ANNEXES

ANNEXES

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ANNEX A

Minutes of Meeting

on

Execution of the Project

of

Special Technical Assistance

for

Maintenance Dredging of the Port of La Unión

in

the Republic of El Salvador

①－1

Minutes of Meeting

on

Special Technical Assistance

for

Maintenance Dredging of the Port of La Union

in

the Republic of El Salvador

Agreed Upon Between

Comisión Ejecutiva Portuaria Autónoma

and

Japan International Cooperation Agency

28 April, 2010
San Salvador, El Salvador

For
Japan International Cooperation Agency

三宅光一

Koichi Miyake
Executive Technical Advisor,
Economic Infrastructure Department

For
Comisión Ejecutiva Portuaria Autónoma

Guillermo López Suárez
President

The mission of Japan International Cooperation Agency (hereinafter referred to as "JICA") and the officials of Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") had discussions on the implementation of the Special Technical Assistance (hereinafter referred to as "TA") for efficient and effective maintenance dredging of the Port of La Union (hereinafter referred to as "the Port").

CEPA and the JICA mission hereby agreed upon the draft Implementing Arrangement for the TA as per Appendix 1, subject to the approval by the competent higher authorities of both sides.

The main points discussed during the discussions are described in Appendix 2.

Appendix 1: Implementing Arrangement
Appendix 2: Main Points Discussed

Appendix 1

IMPLEMENTING ARRANGEMENT

I. Background

Based on the bathymetric surveys conducted during and after the dredging works, it has been observed a "sediment inflow" phenomenon in the channel and basin of the Port, which could seriously affect sustainability of the Port operation because the channel and basin should be maintained at a certain depth to receive large vessels at the Port.

In consideration of the above situation, JICA conducted the SAPI study on the sediment inflow from November 2008 to November 2009 (hereinafter referred to as "the SAPI Study"), and identify the mechanism of siltation as the fluid mud movement and predict the general tendency of siltation volume.

Due to the limited time-series bathymetric data at that time, however, the accuracy of the predicted siltation volume was not always enough to estimate the dredging cost. Furthermore, the variation of nautical depth, which is dependent on the speed of mud consolidation, has also remained unclear. Thus, it is currently difficult to provide a definitive plan for maintenance dredging including location, frequency and method, and hence difficult to elaborate the dredging cost and eventually financial analysis.

To make the Port function properly as a deep sea port, dredging method as well as cost is a vital issue in financial viability and a key factor for successful terminal operation either in the contingent stage of CEPA operation or in the stage of concession. Hence, CEPA requested JICA to provide an effective and efficient maintenance dredging plan.

II. Purpose of the TA

The purposes of the TA are;

1) To prepare an effective and efficient maintenance dredging plan to make the Port function properly as a deep sea port
2) To transfer technology to cope with the siltation of the channel and basin, and assist CEPA to review/revise the prepared dredging plan based on the bathymetric monitoring data

III. Scope of the TA

III-1 To collect natural condition data

1) To compile time-series bathymetric data including the latest data obtained after the SAPI Study (The latest data will be provided by CEPA.)

2) To collect mud samples from the channel and basin

III-2 To predict the variation of nautical bottom/depth after dredging

1) To revise and/or reformulate models, which were built in the SAPI Study, to predict the siltation volume by location based on the analysis of time-series bathymetric data

2) To conduct detailed soil test on collected samples including settlement test and clarify the mud consolidation process

3) To formulate mud consolidation models after dredging works, which were examined in the SAPI Study

4) To predict the time-series variation of nautical bottom/depth after dredging based on the models developed in the above 1) and 3) (Dredging depth will be ranging from -10m to -15m.)

III-3 To formulate maintenance dredging plan by maintained depth

1) To set dredging conditions including particulars of a dredging vessel

2) To examine and prepare maintenance dredging plans to maintain the channel and basin at each depth, possibly ranging from -10m to -14m, based on the result of 4) in III-2 (The plans will include dredging location, volume, frequency and method.)

III-4 To propose a re-dredging plan together with a bathymetric monitoring plan

III-5 To transfer technology to cope with the siltation of the channel and basin

1) To compile the bathymetric monitoring data after the re-dredging work (The re-dredging work and monitoring work will be conduct by CEPA.)

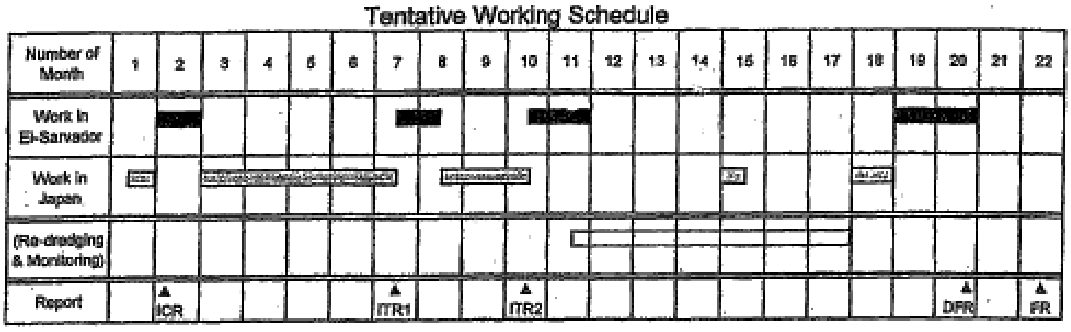
2) To assist CEPA to analyze the above data and to review/revise the maintenance dredging plan examined in III-3

3) To formulate an action plan to cope with the siltation of the channel/basin toward successful terminal operation

IV. Schedule of the TA

The TA will be carried out in accordance with the tentative schedule as follows. The schedule may be subject to change during the course of the TA.

Tentative Working Schedule



ICR : Inception Report
ITR1 - 3 : Interim Report
DFR : Draft Final Report
FR : Final Report

V. Reports

JICA will prepare and submit the following reports in English to CEPA.

- Inception Report

  Ten (10) copies at the commencement of the TA, containing its approach and methodology

- Interim Report 1

  Ten (10) copies, containing the result of work III-2

- Interim Report 2

  Ten (10) copies, containing the result of work III-3 & 4

- Draft Final Report

  Ten (10) copies, containing all works of III-1 to 5 as a draft completion report of the TA

- Final Report and Summary (Summary report will be prepared in English and Spanish)

  Ten (10) copies, within one (1) month after the receipt of the written comments on the Draft Final Report

VI. Undertakings of CEPA

CEPA shall act as a counterpart agency to the Technical Assistant team dispatched by JICA (hereinafter referred to as "the Team") and also as a coordinating body with other organizations concerned for the smooth implementation of the TA.

1. To facilitate the smooth conduct of the TA; the CEPA shall take the following measures in cooperation with other relevant organizations within the laws and regulations in force in El Salvador:
   1) To provide necessary assistance to the Team for the remittance in connection with the implementation of the TA; and
   2) To bear claims, if any arise, against the members of the Team resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the TA, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.
2. CEPA shall, at its own expense, provide the Team with the following, in cooperation with other organizations concerned:
   1) Assistance in customs clearance, with respect to equipment, machinery and other material brought into and out of El Salvador in connection with the implementation of the TA;
   2) Security-related information on as well as measures to ensure the safety of the Team;
   3) Information on as well as support in obtaining medical services;
   4) All the necessary reports, data and information concerning the channel and basin of the Port which shall be basically provided in English;
   5) Counterpart personnel who are well acquainted with dredging work;
   6) Suitable office space with necessary equipment; and
   7) Credentials or identification cards.

VII. Consultation

JICA and CEPA shall consult with each other in respect of any matter that may arise from or in connection with the TA.

[End]

THE MAIN POINTS DISCUSSED

1. Overall goal of the TA

Both sides shared the view that the maintenance dredging of the channel/basin is a critical issue in respect of its cost as well as successful operation of the Port either in the contingent stage of CEPA operation or in the stage of concession, and the TA will intend to assist CEPA to make the Port function properly as a deep sea port.

2. Provision of the latest bathymetric data

CEPA agreed that the latest bathymetric data would be provided to the Team. The data will be obtained in the bathymetric survey conducted by CEPA next May with an echo sounder having the dual frequencies.

3. Estimation of the dredging cost

CEPA agreed to undertake the estimation of the dredging cost based on the result of the TA, while the Team assists/advises CEPA how to estimate it.

4. Re-dredging and monitoring work

The mission of JICA pointed out the importance of re-dredging work after preparing provisional maintenance dredging plans, because the feedback from monitoring depth change afterwards is absolutely vital to revise the said plans and make them more practical to achieve successful operation of the Port. CEPA shared the view and agreed to conduct re-dredging and monitoring work based on the proposal by the Team.

5. Counterpart assignment

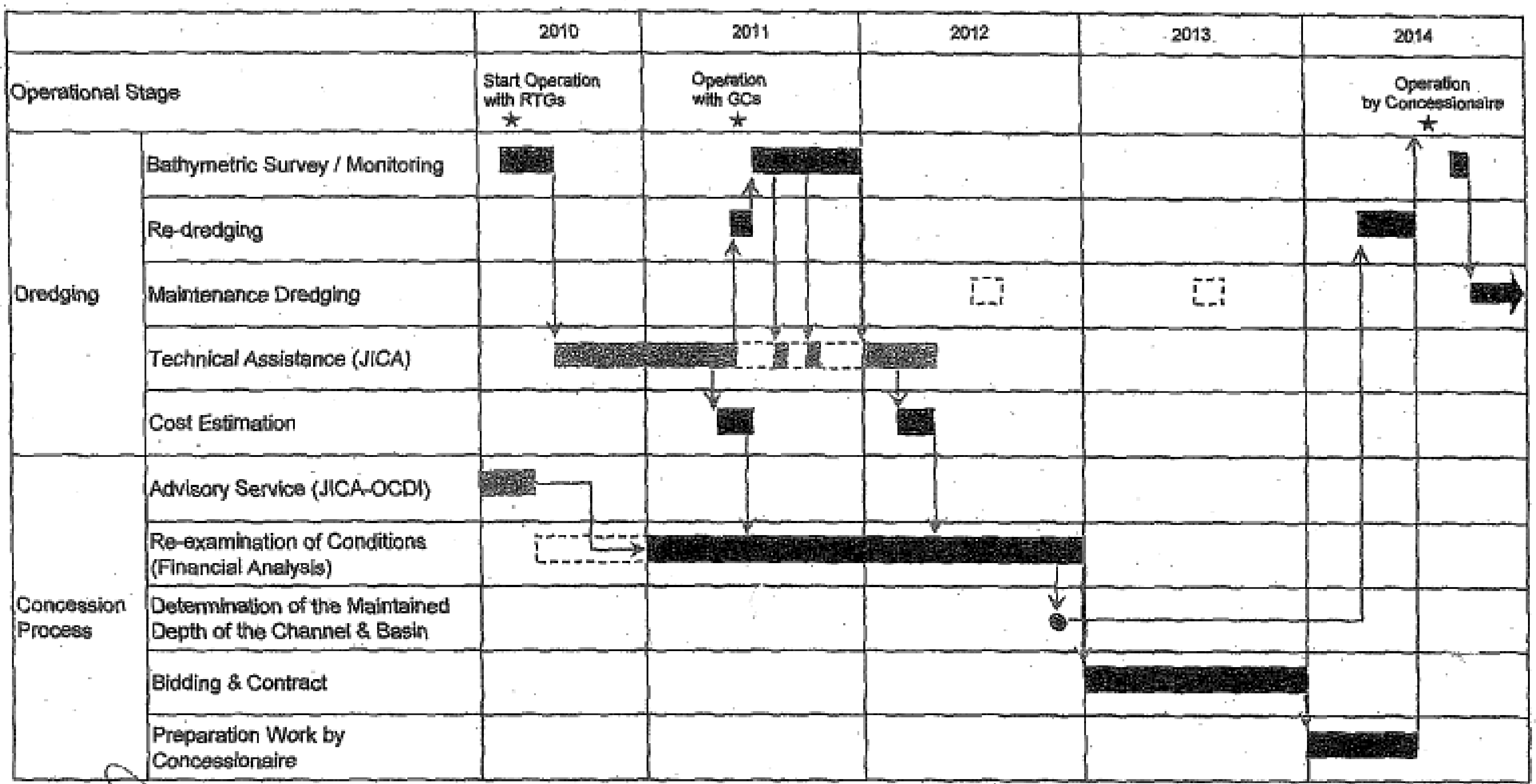
CEPA agreed to assign appropriate counterpart personnel, who are acquainted with maintenance of channels/basins as well as dredging work, in the light of nature of the TA which contains effective technology transfer from the Team.

6. Blueprint of action plan to cope with the siltation and maintenance dredging

The mission of JICA explained a draft of blueprint action plan to cope with the siltation and maintenance dredging as shown in the next page, and CEPA shared that idea.

[End]

Blueprint of Action Plan to Cope with the Siltation and Maintenance Dredging



Amendment
To the Minutes of Meeting
on
Special Technical Assistance
for
Maintenance Dredging of the Port of La Union
in
the Republic of El Salvador

Agreed Upon Between

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

31 October, 2012
San Salvador, El Salvador

For
Japan International Cooperation Agency

Taiji Kawakami
Executive Technical Advisor,
Economic Infrastructure Department

For
Comisión Ejecutiva Portuaria Autónoma

Alberto Arene
President

The mission of Japan International Cooperation Agency (hereinafter referred to as " JICA") and the officials of Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as " CEPA") had discussions about necessary ammendment to " the Minutes of Meeting on Special Technical Assistance (hereinafter referred to as " TA") for Maintenance Dredging of the Port of La Union (hereinafter referred to as " the Port") in the Republic of El Salvador Agreed Upon Between Comisión Ejecutiva Portuaria Autónoma and Japan International Cooperation Agency" dated 28 April, 2010.

CEPA and the JICA mission hereby agreed upon the Implementing Arrangement for the 2nd Term for the TA as per Appendix 1, subject to the approval by the competent higher authorities of both sides.

The main points discussed during the discussions are described in Appendix 2.

Appendix 1: IMPLEMENTING ARRANGEMENT for the 2nd Term
Appendix 2: THE MAIN POINTS DISCUSSED

Appendix 1

IMPLEMENTING ARRANGEMENT for the 2nd Term

Ⅰ. Background

Based on the bathymetric surveys conducted during and after the dredging works, a " sediment inflow" phenomenon has been observed in the channel and basin of the Port, which could seriously affect the sustainability of the port operation.

In consideration of the above situation, JICA conducted the SAPI study on the sediment inflow from November 2008 to November 2009 (hereinafter referred to as " the SAPI Study"), and identified the mechanism of siltation as the fluid mud movement and predicted the general tendency of siltation volume.

Due to the limited time-series bathymetric data at that time, however, the accuracy of the predicted siltation volume was not always enough to estimate the dredging cost. Furthermore, the variation of nautical depth, which is dependent on the speed of mud consolidation, has also remained unclear. Thus, it is currently difficult to provide a definitive plan for the maintenance dredging including location, frequency and method, and hence difficult to elaborate the dredging cost and eventually the financial analysis. To make the Port function properly as a deep sea port, the dredging method as well as the cost is a vital issue in financial viability and a key factor for a successful terminal operation either in the contingent stage of CEPA operation or in the stage of concession. Hence, CEPA requested JICA to provide technical assistance for formulating an effective and efficient maintenance dredging plan.

In January 2011, JICA commenced the TA 1st Term and conducted a series of bathymetric survey and analysis. The survey and analysis has proved that detailed analysis of future shipping service, detailed demand forecast, and the data of trial dredging are inevitable for making valid maintenance dredging plan. Hence, both sides agreed to revise the TOR of TA before the commencement of the 2nd Term.

Ⅱ. Purpose of the TA

The purposes of the TA are;

1) To prepare data, information and analysis utilized by CEPA to formulate an effective and efficient maintenance dredging plan of the Port.
2) To transfer technology to cope with the siltation of the channel and basin.

3) To assist CEPA to prepare dredging plan based on the collected data and analysis.

III. Scope of the TA 2nd Term (as shown in Attachment 1)

III-1 To collect and analyze data and study dredging method

1) To compile the bathymetric monitoring data after the trial dredging work. (The dredging work and monitoring work will be conducted by CEPA.)
2) To survey unit price and method of dredging
3) To examine dredging methods appropriate for various channel depths
4) To validate trial rake dredging
5) To modify sedimentation volume analysis
6) To conduct technical assistance for bathymetric monitoring

III-2 To develop vessels calling model

1) To interview related companies
2) To conduct analysis on trends of container liner shipping service network in Central America
3) To conduct analysis on channel operation rules
4) To develop vessels calling model
5) To forecast number of vessels calling by channel depths

III-3 To review demand forecast and market allocation model

III-4 To analyze optimum channel depth

1) To conduct analysis on dredging cost
2) To forecast cargo amount by channel depths
3) To forecast income of port usage fee by channel depths
4) To analyze technically/financially optimum channel depths at present and in the future
5) To analyze technically/economically optimum channel depths at present and in the future

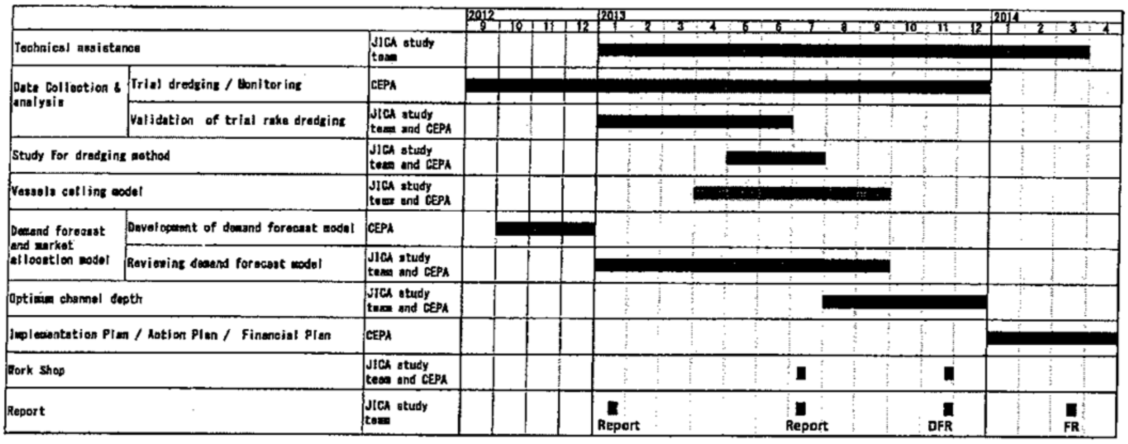
III-5 Technology transfer

1) To transfer CEPA the necessary knowledge to conduct technical and economic analysis through OJT
2) To conduct workshop(s) in order to introduce the methodology relating to III-1 ~III-4

IV. Schedule of the TA 2nd term

The TA will be carried out in accordance with the tentative schedule as follows. The schedule may be subject to change during the course of the TA.

Tentative Working Schedule for 2nd term



Report : Report

DFR : Draft Final Report

FR : Final Report

V. Reports

JICA will prepare and submit the following reports in English to CEPA.

- Report

  Report at the commencement of the TA, containing its approach and methodology

- Draft Final Report

  Ten (10) copies, containing all works of III-1 to 5 as a draft completion report of the TA

- Final Report and Summary (to be prepared in English and Spanish)
  Ten (10) copies, within one (1) month after the receipt of the written comments on the Draft Final Report

VI. Undertaking of CEPA

CEPA shall act as a counterpart agency to the Technical Assistant team dispatched by JICA (hereinafter referred to as " the Team") and also as a coordinating body with other organizations concerned for the smooth implementation of the TA.

1. To facilitate the smooth conduct of the TA; CEPA shall take the following measures in cooperation with other relevant organizations within the laws and regulations in force in El Salvador
   1) To provide necessary assistance to the Team for the remittances in connection with the implementation of the TA; and
   2) To bear claims, if any arise, against the members of the Team resulting from, occurring in the course of, or otherwise connected with, the discharge of their duties in the implementation of the TA, except when such claims arise from gross negligence or willful misconduct on the part of the members of the Team.
2. CEPA shall, at its own expense, provide the Team with the following, in cooperation with other organizations concerned:
   1) Assistance in customs clearance, with respect to equipment, machinery and other material brought into an out of El Salvador in connection with the implementation of the TA;
   2) Security-related information on as well as measures to ensure the safety of the Team;
   3) Information on as well as support in obtaining medical services;
   4) All the necessary reports, data and information concerning the channel and basin of the Port which shall be basically provided in English;
   5) Counterpart personnel who are well acquainted with dredging work and demand forecast;

6) Suitable office space with necessary equipment; and

7) Credentials or identification cards.

VII. Consultation

JICA and CEPA shall consult with each other in respect of any matter that may arise from or in connection with the TA.

[End]

Appendix 2

THE MAIN POINTS DISCUSSED

1. Overall goal of the TA

Both sides shared the view that the maintenance dredging of the channel/basin is a critical issue in respect of its cost as well as successful operation of the Port either in the contingent stage of CEPA operation or in the stage of concession, and the TA will intend to assist CEPA to formulate an effective and efficient maintenance dredging plan of the Port.

2. Provision of the latest bathymetric data

CEPA agreed that the latest bathymetric data would be provided to the Team. The data will be obtained monthly during and after the trial dredging.

3. Estimation of the dredging cost

CEPA agreed to assist in the acquisition of data on unit price of dredging in neighboring countries.

4. Counterpart assignment

Both sides agreed to implement the study on the basis of collaborative works between the Study Team and the counterpart personnel. The counterpart personnel shall be assigned to the project on full-time basis as per Attachment 2. The counterpart team shall consist of at least one dredging engineer in La Union and one port planner in San Salvador.

5. Measurement of tidal level

CEPA accepted to acquire tidal data from the Ministry of Environment and Natural Resources and National Registry Center (CNR) and provide it to the Study Team. Both sides agreed that supplemental measurement of tidal level would be carried out in a simplified manner by CEPA when a bathymetric survey was conducted and the Study Team would provide technical assistance for the measurement.

6. Examination of dredging methodology

Both sides agreed that the examination of dredging methodology in the Study would be conducted focusing only upon geotechnical/oceanographic aspect and cost effectiveness. Accordingly, examinations from other points of view including environmental consideration shall be out of the scopes of the Study.

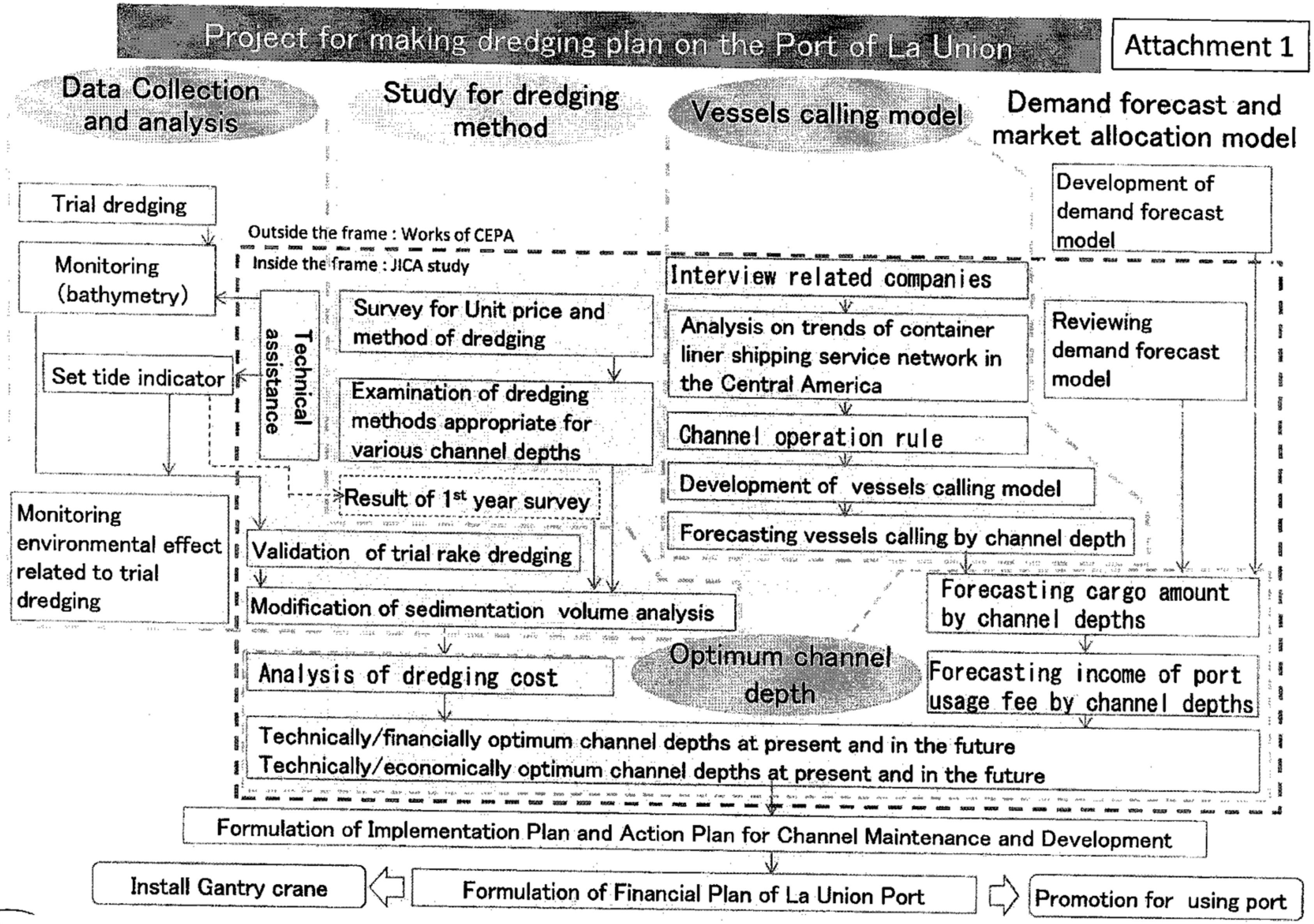
7. Demand forecast and market allocation model

CEPA accepted to develop a demand forecast model, market allocation model and to conduct a survey to cargo owners before the commencement of works of the Study Team in El Salvador, and to provide them to the Study Team with all data set.

8. Formulation of dredging plan

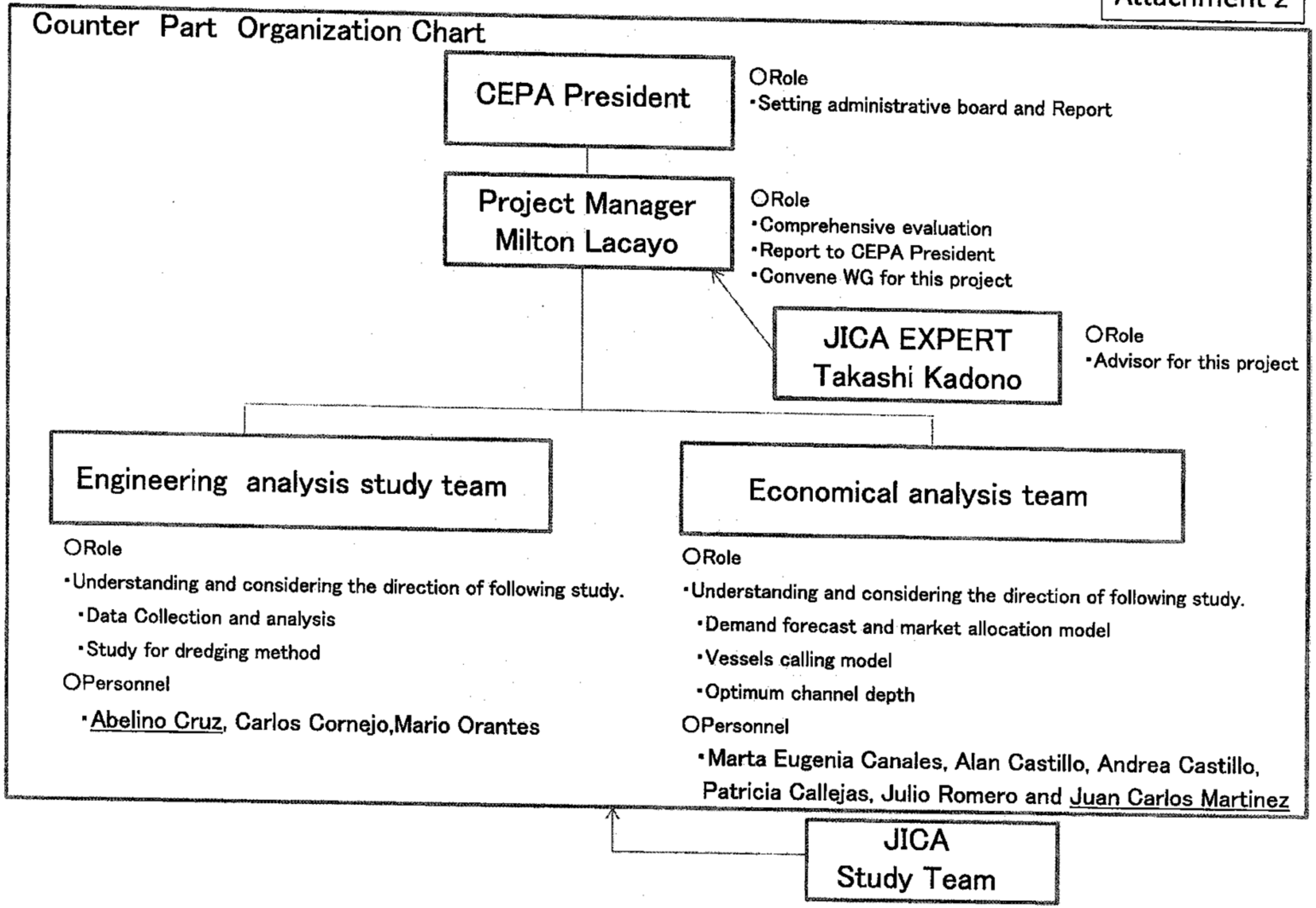
CEPA will formulate and implement a dredging plan for the Port, which is the basis of its financial plan, fully utilizing the result of the Study.

[End]



Project for making dredging plan on the Port of La Union
Attachment 1
Data Collection and analysis
Study for dredging method
Vessels calling model
Demand forecast and market allocation model
Trial dredging
Outside the frame : Works of CEPA
Inside the frame : JICA study
Monitoring (bathymetry)
Technical assistance
Set tide indicator
Survey for Unit price and method of dredging
Examination of dredging methods appropriate for various channel depths
Result of 1st year survey
Monitoring environmental effect related to trial dredging
Validation of trial rake dredging
Modification of sedimentation volume analysis
Analysis of dredging cost
Development of demand forecast model
Interview related companies
Analysis on trends of container liner shipping service network in the Central America
Channel operation rule
Development of vessels calling model
Forecasting vessels calling by channel depth
Reviewing demand forecast model
Forecasting cargo amount by channel depths
Forecasting income of port usage fee by channel depths
Optimum channel depth
Technically/financially optimum channel depths at present and in the future
Technically/economically optimum channel depths at present and in the future
Formulation of Implementation Plan and Action Plan for Channel Maintenance and Development
Install Gantry crane
Formulation of Financial Plan of La Union Port
Promotion for using port

Attachment 2



ANNEX B　Minutes of Meetings between CEPA and Project Team

ANNEX B

Minutes of Meetings

between

CEPA and Project Team

on

Special Technical Assistance

for

Maintenance Dredging of the Port of La Unión Port

in

the Republic of El Salvador

Minutes of Meeting
on
the Project
of
Special Technical Assistance for Maintenance Dredging
of the Port of La Unión
in
the Republic of El Salvador

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

San Salvador, 26 January, 2011

Mr. Luis Enrique Cordova Macias
Presidente,
Comisión Ejecutiva Portuaria Autónoma

Mr. Yoshimi Goda
Leader,
JICA Project Team

Witnessed by

Mr. Alberto Jimenez
Manager of La Unión Port,
Comision Ejecutiva Portuaria Autonoma

In accordance with the Minutes of Discussion on "Special Technical Assistance for Maintenance Dredging of the Port of La Unión in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on April 28, 2010, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Mr. Yoshimi Goda for submitting the Inception Report to CEPA.

The Team had discussions with the officials of CEPA upon the submission of the Inception Report. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Inception Report:

The Team submitted to CEPA the Inception Report and CEPA welcomed the start of the Project by the Team. Explanation was given of the major work items, their methodology, and the work schedule. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Inception Report with a Focus on Section 4.4 "Formulation of Spot Re-dredging and Monitoring Plan"

The Team offered its idea on the size of the spot of re-dredging area as being 200 m by 1000 m around KP03.00 and made inquiry of the technical and financial feasibility of such dredging by CEPA. The latter promised its examination of the feasibility to the Team by the end of the Team's First On-site Works.

3. Collaboration of CEPA in the Team's Bathymetric Survey

The Team requested CEPA for the collaboration for the bathymetric survey. CEPA offered its patrol boat for use by the Team during the survey, and the Team expressed its appreciation for the CEPA's offer.

4. Date of Next Meeting

CEPA and the Team agreed to have the next meeting on February 17 in San Salvador.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comisión Ejecutiva Portuaria Autónoma

Mr. Luis Enrique Cordova Macias	President
Mr. Milton Lacayo	Director of La Unión Port
Mr. Alberto Jimenez	Manager of La Unión Port
Mr. Carlos R. Cornejo	Chief, Civil Works Section
Mr. Mario Orantes	Navigation Aids
Mr. Abelino Cruz	Chief of Maintenance Department

JAPANESE SIDE

JICA Study Team

Mr. Yoshimi Goda	Leader, Siltation Analysis
Mr. Takahisa Aoyama	Dredging Works and Planning
Mr. Yoshimasa Ito	Oceanographic Survey
Mr. Anuratoshimitu Matsumoto	Bathymetric Survey
Mr. Santiago Mauricio Angulo	Interpreter

JICA El Salvador Office

Mr. Ryuichi Nasu	Regional Representative
Mr. Nobutaka Kondo	Deputy Regional Representative
Ms. Stephanie Ehrhardt	Program Officer

Minutes of Meeting
on
the Project
of
Special Technical Assistance for Maintenance Dredging
of the Port of La Unión
in
the Republic of El Salvador

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

San Salvador, 16 August, 2011

Mr. Luis Enrique Cordova Macias
Presidente,
Comisión Ejecutiva Portuaria Autónoma

Mr. Nobuyuki Ono
Sub Leader,
JICA Project Team

Witnessed by

Mr. Milton Lacayo
Manager of La Unión Port,
Comision Ejecutiva Portuaria Autonoma

In accordance with the Minutes of Discussion on "Special Technical Assistance for Maintenance Dredging of the Port of La Unión in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on April 28, 2010, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Mr. Nobuyuki Ono for execution of the Second On-site Works at La Unión Port on August 15, 2011.

The Team had discussions with the officials of CEPA upon the submission of the Interim Report 1. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Interim Report 1:

The Team submitted to CEPA the Interim 1 Report and CEPA welcomed the progress of the Project by the Team. Explanation was given of the major work results since the start of the Project in January 2011 till August 2011. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Interim Report 1

Some questions on the content of the Interim Report 1 were raised by CEPA and the Team answered them.

3. Collaboration of CEPA in the Team's Bathymetric Survey and Examination of Tidal Information

The Team requested CEPA for the collaboration for the bathymetric survey. CEPA offered its patrol boat for use by the Team during the survey, and the Team expressed its appreciation for the CEPA's offer. The Team also requested CEPA for support in the Team's examination of tidal information of La Unión Port. CEPA promised its willingness in supporting the Team.

4. CEPA's Action on Spot Re-dredging Works

The Team proposed three alternatives for the spot re-dredging works of the approach channel, and requested CEPA to make a selection among the alternatives and to prepare the commencement of the spot re-dredging works. CEPA promised the Team to examine the feasibility of the spot re-dredging works and provide the Team with its decision at the next meeting.

5. Technical Training of CEPA Personnel in Japan

A tentative program for the technical training of CEPA personnel in Japan was proposed to CEPA by the Team. CEPA appreciated the preparation of program and gave its general consent to the program.

6. Date of Next Meeting

CEPA and the Team agreed to have the next meeting on September 2 in San Salvador.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comisión Ejecutiva Portuaria Autónoma

Mr. Luis Enrique Córdova Macias	President
Mr. Salvador Villalobos Brizuela	General Manager
Mr. Milton Lacayo	Director of La Unión Port
Mr. Juan Caros Martinez	Concession department

JAPANESE SIDE

JICA Study Team

Mr. Nobuyuki Ono	Sub Leader, Siltation Analysis
Mr. Takahisa Aoyama	Dredging Works and Planning
Mr. Anuratoshimitu Matsumoto	Bathymetric Survey
Mr. Santiago Mauricio Angulo	Interpreter

JICA El Salvador Office

Mr. Luis Miguel Vasquez	Program Officer

Minutes of Meeting
on
the Project
of
Special Technical Assistance for Maintenance Dredging
of the Port of La Unión
in
the Republic of El Salvador

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

San Salvador, 1 September, 2011

Mr. Luis Enrique Cordova Macias
Presidente,
Comisión Ejecutiva Portuaria Autónoma

Mr. Nobuyuki Ono
Sub Leader,
JICA Project Team

Witnessed by

Mr. Milton Lacayo
Manager of La Unión Port,
Comision Ejecutiva Portuaria Autonoma

In accordance with the Minutes of Discussion on "Special Technical Assistance for Maintenance Dredging of the Port of La Unión in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on April 28, 2010, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Mr. Nobuyuki Ono for execution of the Second On-site Works at La Unión Port on August 15, 2011.

Upon completion of the Second On-site Works, the Team presented the Tentative Summary Report 2 to the officials of CEPA. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Tentative Summary Report 2:

The Team submitted to CEPA the Tentative Summary Report 2 and CEPA welcomed the progress of the Project by the Team. Explanation was given of the major work results during the Second On-site Works. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Interim Report 1

Some questions on the content of the Interim Report 1 were raised by CEPA and the Team answered them.

3. CEPA's Action on Spot Re-dredging Works

Among the three alternatives for the spot re-dredging works of the approach channel, and requested, CEPA expressed is still considering alternatives shown in the Interim Report 1.

4. Technical Training of CEPA Personnel in Japan

The Team informed CEPA of the technical training in Japan, which is planned from the end of November to the beginning of December, 2011. CEPA accepted the program and to dispatch two trainees to be selected.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comisión Ejecutiva Portuaria Autónoma

Mr. Luis Enrique Córdova Macias	President
Mr. Salvador Villalobos Brizuela	General Manager

JAPANESE SIDE

JICA Study Team

Mr. Nobuyuki Ono	Sub Leader, Siltation Analysis
Mr. Takahisa Aoyama	Dredging Works and Planning
Mr. Santiago Mauricio Angulo	Interpreter

JICA El Salvador Office

Mr. Kenji Kaneko	Sub Director

OTHERS

International Finance Corporation, World Bank Group

Ms. Katherine Downs	Principal Investment Officer, Infrastructure Advisory
Mr. Juan Luis Flores Flores	Investment Officer, Advirory Service
Ms. Amelia Santana Oliveros	Investiment Analyst

Julian Associate (Financial Analysis, Management Consulting, Transaction Advisory)

Mr. Brad Julian	Principal, Port Consultant

Autoridad Maritima Portuaria

Ms. Arq. Lorenna Arriola	Port Infrastructure
Mr. Ing. Enrique Sandoval	Port Technician

Minutes of Meeting
on
the Project
of
Special Technical Assistance for Maintenance Dredging
of the Port of La Unión
in
the Republic of El Salvador

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

La Union, 24 January, 2012

COMISION EJECUTIVA PORTUARIA AUTONOMA
CEPA
GERENCIA
PUERTO DE LA UNION

小野 信幸

Mr. Milton Lacayo
Manager of La Unión Port,
Comision Ejecutiva Portuaria Autonoma

Mr. Nobuyuki Ono
Sub Leader,
JICA Project Team

In accordance with the Minutes of Discussion on "Special Technical Assistance for Maintenance Dredging of the Port of La Unión in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on April 28, 2010, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Mr. Nobuyuki Ono for execution of the Third On-site Works at La Unión Port on January 15, 2012.

The Team had discussions with the officials of CEPA upon the submission of the Interim Report 1. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Interim Report 2:

The Team submitted to CEPA the Interim Report 2 and CEPA welcomed the progress of the Project by the Team. Explanation was given of the major work results since the start of the Project in January 2011 till January 2012. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Interim Report 2

Some questions on the content of the Interim Report 2 were raised by CEPA and the Team answered them.

3. CEPA's Action on Spot Re-dredging Works

The Team proposed three alternatives for the spot re-dredging works of the approach channel, and requested CEPA to execute the works in the Second On-site works. However, CEPA gave up executing the works because of any difficulties on budget, processing concession, and so on. Therefore, the Team will conduct siltation analysis and calculation of dredging volume by using available data obtained so far.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comisión Ejecutiva Portuaria Autónoma

Eng. Milton Lacayo	Manager of La Unión Port
Eng. Abelino Cruz	Maintenance Manager
Eng. Amilto Orellana	Administration Manager
Eng Carlos Cornejo	Maintenance Engineer
Ing. Mario Orantes	Navigation Aids
Arquitect Karen Martinez	
Liutenant Miguel Martinez	Operations
Eng. Osman Montoya	IT Manager

Guest

Arquitect Lorena Arriola	Asociacion Maritima Portuaria
Mr. Brad Julian	International Finance Corporation
Mr. Robet Bennet	International Finance Corporation
Mr. Michel Horton	International Finance Corporation

JAPANESE SIDE

JICA Study Team

Mr. Nobuyuki Ono	Sub Leader, Siltation Analysis
Mr. Takahisa Aoyama	Dredging Works and Planning
Mr. Yoshimasa Ito	Natural Condition Analysis
Mr. Anuratoshimitu Matsumoto	Bathymetric Survey
Mr. Santiago Mauricio Angulo	Interpreter

Minutes of Meeting
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Special Technical Assistance for Maintenance Dredging
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the Republic of El Salvador

Comisión Ejecutiva Portuaria Autónoma
and
Japan International Cooperation Agency

San Salvador, 2 February, 2012

Mr. Alberto Arene Presidente, Comisión Ejecutiva Portuaria Autónoma	Mr. Nobuyuki Ono Sub Leader, JICA Project Team

In accordance with the Minutes of Discussion on "Special Technical Assistance for Maintenance Dredging of the Port of La Unión in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comisión Ejecutiva Portuaria Autónoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on April 28, 2010, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Mr. Nobuyuki Ono for execution of the Third On-site Works at La Unión Port on January 15, 2012.

Upon completion of the Third On-site Works, the Team presented the Interim Report 2 revised including results of Third On-site Works to the officials of CEPA. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Interim Report 2:

The Team submitted to CEPA the Interim Report 2 (Revised including results of 3rd On-Site Works) and CEPA welcomed the progress of the Project by the Team. Explanation was given of the major work results examined so far. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Interim Report 2

Some questions on the content of the Interim Report 2 were raised by CEPA and the Team answered them.

3. CEPA's Alternative Action on Spot Re-dredging Works

About Spot Re-dredging works the Team proposed previously, CEPA decided not to execute the Spot Re-dredging work. Instead, CEPA plans to carry out leveling the shallowest portion in the inner channel by special equipment called rake (bed leveler). The rake is previously used in Acajutla Port and it is usually utilized to make the sea bed even after dredging by being towed by a tugboat. CEPA has already brought the rake from Acajutla Port to La Union and ready to carry out the leveling works. Some Discussion on effectiveness of the leveling works have been made .

4. CEPA's request to calculate dredging volume for the target depth of -9 m

CEPA requested to the Team to calculate the dredging volume for the target depth of -9 m. The team promised to calculate and send the result soon.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comisión Ejecutiva Portuaria Autónoma

Lic. Alberto Arene	President
Lic. Salvador Villalobos	Gerente General
Lic. Rolando Alberto Diaz	Gerente de Concesiones
Eng. Milton Lacayo	Manager of La Unión Port
Srita. Andrea Castillo	Asistente President
Mr. Hiefumi Ikeda	Consultor para CEPA

JAPANESE SIDE

JICA El Salvador

Mr.Yuichiro Inoue	Representante Residente Adjunto JICA

JICA Study Team

Mr. Nobuyuki Ono	Sub Leader, Siltation Analysis
Mr. Takahisa Aoyama	Dredging Works and Planning
Mr. Yoshimasa Ito	Natural Condition Analysis
Mr. Santiago Mauricio Angulo	Interpreter

Minutes of meeting
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the Republic of El Salvador

Comision Ejecutiva Portuaria Autonoma

and

Japan International Cooperation Ageny

San Salvador, 11 April, 2013

Mr. Alberto Arene
Presidente,
Comision Ejecutiva Portuaria Autonoma

Dr. Kazumasa KATO
Leader,
JICA Project Team

Witnessed by

Mr. Milton Lacayo
Manager of La Union Port
Comision Ejecutiva Portuaria Autonoma

In accordance with the Amendment to "the Minutes of Meeting on Special Technical Assistance for Maintenance Dredging of the Port of La Union in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comision Ejecutiva Portuaria Autonoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on 31 October, 2012, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Dr. Kazumasa Kato for submitting the Inception Report 2 to CEPA.

The Team had discussions with the officials of CEPA upon the submission of the Inception Report 2. The following is the main points discussed in the meeting. The list of attendees is attached as Annex.

1. Acceptance of Inception Report:

The Team submitted to CEPA the Inception Report 2 and CEPA welcomed the start of the Project by the Team. The Team explained the Inception Report 2 by using a Power Point presentation. Explanation was provided for the major findings in the First Term Study, the principal items to work on during the Second Term Study, their methodology, and the work schedule. Brief discussions were made among the attendees. There was no modification of the Inception Report 2, no addition to it, no elimination from it. CEPA gave its general consent to the content of the Report.

2. Discussion of Inception Report

Some questions on the content of the Inception Report 2 were raised by CEPA and the Team answered.

3. Provision of the latest bathymetric data by CEPA

The Team requested CEPA for the provision of information related to the rake dredging and the data of bathymetric survey. CEPA promised its willingness in offering the data to the Team.

4. Support from CEPA in the Team's acquisition of information related to economics

The Team also requested CEPA to support the Team, when the Team interviews with shippers and forwarders for acquiring the information related to economics. CEPA promised its willingness to support the Team.

5. Practical use of Draft Final Report

CEPA will probably need to commence dredging works by January 2014 as requested by the potential concessionaires of la Union port. CEPA plans to use the draft final report, which will be submitted from the Team to CEPA by the end of November, 2013, as the basis for this dredging, since CEPA cannot wait till final draft is ready.

6. Requests from CEPA

CEPA asked the Team to include in the draft final report the verification of volumes to be dredged for -12 depth without over dredging in the permanent basis with a TSHD of 2500m^3 capacity.

In the analysis of the deterioration of the side slopes, CEPA wanted to include the inner channel as well.

The Team accepted above two requests from CEPA.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comision Ejecutiva Portuaria Autonoma

Mr. Alberto Arene	President
Mr. Milton Lacayo	La Union Port Manager
Mr. Andres Abelino Cruz	Maintenance Manager Port of La Union
Mr. Marcos Vasquez	Concesions department
Mr. Juan Carlos Martinez	Concesions department
Mr. Rolando Diaz	CEPA Consultant

JAPANESE SIDE

JICA Study Team

Mr. Kazumasa KATO	Leader, Siltation Analysis
Mr. Takahisa Aoyama	Channel Dredging Works and Planning
Mr. Ryuichi Shibasaki	Demand Forecast
Mr. Takayuki Iijima	Economic Analysis
Mr. Tadahiko Kawada	Port Planning
Mr. Santiago M Angulo	Interpreter

JICA El Salvador Office

Mr. Takashi Kadono	Expert
Mr. Yuichiro Inoue	Assistant Resident Representative
Ms Gabriela Alfaro	Program Officer

Minutes of meeting
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Comision Ejecutiva Portuaria Autonoma
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Japan International Cooperation Ageny

San Salvador, 27 August, 2013

Mr. Alberto Arene
Presidente,
Comision Ejecutiva Portuaria Autonoma

Dr. Kazumasa KATO
Leader,
JICA Project Team

Mr. Milton Lacayo
Manager of La Union Port
Comision Ejecutiva Portuaria Autonoma

In accordance with the Amendment to "the Minutes of Meeting on Special Technical Assistance for Maintenance Dredging of the Port of La Union in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comision Ejecutiva Portuaria Autonoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on 31 October, 2012, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Dr. Kazumasa Kato for execution of the Second On-site Works at La Union Port in El Salvador and in the neighboring countries, on 18 August, 2013.

In the Workshop on Special Technical Assistance for Maintenance Dredging of the Port of La Union in the Republic of El Salvador, which was held on 27 August, 2013, the Team submitted the Interim Report 3 and presented its outline to the officials of CEPA. The following is the main points discussed in the workshop. The list of attendees is attached as Annex.

1. Acceptance of Interim Report 3

The Team submitted to CEPA the Interim Report 3 and CEPA welcomed the progress of the Project by the Team. The Team explained the Interim Report 3 by using a Power Point presentation in the workshop. Explanation was provided for the major results examined so far. Brief discussions were made among the attendees. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Discussion of Interim Report 3

Some questions on the content of the Interim Report 3 were raised by CEPA and the Team answered.

The bathymetric data newly obtained in July, 2013 would be included in the draft final report.

CEPA has started to improve the present rake and develop a new type rake. The Team will continue to examine the effectiveness of the rake-dredging if the new data will be obtained with regard to the rake-dredging.

There are two prediction models of siltation, which provide different results at present. In order to improve this problem, it is basically important to carry out a monitoring of siltation for getting the data for the appropriate analysis.

The results so far obtained on the economic issues have been well understood because a precise explanation has already been given to the counterparts in the previous workshops by the Team.

ANNEX: LIST OF ATTENDEES

EL SALVADOR SIDE

Comision Ejecutiva Portuaria Autonoma

Mr. Alberto Arene	President
Mr. Carlos Federico Paredes Castillo	Presidential Advisor
Mr. Milton Lacayo	Port Manager Port of La Union
Mr. Pedro Amilto Orellana	Financial Manager Port of La Union
Mr. Andres Abelino Cruz	Maintenance Chief Port of La Union
Ms. Marta Eugenia Canales	Administrator Data Base Port of La Union
Ms. Andrea Castillo	Assistant President
Ms. Patricia Callejas	Financial Assistant
Mr. Carlos Alejandro Molina Paz	Specialist Bathymetric and Dredging Port of La Union
Ms. Egly Tatiana Chacon	Specialist Bathymetric and Dredging Port of La Union
Mr. Rafael Antonio Hernandez	Engineering Department
Mr. Damian Reyes	Marketing Analyst
Mr. Jaime Flores	Financial Technician
Mr. Marcos Vasquez	Concessions department
Mr. Juan Carlos Martinez	Concessions department
Mr. Julio Alberto Romero Mejia	Concessions department
Mr. Takashi Kadono	JICA Expert

JAPANESE SIDE

JICA Tokyo Headquarters

Mr. Taiji Kawakami	Executive Technical Advisor Economic Infrastructure Department
Dr. Kazuo Murakami	Emeritus Professor Tokyo City University
Dr. Yasuyuki Nakagawa	Team Leader of Coastal and Estuary Sediment Dynamics Research Group, Port and Airport Research Institute
Mr. Masatomo Kihara	Director for International Policy, Ports and Harbors Bureau

JICA Study Team	
Mr. Kazumasa Kato	Leader, Siltation Analysis, ECOH
Mr. Nobuyuki Ono	Siltation Analysis and Prediction, ECOH
Mr. Takahisa Aoyama	Channel Dredging Works and Planning, ECOH
Mr. Tatsuyuki Shishido	Maritime Economics, OCDI
Mr. Ryuichi Shibasaki	Demand Forecast, OCDI
Mr. Takayuki Iijima	Economic Analysis, OCDI
Mr. Tadahiko Kawada	Port Planning, OCDI
Mr. Santiago M Angulo	Interpreter
Ms. Victoria Soledad Anguro	Interpreter
JICA El Salvador Office	
Mr. Shinji Sato	Adjunct Resident Representative
Mr. Yuichiro Inoue	Director of Reimbursable Financial Cooperation
Ms. Miwako Kamimura	Project Formulation Adviser
Ms Gabriela Alfaro	Program Officer

Minutes of meeting
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Special Technical Assistance for Maintenance Dredging
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Comision Ejecutiva Portuaria Autonoma
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Japan International Cooperation Ageny

San Salvador, 13 December, 2013

Mr. Alberto Arene
Presidente,
Comision Ejecutiva Portuaria Autonoma

Dr. Kazumasa KATO
Leader,
JICA Project Team

Mr. Milton Lacayo
Manager of La Union Port
Comision Ejecutiva Portuaria Autonoma

In accordance with the Amendment to "the Minutes of Meeting on Special Technical Assistance for Maintenance Dredging of the Port of La Union in the Republic of El Salvador" (hereinafter referred to as "the Project") agreed upon between the Comision Ejecutiva Portuaria Autonoma (hereinafter referred to as "CEPA") and Japan International Cooperation Agency (hereinafter referred to as "JICA") on 31 October, 2012, JICA dispatched the Project Team (hereinafter referred to as "the Team") headed by Dr. Kazumasa Kato for execution of the Third On-site Works at San Salvador in El Salvador, on 4 December, 2013.

In the meeting held on 10 December, 2013, the Team presented the outline of Draft Final Report (DFR) to the officials of CEPA. The Team explained DFR by using a Power Point presentation, which was provided for the major results examined. Brief discussions were made among the attendees. The list of attendees is attached as Annex A.

On 11 December, 2013, the Team explained the conclusions of study to the president of CEPA. Additional explanations were made for the questions from the president. The list of attendees is attached as Annex B.

