

**THE STUDY
ON
THE DEVELOPMENT PROJECT OF
THE PORT OF MANZANILLO
IN
THE UNITED MEXICAN STATES**

FINAL REPORT

NOVEMBER 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

SDF



85-122

JICA LIBRARY



1029963141

**THE STUDY
ON
THE DEVELOPMENT PROJECT OF
THE PORT OF MANZANILLO
IN
THE UNITED MEXICAN STATES**

FINAL REPORT

NOVEMBER 1985

国際協力事業団	
受入 月日 '86. 5. 15	615
	728
登録No. 12658	SDF

PREFACE

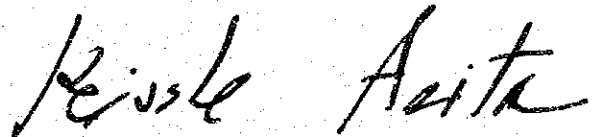
In response to a request from the Government of the United Mexican States, the Government of Japan decided to conduct a study on the Development Project of the Port of Manzanillo and entrusted the study to the Japan International Cooperation Agency (JICA). JICA sent to Mexico a study team headed by Dr. Kazuo Kudo, Adviser of the Overseas Coastal Area Development Institute of Japan, several times from September 1984 to October 1985.

The team exchanged views on the Project with the officials concerned of the Mexican Government, conducted field surveys and collected reference materials. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve to assist the development of Manzanillo Port and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to all the officials concerned of the Government of the United Mexican States for their close cooperation extended to the team.

November, 1985



Keisuke Arita

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

November 1985

Mr. Keisuke Arita
President
Japan International Cooperation Agency

Dear Mr. Arita:


It is my great pleasure to submit herewith a report on the Development Project of the Port of Manzanillo, the United Mexican States.

The Japanese study team, headed by myself, conducted a survey on the Project in Mexico for 45 days from September 17, 1984, at the request of the Japan International Cooperation Agency. The findings of this study were discussed to make the Master Plan and to study the feasibility of the Development Project of the Port of Manzanillo, and were then compiled into this report. The study shows that the Project is extremely important, so I hope the Project is executed promptly.

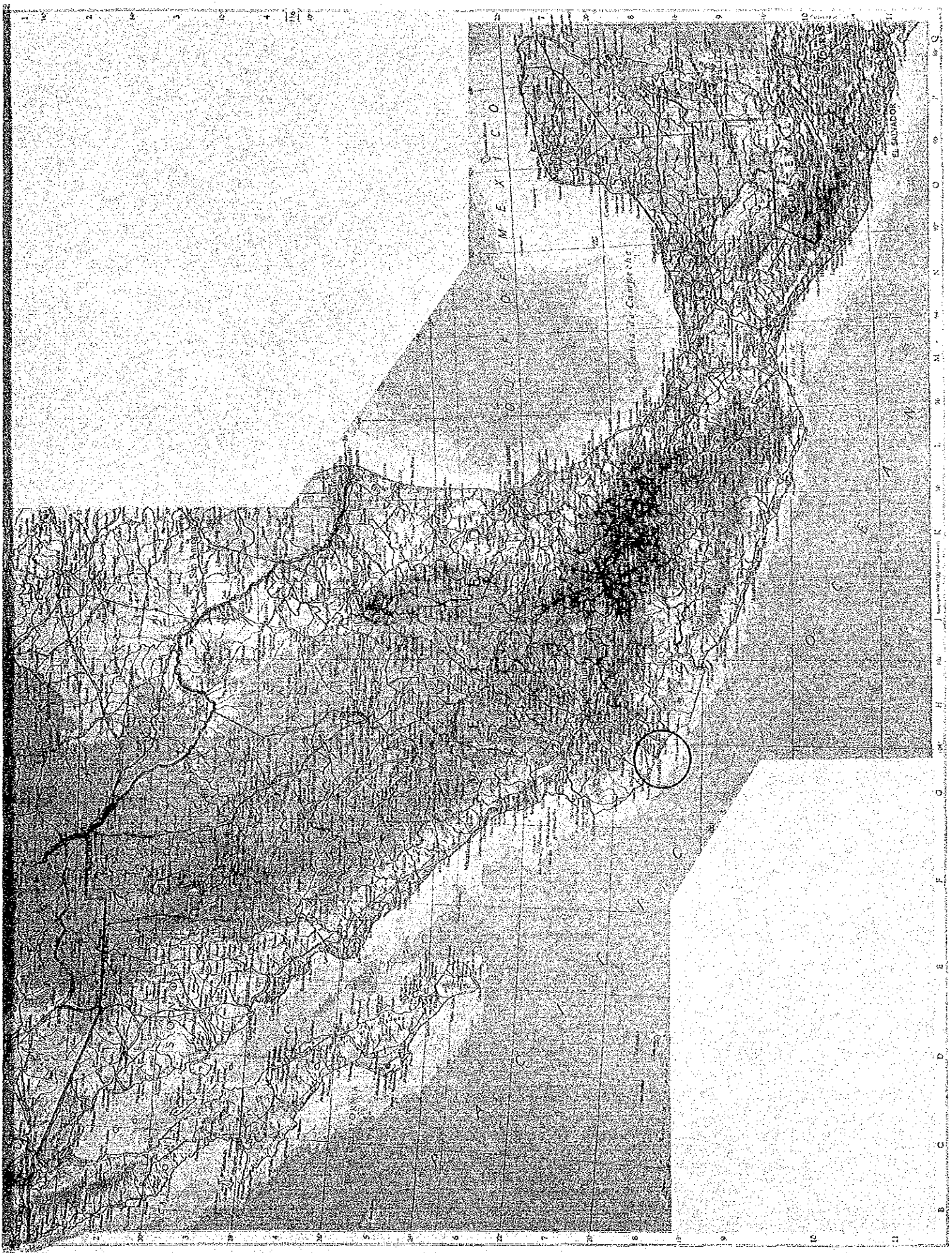
On behalf of the Japanese study team and myself, I would like to express my deepest appreciation to the Government of the United Mexican States and to the various organizations concerned with the Project for the unlimited cooperation and assistance, and the warm hospitality they extended to the team during our stay in Mexico.

I am also greatly indebted to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs and the Japanese Embassy in Mexico for giving us valuable suggestions and assistance during the field survey and the preparation of this report.

Sincerely yours,



Kazuo Kudo
Head
Japanese Study Team for the Development
Project of the Port of Manzanillo
(Adviser, the Overseas Coastal Area
Development Institute of Japan)



MEXICO

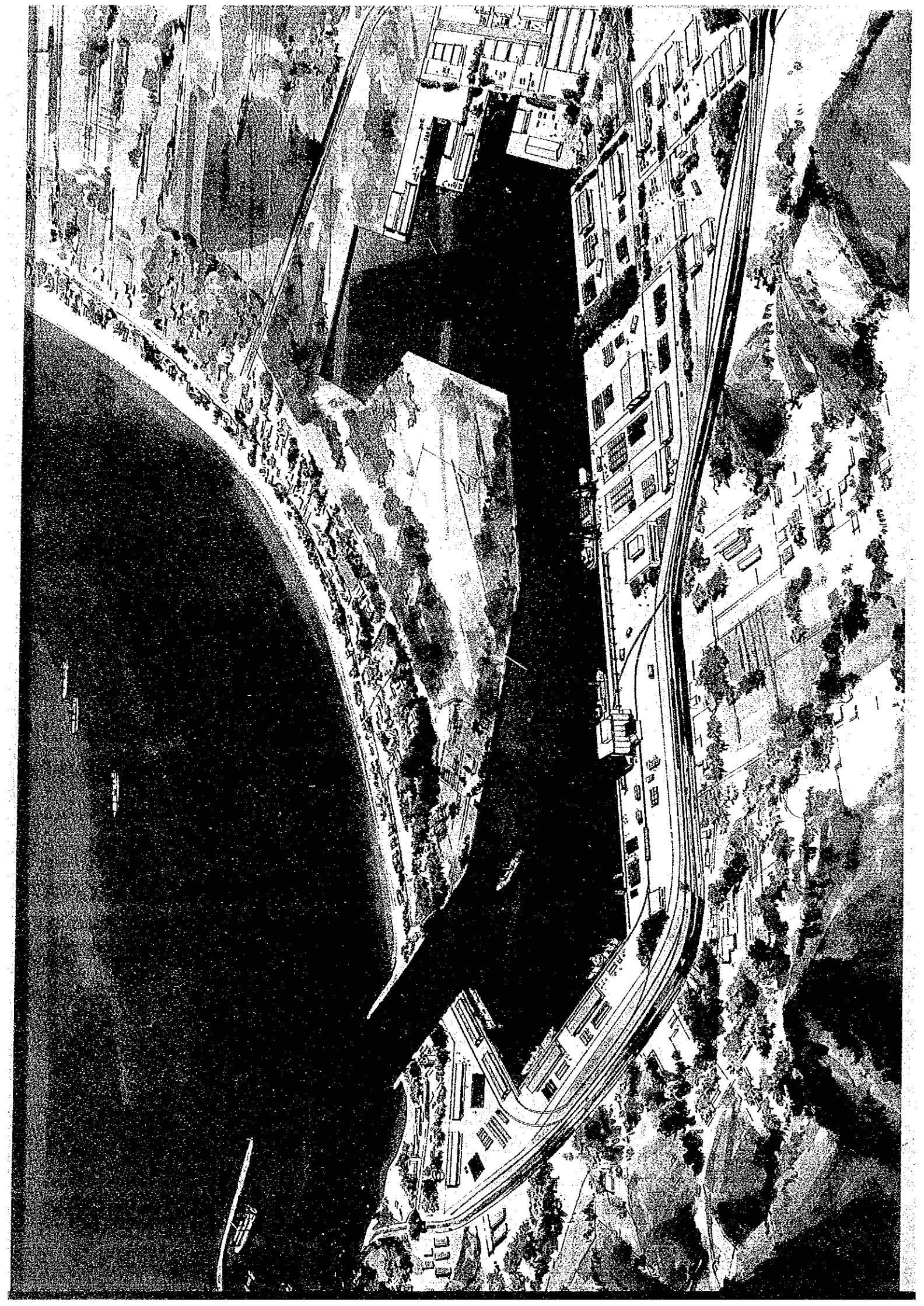
GUATEMALA

EL SALVADOR

GULF OF CENTRAL AMERICA

EL SALVADOR

11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11



EXCHANGE RATE

1U.S.\$ = 192 Pesos = 240 Japanese Yen

(As of December, 1984)

ABBREVIATIONS (Organizations)

CANACERO	Camara Nacional de Acero
CDX	Centro de Desarrollo de Exportaciones
CFE	Comisión Federal de Electricidad
CNCP	Comisión Nacional Coordinadora de Puertos
COCOMABA	Comisión de Conurbación de Manzanillo- Barra de Navidad Apartado
CONAPO	Consejo Nacional de Poblacion
CONASUPO	Compañía Nacional de Subsistencias
COPLADE	Comité de Planeación para el Desarrollo del Estado de Colima
DGODP	Dirección General de Operación y Desarrollo Portuario, SCT
DGOM	Dirección General de Obras Maritimas, SCT
FAO	Food and Agriculture Organization
FERTIMEX	Fertilizante de México
FONDEPORT	Fondo Nacional para los Desarrollos Portuarios
GCBS	General Council of British Shipping
IMCE	Instituto Mexicano de Comercio Exterior
IMSS	Instituto Mexicano del Seguro Social
ISSSTE	Instituto de Seguridad y Servicios Sociales para los Trabajadores del Estado
JETRO	Organización Oficial para el Intercambio Económico del Japón
JICA	Agencia de Cooperación Internacional del Japón
N de M	Ferrocarriles Nacionales de México
OCDI	Overseas Coastal Area Development Institute of Japan
OTCA	Overseas Technical Cooperation Agency (the present JICA)
PEMEX	Petroleos Mexicanos
PESCA	Secretaría de Pesca
SAHOP	Secretaría de Asentamientos Humanos y Obras Públicos
SARH	Secretaría de Agricultura y Recursos Hidráulicos
SEDUE	Secretaría de Desarrollo Urbano y Ecología
SHCP	Secretaría de Hacienda y Crédito Público
SCT	Secretaría de Comunicaciones y Transportes
SM	Servicios Médicos
SPP	Secretaría de Programación y Presupuesto
SS	Secretaría de Salud
TMM	Transportación Marítima Mexicana, S.A.
TRISMO	Secretaría de Turismo
UNAM	Universidad Autónoma de México
UNCTAD	United Nations Conference on Trade and Development

ABBREVIATIONS (Units)

mm	millimeter	A	ampere
m	meter	V	volt
km	kilometer	KV	kilovolt
"	inch	W	watt
', ft	foot/feet	KW	kilowatt
m ²	square meter	MW	megawatt
km ²	square kilometer	KVA	kilovolt-ampere
ha	hectare	MVA	megavolt-ampere
m ³	cubic meter	KWH	kilowatt-hour
ℓ	liter	T	wave period
kℓ	kiloliter	T _{1/3}	significant wave period
bls	barrels	H	wave height
g	gram	H _{1/3}	significant wave height
kg	kilogram	H.W.L.	high water level
t	ton, tonnage	L.W.L.	low water level
G/T	gross ton	L	length
DWT	dead weight ton	φ	diameter
sec	second	t	thickness
hr	hour		
mb	millibar		
°C	degrees centigrade		

CONTENTS

LIST OF FIGURES

LIST OF TABLES

CONCLUSIONS AND RECOMMENDATIONS

SUMMARY

	Page
CHAPTER I. INTRODUCTION	
1. Background and Objectives of the Study	1
1-1 Background	1
1-2 Objectives	1
2. Circumstances	1
3. Scope of the Study	2
4. Field Survey	3
4-1 Organization of the Study Team	3
4-2 Field Surveys	4
4-3 Counterparts	5
CHAPTER II. PRESENT SITUATION OF MEXICO	
1. Natural Conditions	7
1-1 Geography and Topography	7
1-2 Climate	11
2. Socio-Economic Conditions	14
2-1 Population	14
2-2 Economic Activities	19

	Page
2-3 Industrial Composition	21
2-4 Centralization	23
3. Transportation	24
3-1 General View of Cargo Movement	24
3-2 Roads	26
3-3 Railways	34
3-4 Ports and Shipping	40

