FINAL REPORT

No. 9

THE FEASIBILITY STUDY ON THE SECOND STAGE EXPANSION PROJECT OF THE PORT OF CALDERA REPUBLIC OF COSTA RICA

DECEMBER, 1981

JAPAN INTERNATIONAL COOPERATION AGENCY

FINAL REPORT

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PREFACE

In response to the request of the Government of the Republic of Costa Rica, the Japanese Government decided to conduct a study on the Construction Project of the Port of Caldera, and entrusted the study to the Japan International Cooperation Agency (JICA).

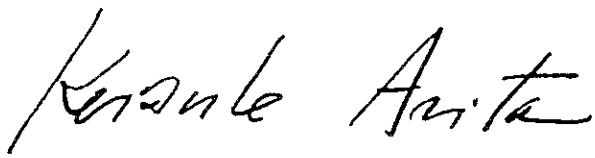
The JICA sent to Costa Rica a survey team headed by Mr. Masahiko Matsuyama, Director of the Overseas Coastal Area Development Institute of Japan several times.

The team exchanged views with the officials concerned of the Government of Costa Rica, collected reference materials and conducted a field survey. After returning to Japan, further studies were made and the present report has been prepared.

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

I wish to express my deep appreciation to the officials concerned of the Government of Costa Rica for their close cooperation extended to the Team.

December, 1981



Keisuke Arita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

December 1981

Mr. Keisuke Arita
President
Japan International Cooperation Agency

Dear Mr. Arita:

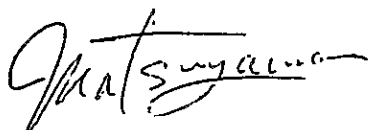
It is my great pleasure to submit herewith a report on the Construction Project of the Port of Caldera, the Republic of Costa Rica.

The Japanese study team, headed by myself, conducted a survey on the Project in San Jose and Caldera for 35 days from July 9, 1980, at the request of the Japan International Cooperation Agency. The findings of the feasibility study and our proposition on the port construction are included in this report. The study shows that the importance of the Project is very high so that I hope the Project be executed steadily.

On behalf of the Japanese study team and myself, I would like to express my deepest appriciation to the Government of the Republic of Costa Rica and various organizations concerned the Project for their unlimited cooperation, assistance and warm hospitality extended to the team during our stay in Costa Rica.

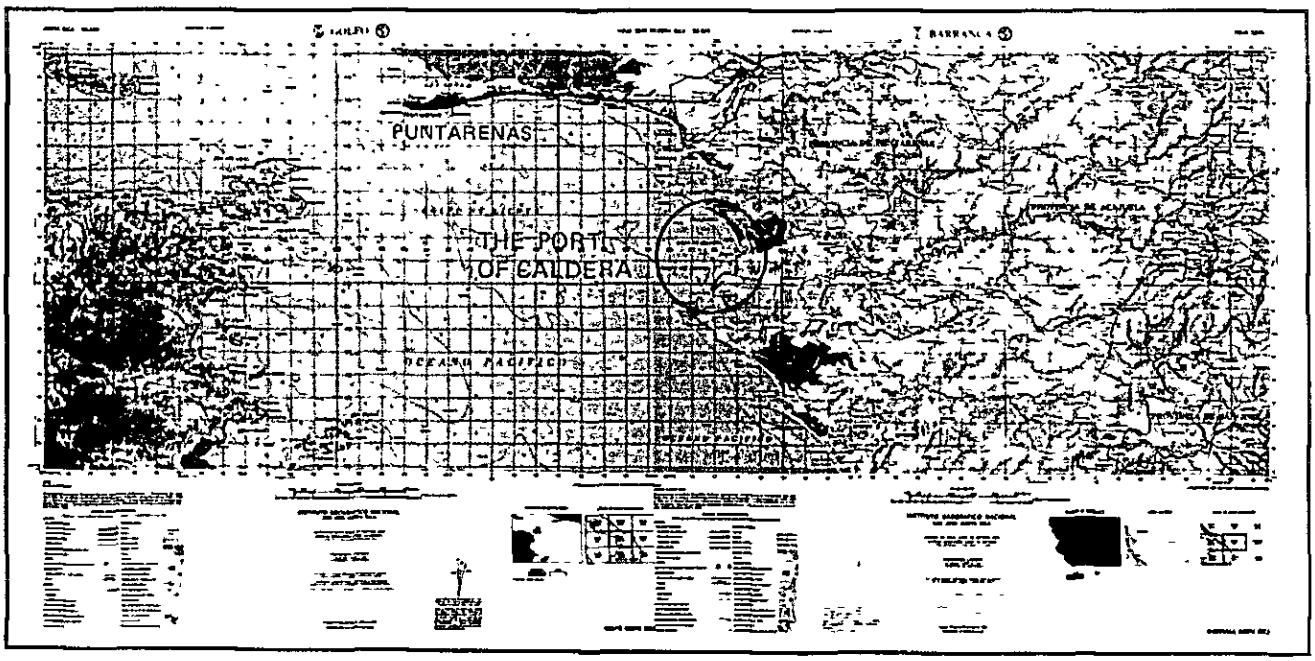
My indebtedness also is great to the Japan International Cooperation Agency, the Ministry of Transport, the Ministry of Foreign Affairs and the Japanese Embassy in Costa Rica for giving us valuable suggestions and assistance in the field study and in preparation of this report.

Sincerely yours,



Masahiko Matsuyama
Head
Japanese Study Team for the Construction of the Port of Caldera
(Director, the Overseas Coastal Area Development Institute of Japan)


MAPA FISICO POLITICO 1:500.000
COSTA RICA
EDICION 1979
LAGO DE NICARAGUA
NICARAGUA
ISLAS DE PAPAGAYO
ALAJUELA
GUANACASTE
HEREDIA
LIMON
SAN JOSE
CARTAGO
PUNTARENAS
OCEANO PACIFICO
PANAMA
ZONA CENTRAL
BARVA
SAN JOSE
CARTAGO


PUNTARENAS
THE PORT
OF CALDERA
OCEANO PACIFICO

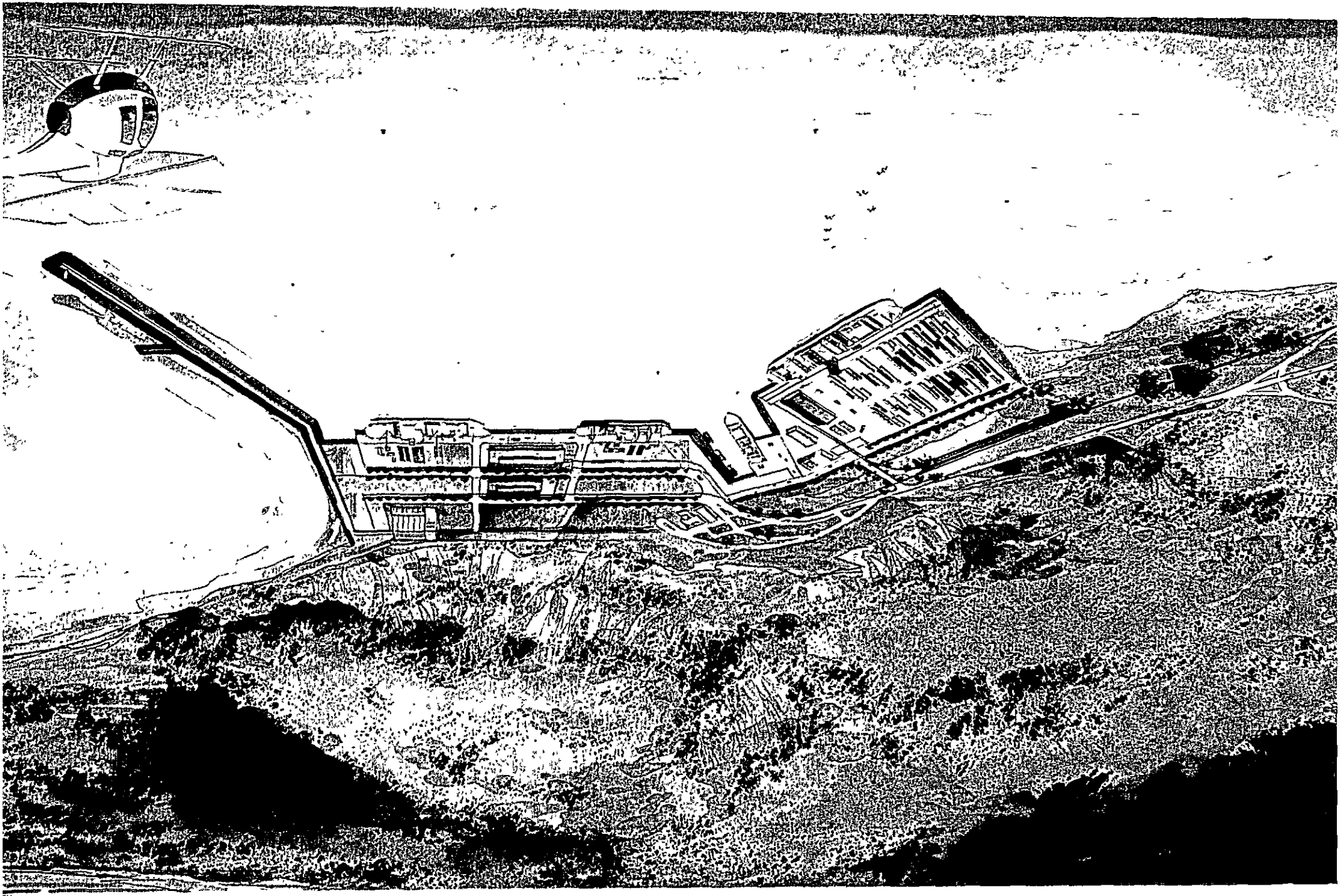


Photo-1. A General View of the Port of Puntarenas and Puntarenas City

Photo-2. Cargo Handling on the National Pier at the Port of Puntarenas

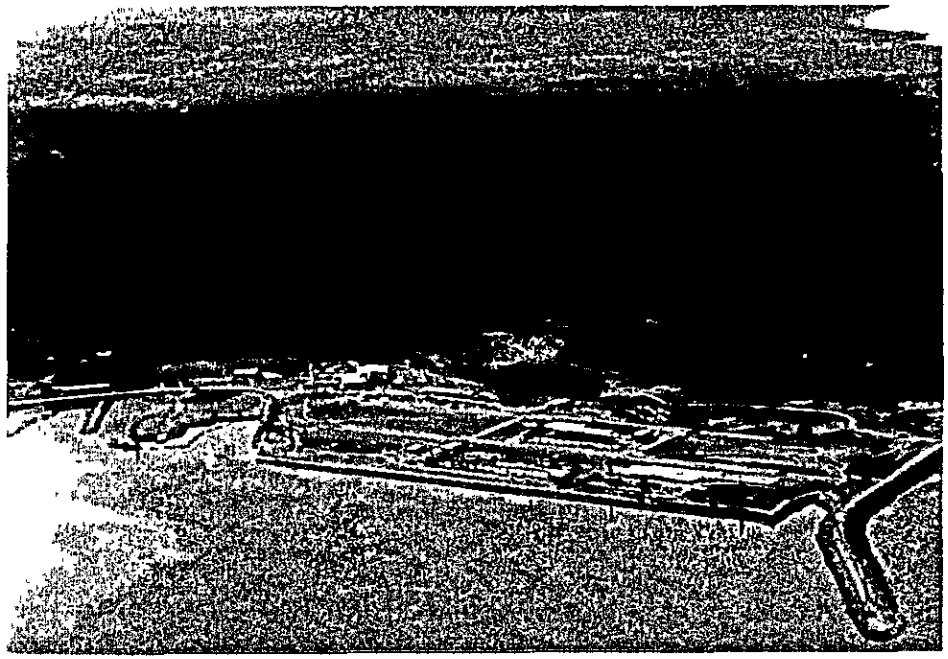


Photo-3. The Construction Site of the First Stage Project of the Port of Caldera – (1)