1. Acceptance of DFR

After the explanation and discussion on DFR, the Team submitted to CEPA the Draft Final Report and CEPA received it. CEPA gave its general consent to the content of the Report and expressed its appreciation for the Team's efforts for the Project.

2. Schedule to the Final Report

The study Team and CEPA confirmed together with respect to the schedule to the Final Report as follow;

+ CEPA will submit the written comment on DFR to the JICA by 20 January, 2014.

+ The Study team will compile the Final Report by taking the comments into account and should submit it to CEPA by the end of March, 2014.

ANNEX A: LIST OF ATTENDEES

December 10, 2013

EL SALVADOR SIDE

Comision Ejecutiva Portuaria Autonoma

Mr. Carlos Federico Paredes Castillo	President Adviser
Mr. Milton Lacayo	Port Manager Port of La Union
Mr. Andrés Abelino Cruz	Maintenance Chief Port of La Union
Ms. Andrea Castillo	President's Assistant
Ms. Patricia Callejas	Concessions Management Technician
Mr. Carlos Alejandro Molina Paz	Bathymetric and Dredging Specialist Port of La Union
Ms. Egly Tatiana Chacón	Bathymetric and Dredging Specialist Port of La Union
Mr. Damian Reyes	Economical Financial Analyst
Mr. Marcos Vasquez	Concessions Infrastructure
Mr. Juan Carlos Martínez	Concessions Technician
Mr. Julio Alberto Romero Mejía	Concessions Technician
Mr. Eugenia Luna	Concessions Technician
Takashi Kadono	JICA Expert

JAPANESE SIDE

JICA Tokyo Headquarters

Mr. Taiji Kawakami	Executive Technical Advisor

JICA Study Team

Mr. Kazumasa Katoh	Leader Siltation Analysis, ECOH
Mr. Nobuyaki Ono	Siltation Analysis and Prediction, ECOH
Mr. Takahisa Aoyama	Channel Dredging Works and Planning, ECOH
Mr. Tatsuyuki Shishido	Maritime Economics, OCDI
Mr. Ryuichi Shibasaki	Demand Forecast, OCDI
Mr. Takayuki Iijima	Economic Analysis, OCDI
Mr. Santiago Angulo	Interpreter
Ms. Victoria Angulo	Interpreter

JICA El Salvador Office

Mr. Yuichiro Inonc	Director of Reimbursable Financial Cooperation
Ms. Miwako Kamimura	Project Formulation Adviser
Ms. Gabriela Alfaro	Program Office

ANNEX B: LIST OF ATTENDEES

December 11, 2013

EL SALVADOR SIDE

Comision Ejecutiva Portuaria Autonoma

Mr. Alberto Arene	President
Mr. Milton Lacayo	Port Manager Port of La Union
Takashi Kadono	JICA Expert

JAPANESE SIDE

JICA Tokyo Headquarters

Mr. Taiji Kawakami	Executive Technical Advisor

JICA Study Team

Mr. Kazumasa Katoh	Leader Siltation Analysis, ECOH
Mr. Nobuyaki Ono	Siltation Analysis and Prediction, ECOH
Mr. Takahisa Aoyama	Channel Dredging Works and Planning, ECOH
Mr. Tatsuyuki Shishido	Maritime Economics, OCDI
Mr. Ryuichi Shibasaki	Demand Forecast, OCDI
Mr. Takayuki Iijima	Economic Analysis, OCDI
Mr. Santiago Angulo	Interpreter

JICA El Salvador Office

Mr. Shinji Sato	Adjunct Resident Representative
Ms. Miwako Kamimura	Project Formulation Adviser
Ms. Gabriela Alfaro	Program Office

ANNEX C

Topics related to channel sedimentation in La Union Port

C.1 Side Slope Stability

The Harbor Basin and the Inner Channel were built with the side-slope of 1V/5H. The stabilities of side-slope of 1V/5H have been examined by utilizing the bathymetric data.

C.1.1 Stability of side-slope in Harbor Basin

The stability of side-slope in the Harbor Basin has been examined on the cross sections along the reference line L22 shown in Figure C.1. The dredging periods and the dates of bathymetric data which are utilized for analyses are shown in Figure C.2.

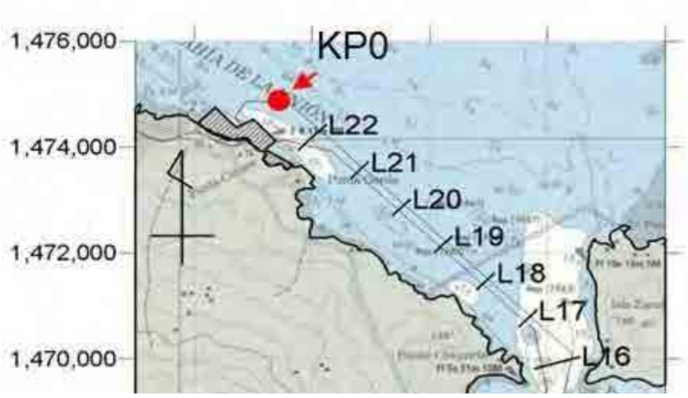


Figure C.1 Reference lines in Harbor basin and Inner Channel

Figure C.3 shows the superposition of five cross sections, in which a black solid line is a planned section with 1V/5H slope and a black broken line is a slope of 1V/10H. As seen in Figure C.3, the slope is built almost in accordance with the plan. The slope is kept with a slope of 1V/5H without changing during 14 months from June, 2007 to August, 2008.

Reference line	Date of bathymetric survey				
L22	17 Jun'07	16 Aug'07	18 Jan'08	11 Jun'08	11 Aug'08

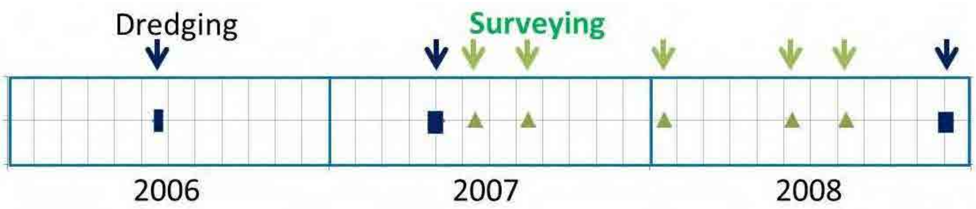


Figure C.2 Period of dredging in Harbor Basin and date of bathymetric data utilized for analysis

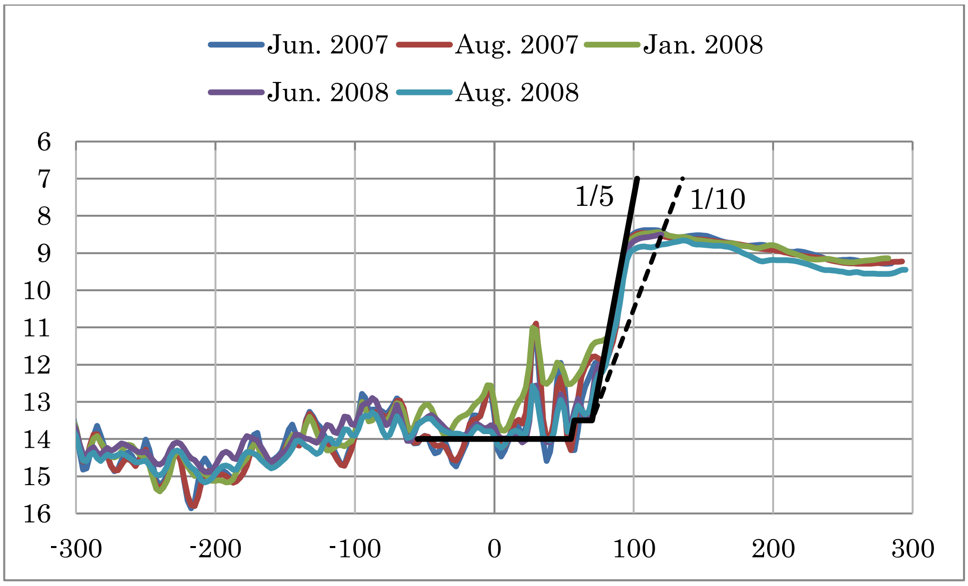


Figure C.3　Superposition of cross section of L22

C.1.2 Stabilities of side-slope in Inner Channel

The stabilities of side-slope in the Inner Channel are examined for the reference lines from L21 to L18 (see Figure C.1).

The dredging periods in the Inner Channel and the dates of bathymetric data which are utilized for analyses are shown in Figure C.4.

	Date of bathymetric survey					
L21		17Jun'07	16Aug'07	18Jan'08	11Jun'08	11Aug'08
L20	04May'2007	17Jun'07	16Aug'07	18Jan'08	11Jun'08	11Aug'08
L19	04May'2007	17Jun'07	16Aug'07	18Jan'08	11Jun'08	11Aug'08
L18	04May'2007	17Jun'07	16Aug'07	18Jan'08	11Jun'08	11Aug'08

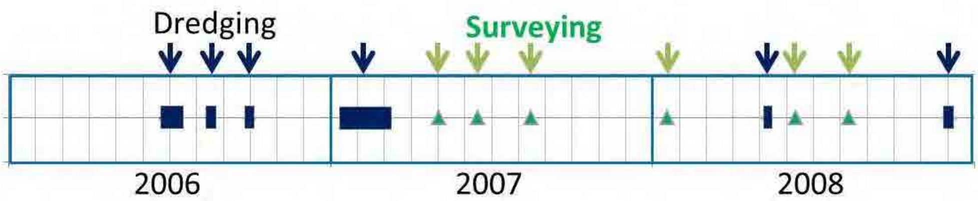


Figure C.4 Periods of dredging in Inner Channel and date of bathymetric data utilized for analysis(L21~L18)

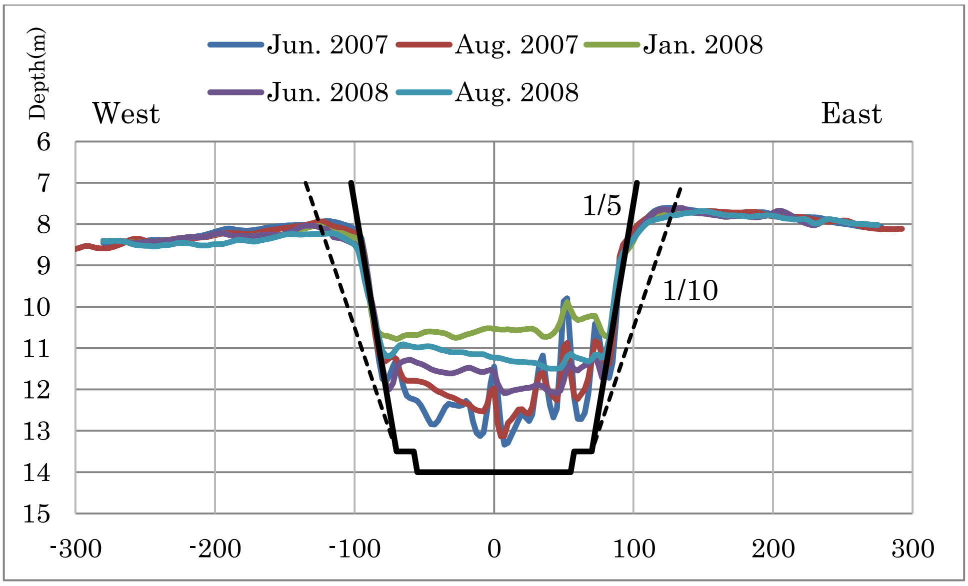


Figure C.5　Superposition of 5 cross sections along L21

Figure C.5 shows a superposition of 5 cross sections along the reference line L21, from which it is understood that both eastern and western side slopes were being stable with the same slope of 1V/5H as the plan.

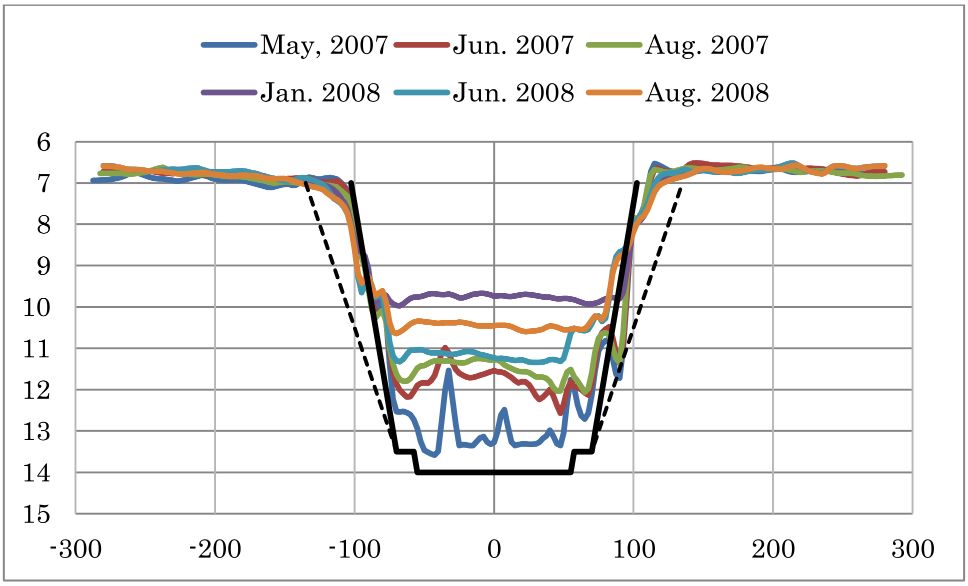


Figure C.6　Superposition of 6 cross sections along L20

Also with respect to the cross section along the reference line L20, both the eastern and the western side slopes were being stable with a slope of 1V/5H as seen in Figure C.6.

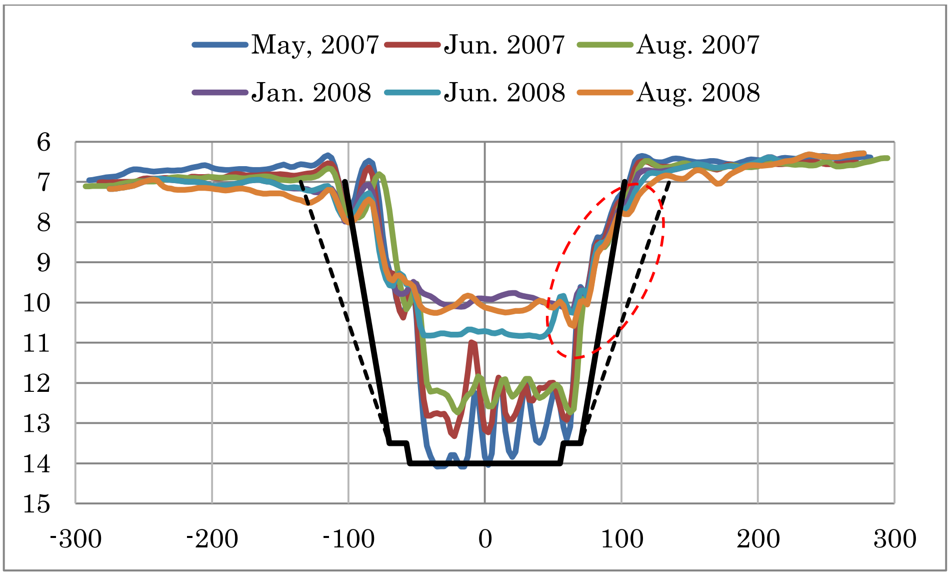


Figure C.7 Superposition of 6 cross sections along L19

Figure C.7 shows a superposition of 6 sections along the reference line L19. Although a western side-slope was out of position, being about 20 meters eastward from the planned location, its slope was being stable with a slope of 1V/5H during about 16 months from May, 2007 to August, 2008. Whereas, a slope surrounded by a red dotted line on the eastern side-slope was being stable, but its slope was about 1V/10H. As of May, 2007, when the oldest bathymetric data was obtained, the slope was already 1V/10H. Then at this location, there was a possibility that the channel was built with a slope of 1V/10H.

Accordingly, cross sections of different time were inspected along the same reference line, L19. Figure C.8 shows a comparison between the bathymetric data obtained in December, 2008, when the second full dredging was completed, and in June, 2009. During this period the slope was stable with a slope of 1V/5H. It can be concluded that the eastern side-slope was built with a slope of 1V/10H in Figure C.7. Then, it is appropriate not to take the data related to this location into consideration.

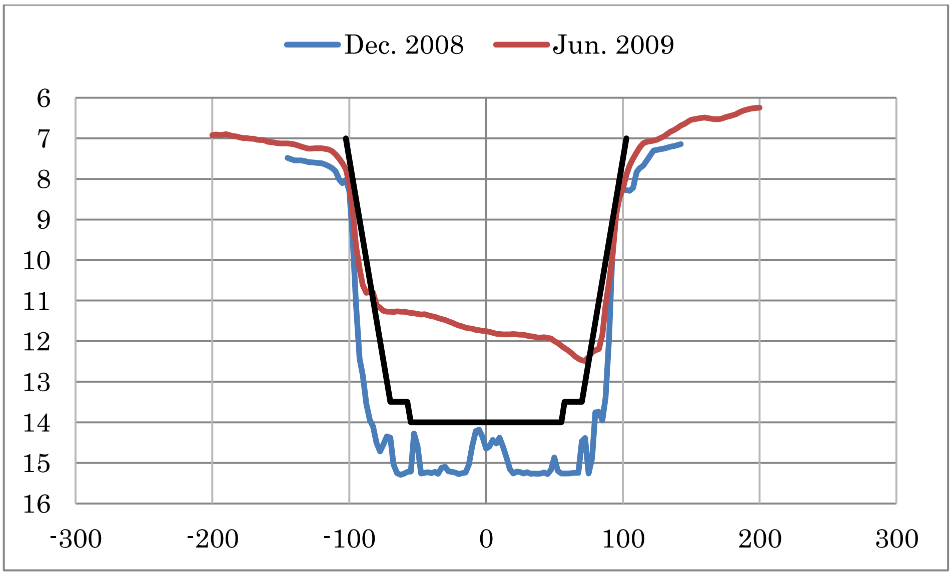


Figure C.8 Comparison of cross sections along L19, after the second full dredging

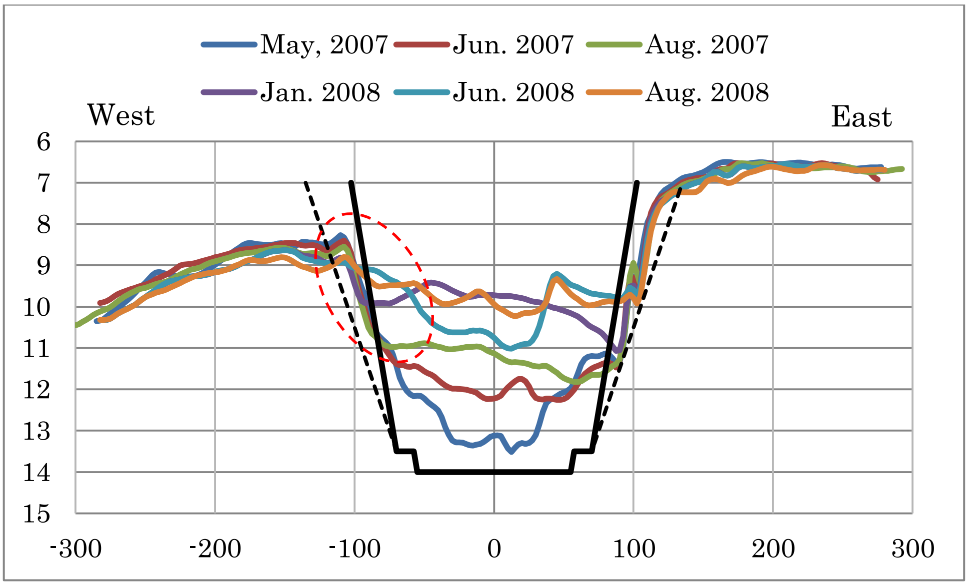


Figure C.9 Superposition of 6 cross sections along L18

Figure C.9 shows a superposition of 6 sections along the reference line L18. Although the eastern side-slope was out of position, being slightly eastward from the planned location, its slope was being stable with a slope of 1V/5H during about 16 months from May, 2007 to August, 2008. On the other hand, the western side-slope was 1V/10H in the first half period. However, as of May, 2007, which was an initial point of monitoring, the slope was already 1V/10H. In the second half of period, the slope itself disappeared due to the sedimentation. Then, the situation was indistinct.

The results of consideration are listed in Table C.1. According to this table, the side-slope in the Inner Channel was stable after dredging, being 1V/5H as the plan.

Table C.1 Stabilities and slope of the side-slope in Harbor basin and Inner Channel

	Western slope	Eastern slope
L22	Non	Stable 1/5
L21	Stable 1/5	Stable 1/5
L20	Stable 1/5	Stable 1/5
L19	Stable 1/5	Neglected
L18	Indistinct	Stable 1/5

C.2 Possibility of Channel Relocation

As one of the alternatives, possibility of channel relocation has been examined. Figure C.10 and Figure C.11 show the results of bathymetric survey conducted on 19 April, 2013.

From the figures, some characteristics on bathymetry of western side of the present channel are found as follows,

- The western deeper area is quite locally.
- There is information that eastern area was deeper previously, and channel relocation based on one bathymetric data is risky.
- The present channel was dredged twice although it has been refilled. Re-dredging can be easy because the refilled mud is probably softer than that of other areas.
- If the constant siltation speed will be verified, siltation does not depend on the depth difference between in and out the channel. This indicates that the deep original depth cannot be an advantage for maintenance dredging.

These characteristics indicate that there is no positive reason to relocate the channel westward.

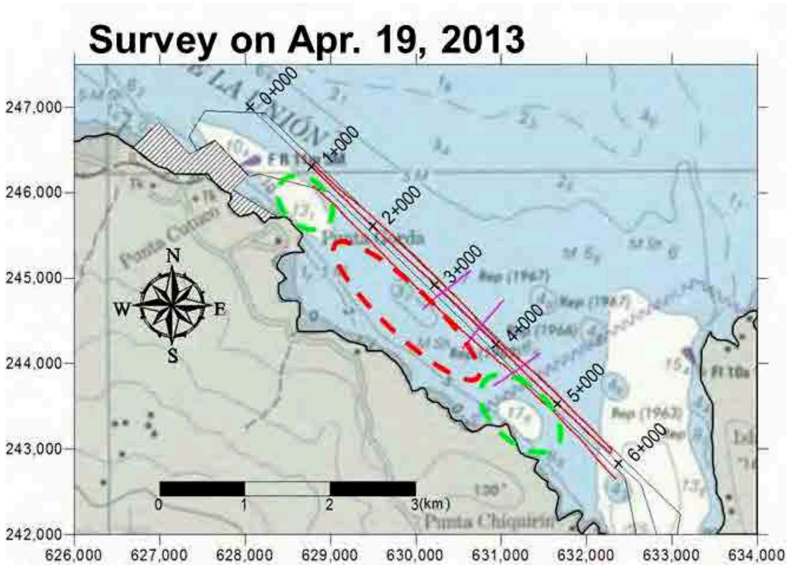


Figure C.10 Track chart of bathymetric survey on 19 April, 2013

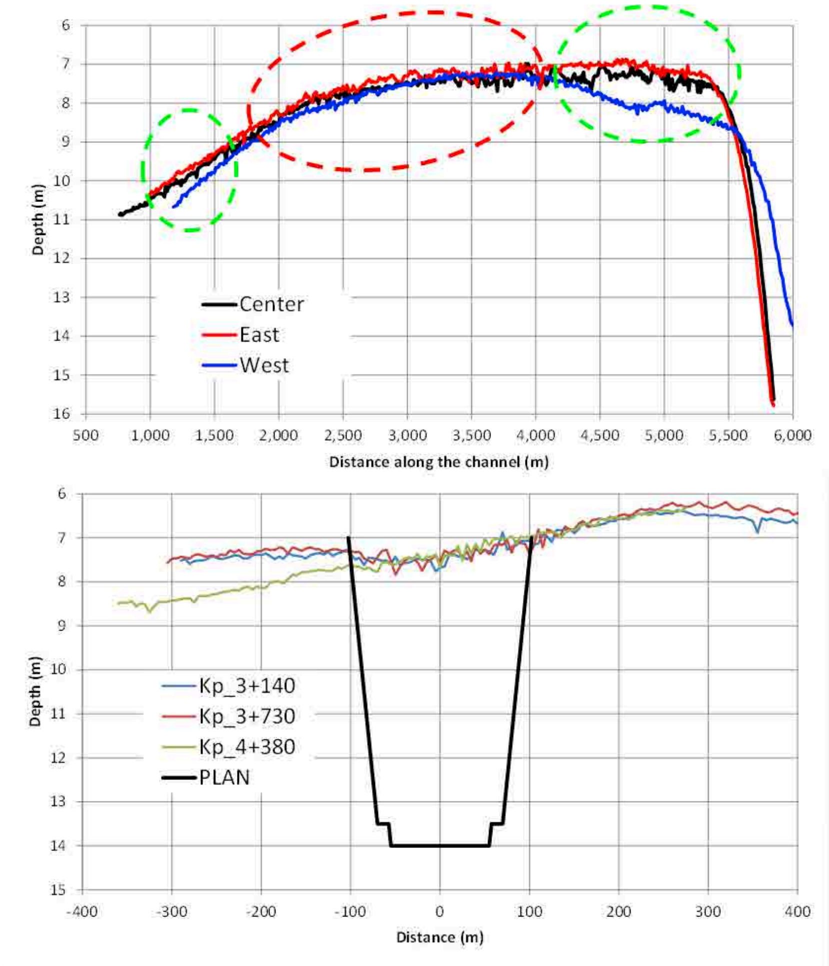


Figure C.11 Result of bathymetric survey on 19 April, 2013

C.3 Rake-Dredging

C.3.1 Method of Rake-Dredging

In La Union port, rake-dredging was conducted in the period from August 2012 to January 2013. The rake-dredging is a kind of agitation dredging, and is expected as a dredging method easily implemented for La Union Port. Figure C.12 shows the rake utilized in La Union port. The method of rake-dredging which conducted in La Union port is described below.

Figure C.12 Photographs of Rake utilized for rake-dredging

Figure C.13 shows an area of the rake-dredging. The rake-dredging was conducted in the section of about 4km between the buoy No.15 and the buoys No.13, 14 in the Inner Channel.

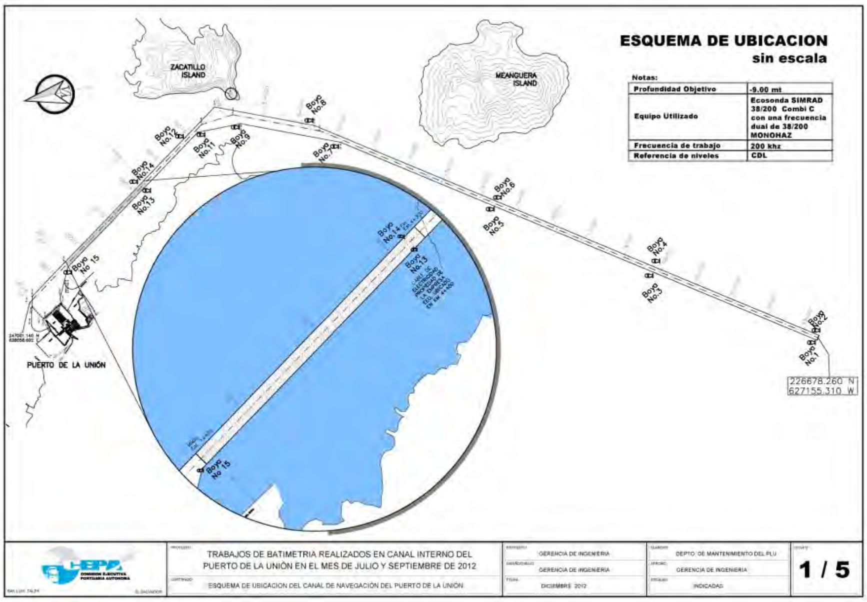


Figure C.13 Area of rake-dredging in Inner Channel

Figure C.14 shows a method of rake-dredging. The channel section of about 4km in the longitudinal direction is divided in three segments, of which length is about 1.3km each. In one segment, the rake-dredging was continued for five days, by repeating the dredging pattern 1 and

2 in turns. A sequence of segment for the rake-dredging is from segment A to B, to C, and to A again. The rake-dredging was usually conducted during the ebb tide.

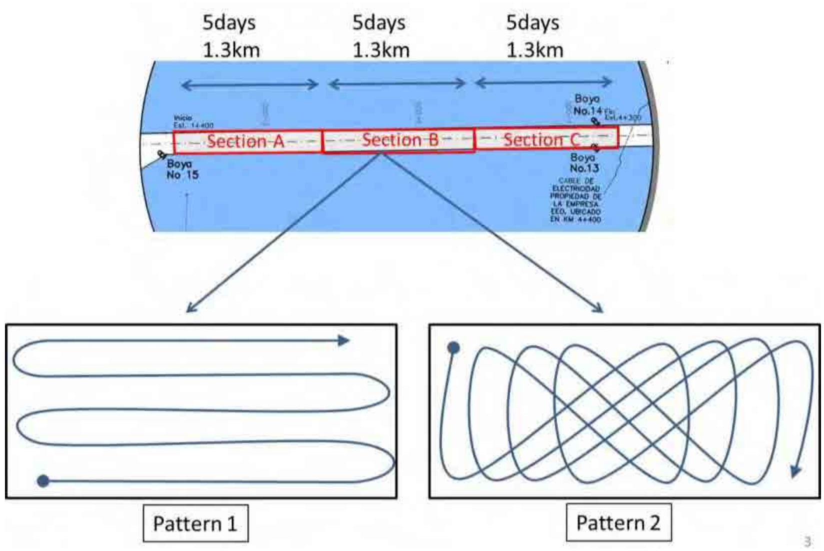


Figure C.14 Method of Rake-dredging

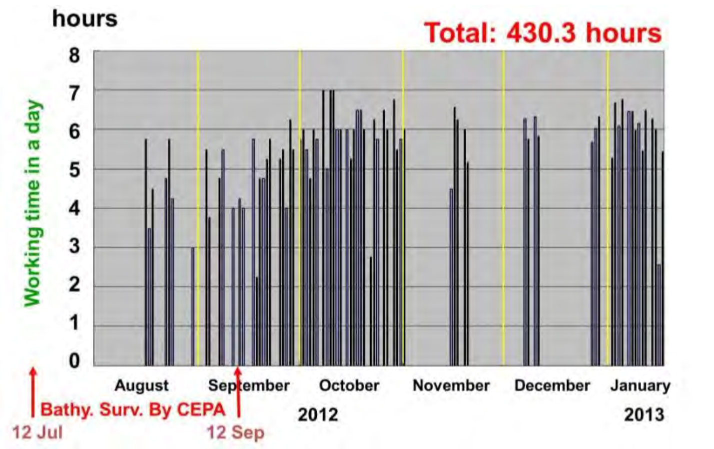


Figure C.15 Record of working hours for Rake-dredging

There is no record which is directly related to the rake-dredging, such as date, time, location and route of rake dredging. The data only remained is the time card of crews and workers of tugboat, in which the time of departure from the port and that of return to the port on the working day.

Figure C.15 is a bar graph, which shows working hours in a day during the term from August, 2012 to January, 2013. The actual hours for rake-dredging are shorter than the working hours shown in Figure C.15, which is unknown.

The rake-dredging was started in mid-August, 2012, and it was conducted intensively during a term from the mid-September to the end of October. Implementation rate of rake-dredging was very low in two months of November and December. Although the rake-dredging seemed to revive in January, 2013, it was not conducted thoroughly during a term from late in January to the end of March, 2013.

C.3.2 Evaluation of Rake-Dredging

Figure C.16 and Figure C.17 are only bathymetric data we can obtain for examining an effectiveness of the rake-dredging. The bathymetric survey were conducted two times, that is to say, on 12 July, 2012 and on 12 September, 2012 which are before and after the start of rake-dredging respectively (see Figure C.15). According to comparisons between the sea bottom profiles before and after the rake-dredging in the longitudinal direction in Figure C.16 and that of cross section in Figure C.17, those are almost the same. In short, it is very hard to confirm the effectiveness of the rake-dredging by utilizing these data.

By checking dates of bathymetric surveying, we can understand that the term between these dates does not include the intensive dredging during the period from mid-September to the end of October. Therefore, it must be considered very carefully to conclude that the rake-dredging is not effective.

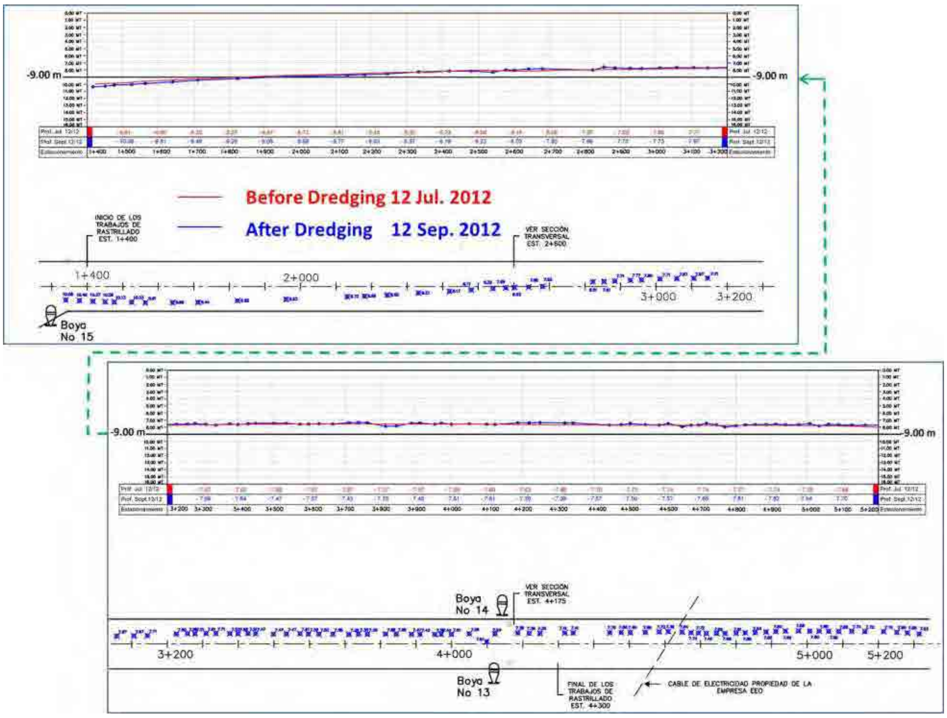


Figure C.16 Comparison of bottom profiles, before and after rake-dredging (Longitudinal section)

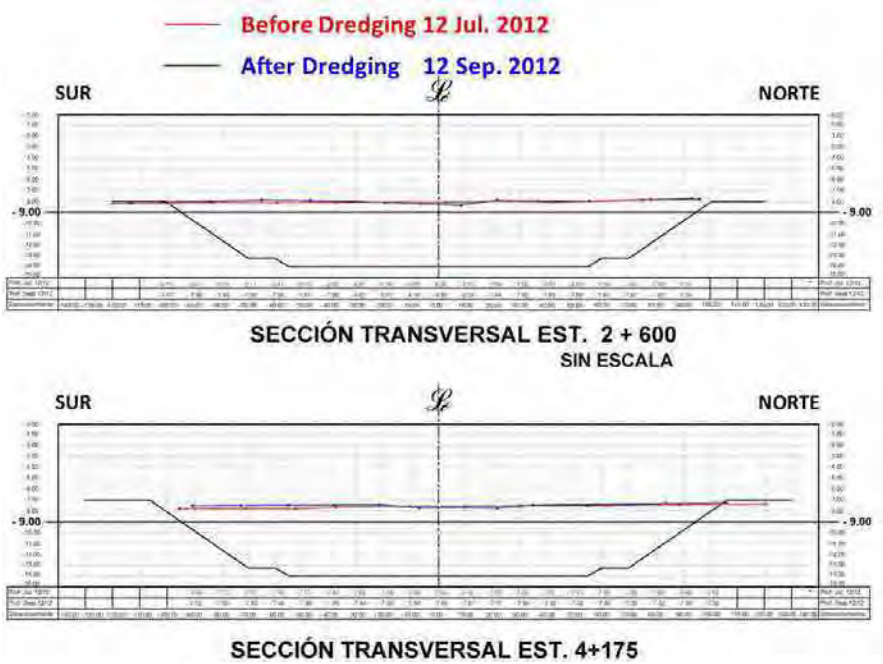


Figure C.17 Comparison of cross sections, before and after Rake-dredging

C.3.3 Dredging methods by using current

(1) Water Injection Dredging (WID)

Water Injection Dredging (WID) is the kind of new dredging method which has only 25 years history and the patent is owned by Van Oord. WID is to move the solid in the condition of fluid mud, fluidizing the layer of the soil in the vicinity of the surface of sea bed, by means of injecting low pressured water jet into the sea bed from the nozzles with the diameter of around 5 cm installed in submersible pipe frame installed to the self-propelled boat like the one shown in Figure C.18.

This method is based on the hydrodynamic theory of density flow and then completely different from agitation dredging which relies on dispersion of soil turbidity plume. Fluid mud layer moves just over the sea bottom only and thus the environmental effect is very limited comparing the dispersion when it makes meaningful effect of dredging. And also this method does not need any energy for transportation of soil and thus extremely economical and thus environmentally friendly not like conventional types of dredgers.

Figure C.18 WID vessel (Source: PIANC Report No. 120-2013 INJECTION DERDGING (J. Smith et al. 2013))

The dredging process is like below:

1) To decrease cohesion of soil of sea bottom layer by water injection
2) To fluidize the soil layer (1 to 3m thickness) of sea bottom
3) Generation of density current due to the difference of density between the fluidized soil layer (fluid mud) and the sea water around (just like salt edge of estuary)
4) Settlement of soil particle when internal friction of the fluidized soil layer overcomes the driving power due to consolidation of the soil layer during transportation

The driving power of the flow in the step 3) above is the difference of hydraulic static pressure due to the difference of the density and static liquid pressure between the fluid mud and the sea water. And then when the driving power overcomes the internal friction and friction at the sea bottom, the density flow starts. (Refer to Figure C.19) The soil particles once fluidized by the water jet gradually is consolidated during transporting. And then the internal friction increases to overcome the driving power, the soil particles start settling. The transport distance depends on site conditions. The natural flow such as river flow and tidal current will support the density flow depending on the direction.

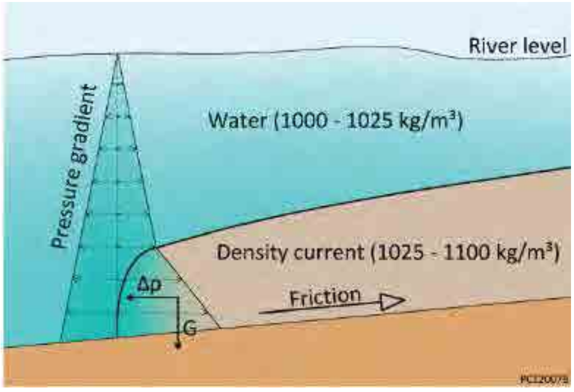


Figure C.19 Driving force of fluidized soil layer (Source: PIANC Report No. 120-2013 INJECTION DERDGING(J. Smith et al. 2013))

As mentioned above, WID is to transport soil by its own power, supported by the natural flow, thus, the application needs the study of natural conditions such as soil characteristics, tidal currents, wave, bathymetric condition, the mechanism of sedimentation. Simply saying, the smaller the soil particles and the less the soil cohesion, the easier the fluidizing. However, in the actual conditions the matter does not go completely theoretically.

In PIANC Report No. 120-2013 are reported 10 examples of river ports or river mouths. These examples show that the theory only works where a unidirectional river current exists. The production rates are shown in Table C.2.

Table C.2 Typical production rates in WID project

Project Name	Soil Description	Volume (m^3)	Duration (hours)	Production Rate (m^3/hr)
Epon Harbour, Delfzijl, The Netherlands	Silt & sand D_{50} 0.3mm	160,000	200	800
Haringvliet Harbour, The Netherlands	Silt/clay	121,000	252	480
Crouch River, United Kingdom	Clayey silt	6,200	12	540
Upper Mississippi River 1992	Sand 0.3 – 0.4mm	6,154	44	140
Calumet 1994	Silt 0.004-0.05mm	12,034	24	502
East and West Calumet floodgates	Silt 0.004-0.05mm	17,900	17	1,080
Michoud 2002	Silt 0.06mm	178,642	96	1,861
Mississippi River Gulf Outlet (MRGO) 2003	Silt	269,230	96	2,800
Weser Estuary, Germany, 2009	Sand 0.6 mm	650,000 (per year)	1,200	550
Elbe Estuary, Germany, 2009	Sand and Silt 0.05-0.6 mm	1,500,000 (per year)	2,000	750

(Source: PIANC Report No. 120-2013 INJECTION DERDGING (J. Smith et al. 2013))

(2) Underwater Plough

Plough is to agitate the sea bottom dragging the large steel frame, which is similar to the plough used in cultivating farms, lifted down from a tug boat so that the soil particles are expected to suspend into the water and to move away by dispersion. Since this method makes agitation of sea bottom, it may be categorized as one of agitation dredging. However, as it is called “bed leveler”, it is normally used as the supporting measure for the other dredging methods, for example, to mitigate the unevenness of the dredged surface after dredging especially by a grab dredger, basically making balance of soil volume within the area with the short distance.

This method expects soil transportation by mechanical power or by dispersion system with the aid of natural water flow. Which system is dominant is depending on the shape of the leveler (plough). The leveler which has the shape like a dust pan (See Figure C.20) can bulldoze soil inside of the pan mechanically, and the leveler which has the shape like a fork, may expect agitation and dispersion.

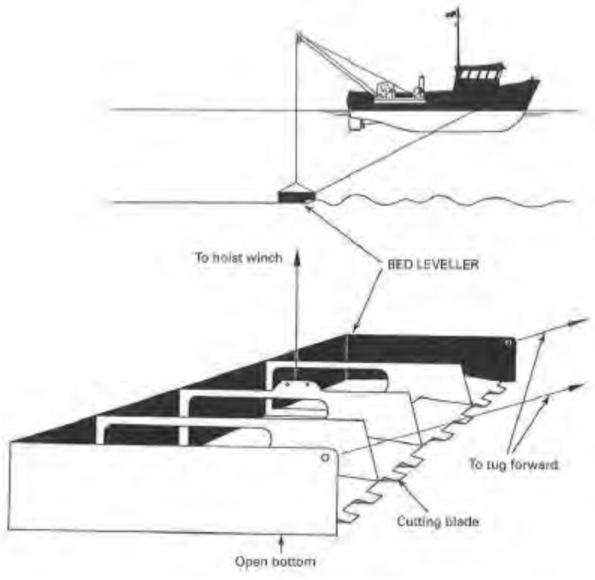


Figure C.20 Bed Leveller (Dust Pan Type)
(Source: “Dredging; A handbook for engineers” R N Bray et al. 1998)

There is an area in Japan where affects adverse impact to the fishery in shallow sea area due to the deterioration of water quality and bottom sediment. Cultivations of sea bottom have been tried throughout Japan to improve this situation. As the result, the water quality has been improved (the turbidity at bottom layer is observed as 150 to 300mg/ℓ at the maximum) however, the bottom sediment was not clearly improved. Underwater plough used is generally 2m x 2m to 2m x 5m with the weight of about 300kg. Generally, plough dropping down to sea bottom from stem of fishing boat is towed. The covering area by one time is about 1km x 1.5km and approx. 10 fishing boats make round trips for 8 hours with about 4 knots at the same time. The above is referred to “Study on “Cultivation of Sea Bottom” to Adjust Seawater Nutrient Imbalance” (Nakanishi et al. 2012). Figure C.21 shows the example of plough. Plough and rake are almost the same dredging method though plough is used as the bed leveler in Europe and to improve sea bed quality in Japan. However, there is no case that rake size now used in La Union Port is used for maintenance dredging.

Figure C.21 Example of plough in Japan
(Source: Impact on survival and growth of young shell with the change of bottom sediment of the cultivation of sea bottom in Japanese (Mizuno et al. 2006))

(3) Agitation Dredging

The agitation dredging is to transport the soil particles, which are suspended into the water by agitation of the vicinity of the surface of the sea bottom by some measures, by means of dispersion with the aid of natural flow such as river flow or tidal current. Agitation methods are for example, "plough" as mentioned above, water jet and cutter head of cutter suction dredger. In case of cutter head, dredged material from cutter head by cutter suction dredger is discharged overboard instead of transporting by discharge pipeline. If plough is found effective by experiment, it needs only a tug boat and "plough" steel frame and thus should be very economical.

According to Francis Way et al., dragging I-shaped steel beam by a tug boat during ebb tide as the maintenance dredging was performed in Savannah Harbor, Georgia, USA since 1932. Since this method was stopped in recent years from the environmental consideration, the experimental research of the dredging method was executed to evaluate the effect.

In the experiment, two methods i.e.; dragging the I-beam frame with comb-like projections and the cutter suction dredger's outboard discharging were performed, and chronological and geometrical change of TSS(Total Suspension Solid), water temperature, salinity, turbidity dissolved oxygen, pH, etc. were measured.

As the result they found the followings:

-Suspended soil by the result of I-Beam agitation was found not more than 3 m above the sea bottom and not farther than 600m from the agitated point.
-The concentration of the suspended soil was found maximum 200mg/ℓ at the place of the agitation.
-The above concentration rate is almost same level of the turbidity of the agitation by approximately 15 minutes operation of the propeller of the navigating vessel.
-Suspended soil by the cutter suction dredger's outboard discharging was found TSS 760mg/ℓ at 30m downstream of the agitated point and the maximum transportation found was 1,500m.
- At this time, comparatively coarse soil particles settled within 600m downstream where TSS dropped to approximately 150mg/ℓ and only fine particles went more than 600m.
-Therefore, they concluded that they did not find the facts that agitation dredging caused unacceptable serious environmental effect

However, this conclusion means that it does not produce considerable dredging result from on the other hand. Although it is not yet clearly asserted since the above report did not include the detail data of water flow and soil characteristic, it seems that the substantial movement of soil by I-beam frame agitation is limited to the maximum of 300m and the solid content is 0.1% to the maximum, that is less than 1/100 of the dredged material of TSHD. Therefore, it may be reasonable to assume the dredging effect is in the smaller area than 300m. On the other hand, since Inner Channel is 5km long and Outer Channel is 16km in this project, the distance of transportation must be too short. More than that, since the effect seems less than 1/100 of TSHD, this agitation dredging should have 100 vessels in order to make equivalent productivity of 1 TSHD.

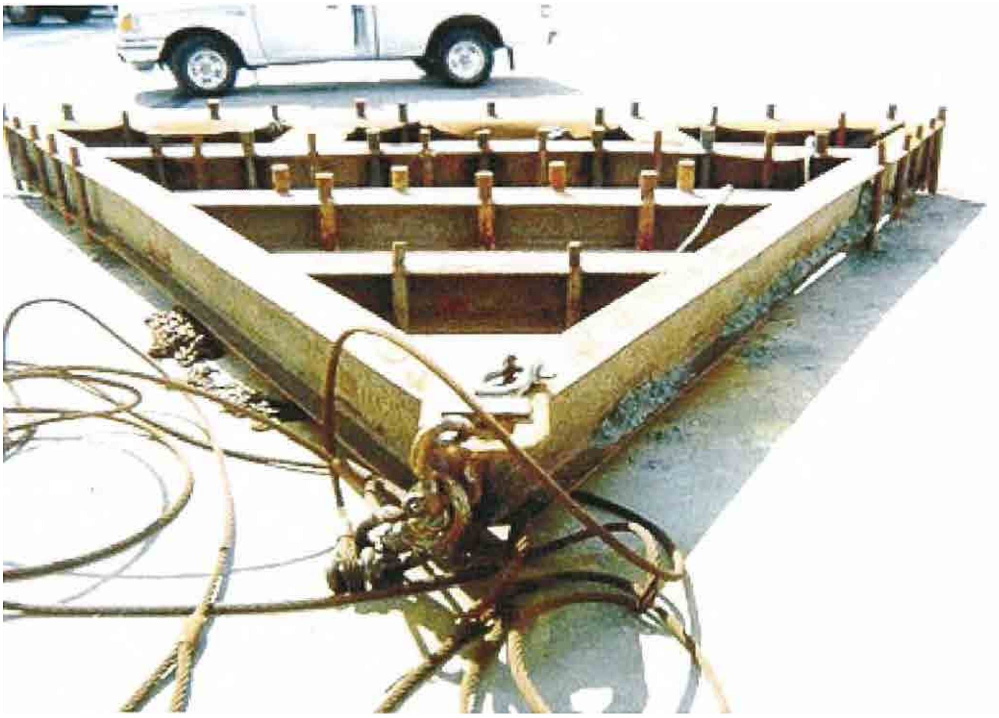


Figure C.22 Example of I-beam agitation dredging

(Source: EFFECTS OF AGITATION DREDGING IN SAVANNAH HARBOR(Francis Way et al.) (https://www.westerndredging.org/index.php/information/proceedings-presentations/category/72-session-8c-dredging-project-case-studies%3Fdownload=300%3A4-way-et-al-effects-of-agitation-dredging-in-savannah-harborpdf , February 28 2014))

C.4 Comments on CEPA's Plan

(1) CEPA's Plan of island construction

CEPA is considering that, in order to reduce the volume of siltation in the navigation channel, turning basin, and the berthing stations, the semicircular artificial island will be constructed in the waters of the La Union Bay as a one of long-term alternatives, for which a site has been identified one kilometer to the North-west of the port (see Figure C.23). This island is called the semicircular island hereinafter.

They expect the benefits of construction of this island for the La Union Port are as follows:

a) An alternate dump site for sediment materials located just one kilometer away from the port would represent saving of 40% compared to the current dredging plan.
b) Redirecting materials pulled by marine currents will greatly reduce the future sedimentation of the navigation channel of the La Union Port.

c) Reforestation of the island with mangrove plantation will provide expanded marine habitat for different species to avoid their extinction; mangrove reforestation will also help prevent the erosion of the marine environment of the La Union Bay.

Among these expected benefits, the items a) and b) will be examined briefly.

Figure C.23 Location of Planned artificial island, one kilometer north-west of the port

(2) Benefit of artificial island for dumping site

As a radius of the semicircular island is 1km, an area of this island is 1.57million m^2. If the water depth at the construction site is assumed to be 5 meters based on a marine chart, the capacity for accepting the dredged soil is 7.85 million m^3. Whereas, the volume of dredged soil from the basin and the Inner Channel is shown by the maintenance depth in Figure C.24, which are predicted by the modified Exponential Model for the dredging cycle of three months. For example, in the case of 12 meters as the maintenance depth, the volume of dredged soil is 2.3 million m^3 per year. If all of dredged soil from the basin and the Inner Channel is dumped into the semicircular island, it is filled in 3.4 years. In short, a period when the semicircular island has a function as the dumping site is limited.

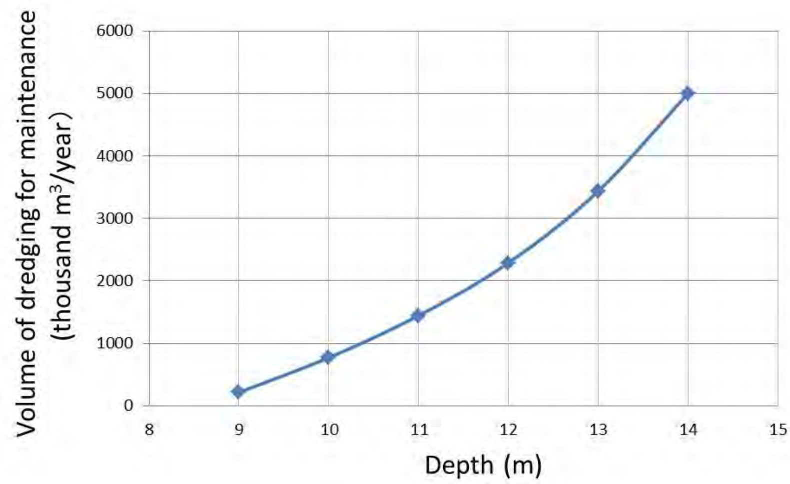


Figure C.24 Volume of dredging for maintenance in the Basin and the Inner Channel

As an example, the trial estimation is done about how much the dredging cost is reduced when the dredged soil from the basin and the Inner Channel is dumped into the semicircular island. The method of dredging cost estimation will be explained precisely in Chapter 6. The conditions of estimation are as follows;

- Dredging works : Contract base
- Prediction model : Modified Exponential Model
- Dredging cycle : Three months
- Dumping system : The same as offshore dumping (no additional use of special measures)
- In the estimation of dredging cost, the dredging of the Outer Channel is also included.

Results of estimation are shown in Figure C.25 and Figure C.26. Figure C.25 is a comparison of dredging costs between the dumping of dredged soil at the offshore and into the semicircular island. A cost reduction rate, which is a ratio of the former dredging cost to the latter one, is also shown in the same figure. The cost reduction rate decreases with the target depth of maintenance down to less than 60 percent, as expected by CEPA. The reduction of cost is due to the decrease of distance from the dredging site to the dumping site. The time required for one turnover of vessel becomes shorter, which reduces the hopper capacity necessary for dredging, as seen in Figure C.26.