CHAPTER III. PRESENT SITUATION AT THE PORT OF MANZANILLO

1. Natural Conditions	51
1-1 Topographical and Geological Features	51
1-2 Meteorological Conditions	56
1-3 Seismicity	59
1-4 Oceanographical Conditions	63
1-5 Soil Conditions	90
2. Manzanillo City	99
2-1 Population	99
2-2 Socio-Economic Activities	100
2-3 Transportation	103
2-4 Land use	105
2-5 Urban Facilities	107
3. Port Facilities	110
3-1 Commercial Port	110
3-2 Fishery Port	115
4. Cargo and Vessel Movement	117
4-1 Handling Volume and Commodities	117
4-2 Trading Counterparts and Vessel Movement	121
4-3 Cargo Flow in the Port Area	123

	Page
5. Administration and Operation	124
5-1 Administration	124
5-2 Operation	126
5-3 Port Dues	127
6. Fishery Activity	128
6-1 Fishery Production	128
6-2 Fishing Boats	131
6-3 Distribution of Fishery Products	133
6-4 Processing Facilities	133
7. Tourism	135
7-1 Tourists Visiting Manzanillo	135
7-2 Cruising Vessels	136

CHAPTER IV. BASIC CONCEPT FOR THE DEVELOPMENT

1. National and Regional Development Plan	139
1-1 National Plan	139
1-2 Regional Plans	140
2. Development Policy	143
2-1 Purpose of the Development	143
2-2 Role of Manzanillo Port	143
2-3 Development Strategy	144

CHAPTER V. SOCIO-ECONOMIC FRAME FOR DEMAND FORECAST

1. Hinterland of the Port	147
2. Future Socio-Economic Conditions	151
2-1 Socio-Economic Frame in the National Plan	151
2-2 Socio-Economic Frame for the Target Years	154

CHAPTER VI. DEMAND FORECAST

1. Commercial Port Cargo	157
1-1 Methodology	157
1-2 Macro Forecast	157
1-3 Micro Forecast	169
1-4 Cargo Forecast	222
2. Fish Catch	224
2-1 Methodology	224
2-2 Fish Catch of All Mexico	225
2-3 Landing Volume at Manzanillo Port	230
3. Tourists	232

CHAPTER VII. MASTER PLAN

1. Land Use	233
1-1 Planning Concepts	233
1-2 Industrial Location	233
1-3 Transportation	239
2. Scale of Port Facilities	244
2-1 Planning Concepts	244
2-2 Commercial Port	245
2-3 Fishery Port	281
2-4 Passenger Terminal and Marina	290
2-5 Harbour Facilities	294
3. Layout Plan	296
3-1 Outer Port	296
3-2 Inner Port	300
4. Other Facilities	305
4-1 Supply Facilities	305

	Page
4-2 Aids to Navigation	315
5. Environmental Aspect	317
5-1 General	317
5-2 Impact of Industries on the Environment	320
5-3 Environmental Protection Measures	321
5-4 Spread of Water Pollution	323
5-5 Measures in the Future	324
6. Design, Construction and Cost Estimate	326
6-1 Design	326
6-2 Construction	334
6-3 Cost Estimate	345

CHAPTER VIII. SHORT-TERM DEVELOPMENT PLAN

1. Purpose of the Short-term Development Plan	351
1-1 Basic Policy	351
1-2 Goals of the Short-term Plan	351
2. Site Selection	352
3. Scale of the Port Facilities	353
3-1 Commercial Port	353
3-2 Fishery Port	361
4. Alternative Options for the Short-term Plan	365
5. Short-term Development Plan	370

CHAPTER IX. ADMINISTRATION AND OPERATION

1. General	373
2. Present Situation and Problems	373
2-1 Present Situation	373
2-2 Present Administrative and Operational Problems	378

	Page
3. Administrative Recommendations	380
4. Proposed Operation System	382
4-1 Bulk Cargo Operation	382
4-2 Container Cargo Operation	382
4-3 Conventional General Cargo	386
4-4 Maintenance	387

CHAPTER X. DESIGN, CONSTRUCTION AND COST ESTIMATE

1. Design	389
1-1 Basic Premises	389
1-2 Design Conditions	389
1-3 Design of Main Port Facilities	391
2. Construction	395
2-1 Construction Quantities	395
2-2 Construction Procedure	395
3. Cost Estimate	399
3-1 Estimation Limit	399
3-2 Estimation Result	399

CHAPTER XI. ECONOMIC ANALYSIS

1. Purpose and Methodology of Economic Analysis	403
1-1 Purpose	403
1-2 Methodology	403
1-3 Alternative Case	403
1-4 Prerequisites to Economic Analysis	404
2. Benefits	405
2-1 Benefit Items	405
2-2 Reduction in Ship's Staying Cost	405
2-3 Reduction in Cargo Handling Costs	411

	Page
2-4 Reduction in Time Costs	412
2-5 Other Intangible Benefits	413
3. Costs	415
3-1 Construction Costs	415
3-2 Maintenance Costs	415
4. Shadow Pricing	419
4-1 Calculating Shadow Prices	419
4-2 Calculation of the Conversion Factors	420
4-3 Shadow Prices of Benefit Items	422
4-4 Shadow Prices of Cost Items	424
5. Economic Profitability	426
5-1 Definition of the Internal Rate of Return (IRR)	426
5-2 Calculation and Assessment of the Internal Rate of Return	426
6. Sensitivity Analysis	428
6-1 Identification of Cases	428
6-2 Result of the Sensitivity Analysis	428

CHAPTER XII. FINANCIAL ANALYSIS

1. Purpose and Methodology of Financial Analysis	431
1-1 Purpose	431
1-2 Methodology	431
1-3 Assumptions for Financial Analysis	431
2. Revenues	433
2-1 Revenue from Port Tariffs	433
2-2 Revenue from Stevedoring Charges and Storage Fees	433
3. Expenditures	438
3-1 Personnel and Others	438
3-2 Maintenance and Repair Costs	438

	Page
3-3 Depreciation Expense	438
3-4 Interest on Long-term Loans	438
4. Financial Situation	441
4-1 Evaluation by Financial Statements	441
4-2 Evaluation by Discount Cash Flow (DCF)	443
4-3 Conclusion	443
4-4 Financial Situation of Servicios Portuarios de Manzanillo, S.A. de C.V.	443
4-5 Balance of Revenues and Expenditures of the Passenger Terminal	445
5. Sensitivity Analysis	448
5-1 Identification of Cases	448
5-2 Result	448

APPENDIX

	Page
1. Detailed Soil Profile at the Port of Manzanillo	451
2. Construction and Cost Estimate for the Master Plan	463
3. Construction and Cost Estimate for the Short-Term Plan	466
4. Financial Statements for Financial Analysis	467

LIST OF TABLES

Table No.	Title	Page
Table II-1	Number of Cyclones (1960 ~ 1980).....	12
Table II-2	Population of Mexico	14
Table II-3	Population Density (1982)	15
Table II-4	Gross Domestic Product by Sector in Constant (1970) Prices	19
Table II-5	Growth Rate of GDP by Sector in Constant (1970) Prices	20
Table II-6	Balance of Foreign Account in Current Prices	21
Table II-7	Sectoral Composition of GDP (1970 prices).....	22
Table II-8	Labor Population by Sector	22
Table II-9	Composition of Employment	22
Table II-10	Socio-Economic Indices by District	23
Table II-11	Cargo Movement in Mexico	24
Table II-12	Cargo Movement for Foreign Trade	25
Table II-13	Share of Marine Transportation for Foreign Trade (percent of the national total)	25
Table II-14	Balance of Border Transactions	26
Table II-15	Constitution of the Road Network	27
Table II-16	Number of Registered Vehicles	31
Table II-17	Transportation Time by Road	32
Table II-18	Total Length and Rolling Stock of Mexican Railways (1)	34
Table II-19	Rolling Stock of Mexican Railways (2)	35
Table II-20	Transportation Time by Railway	36
Table II-21	Volume of Cargo Handled at the Mexican Ports	41
Table II-22	Volume of Export by Major Items	43
Table II-23	Volume of Import by Major Items	43
Table II-24	Cargo Volume other than Petroleum and its Derivatives.....	44
Table II-25	Trade Partners	45

Table No.	Title	Page
Table II-26	Number of Oceangoing Vessels	45
Table II-27	Container Cargo Handled at the Mexican Ports	46
Table II-28	Percent of Containerized Cargo	46
Table II-29	Container Cargo Volume by Major Ports in 1983	47
Table II-30	Cargo Volume other than Petroleum and its Derivatives at Pacific Coast Ports	48
Table II-31	Cargo Handling Volume at the Major Pacific Coast Ports (1983)	48
Table II-32	Cargo Volume Handled at the Six Major Pacific Ports by Commodity Type (1983)	50
Table III-1	Record of Main Earthquakes in Mexico and Guatemala	60
Table III-2	Tide at Manzanillo Port	64
Table III-3	Relation between Wave Height and Wave Period	70
Table III-4	Maximum Waves in Each Direction	71
Table III-5	Estimated Waves at Manzanillo Port	79
Table III-6	Major Tsunami at Manzanillo Port	87
Table III-7	List of Boring Data	92
Table III-8	Characteristics of Surface Layer	93
Table III-9	Characteristics of Sandy Soil Layer	96
Table III-10	Supply and Demand of Primary Agricultural Products in Colima State (1980)	101
Table III-11	Output of Salt in Cuyutlan Lagoon	102
Table III-12	Daily Scheduled Flights at Manzanillo International Airport	105
Table III-13	Present Conditions of Land Use in Colima State	105
Table III-14	Public Administrative Offices in Manzanillo	109
Table III-15	Mooring Facilities (Large Facilities)	112
Table III-16	Mooring Facilities (Small Facilities)	112
Table III-17	Other Port Facilities (Breakwater, Channel and Turning Basin)	113
Table III-18	Capacity of Main Storage Facilities	113
Table III-19	Principal Cargo Handling Machines	114

Table No.	Title	Page
Table III-20	Aids to Navigation	115
Table III-21	Volume of Cargo Handled at Manzanillo Port	117
Table III-22	Volume of Foreign Trade Cargo by Major Items	119
Table III-23	Volume of Domestic Trade Cargo by Major Items	119
Table III-24	Principal Commodities for Foreign Trade (1983)	120
Table III-25	Container Cargo at Manzanillo Port	120
Table III-26	Export and Import by Nation (1983)	121
Table III-27	Number of Vessels	122
Table III-28	Principal Port Services Provided at Manzanillo	126
Table III-29	Working Efficiency by Type of Cargo (1983)	126
Table III-30	Main Port Dues/Charges	127
Table III-31	Fishery Production by Region	128
Table III-32	Fishery Production by Office in Colima State (1981)	129
Table III-33	Fishery Production and Use by Zone (1981)	130
Table III-34	Fishery Production of Main Species in Zone I and Zone II (1981)	131
Table III-35	Fishing Boats by Region (1980)	131
Table III-36	Number of Fishing Boats by Region, Main Species and Method of Propulsion	132
Table III-37	Fishing Boats Registered in the Manzanillo Region	132
Table III-38	Facilities for Fishery Processing	133
Table III-39	Tourists Visiting Colima State	135
Table III-40	Number of Lodging Facilities	135
Table III-41	Cruising Vessels and Passengers Calling at Pacific Coast Ports	136
Table III-42	Characteristics of Vessels Moving along the Pacific Coast	137
Table IV-1	Area of Development and Type of Land Use in the Manzanillo Metropolitan Zone	141

Table No.	Title	Page
Table V-1	Origin and Destination of the Foreign Trade Cargo Passing through Manzanillo Port	148
Table V-2	Population Forecast	151
Table V-3	GDP Growth Rate Forecast	151
Table V-4	Important Economic Indicators	152
Table V-5	Change of GDP's Growth Rate by Industrial Sector	153
Table V-6	Forecast of Important Economic Indicators	154
Table V-7	Population Forecast	155
Table V-8	GDP Growth Rate Forecast	155
Table V-9	GDP Forecast	156
Table VI-1	Cargo Handling Volume at Manzanillo Port (Commodity)	158
Table VI-2	Cargo Handling Volume at Manzanillo Port (Package Type)	164
Table VI-3	Macro Forecast by Time Series Analysis	167
Table VI-4	Macro Forecast by Population and GDP Correlation	168
Table VI-5	Macro Forecast by GDP and Population Correlation	169
Table VI-6(a)	General Cargo Volume Handled at Manzanillo Port (Import)	170
Table VI-6(b)	General Cargo Volume Handled at Manzanillo Port (Export)	171
Table VI-6(c)	General Cargo Volume Handled at Manzanillo Port (Domestic Trade) ..	171
Table VI-7	Import of Agricultural Products	172
Table VI-8	Area, Yield and Production of Rice and Sugar Cane	172
Table VI-9	Per Capita Consumption of Rice	175
Table VI-10	Capita Consumption of Sugar	178
Table VI-11	Import of Forest Products	180
Table VI-12	Production, Consumption and Seaborne Trade of Crude Rubber	180
Table VI-13	Production Foreign Trade Cargo Volume and Consumption of Steel and Iron Products	182
Table VI-14	Production Capacity for Iron and Steel Products	183
Table VI-15	Present Coefficients	185
Table VI-16	Target Year Coefficients	185

Table No.	Title	Page
Table VI-17	Social and Economic Indices	186
Table VI-18	Handling Volume of Principal Commodities	187
Table VI-19	Other Products (Import)	189
Table VI-20	World Lead Production	190
Table VI-21	Other Products (Export)	193
Table VI-22	Baryta Production	194
Table VI-23	Ratio of the Cultivated Area for Each Crop to the Total Cultivated Area	198
Table VI-24	Cultivated Area of Each Crop	199
Table VI-25	Yield Rate of Each Crop	200
Table VI-26	Forecast Agricultural Production	200
Table VI-27(a)	Per Capita Consumption (Maize)	201
Table VI-27(b)	Per Capita Consumption (Wheat)	201
Table VI-27(c)	Per Capita Consumption (Sorghum)	202
Table VI-27(d)	Per Capita Consumption (Soybeans)	202
Table VI-28	Forecast Per Capita Consumption of Each Crop	204
Table VI-29	Demand Forecast of Each Crop	204
Table VI-30	Import Volume	204
Table VI-31	Total Import Volume Including Production Variation	206
Table VI-32	Share of Transportation	208
Table VI-33	Agricultural Bulk Cargo Volume Forecast	208
Table VI-34	Fertilizer Production Capacity	212
Table VI-35	Salt Handling Volume	213
Table VI-36	Volume of Container Cargo (All Mexican Ports)	216
Table VI-37	Ratio of Containerized Cargo to General Cargo	216
Table VI-38	Container Cargo Volume at Pacific Coast Ports	217
Table VI-39	General Cargo Handled at the Pacific Coast Ports (Export)	218
Table VI-40	General Cargo Handled at the Pacific Coast Ports (Import)	218