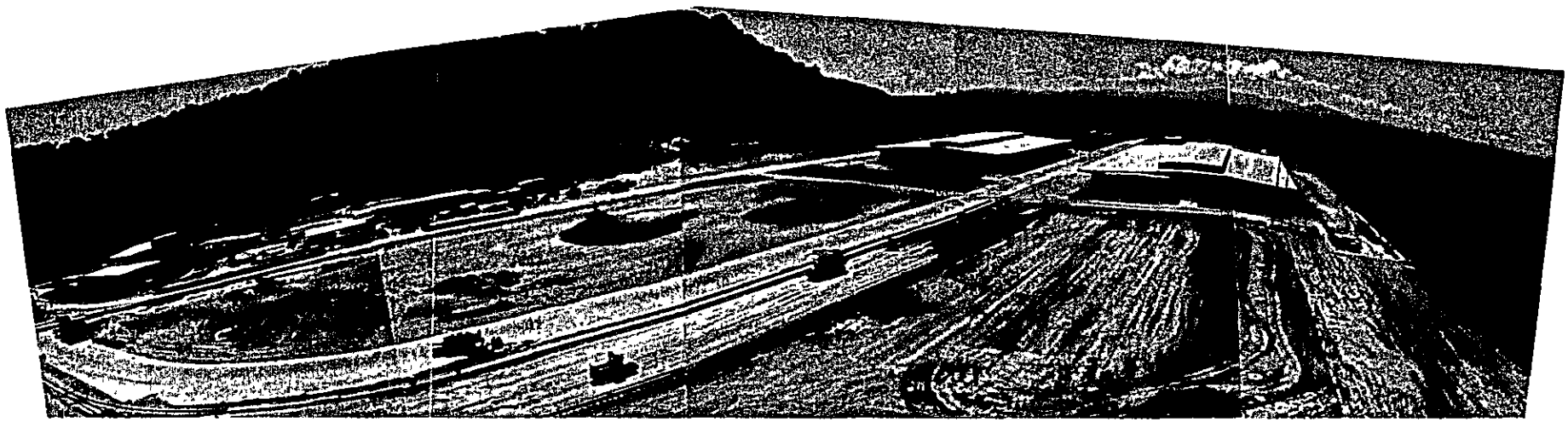


Photo-4 The Construction Site of the First Stage Project of the Port of Caldera – (2)

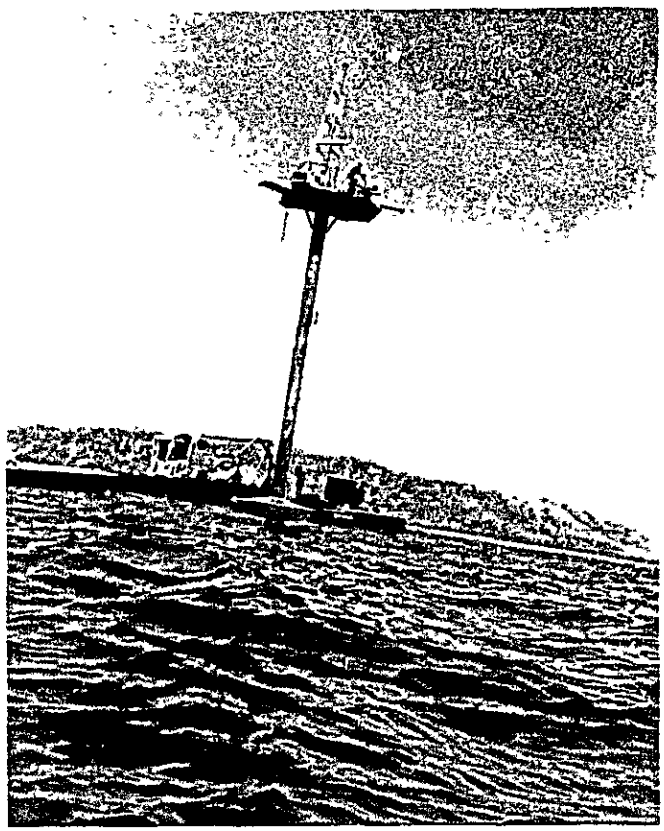


Photo-5. Boring Work at the Breakwater Site

Photo-6. The Construction Site of – 11m Wharf

Exchange Rate

US$1.00 = Colones 15

ABBREVIATIONS

In this report, the following abbreviations are used:

ABBREVIATIONS	FULL NAME (SPANISH)	FULL NAME (ENGLISH)
JICA	Agencia de Cooperación Internacional del Japón.	Japan International Cooperation Agency.
OCDI	Instituto Japonés para el Desarrollo de Litorales en Ultramar.	Overseas Coastal Area Development Institute of Japan
MOPT	Ministerio de Obras Públicas y Transportes.	Ministry of Public Works and Transports.
DGP	Dirección General de Planificación.	Directorate General of Planning.
DGOP	Dirección General de Obras Portuarias y Fluviales.	Directorate General of Port Works.
DGTA	Dirección General de Transportes por Agua.	Directorate General of Transports by Water.
INCOP	Instituto Costarricense de Puertos del Pacífico.	Costa Rican Pacific Ports Agency.
JAPDEVA	Junta de la Administración Portuaria y de Desarrollo Económico de la Vertiente Atlántica.	Agency for Atlantic Ports Administration and Economic Development.
FECOSA	Ferrocarriles de Costa Rica, S.A.	Costa Rican Railway Co.
RECOPE	Refinadora Costarricense de Petroleo S.A.	Oil Refinary Agency.
ZONA FRANCA	Corporación Zona Franca de Exportación y Parques Industriales.	Export Free Zone and Industrial Parks Corporation.
OFIPLAN	Oficina de Planificación Nacional y Política Económica.	Directorate of Economical Planning.
DGEC, MEIC	Dirección General de Estadística y Censos. Ministerio de Economía. Industria y Comercio.	Directorate General of Statistics and Census. Ministry of Economy. Industry and Commerce.
SYSTAN		Systan International Inc
BCCR	Banco Central de Costa Rica.	Central Bank of Costa Rica.
FERTICA	Fertilizantes de Centroamérica (Costa Rica) S.A.	Fertilizer of Central America (Costa Rica)
ASBANA	Asociación Bananera Nacional.	National Banana Producers' Asociation.
INVU	Instituto Nacional de Vivienda y Urbanismo.	National Agency for Housing Planning and Development.
CODESA	Corporación de Desarrollo, S.A.	National Development Agency.
CNP	Consejo Nacional de Producción	National Counsel of Production.

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CONCLUSION AND RECOMMENDATIONS

Conclusion

1. The Timing of the Construction of the Second Stage Expansion Project

In the Second Stage Expansion Project of the Port of Caldera, containerization is one of the basic factors considered in determining the plan. Although most of the world's major regular shipping lines have now been containerized, the Central and South American Pacific Route is one of the few remaining uncontainerized lines.

The facilities of the Port of Caldera completed under the First Stage Project can smoothly and efficiently be used for at least the next ten years, if the same types of cargo and vessels are handled as at the facilities of the Port of Puntarenas. However, it is anticipated within world shipping circles that full container vessels are likely to be put into service on the Central and South American Pacific Route around 1985, calling at the Port of Caldera.

While container transportation by full container vessels offers great merits from the international point of view and also from that of national economy, it requires the construction of container berths and container handling facilities in order to achieve shortened cargo handling hours and an increase in shipping turnover, which are the merits of the containerized transportation system.

Under the First Stage Project, a receiving system can be arranged whereby container handling facilities are provided for the -11m berth, with priority given to full container vessels.

Our simulation study of the use of this berth with priority given to full container vessels shows that the average waiting hours for shipping will drastically increase to 24 hours in 1985 and 50 hours in 1987; back to the 1979 level of Puntarenas.

As regards the timing of the construction under the Second Stage Expansion Project, considering the waiting hours for vessels, waiting vessels ratio, berth occupancy rate and internal rate of return, it will be ideal if the new facilities are completed in 1986.

2. Facilities Plan

As regards the scale of the Second Stage Expansion Project, it is to include a container wharf with a container handling capacity of 20,000 TEU/year with 1990 as the target year, a breakwater, mooring basins and port transport facilities to ensure safe and smooth running of the wharf.

As regards berths, a single berth of 12m in depth and 250m in length will be appropriate in view of the sizes of full container vessels expected to call.

As for the container handling system at the container terminal, it should be sufficient to continue using the machinery installed under the First Stage Project, and to select the most suitable straddle carrier system from among the initial investments.

As regards the breakwater, it will be necessary to extend it by 150m to secure the required calmness of the mooring basins which front the wharf.

3. Natural Conditions

The results of a geological survey show that the ground on the proposed site of the wharf poses no problem for designing, construction and operation. However, the proposed area for the breakwater has a soft stratum that gets even softer as it extends out to sea. Although the extension of the breakwater by 150m proposed under the Second Stage Expansion Project is possible, attention must be paid to this soft ground in the designing and construction stages.

Design wave height for the First Stage Project employed $H_{1/3}$ = 3.0m. However, on May 21, 1981, waves higher than the design wave height of $H_{1/3}$ = 3.55m hit and broke the top end of the breakwater. Therefore, the design wave height was restudied including new observation data and it has been changed to $H_{1/3}$ = 4.3m, $T_{1/3}$ = 18.4sec. equal to the probable wave height of a realizing period of 30 years.

Littoral drift around the Port of Caldera is observed shifting and depositing around the mouth of Lake Mata De Limon inside the port and outside the breakwater. In regards to the shifting of sand around Lake Mata De Limon, work is being carried out to alter the mouth of the lake by constructing a training wall.

Through these measures, the flow of sand into the anchorage area inside the port has largely been prevented, but silt and clay outflow from the Mata De Limon is still depositing in the calm anchorage area in front of the wharf, where signs of soft mud are beginning to show up.

Also, on the north beach of the lake mouth, corrosion has started to occur. Deposits of littoral drift outside the breakwater started to show up from around April, 1981.

This phenomenon of sand deposits is still increasing.

The source of the littoral drift is from the Rio Jesus Maria and has been observed coming around Punta Caldera.

As survey and observation data are not sufficient, the condition and amount of the deposits is not exactly known.

4. Design and Construction

With regard to the construction of the breakwater and quaywall, which are basic facilities for the Second Stage Expansion Project, a study was made comparing 3 plans. Plan I uses a rubble mound type breakwater and a steel sheet pipe pile type quaywall as in the First Stage Project, Plan II uses a wave breaker block type breakwater and a steel sheet pipe pile type quaywall and Plan III uses both a caisson type breakwater and quaywall. The study was made in terms of construction costs, durability and construction period. As a conclusion, Plan I is the most suitable. This is because when constructing a rubblemound type breakwater as called for in Plan I, the same throwing stone, quarrying methods, transportation and equipment can be used as in the First Stage Project. However, a drawback is that the rubble that can be used according to this plan is limited to about 4 tons, which is not heavy enough to provide a stable weight for the designed wave height of 4.3 meters. By thus departing from the optimum rubble weight for a designed wave height of 4.3 meters, an allowance for damage of 10% must be calculated. If damage of 10% is allowed, the cost of restoration must then be budgeted and the possibility of

damage by high waves occurring once in several years still remains. But even with restoration costs added, rubblemound type breakwater is still economically more advantageous.