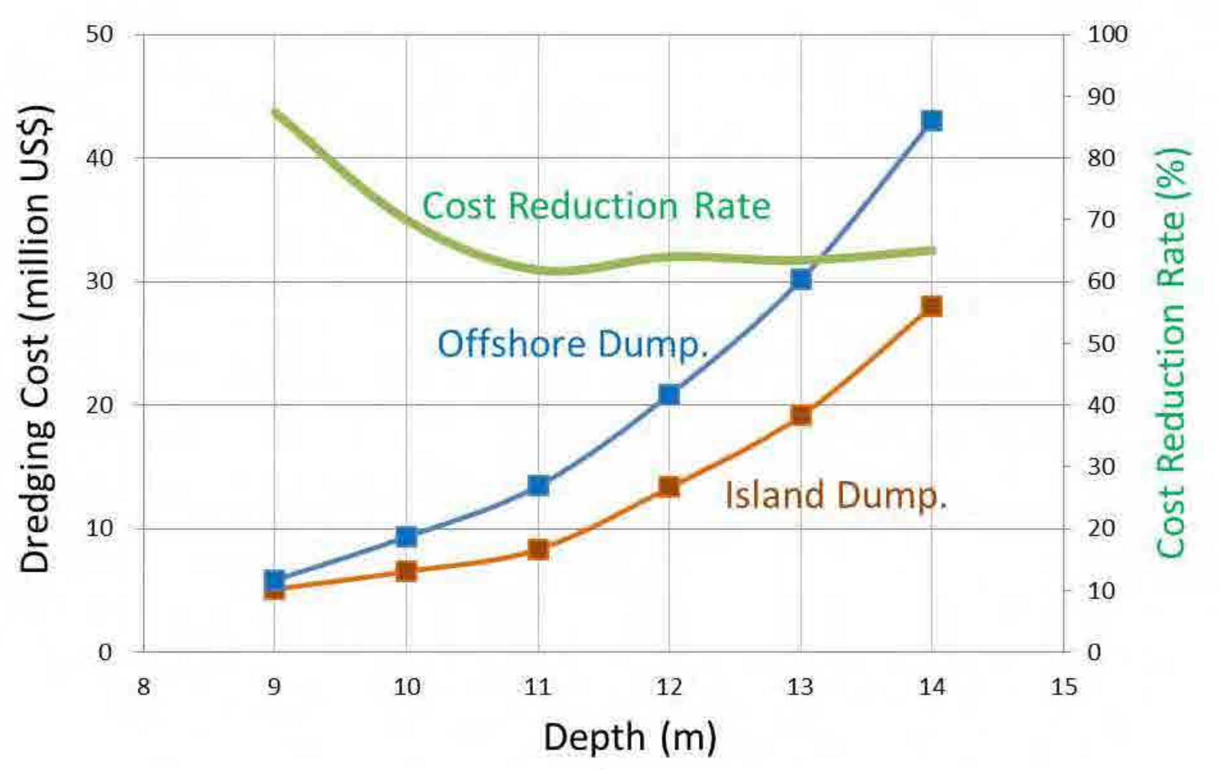


Figure C.25 Comparison of dredging costs between the dumping at the offshore and into the semicircular island

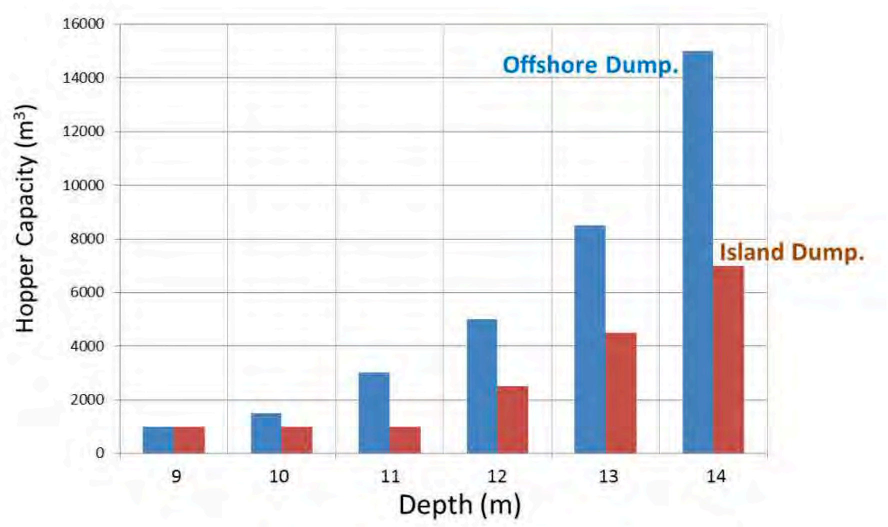


Figure C.26 Comparison of required Hopper Capacity between the dumping at the offshore and into the semicircular island

(3) Benefit of artificial island for reducing the siltation volume

Figure C.27 to Figure C.30 show some examples of artificial island constructed in Japan. The construction works of these islands are combined with disposal of dredged soil from the channel and the basin. When a large-scale structure such as an artificial island is constructed in the sea, special care shall be paid so that its influence on its surrounding environment, of which a representative physical condition is currents, becomes less as much as possible.

Figure C.27 shows the Kita-Kyushu Airport constructed nearly parallel to the land, which can reduce its influence on tidal currents.

Figure C.28 shows the Chubu Centrair International Airport in Ise Bay. A corner of island which is located closest to the land is removed and curved smoothly to avoid the disturbance of tidal currents.

Figure C.29 shows two semicircular-like islands with beach and tidal flat at the Kasai Seaside Park, in Tokyo Bay. As there is a bridge to the island on the left, people can cross, while they cannot do it to the island on the right because it does not exist a bridge here. The latter is for preservation of diversity of an ecosystem including wild birds. The side walls of semicircular are designed and aligned so that the currents from the river are not disturbed.

Figure C.27 Kita-Kyushu Airport

Figure C.28 Chubu Centrair International Airport

Figure C.29 Kasai Seaside Park

Figure C.30 Tokyo International Airport (Haneda Airport)


Figure C.31 Runway supported by pile group

Figure C.30 shows the Tokyo International Airport, or Haneda Airport, in Tokyo Bay. The runway cannot be shifted in the direction to Point A because there is a large navigation channel. As a result, the runway is extended to the area in front of river mouth, which blocks discharge from a river. In order to avoid this situation, a part of runway surrounded by a dotted line in Figure C.30 is supported by a pile group (see Figure C.31). As the pile group is permeable against the river current, the undesirable influence is reduced as less as possible.

Like in these examples, it is a general rule that the influence of a large-structure on the surrounding waters should be reduced as less as possible when it is constructed in the sea.

In Japan, there is few experience of controlling the tidal currents by the large scale structure such as planned by CEPA. So it is very difficult to empirically predict what kinds of results are expected. Although a lack of experience, the influence (or effect) of the semicircular island on the siltation in the channel is ventured to expect.

Figure C.32 shows a result of a movable-bed physical model on the change of sea bottom topography around a columnar caisson due to the tidal currents. The caisson with a diameter of 80 meters in a field is represented in the model. Erosions occur at both sides of the caisson to the direction of tidal currents, where the currents become faster after the construction of the caisson. Whereas, sand deposits in front of and behind the caisson, where the currents become slower. In this experiment, sand is used as a movable bed material. In a case of fine silt, areas of erosion and deposition may expand wider in the field than those of the experiment.

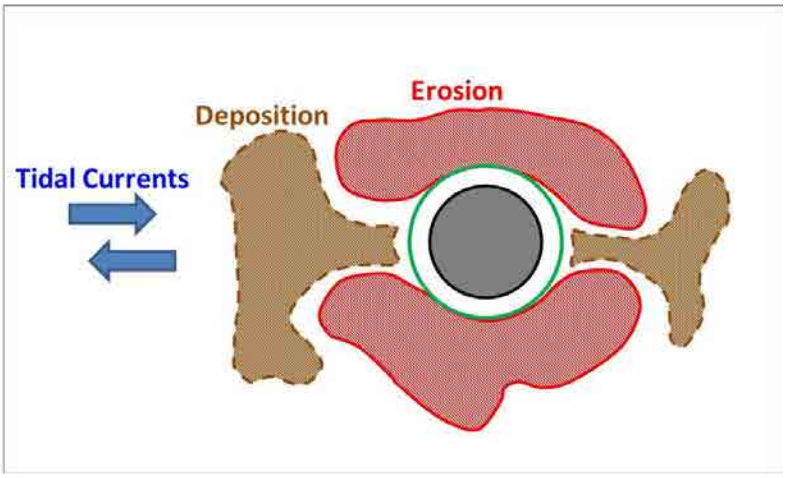


Figure C.32 Erosion and sand deposition around a column in physical model

Kashima, S., et al.(1991): Study on scour characteristics for large bridge foundation under strong tidal current, Journal of Civil engineering, JSCE, No.438/ II -17, pp.51-60 (in Japanese).

Figure C.33 El Tigre Island in Fonseca Bay shows the Fonseca Bay, in which the El Tigre Island of circular configuration is located in the sea area enclosed by a red line. Figure C.34 shows the sea bottom topography around the island. Against the principal direction of tidal currents, the pattern of erosion at both sides and the accumulation in front of and behind the island is very similar to that shown in Figure C.32.

Figure C.33 El Tigre Island in Fonseca Bay

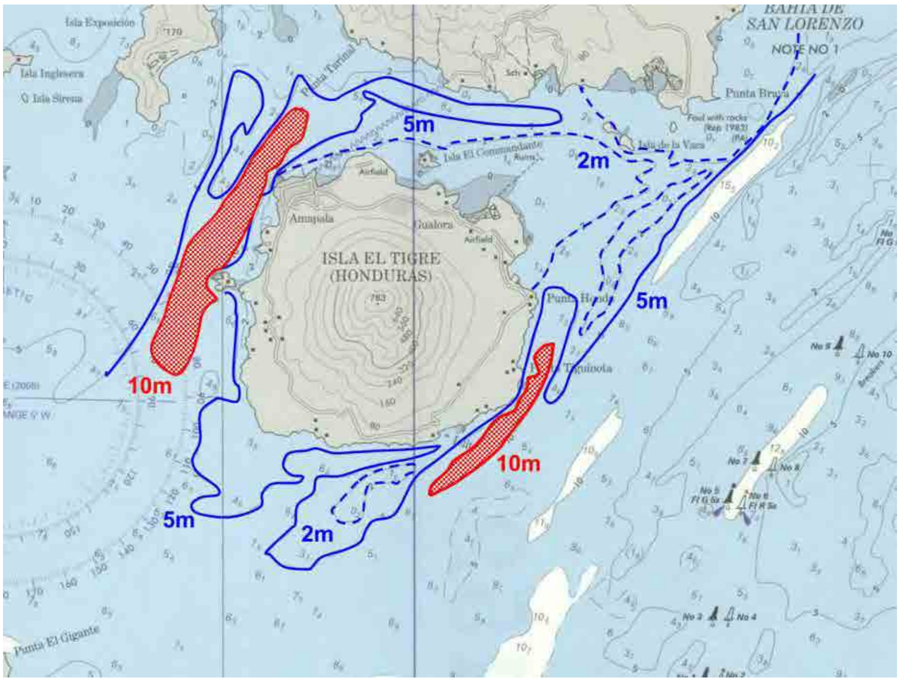


Figure C.34 Sea bottom topography around the Isla El Tigre Island

When some structure will be constructed in the sea, changes of sea bottom topography around it can be found by inferring the change of flow pattern. The pattern of topographic change is simple, that is to say, the area where the current velocity becomes faster comparing before the construction of structure is eroded and the water depth is deeper, while sediment deposits in the area where the current velocity becomes slower and the water depth is shallower.

Figure C.35 shows the changes of currents around the semicircular island in the ebb tide, which are expected only on the desk. According to the expected result, in the lee of the semicircular island the wake is generated, which reduces the current velocity in the area of the Inner Channel.

In short, the expected result means that the siltation becomes more severe than that before the construction of the semicircular island in the Inner Channel.

And also, in the narrow sea area sandwiched between the semicircular island and the land, the current velocity becomes faster. Then, the sea bottom is eroded, and the water depth becomes considerably deep which might cause the erosion of La Union City in the worst case. The situation that the water depth becomes considerably deep in the narrow pass can be easily understood in Figure C.36, where the water depth is deeper than 30 meters.

When we consider this way, there is a possibility that the semicircular island makes the situation worse rather than it will produces the benefits which CEPA expects.

Anyway, the consideration is done only on the desk. It is recommended that the influence (and effect) of semicircular island must be examined very carefully by taking enough time before construction it.

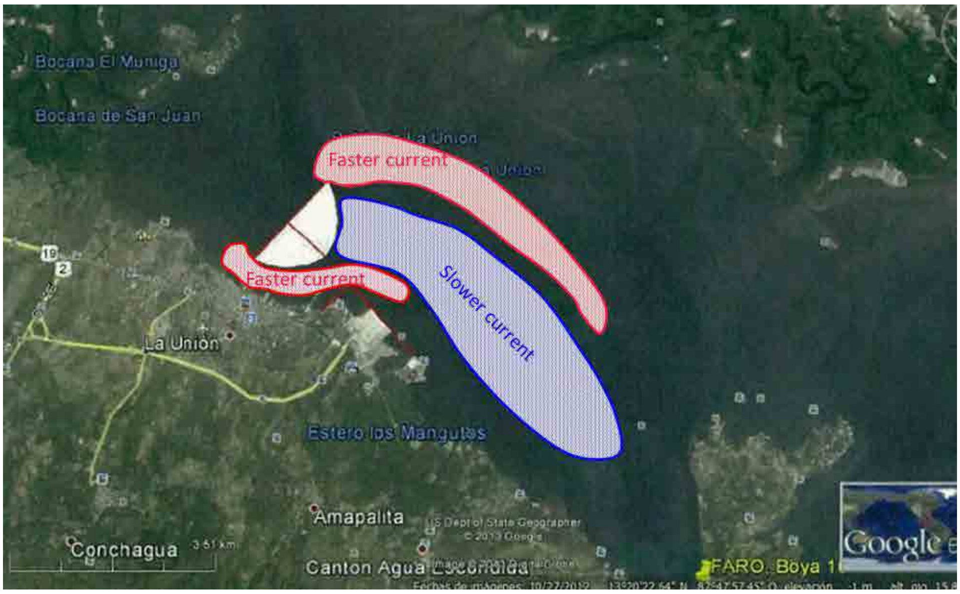


Figure C.35 Expected changes of currents in the ebb tide

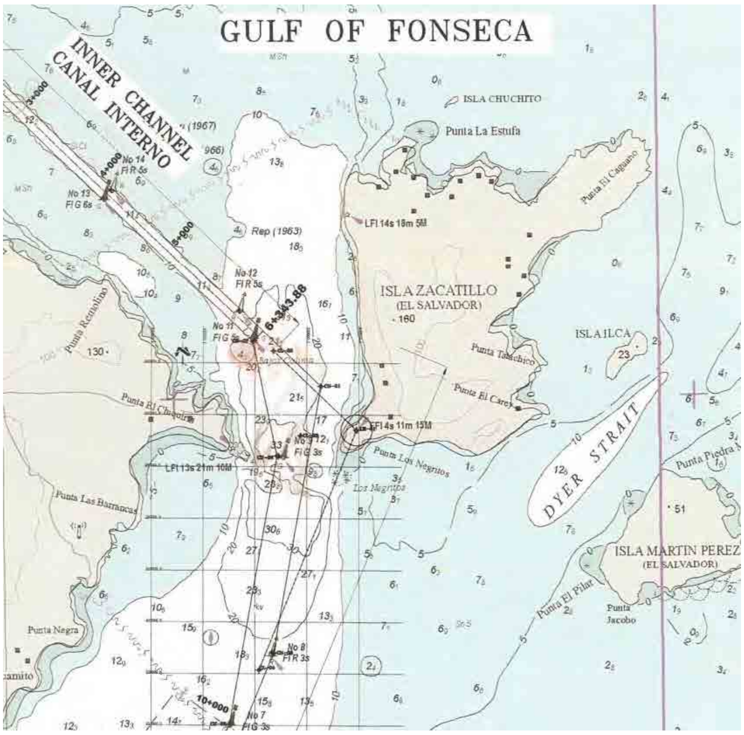


Figure C.36 Deep depth at the narrow pass

C.5 Dredging Method

C.5.1 Type of Dredger

This section presents the overview on several major types of dredging equipment.

(1) Non-Self-Propelling Cutter Suction Dredger (CSD)

1) Overview

Cutter suction dredger is the dredging vessel equipped with a large centrifugal pump on the main pontoon type body. This pump sucks slurry of excavated soil and water agitated by a cutter head (crown shape frame with teeth attached, which is rotating) through the riser pipe along the steel beam arm called "ladder". The sucked slurry is transported hydraulically through the discharge pipeline which is made normally of steel pipes to a designated soil dumping site. Therefore, this dredging method is called hydraulic dredging. The photo and the conceptual drawing of typical cutter suction dredger are shown in Figure C.37 and Figure C.38.

This type of dredger is positioned by the spuds, which are 2 sets of pile to be able to elevate and to insert into sea bottom, and by the swing winch wires drawing through the end of the ladder connecting to the anchors installed on the sea bottom.

In this type of dredger, there is also cutter-less suction dredger which agitates the sea bottom by water jet injection, not by a cutter head, and sucks the agitated soil mixed with water by suction pump. Also there is "sediment-slime-dredger", which sucks the slime of sea bottom without agitation. It will be applied to the dredging of environmentally contaminated slime so that the dispersion of such slime should be minimized.

Figure C.37 Photo of Cutter Suction Dredger
(Source: "IHC Beaver Cutter Suction Dredger" International Marine Consultancy)

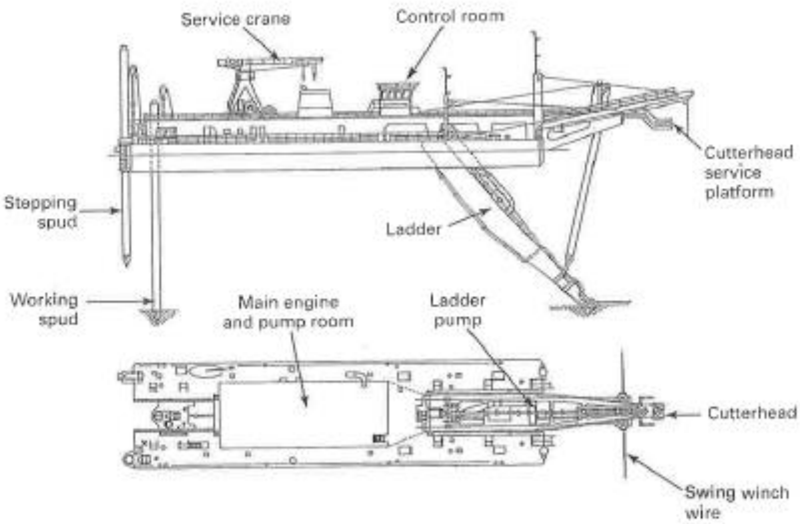


Figure C.38 Conceptual Drawing of Cutter Suction Dredger
(Source: "Dredging; A handbook for engineers" R N Bray et al.)

2) Dredging Method

A cutter suction dredger, while inserting one of its spuds into the sea bottom, swings its pontoon body around the inserted spud (working spud inFigure C.38) by means of operating its swing winch wires connecting to the anchors on the sea bed. By this operation, the cutter head locating at the end of the ladder swings along circular arc at the same time.

The cutter head is rotating by electric or hydraulic power, so that it agitates the sea bed soil around while a centrifugal pump suck the agitated soil mixed with water around through the riser pipe line to the pump. This operation continues along swinging arc. Once one swing arc cycle completes, the dredger goes forwards when another spud is inserted into sea bed. When all the area was dredged by this procedure over the area covered by the same anchor location, the anchors are weighed and re-installed at the next area. The dredging operation is done by repeating of the above.

<u>Characteristics</u>

The characteristics of cutter suction dredging are summarized as below:

- Cutter suction dredger is normally non-self-propelled and pontoon type body
- Its positioning system is by means of spuds and swing winches
- Anchor boat and tug boats are normally required as ancillary equipment
- Slurry of soil mixed with water is hydraulically transported through pipeline
- Discharged material contains a lot of water
- The dredging depth is structurally limited by the length of ladder

Operation Cycle

Dredging operation by cutter suction dredging is almost continuous repeating way. The flow chart of the cutter suction dredging is as shown in Figure C.39 below.

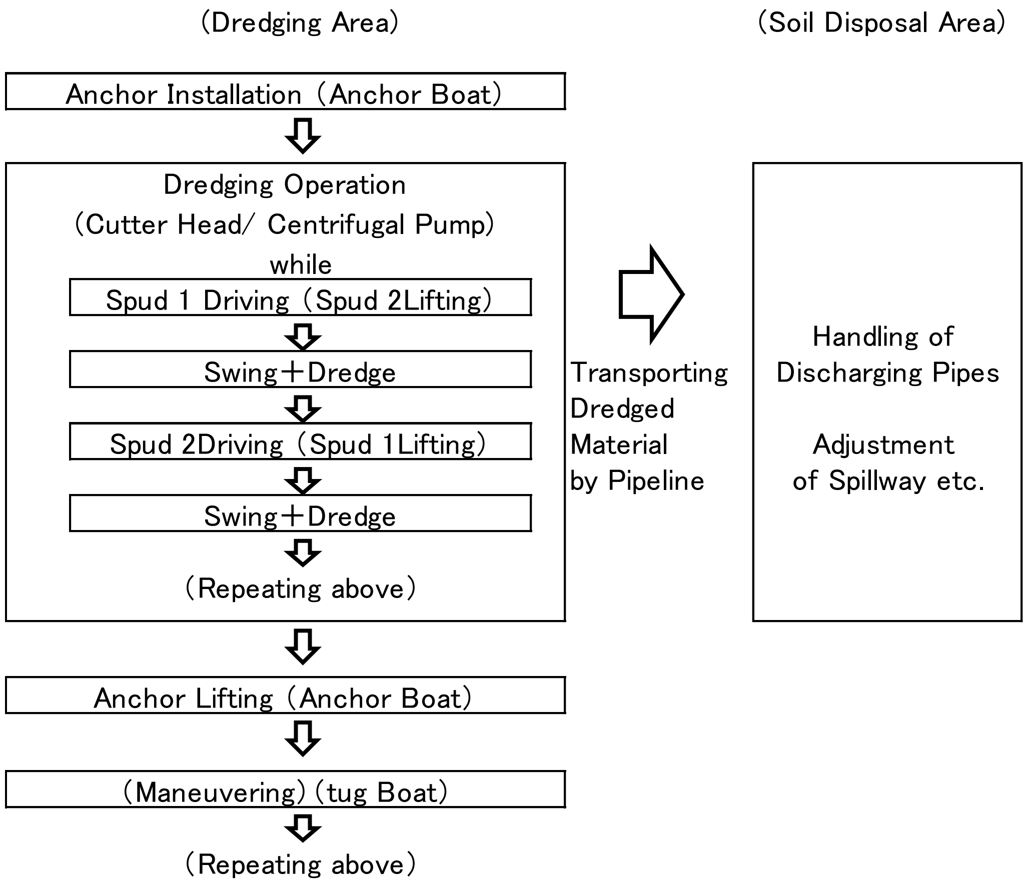


Figure C.39 Flow Chart of Cutter Suction Dredging

Soil Disposal Method

The most normal soil disposal method for the cutter suction dredging is to discharge dredged material from the end of pipeline to the dumping site, either on land or on water, which is often the reclaimed area for future use. The discharged dredged material is the slurry containing a large volume of water. Thus, the dumping site on water should be normally surrounded by seawall for reclamation project. The dumping site without boundary seawall is also possible; however, in this case, a certain level of turbidity may take place depending on the size of soil particles of dredged material. Therefore, mitigation measures for environmental impact such as installation of silt curtain should be required.

3) Advantage

Major advantages are as follows:

-The cutter suction dredger can correspond to wide range of material to be dredged, adjusting teeth and a cutter head together with the capacity of dredger

-The cutter suction dredger has comparatively high productivity if it is used under appropriate condition

-Reclamation and dredging can be performed simultaneously

-Soil transporting barges are not required

-The accuracy level of dredged finish is comparatively better

4) Disadvantage

Major disadvantages are as follows:

-The sea condition operable for cutter suction dredge is limited (it cannot be operated in the wavy sea due to its spud positioning system)

-When the dumping site is far, it is not economical (although it is possible to transport using booster pumps)

-Mobilization cost is high (since the dredger is non-propeller pontoon type hull, special vessel like lift barge is required for ocean mobilization)

-Not suitable for the heavy traffic navigation channels (discharging pipeline when it is installed on water with floaters may close the channel against navigation of other vessels)

-Solid content of dredged material is the smallest. Dredged material is in the slurry condition due to agitation of soil mixed with water, thus the excessive water should be drained and treated in dumping site, especially for fine soil, drain needs very long time.

-When the dredging area contains cobbles and the artificial debris with a certain level of strength such as steel wires, re-bars etc., the productivity of cutter suction dredger remarkably drops due to the stoppage of pump by their clogging.

5) Operational Limit

The economical operational limits of cutter suction dredgers are normally as below:

-Minimum depth that can be dredged: 0.75m

-Maximum depth that can be dredged: 35m

-Maximum wave height of operation: 2.0m (for big dredger)

-Maximum swell height of operation: 1.0m (for big dredger)

-Maximum cross current: 2.0knot

-Maximum particle size: 500mm (for big dredger)

-Maximum compressive strength of material that can be dredged: 10-20MPa

(2) Self-Propelling Trailing Suction Hopper Dredger (TSHD)

1) Overview

TSHD is the dredging vessel equipped with the hopper to load its dredged material and it has the suction pipe(s) lifted by gantries along the hull. A drag head is installed at the bottom end of the suction pipe, and the dredged material is sacked from the drag head by centrifugal pump and other supporting pumps, while the vessel sails forward. The photo and the conceptual drawing of a typical TSHD are shown in Figure C.40 and Figure C.41. The most of TSHD is equipped with twin-propulsion system and with bow thruster to enable the accurate maneuvering. The dredged material loaded in the hopper is normally dumped from the bottom windows of the hopper, or else the dredged material is discharged with discharge pipe connected at the shore. For reclamation along coast, the dredged material is sometime discharged by blowing through a nozzle at the bow (this activity is called “rainbow” because of the parabolic orbit of blown dredged material) Approximately 80% of TSHD is with the hopper capacity of 750 to 5,000m^3 although the hopper capacity available reaches 20,000m^3 at the maximum range.

Figure C.40 Photo of TSHD
(Source: “TSHD Glenn Edwards 10,000m^3” The art of dredging.com)

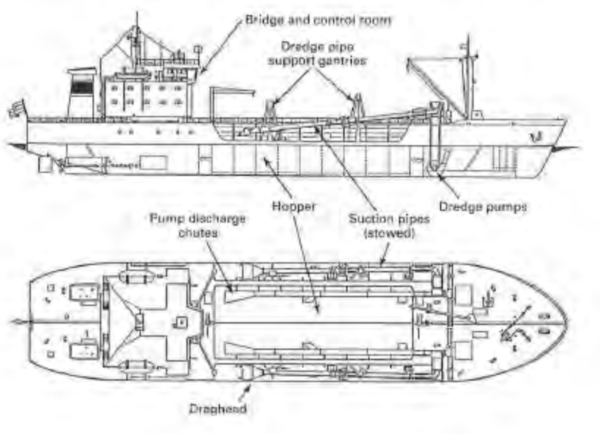


Figure C.41 Conceptual Drawing of TSHD
(Source: “Dredging; A handbook for engineers” R N Bray et al.)

2) Dredging Method

TSHD dredging method is the hydraulic dredging by means of drag head which is drug during the vessel sailing with the speed of 1 to 5 knot. The sea bottom soil collapsed around the drag head is sucked into it due to the water pressure difference between the inside and the outside of the suction pipe. Supporting device such as high pressure water jet and scraper may be used for hard sea bed. Drag head level is adjusted by winch with the aid of the sea bed contact pressure adjustment system so called “swell compensator” so that the vertical movement of drag head can be compensated for the vertical movement of hull body.

The dredged material is loaded in the self-contained hopper. The supernatant water of the top of the hopper after settlement of dredged soil in the hopper is discharged through overflow pipe through the bottom of the hull. The height of the overflow can be adjusted in accordance with the characteristics of the dredged material. In case of the fine particle soil, the loading operation is stopped once the overflow starts since the small particle soil does not quickly settle and continuous operation does not make difference. In case of the coarse particle soil such as coarse sand and gravel, the density of material in the hopper becomes high and thus TSHD loads normally 80% of the hopper capacity in the volume. Therefore, in this case the overflow level may be adjusted low. Hopper shape is designed so that the internal turbulence is minimized.

Recent TSHD is equipped with the system of LMOB (Light Mixture Overboard) or ALMOB (Automatic Light Mixture Overboard), which is to by-pass and discharge the sucked material not containing enough solid before loading to the hopper, in order to improve the efficiency. However, these bypass discharging systems and hopper overflow is the major cause of turbidity in this dredging method.

When the hopper is filled up, the suction pipes are stowed in the hull and the vessel self-propels to the soil dumping site and disposes the dredged material of the hopper through the bottom window of the hopper. Then, it comes back to the dredging area for continuous dredging procedure.

The soil disposal through the bottom window of the hopper needs only a few minutes, conversely, the soil disposal using the discharging pipe requires approximately an hour.

The main part of the vessel is occupied with hopper. The centrifugal pump is located at the bottom of the hull; however, submersible pumps are sometimes equipped in suction pipes.

Operation Cycle

Operation cycle becomes Figure C.42 as below:

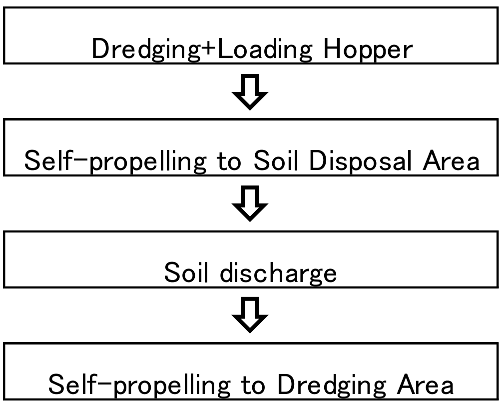


Figure C.42 Flow Chart of Operation of TSHD

Soil Disposal Method

For ocean disposal: dumping from the hopper bottom window

For coastal reclamation: hydraulic reclamation through discharge pipe line or blowing through bow nozzle

3) Advantage

- -TSHD is workable in wide range of sea climate due to ship hull structure and level stabilizing system of drag head
- -Maximum independency of operation without need of supporting vessel
- -Great transportation capacity of dredging material over long distance
- -Comparatively high productivity
- -Easy and thus economical mobilization due to its ship hull structure with self-propulsion system

4) Disadvantage

- -Not applicable to hard sea bottom
- -Sensitive for the concentration of gravel, cobble etc.
- -Small solid content as same as cutter suction dredging. (Solid content at the dumping site is a little more than cutter suction dredging since supernatant water in hopper is discharged by overflow)
- -The productivity drops when strong debris exists in dredging area just like cutter suction dredging

5) Operational Limit

The economical operational limits of TSHD are normally as below:

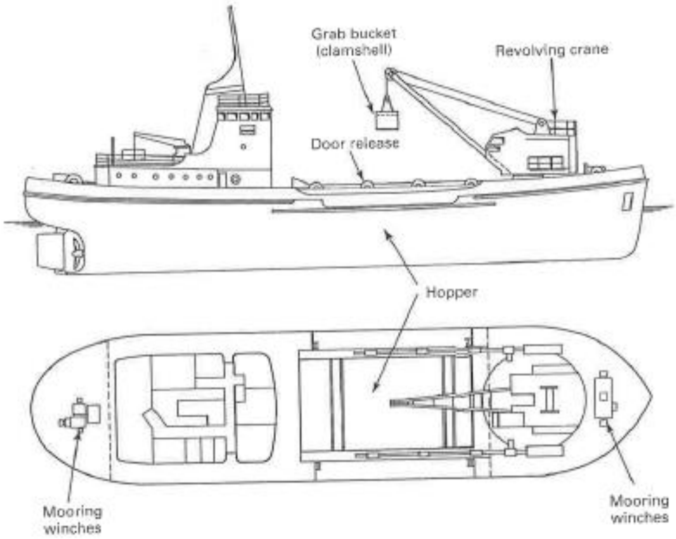
- -Range of dredging capability: 4-45m
- -Maximum navigational speed: 17knot
- -Minimum turning diameter: 75m
- -Maximum wave height: 5m
- -Maximum cross current: 3.0knot
- -Maximum particle size: 300mm
- -Maximum shear strength of material that can be dredged (clay): 75kPa

(3) Grab Hopper Dredger (GD)

1) Overview

Grab bucket dredger is equipped with slewing jib-crane and an attached grab bucket (clam shell), which can grab the sea bottom soil, then lift and load it to the hopper on its hull. Besides grab hopper dredger, there is pontoon type grab dredger, which does not have own hopper. Pontoon type grab dredger loads dredged material into hoppers of other soil transporting barges. These sketches and photos are shown in Figure C.43 (a), (b) and Figure C.44 (a), (b). The grab hopper dredger is positioned by anchor wires, thus, the ship motion acting to wave is easy to absorb so that it can work much wider range of sea climate than cutter suction dredger. The pontoon type grab dredger is either positioned by anchor wires or by spuds. This section describes particularly for Grab Hopper Dredger.

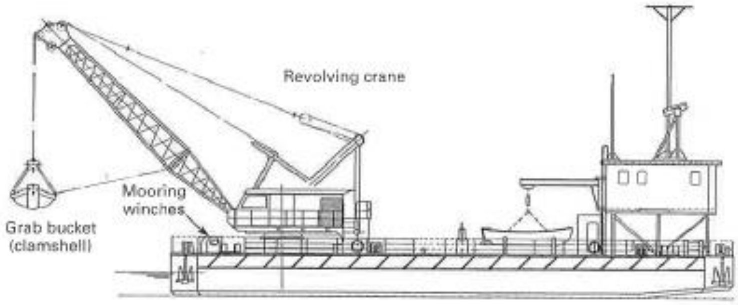
(a) Source: "Hopper Dredger CRANE" Axeonalias, RC Groups.com



(b) Source: "Dredging; A handbook for engineers" R N Bray et al.

Figure C.43 Photo and Conceptual Drawing of Grab Hopper Dredger

(a) Source: "The closing process of clamshell dredges in water-saturated sand" Dr. ir. S.A. Miedema et al.



(b) Source: "Dredging; A handbook for engineers" R N Bray et al.

Figure C.44 Photo and Conceptual Drawing of Grab Dredger (pontoon type)

Dredging method is to excavate the sea bottom by grab bucket (clam shell) just like the land based clam shell bucket operation. Excavated soil is loaded to the hopper equipped in the vessel. When the hopper is filled up, the anchors are weighed and the dredger sails to the soil dumping site by self-propulsion. At the dumping site, the dredged material is disposed through the window at the bottom of the hopper. After disposal, the dredger comes back to the dredging area and casts the anchors and then re-starts dredging after positioning its location.

Characteristics

The followings are the major characteristics of grab hopper dredger

- Ship hull structure vessel with self-propulsion system
- Positioning system is by anchor wires
- Hopper is equipped on its ship
- Dredging is mechanical dredging by grab

Operation Cycle

Operation cycle is shown in Figure C.45.

Soil Disposal Method

Soil disposal method of grab hopper dredger is to transport dredged material in its hopper to soil dumping site and then dump by bottom opening, which is similar to TSHD.

2) Advantage

-Disturbance of the sea bottom is comparatively low and the solid content in the dredged material is much more than hydraulic dredging i.e. cutter suction dredging and TSHD

-Applicable to wide range of dredged material. Especially cobbles, rocks, and hard debris such as steel wires and re-bars can be easily treated, therefore, suitable for the maintenance dredging of old port basin used for long time

-Applicable to wide range of sea condition due to the ship hull structure and the positioning system of anchor wires

-High independency of the operation without need of other vessels

-Great capability of transportation of dredging material for long distance

-Dredging depth can be very deep since only wire rope capacity is the major limiting component

-Easy to mobilize due to ship hull structure and self-propulsion system

-Suitable for comparatively narrow dredging area

3) Disadvantage

-Accuracy of dredging finish level is comparatively small. Thus, the additional dredging is required to cover its tolerance.

-Productivity is comparatively small (because excavation operation is not continuous, additional dredging is required, and anchor positioning required at each return from soil disposal needs some time)

-Existing sea bottom level should have a certain depth for operation since the vessel is ship hull structure

4) Operational Limit

The economical operational limits of grab hopper dredger are normally as below:

-Minimum required depth for operation: 3m

-Maximum dredging depth: 45m

-Maximum wave for operation: 2.0m

-Maximum cross current: 1.5knot

-Maximum shear strength (clays): 100kPa

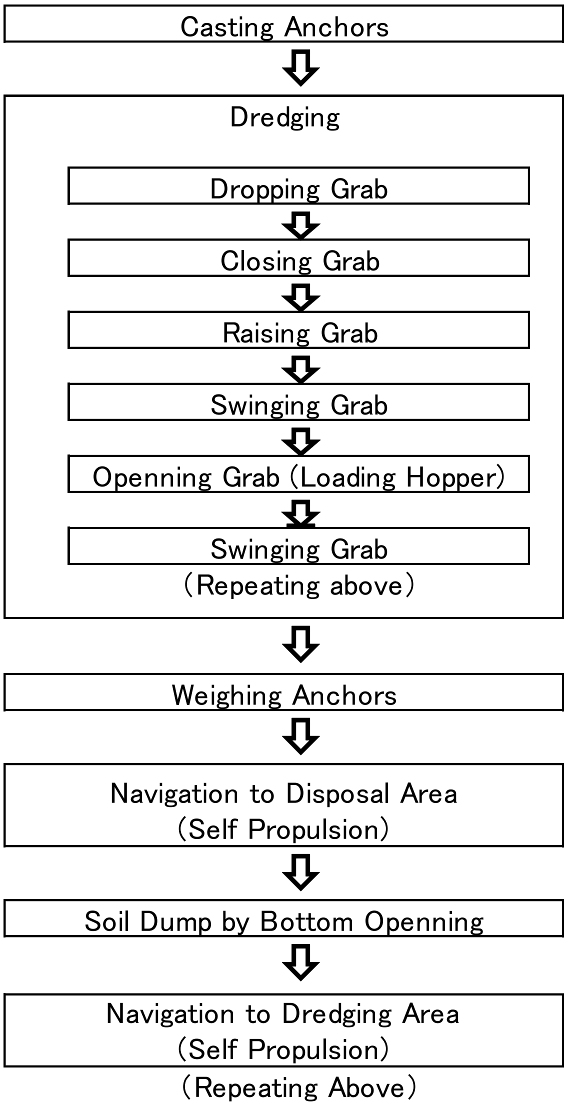


Figure C.45 Flow Chart of Grab Hopper Dredger Operation

(4) Non-Self-Propelling Backhoe Dredger (BHD)

1) Overview

Backhoe dredger is the vessel which is equipped with a backhoe (hydraulic shovel); the land based normal construction equipment on a pontoon (either its upper carriage only or whole equipment). Then the backhoe dredger is to excavate sea bottom by the backhoe's bucket. Backhoe dredger is normally equipped with spuds 2 or 3 sets for positioning and for resisting the force of bucket excavation. The photo and the conceptual drawing of a typical backhoe dredger are shown in Figure C.46 and Figure C.47.

Among backhoe dredgers, there are ones with self-propulsion and/or with own hopper for high independency of the work like grab hopper dredger. However, since backhoe dredgers normally available are the pontoon type dredger without propulsion, the further overview should be on this pontoon type dredger. Therefore, soil loading barges with tug boats are normally required in addition to the backhoe dredgers. The required quantity of soil barges and tug boats depends on the distance of soil dumping site and should be decided in order to avoid stand-by time of the dredging operation. When soil loading barges are equipped with bottom dumping system, soil disposal is easy on the sea; otherwise another set of dredger is required for handling of dredged material at dumping site.

The maneuvering method of backhoe dredger is to swing the pontoon body around one spud by backhoe itself or by anchor wires and then to drive another spud to move the pontoon body by crawling sea bottom by the bucket. Another way is to raise all the spuds and move the pontoon body by crawling sea bottom by the bucket and then to drive all the spuds for excavation operation. For the former one, the spud section should be round shape to allow the rotation of the pontoon around.   Anchor wires are sometimes equipped for supporting positioning.

Figure C.46 Photo of Backhoe Dredger
(Source: "Mimar Sinan" Jan De Nul Group)

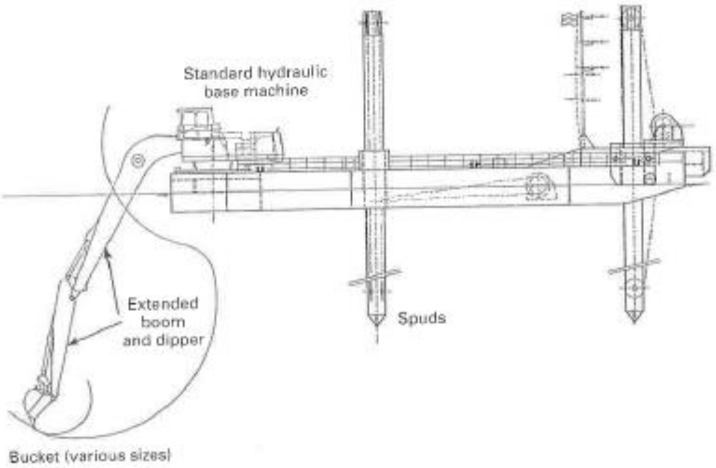


Figure C.47 Conceptual Drawing of Backhoe Dredger
(Source: "Mimar Sinan" Jan De Nul Group)

2) Dredging Method

Dredging method is to excavate the sea ground by backhoe bucket just like excavation operation of backhoe on land. Excavated soil is to load into the hopper of the soil loading barge moored alongside the backhoe dredger. When the hopper is filled up, the tug boat (or maybe pusher boat) is connected to the soil loading barge by tugging rope. Then the mooring ropes between soil loading barge and backhoe dredger is released. The soil loading barge is then tugged to the soil dumping site by the tug boat. After one soil loading barge leaves, another soil loading barge should be moored alongside the backhoe barge so that the dredging operation can be continued without stand-by time. Such maneuvering operation of soil loading barges should be possible only at calm sea considering safety.

Characteristics

The followings are the major characteristics of backhoe dredger

- Pontoon structure
- Positioning system is by spuds
- Transportation of soil needs other soil loading barges
- Dredging is mechanical dredging by backhoe

Operation Cycle

Operation cycle is shown in Figure C.48.

Soil Disposal Method

Soil disposal method of backhoe dredger is to transport dredged material in the hoppers of other soil loading barges (maybe self-driving or otherwise with tug boat) which sail to dumping site and then dump by bottom opening when soil loading barges with bottom opening function or other ways

3) Advantage

- Similar to the grab hopper dredging, the disturbance of the sea bottom is comparatively small. And then the solid content in dredged material is much more than the hydraulic dredging (cutter suction, TSHD)
- Wide range of dredged material to be applied, especially strong debris can be handled easily.
- The obstruction to the vessel traffic around is small if anchor wires are not used
- Comparing with same size of grab bucket, backhoe bucket is more productive
- Possible to work in narrow dredging area
- Dredging accuracy is high (hydraulic arm can be operated accurately)
- To enable breaking rock ground using breaker attachment

4) Disadvantage

- Difficult to work in rough sea condition due to the spud structure
- Productivity is less than hydraulic dredger (but more than grab dredger)
- Backhoe dredger cannot work for deep dredging depth or existing deep sea bottom
- Mobilization is not easy in case of offshore navigation

5) Operational Limit

The economical operational limits of backhoe dredger are normally as below:

- Minimum required depth for operation: 2m
- Maximum Dredging Depth: 24m

-Maximum Wave Height for Operation: 1.5m

-Maximum Swell Height: 1.0m

-Maximum Cross Current: 20.knot

-Maximum Particle to be dredged: 500mm or more

-Maximum ground compression strength (Rock): 10MPa

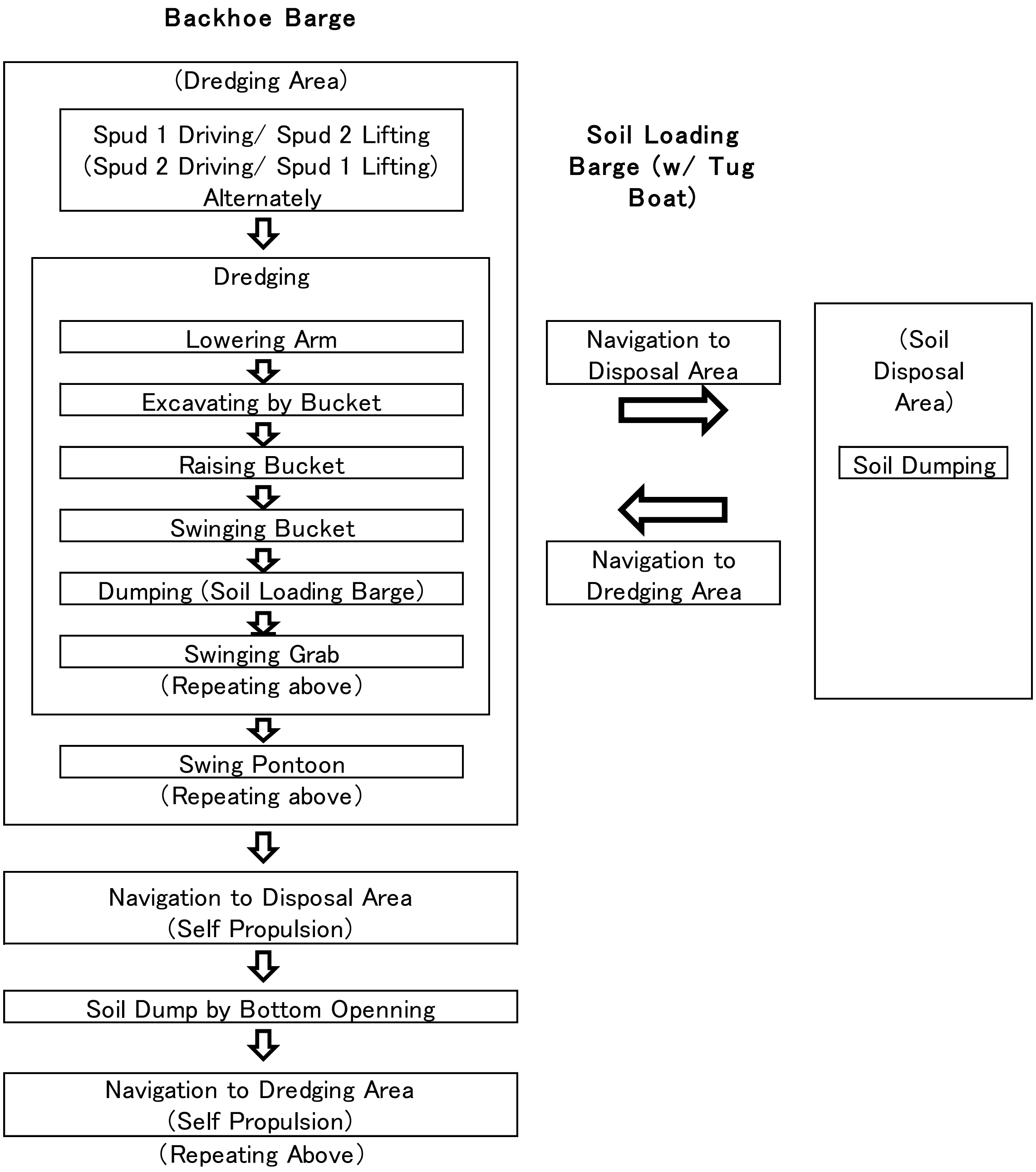


Figure C.48 Flow Chart of Backhoe Dredger Operation

C.5.2 Appropriate Dredging Method

(1) Comparison among dredging methods

Selection of dredging method and equipment suitable for the particular dredging work should be performed considering the following points:

1) Characteristics of soil to be dredged
2) Conditions of dredging area
3) Soil dumping site

Primarily operational limit conditions may exclude some types of dredgers whose operational limit do not match with the above 4 points of the relevant dredging work. Secondary the comparison of the dredging methods should be carried out based on the advantage, disadvantage, and operational conditions of each type of dredger, to evaluate the productivity, operational cost and unit cost of the work of the dredging methods. Then, the most economical method should be generally chosen. However, occasionally the one with maximum productivity should be chosen in case the speed of the project is the most important. The above considerable points are overviewed as below:

1) Characteristics of soil to be dredged

The characteristics of the soil to be dredged are normally the most important factor for the selection of dredging method. Therefore the satisfactory performance of geotechnical site investigation to explore the soil characteristics prior to plan dredging work is important.

Very hard soil layer, gravelly ground, and ground with many debris such as steel material, requires mechanical dredging method; i.e. grab dredger or backhoe dredger. In other cases, hydraulic dredger such as cutter suction dredger and TSHD may be selected from the point of dredging productivity.

In case of maintenance dredging, the material to be dredged should be the sediment in navigational channels and anchorages during a limited time thus has the following characteristics:

-No rocky layer exists in maintenance dredging

-Fine particle soil which is normally easy to move (fine sand, silt, clay etc.)

-Actual characteristics of sediment can be gained by actual sample test in the maintenance phase, although they are estimated from the potential source and transporting mechanism; i.e. erosion, transportation, and sedimentation, in the port plan phase

The dredging work to be studied in this project is re-dredging (intensive maintenance dredging) in the first place, and continuous maintenance dredging in the second place. In the case of re-dredging, sediment has consolidated to a certain level and gained the strength to some extent. However, in spite of this, the dredging method is not limited by the strength of the material to be dredge. And since the existence of the hard debris in the dredging area is not found in this case, hydraulic dredger such as cutter suction or TSHD is considered suitable from the efficiency. When the application of WID is considered, re-dredging and continuous maintenance dredging may be different. It should be studied in the latter chapter.

2) Conditions of dredging area

As for the conditions of dredging area, the following points should be evaluated:

Access for Dredging Area

Access for dredging area in case of mobilization is important point to select the dredging equipment. For example, when a dredging area locates in a hydraulic dam reservoir on a high mountain without appropriate inland waterways, dredging equipment should be transported on land. In this case the dredger should be module or segment type bodies so that they can be transported by trailers then segment units should be assembled on water of the reservoir. Some dredging areas in rivers or even in coast may be shallow and then the access waterways may have enough depth only during rainy season or in high water. In this case, the mobilization timing is very limited.

In La Union Port, this matter does not become the prevailing point since the existing water depth is around 7m which does not interrupt major types of dredgers. Also occurrence of the sea climate with the wind velocity of more than 10m/sec and with the wave height of more than 2m is estimated less than 10days, thus there is no great interference to the access of dredgers.

Water Depth

Following points should be generally considered:

-Maximum planned dredging depth

-Existing depth and dredger’s draft

-Possibility for dredger to make headway while dredging

In this project, if the planned depth of channel is 14m, the planned dredging depth will be 15 to 16m, which is rather deep for backhoe dredger so that only limited number of backhoe dredger has capability to dredge with standard arm and even so the efficiency is not very high. Therefore, backhoe dredger is not very much suitable unless the dredging area needs high accuracy of dredging with the reason like port facilities exist near the dredging area. Other dredging methods are applicable without limit for this project.

Length of dredging area configuration

Since TSHD is the dredger to dredge while it is sailing forward, the longer the dredging area the higher the efficiency. Conversely when the dredging area is short TSHD has remarkable work loss due to the stoppage of dredging during turning vessel. The length more than 1,000m is normally considered as economically acceptable. In this project, both of Inner Channel and Outer Channel are long enough to be suitable to TSHD.

Width of dredging area configuration

TSHD needs a certain width of the area with enough depth at the end of the dredging area for it to turn. (Normally the width should be at least 4 times of LOA of TSHD. When TSHD is equipped with bow thruster, it should be at least 2.5 times of LOA of TSHD. In this project, the area outside the border of the dredging area has enough depth which is more than 6m. Therefore, this matter is not the limitation for TSHD. For the other dredgers, width is no problem.

Dredging Thickness etc.

The efficiency normally drops regardless of dredging methods when dredging thickness is smaller than a certain limit. Also the efficiency drops when the required accuracy of dredged finish is high for example where berthing structures or underground structures exist in the vicinity of dredging area. In this project, for the case of re-dredging (intensive maintenance dredging), the thickness of dredging will be thick enough to keep good efficiency. For the case of maintenance dredging, the thickness of dredging depends on the frequency of maintenance dredging operation and the efficiency is anyway smaller than intensive dredging due to the smaller thickness of dredging.

Wind

Dredgers are forced to sway when they receive wind from alongside. At this time spuds and/or anchors depending on types of dredges should stand for the wind load to keep their positions. In case of TSHD, it sways by wind force alongside; however, it can correspond to wind more flexibly since it does not have spuds or anchors. In this project, strong wind is very rare, thus it is not necessary to consider.

Wave

In case of the dredging of navigation channel offshore, the wave influence should be generally the important point to consider. The operation limit about wave depends on the positioning system of dredgers. In case of spud positioning of backhoe dredgers and cutter suction dredgers, the spuds and the spud holders should stand for the forces generated by wind between spud and hull body and between spud and sea bottom. In case of anchor positioning of grab dredgers, it can correspond more flexibly to the movement of the vessels. Also, for backhoe dredgers, alongside of which soil loading barges have to be moored, mooring operation is dangerous in rough sea. In case of TSHD and grab hopper dredgers, they have ship hull structure being designed for offshore navigation, thus they can stand for wave condition the most widely. Modern TSHD is equipped with the function to stabilize the depth of drag head against the movement of the main hull body corresponding to wave. And normally the bigger the TSHD, the better it stand for the waves.

Current

Grab dredgers are comparatively easy to move by currents with anchor positioning. In case of cutter suction dredgers, the discharge pipes floated on the water surface tend to flow, therefore, the discharge pipes have to be fixed by anchor wires.