Table No.	Title	Page
Table VI-41	Containerizable Ratio	219
Table VI-42	Progress Rate of Containerization	220
Table VI-43	Cargo Forecast Summary	222
Table VI-44	Comparison of Macro and Micro Cargo Forecasts	223
Table VI-45	Quantity of Fish Catch	224
Table VI-46	Fish Utilization	225
Table VI-47	Forecast of Fish Catch by Method-A	227
Table VI-48	Fish Consumption and GDP Per Capita	228
Table VI-49	Forecast of Fish Catch by Method-B	229
Table VI-50	Forecast of Total Fish Catch of Mexico	230
Table VI-51	Dependence Rate of Manzanillo Port	231
Table VI-52	Forecast of Fish Catch at Manzanillo Port	231
Table VI-53	Forecast of Tourists of Colima State	232
Table VII-1	List of Selected Industries	237
Table VII-2	Forecast Traffic Volume by Transport Modes for Land Transport Cargoes in 2000	240
Table VII-3	Average Discharging/Loading Volume at Manzanillo Port	246
Table VII-4	Cargo Handling Capacity of the Port of Manzanillo	247
Table VII-5	Berth Occupancy Ratio	249
Table VII-6	Size of General Cargo Ships	255
Table VII-7	Liner Ships Calling at Manzanillo Port	255
Table VII-8	Dimensions of Proposed General Cargo Berths	256
Table VII-9	Berth Occupancy Ratio by Number of Berths	257
Table VII-10	Movement of General Cargo at Manzanillo Port	257
Table VII-11	Cargo Handling Share at Manzanillo Port in 2000	258
Table VII-12	Volume of Cargoes Passing through Storage Facilities and Storeyard in 2000	258
Table VII-13	Cargo Handling Equipment for General Cargo	260

Table No.	Title	Page
Table VII-14	Present Situation of Holding Ships for Foreign Trade in Mexico	262
Table VII-15	Characteristics of Full-container Ships in Japan	263
Table VII-16	Dimensions of Proposed Container Berth	263
Table VII-17	Cargo Handling Equipment for Container Cargo	266
Table VII-18	Size of Agricultural Bulk Cargo Carriers	269
Table VII-19	World Grain Carriers	269
Table VII-20	Specifications of CONASPO Grain Wharf at Lázaro Cárdenas Port	270
Table VII-21	Berth Occupancy Ratio by Number of Berths	271
Table VII-22	Movement of Grain in 2000	271
Table VII-23	Handling Equipment for Agricultural Bulk	272
Table VII-24	Dimensions of Proposed Mineral Bulk Berths	274
Table VII-25	Cargo Handling Equipment for Mineral Bulk	275
Table VII-26	Berth Occupancy Ratio by Number of Berths	276
Table VII-27	Volume of Cargoes Passing through Storage Facilities in 2000	277
Table VII-28	Two Simulation Test Cases	277
Table VII-29	Simulation Input Data	278
Table VII-30	Results of Simulation Tests	279
Table VII-31	Berths Proposed in the Master Plan	280
Table VII-32	Scale of Storage Facilities to be Newly Constructed	280
Table VII-33	Estimated Ship Size	282
Table VII-34	Relation between Number of Boats and Landing Volume	282
Table VII-35	Number of Fishing Boats and Landing Volume in 2000	283
Table VII-36	Landing Wharf Calculation	285
Table VII-37	Preparatory Wharf Calculation	285
Table VII-38	Rest Wharf Calculation	286
Table VII-39	Anchorage Basin	286
Table VII-40	Fishery Wharf	289

Table No.	Title	Page
Table VII-41	Proposed Functional Facilities for the Fishery Port	289
Table VII-42	Dimensions of the Touristic Berth at Muelle Fiscal	291
Table VII-43	Specification of Launches	292
Table VII-44	Total Oil Volume in 2000	314
Table VII-45	Aids to Navigation	315
Table VII-46	Environmental Impact during Construction	318
Table VII-47	Environmental Impact during Operations	319
Table VII-48	Estimates of Air Pollutants	320
Table VII-49	Estimates of Water Pollutants	321
Table VII-50	Required Air Quality Level (Daily Average)	322
Table VII-51	COD Level in the Future	323
Table VII-52	Fundamental Design Conditions	326
Table VII-53	Structural Comparison of Berths	328
Table VII-53	Port Facilities and Construction Quantities (Commercial Port)	335
Table VII-55	Main Construction Materials	339
Table VII-56	Construction Cost of the Typical Quay	340
Table VII-57	Construction Schedule	343
Table VII-58	Construction Costs (Commercial Port)	347
Table VII-59	Construction Cost of Each of the Facilities	348
Table VIII-1	Summary of Cargo Movement in 1990	353
Table VIII-2	Cargo Handling Efficiency in 1990	354
Table VIII-3	Berth Occupancy Ratio by Number of Berths	355
Table VIII-4	Berth Occupancy Ratio by Case and Number of Berths	356
Table VIII-5	Berth Occupancy Ratio by Number of Berths	356
Table VIII-6	Berth Occupancy Ratio by Number of Berths	357
Table VIII-7	Simulation Test Cases	358
Table VIII-8	Simulation Test Input Data	359
Table VIII-9	Simulation Test Results by Case	359

Table No.	Title	Page
Table VIII-10	Volume of Cargoes Passing through Storage Facilities and Storeyards in 1990	360
Table VIII-11	Scale of Storage Facilities to be Newly Constructed	361
Table VIII-12	Estimated Ship Size	361
Table VIII-13	Number of Fishing Boats and Landing Volume in 1990	362
Table VIII-14	Landing Wharf Calculation	362
Table VIII-15	Preparatory Wharf Calculation	363
Table VIII-16	Rest Wharf Calculation	363
Table VIII-17	Fishery Wharf	364
Table VIII-18	Proposed Functional Facilities for the Fishery Port	364
Table VIII-19	Items and Viewpoints of Evaluation	370
Table VIII-20	Evaluation of Alternative Plans	370
Table IX-1	Turn-around of Vessels	374
Table IX-2	Time Lost due to Unnecessary Interruptions (Manzanillo)	376
Table IX-3	Time Lost due to Unnecessary Interruptions (Average of major Mexican ports)	376
Table IX-4	Working Efficiency at the Port of Manzanillo	377
Table IX-5	Working Efficiency (Average of major Mexican ports)	377
Table IX-6	Causes of Time Lost at Manzanillo (1983)	378
Table IX-7	Cargo Handling Equipment for Bulk Cargo	382
Table IX-8	Cargo Handling Equipment for Container Cargo	386
Table IX-9	Cargo Handling Equipment for General Cargo	387
Table X-1	Basic Conditions	389
Table X-2	Port Facilities and Construction Quantities (Commercial Port)	396
Table X-3	Main Construction Materials	397
Table X-4	Construction Schedule	398
Table X-5	Construction Costs (Commercial Port)	399
Table X-6	Construction Cost of Each of the Facilities	400
Table X-7	Annual Investment at the Commercial Port	402

Table No.	Title	Page
Table XI-1	Total Staying Period (1990)	406
Table XI-2	Reduction in Staying Period	406
Table XI-3	Time Charterage of Dry Cargo Vessels	407
Table XI-4	Mexican Share in Dry Cargo by Commodity	409
Table XI-5	Benefit to the Mexican Economy from Reduction in Ships' Staying Cost	411
Table XI-6	Reduction in Cargo Handling Costs	412
Table XI-7	Reduction in Time Costs	413
Table XI-8	Yearly Allocation of Employment	414
Table XI-9	Construction Costs	416
Table XI-10	Purchase Costs for Cargo Handling Equipment	417
Table XI-11	Maintenance Costs	418
Table XI-12	Standard Conversion Factors (SCF) (exclusive of petroleum)	420
Table XI-13	Foreign Trade	421
Table XI-14	Reduction in Cargo Handling Costs (Shadow Price)	423
Table XI-15	Total Benefit to Mexico (Shadow Price)	423
Table XI-16	Construction Costs (Shadow Price)	424
Table XI-17	Maintenance Costs (Shadow Price)	425
Table XI-18	Total Cost (Shadow Price)	425
Table XI-19	Cost/Benefit and IRR (Shadow Price)	427
Table XI-20	Cost/Benefit and IRR (Shadow Price)-Alternative Case	429
Table XII-1	Tariff Rate	435
Table XII-2	Number of Ships	436
Table XII-3	Volume of Cargo Passing through Manzanillo Port	437
Table XII-4	Life Cycle and Depreciation Rate of Main Facilities	439
Table XII-5	Schedule of Long-term Loans	440
Table XII-6	Financial Ratios	442
Table XII-7	Cost/Benefit and FRR	444

Table No.	Title	Page
Table XII-8	Tariff Rates for the Passenger Terminal	445
Table XII-9	Life Cycle and Depreciation Rate	446
Table XII-10	Investments for the Passenger Terminal	446
Table XII-11	Balance of Revenues and Expenditures	447
Table XII-12	Cost/Benefit and FRR-Alternative Case	449

LIST OF FIGURES

Fig. No.	Title	Page
Fig. II-1	Topography of The Mexican States	8
Fig. II-2	Topographical Map of Colima State	10
Fig. II-3	Rough Classification of Climate	11
Fig. II-4	Courses of Cyclones in 1978	13
Fig. II-5	Population Growth	14
Fig. II-6	States and Districts of Mexico	16
Fig. II-7	Population Density	17
Fig. II-8	Population of Major Cities	18
Fig. II-9	Road Network	29
Fig. II-10	Traffic Volume on Main Roads in the Pacific Central Region	33
Fig. II-11	Railway Network	37
Fig. II-12	Traffic Volume on the Main Railways	39
Fig. II-13	Locations of Major Ports	40
Fig. II-14	Cargo Volume Handled at the Mexican Ports	42
Fig. II-15	Foreign Cargo Handling Volume other than Petroleum and its Derivatives at the Six Major Pacific Coast Ports	49
Fig. III-1	Topographical Map of Manzanillo	52
Fig. III-2	Topographical Map of the Inner and Outer Port	54
Fig. III-3	Geological Map of Manzanillo	55
Fig. III-4	Wind Diagram	56
Fig. III-5	Temperature and Precipitation at Manzanillo and Mexico City	57
Fig. III-6	Distribution of Rainfall and Temperature in Colima	58
Fig. III-7	Seismicity of Mexico	61
Fig. III-8	Rough Zoning of Earthquake Probability in Mexico	61
Fig. III-9	Damping of Maximum Horizontal Acceleration	62
Fig. III-10	Distribution of Main Earthquakes around Manznaillo	63

Fig. No.	Title	Page
Fig. III-11(a)	Predominating Currents in December, January and February	65
Fig. III-11(b)	Predominating Currents in March, April and May	65
Fig. III-11(c)	Predominating Currents in June, July and August	66
Fig. III-11(d)	Predominating Currents in September, October and November	66
Fig. III-12(a)	Wave Height Rose	68
Fig. III-12(b)	Wave Height Rose	69
Fig. III-13	Course of the Hurricane "Norman" and the Calculated Area	72
Fig. III-14(a)	Distribution of Wave Heights ("Norman")	73
Fig. III-14(b)	Distribution of Wave Heights ("Norman")	73
Fig. III-14(c)	Distribution of Wave Heights ("Norman")	74
Fig. III-15	Distribution of Wave Periods ("Norman")	74
Fig. III-16(a)	Distribution of Wave Directions ("Norman")	75
Fig. III-16(b)	Distribution of Wave Directions ("Norman")	75
Fig. III-17	Wave Heights and Periods Versus Time ("Norman": Wind Waves)	76
Fig. III-18	Wave Heights and Periods Versus Time ("Norman": Swells)	77
Fig. III-19	Bathymetric Contour of Manzanillo Bay	78
Fig. III-20	Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (WNW)	80
Fig. III-21	Calculated Wave Direction (WNW)	80
Fig. III-22(a)	Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (S)	81
Fig. III-22(b)	Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (SW)	81
Fig. III-23(a)	Calculated Wave Direction (S)	82
Fig. III-23(b)	Calculated Wave Direction (SW)	82
Fig. III-24	Calmness in the Inner Port	83
Fig. III-25	Water Surface Changes by the Wind-Induced Surface Current	84
Fig. III-26(a)	Wave Refraction at Manzanillo Bay	86
Fig. III-26(b)	Wave Refraction at Manzanillo Bay	86

Fig. No.	Title	Page
Fig. III-27	Wave Records of Tsunami	88
Fig. III-28	Probability of Tsunami Occurrence	89
Fig. III-29	Location of Borings	91
Fig. III-30	Boring Sections	94
Fig. III-31	Soil Profile, Section ①-①	95
Fig. III-32	Typical Soil Conditions in San Pedrito Lagoon	97
Fig. III-33	Distribution of Population (1981)	99
Fig. III-34	Sectoral Distribution of Economic Activity (By Number of Workers)	100
Fig. III-35	Distribution of Mineral Resources in Colima State	102
Fig. III-36	Existing Transportation Network in Colima State	104
Fig. III-37	Present Condition of Land Use around Manzanillo	106
Fig. III-38	Existing Port Facilities in the Port of Manzanillo	111
Fig. III-39	Aids to Navigation in Manzanillo Port	116
Fig. III-40	Cargo Handling Volume at Manzanillo Port	118
Fig. III-41	Modal Split of Cargo Traffic	123
Fig. III-42	Organizational Chart of "Servicios Portuarios de Manzanillo S.A. de C.V."	125
Fig. III-43	Fishery Sea Areas in Mexico	130
Fig. III-44	Transportation Share of Fishery Products	134
Fig. III-45	Operation Diagram of Four Cruising Vessels	138
Fig. IV-1	Land Use Plan in the Manzanillo Metropolitan Zone in 2000	142
Fig. V-1	Share of Export Cargo Volume Handled at the Port of Manzanillo by Origin	149
Fig. V-2	Share of Import Cargo Volume Handled at the Port of Manzanillo by Destination	149
Fig. V-3	Share of Total Foreign Trade Cargo Volume Handled at the Port of Manzanillo	150
Fig. V-4	Hinterland and Influence Area of the Port of Manzanillo	150
Fig. V-5	Monthly Change of Consumer Price Index	153

