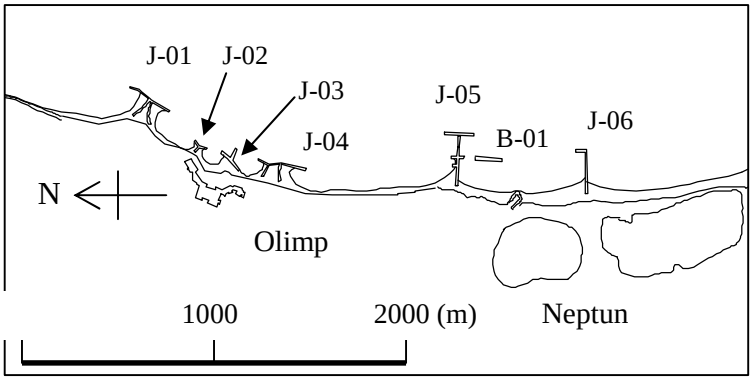


Fig. D.6.32: Map of Olimp and Neptune areas

Figure D.6.33 shows the beach profile between the Jetties J-02 and J-03. The opening between the both jetties is narrow with spacing of only 80 m or so. The beach formed between these jetties has a plan shape of an arc regardless of the direction of incoming waves; the shape does not seem to change in response to the wave characteristics. The foreshore is steep with the slope of 1/7. Behind the beach a low revetment made of stone blocks, and a cliff with a mild slope extends above it.

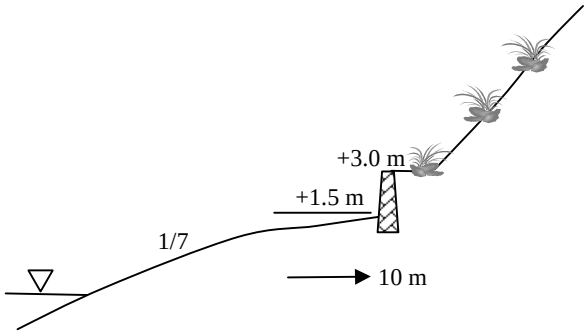


Fig. D.6.33: Beach profile at Olimp

The Jetty J-04 has a shape of a deformed letter Π with the size of 100 m in the cross-shore direction and 150 m in the alongshore direction. A characteristic feature of this location is the presence of a shallow water area at the distance of 200 to 300 m from this jetty, where even small waves often break. Local people said that the layer of limestone is exposed at the seabed there.

[Neptune Resort Area]

This area is provided with a landing pier (J-05) for the President's villa, a detached

breakwater south of the pier J-05, and an L-shaped jetty J-06. They are built with a large spacing so that a broad ocean view can be enjoyed.

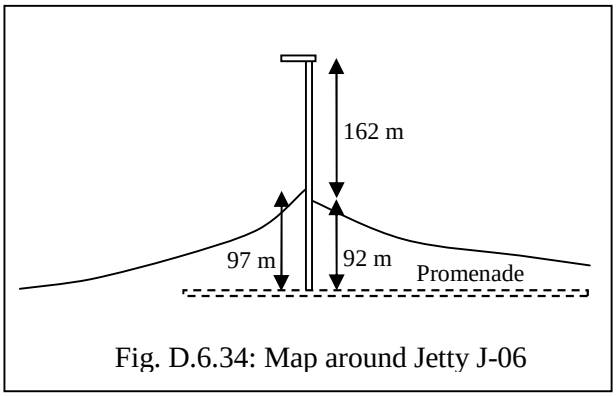


Fig. D.6.34: Map around Jetty J-06

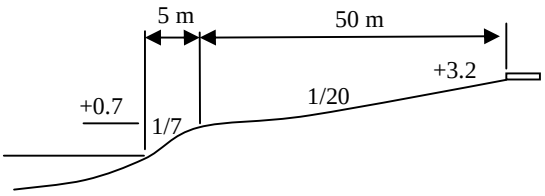


Fig. D.6.35: Beach profile at Neptune area

Figure D.6.34 shows the shoreline shape around the Jetty J-06. At the south of this jetty, a beach has the width of more than 50 m to the promenade. Though the jetties in the sectors of Tomis and Eforie are small in size, the Jetty J-06 is long and has a crest elevation of +1.3 m. This jetty is a good example of sediment control in maintaining a stable beach by means of a jetty with a high crest that can check alongshore sediment transport by storm waves.