Other Vessel Traffic

In case of capital dredging in new port construction, there is no other vessel traffic to worry. Conversely in case of maintenance dredging, other vessels navigation in the dredging area cannot be ignored. The interruption rate against other vessels traffic is related to the positioning system of the dredgers. Grab dredgers use anchor wires which may interrupt the traffic of the other vessels nearby. Grab dredger may have to loosen the anchor wires to make the depth safe enough for the draft of the vessel passing over and thus it needs to stop dredging operation at the time. The spud system does little affect against the vessel traffic. TSHD does also little affect against the vessel traffic since it does not have anchors. In case of the cutter suction dredger, the discharge pipe lines if floated on the surface, they may block the navigation channel. In order to avoid it, the discharge pipe lines should be placed on the sea bottom and it needs more work effort.

3) Soil Dumping Site

Soil dumping site may be either on land or on sea. In both cases, the purpose of dumping site may be two cases i.e. reclamation/ filling for future use or only disposal, depending on the purpose of the project. Also the ways of transporting dredged materials are categorized as 3 as below:

-Hydraulic transportation

-By hopper of the dredger itself which self-propelled

-By hoppers of other vessels beside the dredger

Besides the above, there is the transportation way of using natural current. It is explained in the latter chapter.

In case of hopper transportation, disposal way is either dumping from the bottom window of the hopper or unloading the soil from the hopper by other dredgers at the dumping site. Especially in the case of reclaiming coast area by TSHD, TSHD may blow the dredged material from the nozzle installed at the bow of the dredger.

Among the above transporting ways, the hydraulic transportation is the most efficient and thus economical when the soil dumping site is near the dredging area and the soil is suitable. If the soil dumping site becomes farther, hopper dredgers like TSHD or grab hopper dredger, or also soil loading vessels become more economical. In this project, the soil dumping site locates offshore 15.5 to 26.5km away from the dredging site, and no reclamation is considered. Therefore, hydraulic transportation should not be considered.

C.6 Over dredging depth and volume by sections

The maintenance dredging volume by sections (L1 to L21 for access channel and x1200 to x0200 for port channel and basin) is shown in the tables below.

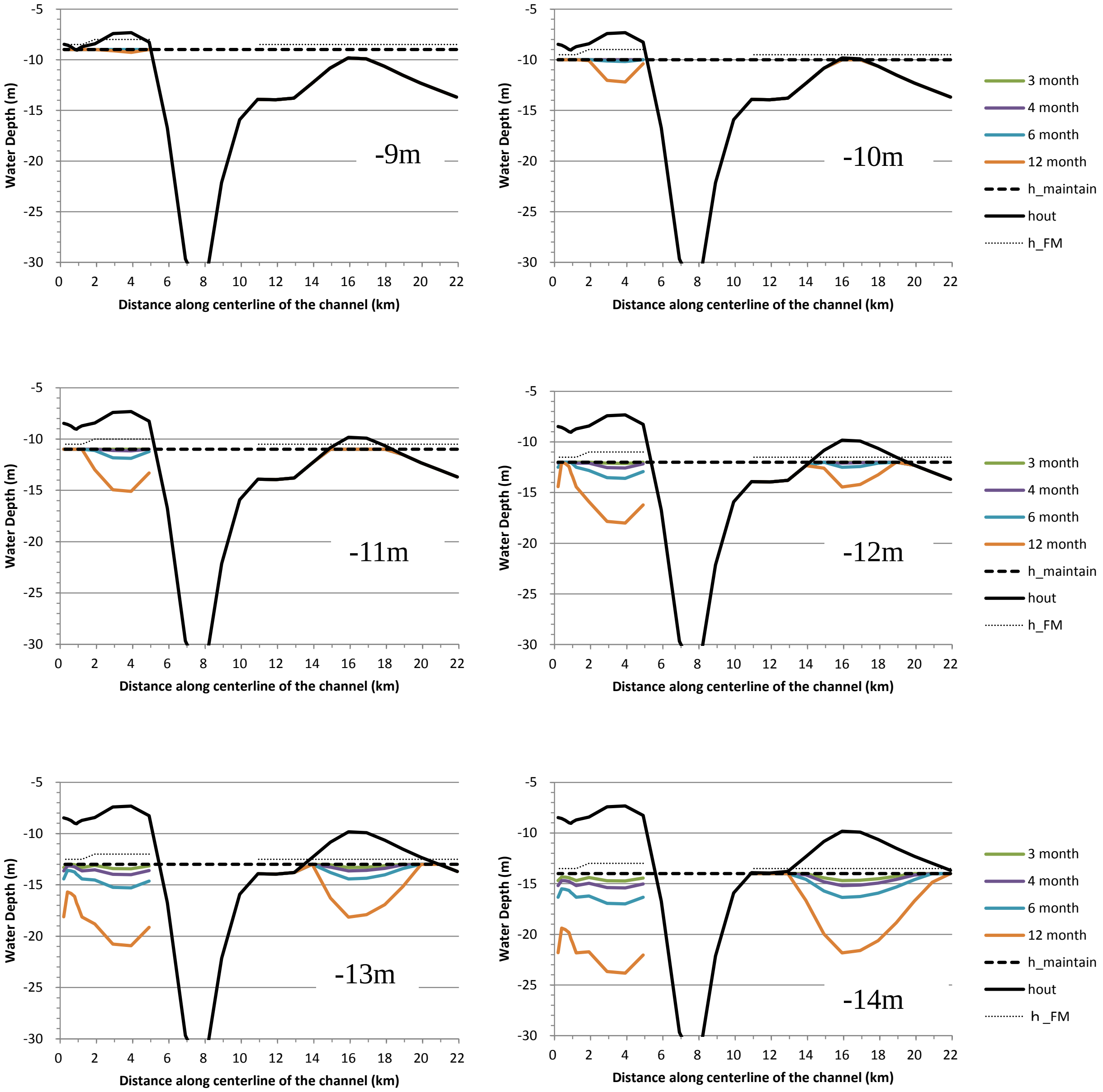


Figure C.49 Over Dredging Depths estimated by Mod. Exp. Model

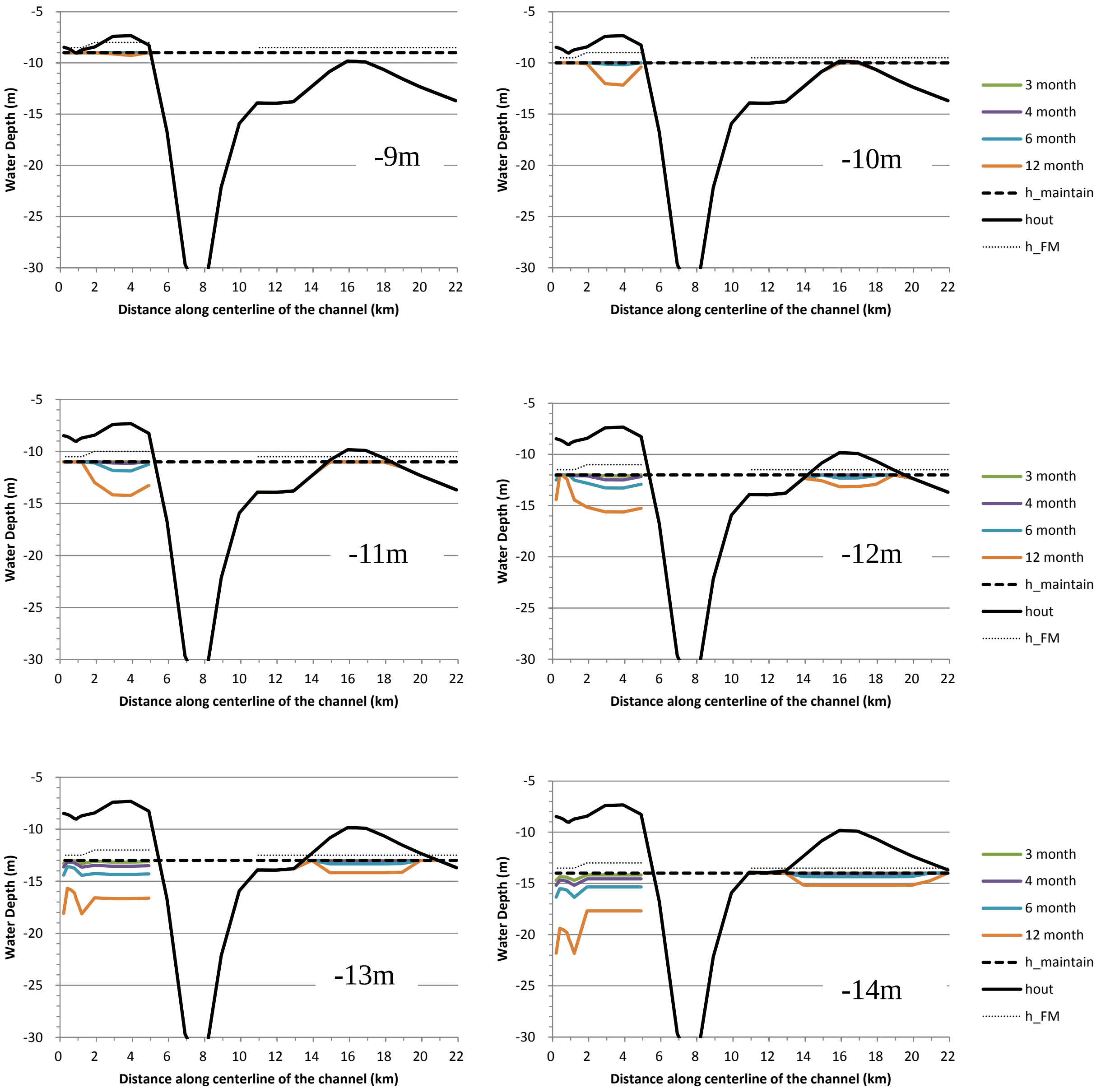


Figure C.50 Over Dredging Depths estimated by Linear Model

Table C.3 Height and Volume of maintenance dredging (over dredging) estimated by Mod. Exp. Model for Target depth of 11 m

Mod.Exponential Model

Target Depth = 11m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/section/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.00	0.00	0.00	0.00	0	0	0	0
L6	16.91	0.00	0.00	0.00	0.00	0	0	0	0
L7	15.91	0.03 (0.00)	0.05 (0.00)	0.08 (0.00)	0.24 (0.00)	5	7	11	33
L8	14.91	0.00	0.00	0.00	0.00	0	0	0	0
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.53 (0.00)	0.74 (0.00)	1.22 (0.22)	3.31 (2.31)	73	101	164	409
L19	3.91	0.82 (0.00)	1.14 (0.14)	1.89 (0.89)	5.10 (4.10)	111	153	246	584
L20	2.91	0.79 (0.00)	1.11 (0.11)	1.83 (0.83)	4.94 (3.94)	108	149	239	570
L21	1.91	0.48 (0.00)	0.67 (0.00)	1.11 (0.11)	2.99 (1.99)	66	92	149	374
Port Ch. & Basin									
X1200(P)	1.20	0.03 (0.00)	0.05 (0.00)	0.08 (0.00)	0.23 (0.00)	1	2	3	10
x1000(P)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(P)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(P)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(P)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(P)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(P)	0.20	0.03 (0.00)	0.04 (0.00)	0.07 (0.00)	0.21 (0.00)	1	2	3	9
x1000(B)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(B)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

Table C.4 Height and Volume of maintenance dredging (over dredging) estimated by Mod. Exp. Model for Target depth of 12 m

Mod.Exponential Model

Target Depth = 12m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/section/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.25 (0.00)	0.35 (0.00)	0.59 (0.09)	1.74 (1.24)	34	48	80	223
L6	16.91	0.39 (0.00)	0.55 (0.05)	0.92 (0.42)	2.70 (2.20)	52	73	122	333
L7	15.91	0.42 (0.00)	0.60 (0.00)	1.01 (0.51)	2.94 (2.44)	57	80	133	360
L8	14.91	0.15 (0.00)	0.22 (0.00)	0.37 (0.00)	1.08 (0.58)	21	30	50	142
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.84 (0.00)	1.17 (0.17)	1.93 (0.93)	5.22 (4.22)	114	157	251	594
L19	3.91	1.12 (0.12)	1.57 (0.57)	2.59 (1.59)	7.01 (6.01)	151	207	329	515
L20	2.91	1.10 (0.10)	1.53 (0.53)	2.53 (1.53)	6.85 (5.85)	148	203	323	725
L21	1.91	0.79 (0.00)	1.10 (0.10)	1.81 (0.81)	4.90 (3.90)	107	148	237	566
Port Ch. & Basin									
X1200(P)	1.20	0.42 (0.00)	0.59 (0.09)	1.00 (0.50)	2.93 (1.43)	18	25	41	117
x1000(P)	1.00	0.28 (0.00)	0.39 (0.00)	0.66 (0.16)	1.94 (1.44)	4	5	9	26
L22(P)	0.91	0.23 (0.00)	0.32 (0.00)	0.54 (0.04)	1.57	3	4	7	21
x0800(P)	0.80	0.13 (0.00)	0.19 (0.00)	0.32 (0.00)	0.93	4	5	9	26
x600(P)	0.60	0.09 (0.00)	0.13 (0.00)	0.21 (0.00)	0.63	3	4	6	17
x0400(P)	0.40	0.07 (0.00)	0.10 (0.00)	0.17 (0.00)	0.49	2	3	5	14
x0200(P)	0.20	0.42 (0.00)	0.59 (0.09)	0.99 (0.00)	2.91	17	24	41	116
x1000(B)	1.00	0.10 (0.00)	0.14 (0.00)	0.23 (0.00)	0.68	2	2	4	12
L22(B)	0.91	0.04 (0.00)	0.06 (0.00)	0.10 (0.00)	0.30	1	1	2	7
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

Table C.5 Height and Volume of maintenance dredging (over dredging) estimated by Mod. Exp. Model for Target depth of 13 m

Mod.Exponential Model

Target Depth = 13m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.07 (0.00)	0.10 (0.00)	0.18 (0.00)	0.51 (0.01)	10	14	24	69
L4	18.91	0.38 (0.00)	0.54 (0.04)	0.91 (0.41)	2.66 (2.16)	52	72	121	329
L5	17.91	0.64 (0.00)	0.90 (0.40)	1.52 (1.02)	4.43 (3.93)	85	119	196	509
L6	16.91	0.77 (0.00)	1.09 (0.59)	1.85 (1.35)	5.40 (4.90)	103	144	236	594
L7	15.91	0.81 (0.00)	1.14 (0.64)	1.93 (1.43)	5.64 (5.14)	107	150	246	613
L8	14.91	0.54 (0.00)	0.77 (0.27)	1.29 (0.79)	3.78 (3.28)	73	102	169	446
L9	13.91	0.06 (0.00)	0.09 (0.00)	0.15 (0.00)	0.44 (0.00)	9	12	20	59
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	1.14 (0.14)	1.60 (0.60)	2.63 (1.63)	7.13 (6.13)	153	211	334	524
L19	3.91	1.43 (0.43)	2.00 (1.00)	3.30 (2.30)	8.92 (7.92)	190	260	407	649
L20	2.91	1.40 (0.40)	1.96 (0.96)	3.24 (2.24)	8.76 (7.76)	187	255	401	638
L21	1.91	1.09 (0.09)	1.53 (0.53)	2.52 (1.52)	6.81 (5.81)	147	202	321	722
Port Ch. & Basin									
X1200(P)	1.20	0.81 (0.31)	1.14 (0.64)	1.93 (1.43)	5.63 (5.13)	33	47	78	213
x1000(P)	1.00	0.66 (0.16)	0.94 (0.44)	1.59 (1.09)	4.64 (4.14)	9	13	22	60
L22(P)	0.91	0.61 (0.11)	0.86 (0.36)	1.46 (0.96)	4.27 (3.77)	8	12	20	55
x0800(P)	0.80	0.52 (0.02)	0.74 (0.24)	1.24 (0.74)	3.63 (3.13)	14	20	34	95
x600(P)	0.60	0.48 (0.00)	0.67 (0.17)	1.14 (0.64)	3.33 (2.83)	13	19	31	88
x0400(P)	0.40	0.46 (0.00)	0.65 (0.15)	1.09 (0.59)	3.19 (2.69)	13	18	30	84
x0200(P)	0.20	0.80 (0.30)	1.14 (0.64)	1.92 (1.42)	5.61 (5.11)	33	47	78	212
x1000(B)	1.00	0.48 (0.00)	0.68 (0.18)	1.16 (0.66)	3.38 (2.88)	8	12	20	53
L22(B)	0.91	0.43 (0.00)	0.61 (0.11)	1.03 (0.53)	3.00 (2.50)	10	14	23	65
x0800(B)	0.80	0.28 (0.00)	0.39 (0.00)	0.67 (0.17)	1.95 (1.45)	17	24	40	113
x600(B)	0.60	0.18 (0.00)	0.26 (0.00)	0.44 (0.00)	1.27 (0.77)	16	23	38	110
x0400(B)	0.40	0.06 (0.00)	0.08 (0.00)	0.14 (0.00)	0.41 (0.00)	6	9	15	42
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

Table C.6 Height and Volume of maintenance dredging (over dredging) estimated by Mod. Exp. Model for Target depth of 14 m

Mod.Exponential Model

Target Depth = 14m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.19 (0.00)	0.27 (0.00)	0.46 (0.00)	1.35 (0.85)	26	37	62	176
L3	19.91	0.46 (0.00)	0.65 (0.15)	1.10 (0.60)	3.21 (2.71)	62	87	144	388
L4	18.91	0.77 (0.27)	1.09 (0.59)	1.83 (1.33)	5.36 (4.86)	102	143	234	591
L5	17.91	1.02 (0.52)	1.44 (0.99)	2.44 (1.94)	7.13 (6.63)	135	187	305	513
L6	16.91	1.16 (0.66)	1.64 (1.14)	2.77 (1.27)	8.09 (7.59)	152	211	341	581
L7	15.91	1.19 (0.69)	1.69 (1.19)	2.85 (2.35)	8.34 (7.84)	157	217	350	598
L8	14.91	0.93 (0.43)	1.31 (0.81)	2.22 (1.72)	6.48 (5.98)	123	171	279	678
L9	13.91	0.45 (0.00)	0.64 (0.14)	1.07 (0.57)	3.14 (2.64)	61	85	141	381
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	1.45 (0.45)	2.02 (1.02)	3.34 (2.34)	9.04 (8.04)	192	228	225	186
L19	3.91	1.74 (0.74)	2.43 (1.43)	4.00 (3.00)	10.83 (9.83)	263	310	306	254
L20	2.91	1.71 (0.71)	2.39 (1.39)	3.94 (2.94)	10.67 (9.67)	412	480	474	399
L21	1.91	1.40 (0.40)	1.95 (0.95)	3.22 (2.22)	8.72 (7.72)	657	783	772	635
Port Ch. & Basin									
X1200(P)	1.20	1.19 (0.69)	1.69 (1.19)	2.85 (2.35)	8.33 (7.83)	49	69	114	298
x1000(P)	1.00	1.05 (0.55)	1.49 (0.99)	2.51 (2.01)	7.34 (6.84)	14	20	34	89
L22(P)	0.91	1.00 (0.50)	1.41 (0.91)	2.38 (1.88)	6.97 (6.47)	14	19	32	85
x0800(P)	0.80	0.91 (0.41)	1.28 (0.78)	2.16 (1.66)	6.33 (5.83)	25	35	58	157
x600(P)	0.60	0.86 (0.36)	1.22 (0.72)	2.06 (1.56)	6.03 (5.53)	24	33	56	151
x0400(P)	0.40	0.84 (0.34)	1.19 (0.69)	2.01 (1.51)	5.89 (5.39)	23	33	54	148
x0200(P)	0.20	1.19 (0.69)	1.68 (1.18)	2.84 (2.34)	8.31 (7.81)	49	69	113	297
x1000(B)	1.00	0.87 (0.37)	1.23 (0.73)	2.08 (1.58)	6.08 (5.58)	15	21	34	88
L22(B)	0.91	0.82 (0.32)	1.15 (0.65)	1.95 (1.45)	5.70 (5.20)	19	26	44	117
x0800(B)	0.80	0.67 (0.17)	0.94 (0.44)	1.59 (1.09)	4.65 (4.15)	40	56	93	257
x600(B)	0.60	0.57 (0.07)	0.80 (0.30)	1.36 (0.86)	3.97 (3.47)	50	70	117	332
x0400(B)	0.40	0.45 (0.00)	0.63 (0.13)	1.06 (0.56)	3.11 (2.61)	46	65	109	314
x0200(B)	0.20	0.34 (0.00)	0.48 (0.00)	0.80 (0.30)	2.35 (1.85)	52	74	125	359

*) (P):Port Channel, (B):Basin

Table C.7 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 9 m

Linear model

Target Depth = 9m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.00	0.00	0.00	0.00	0	0	0	0
L6	16.91	0.00	0.00	0.00	0.00	0	0	0	0
L7	15.91	0.00	0.00	0.00	0.00	0	0	0	0
L8	14.91	0.00	0.00	0.00	0.00	0	0	0	0
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.00	0.00	0.00	0.00	0	0	0	0
L19	3.91	0.21 (0.00)	0.29 (0.00)	0.47 (0.00)	1.28 (0.28)	29	40	65	171
L20	2.91	0.18 (0.00)	0.25 (0.00)	0.42 (0.00)	1.13 (0.13)	25	35	57	151
L21	1.91	0.00	0.00	0.00	0.00	0	0	0	0
Port Ch. & Basin									
X1200(P)	1.20	0.00	0.00	0.00	0.00	0	0	0	0
x1000(P)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(P)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(P)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(P)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(P)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(P)	0.20	0.00	0.00	0.00	0.00	0	0	0	0
x1000(B)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(B)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

Table C.8 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 10 m

Linear model

Target Depth = 10m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.00	0.00	0.00	0.00	0	0	0	0
L6	16.91	0.00	0.00	0.00	0.00	0	0	0	0
L7	15.91	0.00	0.00	0.00	0.00	0	0	0	0
L8	14.91	0.00	0.00	0.00	0.00	0	0	0	0
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.22 (0.00)	0.31 (0.00)	0.52 (0.00)	1.40 (0.40)	31	43	71	186
L19	3.91	0.51 (0.00)	0.71 (0.00)	1.18 (0.18)	3.17 (2.17)	70	98	158	393
L20	2.91	0.49 (0.00)	0.68 (0.00)	1.12 (0.12)	3.03 (2.03)	67	93	151	378
L21	1.91	0.17 (0.00)	0.24 (0.00)	0.40 (0.00)	1.08 (0.08)	24	34	55	146
Port Ch. & Basin									
X1200(P)	1.20	0.00	0.00	0.00	0.00	0	0	0	0
x1000(P)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(P)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(P)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(P)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(P)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(P)	0.20	0.00	0.00	0.00	0.00	0	0	0	0
x1000(B)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(B)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

Table C.9 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 11 m

Linear model

Target Depth = 11m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x103 m3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.00	0.00	0.00	0.00	0	0	0	0
L6	16.91	0.00	0.00	0.00	0.00	0	0	0	0
L7	15.91	0.03 (0.00)	0.05 (0.00)	0.08 (0.00)	0.24 (0.00)	5	7	11	33
L8	14.91	0.00	0.00	0.00	0.00	0	0	0	0
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.53 (0.00)	0.74 (0.00)	1.22 (0.22)	3.26 (2.26)	73	101	164	404
L19	3.91	0.82 (0.00)	1.14 (0.14)	1.88 (0.88)	4.22 (3.22)	111	153	246	502
L20	2.91	0.79 (0.00)	1.11 (0.11)	1.83 (0.83)	4.17 (3.17)	108	149	239	497
L21	1.91	0.48 (0.00)	0.67 (0.00)	1.11 (0.11)	2.99 (1.99)	66	92	149	374
Port Ch. & Basin									
X1200(P)	1.20	0.03 (0.00)	0.05 (0.00)	0.08 (0.00)	0.23 (0.00)	1	2	3	10
x1000(P)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(P)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(P)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(P)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(P)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(P)	0.20	0.03 (0.00)	0.04 (0.00)	0.07 (0.00)	0.21 (0.00)	1	2	3	9
x1000(B)	1.00	0.00	0.00	0.00	0.00	0	0	0	0
L22(B)	0.91	0.00	0.00	0.00	0.00	0	0	0	0
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

Table C.10 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 12 m

Linear model

Target Depth = 12m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.00	0.00	0.00	0.00	0	0	0	0
L4	18.91	0.00	0.00	0.00	0.00	0	0	0	0
L5	17.91	0.25 (0.00)	0.35 (0.00)	0.59 (0.09)	1.43 (0.93)	34	48	80	186
L6	16.91	0.38 (0.00)	0.52 (0.02)	0.80 (0.30)	1.64 (1.14)	52	70	107	212
L7	15.91	0.40 (0.00)	0.54 (0.04)	0.82 (0.32)	1.66 (1.16)	54	73	109	214
L8	14.91	0.15 (0.00)	0.22 (0.22)	0.37 (0.00)	1.07 (0.57)	21	30	50	140
L9	13.91	0.00	0.00	0.00	0.00	0	0	0	0
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	0.84 (0.00)	1.17 (0.17)	1.92 (0.92)	4.26 (3.26)	114	157	250	506
L19	3.91	1.11 (0.11)	1.50 (0.50)	2.28 (1.28)	4.62 (3.62)	149	198	293	540
L20	2.91	1.09 (0.09)	1.48 (0.48)	2.26 (1.26)	4.60 (3.60)	146	196	291	538
L21	1.91	0.79 (0.00)	1.10 (0.10)	1.81 (0.81)	4.15 (3.15)	107	148	237	495
Port Ch. & Basin									
X1200(P)	1.20	0.42 (0.00)	0.59 (0.09)	1.00 (0.50)	2.93 (2.43)	18	25	41	117
x1000(P)	1.00	0.28 (0.00)	0.39 (0.00)	0.66 (0.16)	1.94 (1.44)	4	5	9	26
L22(P)	0.91	0.23 (0.00)	0.32 (0.00)	0.54 (0.04)	1.57 (1.07)	3	4	7	21
x0800(P)	0.80	0.13 (0.00)	0.19 (0.00)	0.32 (0.00)	0.93 (0.43)	4	5	9	26
x600(P)	0.60	0.09 (0.00)	0.13 (0.00)	0.21 (0.00)	0.63 (0.13)	3	4	6	17
x0400(P)	0.40	0.07 (0.00)	0.10 (0.00)	0.17 (0.00)	0.49 (0.00)	2	3	5	14
x0200(P)	0.20	0.42 (0.00)	0.59 (0.09)	0.99 (0.49)	2.91 (2.41)	17	24	41	116
x1000(B)	1.00	0.10 (0.00)	0.14 (0.00)	0.23 (0.00)	0.68 (0.18)	2	2	4	12
L22(B)	0.91	0.04 (0.00)	0.06 (0.00)	0.10 (0.00)	0.30 (0.00)	1	1	2	7
x0800(B)	0.80	0.00	0.00	0.00	0.00	0	0	0	0
x600(B)	0.60	0.00	0.00	0.00	0.00	0	0	0	0
x0400(B)	0.40	0.00	0.00	0.00	0.00	0	0	0	0
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

Table C.11 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 13 m

Linear model

Target Depth = 13m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.00	0.00	0.00	0.00	0	0	0	0
L3	19.91	0.07 (0.00)	0.10 (0.00)	0.18 (0.00)	0.51 (0.01)	10	14	24	69
L4	18.91	0.38 (0.00)	0.52 (0.02)	0.80 (0.30)	1.64 (1.14)	51	70	106	211
L5	17.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L6	16.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L7	15.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L8	14.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L9	13.91	0.06 (0.00)	0.09 (0.00)	0.15 (0.00)	0.44 (0.00)	9	12	20	59
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	1.12 (0.12)	1.51 (0.51)	2.29 (1.29)	4.63 (3.63)	150	200	294	541
L19	3.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
L20	2.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
L21	1.91	1.08 (0.08)	1.47 (0.47)	2.25 (1.25)	4.59 (3.59)	146	195	290	538
Port Ch. & Basin									
X1200(P)	1.20	0.81 (0.31)	1.14 (0.64)	1.93 (1.43)	5.63 (5.13)	33	47	78	213
x1000(P)	1.00	0.66 (0.16)	0.94 (0.44)	1.59 (1.09)	4.64 (4.14)	9	13	22	60
L22(P)	0.91	0.61 (0.11)	0.86 (0.36)	1.46 (0.96)	4.27 (3.77)	8	12	20	55
x0800(P)	0.80	0.52 (0.02)	0.74 (0.24)	1.24 (0.74)	3.63 (3.13)	14	20	34	95
x600(P)	0.60	0.48 (0.00)	0.67 (0.17)	1.14 (0.64)	3.33 (2.83)	13	19	31	88
x0400(P)	0.40	0.46 (0.00)	0.65 (0.15)	1.09 (0.59)	3.19 (2.69)	13	18	30	84
x0200(P)	0.20	0.80 (0.30)	1.14 (0.64)	1.92 (1.42)	5.61 (5.11)	33	47	78	212
x1000(B)	1.00	0.48 (0.00)	0.68 (0.18)	1.16 (0.66)	3.38 (2.88)	8	12	20	53
L22(B)	0.91	0.43 (0.00)	0.61 (0.11)	1.03 (0.53)	3.00 (2.50)	10	14	23	65
x0800(B)	0.80	0.28 (0.00)	0.39 (0.00)	0.67 (0.17)	1.95 (1.45)	17	24	40	113
x600(B)	0.60	0.18 (0.00)	0.26 (0.00)	0.44 (0.00)	1.27 (0.77)	16	23	38	110
x0400(B)	0.40	0.06 (0.00)	0.08 (0.00)	0.14 (0.00)	0.41 (0.00)	6	9	15	42
x0200(B)	0.20	0.00	0.00	0.00	0.00	0	0	0	0

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

Table C.12 Height and Volume of maintenance dredging (over dredging) estimated by Linear Model for Target depth of 14 m

Linear model

Target Depth =14m		Height of Dredging (m) (Over dredging height below the target depth, m)				Dredging Volume (x10^3 m^3/km/cycle)			
Location		Dredging cycle				Dredging cycle			
Line No.	KP	3 month	4 month	6 month	12 month	3 month	4 month	6 month	12 month
Outer Ch.									
L1	21.91	0.00	0.00	0.00	0.00	0	0	0	0
L2	20.91	0.19 (0.00)	0.27 (0.00)	0.46 (0.00)	1.25 (0.75)	26	37	62	164
L3	19.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	56	75	111	216
L4	18.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L5	17.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L6	16.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L7	15.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L8	14.91	0.42 (0.00)	0.56 (0.06)	0.84 (0.34)	1.68 (1.18)	57	75	112	216
L9	13.91	0.41 (0.00)	0.55 (0.05)	0.83 (0.33)	1.67 (1.17)	56	74	111	215
L10	12.91	0.00	0.00	0.00	0.00	0	0	0	0
L11	11.91	0.00	0.00	0.00	0.00	0	0	0	0
L12	10.91	0.00	0.00	0.00	0.00	0	0	0	0
Inner Ch.									
L18	4.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
L19	3.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
L20	2.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
L21	1.91	1.17 (0.17)	1.56 (0.56)	2.34 (1.34)	4.68 (3.68)	157	206	300	546
Port Ch. & Basin									
X1200(P)	1.20	1.19 (0.69)	1.69 (1.19)	2.85 (2.35)	8.33 (7.83)	49	69	114	298
x1000(P)	1.00	1.05 (0.55)	1.49 (0.99)	2.51 (2.01)	7.34 (6.84)	14	20	34	89
L22(P)	0.91	1.00 (0.50)	1.41 (0.91)	2.38 (1.88)	6.97 (6.47)	14	19	32	85
x0800(P)	0.80	0.91 (0.41)	1.28 (0.78)	2.16 (1.66)	6.33 (5.83)	25	35	58	157
x600(P)	0.60	0.86 (0.36)	1.22 (0.72)	2.06 (1.56)	6.03 (5.53)	24	33	56	151
x0400(P)	0.40	0.84 (0.34)	1.19 (0.69)	2.01 (1.51)	5.89 (5.49)	23	33	54	148
x0200(P)	0.20	1.19 (0.69)	1.68 (1.18)	2.84 (2.34)	8.31 (7.81)	49	69	113	297
x1000(B)	1.00	0.87 (0.37)	1.23 (0.73)	2.08 (1.58)	6.08 (5.58)	15	21	34	88
L22(B)	0.91	0.82 (0.32)	1.15 (0.65)	1.95 (1.45)	5.70 (5.20)	19	26	44	117
x0800(B)	0.80	0.67 (0.17)	0.94 (0.44)	1.59 (1.09)	4.65 (4.15)	40	56	93	257
x600(B)	0.60	0.57 (0.07)	0.80 (0.30)	1.36 (0.86)	3.97 (3.47)	50	70	117	332
x0400(B)	0.40	0.45 (0.00)	0.63 (0.13)	1.06 (0.56)	3.11 (2.61)	46	65	109	314
x0200(B)	0.20	0.34 (0.00)	0.48 (0.00)	0.80 (0.30)	2.35 (1.85)	52	74	125	359

*) (P):Port Channel, (B):Basin

**) Values for Port Channel and Basin are estimated by mod. Exponential Model

C.7 Westward Over-dredging in Outer Channel

According to Section 4.3.3, in outer channel, the sediment transport in the east direction has been implied by the bathymetry data analysis. On the western side-slope, the coarse material having the high falling velocity accumulated, while the sediment having the high fluidity such as the fluid mud deposited in the east side in the channel.

As the sediment transport in the east direction and the accumulation on the western side-slope make the channel width narrower, westward over-dredging is required in order to keep the channel width. To estimate the required volume of westward over-dredging, the volume of sediment supplied into the channel from the west side has been estimated by the topography change in cross-sections of L5, L6, L7 and L8.

Figure C.51 shows the idealized siltation process observed in the outer channel. As described in Section 4.3.3, the siltation process in the Outer Channel can be divided into two successive stages, that is to say, the rapid siltation in a few months just after the dredging and the slow siltation in the following period. Figure C.51 illustrates the idealized situation of the slow siltation in the second stage. From the diagram, the siltation volume due to coarse material can be estimated by the difference between the siltation volume of west half of the channel and that of east half of the channel.

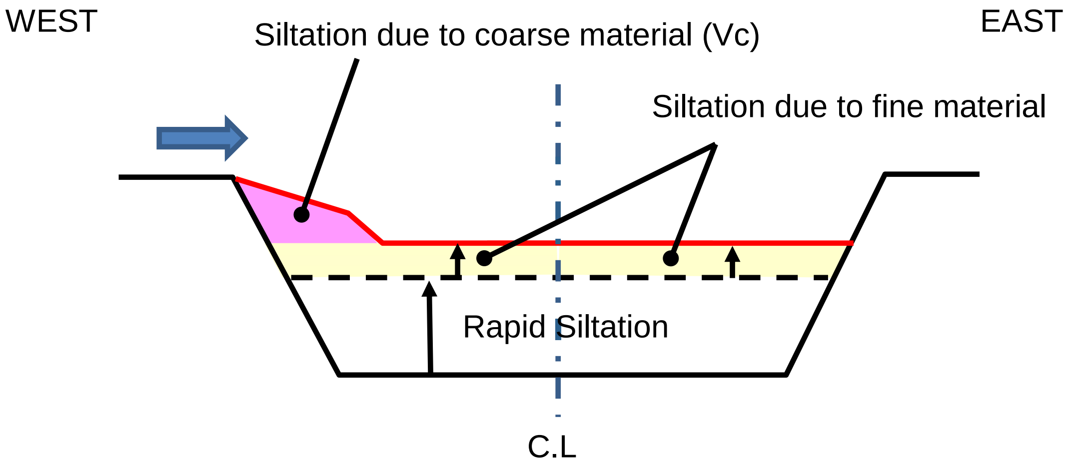


Figure C.51 Idealized siltation process observed in outer channel

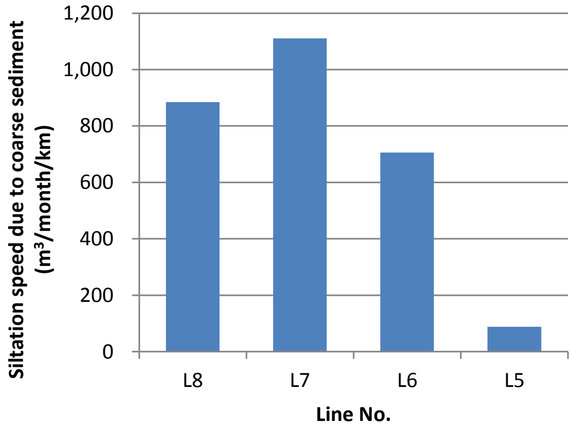


Figure C.52 Estimated siltation speed due to coarse material

By using bathymetry data measured only in the slow siltation stage of L5, L6, L7 and L8, the siltation speed due to coarse material has been estimated as shown in Figure C.52.

Next, we consider the situation that maintenance dredging is conducted continuously. Assuming that no rapid siltation occur in the maintenance dredging stage as described in Section 4.3.3, the siltation process is expected as shown in Figure C.53. Because the siltation speed due to coarse material is considered to be the same as that shown in Figure C.52, the forward speed of the western side bank can be calculated as,

$$v_w = V_{coarse} / \Delta h \qquad \text{(C.1)}$$

where v_w is the forward speed of the western side-slope (m/month), V_{coarse} is the siltation speed due to coarse material (m^3/month/m) estimated by bathymetric data, and Δh is the dredging depth.

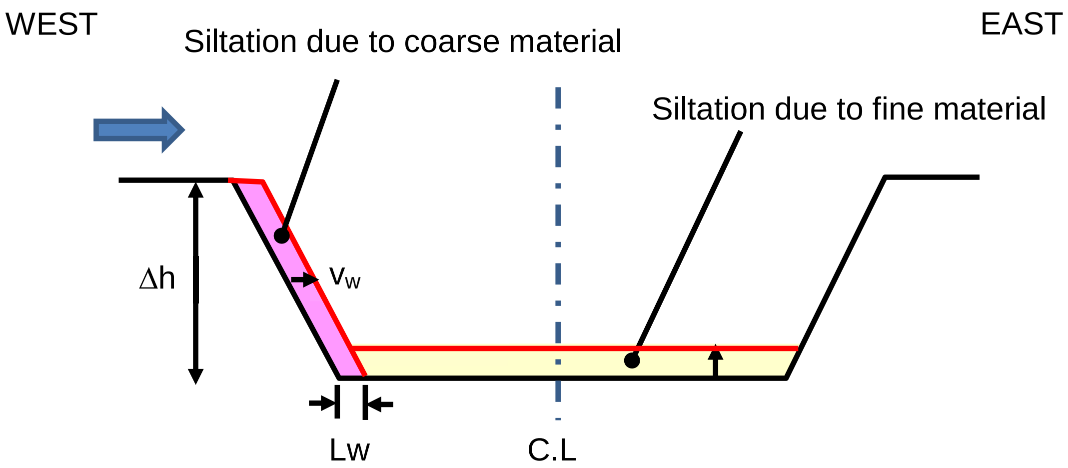


Figure C.53 Idealized siltation process in outer channel for the stage of maintenance dredging

Figure C.54 shows the forward speed of the western side-slope calculated by Eq. (C.1). The forward speed decreases with increasing the dredging depth because of constant siltation speed due to coarse material.

The westward over-dredging rates by depths are summarized in Table C.13. Taking the forward speed of western side bank into account, it is recommended that the westward over-dredging for L6, L7, and L8 is carried out once a year or two as listed in Table C.13.

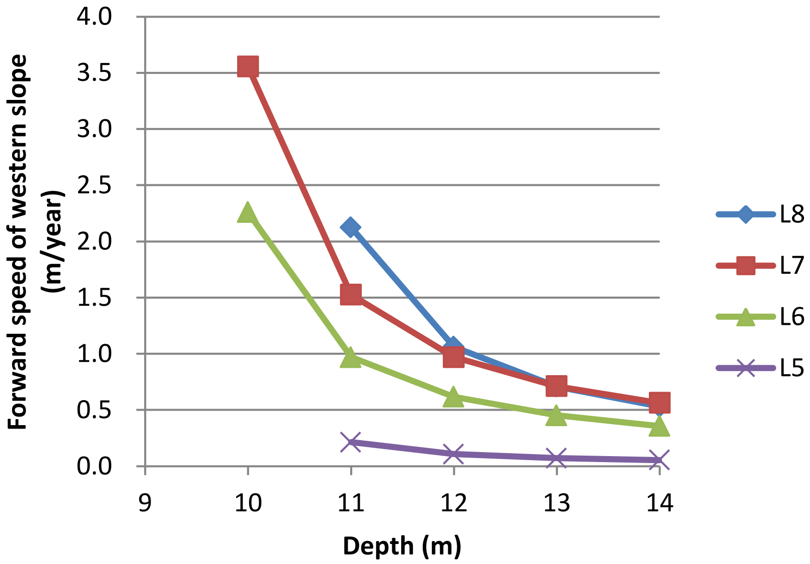


Figure C.54 Estimated forward speed of western slope by depths

Table C.13 Estimated forward speed and recommended cycle of dredging for western slope

Line No.	Depth on the top of slope (m)	Siltation Speed (Coarse) (m^3/month/km)	target depth (m)	Forward speed of western slope		Recommended cycle of dredging for west side slope
				(m/month)	(m/year)	
L8	10.00	885	10	–	–	
			11	0.177	2.1	1.1m /6 months
			12	0.089	1.1	1.1m /1 year
			13	0.059	0.7	1.4m /2 years
			14	0.044	0.5	1.0m /2 years
L7	9.25	1,111	10	0.296	3.6	1.8m /6 months
			11	0.127	1.5	1.5m /1 year
			12	0.081	1.0	1.1m /1 year
			13	0.059	0.7	1.4m /2 years
			14	0.047	0.6	1.2m /2 years
L6	9.25	706	10	0.188	2.3	1.2m /6 months
			11	0.081	1.0	1.0m /1 year
			12	0.051	0.6	1.2m /2 years
			13	0.038	0.5	1.0m /2 years
			14	0.030	0.4	1.2m /3 years
L5	10.00	89	10	–	–	
			11	0.018	0.2	1.0m / 5 years
			12	0.009	0.1	1.0m / 10 years
			13	0.006	0.1	1.0m / 10 years
			14	0.004	0.1	1.0m / 10 years

C.8 Re-Dredging Volume Calculation

C.8.1 Re-Dredging Volume by ECOH

Re-Dredging Volume by ECOH is calculated by integrating volumes of each segment, the interval of which is 1 km, as shown in Figure C.55. The channel cross-section profile for the volume calculation is assumed as a trapezoidal shape shown in Figure C.56 and it does not include overbreak.

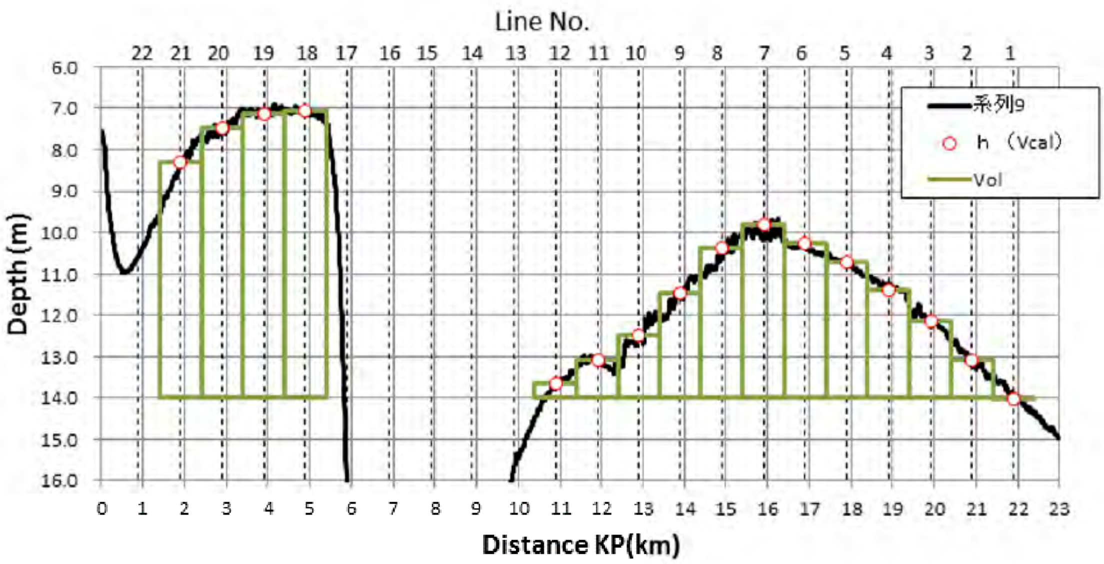


Figure C.55 Longitudinal profile and segments for volume calculation

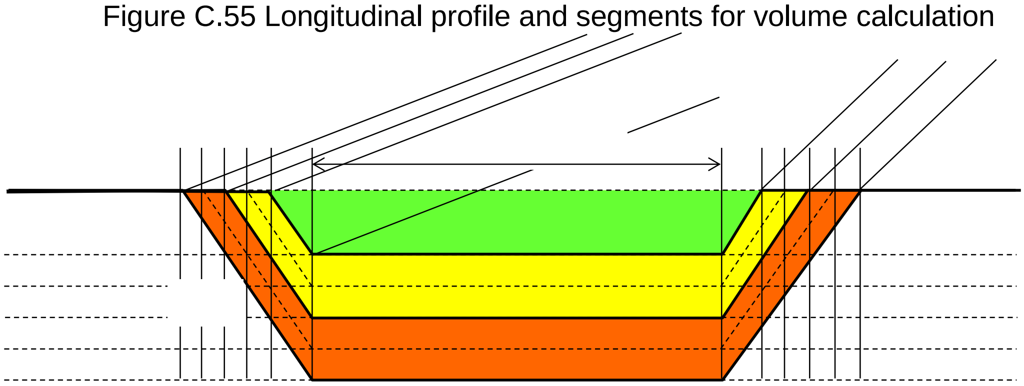


Figure C.56 Channel Shape for Re-Dredging volume calculation

Table C.14 Estimated re-dredging volume (units: 1000 m^3)

Depth (m)	Outer Ch.	Inner Ch.	Basin	Total
D.L.-9.0	0	895	0	895
D.L.-10.0	25	1,535	59	1,619
D.L.-11.0	404	2,215	344	2,964
D.L.-12.0	1,161	2,936	798	4,895
D.L.-13.0	2,284	3,696	1,471	7,452
D.L.-14.0	3,882	4,496	2,186	10,565

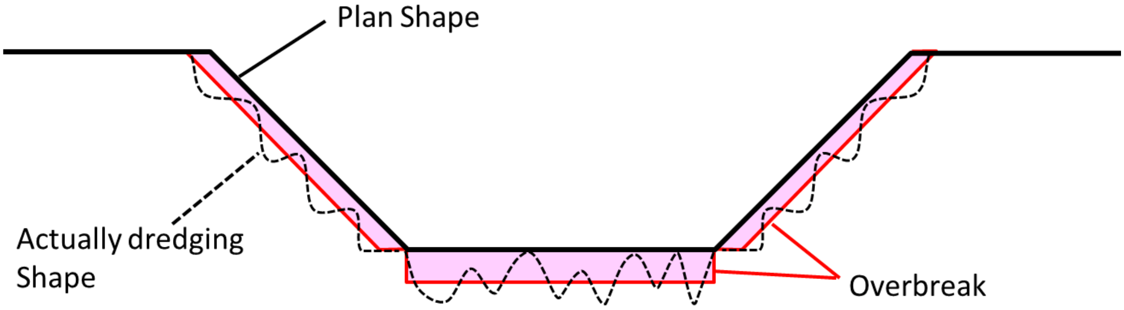


Figure C.57 Definition of overbreak in channel dredging

Now, we used a new word of "overbreak." As illustrated in Figure C.57, the overbreak is defined as an extra portion of dredging to make the bed level lower than the plan shape because the channel shape cannot be dredged perfectly evenness.

Also, we have already defined over-dredging in the Final Report, where the over-dredging is the dredging to deal with siltation. Please note that the overbreak is not the same meaning as the over-dredging in our study.

C.8.2 Re-Dredging Volume by TOPONORT

According to the report by TOPONORT, Re-Dredging volume by depths is calculated as shown in Table C.15. By using the data of Table C.14 and Table C.15, Re-Dredging volume calculated by ECOH is compared to that by TOPONORT as shown in Figure C.58, where the comparison was done for Inner channel and Outer channel. (Because of complex topography, we exclude the volume of basin area in the comparison.) According to Figure C.58, it is surely found that the re-dredging volume by ECOH is much smaller than that by TOPONORT.

Table C.15 Re-Dredging Volume by depths calculated by TOPONORT

ZONA	COTA 9.5 (M3)	COTA 10 (M3)	COTA 11 (M3)	COTA 12 (M3)	COTA 13 (M3)	COTA 14 (M3)
DARSENA DE PASAJEROS Y MULTIPROPÓSITO	*430,311*	*533,734*	*891,888*	*1,506,807*	*2,295,487*	*3,173,792*
CANAL INTERNO	*1,921,359*	*2,406,047*	*3,392,821*	*4,389,925*	*5,394,936*	*6,407,227*
CANAL EXTERNO	*30,688*	*109,705*	*637,150*	*1,744,329*	*3,289,747*	*5,386,543*

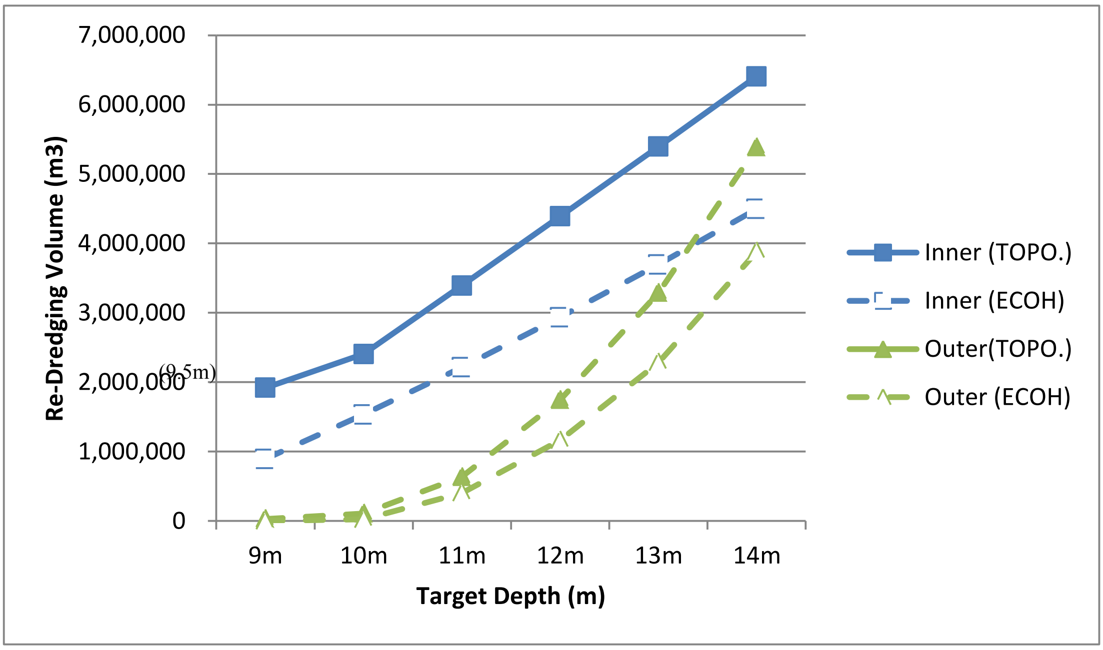


Figure C.58 Comparison of Re-Dredging volume between TOPONORT and ECOH

C.8.3 Difference of Re-Dredging volumes

In order to examine the reason why re-dredging volume by ECOH is smaller than that by TOPONORT, we calculated the re-dredging volume again to match the result by TOPONORT, by taking overbreak volume into account. The modification points for volume calculation are as follows:

- Change 9.0 m in target depth to 9.5 m to match the calculation condition
- Add **+0.5 m** of overbreak for Outer Channel
- Add **+1.0 m** of overbreak for Inner Channel

The result is as shown in Figure C.59. By the modification described above, the re-dredging volume by ECOH became the same order as that by TOPONORT. Therefore, we guess that TOPONORT calculates the re-dredging volume including outbreak volume. We think that CEPA should confirm the channel shape for volume calculation to TOPONORT again, whether overbreak is included or not.