Additionally, the most effective countermeasure to prevent littoral drift from filling in the port, would be to construct a "groyne" of about 50 meters long, bent 45° offshore from the top end of the present breakwater.

5. Construction Cost

The construction cost of the Second Stage Expansion Project is US$ 30,450,000. All prices are expressed in April 1981 prices. Foreign currency is US$ 18,500,000 (61% of total), and local currency is US$ 11,950,000. Exchange rate is US$ 1.00 = Colones 15.00.

6. Evaluation

Economic effects anticipated from the Second Stage Expansion Project include maintenance of effective and economic loading conditions in the face of increasing volumes of cargo, and also benefits resulting from implementation of the container transport system.

Of these benefits, the internal rate of return is about 15%, calculated from analysis of the cost benefit derived from reduction of waiting time and loading/unloading time in direct relation to transportation.

This is an appropriate value in comparison with the internal rate of return of similar projects that have been carried out in Costa Rica, so this project is considered feasible from the viewpoint of the national economy. With regard to the financial soundness of the Second Stage Expansion Project, studies have been made based on financial statements prepared using provisional tafiffs and similar financing arrangements as with the First Stage Project.

The results of these studies indicate that it is not feasible for the Port of Caldera to successfully balance its income and expenses on its own profitability independantly.

In order to balance income and expenses, the government must share the burden of payment on loans and interest, or the tariff must be revised.

Recommendations

I. The Second Stage Expansion Project of the Port of Caldera will not be immediately financially feasible in terms of independant profitability. It will require government subsidies to pay back loans. But from the standpoint of the national economy, it is a highly feasible project and must be carried out from the national point of view.

II. The most appropriate target year for the completion of the Second Stage Expansion Project is 1986. However, as the target year is closely related to the future implementation of containerization, it will be necessary to adjust the timing of projected completion until after the Port of Caldera starts full operations, so as to precisely confirm trends in regards to cargo and full container ships.

III. Study of the Second Stage Expansion Project is not yet sufficient. Soil investigation at the planned site of the breakwater and the study of littoral drift outside the breakwater would be especially useful.

IV. In constructing the breakwater, rubble of more than 4 tons in weight must be strictly selected and the work must be carefully carried out to assure a designated grade slope with a perfect two layer deposit.

Moreover, Costa Rica's economic condition has been unstable due to the country's adverse balance of payments with the possibility of affecting the values of port demand forecasts. It is, therefore, necessary to pay adequate attention to future changes in circumstances.

SUMMARY

SUMMARY

CHAPTER 1 OUTLINE OF STUDY

The purpose of this study is to assess the feasibility of preparing the Second Stage Expansion Project by the target year of 1990 and masterplan by the target year of 2000, so as to meet the demand for new port facilities that can cope with the increase of cargo volume resulting from the future economic growth of the country and the modernization of marine cargo transportation through containerization.

CHAPTER 2 GENERAL DESCRIPTION OF COSTA RICA

2-1 Population

The total population of Costa Rica stood at 2,070,000 in July, 1977, registering an average annual rate of increase of 2.68% during the preceding decade. It is estimated that the rate of population increase will gradually fall with the total population numbering 2,780,000 in 1990. The rate of increase is expected to be below 2% around 1995 and the total population is estimated to be 3,380,000 in 2000. The population is concentrated in the central plateau which accounts for about 60% of the total.

2-2 Economic growth

As regards the growth rate of GDP, during the 22-year period from 1958 to 1979, the average nominal rate of growth was 12.6% and the real rate 5.9%. During the decade from 1970 to 1979, the nominal rate averaged 19.9% per annum and the real rate 6.2%. The GDP in 1979 amounted to 34,233 million colones (≒ $4,000 million). Although there is no long-term economic planning in operation as a national policy, the OFIPLAN and BCCR forecasts the average annual rate of GDP growth at 4.96% and 4.23% respectively until 1985.

2-3 Industry

In the field of agriculture, beef, bananas, sugar and coffee are the major items for export: wheat and processed food are imported. Rice, dairy products and vegetables are domestically supplied.

In the field of manufacturing industry, oil is entirely imported and heavy industry hasn't yet developed. The main items for export are fertilizers manufactured by Fertica, a government enterprise, exported to central and south America. In the field of light industry, plastic, metal and chemical products are processed for export to central American countries

2-4 Foreign trade

For the last two decades Costa Rica has run trade deficits averaging 35% per annum with imports always exceeding exports on a value basis. With 1960 as the base year, foreign trade on a quantity basis doubled in 1968, trebled in 1971 and quadrupled in 1977 with 1,540,000 tons of imports and 1,850,000 tons of imports.

On a value basis, exports to north America account for 30 – 40% of the total, 25 – 35% to Europe and 20 – 30% to central America. In imports, too, north America accounts for 30 – 40% of the total with central America and Europe accounting for 20 – 30% respectively. There has been a rapid increase in imports from the Far East in recent years, particularly from Japan.

2-5 Ports and Harbors

Costa Rica has six ports: four on the Pacific side – Puntarenas, Punta Morales, Golfito and Caldera – and two on the Caribbean Sea side – Limon and Moin.

Of these, Puntarenas (in the future, Caldera) and Limon are public ports for foreign trade. Punta Morales and Golfito are exclusively used for sugar and bananas, respectively, while Moin is used exclusively for petroleum and bananas.

CHAPTER 3 PRESENT CONDITIONS OF THE PORT OF PUNTARENAS

3-1 Administration and Management of Costa Rican Ports

(1) In Costa Rica, the planning and construction of port facilities is the charge of the Ministry of Public Works and Transport and their administration and management is the charge of port authorities. The main ports are the Port of Puntarenas and the Port of Limón. Their adminstration and management is the charge of the INCOP and the JAPTEVA, respectively.

Further, there is the National Port Council as the organization for overall coordination among national agencies concerned with ports. It is composed of six members including the Minister of Public Works and Transportation and the proxies of the Minister of Finance and an INCOP representative.

(2) INCOP

The INCOP, which is in charge of the administration and management of the Port of Puntarenas, is the port authority in accordance with Law No. 1721 dated December 28, 1953.

It was formerly also in charge of the management of the railway between Puntarenas and San Jose along with the port. But by now, the railway has been separated from its control and, at present, it is charged with the management of only the port.

3-2 The main Facilities of the Port of Puntarenas

The main facilities of the Port of Puntarenas are the Muelle Nacional for large vessels and the Muelle Municipal for small coasters.

The layout of the Muelle Nacional is an inverted L-shape, with the berth on the south having a length of 137m and depth of −9.1m ~ −12.2m and the one on the north a length of 110m and depths of −7.6m ~ −10.7m. Six railway tracks run on the wharf with freight cars for direct cargo handling. This wharf, constructed in steel pipes in 1929, shows extensive corrosion after a lapse of more than 50 year.

In 1979, a total of 254 vessels called at the Port of Puntarenas and the total cargo handled was 380,474 tons (imports: 354,401 tons, exports: 26,073 tons). In the meantime, 4 vessels entered Punta Morales and the total volume of cargo handled was 62,245 tons (exports only), while 52 vessels called at the Port of Puntarenas to take on Fertica (offshore) cargo, which amounted to 178,000 tons (imports: 142,424 tons, exports: 35,976 tons).

CHAPTER 4 LOCATIONAL CONDITIONS OF THE PORT OF CALDERA

4-1 Geographical Conditions

The Port of Caldera is located about 30km to the south of Puntarenas and about 1.5 hours' drive from San José, the capital of Costa Rica. These ports are linked with the Inter-American Highway at El Roble through existing roads.

The Inter-American Highway is an important trunk road, reaching Nicaragua in the north and Panama in the south. Since the Caldera-San José Highway is expected to be completed in 1985, the traveling time between the two areas will further be reduced.

The port of Caldera is linked with the San José-Puntarenas line at Salinas.

Puntarenas is the core city developed on a sand spit surrounded by sea on three sides. It is completely urbanized and has less space for expansion. On the other hand, Caldera still has ample space for future expansion.

4-2 Natural Conditions

4-2-1 Wind

According to the data of the weather station at the Chacarita Airport, Puntarenas, prevailing wind directions are N to E at night and S to SW during daytime. Mean wind speeds at daytime are approximately 1.7m/sec. in the dry season (December to March) and 1.1m/sec. in the rainy season (April to November), meanwhile, at night 0.8m/sec. in the dry season and 0.6m/sec. in the rainy season.

4-2-2 Precipitation

The precipitation at the coast of the Gulf of Nicoya is lowest in Costa Rica. The mean annual precipitation for 20 years (1959 – 1979) is 1,556mm at Puntarenas. The maximum mean monthly precipitation is 298mm in September, and minimum is 3mm in January. Thus there is a remarkable difference between the rainy and the dry season.

4-2-3 Temperature

The variation of temperature through a year is relatively low in Costa Rica. The records at Puntarenas show that mean annual temperature is 27.4°C, meanwhile maximum mean monthly temperature is 28.7°C in March and April, and minimum is 26.6°C in September and October.

4-2-4 Waves

The following results were obtained from calculations of the reappearance periods of high waves and their probable heights based on the statistical analysis of wave observation records of the period from June 1978 to June 1981.

Reappearance period	10 years	Wave height	$H^1/_3 = 3.7m$
	20 years		$H^1/_3 = 4.1m$
	30 years		$H^1/_3 = 4.3m$

From the above, $H^1/_3$ = 4.3m, $T^1/_3$ = 18.4 sec. of the probable wave height for the reappearance period of 30 years is suitable as a design wave height for the breakwater.

High waves at $H^1/_3$ = 3.55m and $T^1/_3$ = 17.9 sec. were observed on May 21, 1981. These long-period waves are swells consisting of waves generated in the large area of lat. 50° - 60°S. and long. 120° – 160°W. and propagated over a long distance of 7,000 ~ 9,000km. Thus, long-period waves that often arrive at the Port of Caldera are swells from a great distance. By character, they are close to regular waves and the dispersion width of their directions is presumed to be very small.

The angle of incidence of waves that reach the breakwater of the Port of Caldera is N 220° ~ 230° for periods of 12 ~ 20 sec. thus coming at approximately right angle to the breakwater, after being refracted in Nicoya Bay.

4-2-5 Tide

The design tidal level of the Port of Caldera is the same as the Port of Puntarenas. It is as follows; HWL = +2.84m, MSL = +1.40m LWL = -0.04m.

4-2-6 Littoral Drift

The coast ranging for about 20km each to the north and the south of the Port of Caldera is divided from the view-point of littoral drift characteristics into the following three areas

1 Coast from Puntarenas to Rio Barranca . . . . . (Puntarenas area)
2 Coast from Roca Carballo to Rio Jesus Maria . . . (Caldera area)
3 Coast from Punta Loros to Rio Grande Tárcoles . (Tárcoles area)

The Port of Caldera is situated in the Caldera area which differs from the other two areas in coastal characteristics and the movement of littoral drift there is most unlikely. The accumulation of sand now in progress on the coast to the south of the Port of Caldera is presumably caused by the sediments from Rio Jesus Maria that come round Punta Caldera.

As for Mata de Limón, its catchment area is so small that it is believed to supply hardly any earth and sand to the sea. However, there are signs that its silt and clay washed down in heavy rain have descended into the sea at low tide and settled in the calm waters of the anchorage in front of the wharves to become soft mud.

4-2-7 Earthquake

PGAs (peak ground acceleration) at Caldera are 0.15g for a 50 year return period and 0.175 – 0.2g for 100 year return period. Referring to the relation between designing seismic coefficients and PGAs concerning the various ports in Japan, 0.15 is applied as a seismic coefficient.