The distance between the Jetties J-05 and J-06 is about 600 m. The two jetties provide an example such that a wide beach can be maintained by construction of properly designed facilities in an appropriate layout.

Figure D.6.35 shows a beach profile at the distance of about 200 m south of the Jetty J-06. Though the foreshore has a steep slope of 1/7, the nearshore zone has a mild slope according to visual observation from the shore and is suitable for ocean bathing. The backshore has the slope of about 1/20 and a sufficient width.

[Resort Areas of Jupiter, Aurora, and Venus]

These areas have been developed with groups of hotels built behind the shore and these hotels are using small pocket beaches protected by groups of short jetties as their private beaches.

From the Jetty J-07 located at the northern end of the Jupiter area to the Jetty J-16 at the southern end of the Venus area, there are built ten jetties and one detached breakwater within the distance of 2.2 km as shown in Fig. D.6.36; the mean spacing between jetties is only 240 m. Especially the Jupiter area is provided with densely spaced jetties of short lengths.

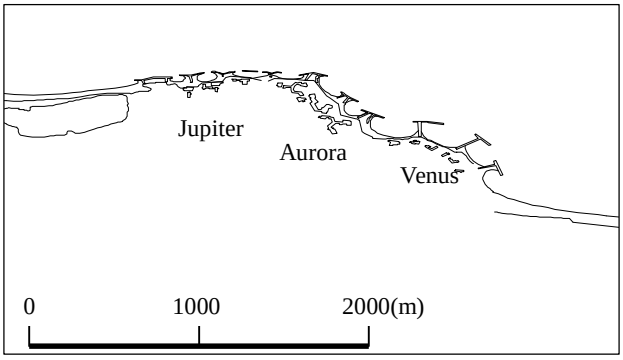


Fig. D.6.36: Map of Jupiter to Venus areas

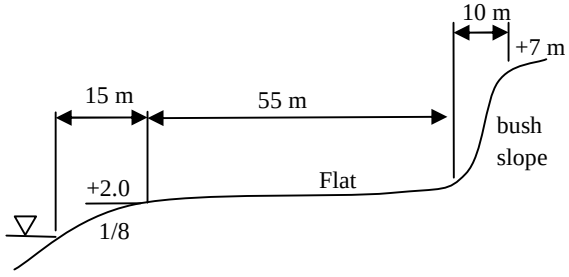


Fig. D.6.37: Beach profile at Aurora to Venus

When visited in early June, beaches between the jetties in the Jupiter area had many seaweeds having been pushed up by waves and the seawater there looked nebular. The beach as a whole smelled bad. The beaches in the resort areas of Jupiter, Aurora and Venus are not visited by many customers even in the middle of August. It may be due to insufficient exchange of seawater with the outside and narrow ocean views from the shore.

A beach profile around the boundary between the Aurora and Venus areas (location between the Jetties J-13 and J-14) is shown in Fig. D.6.37. Beach is broad with the width of about 70 m with the foreshore slope of 1/8 and a flat backshore. Beach surface seems to have been leveled artificially. When compared with the beach condition in late May, the beach looked better when the measurement of beach profile was made on June 17. Beach cleaning seems to have been made in early to mid-June. The Jetty J-13 at the southern tip of the Aurora area has been rehabilitated with addition of new stabilopods marked with the date in 2004 at its head portion.

Beaches surrounded by the Jetties J-14, J-15, and J-16 in the Venus area are rather small despite the large sizes of the jetties.

D.6.15 Balta Mangalia (Sub-Sector VI-2)

This sub-sector covers the length of 1.9 km, among which 1.3 km constitutes a wide beach between Venus and Saturn. There are several drain pipes around the northern end, and one of them spouts out strong sulfur-smell water. The water is said to be good for skin care and a cup is provided at the pipe outlet.