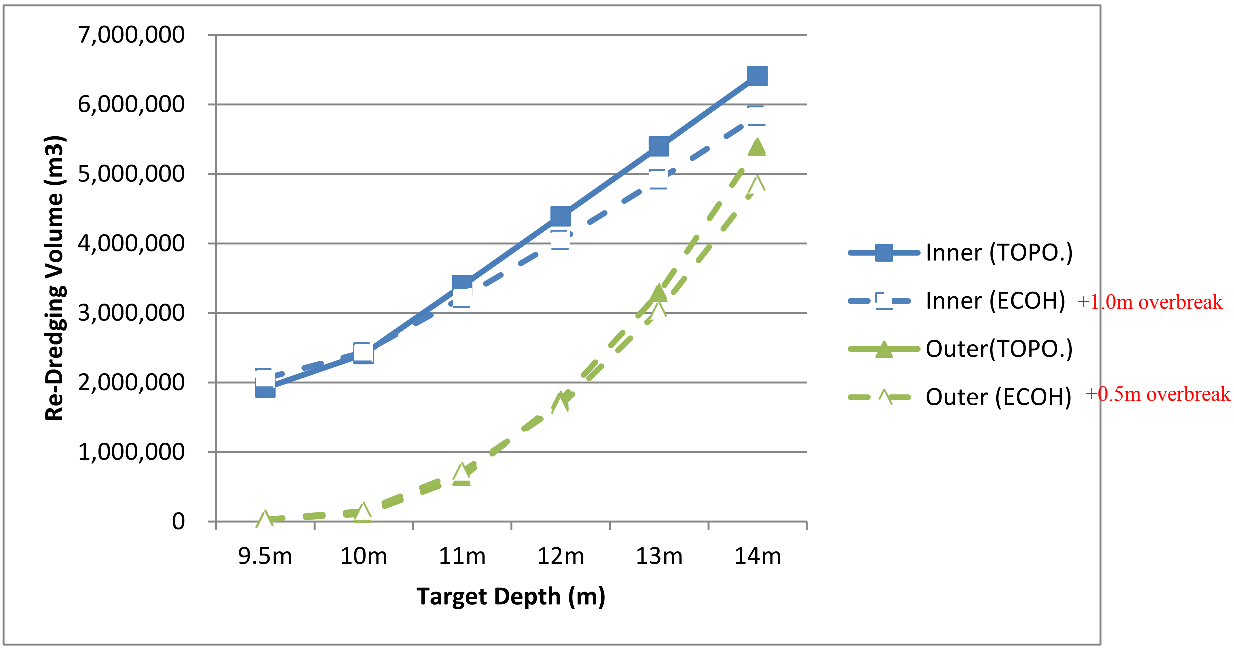


Figure C.59 Comparison of Re-Dredging volume between TOPONORT and ECOH, calculated by including overbreak of 0.5m for Outer Ch. or 1.0m for Inner Ch.

ANNEX D

Topics related to economic study

for La Union Port

D.1 A Ports in Neighboring Countries

D.1.1 Guatemala

(1) Outline of Guatemala

Republic of Guatemala faces the Pacific Ocean and the Caribbean Sea and has borders between United Mexican States, Republic of El Salvador, Republic of Honduras and Belize. Its land area is 108,889 km2 and has a population of 14.71 million in 2011. Guatemala City is the capital, Puerto Quetzal faces the Pacific Ocean while the ports of Saint-Tomas and Puerto Barrios face the Caribbean Sea.

Main industries are agriculture and textiles. GDP is USD 46,910 million and Per Capita is USD 3,188 in 2011 and has been increasing steadily by 2 – 3% per year in recent years.

The exports amounted to USD 10,450 million and the imports to USD 16,128 million in 2011. Main export goods are garments, textile/needle work products, coffee, precious stones, precious metals sugar and banana and main import goods are food products, mineral, manufactures, electronic manufactures, chemical products and textile/needle work products. Major trading partners are USA, Central American countries, EU, Mexico and Panama for export, and USA, Mexico, China, Central American countries and EU for import.

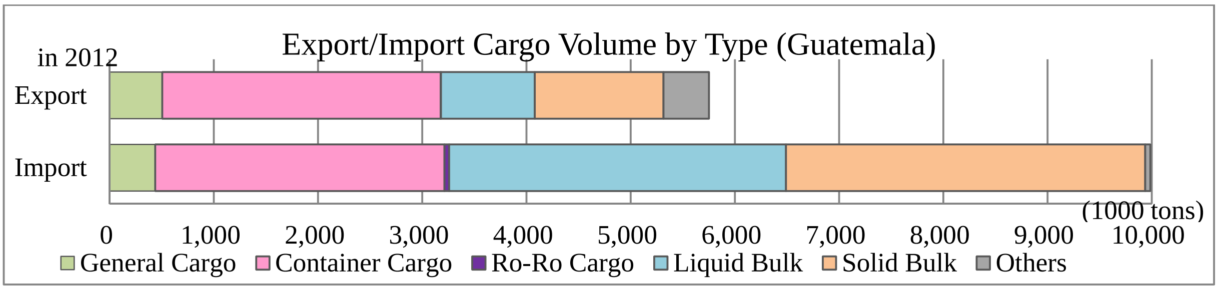
(2) Ports in Guatemala

Puerto Quetzal plays a role of gateway to the Pacific Ocean and Puerto Santo Tomas de Castilla plays a role of gateway to the Caribbean Sea. In addition to these two ports, Puerto Barrios is located near Puerto Santo Tomas Castilla and is mainly used for exporting fruits.

Table D.1 Main Ports of Guatemala

Pacific side	Puerto Quetzal, Boyas de San Jose
Caribbean Sea side	Santo Tomas de Castilla, Puerto Barrios

In 2012, calling vessels at these ports amounts to 2,723 and cargo volume through these ports was 15,738 thousand tons. A breakdown of import and export cargo by type is shown in Figure D.1Container cargo accounts for 27.8 % of import cargo and 46.5 % of export cargo. Table D.2 shows the trend of ship calls and cargo volume of the ports from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.1 Export/Import cargo of Ports of Guatemala

Table D.2 Tendency of Ship Call and Handling Cargo of Main Ports of Guatemala

		2007	2008	2009	2010	2011	2012
Ship Call		3,546	3,370	3,263	3,501	3,328	2,723
Cargo Volume (thousand tons)	Export	5,755	5,922	6,275	6,468	7,057	5,751
	Import	11,121	9,938	9,703	10,408	11,244	9,987
	Total	16,876	15,860	15,978	16,876	18,301	15,738

Source: prepared from data on the website of COCATRAM

(3) Puerto Quetzal

1) Overview

The port is located at latitude 13°55’north and longitude 90°47’03” west on the Pacific Coast and 98 km SE from Guatemala City. It is located 430 km from Puerto Barrios and Santo Tomas de Castilla on the Caribbean Sea side by land. On the other hand, it is located 1,618 km south from the port of Manzanillllo (Mexico) and 150 km north from Acajutla Port by sea. The road network is connecting those cities and the port as well as the neighboring countries of Central America.

The port is a multi-purpose port and gateway to the Pacific Ocean.

The port is managed by Empresa Portuaria Quetzal (EPQ) which is a decentralized autonomous state entity.

2) Port facilities

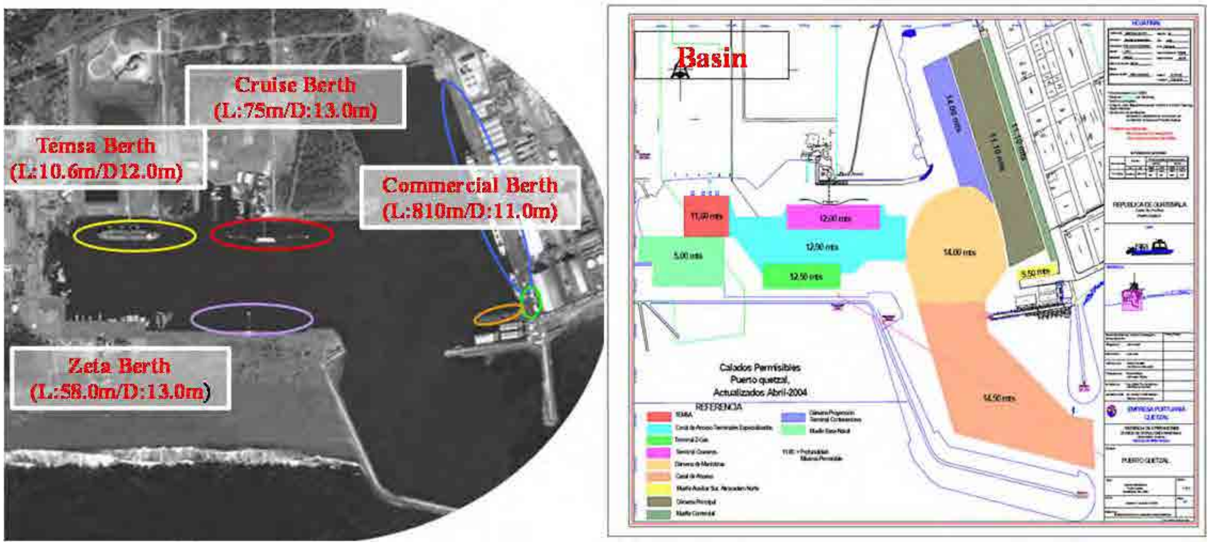
The depth of the channel varies between 14.0m and 16.0 m (The width at the mouth of breakwaters is 210 m.

Main dock has a marginal 810 m long wharf which is divided into four (4) berths with depth of 12m. Two (2) berths are for general cargo/containers, and two (2) berths are for dry bulk general cargo and liquid cargo. The other side of the port area has a large basin to accommodate a Cruise ship terminal (depth 12m), a Coal terminal (depth 14m) and a LPG terminal (depth 13m).

The port has a sedimentation problem due to drifting sand caused by the swell of the Pacific Ocean.

The maximum size of the container vessels which the port receives has a draft of 11.1 m at MLSW according to Guide to Port Entry (2013/2014) by Shipping guideline Ltd.

Figure D.2 shows the layout of port facilities while an outline of main facilities are shown in Table D.3.



Source: prepared from Website of EPQ

Figure D.2 Layout of Puerto Quetzal

Table D.3 Main Port Facilities of Puerto Quetzal

Channel	Depth: 14.0m - 16.0m, Width(between breakwaters): 210 m
Dock	Commercial Berth (4 berths) / Length:810m, Depth: 11 m Cruise Berth / Length 75.0m. Depth 1.0 m Temsa Berth / Length: 10.6 m, Depth: 12.0 m Zeta Berth / Length: 58.0 m, Depth 13.0 m

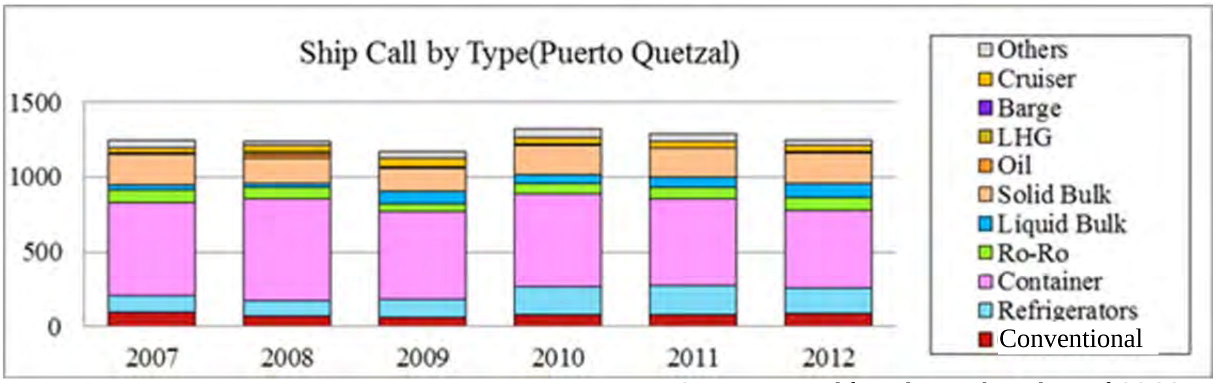
Source: prepared from Website of EPQ

2) Port activities

Puerto Quetzal received 1,247 vessels and handled approximately 8.5 million tons of cargo (5.8 million tons of import cargo and 2.7 million tons of export cargo) in 2012.

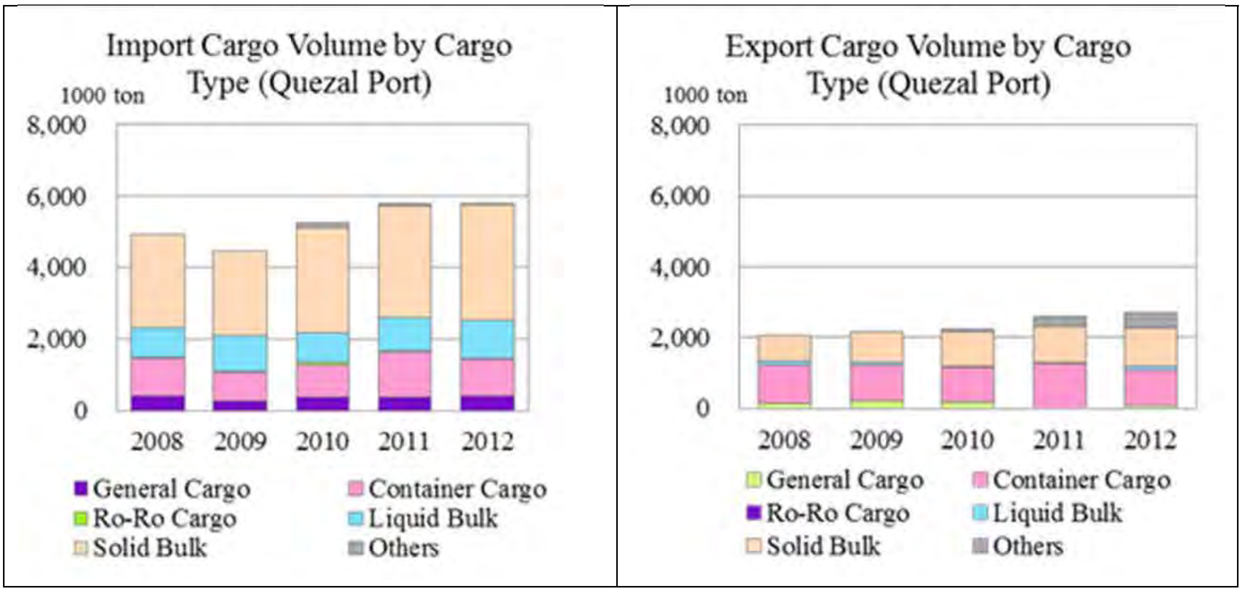
The breakdown of the vessels by type is 85 conventional ships, 174 refrigerator ships, 517 container ships, 84 Ro-Ro ships, 94 liquid bulk ships, 204 solid bulk ships, 9 LHG and 42 other type vessels. Figure D.3 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 399 thousand tons of general cargo, 1,024 thousand tons of container cargo, 44 thousand tons of Ro-Ro cargo, 1,074 thousand tons of liquid bulk cargo, 3,207 thousand tons of solid bulk cargo and 49 thousand tons of other cargo. That of the export cargo volume is 66 thousand tons of general cargo, 1,020 thousand tons of container cargo, 2 thousand tons of Ro-Ro cargo, 113 thousand tons of liquid bulk cargo, 1,060 thousand tons of solid bulk cargo and 437 thousand tons of other cargo. Figure D.4 shows the trend of import/export cargo from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.3 Ship Calls of Puerto Quetzal by Type



Source: prepared from data on the website of COCATRAM

Figure D.4 Import/Export Cargo of Puerto Quetzal by Type

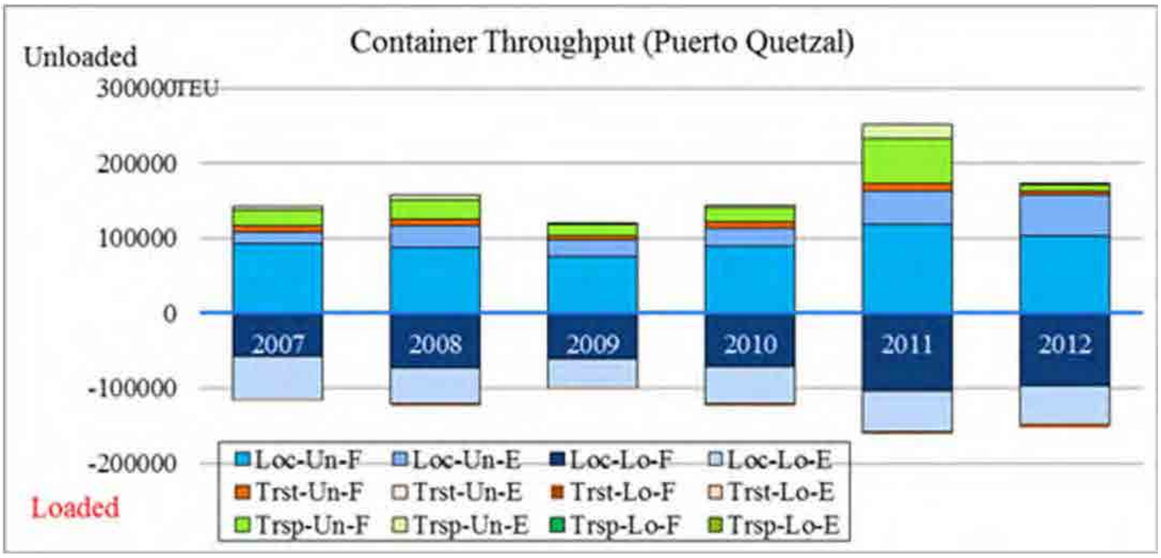
4) Container handling

Puerto Quetzal handled 324,506 TEU containers (218,806 TEU laden containers and 105,700 TEU empty containers) in 2012. 305,589 TEU, 97.3% of them, are local containers, 8,804 TEU (2.7%) are transit containers and 10,114 TEU (3.1%) are transshipment containers. 158,269 TEU unloaded local containers are composed of 103,846 TEU (65.6%) of laden containers and 54,423 TEU (34.4%) of empty containers. 147,320 TEU loaded local containers are composed of 96,744 TEU (65.7%) of laden containers and 50,576 TEU (34.3%) of empty containers. All transit containers (3,793 TEU of unloaded containers and 5,011 TEU of loaded containers) are laden ones. 9,413 TEU unloaded transshipment containers are laden and 701 TEU unloaded transshipment containers are empty and no transship containers are loaded. Table D.4 and Figure D.5 show the trend of container throughput of Puerto Quetzal from 2007 to 2012.

Table D.4 Container Throughput of Puerto Quetzal

Year			2007	2008	2009	2010	2011	2012
Local	Unloading	laden	92,728	88,314	75,417	88,604	117,633	103,846
		Empty	16,264	28,724	21,720	24,059	45,937	54,423
	Loading	laden	57,576	71,995	60,566	71,613	103,039	96,744
		Empty	57,089	49,230	38,599	49,317	55,374	50,576
Transit	Unloading	laden	7,090	8,143	5,076	9,553	9,530	3,793
		Empty	0	0	0	0	0	0
	Loading	laden	892	970	311	471	1,916	5,011
		Empty	0	0	0	0	0	0
Transshipment	Unloading	laden	21,519	24,879	16,042	18,556	60,371	9,413
		Empty	4,131	8,026	1,645	2,984	18,554	701
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Total		laden	179,806	194,300	157,410	188,798	292,488	218,806
		Empty	77,485	85,981	61,964	76,359	119,865	105,700
TOTAL			257,291	280,281	219,374	265,157	412,353	324,506

Source: prepared from data on the website of COCATRAM



<Note>**Loc-Un-F**:Local/Unloading/Full, **Loc-Un-E**:Local/Unloading/Empty, **Loc-Lo-F**:Local/Loading/Full, **Loc-Lo-E**: Local/Loading/Empty, **Trst-Un-F**:Transit/Unloading/Full, **Trst-Un-E**:Transit/Unloading/Empty, **Trst-Lo-F**:Transit/Loading/Full, **Trst-Un-E**:Transit/Loading/Empty, **Trsp-Un-F**:Transshipment/Unloading/Full, **Trsp-Un-F**:Transshipment/Unloading/Empty, **Trsp-Lo-F**:Transshipment/Loading/Full, **Trsp-Un-F**: Transshipment/Loading/Empty,

Source: prepared from data on the website of COCATRAM

Figure D.5 Container Throughput of Puerto Quetzal

5) Development

A new container terminal is planned at the opposite side of the existing commercial berth and the development of the terminal will be implemented by Group TCB (Barcelona) under a concession contract. The period of the concession is 25 years and the company will invest USD 250 million.

The container throughput is estimated as 150 thousand TEU after 2 to 3 years and 450 to 600 thousand TEU after five to ten years. The terminal is composed of two berths over a 540 m-long quay with 14 to 15 m in depth and will provide four gantry cranes corresponding to post-panamax size vessels and introduce RTG for terminal operation. The project will be carried out in 2 phases. It is planned that a 300 m-long quay with 12.5 min depth and yard area of 13 ha will be constructed and opened in 2015 as the Phase 1 project. However, the implementation of the project is behind schedule.

In addition to this container terminal development, EPQ has a plan to improve the existing commercial berth into a 400 m-long multi-purpose berth.

Source: **EMPRESA PORTUARIA QUETZAL**

Figure D.6 Location of New Container Terminal

(4) Puerto Barrios

1) Overview

The port is located at latitude 15°44’03” north and longitude 88°36’21” west on Caribbean Sea Coast and 295 km by road or 320 km by rail from Guatemala City. It is located 430 km from Puerto Quetzal by land. The road network is connecting those cities and the port as well as the neighboring countries of Central America.

The port is mainly serving for the export of fruits (Banana etc.) on account of Chiquita and Dole and coffee. The port is managed by Compania Bananera Guatemalteca Independiente SA (Cobigua) which is an association of major fruit growers led by Chiquita.

2) Port facilities

The length, depth and width of the channel are 19.7 km, 11.0m and 90 m respectively. This channel is shared with Puerto Saito Tomas de Castilla. Tidal range at the port is 0.3m.

Main dock is a jetty type structure with 303.6 m in length and 15.21m in width. It has four mooring posts: No1 dock with 155 m in length and No.2 dock with a 140-m dock in length at its south side, and No.3 dock with 175 m in length and No.4 dock with 65 m in length at its north side.

The maximum size container vessel which the port receives has a draft of 9.5 m according to Guide to Port Entry (2013/2014) by Shipping guideline Ltd.

Table D.5 Main Port Facilities of Puerto Barrios

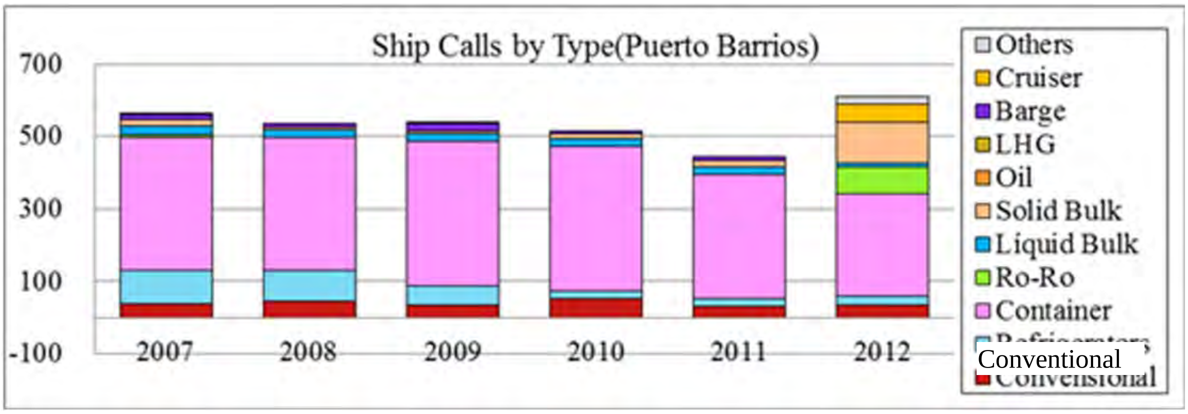
Channel	Length: 19.7 km, Depth: 11.0m - 16.0m, Width: 90 m
Dock	Length:303.6 m, Berth: 4, Depth: 9.5 m Three berths of the above serve container vessels.

3) Port activities

The port received 611 vessels and handling approximately 2.6 million tons of cargo (1.22 million tons of import cargo and 1.38 million tons of export cargo) in 2011.

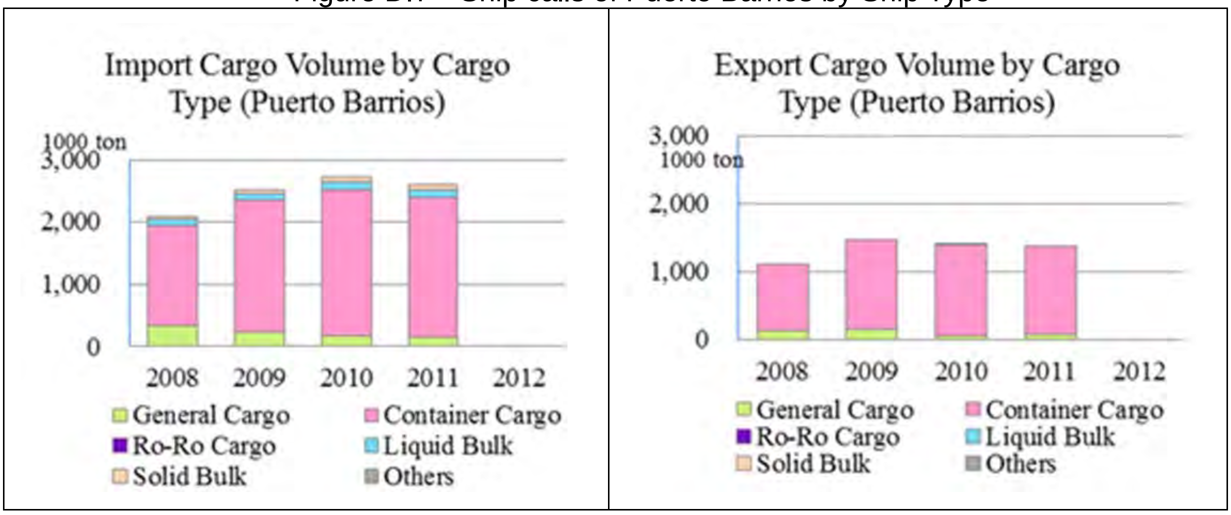
The breakdown of the vessels by type is 33 conventional ships, 25 refrigerator ships, 282 container ships, 74 Ro-Ro ships, 12 liquid bulk ships, 112 solid bulk ships and 71 other type vessels. Figure D.7 shows the trend of ship calls from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 69 thousand tons of general cargo, 940 thousand tons of container cargo, 132 thousand tons of liquid bulk cargo and 79 thousand tons of solid bulk cargo. That of the export cargo volume is 82 thousand tons of general cargo and 1,301 thousand tons of container cargo. Figure D.8 shows the trend of import/export cargo from 2007 to 2011.



Source: prepared from data on the website of COCATRAM

Figure D.7 Ship calls of Puerto Barrios by Ship Type



Source: prepared from data on the website of COCATRAM

Figure D.8 Import/Export Cargo of Puerto Barrios by Cargo Type

4) Container handling

Puerto Barrios handled 365,242 TEU containers (298,878 TEU full containers and 70,364 TEU empty containers) in 2012. 226,361 TEU, 62.0 3% of them, are local containers, 35,505 TEU (9.5%) are transit containers and 103,833 TEU (28.4%) are transshipment containers. 109,980 TEU unloaded local containers are composed of 53,313 TEU (48.5 %) of full containers and 56,667 TEU (51.5 %) of empty containers. 116,381 TEU loaded local containers are composed of 96,113,171 TEU (88.6 %) of full containers and 13,210 TEU (11.4 %) of empty containers.

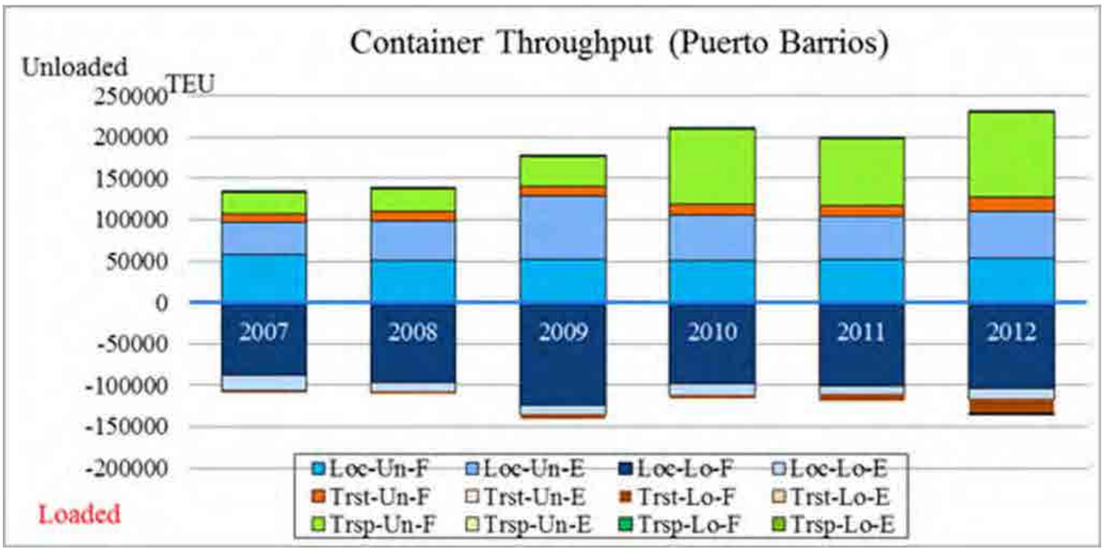
All of transit containers (17,392 TEU of unloaded containers and 17,757 TEU of loaded containers) are full ones. 102,347 TEU unloaded transshipment containers are full and 1,486 TEU unloaded transshipment containers are empty and no transship containers are loaded. Table D.6 and Figure D.9 show the trend of container throughput of Puerto Barrios from 2007 to 2012.

Table D.6 Container Throughput of Puerto Barrios

Year			2007	2008	2009	2010	2011	2012
Local	Unloading	laden	57,916	50,674	52,603	50,273	52,396	53,313
		Empty	39,321	47,373	75,806	54,831	51,278	56,667
	Loading	laden	88,408	96,445	124,402	98,472	100,453	103,171
		Empty	18,441	11,298	10,828	13,841	10,272	13,210
Transit	Unloading	laden	10,125	11,820	12,361	14,130	13,944	17,392
		Empty	0	0	0	0	0	0
	Loading	laden	1,962	2,893	5,760	4,190	8,212	17,657
		Empty	0	0	0	0	0	1
Transshipment	Unloading	laden	26,472	28,278	35,824	91,090	80,287	102,347
		Empty	58	18	62	8	961	1,486
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Total		laden	184,883	190,109	230,950	258,155	255,293	293,878
		Empty	57,820	58,690	86,696	68,679	62,511	71,364
TOTAL			242,703	248,799	317,646	326,834	317,804	365,242

source: COCATRAM

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.9 Container Throughput of Puerto Barrios

5) Development

The port is located in the city center of Puerto Barrios and that makes it difficult to freely expand the facilities.

(5) Santo Tomas de Castilla

1) Overview

The port is located at latitude 15°42'north and longitude 88°37' west in the bottom of Amatique

Bay of Caribbean Sea Coast and 320 km from Guatemala City. It is located 430 km from Puerto Quetzal by land. On the other hand, it is located 1,789 km south from the port of Veracrzu (Mexico) and 117 km north from Puerto Cortes by sea.

The road network is connecting those cities and the port as well as the neighboring countries of Central America.

The port is a multi-purpose port and a gateway to the Caribbean Sea.

The port is managed by Empresa Portuaria Nacional Santo Tomas de Castilla which is a semi-autonomous state entity.

2) Port facilities

The depth of the channel is 11.0m while it is 90 m in length. Tidal range at the port is 0.54 m.

Main dock has a marginal 914.52m long wharf which is divided into six (6) berths with average depth of 9.5m.

The maximum size container vessels which the port receives has a draft of 9.14 m and LOA of 229 m according to Guide to Port Entry (2013/2014) by Shipping guideline Ltd.

Table D.7 Main Port Facilities of Santo Tomas de Castilla

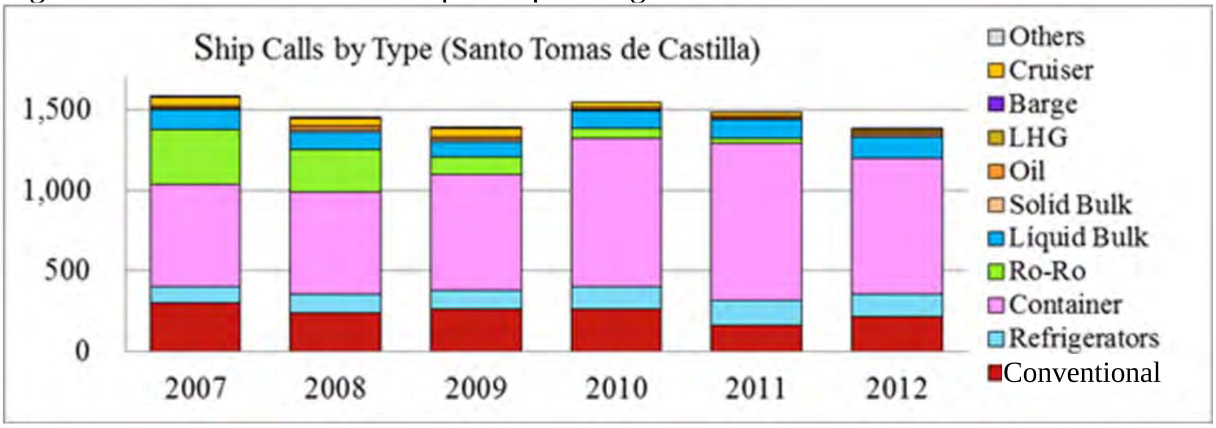
Channel	Depth: 11.0m draft, Length: 90 m
Dock	Length:914.52m, Berth: 6, Depth: 9.5 m on average

3) Port activities

The port received 1,380 vessels and handled approximately 5.5 million tons cargo (2.64 million tons of import cargo and 2.86 million tons of export cargo) in 2012.

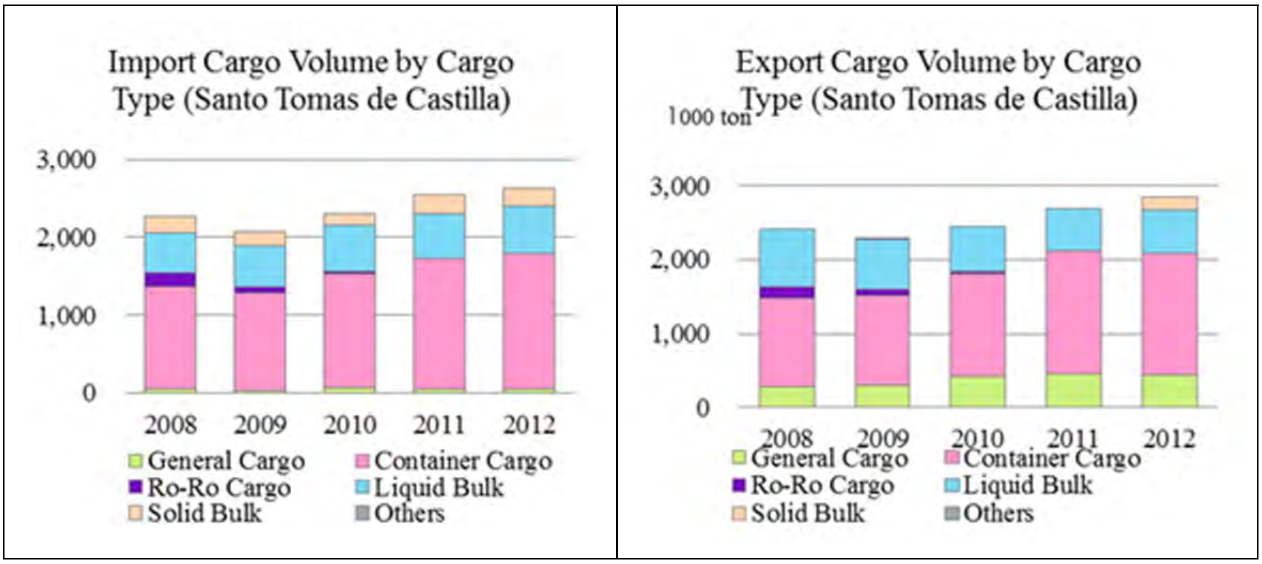
The breakdown of the vessels by type is 215 conventional ships, 144 refrigerator ships, 837 container ships, 2 Ro-Ro ships, 128 liquid bulk ships, 18 solid bulk ships, 13 Oil tanker and 23 other type vessels. Figure D.10 shows the trend of ship calls from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 39 thousand tons of general cargo, 1,752 thousand tons of container cargo, 0.8 thousand tons of Ro-Ro cargo, 603 thousand tons of liquid bulk cargo and 241 thousand tons of solid bulk cargo. That of the export cargo volume is 439 thousand tons of general cargo, 1,651 thousand tons of container cargo, 1 thousand tons of Ro-Ro cargo, 594 thousand tons of liquid bulk cargo and 174 thousand tons of solid bulk cargo. Figure D.11 shows the trend of import/export cargo from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.10 Ship calls of Puerto Barrios by Ship Type



Source: prepared from data on the website of COCATRAM

Figure D.11 Import/Export Cargo of Santo Tomas de Castilla by Cargo Type

4) Container handling

Puerto Santo Tomas de Castillo handled 365,242 TEU containers (293,878 TEU full containers and 71,364 TEU empty containers) in 2012.

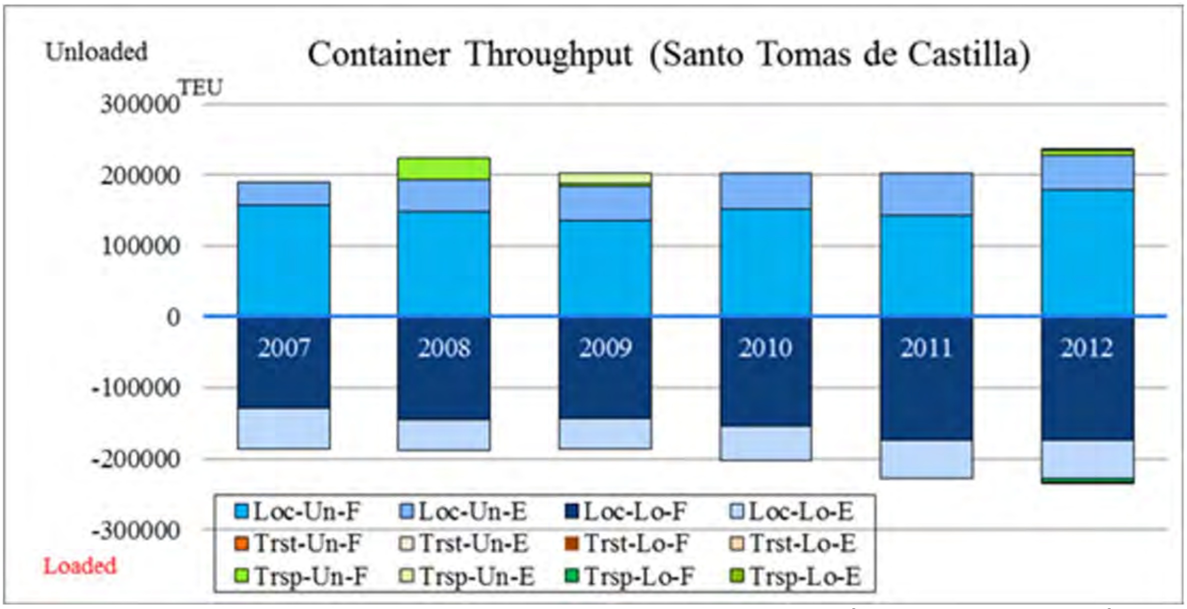
468,734 TEU, 97.3 % of them, are local containers and 12,842 TEU (2.7%) are transshipment containers. 228,339 TEU unloaded local containers are composed of 179,616 TEU (78.7%) of laden containers and 48,723 TEU (21.3 %) of empty containers. 227,555 TEU loaded local containers are composed of 173,697 TEU (78.7 %) of full containers and 53,853 TEU (23.7 %) of empty containers. 6,518 TEU unloaded transshipment containers are composed of 5,576 TEU (90.5 %) of laden containers and 582 TEU (9.45 %) of empty containers. 6,684 TEU unloaded transshipment containers are composed of 5,547 TEU (83.0 %) full containers and 1,137 TEU (17%) of empty containers. Table D.8 and Figure D.12 show the trend of container throughput of Puerto Santo Tomas de Castillo from 2007 to 2012.

Table D.8 Container Throughput of Santo Tomas de Castilla

Year			2007	2008	2009	2010	2011	2012
Local	Unloading	laden	157,199	148,246	135,296	15,1255	143,056	179,616
		Empty	32,557	44,308	49,883	50,891	60,053	48,723
	Loading	laden	128,926	144,334	142,977	154,412	174,178	173,697
		Empty	57,333	43,418	43,413	48,245	53,950	53,858
Transit	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Transshipment	Unloading	laden	0	30,643	2,705	0	0	5,576
		Empty	0	0	13,947	0	0	582
	Loading	laden	0	0	0	0	0	5,547
		Empty	0	0	0	0	0	1,137
Total		laden	286,125	323224	280,978	305,667	317,233	364,435
		Empty	89890	87,726	107,243	99,137	114,002	104,299
TOTAL			376,015	410,950	388,221	404,804	431,235	468,734

source: COCATRAM

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.12 Container Throughput of Santo Tomas de Castilla

5) Development

The port has a plan to moderinize port facilities in order to correspond to increasing container traffic. Four new specialized terminals will be constructed from 2008 to 2012 and start operation. US $ 300 million will be invested in the four terminals and the logistic-industrial area. In addition, a modern cruise ship terminal with the capacity for two large cruise ships will begin operating in 2012. The project cost is estimated at USD 40 million. (Empresa Portuaria Nacional Santo Tomas de Castilla)

D.1.2 Honduras

(1) Outline of Honduras

Republic of Honduras faces the Pacific Ocean and the Caribbean Sea and has borders between Republic of Guatemala, Republic of El Salvador and Nicaragua. Its land area is 112,492 km^2 and has a population of 7.75 million in 2011. Tegucigalpa is the capital.

Main industries are agricultural, forestry, fishery and stock breeding industries (coffee, banana, shrimp). GDP is USD 17,200 million and Per Capita is USD 2,015 in 2011. National economy which was damaged by an unprecedented hurricane disaster has recovered but it is listed as one of the countries of the enhanced HIPC Initiative.

The exports amounted to USD 7,204.3 million and the imports to USD 10,337.6 million in 2011. Main export goods are coffee, banana, cultured shrimp and cultured freshwater fish and main import goods are fuels, machinery and electronic products and chemical products. Major trading partner countries are USA, Central American countries and EU.

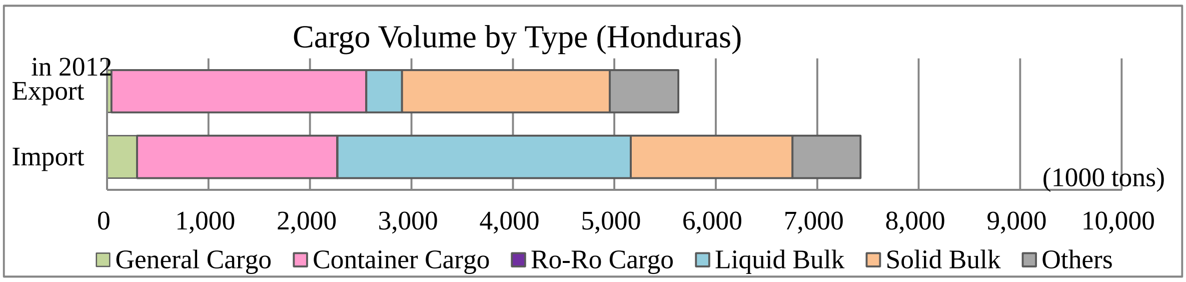
(2) Ports in Honduras

Puerto Cortes and Puerto Castilla are located on the Caribbean Sea. In addition to these two ports, Puerto San Lorenzo is located in Fonseca Bay on the Pacific Coast. These ports are managed by Empresa Nacional Portuaria (ENP) which is a decentralized state entity. Every port in Honduras applies a unified port tariff.

Table D.9 Table D.9 Main Ports of Honduras

Pacific side	San Lorenzo
Caribbean Sea side	Puerto Cortes, Puerto Castilla, Tela, La Ceiba

In 2012, calling vessels at these ports amounts to 2,165 and cargo volume through these ports was 1,347 thousand tons. A breakdown of import and export cargo by type is shown in Figure D.13. Container cargo accounts for 26.6% of import cargo and 44.6 % of export cargo. Table D.10 shows the trend of ship calls and cargo volume of these three ports from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.13 Cargo Volume of Main Ports of Honduras

Table D.10 Tendency of Ship calls and Handling Cargo of Main Ports of Honduras

		2007	2008	2009	2010	2011	2012
Ship Call		2,547	2,456	2,328	2,252	2,570	2,165
Cargo Volume (thousand tons)	Export	3,193	3,486	3,162	3,783	4,844	5,630
	Import	6,626	6,990	6,289	6,798	7,293	7,427
	Total	9,819	10,476	9,450	10,582	12,137	13,057

Source: prepared from data on the website of COCATRAM

(3) Puerto Cortes

1) Overview

The port is located at latitude 16°30’10” north and longitude 88°24’00” east on the Caribbean Sea Coast and 400 km SE from Tegucigalpa City. It is located 117 km east from Puerto Santo Tomas de Castilla and 1,144 km north from Puerto Limon by sea.

Rail track of 11km is extended in the port area with double track on berth. The port is linked by railroad and highway to several other centers and a main road leads to the capital city, Tegucigalpa.

The port is a multi-purpose port and a gateway to the Caribbean Sea.

2) Port facilities

The approach channel is 1200 m long, 400 m wide with an average draft of 14 m. Tidal range at the port is no more than 0.3 m.

Total length of the wharf is 1,157m. The port has three berths for Container and General Cargo. Wharf No.3 has one general cargo/Ro-Ro/container berth with length of 198m and depth of 9-12m. Wharf No. 4 has two general cargo/Ro-Ro/container berths with length of 325m and depth of 8-9.2m. Wharf No. 5 has three general container berths with length of 476m and depth of 9-11m. In addition to these wharves, there are two Ro-Ro berths with depth of 10.6m.

The wharves are equipped with two gantry cranes of 45-t capacity, one mobile crane (truck mounted) of 125-t capacity and five mobile cranes for 125-t capacity to 15-t capacity.

The maximum size container vessel which the port receives is has a draft of 12.0 m at MLW according to Guide to Port Entry (2013/2014) by Shipping guideline Ltd.

The outline of main facilities is shown in Table D.11.

Table D.11 Main Port Facilities of Puerto Cortes

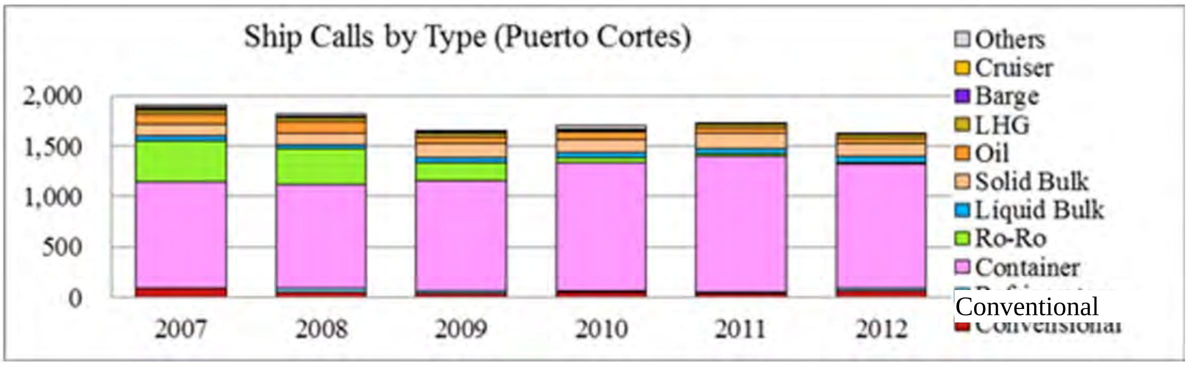
Channel	Length:1,200 m, width:400 m, Draft (average): 14.0 m
Dock	Total Length: 1157m/ a 198-m long berth with the depth of 9-12 m, a 325-m long berth with the depth of 8-9.2 m, a 476-m long berth with the depth of 9-11 m, RORO berth with the depth of 10.6m

3) Port activities

Puerto Cortes received 1,630 vessels and handled approximately 9.6 million tons of cargo (6.1 million tons of import cargo and 3.5 million tons of export cargo) in 2012.

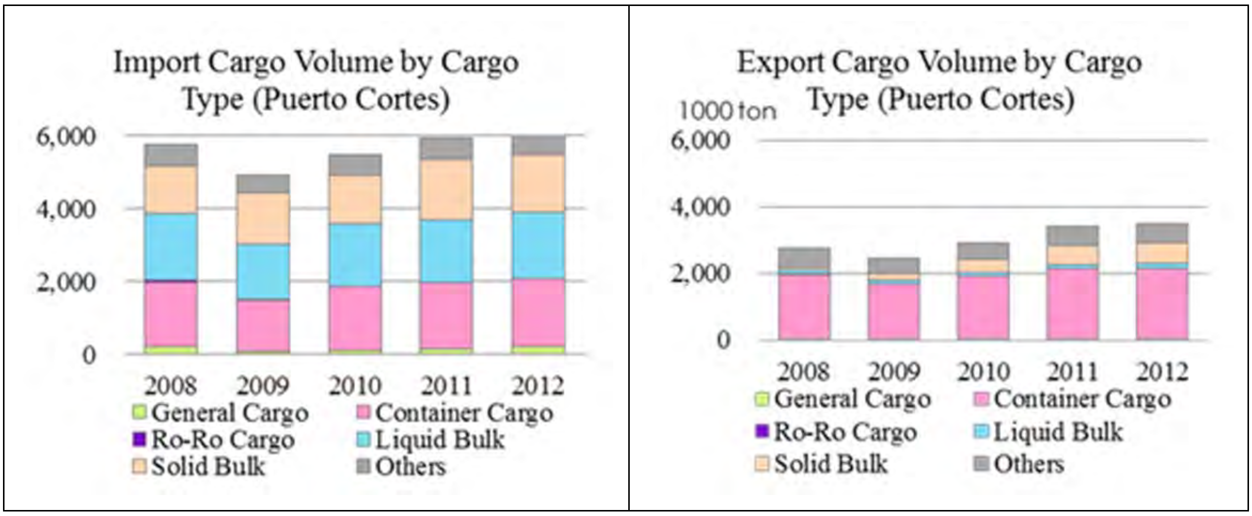
The breakdown of the vessels by type is 68 conventional ships, 1,171 refrigerator ships, 1,243 container ships, 13 Ro-Ro ships, 57 liquid bulk ships, 131 solid bulk ships, 54 Oil tankers, 33 LHG and 14 other type vessels. Figure D.14 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 227 thousand tons of general cargo, 1,806 thousand tons of container cargo, 2thousand tons of Ro-Ro cargo, 1,818 thousand tons of liquid bulk cargo, 1,563 thousand tons of solid bulk cargo and 588 thousand tons of other cargo. That of the export cargo volume is 27 thousand tons of general cargo, 2,137 thousand tons of container cargo, 2 thousand tons of Ro-Ro cargo, 148 thousand tons of liquid bulk cargo, 598 thousand tons of solid bulk cargo and 589 thousand tons of other cargo. Figure D.15 shows the trend of import/export cargo from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.14 Ship Calls of Puerto Cortes by Type



Source: prepared from data on the website of COCATRAM

Figure D.15 Import/Export Cargo of Puerto Cortes by Type

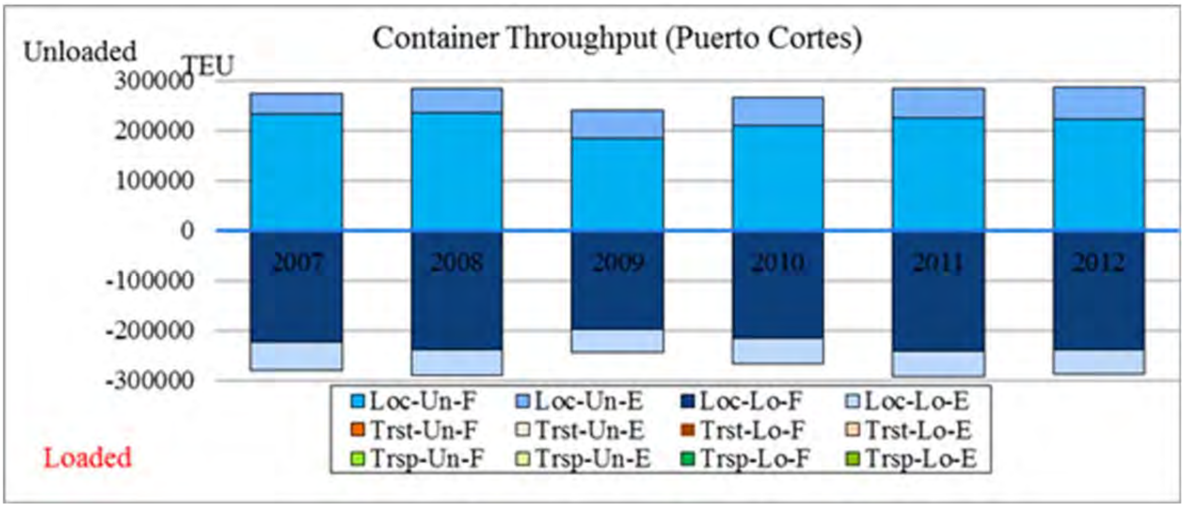
4) Container handling

Puerto Cortes handled 573,322 TEU containers (461,571 TEU laden containers and 111,751 TEU empty containers) in 2012. All containers handled at the port are local containers. 285,465 TEU unloaded local containers are composed of 221,882 TEU (77.7 %) of laden containers and 63,585 TEU (22.3 %) of empty containers. 287,858 TEU loaded local containers are composed of 239,961 TEU (83.3 %) of laden containers and 48,167 TEU (16.7 %) of empty containers. Table D.12 and Figure D.16 show the trend of container throughput of Puerto Cortes from 2007 to 2012.