Fig. No.	Title	Page
Fig. VI-1(a)	Cargo Handling Volume at Manzanillo Port [Import-1]	161
Fig. VI-1(b)	Cargo Handling Volume at Manzanillo Port [Import-2]	161
Fig. VI-1(c)	Cargo Handling Volume at Manzanillo Port [Import-3]	162
Fig. VI-2(a)	Cargo Handling Volume at Manzanillo Port [Export-1]	162
Fig. VI-2(b)	Cargo Handling Volume at Manzanillo Port [Export-2]	163
Fig. VI-3	Cargo Handling Volume at Manzanillo Port [Domestic Trade]	163
Fig. VI-4	Cargo Handling Volume at Manzanillo Port by Package Type [Total]	165
Fig. VI-5	Cargo Forecast by Time Series Analysis	166
Fig. VI-6	Relation between Total Cargo Volume Handled at Manzanillo Port and GDP	168
Fig. VI-7	Harvest Area of Rice	173
Fig. VI-8	Yield Rate of Rice	174
Fig. VI-9	Per Capita Consumption of Rice	175
Fig. VI-10	Harvest Area of Sugar Cane	177
Fig. VI-11	Yield Rate of Sugar Cane	177
Fig. VI-12	Per Capita Consumption of Sugar	179
Fig. VI-13	Relation between Crude Rubber Import Volume and GDP	181
Fig. VI-14	Relation between Iron and Steel Product Consumption Volume and GDP	183
Fig. VI-15	Relation between Machinery Import Volume at Manzanillo Port and GDP	188
Fig. VI-16	Production and Export of Lead	190
Fig. VI-17	Production and Export of Zinc	191
Fig. VI-18	World Production of Zinc	191
Fig. VI-19	Relation between Chemical Goods Export and GDP	192
Fig. VI-20	Production of Baryta	194
Fig. VI-21	Methodology of Agricultural Bulk Cargo Volume Forecast	196

Fig. No.	Title	Page
Fig. VI-22	Cultivated Area	197
Fig. VI-23	Cultivated Area Ratio to the Total Cultivated Area	198
Fig. VI-24(a)	Yield Rate of Maize	199
Fig. VI-24(b)	Yield Rate of Wheat	199
Fig. VI-24(c)	Yield Rate of Sorghum	200
Fig. VI-24(d)	Yield Rate of Soybeans	200
Fig. VI-25(a)	Per Capita Consumption (Maize)	203
Fig. VI-25(b)	Per Capita Consumption (Wheat)	203
Fig. VI-25(c)	Per Capita consumption (Sorghum)	203
Fig. VI-25(d)	Per Capita Consumption (Soybeans)	203
Fig. VI-26	Yearly Variation of Principal Grain Production	205
Fig. VI-27	Statistical Distribution of Deviation	206
Fig. VI-28	Fertilizer Consumption per Unit Area	210
Fig. VI-29	Total Fertilizer Consumption	211
Fig. VI-30	Relation between Caustic Soda Production and GDP	214
Fig. VI-31	Containerized Ratio at Manzanillo and Lázaro Cárderas Ports	219
Fig. VI-32(a)	Progress Rate of Containerization (Export)	221
Fig. VI-32(b)	Progress Rate of Containerization (Import)	221
Fig. VI-33	Direct Consumption	226
Fig. VI-34	Relation between Industrial Use and GDP	227
Fig. VII-1	Centers for Industrial Development	236
Fig. VII-2	Typical Cross Section of the Main Roads	242
Fig. VII-3	Erlung Distribution	250
Fig. VII-4(a)	Flow Chart of the Simulation Model	251
Fig. VII-4(b)	Flow Chart of Ship's Arrival	252
Fig. VII-5	Relation between Mooring Period and Number of Ships (General Cargo Carriers, 1983)	253
Fig. VII-6	Flow Chart for Determining Number of Berths	254

Fig. No.	Title	Page
Fig. VII-7	Throughput of Indirect Cargo and Handling Equipment	261
Fig. VII-8	Layout of Container Terminal	265
Fig. VII-9(a)	Container Gantry Crane	267
Fig. VII-9(b)	Straddle Carrier	268
Fig. VII-10	Layout of Silos	272
Fig. VII-11	Cargo Flow in the Port Area	272
Fig. VII-12	Flow Chart of Grain Silo System	273
Fig. VII-13	Method of Determining the Standard Day	281
Fig. VII-14	Fishing Boat Tonnage – Length	284
Fig. VII-15	Fishing Boat Tonnage – Width	284
Fig. VII-16	Fishing Boat Tonnage – Wharf Water Depth	284
Fig. VII-17	Parking Lot Plan	289
Fig. VII-18	Ship Size of Present Cruising Vessels	290
Fig. VII-19	Study Zones of Harbor Facilities Plan	294
Fig. VII-20	Cross Sections in the Promenade/Seawall	297
Fig. VII-21	Master Plan of the Outer Port	298
Fig. VII-22	Image Sketches of the Outer Port	299
Fig. VII-23	Concept of the Commercial Port Facilities Lyaout	301
Fig. VII-24	Fishery Port Facilities Layout	302
Fig. VII-25	Master Plan of the Inner Port	303
Fig. VII-26	Main Water Supply Network	308
Fig. VII-27	Main Drain Network	310
Fig. VII-28	Main Electric Supply Network	313
Fig. VII-29	Aids to Navigation in 2000	316
Fig. VII-30(a)	Spread of Water Pollution (1)	325
Fig. VII-30(b)	Spread of Water Pollution (2)	325
Fig. VII-31	Soil Conditions	327

Fig. No.	Title	Page
Fig. VII-32	Mineral Bulk and Grain Berths (Alternative A)	330
Fig. VII-33	Mineral Bulk and Grain Berths (Alternative B)	331
Fig. VII-34	Container Berth (Alternative C)	332
Fig. VII-35	Container Berth (Alternative D)	333
Fig. VII-36	Water Depth in the Inner Port	337
Fig. VII-37	Construction Procedure of the Quay	341
Fig. VIII-1	Alternative Short-term Plan A	366
Fig. VIII-2	Alternative Short-term Plan B	367
Fig. VIII-3	Alternative Short-term Plan C	368
Fig. VIII-4	Fishery Port Facilities Layout in 1990	369
Fig. VIII-5	Short-term Development Plan	372
Fig. IX-1	Container Flow	384
Fig. X-1	Soil Conditions	390
Fig. X-2	Grain Berth	393
Fig. X-3	Container and General Cargo Berth	394
Fig. XI-1	Average Time Charterage of Dry Cargo Vessels	408

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

1. Necessity for the Development of the Port of Manzanillo

The economy of the United Mexican States grew favorably from 1976 to 1981 as shown by the 4% ~ 9% annual growth rate in the GDP. However, from the middle of 1981 through 1983 Mexico entered into an economic crisis, and consequently the annual GDP growth rate became negative.

Since 1983, however, the Mexican economy has recovered to some extent. Owing to the government efforts, overall economic and social activities have been returning to the line indicated in the "Plan Nacional de Desarrollo 1983 ~ 1988".

Since the GDP of Mexico is highly dependant on future oil prices, long range GDP forecasts are inevitably somewhat uncertain.

Mexico suffers from an extreme concentration of population, commerce, and industry in the central region around Mexico City. The Mexican government has been promoting a more balanced development through decentralization of population and commercial and industrial activities based on regional development plans.

One of the best ways to achieve further regional development is creating new productive centers along the coasts. The regional development of the Manzanillo area triggered by the development of Manzanillo Port will play an important role in this policy.

Overall, a comprehensive development plan for the port of Manzanillo should be considered, and adequate and timely action should be taken by the government.

2. Master Plan

The Master Plan is formulated with a target year of 2000. The cargo volume expected for the port of Manzanillo in the target year is estimated as about 3,000,000 tons considering national and regional long term development plans, and the trends of the socio-economic activities in the Port's hinterland including Guadalajara and in the Port's influence area including Mexico City.

To meet the projected increase in cargo movement, the Master Plan proposes twelve berths (seven new berths and five existing berths), on the assumption that existing commercial activities in the outer port will be transferred to the inner port. Five of these berths are for general cargo (three 12m deep, two 11m deep), one for container cargo (13m), two for agricultural bulk (13m), two for mineral bulk (13m and 12m), and two for domestic trade (11m and 9m). Further, related on-shore storage facilities will be constructed in the form of warehouses and transit sheds. Additionally, the plan provides a container yard with two gantry cranes and a container freight station.

The construction cost is roughly estimated at about 19.9 billion pesos (prices as of the end of 1984).

The plan also includes provisions for the construction of fishery port facilities, a related

processing-marketing complex, and an industrial park. Further, it provides some space which is reserved for the future expansion of port facilities.

Naturally, the development of ports must take place in conjunction with urban development plans. In the case of Manzanillo, the proposed port development, namely shifting commercial activities from the outer to the inner port and creating a pleasant waterfront area centering on the rehabilitated pier for cruising vessels, is consistent with the municipal policy regarding the development of the port.

3. Short-term Development Plan

The Short-term Development Plan is aimed at the year 1990, and covers the construction and improvement of port facilities which are considered urgently needed. The estimated cargo volume for 1990, on the basis of which the Short-term Plan is formulated, is about 2,300,000 tons.

Facilities to be newly constructed under the Short-term Development Plan include two berths for agricultural bulk (12m deep), and one berth for container and general cargo (12m). Related cargo handling equipment and facilities include one gantry crane for container cargo and two warehouses.

The construction cost is estimated at about 6.3 billion pesos (prices as of the end of 1984) including the cost of related facilities in the port area such as port roads and railways. About 2.3 billion pesos of the cost, approximately 36%, will come from foreign loans. The construction period is about five years.

Commercial port activities which presently take place in the outer port will gradually be shifted to the inner port in accordance with the port development plan.

In view of the topographical conditions of the inner port, with its single entrance, due consideration shall be paid to maintaining good water quality. To this aim, a scheme to control the discharge of waste water into the port area, including installation of sewerage treatment plants, shall be introduced.

4. Economic and Financial Analyses of the Short-term Development Plan

(1) Economic Analysis

The Short-term Development Plan is evaluated using the Internal Rate of Return (IRR) which is calculated based on cost-benefit analysis from the viewpoint of the national economy. Benefits considered are the reductions, in ships' staying cost, cargo handling cost, and time cost, while costs are the construction, maintenance and administrative costs. The internal rate of return, using 30 years as the period of economic calculation, is 16.04%. This shows that the Short-term Development Plan is advantageous from the viewpoint of the national economy.

(2) Financial Analysis

The port finances are analyzed using projected financial statement from the standpoint

of the port management body, that is the financial situation of the project authority in the event the project is executed. The profitability of the project itself is analyzed based on the Financial Rate of Return (FRR) using the Discount Cash Flow Method. Domestic funds are assumed to come from government funds, and foreign funds from soft loans (annual interest rate: 4.75%, term of repayment: 25 years, grace period: 7 years). Revenues are assumed as port dues, wharfages and stevedoring charges according to the current Mexican tariffs.

The analysis shows that the body will maintain its financial viability throughout the entire period of the project life, including the construction period. The port body will be able to pay all expenditures and will have a surplus even after appropriating funds for the repayment of the foreign loans including interest. As to the profitability of the project itself, a FRR of 7.21% can be expected. This well exceeds the weighted average interest rate of the procured funds (1.2%).

Judging from the above, it is concluded that the Short-term Development Plan with the target year of 1990 is feasible both economically and financially.

Concerning the financial feasibility of converting the outer port from a commercial port to a touristic port, analysis shows that the financial break-evenpoint is port calls of about 100 cruising vessels per year.

RECOMMENDATIONS

Planning, fund raising, detailed design and construction for this project will hereafter be conducted in accordance with the plans presented in this report. The recommendations below concern various matters we noticed while conducting this survey and drafting the plans.

1. The cargo volume at the port of Manzanillo is expected to increase along with the development of national and local economic activities. On the other hand, as the existing port facilities are not satisfactory, the existing commercial functions in the outer port should be transferred to the inner port to spur local economic development. Thus, it is important to implement this plan at the earliest possible time.
2. The Master Plan (target year 2000) was formulated based on the socio-economic frame of the "Plan Nacional de Desarrollo 1983 ~ 1988".
However, the economy is subject to constant flux, and the demand at the Port is greatly influenced by changes in the domestic and world economy. Before implementation, the Master Plan should be reviewed considering current regional and national economic development.
3. Ports cannot function efficiently only by the construction of mooring, storage and other physical facilities. The development of various port controlling and operating systems is also essential.
Based on the site investigation and interviews, various deficiencies were pointed out including the lack of proper handling equipment, and inadequate use of storage facilities. The single most important item, however, is the large amount of time loss due to unnecessary interruptions of cargo handling operations.
In order to overcome such deficiencies, recommendations presented in this report should be implemented, and then an additional in-depth study should be carried out focusing on the further improvement of port operations.
4. The following proposals mentioned in this report must be fully implemented in order to ensure safe and smooth port operations:
 - ① To secure the proposed width of the entrance channel
 - ② To secure the proposed distance between the wharf face of the container terminal and the planned reclamation line of the Naval Base.
 - ③ To remove immediately the shoal which is located near the entrance channel in the anchorage.
5. To complete the plan, it will be necessary to take care of following matters when executing the detailed design:
 - ① The number and the depth of bore holes are not sufficient for the detailed structural design of main facilities and the study of the base soil stability. A more detailed

boring survey is needed at the locations where the main structures and facilities are planned.

② When the dredged sand is used for the reclamation of the wharf, the possibility of liquefaction must be considered, based on the obtained soil data.

An appropriate survey and study will be necessary.

③ When reconstructing the old wharf at the outer port as the terminal for crusing vessels, surveys of the soil conditions and of the conditions of the piles and steel bars will be necessary to determine the extent of the rehabilitation work.

6. To complete the project effectively, the following additional works will be necessary:

① Reconfirm the relation between port and city development plans

② Establish control over the disposal of waste water into the port area and construct sewage treatment plants

③ Adjust the access road and railway

④ Survey water resources to ensure a sufficient water supply for the industrial and seafood products industrial zones

⑤ Relocate the distribution facilities of PEMEX to the suburbs of Manzanillo City

SUMMARY

CHAPTER I INTRODUCTION

1. Background

The economy of the United Mexican States grew favorably from 1976 to 1981 as shown by the 4% ~ 9% annual growth rate in the GDP. This growth was mainly due to increased exports of petroleum and industrial products.

From the middle of 1981 through 1983 the Mexican economy stagnated. Mexico entered into an economic crisis, and consequently the annual GDP growth rate became negative.