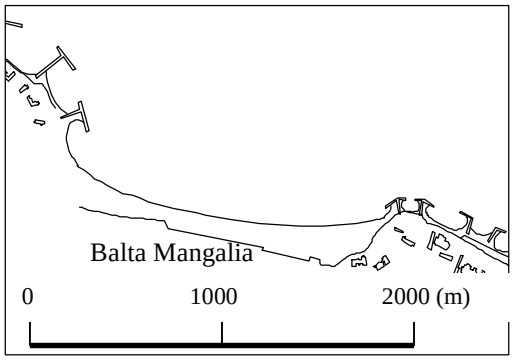


Fig. D.6.38: Map of Balta Mangalia

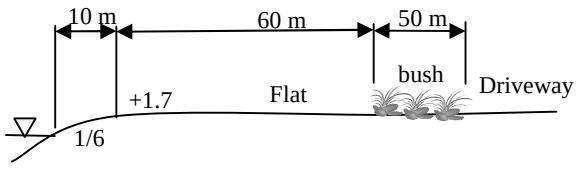


Fig. D.6.39: Beach profile at Balta Mangalia

The foreshore is steep with the slope of 1/6, but the beach extends over the width of 120 m including a bush zone at the back. The shore sector is provided with no shore protection facilities.

D.6.16 Saturn–Mangalia (Sub-Sector VI-3)

This shore sector has a length of 2.5 km at the north of Mangalia Port and is composed of .the areas of Saturn and Mangalia. The Saturn area has several hotels behind the shore and pocket beaches are formed with

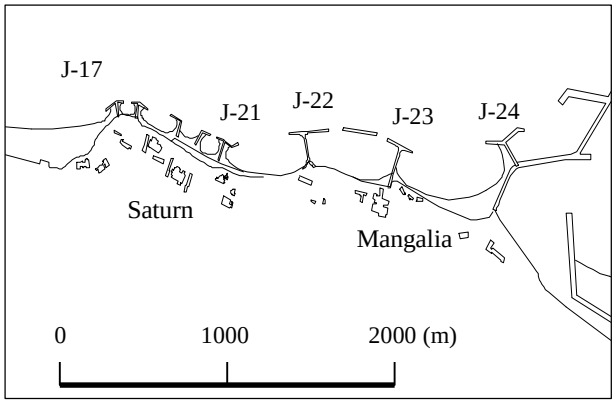


Fig. D.6.40: Map of Saturn–Mangalia

short jetties of J-017 to J-21, just like the Jupiter to Venus areas.

The pocket beach between the Jetties J-17 and J-18 at the northern end has a very short extension. Like other pocket beaches in the Jupiter and Aurora areas, the water quality is bad with heaps of seaweed on beaches; few people were visiting this beach.

The shore is protected with concrete vertical walls and rubbles of 1 ton size are placed in front of them.

The Jetties J-18 and J-19 are placed with the distance of about 240 m and a relatively long shoreline is formed there. The Jetty J-19 is an L-shaped one with a northward wing at the head, while the L-shaped Jetty J-20 has a southward wing. Both jetties have only short trunk portions, and their heads have been damaged considerably. Nevertheless, the shorelines behind their wings have advanced in a shape of tombolo. This morphological change provides evidence of the sand accumulation function of impermeable detached breakwaters.

A detached breakwater is built between the Jetties J-22 and J-23, but the beach between these jetties is very narrow and ineffective to stop waves running up the seawall, which is being protected with stabilopods.

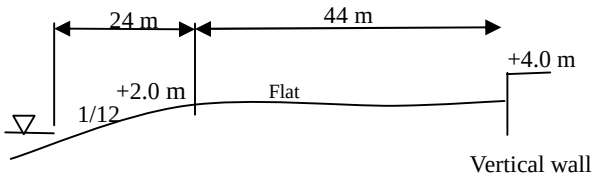


Fig. D.6.41: Beach profile of Mangalia

The shore between the Jetties J-23 and J-24 at the southern end of the Mangalia area has a wide sandy beach. There is no hotel facility behind the beach, and only local people seem to be using this beach. The wide beach is formed in the shape of one-sided tombolo owing to the presence of the impermeable wing head of the T-shaped jetty. The profile of this beach is shown in Fig. D.6.41. The foreshore has the slope of 1.12 and the backshore is flat. The beach is wide enough to accommodate many summer visitors for sunbathing and ocean bathing.