4-2-8 Soil Condition

The project area is occupied by Pleistocene and Holocene deposits that consist of loose sand and soft silt. They underlie most of the seabottom and the plain and overlie the bedrock. The bedrock is composed of sandstone, mudstone and those alternation in Tertiary.

On the project wharf site, there lies fine to coarse sand bed. This sand is compacted and N value is 25 to 45. The thickness is more than 12 meters below sea bottom. Consequently, the results of this soil investigation show good possibility of reliable foundation for port facilities.

On the extension on site of the breakwater, fine to very fine sand bed overlies silt bed. The sand bed is loose, the N value is 10 to 20, and the thickness is 7 to 10 meters. The silt bed is soft, the N value is 1 to 7, and the thickness is about 15 meters. Therefore it is essential that the sufficient and correct soil investigation be carried out. The examination of consolidation and slope stability about the foundation of the breakwater should be performed, prior to its implementation.

CHAPTER 5 THE FIRST STAGE PROJECT OF THE PORT OF CALDERA

5-1 The facilities of the First Stage Project

The facilities included in the First Stage Project are as follows;

• Breakwater,	L = 250 m
• Revetment,	L = 840 m
• Wharf (−11 m),	L = 210 m
(−10 m),	L = 150 m
(−7.5m),	L = 130 m
• Dredging,	V = 360,000 m^3
• Cargo Handling Equipment	Forklift, etc.
• Pneumatic unloader,	60t/h x 4 unit
• Freight Handling Facilities	
Transit Shed	7,200 m^2
Warehouse	5,400 m^2
• Port Traffic Facilities,	Road and Railway
• Salinas Cargo Terminal	66 ha.

5-2 Construction Cost and Results of Funding

(1) Construction cost of main facilities

	Unit: 10^3 colones
Wharf and Revetment	316,020
Reclamation and dredging	98,991
Warehouse and office building	40,430
Pavement	43,920
Others	281,380
Total	780,741

(2) Results of funding

Unit: 10^3 colones

Borrowing from Japanese Government	¢485,711
Borrowing from Venezuela Government	142,030
Government fund	153,000
Total	780,741

5-3 Administration and Operation

Studies concerning the administration and operation of the Port of Caldera are now being consolidated mainly by the Direccion de Transporte por Agua of MOPT. A draft plan entitled Sistema de Operation en el Puerto de Caldera (Borrador) has been prepared and MOPT is coordinating with related agencies on this plan.

CHAPTER 6 FORECAST ON PORT DEMAND

6-1 Cargo Volume handled by the Port of Caldera

The Pacific ports of Costa Rica and the types of cargo they handle are as follows:

Caldera: general cargo, wheat,
Puntarenas (Fertica facilities) . raw materails and products of fertilizer
Punta Morales : sugar
Golfito . bananas

Since wheat is not produced in Costa Rica, it is entirely imported through Caldera. Though the average per capita annual consumption of wheat has been small during the past decade at 38kg, it was estimated to increase to the Latin American figure of 50kg in the future. For general cargoes, the figures given in the report dated September 4, 1980, prepared by the Direccion General de Planificacion for comprehensive transport planning, were used. The report classifies the cargo into 76 items and divides the country into 22 areas to forecast imports and exports by computing the balance between supply and demand for each item on the basis of estimated population and income level in the future for each area. Table 6-1 shows the computation of the cargo to be handled at Caldera based on the forecast values.

6-2 Containerization

As regards the present stage of containerization on the central American Pacific routes, they are all served by semi-container vessels or multi-purpose vessels except those full container vessels on the European routes calling at Corinto and Acajutla. Of these, 7 vessels of the Mercante Grancolombiana serving the north American Pacific routes and the Far East routes call at Puntarenas.

Table 6-2 shows the forecast made of the volume of container cargo to be handled at Caldera in the future on the basis of the containerization ratio of each item. Since full container vessels do not yet call at Caldera, an important point in the Second Stage Expansion Project is to forecast the time of calling of full container vessels. So that container vessels can call at Caldera, it will be necessary to meet several conditions, e.g , entering of full container vessels into central American Pacific services, the volume of container cargo at Caldera and an improvement in container handling facilities. On the basis of the information supplied by shipping companies and the cargo volume forecast, full container vessels on the north American routes are expected to begin calling around 1985, followed by those of the European routes. The Far Eastern routes are expected to be the last ones of the three, operating full container services around 1990.

Table 6-1 Import and Export of Caldera, 1980–2000

Unit 1000 M/T

Import	1980	1985	1990	1995	2000
Agricultural products	8 0	15.3	19.0	23 7	29.5
Rubber and its products	0 9	2.5	4.2	5 5	7 0
Paper and its products	12.5	33.3	41.8	47 6	52.6
Fiber, thread and cloth	4 7	7 0	7.8	9 0	10.5
Chemical products	25.0	31.8	37.8	44.7	52.8
Lubricants	6.9	14.2	20.3	28.5	39 6
Fertilizer products	9.0	10.7	12.8	15.3	18.2
Glass and construction materials	6 8	8.2	10.5	13 9	18 5
Machinery	14 9	19.5	22.1	25 9	29.8
Other manufactured products	9.3	12.1	16.1	23.3	33.3
Ingot and scrap	6.3	18 6	19 9	21 4	23.2
Iron and steel	102.3	125.2	151.6	180.8	212.8
Non-ferrous metal products	2.0	3.4	4.2	5 1	6.0
Vehicles	22.2	31.3	39.3	49 5	62 1
Minerals	4 5	5 7	7 0	8 5	10.0
(Total of general cargo)	(235.3)	(338 8)	(414 4)	(502 7)	(605.9)
Wheat	87.6	104 8	125 2	147 9	173.3
Beans and corn	27 0	8 0	9 0	10 0	11 0
(Total of grain)	(114.6)	(112.8)	(134 2)	(157 9)	(184.3)
Total of Import	349 9	451.6	548.6	660.6	790.2
Export	**1980**	**1985**	**1990**	**1995**	**2000**
Beef	6.2	6 9	7.6	10.2	13.5
Coffee and cacao	22.4	31.9	35 4	39.3	45.6
Food and animal feeds	0 6	2.4	5 7	10 8	19.9
Fertilizer products	87.3	96.4	106.4	117.5	129 7
Cotton thread & clothing	0.1	16 8	19 3	22 0	24 9
Non-ferrous metal products	0	9 0	9 0	9.0	9 0
Other manufactured products	0	2.0	2 8	4 0	5 7
Total of Export	116 6	165.4	186.2	212 8	246 3
Total of Import and Export	466.5	617 0	734 8	873 4	1,036 5

Table 6-2 Amount of Container Cargoes

		1980	1985	1990	1995	2000
Import	Volume (1,000 t)	56 2	102.3	134.7	165.9	204 5
	Number (TEU)	3750	6820	8980	11060	13640
Export	Volume (1,000 t)	12.7	46.2	67 8	77.6	89.6
	Number (TEU)	850	3080	4520	5180	5980
Total	Volume (1,000 t)	68 9	148.5	202.5	243.5	294.1
	Number (TEU	4600	9900	13500	16240	19620

CHAPTER 7 SIMULATION STUDY ON THE NUMBER AND THE CONSTRUCTION TIMING OF BERTHS REQUIRED

Simulation tests were made every year from 1980 to the year 2000 for studying the situations after the completion of the First Stage Project and Second Stage Expansion Project to construct additional berths.

When simulating situations after the First Stage Project, the following two cases for the development of containerization were examined in order to study the timing of the execution of the Second Stage Expansion Project.

Case-1 From 1985 on North American Route and from 1990 on European and Far East Routes, full container vessels will stop at the Port of Caldera and have priority in the use of berths.

Case-2: Unless a container berth is constructed, full container vessels will not stop at the Port of Caldera, but semi-container vessels and feeder ships will stop, in stead, for handling containers. In this case, no priority will be given to any type of ships in the use of berths.

The study on the timing of the execution of the Second Stage Expansion Project was made from the following aspects:

(1) Waiting time
(2) Occurrence of waiting ships
(3) Rate of berth occupancy
(4) Internal rate of return

When the Second Stage Expansion Project is not executed, the situations after the First Stage Project are estimated as follows:

Waiting time

If the marginal average waiting time is assumed to be 48 hours, it will be reached in 1987 for Case 1 and 1998 for Case 2.

Occurrence of waiting ships

The waiting ships will reach 30 ~ 40% of total calling ships in 1985 for Case-1 and in about 1990 for Case-2.

Berth occupancy rate

An optimum berth occupancy rate of 60% for 2 berths for large ships will be attained in 1991 for Case-1 and in 1988 for Case-2. Assuming that a marginal rate is 55%, it will be attained in about 1985 – 1986 for Case-1.

Internal rate of return

If full container vessels are in service starting from 1985, the Second Stage Expansion Project may be most advantageously completed in around 1986. It only semi-container vessels are in service as in the present stage, the Second Stage Expansion Project may not be completed earlier.

From the foregoing studies, the timing of completion of the Second Stage Expansion Project is summarized as follows:

Item	The timing of the completion of the Second Stage Expansion Project	
	Case-1	Case-2
Waiting time	1986	1997
Occurrence of waiting ships	before 1985	around 1990
Berth occupancy rate	1986	1988
Rate of internal return	around 1986	1993

When full container vessels serve the Port of Caldera from 1985 under the First Stage Project, the completion of the Second Stage Expansion Project to provide one container berth will be preferably made in 1986 at the latest, if it must be completed before the average waiting time per ship exceeds 48 hours or the berth occupancy rate exceeds 55%.

If full container vessels are not served under after the First Stage Project, the Second Stage Expansion Project may be completed by about 1988 at the earliest.

As full container vessels are presumed actually to start serving the Port of Caldera during the early second half of the 1980's, the completion of the Second Stage Expansion Project is expected to be accomplished in 1986 at the latest.

CHAPTER 8 FACILITIES PLAN

8-1 Mooring Facilities Plan

From the preceding chapter, it is clear that in the Second Stage Expansion Project large ship berths must be quickly be constructed. The berths constructed in the First Stage Project will be insufficient both in depth and in length for full container ships expected in the future, so container berths must be completed in preparation for berthing of full container ships.

The container berth should be a water depth of −12m and a length of 250m in consideration of the future trend of container vessels serving the Central American Route.

The area of the container yard is determined according to the number of containers handled and the container handling system adopted. From the forecast volume of container cargo, the number of containers to be handled in the Second Stage Expansion Project is given in Table 8-1.

Table 8-1 Number of Containers Handled at the Port of Caldera
(unit TEU)

Year	1980	1985	1990	1995	2000
No. of Containers	8,000	15,000	20,000	25,000	30,000

As regards the container handling system, after comparing different systems, the straddle carrier system will be most appropriate in view of initial investment, storage capacity and accessibility.

As regards the required area for the container yard, the simulation will be carried out for handling 20,000 TEU by the straddle carrier system in 1990. The result of the simulation showed that the number of slots required would be 808 TEU and required area 36,000m^2. Main handling equipment will consist of 1 container crane and 4 straddle carriers (or 3 of them and 1 forklift). Fig. 8-1 shows the layout of this system.

The new projected berth will be used low berth occupancy rate only for the use of container cargo. Therefore, it is desirable that new berth will be used by other vessels so far as container vessels are not affected.