Since 1983, however, the Mexican economy has recovered to some extent. The rate of inflation has dropped, employment has increased, and the GDP has been growing. Overall, economic and social activities have been expanding under "Plan Nacional de Desarrollo 1983 ~ 1988."

Mexico suffers from an extreme concentration of population, commerce, and industry in the central region around Mexico City. The Mexican government has been promoting a more balanced development through decentralization of population and commercial and industrial activities based on regional development plans.

One of the best ways to further regional development is by creating new productive centers along the coasts. The regional development of the Manzanillo area based on Manzanillo Port plays an important role in this policy.

2. Objectives

This study aims at formulating a Master Plan of the port of Manzanillo with a target year 2000, as well as preparing a Short-term Development Plan of the Port up to 1990, including a feasibility study.

CHAPTER II PRESENT SITUATION OF MEXICO

1. Natural Conditions

1-1 Geography and Topography

Mexico is mountainous, and more than 50% of the total area is highland from 1500m to 2000m in altitude. Almost 71% of the land lies above 400m above sea level, and the main portion of Mexico's administration, economy, culture and industry are located in the plateaus. Mexico's mountains are bounded by narrow plains along the coasts. Manzanillo lies in the central portion of the Pacific coastline in the state of Colima. This area is within the belt of high volcanic activity which surrounds the Pacific.

In the state of Colima, highlands approach the coastline and form narrow coastal plains, and there are few suitable areas for ports. Manzanillo is one of most suitable areas. It has good bays, Manzanillo and Santiago Bays, and lagoons, the San Pedrito and Cuyutlan which can be developed as port and industrial areas.

1-2 Climate

The climate of Mexico is diversified. This wide variety is due not only to latitudinal differences but also to varied altitude.

The principal characteristics of the climate are listed below.

- ① There is a wide variety of vegetation
- ② Climatic differences influence human activity, and as a result, population is concentrated on the plateaus.
- ③ The coastal area from Mazatlan to the southern border of the Pacific coast, which is classified as tropical savanna, has a dry and a rainy season.
- ④ Cyclones appear in summer and autumn.

2. Socio-Economic Conditions

The population of Mexico grew at an annual rate of about 3% from 1950 to 1980, and reached 67 million in 1980. The explosive increase in population, however, induced serious social and economic problems such as over-crowding, insufficient housing, and poor supply-demand adjustment.

In addition, due to the topographic and climatic conditions of Mexico as well as to historical trends, the population is concentrated in the central regions, especially in the urban areas. For reference, Fig.-1 shows the location and population of major cities.

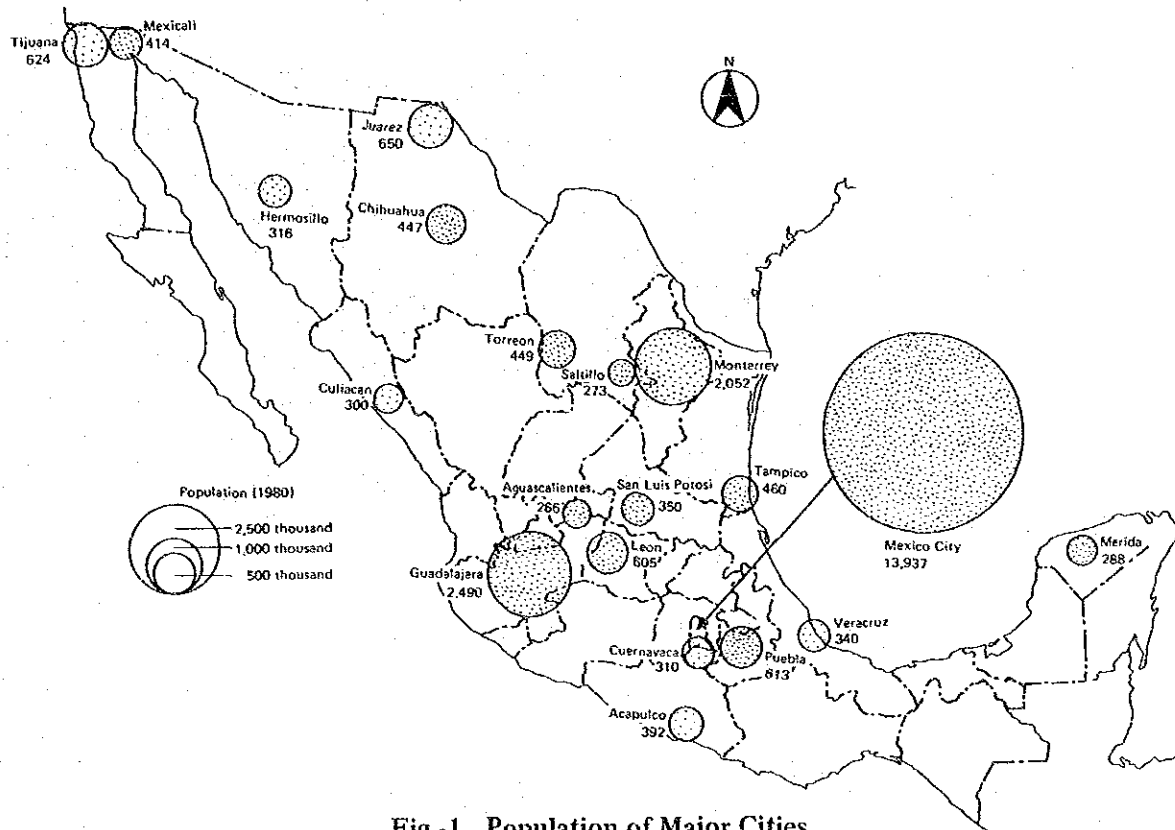


Fig.-1 Population of Major Cities
(in thousands)

Thanks to rich oil resources, Mexico maintained a high level of economic growth, with an annual GDP growth rate of over 8% from 1978 through 1981, as shown in Table-1. However, the GDP became negative in 1982 and 1983 because of decreased oil demand, and the resultant decreased export income seriously impeded Mexico's economic growth. In 1984 a gradual recovery of economic activities took place, and the growth is expected to become positive.

Economic activities are also concentrated in central Mexico. Table-2 shows that in 1980 34.4% of the population and 41.6% of the GDP are concentrated in the central area which represents only 4.4% of the total land area of Mexico. In order to prevent excessive concentration, the Mexican government is aggressively promoting decentralization.

Table-1 Gross Domestic Product by Sector in Constant (1970) Prices

(Unit: '000,000 pesos)

Sector	1976	1977	1978	1979	1980	1981	1982	1983
Total (Annual growth rate)	635,831 +4.2	657,721 +3.4	711,982 +8.3	777,163 +9.1	841,855 +8.3	908,765 +7.9	903,839 -0.6	861,769 -4.7
Agriculture, Forestry, Fishery	63,359	68,122	72,200	70,692	75,704	80,299	79,822	82,552
Mining	15,881	17,084	19,525	22,397	27,391	31,593	34,498	33,743
Manufacturing	155,517	161,037	176,816	195,614	209,682	224,326	217,852	201,937
Construction	34,310	32,494	36,532	41,297	46,379	51,852	49,259	42,196
Electricity	9,242	9,941	10,724	11,830	12,594	13,647	14,554	14,743
Transport, Communication	39,848	42,479	47,780	55,199	62,970	69,710	67,086	64,433
Commerce, Hotel, Restaurant	163,071	165,943	179,045	200,006	216,174	234,491	230,032	210,301
Other Service	154,603	160,621	169,360	180,128	190,961	202,847	210,736	211,864

Source: SPP, "Sistema de Cuentas Nacionales de México"

Table-2 Socio-Economic Indices by District

(Unit: %)

District	Area	Population	GDP				Commerce
			Agriculture	Manufacturing	Service	Total	
North-West	21.0	8.2	18.2	4.4	8.6	8.3	10.8
North	26.5	6.9	11.6	6.1	6.5	7.2	7.7
North-East	7.4	6.5	6.7	12.2	8.5	9.4	9.1
Central-North	7.2	4.9	5.3	1.9	2.5	2.7	2.3
Central-West	12.9	20.2	25.5	13.1	14.4	15.4	12.9
Center	4.4	34.4	14.1	53.9	49.4	41.6	48.2
South	13.5	16.4	16.3	7.2	7.8	13.2	7.2
Peninsula	7.1	2.5	2.3	1.2	2.3	2.2	1.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Colima, Jalisco Aguascalientes	4.7	7.6	11.1	7.6	7.2	7.8	7.7

Source: SPP, "Sistema de Cuentas Nacionales de México"

3. Transportation

The total freight volume of Mexico reached about 488 million tons in 1983, and the modal split of cargo traffic in 1983 is 57.0% by road, 12.7% by railway and 30.3% by ship. For foreign trade, the share of marine transportation is especially high. Marine transportation accounts for about 65% of import, 95% of export and 90% of total foreign trade.

As for roads, the road network linking the principal cities in the central region and the highway running longitudinally from the border of U.S.A. to the central region are well developed, but there are few roads running horizontally across Mexico. On the other hand, the existing railway network is also well developed with numerous arteries which connect the

principal cities of the central region with U.S.A. as its main frame.

As for marine transportation, 148 million tons of cargoes which include 103 million tons of foreign trade were handled in 1983. Fig-2 shows the volume of cargo handled during the last eight years. The main shipping cargoes are petroleum and its derivatives (78% of total tonnage in 1983) and agricultural and mineral bulk cargoes (16%).

In 1983, the Pacific coast ports handled about 41 million tons of cargo, 27.8% of the national total, of which 15.6 million tons were for foreign trade and 25.5 million tons were for domestic trade. There are six major ports on the Pacific coast. These six major ports handled most of the foreign and domestic cargoes other than salt. Fig.-3 shows the foreign cargo handling volume other than petroleum and its derivatives at the six major Pacific coast ports from 1978 to 1983.

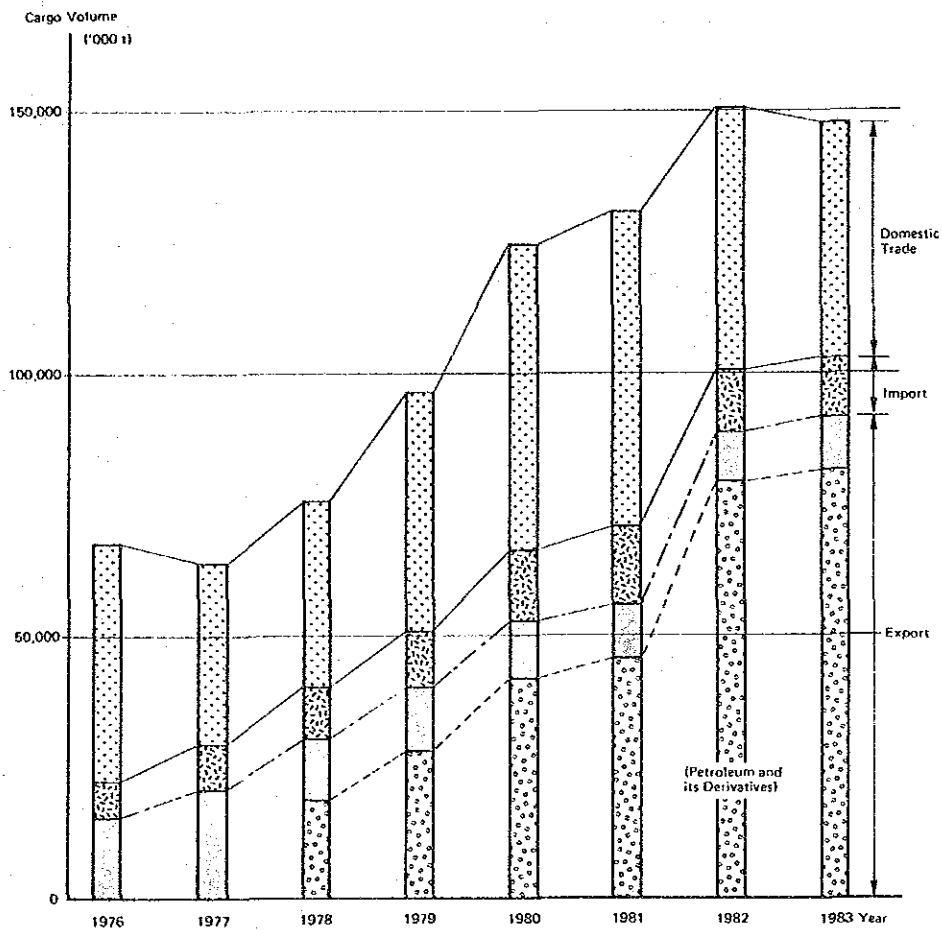


Fig.-2 Cargo Volume Handled at the Mexican Ports

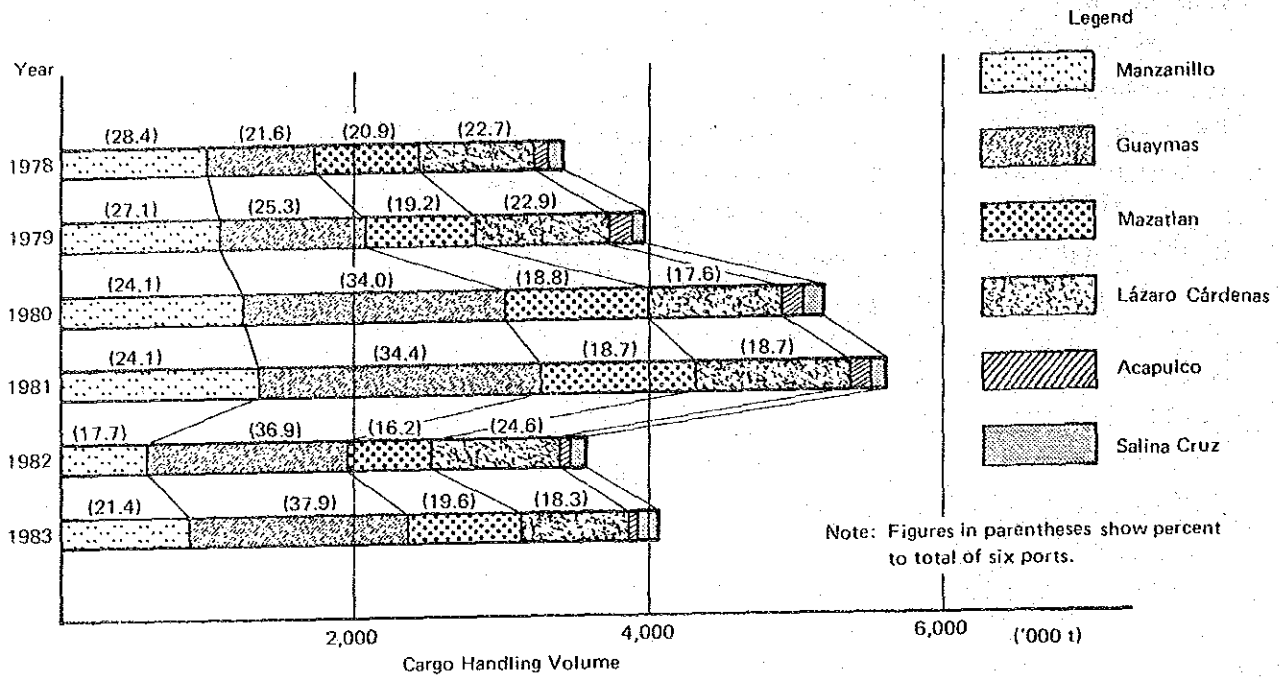


Fig.-3 Foreign Cargo Handling Volume other Petroleum and its Derivatives at the Six Major Pacific Coast Ports

CHAPTER III PRESENT SITUATION OF THE PORT OF MANZANILLO

1. Natural Conditions

1-1 Topographical and Geological Features

1-1-1 Topography and Geography

In and around the port of Manzanillo, the coastal plains under 20 m in altitude are not large, and the naturally benign areas are narrow and restricted. Steeply sloped hills and highlands lie behind the narrow plain areas.