Table D.12 Container Throughput of Puerto Cortes

Year			2,007	2,008	2,009	2,010	2,011	2,012
Local	Unloading	laden	232,199	235,735	184,004	210,231	225,140	221,882
		Empty	41,760	46,883	55,618	55,177	59,217	63,583
	Loading	laden	223,279	239,730	198,915	216,082	241,803	239,691
		Empty	55,899	50,032	45,611	50,340	50,451	48,167
Transit	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Transshipment	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Total		laden	455,477	475,466	382,919	426,314	466,942	461,571
		Empty	97,660	96,913	101,228	105,517	109,669	111,751
TOTAL			553,137	572,379	484,147	531,831	576,611	573,322

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.16 Container Throughput of La Puerto Cortes

5) Development

ENP has a plan to expand and modernize Cortes Port. The overall objectives of the project are to improve the capacity and efficiency of port operation, to promote the improvement of physical conditions and to contribute to sustainable social and economic development of Honduras. Specific objectives are to reduce operating costs for vessels and goods by developing the logistical operations of the container terminal. The Inter- American Development Bank (IDB) has decided to provide an amount of USD135.00 million (ENP) for the project.

(4) Puerto Castilla

1) Overview

Puerto Castilla is located at latitude 16°00’00”north and longitude 86°01’00” west on Atlantic Coast and 400 km NE from Tegucigalpa City. The road network is connecting the other parts of the country.

The port is mostly dedicated to the export of banana produced under Dole Food Company Inc.

2) Port facilities

The port has one berth of 225 m in length and 38m in width. The depth alongside the berth is 10m. There is no shore crane available in the port. The port has two cargo sheds of 3,000m^2 each.

The maximum size vessel which the port can accommodate has a LOA of 225-m and a draft of 10.97 m draft according to Guide to Port Entry (2013/2014 Edition) by Shipping guides LTD.

The outline of main facilities is shown in Table D.13.

Table D.13 Main Port Facilities of Puerto Castilla

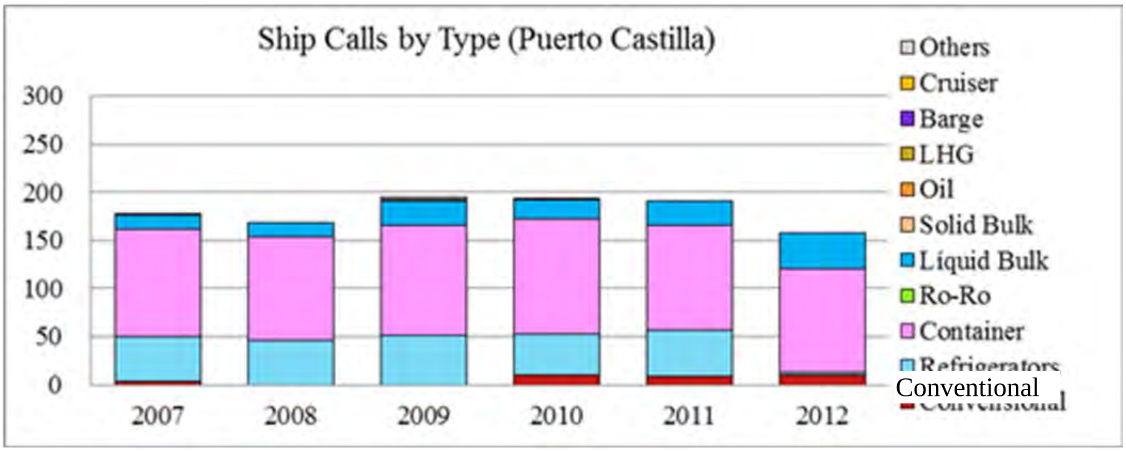
Channel	-
Dock	Length: 225m, width 38 m, depth: approximately 10 m

3) Port activities

Puerto Castilla received 157 vessels and handled approximately 840 thousand tons of cargo (228 thousand tons of import cargo and 614 thousand tons of export cargo) in 2012.

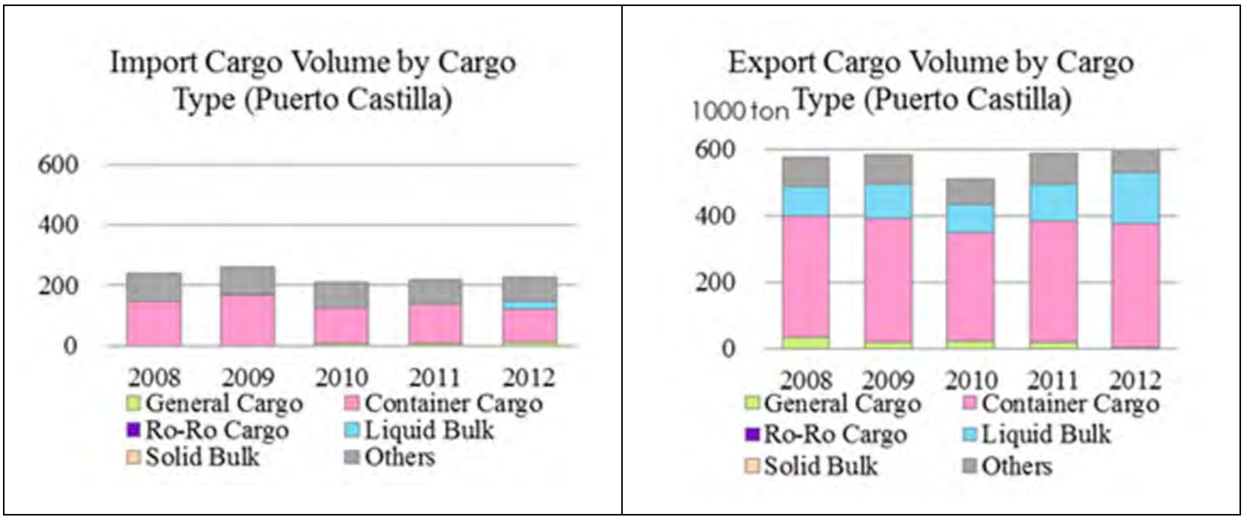
The breakdown of the vessels by type is 10 conventional ships, 2 refrigerator ships, 108 container ships and 7 liquid bulk ships. Figure D.17 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 9 thousand tons of general cargo, 113 thousand tons of container cargo, 22 thousand tons of liquid bulk cargo and 84 thousand tons of other cargo. That of the export cargo volume is 3 thousand tons of general cargo, 374 thousand tons of container cargo, 151 thousand tons of liquid bulk cargo and 86 thousand tons of other cargo. Figure D.18 shows the trend of import/export cargo from 2008 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.17 Ship Calls of Puerto Castilla by Type



Source: prepared from data on the website of COCATRAM

Figure D.18 Import/Export Cargo of Puerto Castilla by Type

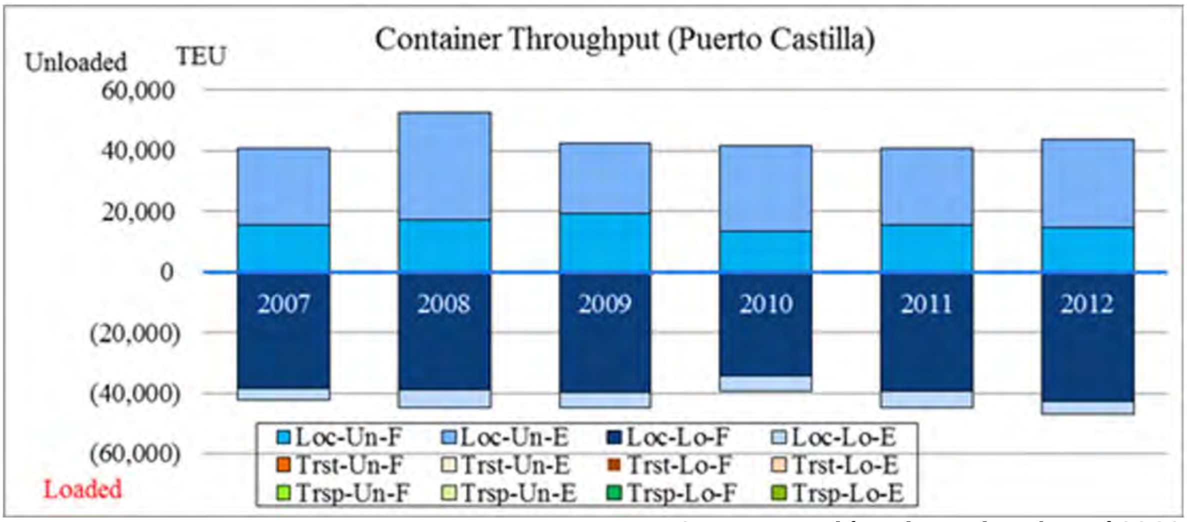
4) Container handling

Puerto Castilla handled 90,586 TEU containers (57,680 TEU laden containers and 32,906 TEU empty containers) in 2012. All containers handled at the port are local containers. 43,774 TEU unloaded local containers are composed of 14,826 TEU (33.9 %) of laden containers and 28,948 TEU (66.1 %) of empty containers. 46,812 TEU loaded local containers are composed of 42,854 TEU (91.5 %) of laden containers and 3,958 TEU (8.5 %) of empty containers. Table D.14 and Figure D.19 show the trend of container throughput of Puerto Castilla from 2007 to 2012.

Table D.14 Container Throughput of Puerto Castilla

Year			2,007	2,008	2,009	2,010	2,011	2,012
Local	Unloading	laden	15,334	17,160	19,336	13,176	15,518	14,826
		Empty	25,650	35,246	23,306	28,286	25,446	28,948
	Loading	laden	38,730	38,978	39,832	34,330	39,542	42,854
		Empty	3,582	6,036	5,098	5,222	5,386	3,958
Transit	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Transshipment	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Total		laden	54,064	56,138	59,168	47,506	55,060	57,680
		Empty	29,232	41,282	28,404	33,508	30,832	32,906
TOTAL			83,296	97,420	87,572	81,014	85,892	90,586

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.19 Container Throughput of Puerto Castilla

(4) San Lorenzo Port

1) Overview

The port is located at latitude 13°24’00” north and longitude 87°25’30” west in Fonseca Bay on the Pacific Coast and 108 km SW from Tegucigalpa City. It is located at 100 km from La Union Port by land. On the other hand, it is located 70 km south from La Union Port and 170 km north from Corinto Port by sea. The road network is connecting other parts of the country and as well as the neighboring countries.

The port is gateway to the Pacific Ocean of Honduras. Various cargoes are imported and exported through the port. Ferric oxide is one of the main cargoes of the port.

Main export cargo commodities are ferric oxide to China (2000 Mt/month), sugar and molasses to UK, scrap in containers and fruits to Taiwan. Main import cargo commodities are petroleum for a power plant near the port from Panama, Peru and Ecuador, vehicles from Japan and Korea and wire from South American countries.

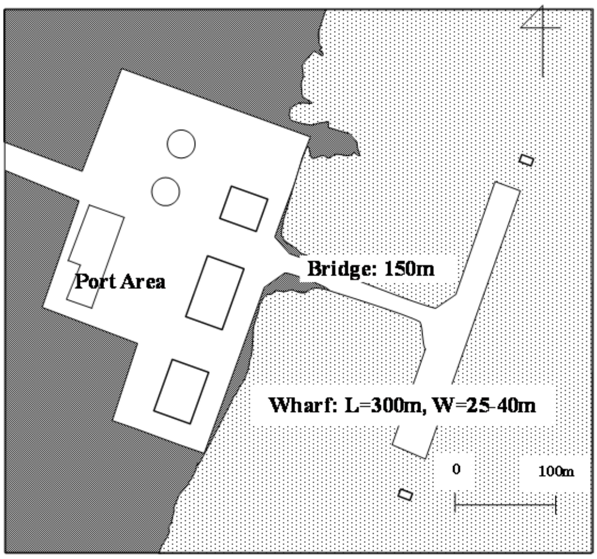
2) Port facilities

The length of the approach channel is 32 km; width is 122 m is 32 km. The dredging works for deepening the channel to 10 m have been conducted twice until today: in 1979 when the port was constructed and 2004. According to MANUAL DE PUERTOS DE CENTROAMERICA (200-2011) published by COCATRAM, the minimum draft at LW is 10.0 m however actual depth of channel is 8 m to 10 m according to San Lorenzo office of ENP. At present, the maximum size vessel which calls at the port has LOA of 220 m and a draft of 9.5 m. The tidal range is 2.5 m to 3.0 m. The sea bed of the channel is mostly sandy but rock is observed at some parts. San Lorenzo office of ENP hopes to dredge the channel to 11 m.

A T-shape dock of 300 m in length and 40/25 m in width is located offshore and is connected with the yard by a 160-m long bridge with width of 15 m. The depth of the dock is 9.0 m at half-tide. Two dolphins are installed at each side in order to moor three vessels at the same time.

The maximum size vessel which the port can accommodate has a LOA of 220 m of LOA and a draft of 9.5 m.

Figure D.20 shows layout of the port facilities and the outline of main facilities is shown in Table D.15.



Source:JICA study team

Figure D.20 Layout of San Lorenzo Port

Table D.15 Main Port Facilities of Puerto San Lorenzo

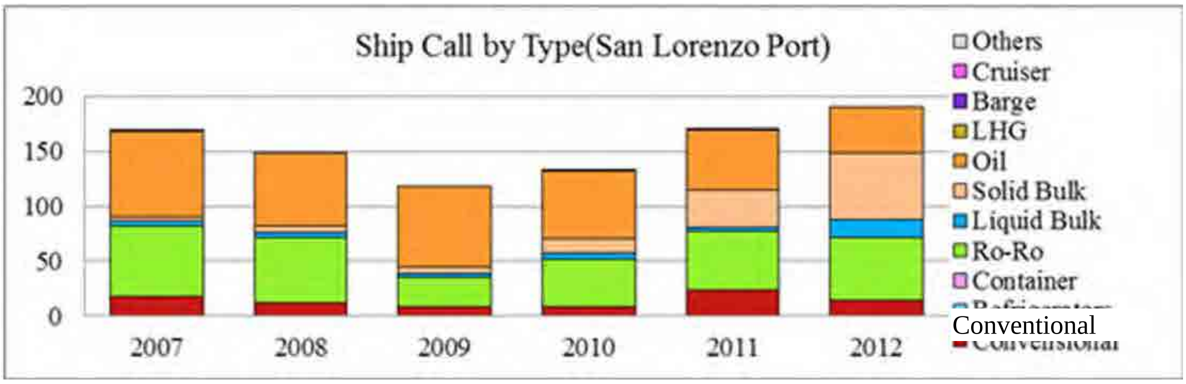
Channel	Length: 32 km, width: 122 m, Depth: 11m (actually 8-10 m)
Dock	Berth length: 300 m, Width: 25/40 m Dolphins are installed at each end of the berth

3) Port activities

Puerto San Lorenzo received 190 vessels and handled approximately 2.4 million tons of cargo (0.8 million tons of import cargo and 1.5 million tons of export cargo) in 2012.

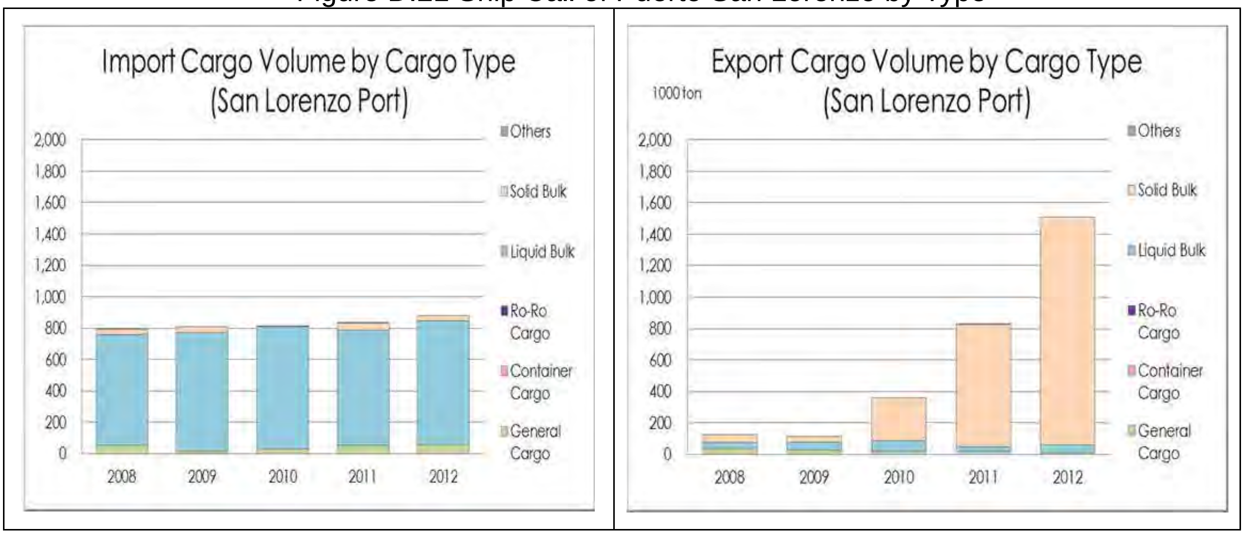
The breakdown of the vessels by type is 14 of conventional ship, 57 Ro-Ro ships, 17 liquid bulk ships, 60 solid bulk ships, and 42 Oil tankers. Figure D.21 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 59 thousand tons of general cargo, 790 thousand tons of liquid bulk cargo and 31 thousand tons of solid bulk cargo. That of the export cargo volume is 6 thousand tons of general cargo, 53 thousand tons of liquid bulk cargo and 1,449 thousand tons of solid bulk cargo. Figure D.22 shows the trend of import/export cargo from 2008 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.21 Ship Call of Puerto San Lorenzo by Type



Source: prepared from data on the website of COCATRAM

Figure D.22 Import/Export Cargo of Puerto San Lorenzo by Type

4) Container handling

According to the Statistics of COCATRAM, the port handled containers in 2011. All containers were local ones and no transit and transshipment containers were handled. The throughput is 171 TEU. 141 TEU containers were unloaded and 30 TEU containers were loaded. 118 TEU of unloaded containers are full and 23 TEU of them are empty. 27 TEU loaded containers are laden and 3 TEU were empty.

5) Future Development

ENP plans to dredge the approach channel to 11 m.

D.1.3 Nicaragua

(1) Outline of Nicaragua

Republic of Nicaragua faces the Pacific Ocean and the Caribbean Sea and has borders between Honduras and Republic of Costa Rica. Its land area is 129,541 km2 and has a population of 5.87 million in 2011. Managua is the capital. The port of Corinto faces the Pacific Ocean while no major port faces the Caribbean Sea.

Main industries are agriculture, stock breeding industries (coffee, beef, peanuts, sugar cane, corn, rice and banana) and garment industry whose products are manufactured in maquiladoras. GDP is USD 7,287 million and Per Capita is USD 1,239.2 in 2011. National economy which was destroyed by the civil war has recovered to a certain level but it is one of the least developed countries in the central-south America.

The exports amounted to USD 4,507 million and the imports to USD 6,125 million in 2011. Main export goods are coffee, beef, gold and sugar and main import goods are consumer products, in-process materials and oil products. Major trading partner countries are USA, El Salvador, Venezuela, Honduras and Costa Rica for export, and USA, Venezuela, Costa Rica, Mexico and Guatemala for import.

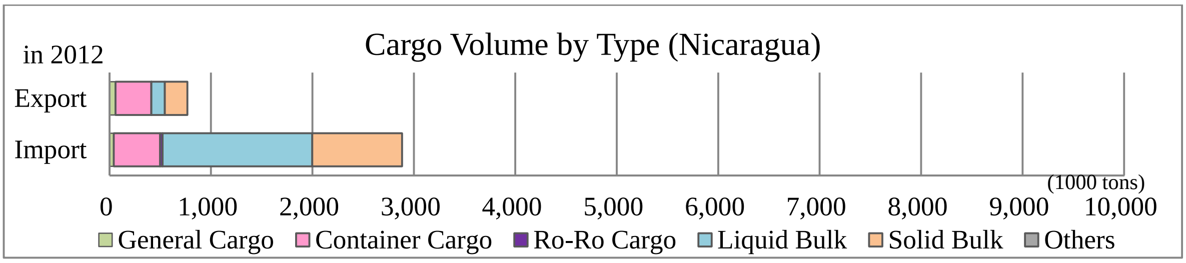
(2) Ports in Nicaragua

Puerto Corinto is gateway of Nicaragua to the Pacific Ocean. On the Caribbean Sea Coast, there is not a satisfactory port which receives vessels serving international trade. The development of a new port on the Caribbean Sea Coast of Nicaragua is required.

Table D.16 Main Ports of Nicaragua

Pacific side	Corinto, Sandino
Caribbean Sea side	El Bluff, Cabezas, Arein Siu (El Rama),

In 2012, calling vessels at these ports amounts to 569 and cargo volume through these ports was 3,651 thousand tons. A breakdown of import and export cargo by type is shown in Figure D.23. Container cargo accounts for 15.8 % of export cargo and 45.8 % of import cargo. Table D.17 shows the trend of ship calls and cargo volume of these three ports from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.23 Cargo Volume of Main Ports of Nicaragua

Table D.17 Tendency of Ship Calls and Handling Cargo of Main Ports of Nicaragua

		2007	2008	2009	2010	2011	2012
Ship Call		676	673	596	640	642	569
Cargo Volume (thousand tons)	Export	492	455	484	692	655	768
	Import	2,446	2,344	2,350	2,317	2,783	2,883
	Total	2,938	2,799	2,834	3,009	3,438	3,651

Source: prepared from data on the website of COCATRAM

(3) Corinto Port

1) Overview

The port is located at latitude 12°29’north and longitude 87°11’west at the mouth of El Realejo estuary on the Pacific Coast and 160 km SNE from Managua. It is located 510 km north from Caldera Port in Costa Rica and 170 km south from San Lorenzo Ports by sea. The road network is available to the major cities of the country including the capital city of Managua.

The port is a sole full scale international port in Nicaragua and plays a role of gateway to the Pacific Ocean.

The port is the state port under management by Empresa Portuaria National (EPN).

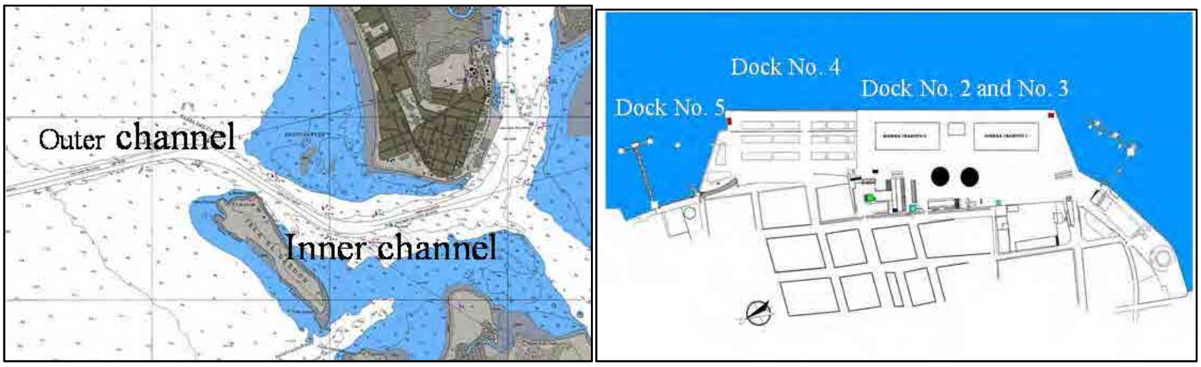
2) Port facilities

A vessel which intends to enter the port needs to go through the outer channel and the inner channel. The length, width and depth of the outer channel are 3.4 km, 150 m and 14.6 m and those of the inner channel are 3.1 km, 115 m and 13.35 m. Draft at LW is 10.95 m in the inner channel and 12.20 m in the outer channel. Tidal range at the port is 2.27 m in neap tides and 3.11 m at the spring tides.

The port has five docks. Dock No. 1 is a jetty type pier of 110 in length, 10 m in width and with a draft of 10.7 m. Dock No. 2 and No. 3 are marginal docks of 370 m in length, 24 m in width and with a draft of 12.6 m for general cargo and bulks. Dock No.4 is a marginal dock of 240 m in length, 40 m in width and a draft of 13.25 m for containers. A 45-t gantry crane is installed on this dock but it is out of use at present. Dock No. 5 is a 115 m jetty type pier for liquid cargo handling.

The maximum size of the vessels which the port receives is 45,000 tons of displacement, 200 m of LOA, 32.0 m of beam and 11.15 m of draft according to Guide of port Entry (2013/2014) by Shipping guides Ltd.

Figure D.24 shows layout of port facilities and outline of main facilities are shown in Table D.18.



Surce:Administración Portuaria de Corinto Terminal Marítima Internacional Puerto Corinto ABRIL 2013

Figure D.24 Layout of Corinto Port

Table D.18 Main Port Facilities of Corinto Port

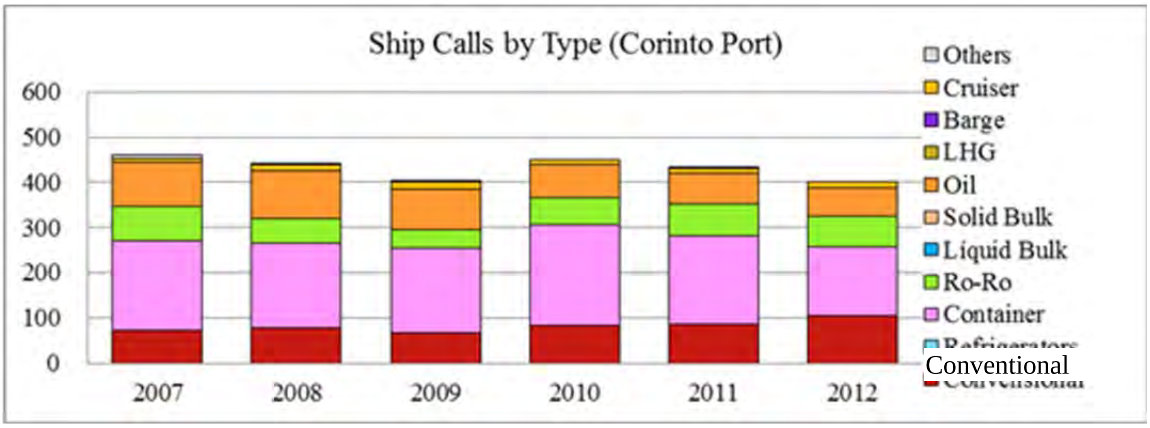
Channel	Outer Channel/ Length: 3.4 km, Width: 150 m, Depth: 14.6 m Inner Channel/ Length: 3.1 km, Width: 110 m, Depth: 13.35 m.
Dock	Dock No. 1 / A jetty type pier, Length: 110, Width: 10 m, Draft:10.7 m Dock No. 2 and No. 3 / Marginal docks, Length:370m, Width: 24 m, Draft: 12.6 m Dock No.4 / A marginal dock, Length: 240 m, Width:40 m, Draft: 13.25 m Dock No. 5 / A 115 m jetty type pier

3) Port activities

Corinto Port received 402 vessels and handled approximately 2.7 million tons of cargo (0.7 million tons of import cargo and 2.0 million tons of export cargo) in 2012.

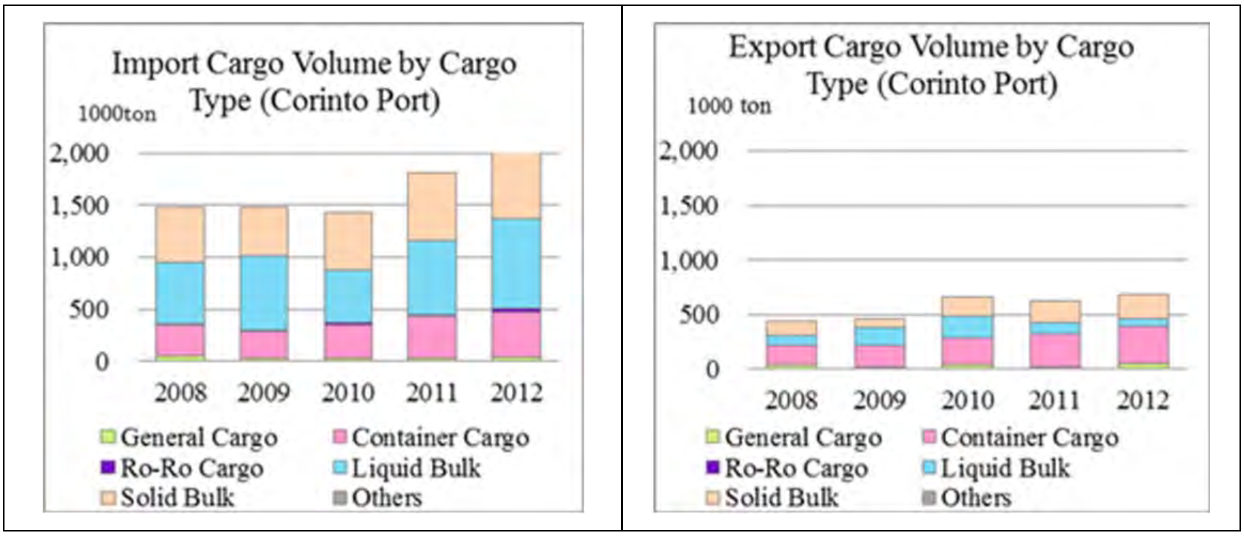
The breakdown of the vessels by type is 106 conventional ships, 150 container ships, 70 Ro-Ro ships, 61 Oil tankers and 15 Cruisers. Figure D.25 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 36 thousand tons of general cargo, 439 thousand tons of container cargo, 26 thousand tons of Ro-Ro cargo, 871 thousand tons of liquid bulk cargo and 642 thousand tons of solid bulk cargo. That of the export cargo volume is 48 thousand tons of general cargo, 339 thousand tons of container cargo 80 thousand tons of liquid bulk cargo and 233 thousand tons of solid bulk cargo. Figure D.26 shows the trend of import/export cargo from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.25 Ship Calls of Corinto Port by Type



Source: prepared from data on the website of COCATRAM

Figure D.26 Import/Export Cargo of Corinto Port by Type

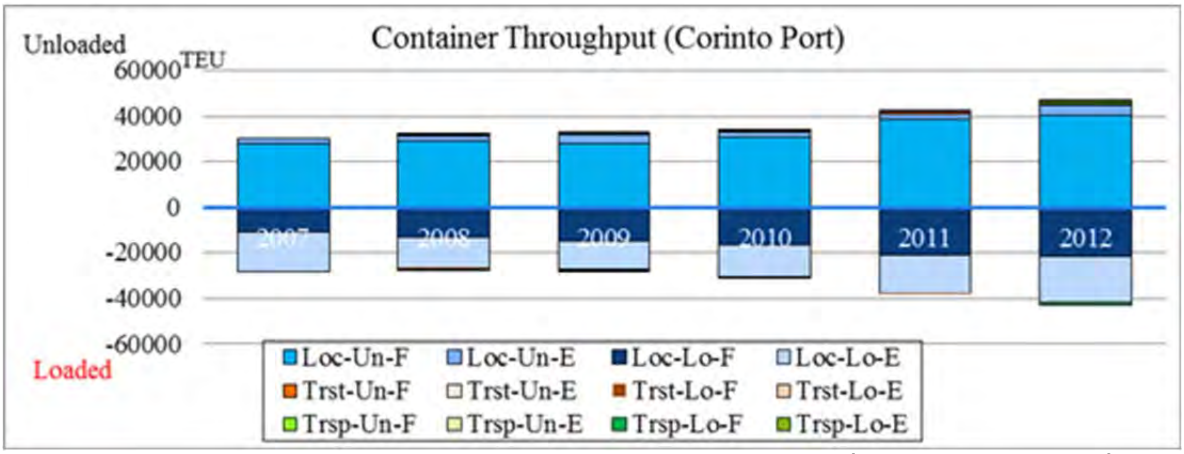
4) Container handling

Corinto Port handled 89,537 TEU containers (64,648 TEU laden containers and 24,889 TEU empty containers) in 2012. 86,937 TEU, 97.1% of them, are local containers, 749 TEU (0.8 %) are transit containers and 1,852 TEU (2.1%) are transshipment containers. 44,725 TEU unloaded local containers are composed of 40,250 TEU (90.0 %) of laden containers and 4,475 TEU (10.0 %) of empty containers. 42,212 TEU loaded local containers are composed of 21,799 TEU (51.6 %) of laden containers and 20,413 (48.3%) of empty containers. Almost all transit containers are unloading laden containers. 1,074 TEU unloaded transshipment containers are and 778 TEU loaded transshipment containers are laden. Figure D.27 and Table D.19 show the trend of container throughput of Corinto Port from 2007 to 2012.

Table D.19 Container Throughput of Corinto Port

Year			2007	2008	2009	2010	2011	2012
Local	Unloading	laden	27,662	28,926	27,920	30,851	38,522	40,250
		Empty	2,479	2,334	4,063	2,104	2,596	4,475
	Loading	laden	10,719	13,028	14,828	16,834	21,084	21,799
		Empty	17,754	13,674	12,695	13,884	16,875	20,413
Transit	Unloading	laden	0	455	559	828	980	748
		Empty	0	4	18	206	8	0
	Loading	laden	0	455	433	5	54	1
		Empty	0	4	18	206	0	0
Transshipment	Unloading	laden	0	0	0	0	0	1,072
		Empty	0	0	0	0	0	2
	Loading	laden	0	0	0	0	0	778
		Empty	0	0	0	0	0	0
Total		laden	38,382	42,864	43,739	48,517	60,641	64,648
		Empty	20,233	16,016	16,793	16,399	19,479	24,889
TOTAL			58,615	58,880	60,532	64,916	80,120	89,537

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.27 Container Throughput of Corinto Port

5) Development

EPN plans to dredge the outer channel of Corinto Port in 2014. The volume is estimated to reach 5.6 million m3. The dredging cost was USD 12 per m3 in the previous work but it is estimated to be USD 5-7 per m3 this time because the dumping cost and ship mobilization cost may be less than the previous time. In addition to the dredging, EPN would like to improve the south wharf which is not used at present. EPN intends to repair the quay crane which is out of work at present. Productivity of the quay gantry crane is 18-22 boxes /h. That of a ship gear is 13-15. However, owing to its high usage charge, only Maersk used the gantry crane. Corinto Port may introduce a concession scheme in the future under the new port act.

D.1.4 Costa Rica

(1) Outline of Costa Rica

Republic of Costa Rica faces the Pacific Ocean and the Caribbean Sea and has borders between Nicaragua and Panama. Its land area is 51,100 km2 and has a population of 4.72 million in 2011. San Jose is the capital. The port of Caldera faces the Pacific Ocean and Puerto Limon/Moin faces the Caribbean Sea.

Main industries are agriculture (coffee, banana and pineapple), manufacture (integrated circuit, medical supplies) and tourism. GDP is USD 41,004 million and Per Capita is USD 8,678 in 2011. It is a stable democratic nation and the most highly-educated country in CA countries.

The exports amounted to USD 10,408 million and the imports to USD 16,219.5 million in 2011. Main export goods are integrated circuits, machinery parts of automatic data processing, banana and pineapple, and main import goods are fuels, integrated circuits and vehicles. Major trading partner countries are USA, Netherland, China and CA countries for export, and USA, Mexico, China and Japan for import.

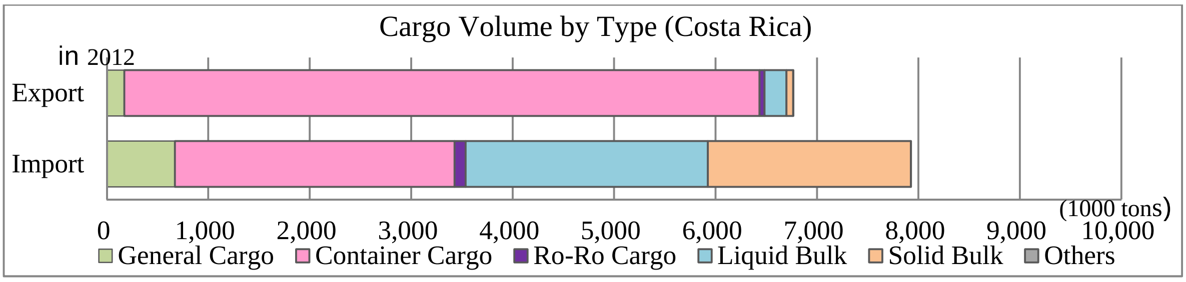
(2) Ports in Costa Rica

Caldera Port is located on the Pacific Coast and Puerto Limon is located on the Caribbean Sea Coast of Costa Rica. Each port serves as a gateway of Costa Rica to the Pacific Ocean or the Caribbean Sea. In addition to these two ports, several terminals are located throughout the country.

Table D.20 Main Ports of Costa Rica

Pacific side	Caldera, Puntarenas, Punta Morales, Terminal Fertica, Qepos, Golfito
Caribbean Sea side	Limon-Moin

In 2012, calling vessels at these ports amounts to 3,322 and cargo volume through these ports was 14,691 thousand tons. A breakdown of import and export cargo by type is shown in Figure D.28. Container cargo accounts for 34.8 % of import cargo and 92.6 % of export cargo. Table D.21 shows the trend of ship call and cargo volume of these three ports from 2007 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.28 Cargo Volume of Main Ports of Costa Rica

Table D.21 Tendency of Ship Call and Handling Cargo of Main Ports of Costa Rica

		2007	2008	2009	2010	2011	2012
Ship Call		3,215	3,078	3,009	3,136	3,373	3,322
Cargo Volume (thousand tons)	Export	5,761	5,703	5,240	5,851	6,380	6,766
	Import	7,913	8,233	6,829	7,623	7,827	7,926
	Total	13,674	13,936	12,069	13,474	14,207	14,691

Source: prepared from data on the website of COCATRAM

(3) Caldera Port

1) Overview

The port is located at latitude 9°54’north and longitude 84°4 west in the Caldera Bay on Pacific Coast and 80 km W from San Jose. It is located 510 km south from Corinto Port in Nicaragua and 870 km north from Balboa Port in Panama by sea. The road network is connecting those cities and the port as well as the neighboring countries of Central America.

The port is a multi-purpose port and a gateway to the Pacific Ocean. Main import cargoes are grains and containers and main export cargoes are general cargo and fruits in containers.

The port was privatized in 2006 as a result of the efforts for modernization of port management. The port is managed on a concession basis by Caldera Port Association and Caldera Port Association for Bulk. Colombia’s Sociedad Portuaria de Buenaventura invested 50 million US$ for 51% interest in the 20-year concession. Remaining 49% was acquired by two other companies. Costa Rican Institute of Pacific Ports (INCOP) has a function as regulator of the port.

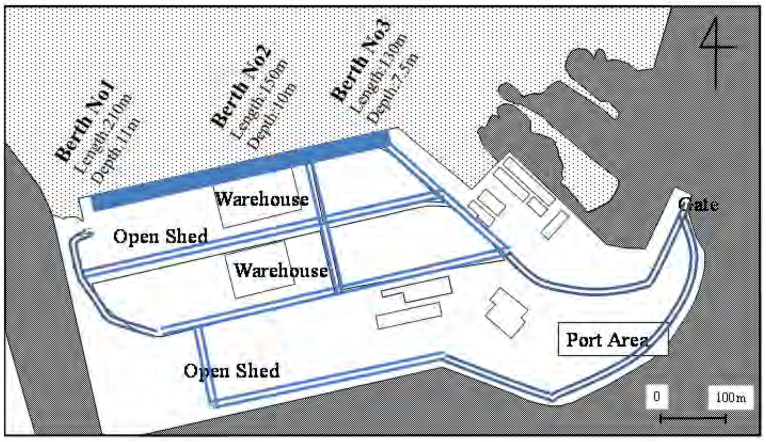
2) Port facilities

The access channel and anchorage area have a minimum depth of 13 m (measured based on the average of the lowest). Tides in Puntarenas and Caldera are 2.5 m (high tide) and 0.3 m (low tide) on average. At certain times, the variation can be up to 3.1 and - 0.3 m.

The port has a marginal 490 m long wharf for general cargo/container, which is divided into three (3) berths. Berth No 1 is used by container/general vessels, berth No2 is by conventional/container vessels and berth No 3 is by conventional vessels. The depth alongside the berths varies from 7 to 13m. Total storage area of the port is 70,000m2 and warehouses cover 13,200m2 for handling general cargo.

The maximum size of the vessels is 25,000DWT for berth No1, 15000DWT for berth No2 and 5,000 DWT for berth No3.

The Figure D.29 shows layout of port facilities and outline of main facilities are shown in Table D.22.



Source:JICA Study team

Figure D.29 Layout of Caldera Port

Table D.22 Main Port Facilities of Caldera Port

Channel	A 13 m-deep natural channel
Dock	Berth No.1 Length: 210m Depth: 11m Max size: 25,000 DWT Berth No.2 Length: 150m Depth: 10m Max size: 15,000 DWT Berth No 3 Length: 130m Depth: 7.5m Max size 5,000 DWT (Depth: at lower low tide)

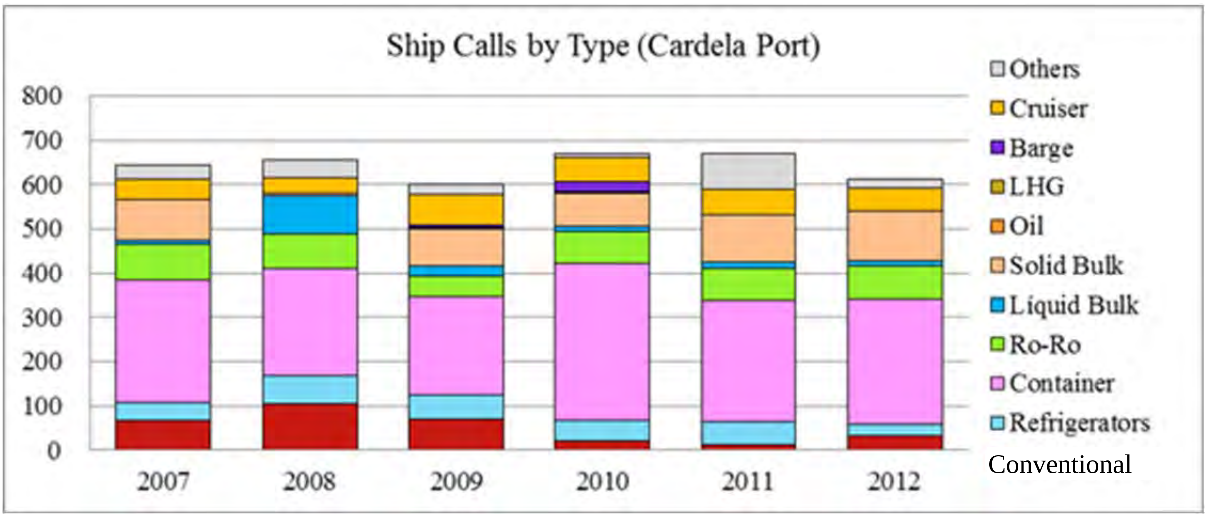
Source: website of INCOP

3) Port activities

Caldera Port received 611 vessels and handled approximately 3.9 million tons of cargo (3.2 million tons of import cargo and 0.7 million tons of export cargo) in 2012.

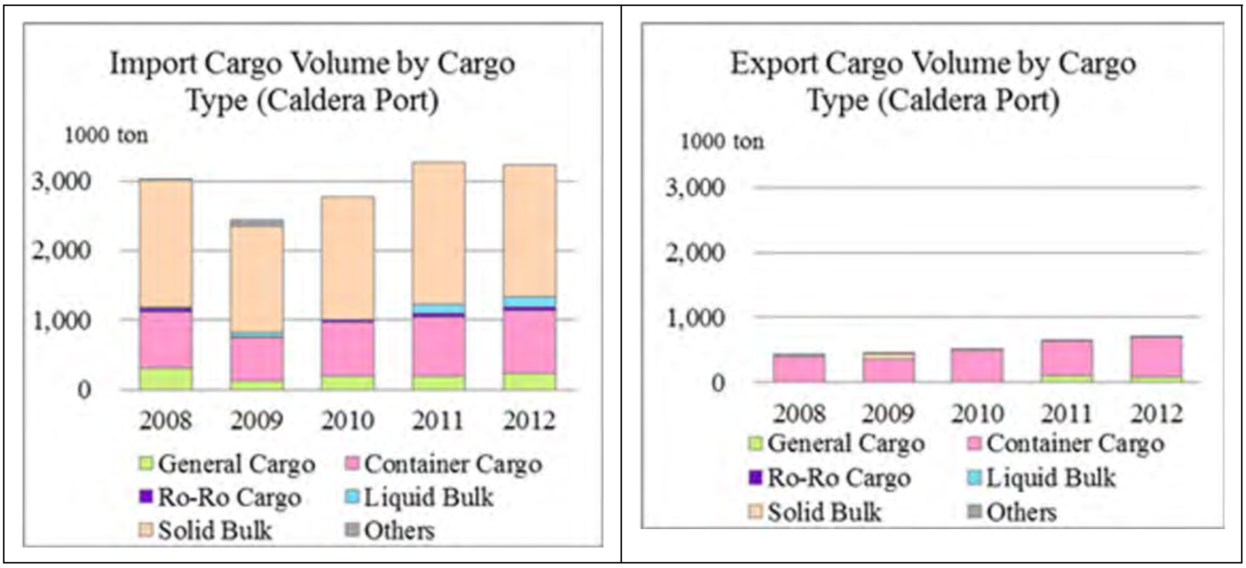
The breakdown of the vessels by type is 32 conventional ships, 25 refrigerator ships, 284 container ships, 74 Ro-Ro ships, 12 liquid bulk ships, 112 solid bulk ships, 51 Cruisers and 20 other type vessels. Figure D.30 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 225 thousand tons of general cargo, 991 thousand tons of container cargo, 57 thousand tons of Ro-Ro cargo, 141 thousand tons of liquid bulk cargo and 1907 thousand tons of solid bulk cargo. That of the export cargo volume is 90 thousand tons of general cargo, 609 thousand tons of container cargo and 1thousand tons of liquid bulk cargo. Figure D.31 shows the trend of import/export cargo from 2008 to 2012.



Source: prepared from data on the website of COCATRAM

Figure D.30 Ship Calls of Caldera Port by Type



Source: prepared from data on the website of COCATRAM

Figure D.31 Import/Export Cargo of Caldera Port by Type

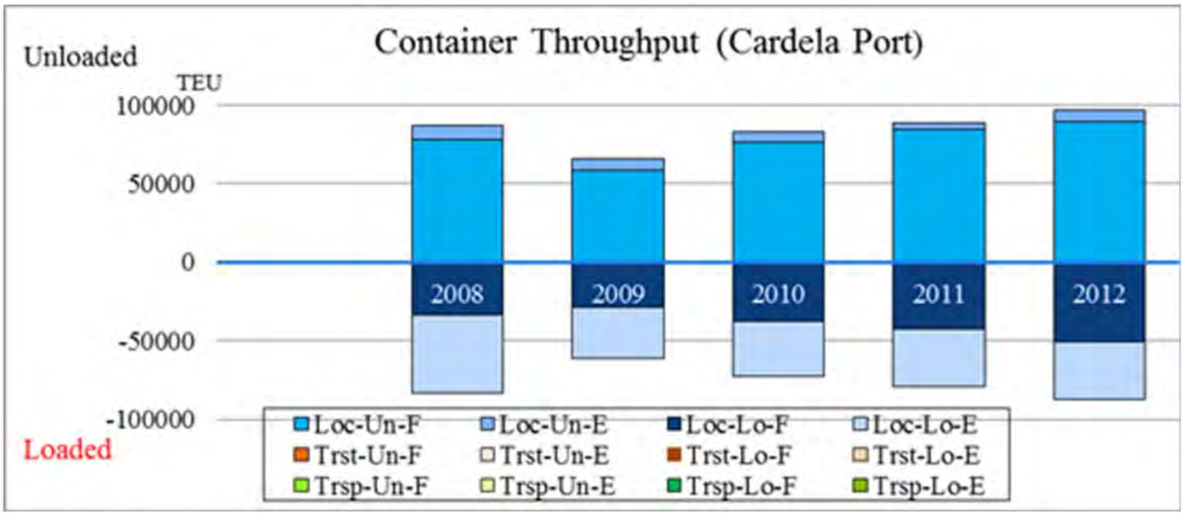
4) Container handling

Caldera Port handled 184,315 TEU containers (139,923 TEU laden containers and 44,393 TEU empty containers) in 2012. All containers handled at the port are local containers. 97,210 TEU unloaded local containers are composed of 89,360 TEU (91.9 %) of laden containers and 7,850 (8.1%) of empty containers. 87,105 TEU loaded local containers are composed of 50,562 TEU (58.0%) of laden containers and 36,543 TEU (42.0%) of empty containers. Table D.23 and Figure D.32 show the trend of container throughput of Caldera Port from 2007 to 2012.

Table D.23 Container Throughput of Caldera Port

Year			2007	2008	2009	2010	2011	2012
Local	Unloading	laden		78,346	58,800	76,597	84,931	89,360
		Empty		8,440	7,401	6,039	3,745	7,850
	Loading	laden		33,695	28,834	37,504	42,586	50,562
		Empty		49,346	32,623	35,167	36,729	36,543
Transit	Unloading	laden		0	0	0	0	0
		Empty		0	0	0	0	0
	Loading	laden		0	0	0	0	0
		Empty		0	0	0	0	0
Transshipment	Unloading	laden		0	0	0	0	0
		Empty		0	0	0	0	0
	Loading	laden		0	0	0	0	0
		Empty		0	0	0	0	0
Total		laden		112,041	87,634	114,101	127,517	139,922
		Empty		57,786	40,024	41,206	40,474	44,393
TOTAL				169,827	127,658	155,307	167,991	184,315

Source: prepared from data on the website of COCATRAM



Source: prepared from data on the website of COCATRAM

Figure D.32 Container Throughput of Caldera Port

5) Development

A bulk berth is being constructed by SPGC to the north-east of berth No3. The terminal is a dolphin type structure whose dimensions are 180 m in length, 13 m in depth and 30 to 40 m in width. It is connected to the end of Berth No3 by a 150 m-long bridge. It is capable of accommodating a bulk vessel up to 200 m LOA and 42,000 DWT.

One of the problems of Caldera Port is the congestion which forces vessels to wait for berthing. The port has a policy of giving priority to cruise ships which has drawn complaints from container shipping companies. However, container vessels are forced to wait not only because of this also because they are competing with bulk vessels for use of the berths. Therefore, the new bulk berth will improve the situation.

(4) Puerto Limon/Moin

1) Overview

Puerto Limon is located at latitude 9°59'30"north and longitude 8°03'48" west on the Caribbean Sea Coast and 160 km E from San Jose. Railroad access is available to San Jose and the road access is also available to the main part of the country. Puerto Moin is located at latitude 10°01'30"north and longitude 8°05'00" west 7 km from Puerto Limon.

The port is a multi-purpose port and a gateway to the Caribbean Sea Coast and handles the largest number of containers in CA5.

The port is managed by Port Administration and Economic Development Association for Atlantic Region (JAPDEVA) which is a Costa Rican autonomous state public entity. JAPDEVA manages Puerto Moin and other ports on the Caribbean Sea Coast of Costa Rica.

2) Port facilities

Puerto Limo has a natural access channel with depth of 11.5 m.

There are several wharves in the port: Muelle Setenta wharf that is a 325 m in length and has a 17 m wide berth with the draft of 7.5 m, Wharf No 2-1 with the length of 180 m, Wharf No 3-1, 3-2 and 3-3 with the length of 300 m, a 450 m long marginal container wharf with the depth of 9.5 to 10 m and another wharf with the length of 217 m. The container berth is equipped with two gantry cranes of 35t capacity. Because Puerto Limon and Puerto Moin are managed in a body by JAPDEVA and containers are handled at both Puerto Limon and Puerto Moin. But containers are mainly handled at container wharf at Puerto Limon.

The maximum size vessel which the port receives has a draft of 9.14 m according to "the Guide to Port (2013/2014) by Shipping guides Ltd.

The outlines of main facilities are shown in Table D.24.

Table D.24 Main Port Facilities of Puerto Limon

Channel	A 11.5m deep natural access channel
Dock	Muelle Setenta wharf / Length:325 m, Draft: 7.5 m Wharf No 2-1 / Length: 180 m, Draft 7.5 m Wharf No 3-1, 3-2 and 3-3 / Length 00 m, Draft: 10 m Container wharf / Length: 450 m, Draft : 9.5-10 m

Source website of JAPDEVA

3) Port activities

Puerto Limon/Moin received 2,223 vessels and handled approximately 10.3 million tons of cargo (4.6 million tons of import cargo and 5.8 million tons of export cargo) in 2012.

The breakdown of the vessels by type is 204 conventional ships, 629 refrigerator ships, 1,131 container ships, 54 Ro-Ro ships, 32 liquid bulk ships, 2 solid bulk ships, 1 Oil tanker, 115 LHG, 60 Cruises and 4 other type vessels. Figure D.33 shows the trend of ship call from 2007 to 2012.

The breakdown of the import cargo volume by cargo type is 446 thousand tons of general cargo, 1,845 thousand tons of container cargo, 52 thousand tons of Ro-Ro cargo, 2,212 thousand tons of liquid bulk cargo and 1 thousand tons of solid bulk cargo. That of the export cargo volume is 45 thousand tons of general cargo, 5,653 thousand tons of container cargo, 48 thousand tons of Ro-Ro cargo and 22 thousand tons of liquid bulk cargo. Figure D.34 shows the trend of import/export cargo from 2008 to 2012.