D.6.17 2 Mai (Sub-Sector VII-1)

The sub-sector of 2 Mai is a sandy coast between the south breakwater of Mangalia Port and the pier of a fishing harbor at its southern tip. As shown in Fig. D.6.42, a small cape of cliff is protruding in this coast. The sandy beach in the north of this cape has an extension of 770 m, while the south beach has the length of 250 m. The fishing pier is an L-shaped jetty with a southward wing, behind which one-sided tombolo has been formed.

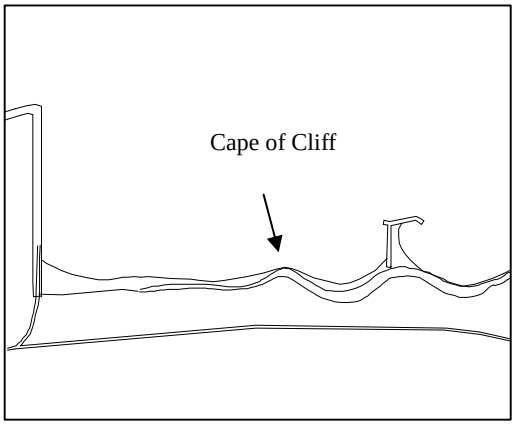


Fig. D.6.42: Map of 2 Mai area

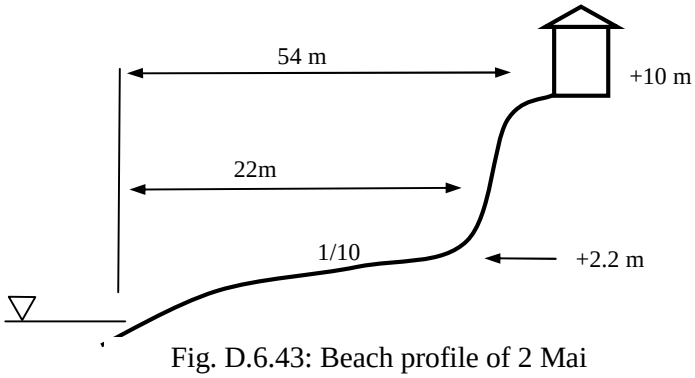


Fig. D.6.43: Beach profile of 2 Mai

An access road between the Mangalia breakwater and the cape descends down from the village toward the shore. The beach profile at this location is shown in Fig. D.6.43. The beach width is 22 m and the beach slope is about 1/10. Behind the beach, a cliff with mild slope rises up and houses are present on top of the cliff.

D.6.18 Vama Veche (Sub-Sector VII-3)

This sub-sector is a beautiful sandy coast, next to the territorial boundary to Bulgaria. Its north is joining to the cliff coast of the sub-sector of Limanu and its south is also adjacent to the cliff coast.

Figure D.6.44 shows the beach profile around the center of sandy beach. The beach extends over 50 m and many commercial facilities, hotels, etc. are present behind the beach. The foreshore is steep with the slope of 1/7 and the slope continues to the depth of about 1 m, according to visual observation. The backshore has the slope of 1/23. This is one of the nature-preserved beautiful beaches.

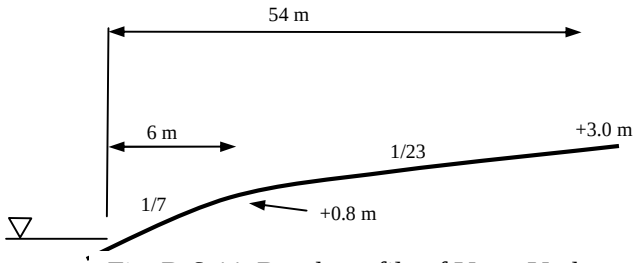


Fig. D.6.44: Beach profile of Vama Veche