The urban portion of Manzanillo lies on a slope backed by hills on a peninsula between Manzanillo Bay and Cuyutlan Lagoon, and there is no room for further urban development in this immediate area.

A topographical map of the inner and outer ports is shown in Fig-4. The outer port of Manzanillo has very suitable natural conditions, and has been developed making use of these favorable conditions. The urban area was developed in the narrow area near the port. Due to the geographical limitations, it would be difficult to further extend the outer port. The inner port is located in San Pedrito Lagoon and is under construction.

1-1-2 Geology

The geology in and around the port of Manzanillo can be classified as follows:

- ① Acid Intrusion, Plutonic Rock
- ② Acid Intrusion, Volcanic Rock
- ③ Alluvial Deposit
- ④ Swampy Soil

Alluvial deposit is distributed in the area of the outer port and swampy soil is distributed in the area of the inner port.

1-2 Meteorological Conditions

The mean annual rainfall at Manzanillo is about 900 mm. It rains heavily from June to October. Mean temperature at Manzanillo in July and August is hot – 28.5°C and from December to April the mean is the lowest – 25°C. The seasonal change of temperature at Manzanillo is small.

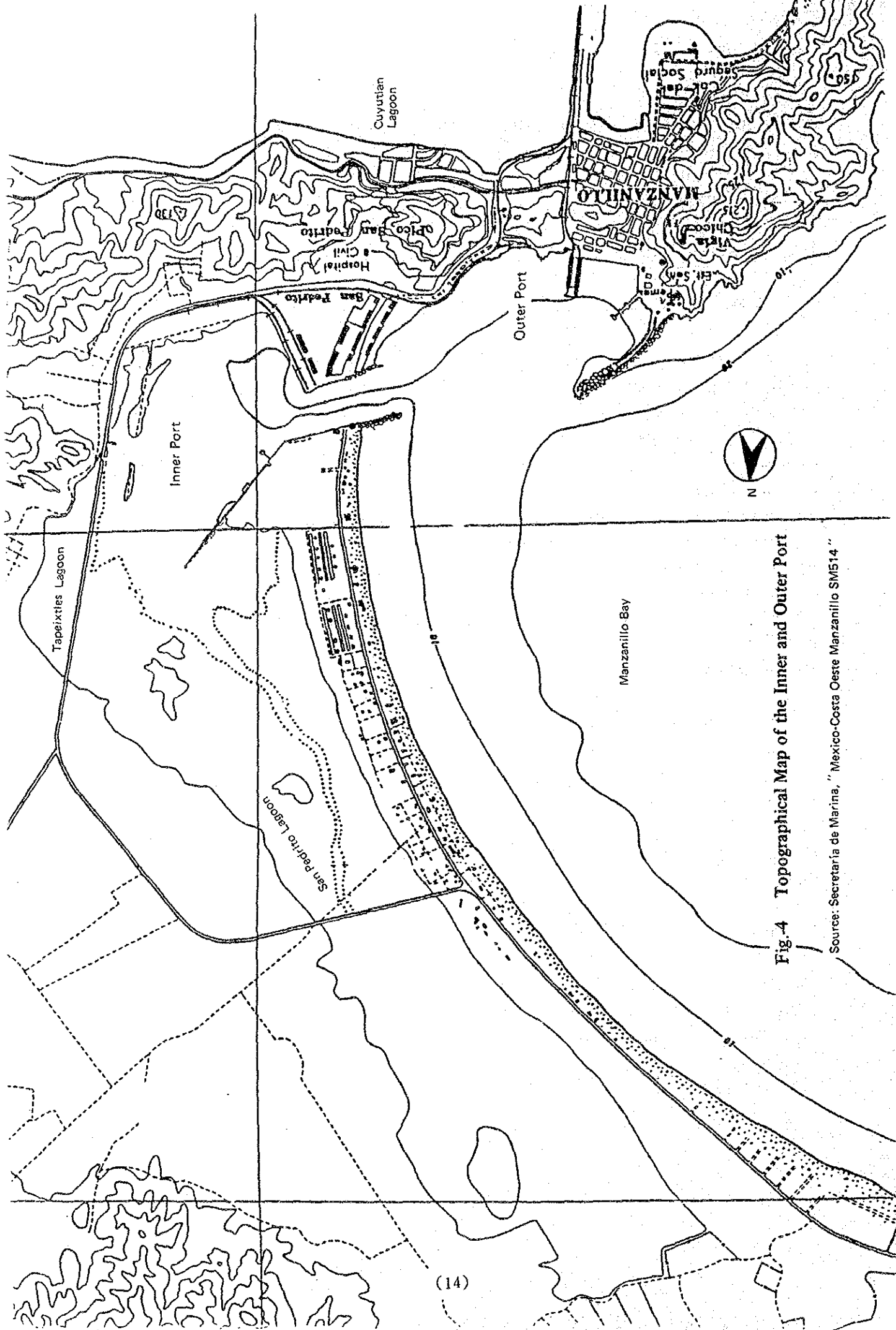


Fig.4 Topographical Map of the Inner and Outer Port

Source: Secretaría de Marina, "Mexico-Costa Oeste Manzanillo SM514"

1-3 Seismicity

Manzanillo is located in the narrow earthquake belt surrounding the Pacific Ocean. Therefore, there is a high possibility of earthquake risk.

A maximum horizontal acceleration of 0.15g is recommended for the design of port facilities at Manzanillo Port.

1-4 Oceanographical Conditions

1-4-1 Tide and Current

The clearance between high tide and low tide is about 70 cm. Ocean and tidal current can be estimated as small.

1-4-2 Waves

The significant wave height ($H_{1/3}$) at the entrance of the inner port is estimated as about 1.5 m, and the wave height in the inner port will be less than half of this height.

1-4-3 Littoral Drift

Serious trouble from shoaling at Manzanillo Port and in the entrance channel will not take place.

1-4-4 Tsunami

It will be necessary to prepare countermeasures to tsunami.

1-5 Soil Conditions

Soil conditions in the inner port are examined using the collected data from 138 points of boring. From them, the typical soil profile, which is shown in Fig.-5, includes the following 4 types of soil.

From the ground surface, the subsoils are as follows:

- ① Soft organic soil or clay
This layer underlies the entire area from 5 m to 20 m in depth. From the engineering point of view, this soil is not useful.
- ② Clayey sand or sandy clay
This layer underlies most of the area and its thickness ranges from 0.3 m to 10 m. This soil has various mechanical characteristics from soft to stiff soil.
- ③ Sand
This layer underlies almost the entire area, but in the northwest portion of the San Pedrito Lagoon this layer is less than 2 m thick. Therefore, this layer can not always be

considered as a bearing stratum.

- ④ Complex layer of sandy, silty and clayey soils
This layer underlies almost the entire area
beneath the sand layer.

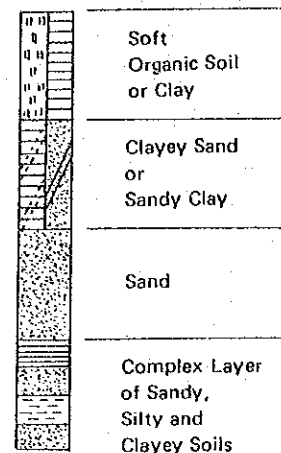


Fig.-5 Typical Soil Conditions
in San Pedrito Lagoon

2. Manzanillo City

The population of the Municipality of Manzanillo is 73,290 (37,255 Men and 36,035 Women) from "X censo de Población y Vivienda 1980."

The primary products of the region are:

Agricultural products

Maize, Sesame, Rice, Sugar cane, Coconut, Lemon, Banana

Animal products

Beef, Pork, Milk, Honey

Marine product

Tuna

Mineal products

Iron pellets, Salt

As for the transportation around Manzanillo City, the main road through Manzanillo City is route MEX-200 connecting with the other cities on the Pacific coast. In recent years a four-lane national road (Manzanillo~Colima~Guadalajara) has been under construction. The railway passes from Manzanillo through Colima and Guadalajara to Mexico City. There is an international airport in Playa de Oro which is about 50 km west of Manzanillo City by road.

The built-up area in the Manzanillo Metropolitan Zone is estimated at 1,760 ha. of which 60% are classified as residential, 25% as touristic and 15% as industrial and port. Currently, the total supply of potable water for the city is 524 ℓ /second. The electric energy service is provided by CFE through a thermo-electric plant situated south of the city with a capacity of 1,200 MW. which will satisfy the present and future demand of the development area.

3. Port Facilities

The existing port facilities at the port of Manzanillo are located in both the outer and inner ports. The inner port can be divided into the commercial port and the fishery port.

3-1 Commercial Port

As for large mooring facilities, there are 10 public berths and 3 private berths excluding the naval facilities, as shown in Table-3. Furthermore, a new large berth with a water depth of 12 m is under construction in the inner port.

Most of the small facilities, with a water depth of less than 4.5 m, are located in the outer port. The -14 m channel leading to the inner port has a length of 600 m and a bottom width of 100 m.

Table-3 Mooring Facilities

(Large Facilities)

Name of Facility	Length of Berths (m)	Water Depth of Berths (m)	Number of Berths	Structural Type	Year Constructed	Public or Private
(Outer Port)						
Muelle Fiscal	512	11.4	3	Open-type Wharf	1946-1952	Public
Malecon Miguel Alemán				Concrete Block	1952	
(Muelle de la Armada)	(100)	5.0-7.0	—			—
(Muelle de Cabotaje)	110	5.0-7.0	1			Public
Malecón de la X Zona Naval	(159)	5.0-7.0	—	—	—	—
Muelle de PEMEX	440	13.4	2	Dolphin	1965	Private
Muelle de PEMEX	100	14.0	1	Sea Berth	1982	Private
(Inner Port)						
Muelle de Altura	450	11.4	3	Open-type Wharf	1967-1969	Public
Muelle de Altura	600	12.0*	3	"	1983	Public
Muelle de la Armada	(260)	5.0-7.0*	—	—	—	—

Note: 1) — indicates no available data

2) *: According to local office of department of marine works, SCT

Source: 1) DGOM, "Catastro Portuario 1982"

2) DGODP, "Sistema Estadístico Operacional Indicadores de Rendimiento 1983"

Other existing port facilities include breakwaters, the turning basin and storage facilities. As for storage facilities, there are four sheds in the outer and inner port, and the total area of these facilities is about 18,500 m².

3-2 Fishery Port

A fishery port has been developed on a large scale at the north end of the San Pedrito Lagoon since 1980, and deep sea fishery berths of about 670 m long are now completed.

4. Cargo and Vessel Movement

4-1 Handling Volume and Commodities

4,025,000 tons of cargo including 871,000 tons of foreign trade were handled at the port of Manzanillo in 1983. Table-4 shows the volume of cargo handled in the last eight years.

The volume of cargo other than petroleum and its derivatives in 1983 was 1,091,000 tons, almost the same as in 1979, of which 854,000 tons (about 80% of the total volume) was foreign trade. The outstanding feature of foreign trade cargo movement at Manzanillo is that most of it is import cargo. The volume of imports is roughly ten times the volume of exports.

Table-4 Volume of Cargo Handled at Manzanillo

(Unit: '000 t)

Year	Grand Total	Foreign Trade			Domestic Trade		
		Export	Import	Total	Out	In	Total
1976	1,302 (853)	100 (100)	783 (672)	883 (772)	138 (130)	281 (79)	419 (81)
1977	1,454 (880)	111 (110)	759 (699)	871 (809)	233 (-)	350 (71)	583 (71)
1978	2,012 (1,056)	172 (172)	1,108 (804)	1,280 (976)	299 (-)	433 (80)	732 (80)
1979	2,925 (1,121)	158 (158)	1,418 (914)	1,576 (1,072)	549 (-)	800 (49)	1,349 (49)
1980	3,282 (1,489)	110 (110)	1,240 (1,240)	1,350 (1,350)	513 (23)	1,419 (116)	1,932 (139)
1981	2,424 (1,425)	89 (89)	1,259 (1,258)	1,348 (1,347)	164 (40)	912 (38)	1,076 (78)
1982	3,314 (757)	62 (62)	831 (571)	893 (633)	507 (23)	1,914 (101)	2,421 (124)
1983	4,025 (1,091)	76 (76)	795 (778)	871 (854)	597 (44)	2,557 (193)	3,154 (237)

Note: Figures in parentheses show the volume except for petroleum and its derivatives.

Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Carga y Buques"

As for foreign trade cargoes by major items, imported agricultural bulk cargo takes a big share, 63% of total foreign trade volume, and imported general cargo accounts for 20% of total foreign trade. On the other hand, petroleum and its derivatives is the most important item for domestic trade, amounting to 92% of total domestic cargo volume.

The principal commodities of foreign trade cargo in 1983, as shown in Table-5, include exports of metallic zinc, lead, ammonium sulfate and sodium sulfate, and imports of maize, sorghum, sugar and steel plate.