8-2 Breakwater

The length of the breakwater is determined in accordance with the number of days that cargoes can be handled for ships berthed at the wharves to be constructed under the Second Stage Expansion Project. The wave height at which container cargo handling is possible at ports, such as the Port of Caldera, infiltrated by long-period waves is 0.2m, at the most. At the present length of 250m of the breakwater, the appearance rate of wave height not exceeding 0.2m is about 80%; thus, container cargo handling is impossible about 75 days per year. For a container wharf, it is desirable to assure about 95% as the appearance rate of wave height to which cargo handling is possible. For this purpose, the breakwater must be extended for 150m to a total of

400m. Since the angle of incidence of waves into the Port of Caldera is at approximate right angle to the breakwater, it is most effective for the breakwater to extended straight from its present line.

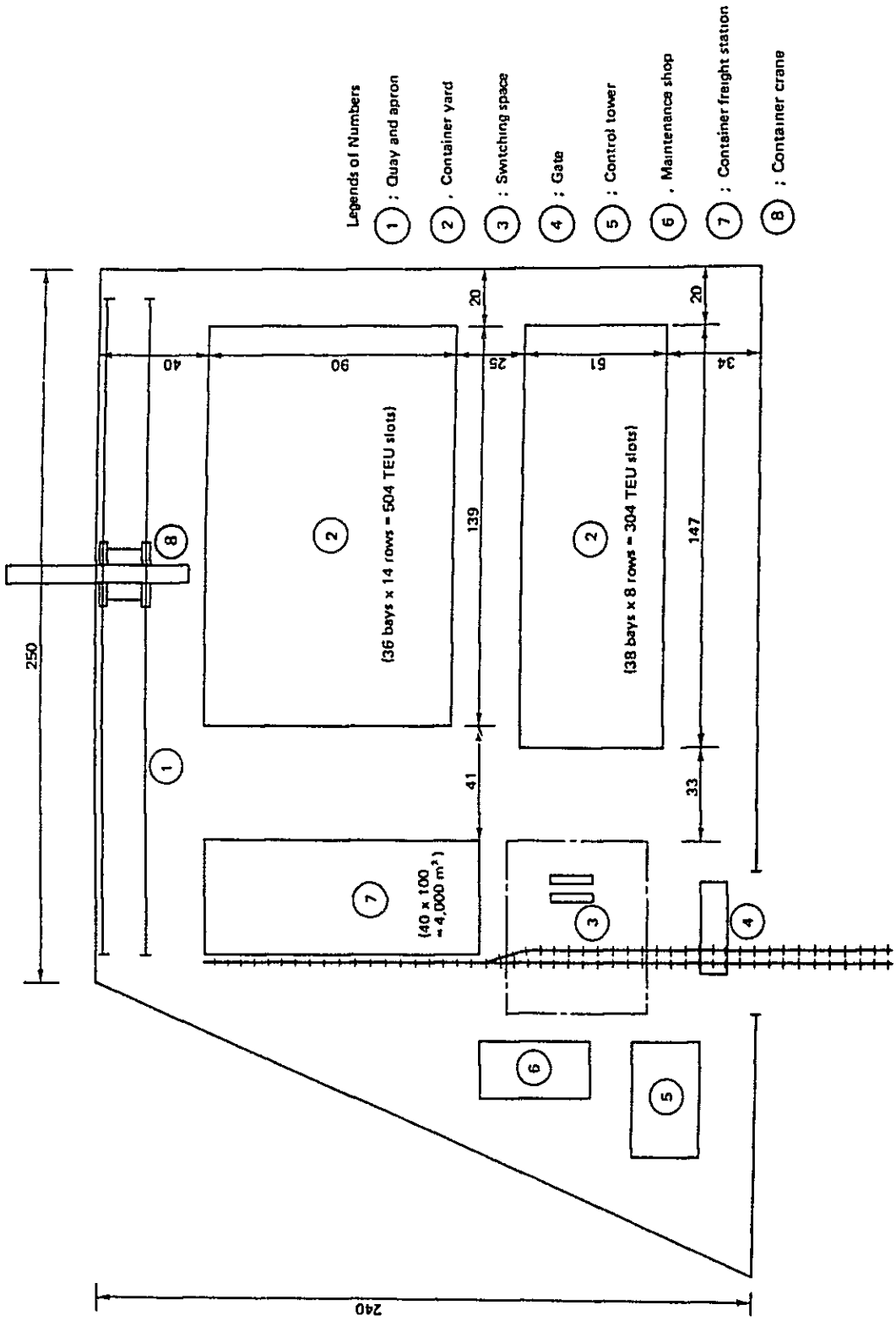
8-3 Facility Against Littoral Drift

Constructing a groyne of about 50m bent by 45° toward the offing from the tip of the existing breakwater is most effective to prevent earth and sand accumulated in front of the breakwater from infiltrating the harbor It will prevent the infiltration of earth and sand into the harbor by not only increasing the earth and sand stock capacity but also causing a flow headed toward the base of the breakwater from its tip. If this groyne cannot stop sand drifting, the next necessary step will be to remove sands in the foreshore of the bulkhead from the land side.

8-4 Long Term Plan

For a long-term plan, the port facilities from 1990 to 2000 have been studied An additional berth of −12m water depth and 240m in length is projected for 30,000 DWT freighter. On the other hand, the container terminal must have a container yard extended by about 20,000cm^2 to handle 30,000 TEU in 2000 The breakwater must be extended by more than 200m.

Fig. 8-1 Layout of Straddle Carrier System



CHAPTER 9 DESIGN, CONSTRUCTION AND COST ESTIMATION

9-1 DESIGN

(1) Breakwater

Three alternatives (a rubble mound type, a wave breaker block type and a caisson type) have been studied. As the design conditions, wave height ($H^{1}/_{3}$) is 4.3m, wave period is 18.5 seconds, and horizontal seismic coefficient is 0.15. The soil condition below −20 m is silt, therefore, the calculation for circular rupture has been done in detail.

(2) Quaywall

Two alternatives (a steel sheet pipe pile type and a caisson type) have been studied. As the design conditions, water depth is −12.0 m, crown elevation is +5.0m, and horizontal seismic coefficient is 0.15. This is not a problem with soil conditions. Regarding the corrosion of steel, a cathodic protection system is adopted in sea water, and thickness allowance is considered in the ground.

(3) Conbinations of structures

Following three combinations should be considered for selecting structures of a breakwater and a quaywall.

Above three alternatives are assessed in terms of four items construction cost, durability, construction period and relative ease of construction. Hence, Plan I has been adopted as basic design.

	Breakwater	Quaywall
Plan I	Rubble mound	Steel sheet pipe pile
Plan II	Wave breaker block	Steel sheet pipe pile
Plan III	Caisson	Caisson

Facilities included in this construction program are as follows:

Table 9-1 List of Facilities

Classification	Facility	Specification
Port facility	Breakwater	Rubble mound L = 150 m
	Quaywall	Steel sheet pipe pile L = 250 m
	Revetment	
	North side	Rubble mound type, L = 300 m
	South side	Rubble mound type, L = 140 m
	Anchorage	Depth −12.0 m, A = 226,000 m²
	Navigation aids	1 lump sum
	Land reclamation	Reclamation, A = 95,000 m²
	and pavement	Pavement, A = 55,000 m²
Related facility	Road	B = 12.0 m, L = 620 m
	Railway sidings	L = 700 m
	Building	Transit shed and container freight station, A = 4,000 m²
		Administration office, A = 1,000 m²
		Repair shop, A = 800 m²
	Water supply, Sewerage, Power distribution system	1 lump sum

9-2 CONSTRUCTION

(1) Execution Plan

The approximate quantities of main materials to be used for this work are generally estimated as follows:

Table 9-2 Construction Materials

Material	Quantity
Steel pipe pile	4,000 tons
Reinforcing bar	250 tons
Tie rod	235 pcs
Other steel	1,200 tons
Concrete	13,000 m³
Rubble	*290,000 m³
Sand	*5,000 m³
Reclamation materials	860,000 m³

(* Excluding materials for concrete)

Of these materials, steel sheet pipe piles and other steels will be imported. Construction equipment, such as bulldozers, payloaders, crawler cranes and dump trucks which were imported for the First Stage Project, can be used for this construction except some equipment that have become worn out. However, main working crafts will be brought from abroad. Labor force can be procured locally, except special skilled laborers such as divers for grading rubble mound

(2) Construction schedule

Construction schedules including the period of executing soil investigation and design is shown in Table 9-3. The period required for completion is 48 months.

9-3 Cost Estimation

The construction cost is $30,450,000. as shown in Table 9-4.

Table 9-4 Construction Cost of Plan

U.S. dollars 1,000.00

Item No.	Description	Unit	Quantity	Amount	Foreign Currency	Local Currency
1	Breakwater	m	150	3,393	949	2,444
2	Wharf	m	250	8,557	7,266	1,291
3	Revetment	m	440	1,366	518	848
4	Dredging & Reclamation	m^3	820,000	2,870	1,886	984
5	Navigation aid	sum	1	158	130	28
6	Road & Container yard pavement	sum	1	1,286	-	1,286
7	Railway	sum	1	331	100	231
8	Buildings	sum	1	2,136	648	1,488
9	Electric power, Water supply & Sewerage	sum	1	950	300	650
10	Container handling equipment	sum	1	4,500	3,350	1,150
11	Mobilization & demobilization	sum	1	970	850	120
	Sub-total			26,517	15,997	10,520
12	Engineering study & Design	sum	1	778	736	42
13	Physical contingency	sum	1	3,155	1,767	1,388
	TOTAL			30,450	18,500	11,950

Table 9-3 Construction Schedule

Work			Month															
Item	Unit	Q'ty	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48
Soil investigation	sum	1.																
Engineering study/Detail design	sum	1.																
Tender/Evaluation/Award	sum	1.																
Mobilization/Demobilization	sum	1.																
Breakwater	m	150.																
Quaywall	m	250.																
Revetment	m	440.																
Dredging/Reclamation	m^3	820,000																
Road/Container yard pavement	sum	1.																
Railway	sum	1.																
Building	sum	1.																
Electric power/Water supply/Sewerage	sum	1.																

CHAPTER 10 ECONOMIC ANALYSIS

This chapter discussed as to whether the Second Stage Expansion Project is economically feasible as a project.

Economic effects expected of the Second Stage Expansion Project are the maintenance of efficient port cargo handling environments for the future increase of the volume of cargoes handled and the enjoyment of the merits of container transport system to be brought about by the call of container ships. These economic effects were evaluated by cost and benefit analysis, assuming a project life of 25 years and using 1981 as the basic year.

A study was made concerning the following two cases:

Case-1: Full container ships will call at the Port of Caldera from 1985 and be given priority in using berths and, from 1986, exclusively use facilities completed under the Second Stage Expansion Project.

Case-2: No full container ships call at the First Stage Project Facilities. After container facilities are completed under the Second Stage Expansion Project, full container ships will call at the Port of Caldera

As benefits, evaluation was made of port staying cost and feeder charges which can be measured in specific terms.

Besides, the following indirect economic effects for users and regional development in the vicinity of the Port of Caldera can be expected as indirect benefits:

(1) Reduction of inventory costs and interest payments as a result of shortening and increased puncturality of transportation time.

(2) Reduction of cargo packing and crating costs.

(3) Prevention of theft and damage of cargoes.

(4) Regional development in the vicinity of the Port of Caldera.

(5) Improved conditions for industrial location, which is conducive to the attraction of companies.

(6) The continuation of port construction will give demand for related industries and increase employment.

(1) Construction cost, (2) operation cost and (3) cost of maintenance and repair were adopted as project costs.