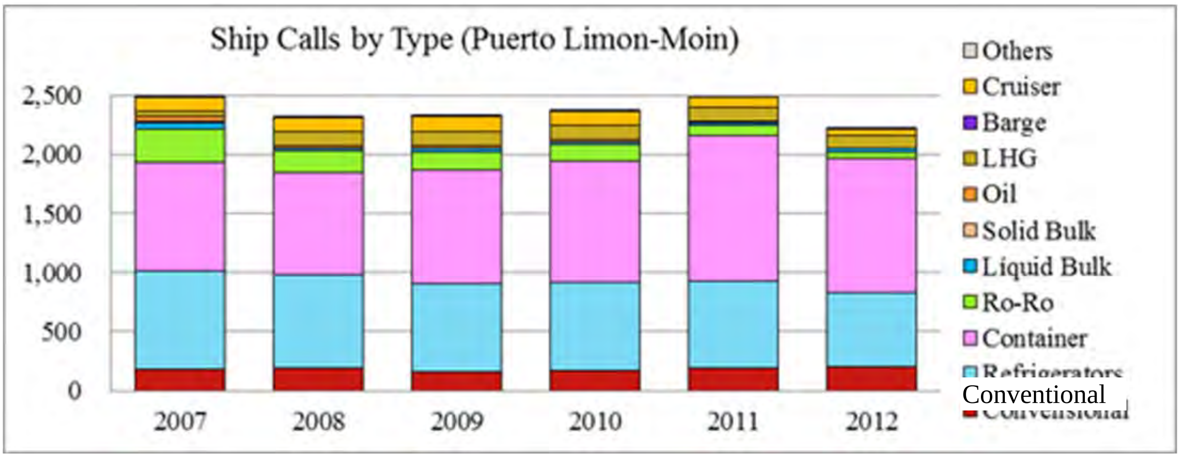


Figure D.33 Ship Calls of Puerto Limon/Moin by Type

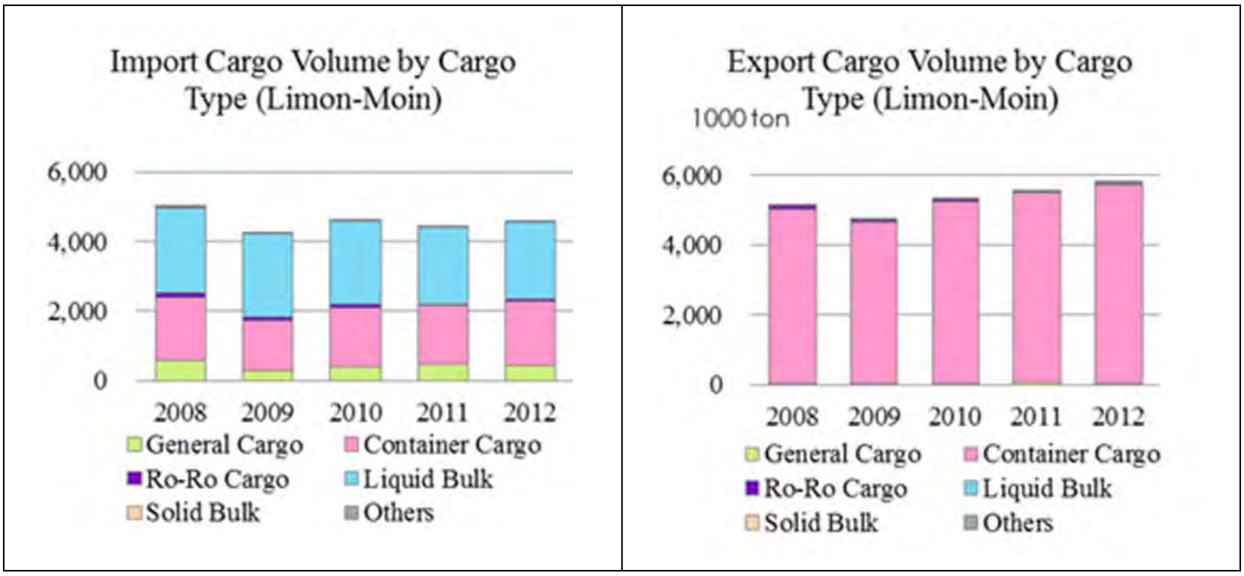


Figure D.34 Import/Export Cargo of Puerto Limon/Moin by Type

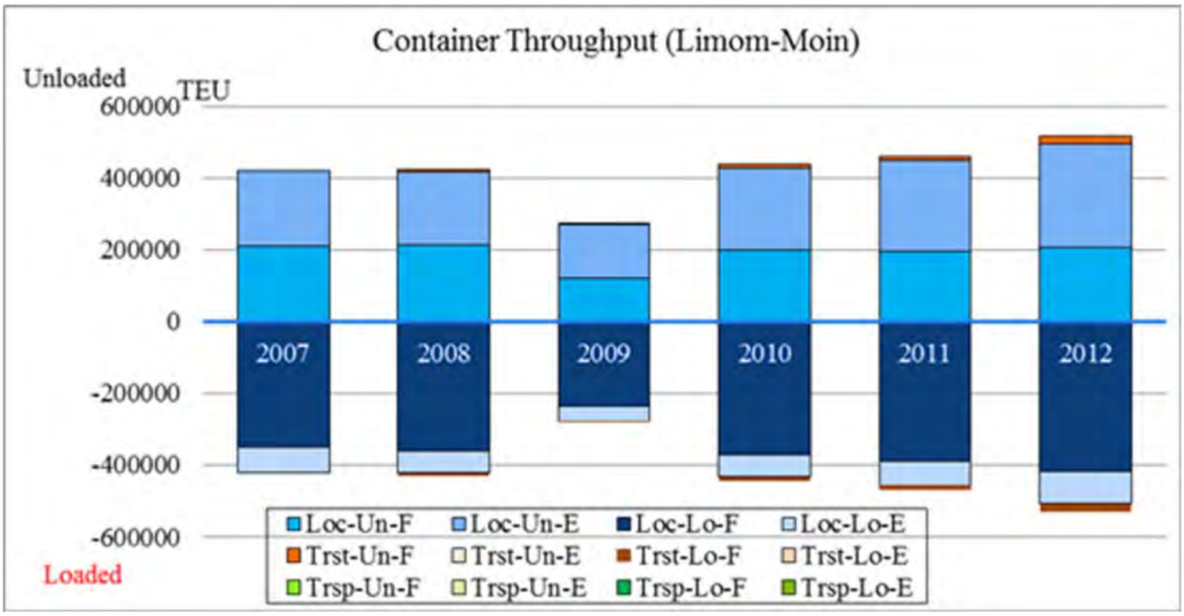
4) Container handling

Puerto Limon/Moin handled 1,045,215 TEU containers (666,540 TEU laden containers and 378,675 TEU empty containers) in 2012. 1,001,341 TEU, 95.8% of them, are local containers, 43,873 TEU (4.2%) are transit containers and no transshipment containers is handled.49,231 TEU unloaded local containers are composed of 205,582 TEU (41.7 %) of laden containers and 287,649 TEU (58.3%) of empty containers. 1508,110 TEU loaded local containers are composed of 417,085 TEU (82.1 %) of laden containers and 91,025 TEU (17.9 %) of empty containers. All of transit containers (21,999 TEU of unloaded containers and 21,874 TEU of loaded containers) are laden ones. Table D.25 and Figure D.34 show the trend of container throughput of Puerto Limon/Moin from 2007 to 2012 respectively.

Table D.25 Container Throughput of Puerto Limon/Moin

Year			2,007	2,008	2,009	2,010	2,011	2,012
Local	Unloading	laden	209,678	211,878	120,371	199,186	197,202	205,582
		Empty	210,122	205,466	148,390	226,963	249,801	287,649
	Loading	laden	351,459	360,798	237,551	370,054	389,600	417,085
		Empty	71,001	60,729	39,526	62,868	65,760	91,025
Transit	Unloading	laden	0	7,184	4,469	10,938	12,510	21,999
		Empty	0	0	0	0	0	0
	Loading	laden	0	7,188	4,396	10,899	12,577	21,874
		Empty	0	0	0	0	0	0
Transshipment	Unloading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
	Loading	laden	0	0	0	0	0	0
		Empty	0	0	0	0	0	0
Total		laden	561,135	587,047	366,786	591,075	611,890	666,540
		Empty	281,124	266,193	187,916	289,831	315,560	378,675

Source: prepared from data on the website of COCATRAM



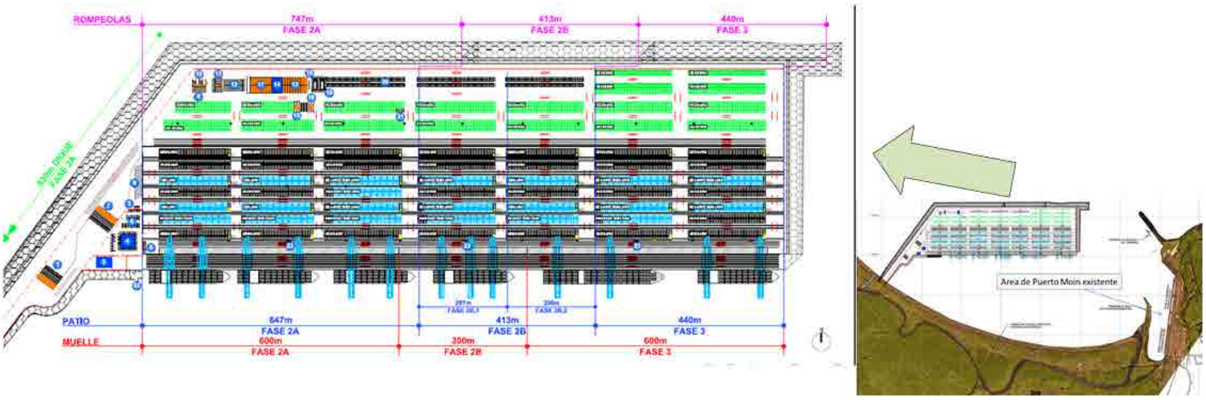
Source: prepared from data on the website of COCATRAM

Figure D.35 Container Throughput of Puerto Limon

5) Development

Limon Port aims at city port of Limon and the existing port area will be redeveloped into a cruise terminal, marina and a fishing port. The World Bank finances around USD 80 million. (PIERTO LIMN Y PUERTO MOIN)

On the other hand, at the Moin port area, container terminal (TCM), oil terminal and multipurpose terminal shall be developed. TCM project is a challenging project which aims to construct a large container terminal which has a 2.2 km long seawall, a 1.5 km-long quay with 13 gantry cranes and a total area of 79.2 ha. Its capacity will be 29,000 TEU. The Government of the Republic promotes the construction and operation of the TCM under a 33 years concession. Container throughput of Puerto Moin/Limon is more than one million in 2012 and it is estimated to increase at a rate of 6.0% annually. According to JAPDEVA, it is planned to close the existing container terminal after the opening of TCM. APM has expressed an interest and has moved forward with the necessary procedures. However, the project is delayed at present.



Source Complejo Portuario Limon-Moin (JAPDEVA)

Figure D.36 TCM project

D.2 Detail of Maritime shipping submodel

The maritime shipping time, TM_{rs}, shown in Equation (7) in 9.6.1 are estimated from the output of the maritime shipping submodel which has been developed by OCDI. Detail of the maritime shipping submodel is as follows.

D.2.1 Basic concept of the model

The model is defined as a problem to allocate container cargo on the liner shipping network prepared from MDS database as mentioned in 9.5.1. Each liner shipping network is structured as shown in Figure D.37. Each service of the same carrier is connected by *unloading*, *loading* and *transhipment link* in a port if vessels of the service call at the port in question. The containers which are neither loaded nor unloaded at the port are passing through an *anchoring link* in the port and go to the next port on a *navigating link*. Similar container shipping network is structured by service for each carrier. Each container of the shipper will choose an “optimum” link from origin node (O node) of an export port to destination node (D node) of an import port. O node and D node are set by port, but not by carrier; in other words, shippers who would like to ship a container will choose a carrier at first, which is described in the network of the model as passing through *a carrier choosing link* at the first and at the end of transportation.

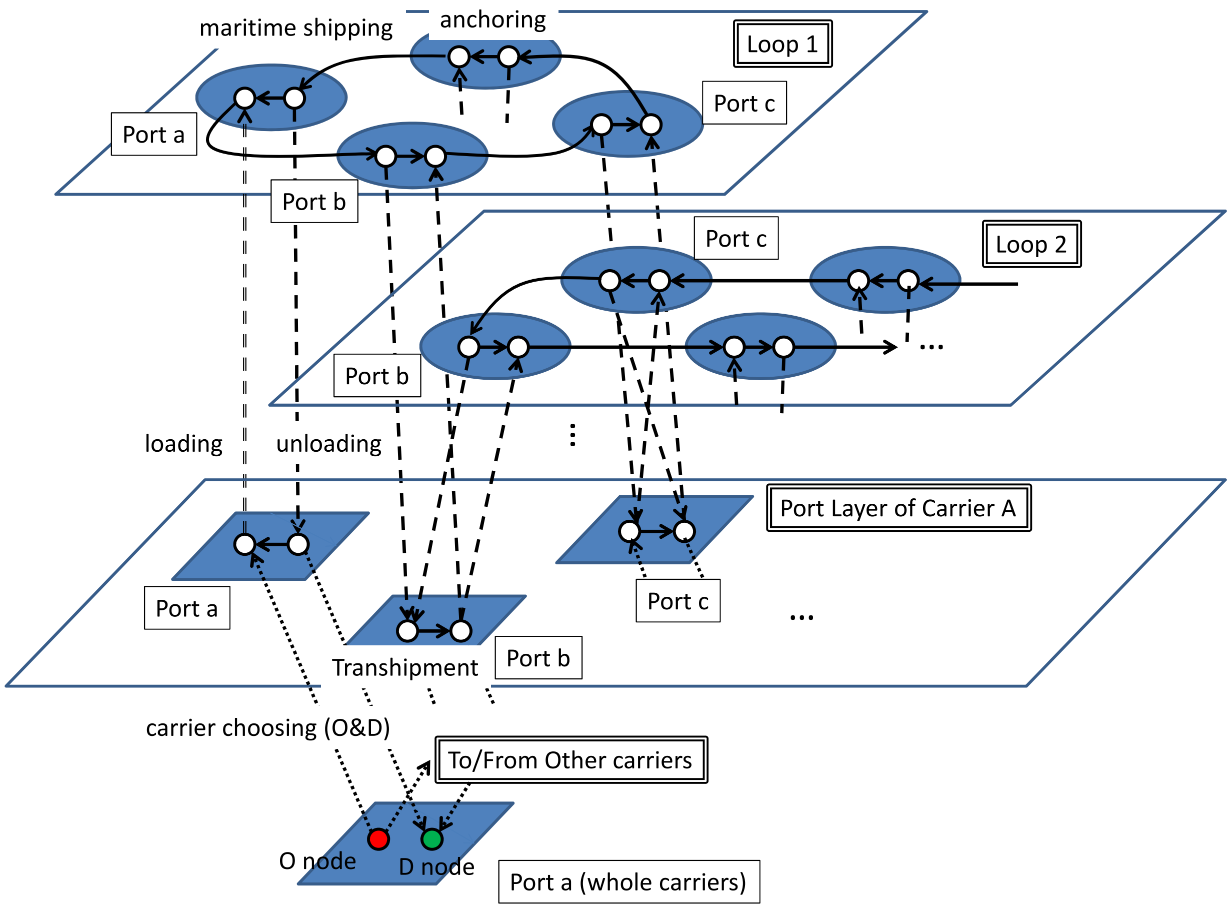


Figure D.37 Network structure of the model
(source: Shibasaki, et al., 2013)

In this submodel, every container of each OD pair is assumed to choose a route to minimize its total transit time, including maritime shipping, port handling, and departure waiting time, etc. In other words, the shipper chooses a carrier with consideration of only transit time that each carrier can provide, with no consideration of price (freight) at all. This assumption is based on the idea that the international maritime container shipping market is oligopolistic but a freight for a OD pair is the same among carriers if the service is provided and utilized; nevertheless either Cournot and Beltrand competition is assumed for the market (ocean freight is estimated from a simple demand-supply model that will be described in next section, reflecting the status of shipping market).

Since vessels of each service have their own capacities, there is diseconomy of scale by concentrating into a specific service. Due to an overcapacity by the concentration, containership may experience delays, or in the worse case, some containers may be left behind and have to wait for the next vessel. In this sense, it considers the congestion of the link when a container is loaded on a containership and applies a User Equilibrium (UE) assignment as network assignment methodology. The problem is defined as the following formulation according to Wadrop's first principle.

$$\min_{x} z(x) = \sum_{a \in A} \int_0^{x_a} t_a(x_a) dx \quad \text{(D.1)}$$

subject to

$$x_a = \sum_{(r,s) \in O \times D} \sum_{k \in K_{rs}} \delta_{a,k}^{rs} \cdot f_k^{rs} \qquad \forall a \quad \text{(D.2)}$$

$$\sum_{k \in K_{rs}} f_k^{rs} - q_{rs} = 0 \qquad \forall r, s \quad \text{(D.3)}$$

$$f_k^{rs} \geq 0 \qquad \forall k, r, s \quad \text{(D.4)}$$

where, a: link, A: set of link, x_a: flow of the link a, $t_a(.)$: cost function of the link a, $z(.)$: objective function, r: origin, s: destination, O: set of origin, D: set of destination, k: path, K_{rs}: set of path for OD pair rs, δ_k^{rs}: Kronecker delta, f_k^{rs}: flow on the path k, and q_{rs}: cargo shipping demand from r to s. Kronecker delta, δ_k^{rs}, is written as

$$\delta_{a,k}^{rs} = \begin{cases} 1 \text{ if } a \in k \\ 0 \text{ if } a \notin k \end{cases} \quad \text{(D.5)}$$

D.2.2 Definition of link cost function

(1) Navigating link

As mentioned in the previous section, in cost functions of all the links, only transit time is considered. In the navigating link connecting each port, maritime shipping time and congestion are considered.

$$t_m(x_a) = \frac{l_a}{v_a} + TW_{a'} \cdot b1 \left(\frac{x_a}{cap_a \cdot freq_a} \right)^{b2} \quad \text{(D.6)}$$

where, t_m: cost of the navigating link (hour), x_a: container cargo flow of the link *a* (TEU/year), l_a: distance of the link *a* (NM), v_a: vessel speed of the link *a* (knot), *a'*: loading link in the departure port of the navigating link *a*, $TW_{a'}$: expected waiting time for the loading of the loading link *a'* (hour), cap_a: average vessel capacity of the loop (TEU/vessel), $freq_a$: service frequency of the loop (vessels/year), and *b1*, *b2*: unknown parameters related to the congestion.

The first term of Equation (D.6) is shipping time. The second term represents the delayed time due to the congestion. The delayed time is defined by multiplying waiting time for the loading as shown in Equation (D.7) by the congestion function which may have some relationship with a load factor ($x_a/cap_a/freq_a$).

$$TW_{a'} = \frac{1}{2} \cdot \frac{YH}{freq_a} \tag{D.7}$$

where, *YH*: constant for conversion from one year to hours (52 (weeks/year) ·7(days/week) ·24(hours/day) = 8,736 (hours/year)). The term ($YH/freq_a$) represents duration hours of each vessel of the loop. The expected waiting time is assumed to be half of it.

(2) Loading link

The link cost t_l (hour) of a loading link *a* is defined as the sum of loading time and expected waiting time for departure.

$$t_l(x_a) = TL_a + TW_a \tag{D.8}$$

(3) Unloading, anchoring and transshipment link

The link cost of an unloading, anchoring, and transshipment link is respectively defined as

$$t_u(x_a) = TU_a \tag{D.9}$$

$$t_n(x_a) = TN_a \tag{D.10}$$

$$t_r(x_a) = TR_a \tag{D.11}$$

where, t_u: cost of the unloading link (hour), t_n: cost of the anchoring link (hour), t_r: cost of the transhipment link (hour), TU_a: unloading time of the unloading link *a* (hour), TN_a: anchoring time of the anchoring link *a* (hour) , and TR_a: transhipment time of the transhipment link *a* (hour).

(4) Carrier choosing link

In this model, container shipping utilizing multiple carriers is not allowed. (In other words, each container should be transported by only one carrier.) Therefore, the cost of the carrier choosing link, t_c (hour), has to be set at a sufficiently large number to avoid transshipment of the container between carriers.

$$t_c(x_a) = SLN \tag{D.12}$$

where, *SLN*: sufficient large number (in this model, *SLN* is set to be 10^4 hours).

D.2.3 Solution

Of the networks in this model, only the navigating link has a flow-dependent cost function. The cost functions of other links are flow-independent. Therefore, the UE problem defined in Equation (D.1) will be solved in the algorithm shown by Sheffi, 1985.

D.2.4 Maritime shipping time

According to the definition of "User Equilibrium assignment" which is applied in the maritime shipping submodel, "the journey times in all paths actually used are equal and less than those which would be experienced by a single vehicle on any unused path" (Wardrop's first principle, 1952). Therefore, maritime shipping time, TM_{rs}, in Equation (7) in 9.6.1 is defined as

$$TM_{rs} = \min_{k} \left\{ \sum_{a \in k} t_a(x_a) \right\}. \tag{D.13}$$

D.2.5 Monetary cost of maritime shipping

Monetary cost of each link included in the maritime shipping submodel, which is needed for the calculation of ocean freight charge described in 9.6.3, is defined per TEU as follows.

(1) Navigating link

Cost of navigation consists of the fuel cost, capital cost, operation cost, and canal toll.

$$c_m(x_a) = \left\{ (FC_a + CC_a + OC_a) \cdot \frac{l_a / v_a}{24} + CT_a \right\} \Big/ \frac{x_a}{freq_a}, \tag{D.14}$$

where, FC_a: fuel cost of container vessel (US$/vessel/day), CC_a: capital cost of container vessel (US$/vessel/day) , OC_a: operation cost of container vessel (US$/vessel/day), and CT_a: canal toll for the Panama and Suez Canal of container vessel (US$/vessel). The term $x_a/freq_a$ represents the average amount of containers transported in one vessel.

The fuel cost, FC_a, is defined as

$$FC_a = FP \cdot FR_a \cdot \frac{cap_a}{Vcap_a}, \tag{D.15}$$

where FP: fuel price (US$/ton; we set FP = 587.0 from average price in 2010), FR_a: fuel consumption rate of container vessel (ton/day), and $Vcap_a$: ship size of container vessel (TEU/vessel). Note that cap_a is defined as the capacity of each shipping company; therefore is different from $Vcap_a$ in case that capacity of the vessel is shared (co-operated or slot-chartered) by multiple companies. The fuel consumption rate, FR_a, is defined from the knowledge of marine engineering as

$$FR_a = \frac{6.49 * DWT_a^{\frac{2}{3}} \cdot v_a^{\,3}}{10^6}, \tag{D.16}$$

where DWT_a: dead weight tonnage of the vessel defined as

$$DWT_a = 11.89 \cdot Vcap_a + 4414.0. \tag{D.17}$$

The capital cost of container vessel, CC_a, is defined as

$$CC_a = SP_a \cdot \frac{ir}{\{1-(1+ir)^{-PP}\}} \cdot \frac{1}{365 \cdot ODR} \cdot \frac{cap_a}{Vcap_a}, \quad \text{(D.18)}$$

where SP_a: ship price of container vessel (US$/vessel), ir: interest rate (we set ir = 0.02), PP: project period (year; we set PP = 15), and ODR: operation day rate (we set ODR = 0.9, i.e. 365*0.9=329 days in operation per year). The term $ir/\{1-(1+ir)^{-pp}\}$ represents annual payment rate by compound interest calculation. The ship price of container vessel, SP_a, is estimated from Drewry's report as

$$SP_a = (0.0099 \cdot Vcap_a + 8.0) \cdot 10^6. \quad \text{(D.19)}$$

The operation cost of container vessel, CC_a, including manning, insurance, stores, spares, lubricating oil, R&D, administration cost is also estimated from Drewry's report as

$$OC_a = (0.7915 \cdot Vcap_a + 4276.0) \cdot \frac{cap_a}{Vcap_a}. \quad \text{(D.20)}$$

The canal toll, CT_a, is respectively defined as

$$CT_a = 72.0 \cdot \frac{x_a}{freq_a} \quad \text{for the Panama Canal, and} \quad \text{(D.21)}$$

$$CT_a = SDRrate \cdot (\beta_1 \cdot scrnt_a + \beta_2) \quad \text{for the Suez Canal,} \quad \text{(D.22)}$$

where $SDRrate$: conversion rate from SDR (unit of account for Suez Canal) to US$ (we set $SDRrate$ = 1.5 from the average in 2010), $scrnt_a$: suez canal net tonnage of container vessel, and β_1, β_2: coefficient established by the Suez Canal Authority. Note that a toll of the Panama Canal is set down by a container (i.e. 72.0 US$/TEU), while a toll of the Suez Canal is set down by a vessel so that a toll per TEU decreases as the size of vessel increases. The suez canal net tonnage of container vessel, $scrnt_a$, is defined as

$$scrnt_a = 10.92 \cdot Vcap_a - 1137.0. \quad \text{(D.23)}$$

The coefficient β_1 and β_2 are set down by the Suez Canal net tonnage as shown in Table D.26.

Table D.26 Coefficient set down by the Suez Canal net tonnage (scrnta) in Equation

(source: Suez Canal Authority)

$scrnt_a$		β_1	β_2
from	to		
0	5000	7.65	0
5000	10000	5.00	38,250
10000	20000	4.00	63,250
20000	40000	2.80	103,250
40000	70000	2.60	159,250
70000	120000	2.05	237,250
120000		1.95	339,750

(2) loading, unloading, transshipment and carrier choosing link

In these links, port charge (terminal handling charge, THC_a) should be considered. In order to reflect an empirical fact that handling charge for the transshipment is less than double of that for the loading or unloading, cost of each link is defined as

$$c_l(x_a) = SSN \, , \tag{D.24}$$

$$c_u(x_a) = SSN \, , \tag{D.25}$$

$$c_r(x_a) = 1.5 \cdot CHC_a \, , \tag{D.26}$$

$$c_c(x_a) = CHC_a \, , \tag{D.27}$$

where c_l: cost function of loading link (US$/TEU), c_u: cost function of unloading link (US$/TEU), c_r: cost function of transshipment link (US$/TEU), c_c: cost function of carrier choosing link (US$/TEU), *SSN*: sufficient small number (in this model, we assume *SSN* = 0.01 US$), and CHC_a: container handling charge when container cargo is loaded or unloaded of port *a* (US$). Note that in order to avoid giving a negative link cost in the transshipment link, the handling charges are imposed in the carrier choosing link, not in the loading and unloading link.

D.2.6 Port in the model

The liner shipping network all over the world is covered in this model. In principle, all the container ports where throughput was more than 500,000 TEU per year (2010, domestic and empty containers are included) are considered. According to CI-online database, there were 155 ports of the world at which throughput exceeded 500,000 TEU in 2010. In addition, several ports are added or eliminated as follows:

- Three Chinese ports (Taicang, Nanjing, and Zhangjiagang) are eliminated because no or very few containership movement data on vessels that call at these ports is available from the MDS database. (The figures shown in parenthesis stand for CI rank in 2010.) The lack of data may be because most of cargo handled in these ports is domestic (or feeder) containers.

- The port of Shenzhen in China is divided into two ports; i) Yantian terminal, and ii) Shekou and other terminals, because these two terminals are located on opposite sides of the port of Hong Kong and both of them are not negligible. By separating into two ports, it becomes easier to make a maritime shipping network.

- On the other hand, the port of Singapore and Jurong in Singapore, port of Puerto Manzanillo and Cristobal in Panama, port of Alexandria and El Dekheila in Egypt, port of Odessa and Illichivsk in Ukraine are treated as one port respectively, because these ports are closely located to each other, with some of them even being located in the same city.

- The port of Fuzhou, China, the port of Taichung, Taiwan, the port of London, UK, the port of Tema, Ghana, and the port of Lagos (Apapa), Nigeria are added to the list. Although these five ports were not listed in CI-online, the authors estimate from other sources that more than 500,000 TEU of container cargoes were handled in these ports in 2010.

The port list is shown in Table D.27 including additional ports in CA4 countries and Port of Houston as mentioned in 9.5.3. As a result, the number of ports included in the revised model is 164 as shown in Figure 9.52 of Chapter 9. The total throughput and number of transshipment containers are also shown, which are utilized for OD cargo estimation presented in the following section.

Table D.27 Ports included in the model and their throughput
(Source: authors made from CI-online database and Drewry Maritime Research, 2011)

No	Port name	Country	Country/region in the GTN	Annual throughput ('000 TEU, 2010)	Transshipped container ('000 TEU, 2010)	Trans-shipment rate
1	Tokyo	Japan	Japan	4,285	689*	16.1%*
2	Yokohama	Japan	Japan	3,281	528*	16.1%*
3	Nagoya	Japan	Japan	2,549	410*	16.1%*
4	Osaka	Japan	Japan	1,980	318*	16.1%*
5	Kobe	Japan	Japan	2,556	411*	16.1%*
6	Hakata	Japan	Japan	749	120*	16.1%*
7	Busan	South Korea	South Korea	14,194	6,272	44.2%
8	Gwangyang	South Korea	South Korea	2,085	335*	16.1%*
9	Incheon	South Korea	South Korea	1,903	306*	16.1%*
10	Dalian	China	China	5,242	843*	16.1%*
11	Yingkou	China	China	3,338	537*	16.1%*
12	Tianjin/Xingang	China	China	10,080	1,621*	16.1%*
13	Qingdao	China	China	12,012	1,931*	16.1%*
14	Lianyungang	China	China	3,870	2,728	70.5%
15	Shanghai	China	China	29,069	6,263	21.5%
16	Ningbo	China	China	13,144	1,830	13.9%
17	Fuzhou	China	China	1,223 (2009)	197*	16.1%*
18	Quanzhou	China	China	1,051	169*	16.1%*
19	Xiamen	China	China	5,820	936*	16.1%*
20	Shenzhen (Yantian)	China	China	10,134	662	6.5%
21	Shenzhen (Shekou, Chiwan, Dachan Bay)	China	China	12,376	5,123	41.4%
22	Guangzhou (Nansha, Huangpu)	China	China	12,550	6,119	48.8%
23	Hong Kong	Hong Kong	Hong Kong	23,699	5,808	24.5%
24	Keelung	Taiwan	Taiwan	1,963	316*	16.1%*
25	Taichung	Taiwan	China	1,193 (2009)	192*	16.1%*
26	Kaohsiung	Taiwan	Taiwan	9,181	4,866	53.0%
27	Manila	Philippines	Philippines	3,155	507*	16.1%*
28	Davao	Philippines	Philippines	524	84*	16.1%*
29	Haiphong	Vietnam	Vietnam	954	91*	9.6%*
30	Ho Chi Minh	Vietnam	Vietnam	3,856	369*	9.6%*
31	Cai Mep/Vung Tau	Vietnam	Vietnam	512	49*	9.6%*
32	Laem Chabang	Thailand	Thailand	5,068	485*	9.6%*
33	Bangkok	Thailand	Thailand	1,453	139*	9.6%*
34	Pasir Gudang	Malaysia	Malaysia	876	84*	9.6%*
35	Tanjung Pelepas	Malaysia	Malaysia	6,530	5,988	91.7%
36	Port Klang	Malaysia	Malaysia	8,872	5,437	61.3%
37	Penang	Malaysia	Malaysia	1,106	106*	9.6%*
38	Singapore/Jurong	Singapore	Singapore	29,179	24,631	84.4%
39	Tanjung Perak	Indonesia	Indonesia	2,427	232*	9.6%*

	(Surabaya)					
40	Tanjung Priok (Jakarta)	Indonesia	Indonesia	4,613	441*	9.6%*
41	Chittagong	Bangladesh	Other Indian Subcontinent	1,329	374*	28.2%*
42	Kolkata	India	India	526	148*	28.2%*
43	Chennai/Madras	India	India	1,520	428*	28.2%*
44	Jawaharlal Nehru (JNPT)/ Nhava Sheva	India	India	4,752	1,339*	28.2%*
45	Mundra	India	India	1,149	324*	28.2%*
46	Colombo	Sri Lanka	Other Indian Subcontinent	4,137	3,078	74.4%
47	Port Mohammad Bin Qasim	Pakistan	Pakistan	779	219*	28.2%*
48	Karachi	Pakistan	Pakistan	1,370	386*	28.2%*
49	St Petersburg	Russia	Russia	1,931	232	12.0%
50	Vancouver BC	Canada	Canada	2,514	141*	5.6%*
51	Seattle	USA	United States (North Pacific)	2,134	119*	5.6%*
52	Tacoma	USA	United States (North Pacific)	1,455	81*	5.6%*
53	Oakland	USA	United States (South Pacific)	2,330	130*	5.6%*
54	Los Angeles	USA	United States (South Pacific)	7,832	438*	5.6%*
55	Long Beach	USA	United States (South Pacific)	6,263	351*	5.6%*
56	Honolulu	USA	United States (South Pacific)	939	53*	5.6%*
57	Manzanillo (Mexico)	Mexico	Mexico	1,509	460*	30.5%*
58	Lazaro Cardenas	Mexico	Mexico	796	242*	30.5%*
581	Puerto Quetzal	Guatemala	Central America	265***	32***	11.9%***
582	Acajutla	El Salvador	Central America	147***	0	0.0%
583	La Union	El Salvador	Central America	0	0	-
584	San Lorenzo	Honduras	Central America	0	0	-
585	Corinto	Nicaragua	Central America	65***	1.2	1.9%***
586	Caldera	Costa Rica	Central America	155***	0	0.0%
59	Balboa	Panama	Central America	2,759	2,621	95.0%
60	Manzanillo (Panama)/ Cristobal/ Colon	Panama	Central America	2,289	1,562	68.2%
61	Puerto Limon	Costa Rica	Central America	858	261*	30.5%*
62	Puerto Cortes	Honduras	Central America	539	164*	30.5%*
621	St. Tomas de Castilla/ Puerto Barrios	Guatemala	Central America	732***	109***	15.0%***
63	Veracruz	Mexico	Mexico	663	202*	30.5%*
64	San Juan	USA (Puerto Rico)	Caribbean Basin	1,526	465*	30.5%*
65	Caucedo	Dominican Rep	Caribbean Basin	1,005	306*	30.5%*
66	Kingston	Jamaica	Caribbean Basin	1,892	1,627	86.0%
67	Freeport	Bahamas	Caribbean Basin	1,125	1,114	99.0%
68	Houston/ Galveston/ Freeport (US)	USA	United States (Gulf)	1,890	106*	5.6%*
681	New Orleans/Gulf Port	USA	United States (Gulf)	635	35*	5.6%*
69	Miami	USA	United States (South Atlantic)	847	47*	5.6%*
70	Port Everglades	USA	United States (South Atlantic)	793	44*	5.6%*
71	Jacksonville	USA	United States (South Atlantic)	857	48*	5.6%*

72	Savannah	USA	United States (South Atlantic)	2,825	158*	5.6%*
73	Charleston	USA	United States (South Atlantic)	1,384	77*	5.6%*
74	Virginia	USA	United States (North Atlantic)	1,895	106*	5.6%*
75	Baltimore	USA	United States (North Atlantic)	611	34*	5.6%*
76	New York/New Jersey	USA	United States (North Atlantic)	5,292	296*	5.6%*
77	Montreal	Canada	Canada	1,331	75*	5.6%*
78	Buenaventura	Colombia	Colombia	663	68*	10.2%*
79	Guayaquil	Ecuador	Ecuador	1,093	112*	10.2%*
80	Callao	Peru	Peru	1,346	137*	10.2%*
81	Valparaiso	Chile	Chile	879	90*	10.2%*
82	San Antonio	Chile	Chile	871	89*	10.2%*
83	Cartagena	Colombia	Colombia	1,433	146*	10.2%*
84	Puerto Cabello	Venezuela	Venezuela	630	64*	10.2%*
85	Santos	Brazil	Brazil	2,722	278*	10.2%*
86	Paranagua	Brazil	Brazil	672	69*	10.2%*
87	Navegantes	Brazil	Brazil	568	58*	10.2%*
88	Itajai	Brazil	Brazil	957	98*	10.2%*
89	Rio Grande	Brazil	Brazil	647	66*	10.2%*
90	Montevideo	Uruguay	Other East Coast of South America	672	69*	10.2%*
91	Buenos Aires	Argentina	Argentina	1,731	177*	10.2%*
92	Shahid Rajaee (Bandar Abbas)	Iran	Arabian Gulf	2,593	249*	9.6%*
93	Dammam	Saudi Arabia	Arabian Gulf	1,333	128*	9.6%*
94	Mina Zayed (Abu Dhabi)	UAE	Arabian Gulf	530	51*	9.6%*
95	Dubai/Jebel Ali	UAE	Arabian Gulf	11,600	5,498	47.4%
96	Khor Fakkan/ Sharjah Combined	UAE	Arabian Gulf	3,023	2,315	76.6%
97	Salalah	Oman	Arabian Gulf	3,485	3,405	97.7%
98	Jeddah	Saudi Arabia	Arabian Gulf	3,831	1,683	43.9%
99	Aqaba	Jordan	Other Mediterranean	619	59*	9.6%*
100	El Sokhna	Egypt	Egypt	607	171	28.2%
101	Port Said	Egypt	Egypt	3,475	2,477	71.3%
102	Damietta	Egypt	Egypt	1,096	187*	17.0%*
103	AlexandriaEl Dekheila	Egypt	Egypt	1,496	255*	17.0%*
104	Tangier/Tangier Med	Morocco	W. Med	2,058	1,980	96.2%
105	Las Palmas De Gran Canaria	Spain (Canary Is)	Western Africa	1,187	334	28.2%
106	Ashdod	Israel	Israel	1,018	173*	17.0%*
107	Haifa	Israel	Israel	1,264	215*	17.0%*
108	Beirut	Lebanon	Other Mediterranean	949	162*	17.0%*
109	Lattakia	Syria	Other Mediterranean	586	100*	17.0%*
110	Mersin	Turkey	Turkey	1,024	174*	17.0%*
111	Izmir	Turkey	Turkey	728	124*	17.0%*
112	Ambarli/Istanbul	Turkey	Turkey	2,540	432*	17.0%*
113	Constantza	Romania	Romania	557	95*	17.0%*
114	Odessa/Illichivsk	Ukraine	Ukraine	653	111*	17.0%*
115	Piraeus	Greece	C. Med	878	149*	17.0%*
116	Marsaxlokk	Malta	Other Mediterranean	2,371	2,265	95.5%
117	Cagliari	Italy	C. Med	553	94*	17.0%*
118	Taranto	Italy	C. Med	582	99*	17.0%*
119	Gioia Tauro	Italy	C. Med	2,852	2,676	93.8%

120	Naples	Italy	C. Med	535	91*	17.0%*
121	Leghorn (Livorno)	Italy	C. Med	628	107*	17.0%*
122	La Spezia	Italy	C. Med	1,285	219*	17.0%*
123	Genoa	Italy	C. Med	1,759	299*	17.0%*
124	Marseilles/Fos	France	France	953	162*	17.0%*
125	Barcelona	Spain	W. Med	1,948	332*	17.0%*
126	Valencia	Spain	W. Med	4,207	2,156	51.2%
127	Algeciras	Spain	W. Med	2,810	2,626	93.4%
128	Felixstowe	UK	United Kingdom	3,400	408*	12.0%*
129	London (Tilbury)/ Thamesport	UK	United Kingdom	424**	51*	12.0%*
130	Southampton	UK	United Kingdom	1,540	185*	12.0%*
131	Liverpool	UK	United Kingdom	681	82*	12.0%*
132	Dublin	Eire	United Kingdom	554	67*	12.0%*
133	Lisbon	Portugal	W. Med	513	87*	17.0%*
134	Bilbao	Spain	W. Med	531	90*	17.0%*
135	Bordeaux	France	France	632	76*	12.0%*
136	Le Havre	France	France	2,358	283*	12.0%*
137	Zeebrugge	Belgium	N. Europe	2,390	287*	12.0%*
138	Antwerp	Belgium	N. Europe	8,468	2,286	27.0%
139	Rotterdam	Netherlands	N. Europe	11,146	3,344	30.0%
140	Bremen/Bremerhaven	Germany	N. Europe	4,871	2,192	45.0%
141	Hamburg	Germany	N. Europe	7,900	2,610	33.0%
142	Gdansk	Poland	N. Europe	509	61*	12.0%*
143	Gothenburg	Sweden	N. Europe	796	96*	12.0%*
144	Abidjan	Ivory Coast	Western Africa	530	149*	28.2%*
145	Tema	Ghana	Western Africa	590**	166*	28.2%*
146	Lagos/Apapa/ Tin Can Island	Nigeria	Western Africa	500**	141*	28.2%*
147	Cape Town	South Africa	Southern Africa	697	196*	28.2%*
148	Durban	South Africa	Southern Africa	2,529	713*	28.2%*
149	Mombasa	Kenya	Kenya	696	196*	28.2%*
150	Djibouti	Djibouti	Other East Africa	600	169*	28.2%*
151	Brisbane	Australia	Australia	929	62*	6.7%*
152	Sydney	Australia	Australia	2,020	135*	6.7%*
153	Melbourne	Australia	Australia	2,322	155*	6.7%*
154	Fremantle	Australia	Australia	583	39*	6.7%*
155	Auckland	New Zealand	New Zealand	894	60*	6.7%*
156	Tauranga	New Zealand	New Zealand	591	39*	6.7%*

* estimated based on the average transhipment rate by region shown in Drewry Maritime Research (2011)
**Authors' estimation
*** COCATRAM,

D.2.7 Making maritime shipping network

As explained in D.2.1, maritime shipping network is basically developed by the MDS database (see also Figure D.37). From the MDS database, not only the data for making network, but also vessel speed, v_a (knot), average vessel capacity, cap_a (TEU/vessel), and frequency, $freq_a$ (vessels/year) for each service is acquired.

Also, the distance between ports, l_a (NM), is acquired from Toriumi's work (2010), based on an assumption that every containership passes through the shortest route on the sea out of the preset navigation routes.

Another two points have to be taken into account when making a network from the list as follows.

(1) In case that a service calls at the same port more than twice

In order to keep the order of the port to call, the nodes in the same port should be differentiated by order and connected through loading, unloading, and transhipment link. The concept of the network structure in this case is shown in Figure D.38.

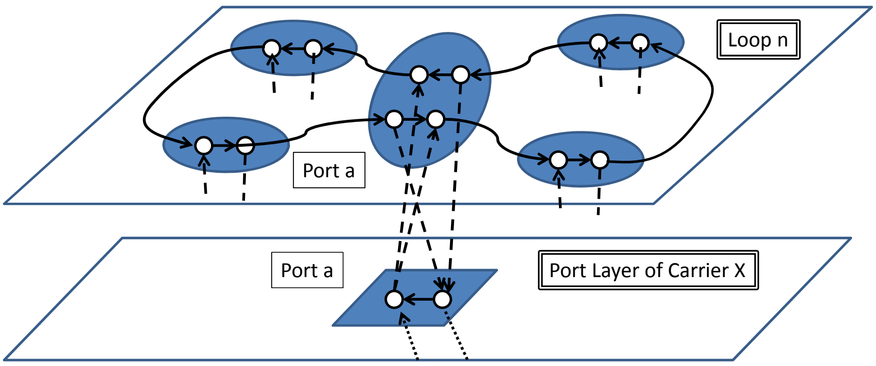


Figure D.38 Network structure of the maritime shipping submodel (2)

- in case that a loop calls at the same port more than twice
(source: Shibasaki, et al., 2013)

(2) In case that a service has more than two routes of the port to call

In some services, the list of ports to call is partly separated into more than two. This separation of the service can be often observed when calling at a relatively minor port among the major ports. The network of this type of loop is described in Figure D.39. The frequency of the service, $freq_a$, is also separated according to the number of vessels which are assigned for each separated route (sub-route). In addition, for the ports on the sub-routes (e.g., in port *b*, *c*, and *d* on the network shown in Figure D.39), duration time between each service is longer; therefore, the additional transit time for the container cargo which is unloaded in these ports should be considered. Namely, the cost of unloading link, tu (hour) described in Equation (D.9), of these ports is rewritten as

$$t_u(x_a) = TU_a + \frac{1}{2} \cdot \mathrm{YH} \cdot \left(\frac{1}{freq_a} - \frac{1}{freq_{a'}} \right) \qquad \text{(D.9')}$$

where, $freq_{a'}$: a service frequency of the loop in the "main" route (e.g., the service frequency in port a and e on the network shown in Figure D.39).

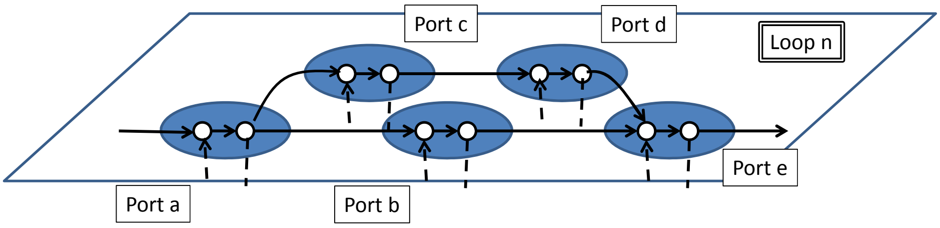


Figure D.39 Network structure of the maritime shipping submodel (3)

- in case that a loop has more than two routes for calling port

(source: Shibasaki, et al., 2013)

D.2.8 Estimation results of maritime shipping submodel

(1) Unknown parameter estimation

The model includes two unknown parameters, *b1* and *b2*, related with congestion. These unknown parameters are estimated to best fit the estimation results to the actual data. Since this model is developed for describing container movement under a given vessel network and OD cargo volume between ports, transshipment containers handled at each port are adopted as a criterion for checking the model fitness. Concretely, the transshipment rate (derived by dividing the number of transshipment containers by the total throughput) for each major transshipment port is used as a criterion.

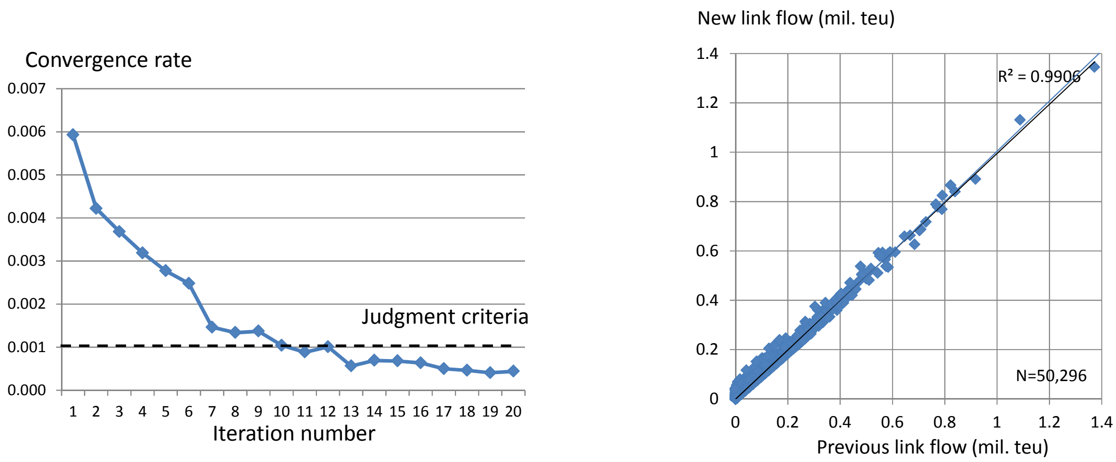
$$\min_{b1,b2} z' = \sum_{p \in P} \left(\hat{R}_p - R_p \right)^2 \quad \text{(D.28)}$$

where, z': objective value, p: port, P: set of port (only the ports of which the estimated transhipment rate is clearly specified by Drewry Maritime Research, 2011), R_p: the actual transhipment rate, $\hat{R}_p$: the estimated transhipment rate by the model.

The authors adopt the steepest descent method to estimate unknown parameters. Since the analytic calculation of the first order differentiation of the objective value, z', is difficult, the steepest direction is judged from the changes of the objective value when each parameter is minimally changed respectively. Based on approximately 50 repeated calculations, the parameters are estimated as *b1* = 2.309 and *b2* = 1.017. The estimated values imply that the congestion function is mostly linear to the load factor of the loop (because *b2* is approximately one) and that when the load factor is 100% (i.e. full capacity), the equivalent additional time due to congestion is slightly more than the duration time of the loop which is expressed as twice the expected waiting time for departure.

(2) Confirmation of convergence

Given are estimated parameters stated as (1), the model calculation is iteratively conducted. The calculation time for one iteration is 90-120 seconds by laptop windows computer with Intel(R) Core(TM) i5-2520M CPU (2x2.50 GHz) and 4.00 GB RAM (The number of links of the network is 50,296). The convergence rate (square sum of differences of the link flow in each iteration) is shown in Figure D.40. According to the figure, a convergence rate is less than 10^{-3} after around ten times calculation. The comparison between the calculated link flow and the link flow in the previous iteration when the convergence rate first becomes less than 10^{-3} (i.e. the iteration number is eleven) is shown in Figure D.40. From these figures and calculation time, the authors set 10^{-3} as a criterion of judgement of convergence.



a) Convergence rate for each iteration b) Link flow change around judgment criteria

Figure D.40 Convergence of model calculation

(3) Model fitness

The comparison between the actual and model estimated transhipment rate for the major transhipment ports is shown in Figure D.41, when the model calculation is converged under the given parameters. From the figure, the authors judge that the model effectively reproduces the transhipment rate for major ports, except for several exceptions.

The largest difference between the actual and estimated rate is observed in the port of Lianyunggang, China, where the estimated transhipment rate is zero. The reason for the underestimation is that most of the domestic feeder services from/to the port of Lianyunggang are supplied by other small carriers which are not considered in the model. Another big difference between the actual and estimated data is observed in the port of Hong Kong. In this port, the actual transhipment rate is not considered to reflect the real shipping, because in the statistics of Hong Kong, re-export is not counted as transhipped cargo although it is actually one type of transhipment (for the detail discussion about "re-export" of Hong Kong, refer to GTAP, 2012 for example).

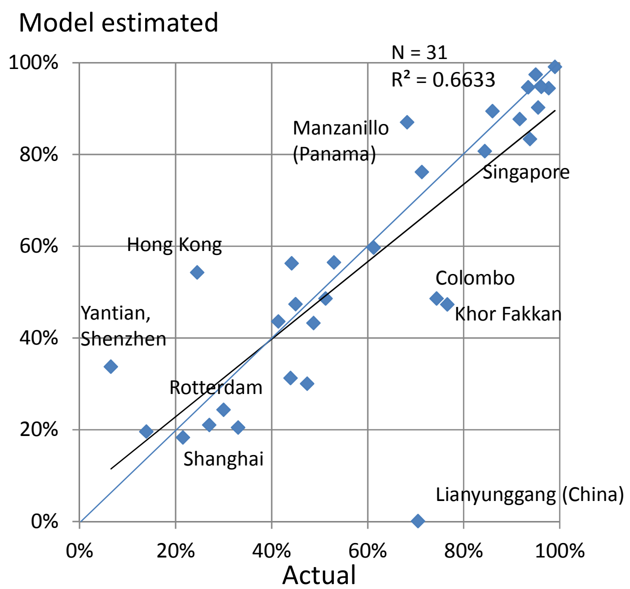


Figure D.41 Comparison of the actual and model estimated transshipment rate for major ports

D.3 Interview and survey together with CEPA economic team members

In this study, we conducted interviews and surveys together with CEPA economic team members.

The CEPA economic team members understood the importance of communication through various interviews with port manager/port operator, shipping companies, and shippers, and deepened their recognition of the problems facing Salvadoran and neighboring countries' ports. They obtained various informations and learned how to conduct an interview.

For the survey of Guatemala and Costa Rica in August, CEPA economic team members voluntarily planned the research program and made appointments with the port manager/port operator. They asked many questions during the interview and engaged in a lively exchange of opinions with the interviewees.