Table-5 Principal Commodities for Foreign Trade (1983)

(Unit: t)

Export		Import	
Commodity	Tonnage	Commodity	Tonnage
Metallic Zinc	17,230	Maize	409,249
Lead	13,049	Sorghum	124,062
Ammonium Sulfate	9,036	Sugar	111,256
Sodium Sulfate	6,450	Steel Plate	25,997
Auto Parts	3,531	Potassium Chloride	21,474
Polyester	3,189	Ammonium Phosphate	20,675
Molasses	3,030	Wheat	19,992

Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Carga y Buques"

The total volume of container cargoes reached about 23,000 tons, or 9% of general cargo in 1983. The principal commodities of containerized cargo are auto parts, electric articles, machinery parts and chemical industrial products.

4-2 Vessel Movement

As for the number of vessels calling at Manzanillo, 175 ocean going vessels and 226 vessels for domestic trade called in 1983.

As for foreign trade, about 80% of the vessels were general cargo carriers and for domestic trade about 90% were oil tankers.

5. Administration and Operation

5-1 Administration

The following agencies are concerned with the administration and operation of the port of Manzanillo.

- ① Comisión Nacional Coordinadora de Puertos, SCT
- ② Dirección General de Obras Maritimas, SCT
- ③ Dirección General de Operación y Desarrollo Portuario, SCT
- ④ Servicios Portuarios de Manzanillo, S.A. de C.V.

5-2 Operation

Cargo handling at Manzanillo is carried out in three shifts. The ordinary working hours are 8:00 ~ 13:00 and 15:00 ~ 18:00 from Monday to Saturday. Extra working hours for night work are 20:00 ~ 6:00.

Table-6 shows the average working efficiency by type of cargo in 1983.

Table-6 Working Efficiency by Type of Cargo (1983)

Type of Cargo	Number of Ships	Discharging/ Loading Volume (t)	Ton/ Hour·Worker	Ton/ Hour·Gang	Ton/ Hour·Ship
Broken General Cargo	111	113,937	3.1	32.7	60.3
Unitized General Cargo	52	202,147	4.3	44.8	91.4
General Cargo	163	316,084	3.8	39.5	77.1
Agricultural Bulk	28	571,572	14.6	42.1	145.8
Mineral Bulk	13	230,412	26.2	70.2	153.9
Liquid	1	4,204			177.0

Note: These figures indicate the working efficiency during actual operational time.

Source: DGODP, "Sistema Estadístico Operacional Indicadores de Rendimiento 1983"

5-3 Port Dues

As for port investment, the basic port facilities such as civil structures, storage facilities and cranes installed on quaywalls are constructed by the federal government.

Cargo handling equipment, tug boats and other movable machines are provided by Servicios Portuarios.

Therefore the port charges are divided into two parts: dues for use of port facilities, which are given to the federal government, and charges for port services.

6. Fishery Activity

6-1 Fishery Production

In the last five years, national fishery production has increased favorably, and totaled about 1,502 thousand tons in 1982. The fishery production in the Manzanillo region was officially recorded as 3,500 tons in 1983, but the volume in the last six years has fluctuated from year to year, as shown in Table-7.

Table-7 Fishery Production by Region (1978–1983)

(Unit: t)

Area	1978	1979	1980	1981	1982	1983
Mexico	818,511	1,002,925	1,257,146	1,565,465	1,502,300	—
Pacific	626,916	769,255	1,006,724	1,232,587	—	—
Gulf and Carib	179,143	189,707	222,329	290,377	—	—
Colima State	4,131	4,644	9,248	10,340	5,461	—
Officially Registered	1,927	2,440	7,044	4,410	4,214	—
Manzanillo	1,329	1,744	6,353	3,454	2,550	3,500

Note: 1) — indicates no available data.

2) This table is based on the fishermen's association statistics.

Source: PESCA

6-2 Fishing Boats

In 1980, the nation's fishing boats numbered about 36 thousand, most of which were small boats below 1 t.

In 1982, 269 boats were registered to the Manzanillo fishery office, but most of these boats were based at other fishery ports because of the insufficient landing and processing facilities at Manzanillo.

6-3 Others

The major destinations of the fishery products in the Manzanillo region are the Federal District, Jalisco State and Aguascalientes State. On the other hand, the Manzanillo region has several small companies with fishery processing facilities located some distance from the port.

7. Tourism

7-1 Tourists Visiting Manzanillo

In 1983, about 480 thousand tourists, which includes about 140 thousand foreign tourists, visited Colima State. More than 50% of these tourists visited the Manzanillo region.

7-2 Cruising Vessels

As for cruising vessels moving along the Pacific coast of Mexico, a total of 36 vessels anchored at Manzanillo Port with about 14 thousand passengers in 1983. This number of vessels and passengers is very small compared with other calling ports.

Six of these vessels periodically anchored at Manzanillo Port in 1983. Of these, representative vessels are the "Pacific Princess" and the "Cunard Princess" with a gross tonnage of 20 thousand tons, which come every fourteen days on route to Acapulco.

CHAPTER IV BASIC CONCEPT FOR THE DEVELOPMENT

1. National and Regional Development Plans

The Port of Manzanillo Development Plan should be written after reviewing the National Development Plan as well as functional and regional development plans so as to take the spirit of these plans into consideration.

1-1 National Plan

“Plan Nacional de Desarrollo 1983 ~ 1988” published in 1983 includes national economic targets, and two main policies for economic reconstruction and structural reformation. Based on this program, concrete execution programs such as “Programa Nacional de Comunicaciones y Transportes 1984 ~ 1988” and regional development plans such as “Plan Colima” have gradually been published.

1-2 Regional Plans

The latest regional development plans which directly concern the development of the port of Manzanillo are “Plan de Desarrollo Urbano de Manzanillo”, “Plan Colima” and “Plan Parcial de Zonas de Crecimiento”.

The development area and the land use plan are shown in Fig.-6.

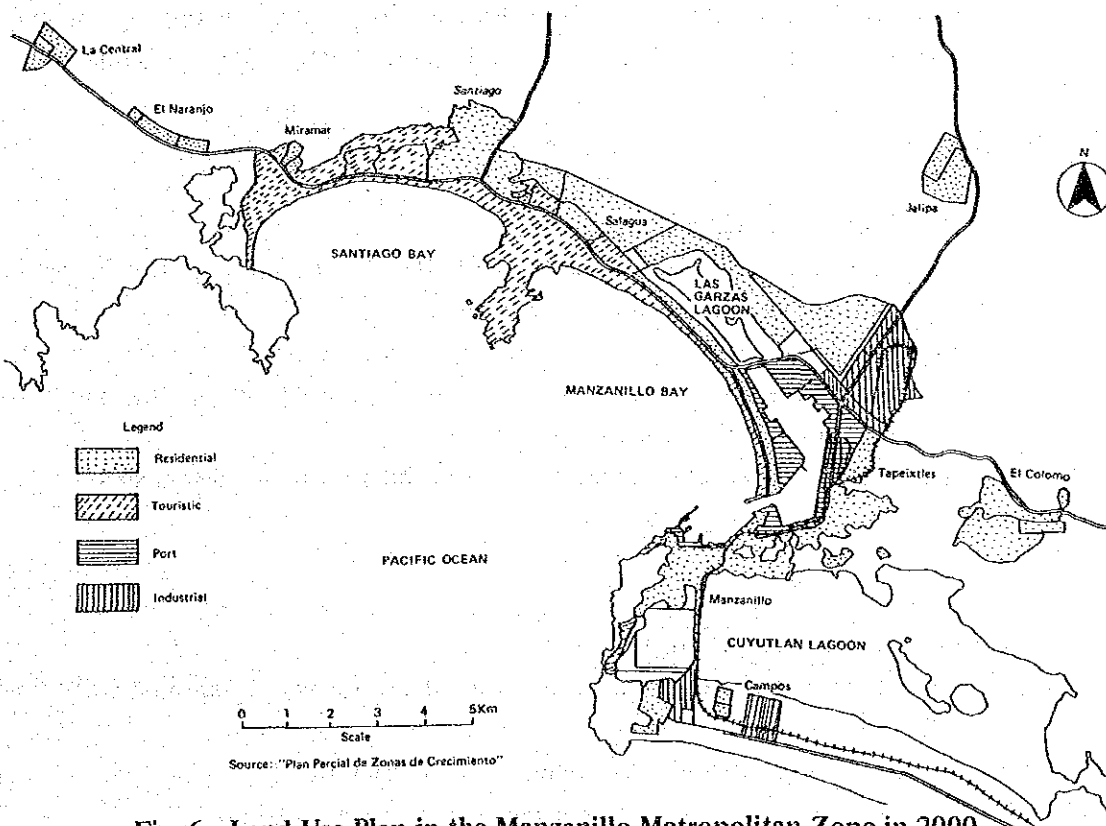


Fig.-6 Land Use Plan in the Manzanillo Metropolitan Zone in 2000

2. Development Policy

The purpose of the development of Manzanillo Port is to help realize various national and regional goals described in the previous section, especially to assist in controlling the future expansion of Mexico City by promoting production and population growth in the Manzanillo area. Manzanillo Port will serve as a key port to facilitate cargo flow throughout the nation.

2-1 Roles of Manzanillo Port

The roles of Manzanillo Port are as follows:

- ① From a historical viewpoint, the port of Manzanillo has been one of the most important ports on the Pacific coast. The port is connected by roads and railways with Guadalajara, the second largest city in Mexico, and with other principal cities throughout the country.
- ② The port of Lázaro Cárdenas has consolidated its position as the primary industrial port and as the key port for grain imports on the Pacific coast. Nevertheless, Manzanillo Port will continue to be of prime importance to its hinterland of Colima, Jalisco and Aguascalientes State and to its influence area as described in Chapter V. 1.

2-2 Development Strategy

2-2-1 Overall Planning

The planning must be in harmony with land use planning around the object area, and with the Manzanillo City development plan. The plan should minimize environmental damage.

2-2-2 Outer Port

The concepts of the outer port are as follows:

- ① Existing commercial activities other than PEMEX in the outer port will cease. The outer port will become exclusively a tourist port.
- ② Because commercial cargo will no longer be handled in the outer port, the railways running to this area and some of the warehouses located behind the wharf will be removed and the space changed to a public use area.
- ③ The existing PEMEX oil facilities on land and in the sea will not be changed.

2-2-3 Inner Port

The concepts of the inner port are as follows:

- ① Fishery and commercial port functions other than petroleum handling will take place within the inner port.
- ② The Tapeixtles Lagoon will be reclaimed for industrial use.
- ③ The largest possible area should be reserved for future expansion.

2-2-4 Port Planning

The main planning concepts are as follows:

- ① To cope with modernization of marine transportation.
- ② To improve traffic flow.
- ③ To ensure port safety.

CHAPTER V SOCIO-ECONOMIC FRAME FOR DEMAND FORECAST

1. Hinterland of the Port

The hinterland of the port of Manzanillo is determined from the data on the origin and destination of cargoes passing through the port, and the inland transportation situation. In conclusion, we may consider the following two categories of hinterlands for the port of Manzanillo as shown in Fig.-7.

Direct Hinterland: Colima, Jalisco, Aguascalientes
Influence Area: D.F., Guanajuato, Michoacan, Nayarit, Queretaro, Mexico

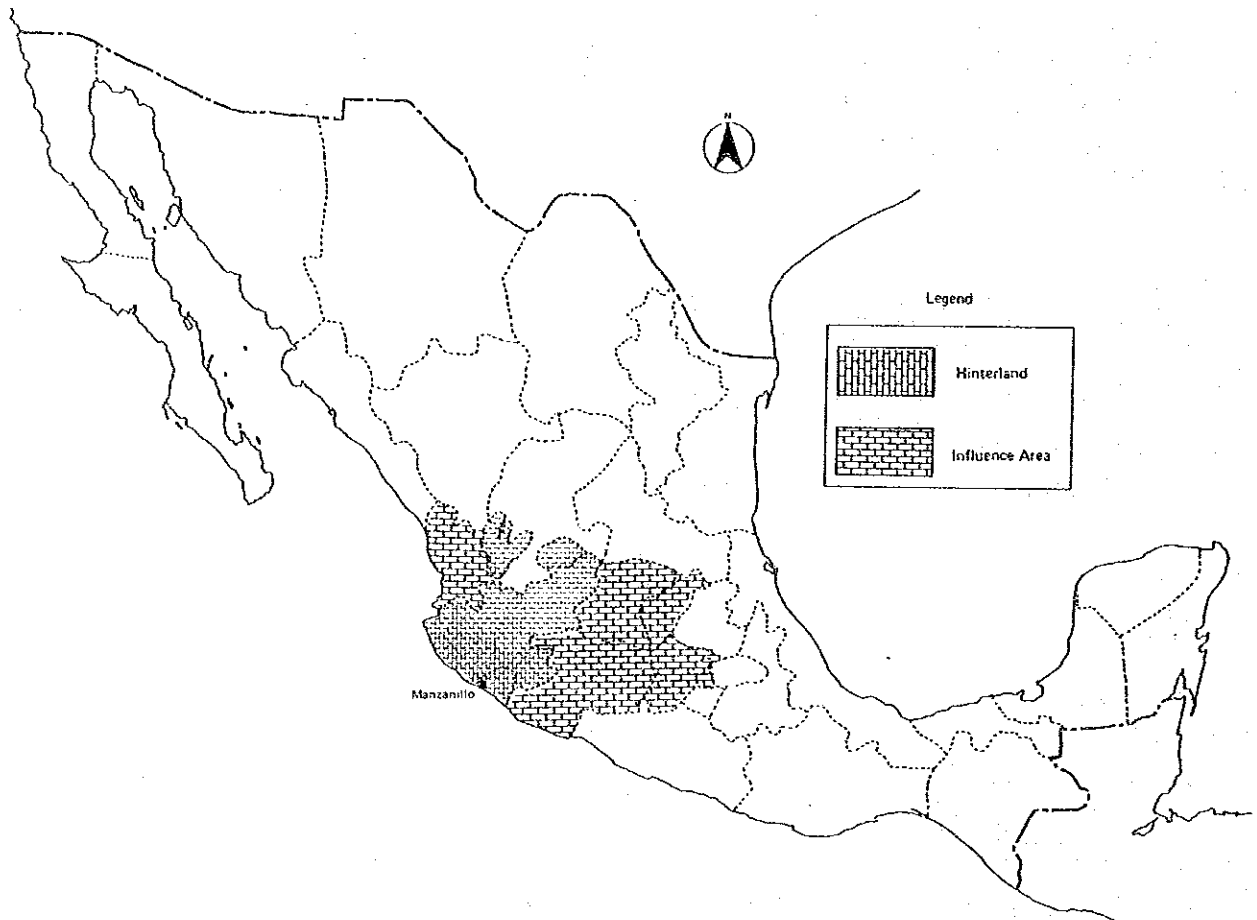


Fig.-7 Hinterland and Influence Area of the Port of Manzanillo

2. Future Socio-Economic Conditions

The forecast population for 1995 was estimated by CONAPO of SPP, and that for 2000 is calculated based on the 1995 estimate. As a result, the population is estimated as 86.4 million in 1990, and 103.0 million in 2000, as shown in Table-8.