Calculated prices evaluated by border prices (international prices) were used for all benefits and costs. As the result, 14.9% and 7.8% were obtained for, respectively, Case 1 and Case 2 as the internal rate of return. Since internal rates of return for other Costa Rican projects, etc. are 13 ~ 18%, Case 1 can be said to be a project that is sufficiently profitable from the view-point of national economy.

In a sensitivity analysis, Case 1 had a considerable internal rate of return and involved no special problem from the view-point of economic profitability.

Therefore, decision on the execution schedule for this project (Case 1) should be comprehensively made in light of the role of the Port of Caldera as a foreign-trade public port and the prospects of fund raising.

CHAPTER 11 FINANCIAL ANALYSIS

The purpose of this financial analysis is to analyze as to how the costs and benefits of the execution of this project affect the financial status of the management body and study its financial health or propose measures to make it healthy.

2. In analyzing, financial statements were prepared and studied under the following conditions:

(1) The Port of Caldera is operated on a self-paying basis by the cost method.

(2) The operation and raising of funds are assumed similarly to the results of the First Stage Project as follows:

<Necessary funds>

Foreign funds	¢277,500,000
Domestic funds	179,250,000
Total	456,750,000

<Fund raising>

Loans 1	¢277,500,000
" 2	89,625,000
Government funds	89,625,000
Total	456,750,000

(3) Depreciation is made by the fixed instalment method. The period of depreciation is in accordance with the standard of the Costa Rican Government.

(4) Revenue

The provisional tariff prepared by the MOPT was used in estimating the revenue of the Port of Caldera.

(5) Financial Statements

When the Second Stage Expansion Project is completed, equipment provided under this project will be operated together with equipment completed by the First Stage Project – including administration. So, the financial statements were prepared on the assumption of integrated operation of First Stage and Second Stage Expansion Project equipment.

The financial statements were prepared as of 1981. Further, it was assumed that investment for the Second Stage Expansion Project will be started in January 1982 and completed in December 1985 and that facilities constructed under this project begin to be used from January 1986.

(6) Taxes and Public Charges

Taxes and public charges for profits were not taken into consideration because the Port of Caldera is operated directly by the Costa Rican Government.

(7) 20% and 16% were assumed for, respectively, the interest for short-term loans and the interest for money on deposit.

The financial statements were prepared under the abovementioned conditions and the financial health of the Port of Caldera was studied using these statements. The results are shown in tables attached to the end of this chapter. The revenue and the expenditure are unbalanced

and financing is constantly difficult: thus it will be difficult to operate the Port of Caldera on a self-paying basis.

Therefore, to maintain the financial health of the Port of Caldera and keep us its operation on a self-paying basis, it will be necessary to consider the following measures:

(1) Re-study of Tariff

The current tariff was set by cost accounting assuming $1 = ¢8.54. So, it will be some time before the operation cost can be financed with the revenue. Also, the revenue cannot cover the payment of interest for loans necessary for equipment investment. Therefore, considering increase of the tariff might be advisable.

(2) Government Subsidy for Short-term Operating Funds

Because of financial difficulties arising from the shortage of revenue, there is no choice but to borrow operating funds. It is assumed that these funds will be financed with short-term loans from city banks. But since no early improvement of profitability is in prospect, the burden of the interest for these loans is heavy. It might, therefore, be advisable for the Government to supply the shortage of operating funds until fund shortages are liquidated.

(3) Heavy Burden of Interest for Borrowed Investment Funds

This project depends on long-term loans for most of the investment funds. Further, the operation cost cannot be financed with the revenue Under these circumstances, the burden of the interest for loans is excessive. It is, therefore, necessary to reconsider fund raising for the Second Stage Project so as to increase financing from government funds, and for government to take over the repayment of the First Stage Project's loans.

CHAPTER 1
OUTLINE OF STUDY

CHAPTER 1. OUTLINE OF STUDY

1-1. Background of Study

The first stage project of the Port of Caldera will be completed within 1981 and port functions will be transferred there from Puntarenas where facilities have become extremely obsolete.

The Port of Puntarenas has until now been the only public port for foreign trade on the Pacific side of Costa Rica. But it is, indeed, inefficient with two berths as mooring facilities for large ships: ship waiting occurs there almost chronocally and only railway freightcars are available for cargo handling.

The Government of Costa Rica, in the belief that the construction of a new port on the Pacific side is indispensable as a basis for the economic and social development of the country decided to construct a new port of Caldera in accordance with the conclusions of the feasibility study conducted by a Japanese study team in 1972 after the study by French consultants in 1955 and the United Nations-aided studies in 1963 and 1968.

The construction of the Port of Caldera started with land reclamation in November 1974. Breakwater construction started from June 1976 and wharf construction from January 1978. The whole construction is expected to be completed by the end of 1981.

When opened, the Port of Caldera will have three berths as mooring facilities. Thus with the modernization of its cargo handling equipment, its capacity and efficiency of cargo handling will increase. Maintaining in the future this greatly improved cargo handling efficiency is, indeed, necessary for the stabilization and development of the Costa Rican economy. For this purpose, the Second Stage Expansion Project of the port of Caldera has been planned so as to be able to meet new port facility needs such as the future increase of cargo volume and the renovation of marine cargo transportation through containerization.

1-2. Purpose of Study

The purpose of this study is to assess the feasibility of preparing the Second Stage Expansion Project by the year 1990 and a masterplan year 2000, so as to meet the demand for new port facilities that can cope with the increase of cargo volume resulting from the future economic growth of the country and the modernization of marine cargo transportation through containerization.

Matters to be studied for this purpose are as follows:

Natural conditions
Forecast on port demand
Simulation study
Facilities plan
Basic design
Construction program
Economic analysis
Financial analysis

1-3 Formation of the survey team

1-3-1 Methods of Investigation

Methods of investigation are generally classified into verbal, field observation and collection of informative materials. Names of the authorities and organizations visited by the team for hearing and collecting informative materials are listed below.

Ministerio de Obras Públicas y Transportes
Instituto Costarricense de Puertos del Pacífico
Junta de la Administración Portuaria y de
Desarrollo Económico de la Vertiente Atlántica
Direccion General de Estadistica y Censos
Banco Central de Costa Rica
Ministerio de Trabajo y Sequridad Social
Export-Investment Promotion Center
Instituto Nacional de Vivienda y Urbanismo
Corporación Zona Franca de Exportacion y Parques Industriales
Oficina de Planificacion Nacional y Política Económica
Ministerio de Hacienda
Systan International Inc.
Fertilizantes de Centroamerica (Costa Rica) S.A.
Refinadora Costarricense de Petroleo S.A.
Asociación Bananera Nacional
Oficina del Café
Molinos de C.R.S.A.
CARREZ S.A.
RECOPE (MOIN)
Agencias Unidas
Agencias Marítimas y Comerciales
Remarsa
Náutica Centroamericana, S.A.
Ambos Mares Ltda.
Rafael Angel Ulloa
Felipe J. Alvarado
Colina & Cia. S.A.

Field observation was conducted at the following places:

The Port of Caldera
The Port of Puntarenas
The Port of Limon
The Port of Moin
The Port of Punta Morales
Dantas (quarry)

1-3-2 Survey Team

(1) Field Investigation

The field investigation was conducted for a period of about one month from July 9 to August 12, 1980.

The members of the team are follows:

Mr. Masahiko MATSUYAMA (Head)
Director
The Overseas Coastal Area Development
Institute of Japan (OCDI)

Mr. Kazumasa ASAYAMA
Port Planning, Port Facilities
Engineer, OCDI

Mr. Shoji KAZAMA
Financial Analysis and Port Management Planning
Economist, OCDI

Mr. Yoshiaki TAHIRA
Cost Estimation, Structural Design and Construction Plan
Engineer, OCDI

Mr. Katsuhiko ONO
Port Demand Survey
Engineer, OCDI

Mr. Kunio SASAKI
Natural Conditions and Subsoil Investigation
Engineer, OCDI

Mr. Hiroyuki NISHIZIMA
Co-ordinator to the Team
The Japan International Cooperation Agency (JICA)

One of the members, Mr. NISHIJAMA returned to Japan on July 22. In addition, Mr. SASAKI stayed on for soil exploration, and returned to Japan on October 3.

(2) Soil Exploration

Soil exploration was conducted again from February 4 to March 10, 1981. The specialist is;

Mr. Kunio SASAKI
Soil Condition, Engineer, OCDI

(3) Interim Report

For the Interim report, a team was dispatched to Costa Rica during 14 days from March 30 to April 12, 1981. The members of the team are as follows:

Mr. Masahiko MATSUYAMA (Head)
Director, OCDI

Mr. Takashi HASHIKAWA
Economic Analysis, Port Planning
Engineer, OCDI

Mr. Yoshiaki TAHIRA
Cost Estimates and Construction
Engineer, OCDI

(4) Explanation and Conference on Draft Final Report

The explanation and conference on the draft final report was held for a period of 19 days from August 12 to August 30, 1981.

The members of the team are follows:

Mr. Masahiko MATSUYAMA (Head)
Director, Natural Condition, OCDI

Mr. Takashi HASHIKAWA
Economic Analysis, Port Planning
Engineer, OCDI

Mr. Yoshiaki TAHIRA
Structural Design, Cost Estimates and Construction
Engineer, OCDI

Mr. Tadashi OHTANI
Economic and Financial Analysis
Economist, OCDI

1-3-3 Counterparts

The Costa Rica counterparts are shown below.

Ing. José Chacón Laurito	Director, Port and River Works, MOPT
Ing. Enrique Marín Arce	Sub-Director, Port Works, MOPT
Ing. Alfredo Wesson Acuña	Chief Design Engineer, MOPT
Ing. Carmen Hidalgo Barrantes	Chief, Basic Studies Section, MOPT
Ing. Edwin Rodríguez Aguilera	Chief, Electric Engineering Section MOPT
Ing. Ronald Mesén Vega	Chief, Resident Engineer, Caldera Project, MOPT
Sr. José F. Rojas Zamora	Staff, Basic Studies Section, MOPT
Sr. Rodolfo Sancho Dittel	Staff, Basic Studies Section, MOPT
Sr. Gene Zamora Chaves	Staff, Basic Studies Section, MOPT

1-3-4 Progress of Investigation

(1) The progress of field investigation (excluding that of the soil expert) is as follows:

July	7 (Mom.)	Tokyo → Los Angeles
	8 (Tue.)	Los Angeles → San Jose
	9 (Wed.)	Courtesy visit at the Embassy of Japan Courtesy visit at the Ministry of Public Works and Transports Explanation of Inception report.
	10 (Thu.)	Courtesy visit to Minister, MOPT Explanation of Questionnaire to MOPT officers
	11 (Fri.)	Discussion with MOPT officers on the questionnaire
	12 (Sat.) 13 (Sun.)	Data analysis and discussion in the Team

	14 (Mon.)	Discussion with MOPT, Planning Dep. and Caldera Commission officers
	15 (Tue.)	Interview to the Directorate General of Transports by Water, MOPT, Central Bank of Costa Rica, Costa Rican Pacific Ports Agency and the Directorate General of Estadistica Censos, Ministerio de Economia Industria y Comercio
	16 (Wed.)	San Jose → Puntarenas The field investigation on Dantas (quarry), the Port of Caldera and Puntarenas
	17 (Thu.)	The field investigation of the Port of Caldera Interview of Costa Rican Pacific Ports Agency and Fertilizer of Central America
	18 (Fri.)	Puntarenas → San Jose The field investigation on the Port of Puntarenas and Punta Morales
	19 (Sat.)	Discussion with MOPT officers on the design and construction of the Port of Caldera
	20 (Sun.)	Data Analysis and discussion in the Team
	21 (Mon.) – 23 (Wed.)	Collection of informative materials
	24 (Thu.)	San Jose → Limon The field investigation of the Port of Limon Interview to the Agency for Atlantic Ports Administration and Economic Development
	25 (Fri.)	Limon → San Jose The field investigation of the Port of Moin, the Industrial Freezone and the Industrial Park
	26 (Sat.)	Discussion with MOPT officers on the loading and unloading System
	27 (Sun.)	Data Analysis and discussion in the Team
	28 (Mon.)	Economic members Discussion with the Directorate of Economical Planning Another members Collection of informative materials
	29 (Tue.)	Collection of informative materials
	30 (Wed.)	Collection of informative materials Discussion with the Vice-Minister of Finance on finance and customs
July	31 (Thu.)	
August	1 (Fri.) – 6 (Wed.)	Preparation of provisional observation report
	7 (Thu.)	Information of the outline of investigation and explanation of the provisional observation report to the Japanese Ambassador

	8 (Fri.)	Explanation of the provisional observation report to MOPT officers
	9 (Sat.) – 10 (Sun.)	Data Analysis
	11 (Mon.)	Drawing up Record of Discussion
	12 (Tue.)	Courtesy visits to the Ministry of Public Works and Transports and the Embassy of Japan to departure for Japan
	13 (Wed.)	San Jose → Los Angeles
	14 (Thu.) – 15 (Fri.)	Los Angeles → Tokyo

(2) The progress of field investigation by the soil expert is as follows. Until July 18, he engaged in the same activities as the other members of the team.