Survey of Ports

Port/Terminal
Interview Items 1. Port facility 2. Port operation 3. Other
-Empresa Nacional Portuaria, San Lorenzo (ENP), Hondulas -Comision Portuaria Nacional Guatemala(CPN), Guatemala -Empresa Portuaria Quetzal, Guatemala - The Costa Rican Institute of Pacific ports (INCOP), Costa Rica -Sociedad Portuaria de Caldera (SPC),S.A./Sociedad Portuaria Granelera de Caldera(SPGC),S.A. Costa Rica -Junta de Administracion Portuaria y de Desarrollo Economico de la Vertiente Atlantica (JAPDEVA) Moin/Limon, Costa Rica -Ministry of Public Work and Transport (MOPT) , Costa Rica

No.1

Date/City	18 April, 2013 / San Lorenzo, Hondulas
Category	Port Management Body
Agency/Company	Empresa Nacional Portuaria, San Lorenzo (ENP), Honduras
Interviewee	Ms. Manuel de Jesus Alvarez, Port Superintendent (sanlorenzo@seposa.com (504)2781-2336)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Dr. Ryuichi Shibasaki, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Patricia Callejas, Ms. Andrea Castillo

No.2

Date/City	13 August, 2013 / Guatemala City, Guatemala
Category	Port Management Body
Name	Comision Portuaria Nacional Guatemala(CPN)
Interviewee	Mr.Juan Estuardo Contreras Aleman, Director Ejecutivo Licda. Ana Lorena Rabbe , Asesor Especializado Tel:+502-2419-4800, Fax:+502-2360-5457 E-mail: jcontreras@cpn.gob.gt
JICA study team	Mr. Takashi Kadono, ,Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Patricia Callejas
	

No.3

Date/City	14 August, 2013 / Guatemala City, Guatemala
Category	Port Operator
Name	Empresa Portuaria Quetzal
Interviewee	Lic. Allan Marroquin Castillo, interventor Mr.Julio Rolando Sandoval Cano, sub interventor Tel:+502-2312-5003, Fax:+502-2361-1327 E-mail:allan.marroquin@puerto-quetzal.com
JICA study team	Mr. Takashi Kadono, Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Patricia Callejas

No.4

Date/City	20 August, 2013 / Caldera Costa Rica
Category	Port Authority
Name	The Costa Rican Institute of Pacific ports (INCOP)
Interviewee	Ing. Luis Antonio Rojas Víquez, Secretario Fiscalizador de Concesiones (506)-2634-9136 Email: lrojas@incop.go.cr
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

No.5

Date/City	20 August, 2013 / Caldera Costa Rica
Category	Port Operator
Name	Sociedad Portuaria de Caldera (SPC),S.A. Sociedad Portuaria Granelera de Caldera(SPGC), S.A.
Interviewee	Juan Carlos Mora Perez, Gerente de Operaciones +506-2534-9500, Cel: +506-8340-2851, Fax: +506-2634-4595 E-mail: j.more@spcaldera.com
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

No.6

Date/City	20 August, 2013 / Caldera Costa Rica
Category	Port Management Body
Name	Junta de Administracion Portuaria y de Desarrollo Economico de la Vertiente Atlantica (JAPDEVA)
Interviewee	Lic Karla Piedra Alfao, Tel (506)2799-0366, Fax(506) 2758-3229 E-mail: kpiedra@japdeve.go.cr
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

No.7

Date/City	21 August, 2013 / San Jose Costa Rica
Category	Ministry
Name	Ministry of Public Work and Transport (MOPT)

Interviewee	Gilberto Rodríguez Pacheco, Dirección de Infraestructura, División Marítima Portuaria MOPT Phone: (506) 2233-5022 Email: Gilberto.rodriguez@gmail.com Ing. Diego Led Obando 506-2233-5022, fax 506-2255-3854, cel: 506-8895-5945 dlealoba@mopt.go.cr topografialeal@gmail.com
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

Interviews with Shipping Agent

Interview Items 1. Present shipping service 2. Ships deployment and container business 3.Views on container service in CA 4. On the port of La Union 5. Container transportation business in CA in future
El Salvador -Shipping agent (NYK) -Shipping agent (Hapag-Lloyd) -Shipping agent (CMA-SGM) -Shipping agent (Evergreen) -Shipping Agent (Maersk) -Shipping Agent (APL) -Shipping agent (CCNI) -Shipping agent (Mediterranean Shipping Company El Salvador) -Shipping agent (CSAV) -Shipping agent (China Shipping) -Shipping agent (Mediterranean Shipping Co. El Salvador, S.A. de C.V) -Shipping Agent (Crowley Liner Service Inc.)
Neighboring Country Guatemala (Guatemala) -Shipping Agent (Hamburg Sud) San Jose (Costa Rica) - Feeder Carrier in CA Region (X-press Feeder)

No.8

Date/City	15 April ,2013 / San Salvador
Category	Shipping agent
Company	Compania Mercantil International, S.A. de C.V. (Agent of NYK) (www.comisasal.com)
Interviewee	Mr. Jose Ricardo Cruz, Gerente de Linea (ricardo.cruz@comisasal.com Tel: 503-2206-5400)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Dr. Ryuichi Shibasaki, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Ms. Andrea Castillo

No.9

Date/City	16 April, 2013 / San Salvador
Category	Shipping Agent
Company	Transmares(Agent of Hapag-Lloyd)
Interviewee	Heinz Ballhaus, President (Heinz.ballhaus@transmaressal.com)
Study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Mr. Alan Castillo

No.10

Date/City	16 April, 2013 / San Salvador
Category	Shipping agent
Company	Transcontinental El Salvador, S.A. de C.V. (Agent of CMA-CGM)
Interviewee	Julio Cesar FIGUEROA (Operation Manager) (Julio.figueroa@transcontinentalsal.com)
Study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Mr. Alan Castillo
	

No.11

Date/ City	16 April ,2013/ San Salvador
Category	Shipping agent (Evergreen)
Company	Maritime Investments, LLC OMARSA
Interviewee	Mr.Alex Sagrera, Maritime Investments, LLC (asagrera@cargo.com.sv) Mr.Ernesto Moreno, OMARSA (emoreno@gruporemor.com.sv)
Study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Mr. Alan Castillo
	

No.12

Date/City	29 April ,2013 / San Salvador
Category	Shipping Agent
Company	Aimar de El Salvador, S.A de C.V. (Agent of APL)
Interviewee	Mr. Amedeo E. Molina Monterrosa (amadeo-molina@aimargroup.com , 503-2209-7900) Mrs. Maritza de Canizales, APL Customer Service (Maritza-canizales@aimargroup.com Cel: 7860-8727)
JICA study team	Mr. Takashi Kadono, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Ms. Patricia Callejas

No.13

Date/City	02 May, 2013 / San Salvador
Category	Shipping Agent
Company	Maersk El Salvador, S.A. de C.V.
Interviewee	Mr. Miguel.Iraheta Miguel.Iraheta@apmterminals.com<Miguel.Iraheta@apmterminals.com>;
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Mr.Tadahiko Kawada. Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Ms. Patricia Callejas, Mr. Alan Castillo,
	

No.14

Date/City	13 August ,2013 /Guatemala
Category	Shipping Agent
Company	Hamburg Süd Guatemala, S.A.
Interviewee	Mr. Víctor Monroy, Gerente General Tel: 2375-7513
JICA study team	Mr. Takashi Kadono, Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Patricia Callejas
	

No.15

Date/City	14 August ,2013 / San Salvador
Category	Shipping Agent
Company	REMASUR, S.A. de C.V. (Agent of CCNI)
Interviewee	Mr. Milton Guillen,General Manager Tel: (503)2452-5117
JICA study team	Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

No.16

Date/City	20 August ,2013 / San Salvador
Category	Shipping Agent
Company	Compañía Sudamericana de Vapores - CSAV SERMARSA (Agent of CSAV)
Interviewee	Mr. Oscar Valladares ,Line Manager Tel:(503) 2239-4399
JICA study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Patricia Callejas

No.17

Date/City	20 August ,2013 / San Salvador
Category	Shipping Agent
Company	REMARSA de C.V. （Agent of China Shipping）
Interviewee	Lic. Jaime Vásquez,Operations Manager Tel:(503) 2206-5555
JICA study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Patricia Callejas

No.18

Date/City	20 August ,2013 / San Jose Costa Rica
Category	Shipping Agent
Company	MARINSA ILG LOGISTICS S.A. (Agent of X-PRESS FEEDERS)
Interviewee	Mr. Jorge Cayasso,Port Operations Tel. (506) 2758-4170
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido, Mr.Tadahiko Kawada. Ms. Marta Eugenia Canales

No.19

Date/City	26 August ,2013 / San Salvador
Category	Shipping Agent
Company	Mediterranean Shipping Co. El Salvador, S.A. de C.V
Interviewee	Abel Sandoval,General Manager Tel. (503)2520-2200
JICA study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Marta Eugenia Canales

No.20

Date/City	28 August ,2013 / San Salvador
Category	Shipping Agent
Company	Crowley Liner Services Inc.
Interviewee	Jose Mario Quinteros, General Manager Tel. (503)2297-0055
JICA study team	Dr. Ryuichi Shibasaki,Mr.Takayuki Iijima Ms. Marta Eugenia Canales

Agency etc.

Customs
Interview Items 1. Necessary Procedures at the Border 2. Required Times for Clealance 3. Others
- Aduana of El Salvador at Amatillo - Aduana of Hondulas at Amatillo

No.21

Date/City	19 April, 2013 / Amatillo
Category	Customs
Agency/Company	
Interviewee	Mr. Fernundo Urbina, Coordinator for the Eastern Area) (fernundo.utbina@mh.gob.sv,) Mr. Jore Eids Perez, Head of Office (edis.perz@mh.gob.sv)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Dr. Ryuichi Shibasaki, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Patricia Callejas, Ms. Andrea Castillo
	

No.22

Date/City	19 April, 2013 / Amatillo
Category	Customs
Agency/Company	Aduana El Amatillo
Interviewee	Ms. Milgian S. Andino C, Administradora Aduana El Amatillo-HN (mandino@dei.gob.hn)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Dr. Ryuichi Shibasaki, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Patricia Callejas, Ms. Andrea Castillo
	

Other Agencies
Interview Items 1. Socio-economic situations of El Salvador 2. Outline of ports in CA 3. Statistics of Transportation in El Salvador and CA 4. Others
- PROESA (Export and Investment Promotion Agency of El Salvador, Government of El Salvador) - Transportation Association

No.23

Date/City	15 April, 2013 / San Salvador
Category	Agency of promotion and investment
Agency/Company	PROESA
Interviewee	Mr. Miguel Mejia Linares, Asesor de Promocion de Inversions (mmejia@proesa.gov.sv Cell: 03-7802-6583)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Mr.Tadahiko Kawada. Mr.Takayuki Iijima Ms. Marta Eugenia Canales, Mr. Alan Castillo,

No.24

Date/City	2 May, 2013 / San Salvador
Category	Transportation Association
Agency/Company	Transportation Association
Interviewee	Mr.Jng David Lapin(Leo's ,S.A.DE C.V.　:General manager) Ms.Robert Alberto Rivas(Carflo,S.A.de C.V.　:President)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Mr.Tadahiko Kawada. Mr.Takayuki Iijima Ms. Patricia Callejas,Ms. Marta Eugenia Canales, Mr. Alan Castillo,
	

Shipper

Shipper
Interview Items 1. Business environment (commodity, logistics etc.) 2. Use of La Union Port 3. Other
Agrolibano (Melon Production and Export)

No.25

Date/City	17 April, 2013 / San Lorenzo, Hondulas
Category	Shipper (Melon Production.Export)
Company	Agrolibano (www.grupocassa.com)
Interviewee	Mr. Rene Navas, Importaciones Cadena de Abastecimiento (renenavas@agrolibano.com Cell: 504-9495-4206)
JICA study team	Mr. Takashi Kadono, Mr. Tatsuyuki Shishido,Dr. Ryuichi Shibasaki, Mr.Tadahiko Kawada.Mr.Takayuki Iijima Ms. Patricia Callejas, Ms. Andrea Castillo
	

D.4 Computer Operation Manual of the Vessel Calling Model

D4.1 Outline and precondition

The current status of the behavior of shipping companies (maritime container shipping network as of May 2010) is made from the MDS database as described in 8.5.1. The future networks of maritime container shipping are made according to the way of thinking described in 9.2.2(3), based on the current network. These network data are respectively input into the container cargo assignment model, and each result is evaluated to determine whether it is viable or not (see 9.2.3(1)).

The container cargo assignment model is programmed by Fortran. An environment compatible with Fortran program is needed. "Absoft Pro Fortran ver.9.0" is recommended as the software to operate the program. In addition, a computer with higher specifications is desirable as the performance of CPU directly affects the speed of model calculation. The program may not work if the memory is lower.

D4.2 Files to be included in the computer program

The files to be included in the folder of the computer program should be prepared for each simulation year (i.e. 2010, 2020 and 2030) as shown in Table D.28, although most of the files are common among the years.

All Fortran files are automatically included when the butch file (.gui file) is launched and compiled (the detailed procedure is explained in D4.3).

A description of each input data file is as follows.

Table D.28 Files to be included in the computer program

simulation year	simulation in the current year (2010)	simulation in 2020	simulation in 2030
butch file	project.gui	project_2020.gui	project_2030.gui
fortran files	main.f90 carr_main.f90 carr_sub.f90 carr_all_not.f90 shpr_main.f90 shpr_dial_ass.f90 derase.f90 NW_info.inc NW_size.inc	main_2020.f90 carr_main.f90 carr_sub.f90 carr_all_not.f90 shpr_main.f90 shpr_dial_ass.f90 derase.f90 NW_info.inc NW_size.inc	main_2030.f90 carr_main.f90 carr_sub.f90 carr_all_not.f90 shpr_main.f90 shpr_dial_ass.f90 derase.f90 NW_info.inc NW_size.inc
input data files (default settings)	IONAME.dat BasicInfo(163r@164p@28g).dat unkown_parameter.dat reg_od10(163r).csv mar_od10(164p@28g).csv port10(164p).csv plength(164p).csv panama_dummy(164p).csv suez_dummy(164p).csv mds_route052010(164p@28g).csv landnw_CA(6r@7p).csv	IONAME2020.dat BasicInfo(163r@164p@28g).dat unkown_parameter.dat reg_od20(163r).csv mar_od20(164p@28g).csv port20(164p).csv plength(164p).csv panama_dummy(164p).csv suez_dummy(164p).csv mds_route052010(164p@28g)S20.csv landnw_CA(6r@7p).csv	IONAME2030.dat BasicInfo(163r@164p@28g).dat unkown_parameter.dat reg_od30(163r).csv mar_od30(164p@28g).csv port30(164p).csv plength(164p).csv panama_dummy(164p).csv suez_dummy(164p).csv mds_route052010(164p@28g)S30.csv landnw_CA(6r@7p).csv

(1) IONAME file

An "IONAME.dat" file as well as "IONAME2020.dat" and "IONAME2030.dat" files is a list of input files which are included in each simulation. An example of the content of an "IONAME.dat" file is shown in the following table. If new input file(s) are created to replace the existing input file(s), the "IONAME.dat" file should be also rewritten.

Table D.29　An example of the content of an IONAME file ("IONAME.dat")

```
BasicInfo(163r@164p@28g).dat　! BasicInfo file
unkown_parameter.dat
reg_od10(163r).csv　! regional container OD
mar_od10(164p@28g).csv　! maritime container OD by shipping company
port10(164p).csv　! port data
plength(164p).csv
panama_dummy(164p).csv
suez_dummy(164p).csv
mds_route052010(164p@28g).csv
landnw_CA(6r@7p).csv
```

(2) BasicInfo file

A "BasicInfo(**r@**p@**g).dat" file provides fundamental information in the simulation including the number of zones (regions), ports and shipping companies. Default settings of these three numbers do not need to be changed in the model simulation except for some extraordinary reason.

The latter four figures in the file are on the convergence calculation of the container cargo assignment model and maritime shipping submodel. The repetitive calculation is conducted until either of the following two conditions are met: the number of iteration reaches the upper limitation, or the error term defined as the square sum of the difference from the link flows calculated in the previous iteration is smaller than a threshold. When the limitation number of iteration is decreased and convergence threshold is increased, the calculation speed may increase but the calculation may not converge causing the fluctuation of the results.

Table D.30　An example of the content of a BasicInfo file ("BasicInfo(163r@164p@28g).dat")

```
163        ! number of zone (region)
164        ! number of port
28         ! number of shipping companies
20         ! limitation number of calculative iteration of maritime shipping submodel
1.0d-3    ! convergence threshold in maritime shipping submodel calculation
5          ! limitation number of calculative iteration of container cargo assignment model
1.0d-2    ! convergence threshold in container cargo assignment model calculation
```

(3) Unknown parameter file

An "unknown_parameter.dat" file includes three unknown parameters to be estimated from the model output in order to best fit to the actual container shipping market as described in 8.8.2. It can be changed as needed; for example, in case of the simulation to reduce the barrier at the national border in land shipping as shown in Figure 9.16, α should be reduced from the default setting (α = 0.3).

Table D.31 An example of the content of a unknown parameter file (“unknown_parameter.dat”)

8.0	! vt (value of time)
0.01	! θ (distribution parameter of stochastic assignment)
0.3	! α (cross-border coefficient: adjustment parameter on bonded transportation)

(4) Regional container OD file

An “od##(**r).dat” file represents a container cargo shipping demand (container OD matrix) in year 20## between the number of regions. The estimation methodology of the current OD (in 2010) is described in 8.7.1(2) and (3) as well as the future OD (in 2020 and 2030) in 9.2.2(1).

Although the default OD matrix is set as “od10(163r).dat”, “od20(163r).dat”, and “od30(163r).dat” respectively for each year, a different matrix should be prepared when simulating a change in the volume of container shipping demand from the default (e.g. a regional development in the eastern El Salvador as described in9.2.3(3)2)).

Table D.32 An example of the content of a regional container OD file (“od10(163r).dat”)

! ↓origin region number, → destination region number

0	1	2	3	4	5	6	7	8	9	10	....
1	0	0	0	0	0	0	64452.7	15197.1	4728.7	11401.0	....
2	0	0	0	0	0	0	50678.6	11949.4	3718.1	8964.5	....
3	0	0	0	0	0	0	37844.7	8923.3	2776.6	6694.3	....
4	0	0	0	0	0	0	22245.0	5245.1	1632.1	3934.9	....
5	0	0	0	0	0	0	37693.7	8887.7	2765.5	6667.6	....
6	0	0	0	0	0	0	8726.4	2057.6	640.2	1543.6	....
7	35945.9	28263.9	21106.3	12406.2	21022.1	4866.8	0	0	0	32483.4	....
8	8475.6	6664.3	4976.6	2925.2	4956.7	1147.5	0	0	0	7659.2	....
9	2637.2	2073.6	1548.5	910.2	1542.3	357.1	0	0	0	2383.2	....
10	18042.7	14186.8	10594.1	6227.2	10551.9	2442.8	44254.4	10434.6	3246.8	0	....
....	....	....	....	....	....	....	....	....	....	....	....

(5) Maritime container OD by shipping company file

An “od##(**p@**g).dat” file represents a maritime container cargo shipping demand by shipping company in year 20## between the number of ports. Note that this OD data is set as a port-basis demand, not a regional-basis. It is only needed as an initial input of the model calculation because the maritime shipping submodel should be first calculated in the entire calculation procedure (as described in 8.8.1(1)). It is estimated by dividing into each shipping company and applying Frater method in order to adjust errors for the port-basis OD described in 8.7.1(1), according to the similar methodology described in 8.7.1(3).

Table D.33 An example of the content of a maritime container OD by shipping company file ("od10(164p@28g).dat")

```
!  ↓export port number,  → import port number
! Group A (Maersk)
0       1       2       3       4       5       6       7       8       9       10      ....
1       0       0       0       0       0       0       2717.9  1465.9  300.2   722.8   ....
2       0       0       0       0       0       0       10260.6 5534.2  1133.4  2728.9  ....
3       0       0       0       0       0       0       5606.7  3024.0  619.3   1491.1  ....
4       0       0       0       0       0       0       1684.5  908.6   186.1   448.0   ....
5       0       0       0       0       0       0       4026.3  2171.7  444.8   1070.8  ....
6       0       0       0       0       0       0       1749.4  943.6   193.2   465.3   ....
7       1430.2  5399.3  2950.3  885.9   2117.5  920.6   0       0       0       3903.2  ....
8       770.1   2907.2  1588.6  477.0   1140.2  495.7   0       0       0       2101.7  ....
....    ....    ....    ....    ....    ....    ....    ....    ....    ....    ....    ....
```

(6) Port file

A "port##(**p).csv" file provides information of each port in year 20## including lead time for export and import, transshipment time, and handling charge per TEU. The default setting of each port is explained in 8.7.2 for the current status (in 2010) and in 9.2.2(2) for the future simulation (in 2020 and 2030).

In addition, amount of local and transshipment container cargo and dummy variable whether it is major hub port or not are provided in the port file. These are utilized for the estimation of parameters included in the maritime shipping model (to best fit to the actual amount of transshipment cargo); not utilized in the simulation this time.

Table D.34 An example of the content of a port file ("port10(164p).csv")

```
!Port number, Export lead time (hours), Import lead time (hours), Transshipment time (hours), Handling charge
(US$/TEU), Amount of local cargo (TEU/year), Amount of transshipment cargo (TEU/year), dummy of major
hub port
1      48     24     24     100     2059057.92     394493.7768     0 !Tokyo
2      48     24     24     100     1616019.76     309612.3318     0 !Yokohama
3      48     24     24     100     1204449.144    230759.7452     0 !Nagoya
4      48     24     24     100     712591.5125    136525.0137     0 !Osaka
5      48     24     24     100     1189751.795    227943.8883     0 !Kobe
....   ....   ....   ....   ....    ....           ....           ....
58     48     24     24     100     315597.571     138200.8982     0 !Lazaro Cardenas
581    60     24     48     117.65  155580.5776    27752.94075     0 !Puerto Quetzal
582    60     48     48     73.48   104554.421     0              0 !Acajutla
583    48     24     48     65.79   0              0              0 !La Union
584    60     48     48     64.7    0              0              0 !San Lorenzo
585    168    84     48     58.82   46231.95469    807.6170337    0 !Corinto
586    48     24     48     100     115486.5602    0              0 !Caldera
59     48     24     24     100     153844.1923    747035.7719    1 !Balboa
60     48     24     24     100     343843.234     1435418.095    1
!Manzanillo(Panama)/Cristobal/Colon
61     48     24     48     100     374074.6639    14350.15597    0 !Puerto Limon
62     48     24     48     64.7    352820.8168    0              0 !Puerto Cortes
621    60     24     48     64.7    355619.6169    85623.68051    0
!St. Tomas de Castilla/Puerto Barrios
....   ....   ....   ....   ....    ....           ....           ....
```

(7) Navigation distance file

A "plength(***p).csv" file provides information on the shipping distance along the navigation route between each combination of departure and arrival port. Each figure is written in NM; acquired from the results of Toriumi (2010) as described in D2.7.

If a new port is added for further analysis, navigation distances between the new port and all other ports to which a direct liner service from the new port are provided. Netpas and other software provide distance table on the sea.

Table D.35 An example of the content of a navigation distance file ("plength(164p).csv")

! ↓departure port number, → arrival port number											
0	1	2	3	4	5	6	7	8	9	10	....
1	0	16	211	361	357	603	662	742	1020	1163	....
2	16	0	197	347	343	589	648	728	1006	1149	....
3	211	197	0	240	236	482	541	621	899	1042	....
4	361	347	240	0	9	290	349	429	707	850	....
5	357	343	236	9	0	282	341	421	699	842	....
6	603	589	482	290	282	0	110	192	483	626	....
7	662	648	541	349	341	110	0	90	381	524	....
8	742	728	621	429	421	192	90	0	339	482	....
9	1020	1006	899	707	699	483	381	339	0	249	....
10	1163	1149	1042	850	842	626	524	482	249	0	....
....	....	....	....	....	....	....	....	....	....	....	....

(8) Panama and Suez Canal dummy file

A "panama_dummy(**p).csv" and "suez_dummy(**p).csv" file provide information on whether each navigation link in the maritime shipping submodel connecting departure and arrival port passes through the Panama and Suez Canal or not, respectively. If the link passes through the canal, it should be 1; otherwise, 0. This information is utilized for the calculation of the canal toll as shown in Equation (D.14) in Annex D2.5. It is also acquired from the Toriumi's work (2010).

Table D.36 An example of the content of a Panama Canal dummy file ("panama_dummy(164p).csv")

! ↓departure port number, → arrival port number											
0	1	2	3	4	5	6	7	8	9	10	....
....	....	....	....	....	....	....	....	....	....	....	....
58	0	0	0	0	0	0	0	0	0	0	....
581	0	0	0	0	0	0	0	0	0	0	....
582	0	0	0	0	0	0	0	0	0	0	....
583	0	0	0	0	0	0	0	0	0	0	....
584	0	0	0	0	0	0	0	0	0	0	....
585	0	0	0	0	0	0	0	0	0	0	....
586	0	0	0	0	0	0	0	0	0	0	....
59	0	0	0	0	0	0	0	0	0	0	....
60	1	1	1	1	1	1	1	1	1	1	....
61	1	1	1	1	1	1	1	1	1	1	....
62	1	1	1	1	1	1	1	1	1	1	....
621	1	1	1	1	1	1	1	1	1	1	....
....	....	....	....	....	....	....	....	....	....	....	....

(9) Maritime shipping network file

A “mds_route052010(**p@**g).csv” file provides information on the maritime shipping network for each liner service as of May 2010 including annual service frequency, average vessel speed, average vessel capacity, share in capacity of each shipping company, number of ports to call at one rotation, dummy variable for multiple routes of a service, port numbers to call (written as the number of ports to call at one rotation).

At the top of the file, the number of liner service is written.

For the future simulation, some variables (e.g. frequency, vessel capacity, and port to call) of several services will be changed according to the scenarios prepared (as described in 9.2.1(3)). One file should be prepared for each scenario.

Table D.37 An example of the content of a maritime shipping network file (“mds_route052010(164p@28g).csv”)

```
859    !number of liner service
!service No., Service frequency (/year), Average speed (knot), Average vessel capacity (TEU), Share in capacity
of Company A, B, ..., Z, AA, and AB, Number of ports to call at one rotation, Dummy for multiple routes of a
service, Port number to call (1, 2, 3, ... to the number of ports to call at one rotation)
1      52     23.9   4190.6  0.0909  0   …   0   0   0    7   0   26    21    23   …
2      52     21.2   660     0       0   …   0   0   0    4   0   4     5     10   …
3      52     17.5   3100    0       0   …   0   0   0    10  0   141   143   138  …
4      52     10     1291.5  0       0   …   0   0   0    3   0   38    41    38
5      26     17     780     0       0   …   0   0   0    3   0   38    41    38
6      104    18     1088    0       0   …   0   0   0    4   0   38    33    32   …
....   ....   ....   ....    ....   ....  ....  ....  ....  ....  ....  ....  ....  ....  ....
```

(10) Land shipping network file

A “landnw_CA(6r@7p).csv” file provides information on the land shipping network in Central America (see Figure 8.33 in 8.7.4). The driving time and cost, and border-crossing time and cost are set as described in Table 8.40 and Table 8.41. The similar time and cost in both directions for each pair of origin (or destination) region and export (or import) port are assumed.

At the top of the file, the number of land shipping link is written.

The variables included in the file can be changed in some policy simulations such as road improvement and facilitation of the border barriers. For example, when simulating the reduction of the barriers at a specific border (e.g. a border between El Salvador and Honduras), border-crossing time and cost would be decreased in the pairs across the border in question.

Table D.38 An example of the content of a land shipping network file (“landnw_CA(6r@7p).csv”)

42 ! Number of land shipping network

! origin/destination region, export/import port, Driving time (hours), Driving cost (US$/TEU), Border-crossing time (hours), Border-crossing cost (US$/TEU)

581	581	1.68	151.5	0	0
581	582	3.18	286.5	84	380
581	583	7	630	84	380
581	584	8.03	723	276	641
581	585	11	990	528	958.5
581	62	6.32	568.5	192	261
581	621	5	450	0	0
582	581	4.48	403.5	240	278.5
582	582	1.43	129	0	0
582	583	3.08	277.5	0	0
582	584	4.13	372	192	261
582	585	7.08	637.5	444	578.5
582	62	6.8	612	192	261
....	....	....	....	....	....

D4.3 Procedure of computer calculation

The following example is in the case that Absoft Pro Fortran ver.9.0 and Absoft Developer Tools Interface are utilized.

1) Launch .gui file (such as “project.gui”) by double-clicking it. Confirm all fortran files are included (see Figure D.42).

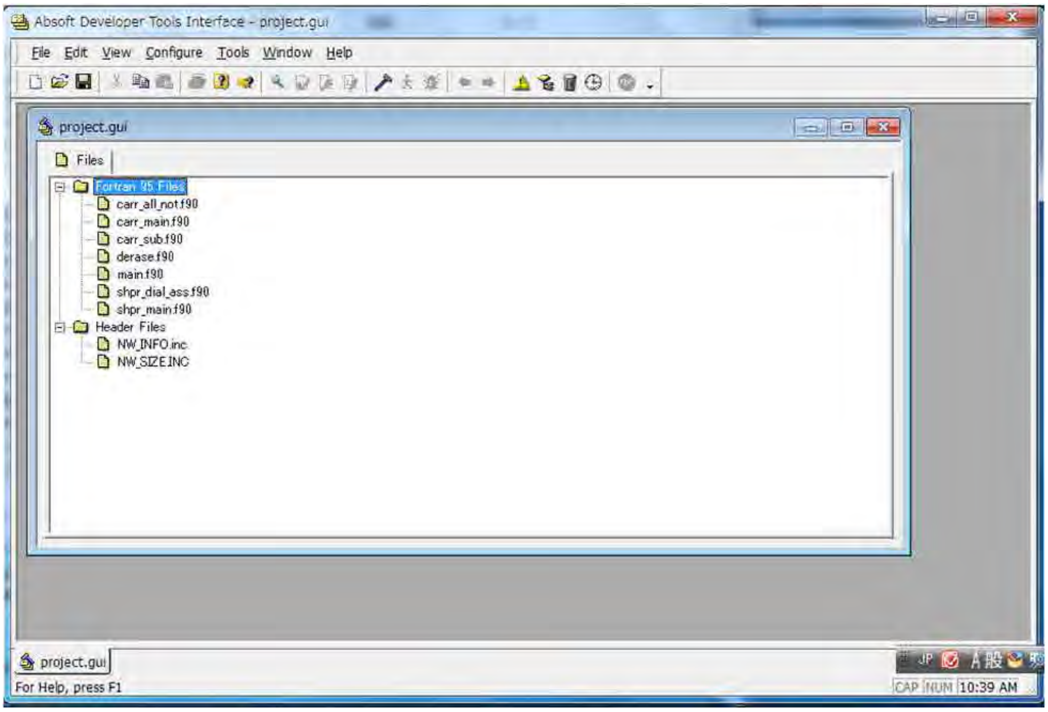


Figure D.42 An example of computer operation of the model (1)

2) Select 'Configure' - "Set Project Options' in the tool bar. Confirm 'Advanced (-O3)' is selected in a 'Optimize' bar in a 'Common Options' box on a 'Target' tab (see Figure D.43). It is necessary to maintain a fast calculation speed. Note that it should be re-selected if a debugging mode is utilized.

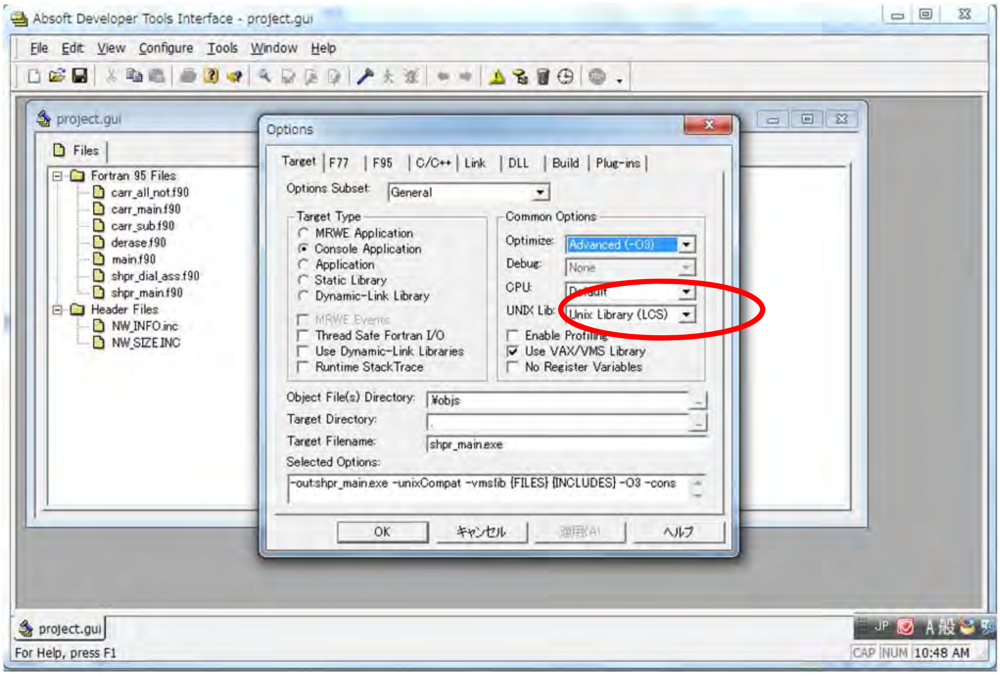


Figure D.43 An example of computer operation of the model (2)

3) Compile all files by selecting 'Tools' - 'Rebuild All' in the tool bar. It must be selected whenever a profram file(s) is revised. If the rebuilding is successfully completed, user can see a dialog box ("Build completed") as shown in Figure D.44.

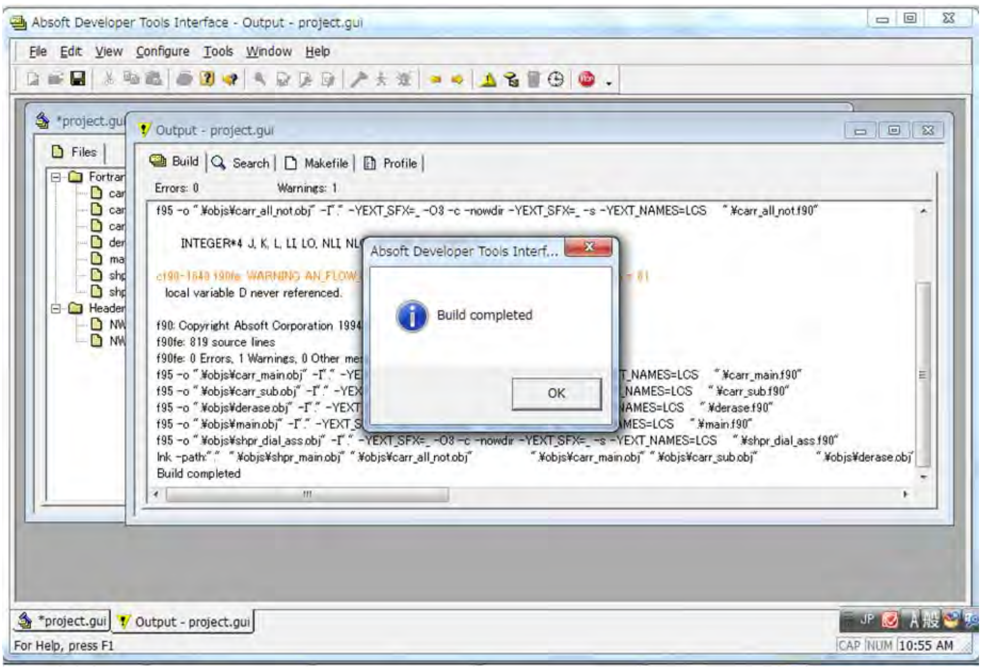


Figure D.44 An example of computer operation of the model (3)

4) Run a program by selecting ‘Tools’ - ‘Execute’ in the tool bar. When starting, a window as shown in Figure D.45 is opened. The calculation runs for a few hours (depending on the specification of the computer as well as the settings of iterative calculation). When the calculation finishes, a calculation window opens as in Figure D.46

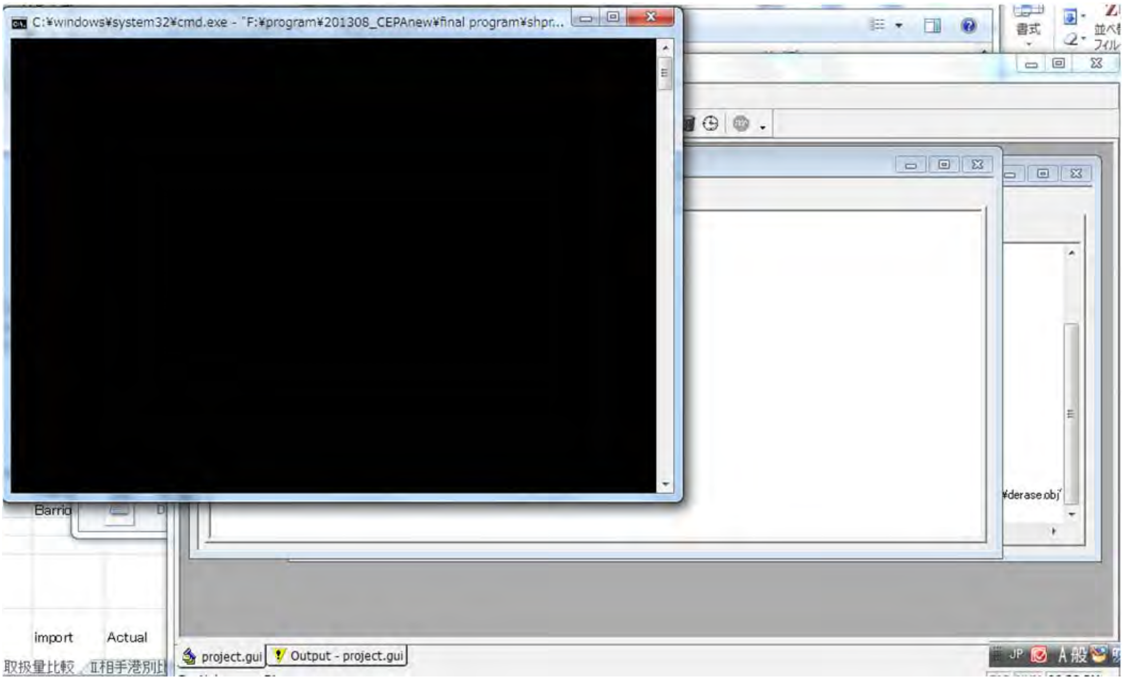


Figure D.45 An example of computer operation of the model (4)

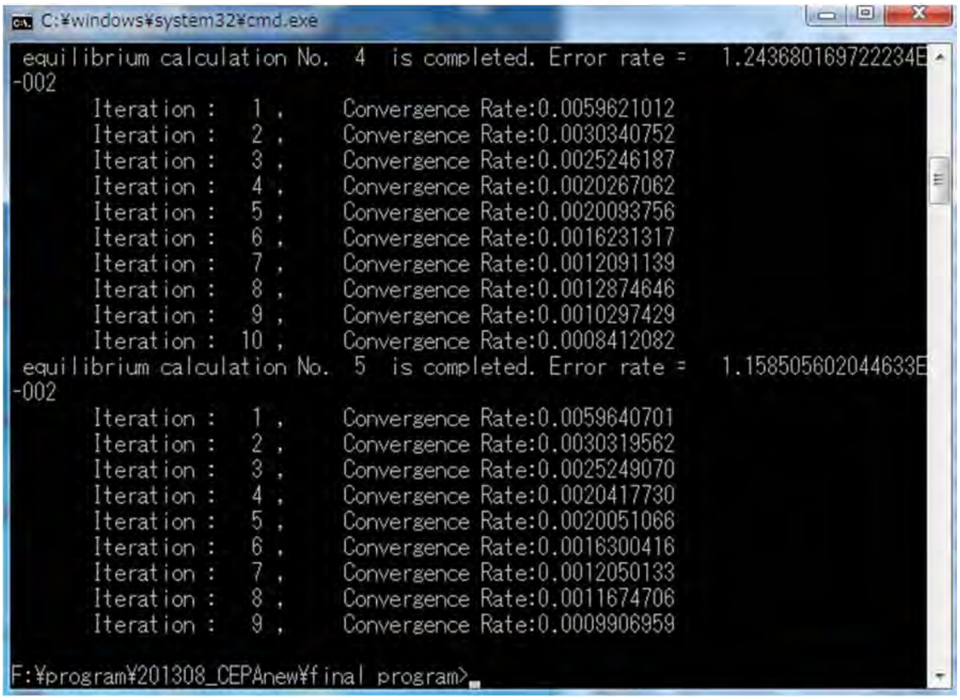


Figure D.46 An example of computer operation of the model (5)

D4.4 Description of output files

There are many kinds of output such as container flow, shipping time and shipping cost of each link including maritime, port and land. The default output files of the model are listed in Table D.39. The user can add an original output file(s) by revising the program.

Table D.39 List of output files of the model as default

convergence.dat
port_output.dat
port_output2.csv
results_carr.dat
SG_Cost.dat
results_shpr.dat

(1) Output on the convergence ("convergence.dat")

A "convergence.dat" file shows the error term (convergence rate) in the iterative calculation for both maritime shipping submodel and container cargo assignment model as shown in Table D.40. It is an exact copy of the result that is shown in the calculation window (see Figure D.46).

Table D.40 An example of output file on the convergence ("convergence.dat")

```
     Iteration :    1 ,      Convergence Rate:0.0060528945
     Iteration :    2 ,      Convergence Rate:0.0031475926
     Iteration :    3 ,      Convergence Rate:0.0024026071
     Iteration :    4 ,      Convergence Rate:0.0016822556
     Iteration :    5 ,      Convergence Rate:0.0018827055
     Iteration :    6 ,      Convergence Rate:0.0016966635
     Iteration :    7 ,      Convergence Rate:0.0013113089
     Iteration :    8 ,      Convergence Rate:0.0012195115
     Iteration :    9 ,      Convergence Rate:0.0010702871
     Iteration :   10 ,      Convergence Rate:0.0009678616
equilibrium calculation No.   1   is completed. Error rate =    6.010866069519585E-002
     Iteration :    1 ,      Convergence Rate:0.0059643401
     Iteration :    2 ,      Convergence Rate:0.0030367353
     Iteration :    3 ,      Convergence Rate:0.0025519040
     Iteration :    4 ,      Convergence Rate:0.0020232198
     ....
```

1st iterative calculation of maritime shipping submodel

error term calculation in the 1st iterative calculation of container cargo assignment model

2nd iterative calculation of maritime shipping submodel

(2) Outputs on the handling amount in ports ("port_output.dat" and "port_output2.csv")

A "port_output.dat" file shows the amount of containers handled in each port on export, import and transshipment as shown in Table D.41. Transshipment amount of containers is also shown for each shipping company.

A "port_output2.csv" file shows not only the amount of containers handled in each CA4 port on export and import in the final calculation, but also those calculated in the previous iteration as shown in Table D.42 so that the convergence of the output in terms of container throughput is checked.

Table D.41 An example of output file on the handling amount in ports (1: “port_output.dat”)

```
! Port No., Export amount handled in port (TEU/year), Import amount handled in port (TEU/year), Transshipped
amount handled in port (TEU/year), Transshipped amount for each shipping company A, B, C, D, ….
1   844759   968094   446048   2738   0   4514   32438   ….
2   664227   761204   417472   121901   9972   20679   5015   ….
3   496017   568435   85120   173   50   396   0   ….
….
58   70191   157932   215021   83521   0   0   0   ….
581   100406   121405   17246   0   1460   812   0   ….
582   30479   60627   0   0   0   0   0   ….
583   0   0   0   0   0   0   0   ….
584   0   0   0   0   0   0   0   ….
585   13315   39015   3257   3257   0   0   0   ….
586   72577   35501   0   0   0   0   0   ….
59   106125   32114   1361823   937398   315717   23427   ….
60   196838   151299   1767354   337885   109550   182100   ….
61   172994   30854   8373   0   0   0   0   ….
62   202477   198863   9492   0.3   0   0   0   ….
621   204162   198253   75750   35272   0   0   0   ….
….
```

Table D.42 An example of output file on the handling amount in ports (2: “port_output2.csv”)

581	95820.13081	115224.8098	100405.9245	121405.232
582	32054.6965	67291.90032	30479.41202	60626.54362
583	0	0	0	0
584	0	0	0	0
585	13352.716	33529.61927	13314.5915	39014.97808
62	203562.4776	199032.3734	202476.6193	198863.4335
621	206048.9233	203061.2102	204162.3969	198253.479

(3) Outputs on the shipping company’s (carrier’s) behavior (“results_carr.dat” and “SG_Cost.dat”)

A “results_carr.dat” file shows an output of each link in the maritime shipping submodel. As shown in Table D.43, it includes the link number (L), shipping company number (G), liner service number (R), departure and arrival port number (P1 and P2), departure and arrival node number (N1 and N2) which is only utilized in the model, shipping time (T; in terms of hour), vessel capacity (Cap; in terms of TEU), annual link flow (X; in terms of TEU), annual number of service (Freq), additional time due to congestion (CT; in terms of hour, see Equation (D.6) in Annex D2), generalized cost including both monetary cost and shipping time cost (G; in terms of US$/TEU), monetary cost (C; in terms of US$/TEU) including fuel cost (FC; in terms of US$/TEU), capital cost (CC; in terms of US$/TEU), operation cost (OC; in terms of US$/TEU), and canal cost (PanamaC and SuezC; in terms of US$/TEU) as described in Annex D2.4.

The former part of the “results_carr.dat” file describes the links on the transshipment and carrier choosing link in each port for each company. For example, a link with link number 1 in Table D.43 represents a transshipment link in port 1 (Tokyo) for company A (Maersk). Also, links with link number 2 and 3 represent a carrier choosing link (O and D, respectively) in port 1 for company A.

The latter part of the file (in the example shown in Table D.43, in and after the link number 13777) describes the links on the anchoring, loading, unloading and navigation link in each port or each combination of departure and arrival port for each liner service provided by company. For example, a link with link number 13777 represents an anchoring link in port 26 (Kaohsiung) for a service 1 ("AAUS-AUS service") provided by company A (Maersk). The links with link number 13778 and 13779 represent a loading and unloading link respectively in port 26 for a service 1 provided by company A. Also, a link with link number 13780 represents a navigation link from port 26 (Kaohsiung) to port 21 Shenzhen (Shekou, Chiwan, or Dachan Bay) for a service 1 provided by company A.

From this output file, the estimated flow of containers for each service departing from (or arriving into) each port as well as the share by shipping company in the amount of containers handled in each port can be derived.

Table D.43 An example of output file on the shipping company's behavior

(1: "results_carr.dat")

```
L G R P1 P2 N1 N2 T Cap X Freq CT G C FC CC OC PanamaC SuezC
1   1   0   1   1   100000101   100000102   24.0   0.   1369.2   0.   0.   24.0   150.0   0.0   0.0   0.0   0.0   0.0
2   1   0   1   1   100000101   104   0.01   0.   83718.2   0.   0.   0.01   100.0   0.0   0.0   0.0   0.0   0.0
3   1   0   1   1   103   100000102   0.01   0.   48768.8   0.   0.   0.01   100.0   0.0   0.0   0.0   0.0   0.0
4   1   0   2   2   100000201   100000202   24.0   0.   60950.3   0.   0.   24.0   150.0   0.0   0.0   0.0   0.0   0.0
5   1   0   2   2   100000201   204   0.01   0.   124523.7   0.   0.   0.01   100.0   0.0   0.0   0.0   0.0   0.0
....
13777   1   1   26   26   100102611   100102612   12.0   381.0   4030.3   52.0   0.   12.0   0.01   0.0   0.0   0.0
 0.0   0.0
13778   1   1   26   26   100102611   100002601   0.01   381.0   3685.4   52.0   0.   0.01   0.01   0.0   0.0   0.0
0.0   0.0
13779   1   1   26   26   100002602   100102612   84.0   381.0   0.0   52.0   0.   84.0   0.01 0.0   0.0   0.0   0.0
0.0
13780   1   1   26   21   100102612   100102111   16.2   381.0   4030.3   52.0   16.2   24.4   67.5   4582.7
721.0   466.9   0.0   0.0
13781   1   1   21   21   100102111   100102112   12.0   381.0   1706.0   52.0   0.   12.0   0.01   0.0   0.0   0.0
0.0   0.0
13782   1   1   21   21   100102111   100002101   0.01   381.0   2324.2   52.0   0.   0.01   0.01   0.0   0.0   0.0
0.0   0.0
....
```

A "SG_Cost.dat" file shows the output on the shipping time and freight charge calculated by the maritime shipping submodel for each combination of export and import port. As shown in Table D.44, it includes iteration of calculation of the container cargo assignment model (IT), number of export and import port (PI and PJ), the annual volume of containers to be shipped (i.e. cargo shipping demand) from PI to PJ (ODflow; in terms of TEU), company number which can provide the minimum shipping time for the transportation from PI to PJ (minG), the number of companies which can provide the shipping time less than the 10% larger of the above minimum shipping time (numG), the minimum shipping time (minUG; in terms of hour) and shipping time that each company can provide (UG; in terms of hour), freight charge calculated from the marginal shipping cost and balance of demand and supply in the shipping market from PI to PJ (see 8.8.1 (2)2)) (FM; in terms of US$/TEU), the maximum marginal shipping cost out of the marginal shipping cost for the shipping companies which can provide the shipping time less than the 10% larger of the minimum shipping time (maxMC; in terms of US$/TEU) and company number which provides the above maximum marginal shipping cost (maxG), and the marginal shipping cost for each shipping companies (MC; in terms of US$/TEU).

From this output file, shipping time and freight charge for the container shipping in each combination of export port PI and import port PJ are acquired.

Table D.44 An example of output file on the shipping company's behavior

(2: "SG_Cost.dat")

```
!IT, PI, PJ, ODflow, minG, numG, minUG, UG(company A, ...., AB), FM, maxMC, maxG, MC(company A, ...., AB)
   5   1   1   0.0   0   28   1.0E+10   0.0   ....   0.0   1.0E+10   0.0   0   0.0   ....   0.0
   5   1   2   0.0   13   13   84.8   85.18   ....   1.0E+10   209.2   209.3   13   202.2   ....   0.0
   5   1   3   0.0   10   1   58.7   117.7   ....   1.0E+10   629.0   597.5   10   3501.6   ....   0.0
   5   1   4   0.0   4   5   107.3   222.7   ....   1.0E+10   249.2   249.9   4   381.0   ....   0.0
   5   1   5   0.0   9   10   102.5   108.0   ....   1.0E+10   335.9   324.6   9   248.7   ....   0.0
....
```

(4) Output on the shipper's behavior ("results_shpr.dat")

A "results_shpr.csv" file shows an output of each link in the container cargo assignment model. As shown in Table D.45, it includes the link number (L), departure and arrival port or zone number (PI/ZI and PJ/ZJ), departure and arrival node number (N1 and N2) which is also only utilized in the model, generalized cost including both monetary cost and shipping time cost (G; in terms of US$/TEU), shipping time (T; in terms of hour), and monetary cost (CV in terms of US$/TEU).

The links described in the file consist of three parts; land, port, and maritime link.

The first part of the file (in the example shown in Table D.45, from the link number 1 to 400) describes the land shipping link in CA4 countries from an origin zone ZI to an export port PJ, or from import port PI to a destination zone ZJ. When the last digit of N1 or N2 is five or six, it is origin and destination zone respectively. When the last digit of N1 or N2 is three or four, it is export and import port respectively. For example, a link with number 1 in Table D.45 represents a link for import containers from port 582 (Acajutla) to zone 581 (Guatemala). Also, a link with link number 2 represents a link for export containers from zone 581 to port 582.

The second part of the file (in the example shown in Table D.45, from the link number 401 to 728) describes the export and import link in each port PI. For example, a link with link number 401 represents an import link in port 1 (Tokyo) and a link with link number 402 represents an export link in port 1. Note that only lead time for export or import is considered in these links as described in Equation (6) and (8) in 8.6.1 except that in Acajutla Port an additional time is considered due to the congestion in handling when the amount of container exceeds the capacity of the port as described in Equation (D.8) and (D.9) in 9.2.2 (2).

The third part of the file (in the example shown in Table D.45, from the link number 729 to the end of the file) describes the maritime shipping link from an export port PI to an import port PJ. The outputs in this part such as shipping time (T) and monetary cost (C) are very similar to the minimum shipping cost (minUG) and freight charge (FM) in the "SG_cost.dat" file as described in (3).

Table D.45 An example of output file on the shipper's behavior (1: "results_shpr.dat")

```
! L, PI/ZI, PJ/ZJ, N1, N2, Flow, G, T, C
  1  582  581  58204  58106  4346.6  627.5  28.4  400.5
  2  581  582  58105  58203  8004.1  627.5  28.4  400.5
  3  583  581  58304  58106  0.0  1001.6  32.2  744.0
  4  581  583  58105  58303  0.0  1001.6  32.2  744.0
  5  584  581  58404  58106  0.0  1641.9  90.8  915.3
  6  581  584  58105  58403  0.0  1641.9  90.8  915.3
  7  585  581  58504  58106  0.0103  2632.8  169.4  1277.6
  8  581  585  58105  58503  2.43E-8  2632.8  169.4  1277.6
  9  62   581  6204   58106  20724.1  1158.2  63.9  646.8
  10  581  62  58105  6203   20467.3  1158.2  63.9  646.8
....
73    1    1    104   106   968094.0567    0.09     0.01    0.01
74    1    1    105   103   844759.0492    0.09     0.01    0.01
75    2    2    204   206   761203.7395    0.09     0.01    0.01
76    2    2    205   203   664226.521     0.09     0.01    0.01
77    3    3    304   306   568435.3021    0.09     0.01    0.01
78    3    3    305   303   496016.7475    0.09     0.01    0.01
79    4    4    404   406   334124.4959    0.09     0.01    0.01
....
401   1    1    101   104   968094.0567    192.01   24      0.01
402   1    1    103   102   844759.0492    384.01   48      0.01
403   2    2    201   204   761203.7395    192.01   24      0.01
404   2    2    203   202   664226.521     384.01   48      0.01
405   3    3    301   304   568435.3021    192.01   24      0.01
406   3    3    303   302   496016.7475    384.01   48      0.01
....
729   1    1    102   101   0              90000000000    10000000000    10000000000
730   1    2    102   201   0              887.6850209    84.8057914     209.2386897
731   1    3    102   301   0              1098.061542    58.63891103    628.950254
732   1    4    102   401   0              1108.021954    107.3480699    249.2373949
733   1    5    102   501   0              1150.813228    101.8584969    335.9452525
734   1    6    102   601   0              2135.135639    210.4634435    451.428091
735   1    7    102   701   64451.4069     1486.908703    144.7192614    329.1546122
736   1    8    102   801   15196.82578    2256.977825    227.2472807    438.999579
737   1    9    102   901   4728.614508    3460.964824    350.43092      657.5174642
738   1    10   102   1001  11400.92528    2571.349725    258.8945561    500.1932765
....
```