As for the economic activities, the growth rate of the GDP in 1984 recovered to 3.5%, exceeding the government's goal (0 ~ 2.5%) for that year. A powerful recovery is expected in the future. The forecast GDP for the target years, considering the recent improvement in the Mexican economy and the planned growth rate at the 15th Meeting of the Mexico-Japan Businessmen's Committee, is given in Table-9.

Table-8 Population Forecast

(Unit: '000,000 persons)

	1980	1990	2000	Annual Rate of Increase (%)	
				1990/1980	2000/1990
Population	67.3	86.4	103.0	2.5	1.8

Table-9 GDP Forecast

(Unit: billion pesos)

Sector	1970 Prices			Ratio to 1983 GDP	
	1983	1990	2000	1990	2000
Total	862	1,197	2,145	1.39	2.49
Agriculture, Forestry, Fishery	83	105	163	1.27	1.97
Mining	34	44	70	1.30	2.07
Manufacturing	202	313	669	1.55	3.31
Construction	42	66	156	1.56	3.70
Electricity	15	22	45	1.49	3.06
Transport, Communication	64	95	187	1.47	2.90
Commerce, Hotel, Restaurant	210	279	473	1.32	2.25
Other Service	212	273	382	1.29	1.81

CHAPTER VI DEMAND FORECAST

1. Commercial Port Cargo

1-1 Methodology

Two methods will be used to forecast the commercial cargo volume handled at the port of Manzanillo. One is a macro forecast which is a method to estimate the cargo volume groups including many commodities, regardless of the volume of each commodity. The other is a micro forecast, which is a method to estimate the cargo volume of each commodity individually.

Petroleum and its derivatives are excluded from the cargo forecast. This is because they are handled mainly at the PEMEX oil pier located in the outer port of Manzanillo, and the loading and unloading facilities for petroleum seem sufficient to handle possible future increases of volume.

1-2 Macro Forecast

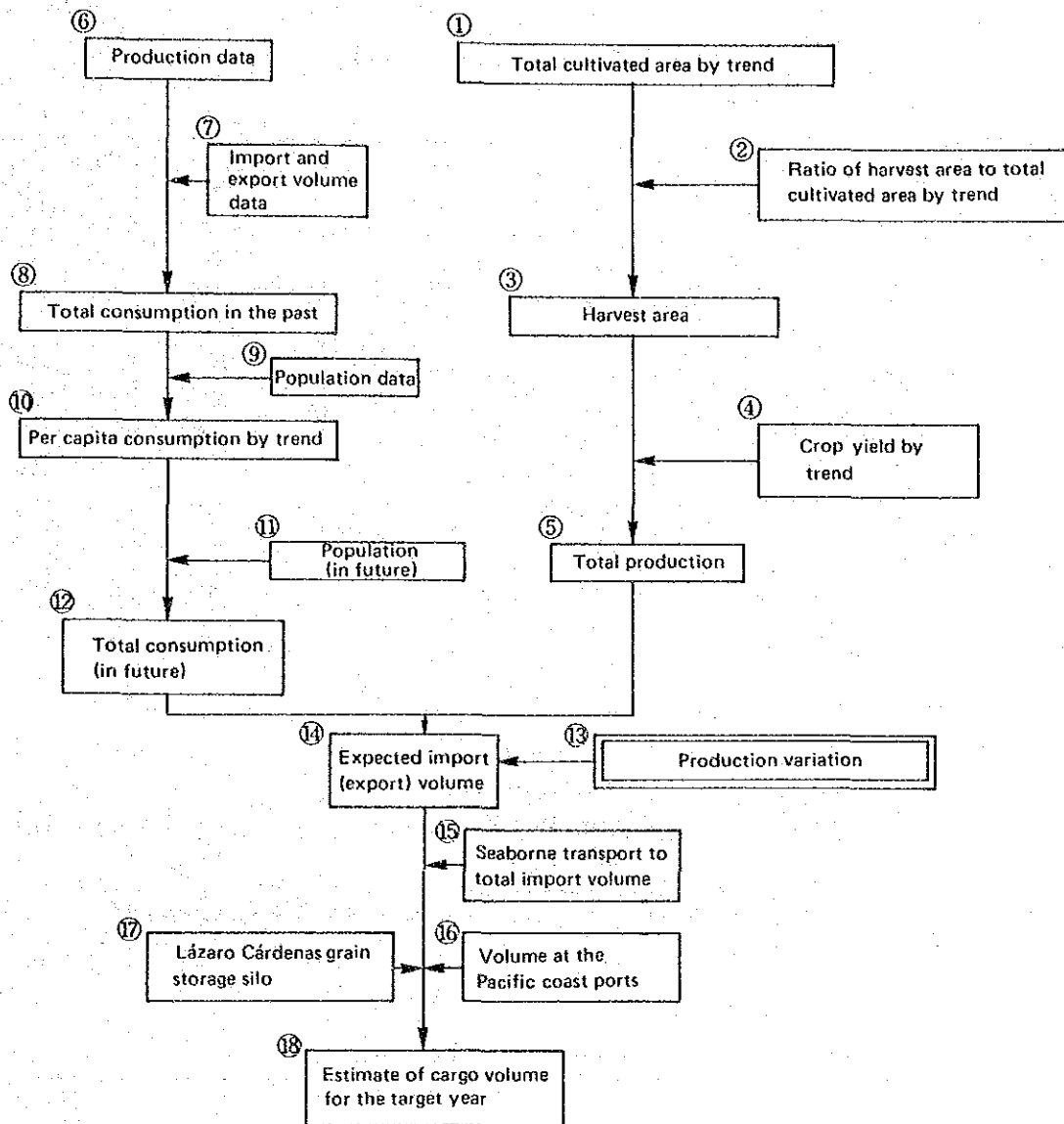
Two methods are used for the macro forecast. One is to grasp the trend of cargo handling volume from the past data and forecast the volume by a time series analysis. The other is to relate the past cargo handling volume at Manzanillo Port to national social or economic indices such as population or GDP, and to forecast the future cargo volume using future estimates of these national figures.

1-3 Micro Forecast

For this forecast, cargo handled at Manzanillo Port is classified according to package type: general cargo, agricultural bulk cargo, mineral bulk cargo and others. Micro forecasts are executed for major commodities individually. The remaining cargo items are estimated by package type.

Two methods are used for the micro forecast. One is to grasp the cargo handling volume from the balance of demand and supply in the future. The other is to relate the past cargo handling volume at Manzanillo Port to national social or economic indices.

As agricultural bulk cargo is the largest item handled in terms of volume at Manzanillo Port after petroleum and its derivatives, the methods of forecasting the volume of each crop are shown as a flow chart in Fig.-8.



Note: ⑥ ~ ⑨, ⑮, ⑯ are past data. Except these, all data are forecast for the target year.

Fig-8 Methodology of Agricultural Bulk Cargo Volume Forecast

Although some cargoes show a big discrepancy between macro and micro forecasts, total cargo volumes seem to be within an allowable difference.

Herein, the cargo volumes handled at the port of Manzanillo for the target year will be forecast as those obtained by the micro forecast method.

As a conclusion, the total cargo forecast at the commercial port of Manzanillo is about 2,300 thousand tons in the year 1990 and about 3,080 thousand tons in the year 2000. Table-10 shows a summary of the cargo forecast for the commercial port.

Table-10 Cargo Forecast Summary

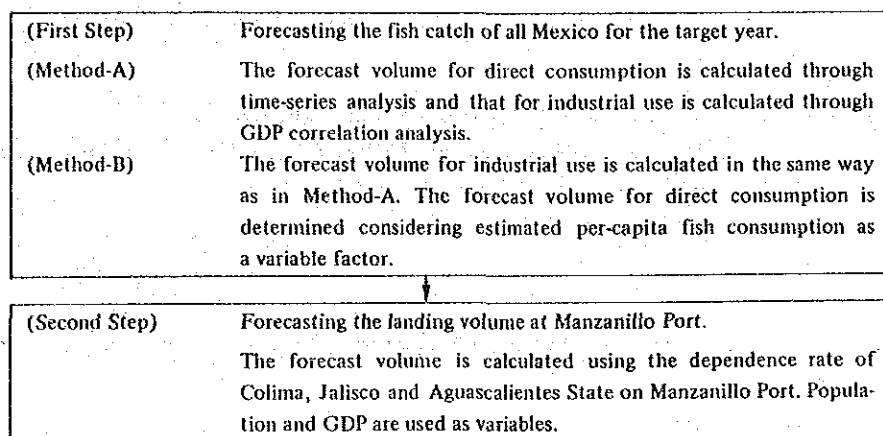
(Unit: '000 t)

Package Type	Trade	Commodity	Cargo Volume	
			1990	2000
General Cargo	Import	Rice	29	48
		Sugar	132	262
		Crude rubber	14	35
		Iron and steel	404	313
		Fertilizer	17	24
		Machinery	87	212
		Other Agriculture	49	76
		Other Industry	20	43
		Others	8	14
		Scrapped iron	60	128
	Sub-total		820	1,155
	Export	Lead	17	17
		Metallic zinc	14	15
		Chemical products	27	55
		Other Agriculture	9	13
Other Mineral		3	5	
Other Industrial		13	27	
Cement, Glass		12	27	
Sub-total		157	287	
Out	Baryta	37	39	
Total		1,014	1,481	
Package Type	Non container		824	965
	Container		190	516
Agricultural Bulk	Import	Maize	387	351
		Wheat	64	83
		Sorghum	261	137
		Soybean	101	134
Total		813	705	
Mineral Bulk	Import	Fertilizer	154	220
	Export	Cement	180	383
	In	Phosphate rock	70	150
		Salt	37	66
	Out	Cement	36	77
Total		477	896	
Grand Total		2,304	3,082	

2. Fish Catch

2-1 Forecast Method

The forecast of the fish catch at Manzanillo Port is carried out using the following procedure:



2-2 Forecast of Fish Catch at Manzanillo Port

Using the above method, the fish catch at Manzanillo Port in 1990 and 2000 is forecast as shown in Table-11.

Table-11 Forecast of Fish Catch at Manzanillo Port

(Unit: '000 t)

Year	Total	Direct Consumption	Industrial Use
1990	70	36	34
2000	156	77	79

3. Tourists

Assuming that the percent of tourists who will come to the Manzanillo region to the total number of tourists visiting Colima State will be 50% in 1990 and 60% in 2000, the number of tourists who will visit the Manzanillo region in 1990 and 2000 are forecast as 320 thousand persons and 480 thousand persons.

Further, assuming that the ratio of tourists engaging in coastal leisure activities to the total number of tourists visiting the Manzanillo region is 50%, the number of these tourists in 1990 and 2000 are 160 thousand persons and 240 thousand persons.

CHAPTER VII MASTER PLAN

1. Land Use

1-1 Planning Concepts

The port area is divided into two main regions, the outer port and the inner port. The functions of each region are:

Outer port	Port (Touristic port), Tourism, and Others
Inner port	Port (Commercial port, Fishery port), Industry, and Others

1-2 Industrial Location

The industries to be located in the industrial zone around the port of Manzanillo are:

- ① Seafood products
- ② Food industry complex
- ③ Soap and detergents

1-3 Transportation

Road transportation in the year 2000 will be sufficient to handle all the port cargoes which travel by road smoothly: the four-lane highway which is presently under construction will connect Manzanillo with Guadalajara via Colima, and the port road will be expanded to four lanes under the Master Plan.

As for railways, in order to avoid transportation confusion in Manzanillo City, the railway within the central zone will be removed and new lines connecting Cuyutlan, El Colomo, Tapeixtles, "Peña Colorada" and the inner port will be established. Further research is needed to decide the exact location of the new lines and the scale of the marshalling yard.

2. Scale of Port Facilities

2-1 Planning Concepts

The concrete concepts for the port planning in accordance with the overall development policy are as follows:

- ① Port development to cope with modernization of sea transportation
 - Development of the container terminal
 - Development of large scale mooring facilities
- ② Port development to improve traffic flow
- ③ Port safety

- ④ Port development reserving space for future development
- ⑤ Port development in harmony with the adjacent urban area

2-2 Commercial Port

2-2-1 Present Port Capacity of Manzanillo Port

The present port capacity of Manzanillo Port is estimated using the total cargo volume converted into general cargo.

Assuming that the berth occupancy ratio is 100%, the port capacity of Manzanillo Port is estimated as 1,983 thousand tons of converted cargo volume. For reference, the converted cargo volume in 1990 is estimated as 1,659 thousand tons with a berth occupancy ratio of 84%. This shows that the cargo handling volume forecast for 1990 will almost reach the limit of the present facilities capacity of Manzanillo Port.

2-2-2 Methods to Determine the Number of Berths

The following two methods are used to determine the required number of berths at Manzanillo Port.

- ① Method considering the frequency of ship entry and cargo handling capacity.
- ② Method of simulation by queuing theory.

The procedure of determining the number of berths using the above two methods is as follows:

- ① First, the number of berths required for the target year is estimated by type of cargo using method- ①.
- ② Next, the simulation test is conducted for the overall plan.

2-2-3 Kind of Wharves to be Improved

The kind of wharves to be improved by 2000 are determined based on the type and handling volume of cargoes forecast in Chapter VI, as shown in Fig.-9.

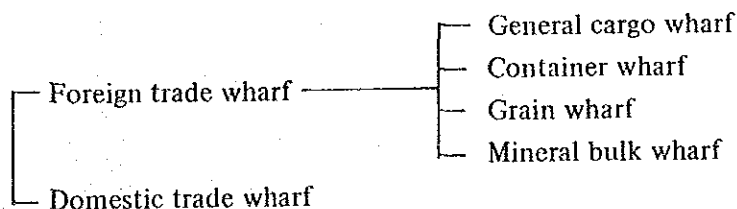


Fig.-9 Kind of Wharves to be Improved

2-2-4 Ship Size and Berth Size for the Master Plan

Table-12 shows the ship size and berth size for the Master Plan