July	19 (Sat.) – 21 (Mon.)	Discussion with MOPT officers on the design and construction of structures
	22 (Tue.) – 31 (Thu.)	Boring Work No. 80-12.
August	1 (Fri.) – 19 (Tue.)	Preparing of the first soil explanation report Guidance of drilling log
	20 (Wed.) – 22 (Fri.)	Work of boring No. 80-16
	23 (Sat.) – 24 (Sun.)	Drawing up the first soil explanation report
	25 (Mon.) – September 18 (Thu.)	Boring Work No. 80-7. 8. 9. 11.
	19 (Fri.) – 29 (Mon.)	Guidance on sampling, preparation of report
	30 (Tue.)	Courtesy visit to the Embassy of Japan
October	1 (Wed.)	San Jose → Mexico
	2 (Thu.) – 3 (Fri.)	Mexico → Tokyo

(3) The progress of second field investigation by the soil expert is as follows.

February	4 (Wed.)	Tokyo → Los Angeles
	5 (Thu.)	Los Angeles → San Jose
	6 (Fri.)	Courtesy visits to the Embassy of Japan and MOPT
	7 (Sat.) – 8 (Sun.)	The field investigation of the Port of Caldera
	9 (Mon.) ~ 26 (Thu.)	Boring Work No. 80-4, No. 80-5 and No. 80-6.
	27 (Fri.) ~ March 6 (Fri.)	Attended uniaxial compression test and triaxial compression test at ICE soil testing laboratory

	7 (Sat.)	Guidance on boring No. 80-7 and sampling
	8 (Sun.)	San Jose → Mexico
	9 (Mon.)	Mexico → Los Angeles
	10 (Tue.)	→ Tokyo

(4) The progress of interim report is as follows·

March	30 (Mon.)	Tokyo → Los Angeles
	31 (Tue.)	Los Angeles → San Jose
April	1 (Wed.)	Courtesy visits to the Embassy of Japan and the Ministry of Public Works and Transports
	2 (Thu.)	Explanation of the interim report to MOPT.
	3 (Fri.)	— ditto —
	4 (Sat.)	San Jose ↔ Caldera The field investigation of the Port of Caldera
	5 (Sun.)	Data Analysis and discussion in the Team
	6 (Mon.)	Discussion with MOPT officers Preparing draft final report
	7 (Tue.)	San Jose ↔ Limon The field investigation of the Port of Limon and Moin
	8 (Wed.)	Discussion and signing of Record of Discussion
	9 (Thu.)	Courtesy visits to the Embassy of Japan and the Ministry of Public Works and Transports
	10 (Fri.)	San Jose → San Francisco
	11 (Sat.)	San Francisco
	12 (Sun.)	→ Tokyo

(5) The progress of explanation and discussion of the draft final report is as follows:

August	12 (Wed.)	Tokyo → Los Angeles
	13 (Thu.)	Los Angeles → San Jose
	14 (Fri.)	Courtesy visit to the Embassy of Japan Arrangements with MOPT officers on schedule
	15 (Sat.)	Data Analysis
	16 (Sun.)	Discussion in the Team
	17 (Mon.)	San Jose → Caldera The field investigation of Dantas (quarry) and the Port of Caldera
	18 (Tue.)	The field investigation around the Port of Caldera by ship
	19 (Wed.)	Survey of breakwater
	20 (Thu.)	Explanation and discussion of the draft final report
	21 (Fri.) – 23 (Sun.)	Discussion of the results of the field investigation and work based of those results
	24 (mon.)	Discussion with MOPT officers

25 (Thu.) Explanation of the draft final report, discussion of policy on future consolidation of report

26 (Wed.) Discussion of record of discussion

27 (Thu.) Signature of Record of Discussion Report to the Embassy of Japan

28 (Fri.) San Jose → San Francisco

29 (Sat.) San Francisco → Tokyo

30 (Sun.)

CHAPTER 2
GENERAL DESCRIPTION OF COSTA RICA

CHAPTER 2. GENERAL DESCRIPTION OF COSTA RICA

2-1. Population

Table 2-1-1 lists the nation's population from 1958 to 1977 according to the statistics furnished by the Directorate General of Statistics and Census (D.G.E.C.) and the annual rates of population increase over each preceding year, as calculated from these populations. The average rate of increase for the past 10 years has been 2.68% and the total population topped two million in 1976.

Table 2-1-2 shows statistics by the Directorate of Economic Planning (OFIPLAN) and population estimates up to the year 2000. Fig. 2-1-1 was prepared from the statistics of Table 2-1-1 and the estimates in Table 2-1-2. According to this forecast, population increases will gradually slow down in the future and are expected to break the 2% level around 1995. The population in 2000 will be about 3,377,000.

Fig. A 2-1-1 shows the distribution of population densities by Cantons in 1977 while Fig. A 2-1-2 shows the population structures in 1960, 1980 and 2000.

2-2. Economic Growth

According to the Cifras de Cuentas Nacionales de Costa Rica issued by the Central Bank of Costa Rica (BCCR), Gross Domestic Products (GDP) from 1957 are as shown in Table 2-2-1 and Fig. 2-2-1. Nominal growth rates, real growth rates and price escalation (all in comparison with preceding years) determined from this table are shown in Table 2-2-2 and Fig. 2-2-2.

Costa Rica uses 4–5 years as the time unit for its economic plans and no plans have covered 10 years or more. Future GDP values estimated by the OFIPLAN and revenues estimated by the Directorate General of Planning, Ministry of Public Works and Transport (DGP/MOPT) are listed in Table A2-2-1. Since these figures are based on different base years and denoted by different units, they are rearranged in Table 2-2-3, using prices as of 1976 and the monetary unit colon for all. According to this table, the future increase rate is likely to be about 5%. Actual and estimated GDP values are shown in Fig. 2-2-3 (logarithmic scale).

GDP per capita of population is shown in Table 2-2-4 from OFIPLAN statistics.

2-3. Industries

(1) Agriculture

① Export Goods: Beef, bananas, sugar and coffee are the nation's major export goods. Cows are produced nationwide and are raised in particularly large numbers in Guanacaste Province and the Peninsula of Nicoya in the West. Bananas are produced in the vicinity of Guapiles in Limón Province, and in the southern part of Golfito and exported from ports in these districts. Sugar cane is mainly produced in Alajuela, Grecia and Turrialba in the central highlands. Coffee is also mainly produced in the central highlands. The supply and demand of rice is generally balanced but more than 10,000 tons have been exported in some years. Rice is mostly produced in the districts of Quepos, Coto, Buenos Aires and Guanacaste. (Fig. 2-3-1)

Table 2-1-1 Population of Costa Rica

Year	Population at 1 of July	Increasing rate (%)
1958	1,153,220	
1959	1,199,745	4.03
1960	1,254,055	4.53
1961	1,297,935	3.50
1962	1,343,370	3.50
1963	1,390,770	3.53
1964	1,439,050	3.47
1965	1,489,825	3.53
1966	1,540,760	3.42
1967	1,589,862	3.19
1968	1,634,423	2.80
1969	1,685,170	3.10
1970	1,727,367	2.50
1971	1,797,836	4.08
1972	1,842,831	2.50
1973	1,872,747	1.62
1974	1,921,572	2.61
1975	1,968,438	
1976	2,017,986	2.52
1977	2,070,560	2.61

Source: Anuario eatadistico de Costa Rica, 1977, Dirección General de Estadistica y Censos

Table 2-1-2 Population of Costa Rica

Record and Projection

Year	Population	Increasing rate, annual average (%)
1950	858,245	
1955	1,023,899	3.59
1960	1,236,082	3.84
1965	1,482,376	3.70
1970	1,732,098	3.16
1975	1,964,900	2.55
1980	2,213,363	2.41
1985	2,484,521	2.34
1990	2,775,530	2.24
1995	3,075,139	2.07
2000	3,377,458	1.89

Source: OFIPLAN

Fig. 2-1-1 Trend of Population Increase

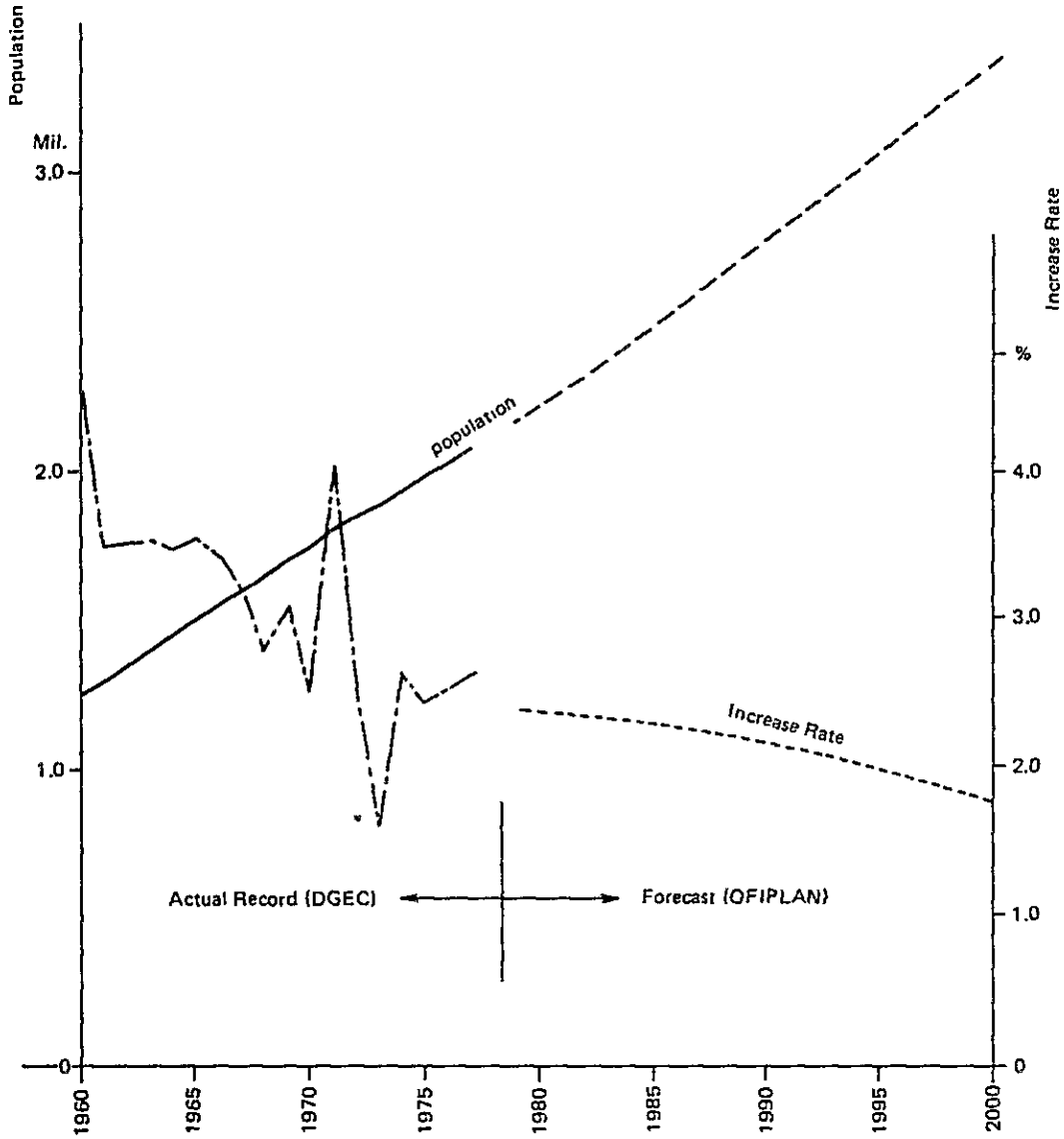


Table 2-2-1 Gross Domestic Product of Costa Rica

Unit; million colones

Year	Current Price	1966		1976	
		Deflator	Constant Price	Deflator	Constant Price
1957	2,500.4	0.9349	2,674.6	0.3565	7,014
1958	2,609.0	0.9322	2,798.7	0.3555	7,339
1959	2,678.5	0.9174	2,919.8	0.3499	7,655
1960	2,860.5	0.9238	3,096.5	0.3523	8,120
1961	2,929.3	0.9551	3,066.9	0.3642	8,043
1962	3,186.6	0.9607	3,316.8	0.3664	8,697
1963	3,404.2	0.9795	3,475.5	0.3735	9,114
1964	3,608.2	0.9968	3,619.7	0.3801	9,493
1965	3,928.5	0.9882	3,975.5	0.3769	10,423
1966	4,288.4	1.0000	4,288.4	0.3814	11,244
1967	4,633.9	1.0228	4,530.7	0.3901	11,879
1968	5,126.7	1.0432	4,914.6	0.3978	12,888
1969	5,655.3	1.0908	5,184.5	0.4160	13,594
1970	6,524.5	1.1706	5,573.5	0.4464	14,616
1971	7,137.0	1.1992	5,951.3	0.4573	15,607
1972	8,215.8	1.2761	6,438.0	0.4867	16,881
1973	10,162.4	1.4655	6,934.3	0.5589	18,183
1974	13,215.7	1.8057	7,318.8	0.6886	19,192
1975	16,804.6	2.2489	7,472.5	0.8576	19,595
1976	20,675.6	2.6222	7,884.8	1.0000	20,676
1977	26,330.7	3.0664	8,586.9	1.1694	22,516
1978	30,193.9	3.3089	9,125.1	1.2619	23.927
1979	34,233.3	3.6332	9,422.3	1.3856	24,706

Source: Cifras de cuentas nacionales de Costa Rica 1957–1977, 1970–1978

1979 – estimate

Fig. 2-2-1 Trend of GDP (As of 1976)

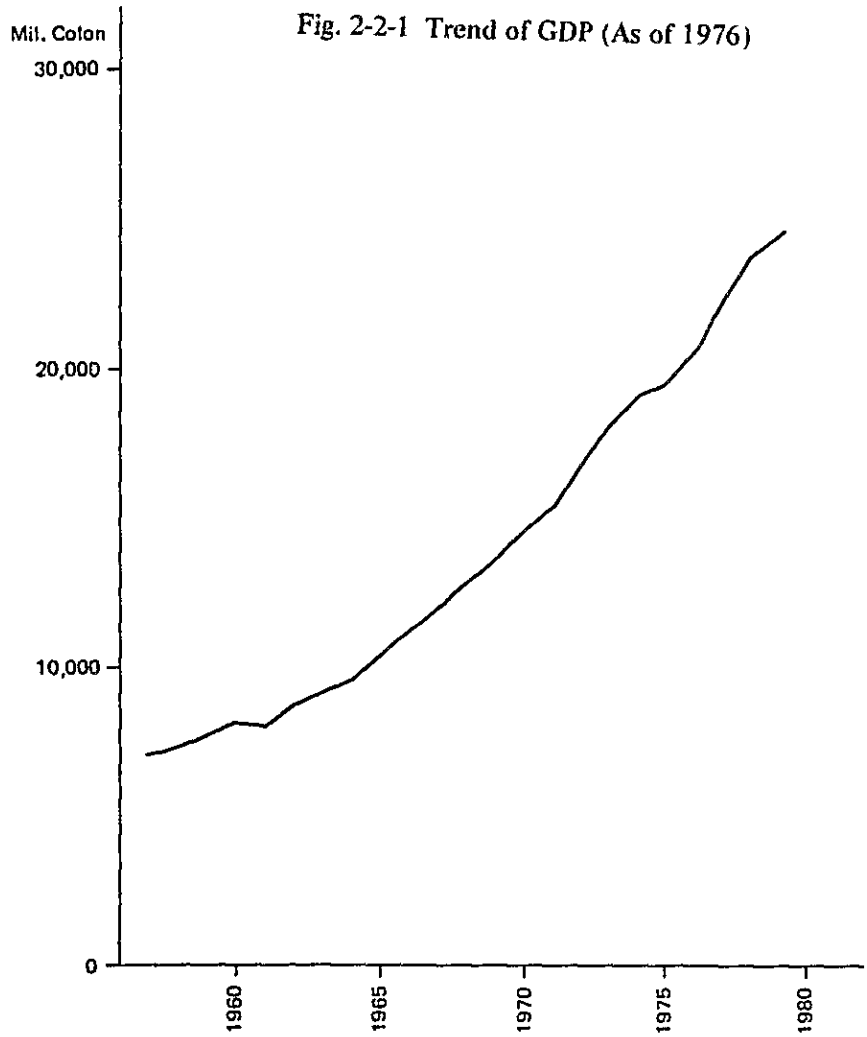


Fig. 2-2-2 Trend of GDP Increase Rate

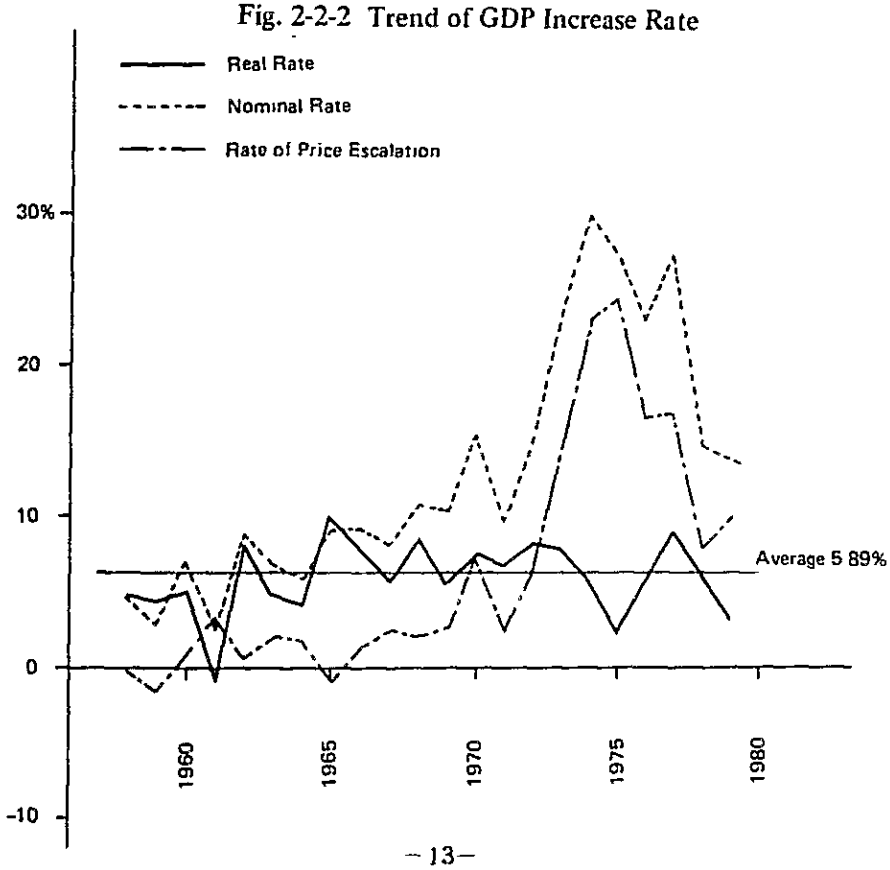


Table 2-2-2 Annual Increase Rate of GDP

Year	Nominal Rate	Real Rate	Rate of Price Escalation
1958	4.34%	4.64%	-0.29%
1959	2.66	4.33	-1.59
1960	6.79	6.05	0.70
1961	2.41	-0.96	3.39
1962	8.78	8.15	0.59
1963	6.83	4.78	1.96
1964	5.99	4.15	1.77
1965	8.88	9.83	-0.86
1966	9.16	7.87	1.19
1967	8.06	5.65	2.28
1968	10.63	8.47	1.99
1969	10.31	5.49	4.56
1970	15.37	7.50	7.32
1971	9.39	6.78	2.44
1972	15.12	8.18	6.41
1973	23.69	7.71	14.84
1974	30.05	5.54	23.21
1975	27.16	2.10	24.51
1976	23.04	5.52	16.60
1977	27.35	8.90	16.94
1978	14.67	6.27	7.91
1979	13.38	3.26	9.80 estimate
Average	12.63%	5.89%	

Source: Cifras de cuentas nacionales de Costa Rica, BCCR

Table 2-2-3 Forecast of Gross Domestic Product of Costa Rica (As of 1976)

unit; million colones (1$ ≈ 8.54₡)

	Year	OFIPLAN	BCCR	DGP/SYSTAN (income)
Actual	1973			17,884
	1976	20,675.6		
	1978	(23,927)	(23,927)	23,551
Estimate	1980	25,318 6	25,124	25,551
	1981		25,857	
	1982	27,907.8	27,200	
	1983		28,513	
	1984		29,715	
	1985	32,250.6	30,904	32,135
	1990	40,978.4		40,731
	1995	51,989.0		51,756
	2000	65,943		65,942
Increase Rate	1980 −1985	4.96%	4.23%	4.69%
	1980 −1990	4.93		4.77
	1980 −1995	4.91		4.82
	1980 −2000	4 90		4.85

Table 2-2-4 GDP per Capita (1976)

Year	GDP (1976) million colones	Population	GDP per capita colones	
1976	20,675.6**	2,017,986**	10,246	
1980	25,318.6	2,213,363	11,439	+2.79%
1985	32,250.6	2,484,521	12,981	+2.56%
1990	40,978.4	2,775,530	14,764	+2.61%
1995	51,989.0	3,075,139	16,906	+2.75%
2000	65,943	3,377,458	19,524	+2.92%

Source: OFIPLAN

* Anuario Estadistico 1977

** Cifras de cuentas nacionales

Fig. 2-2-3 Forecast of GDP

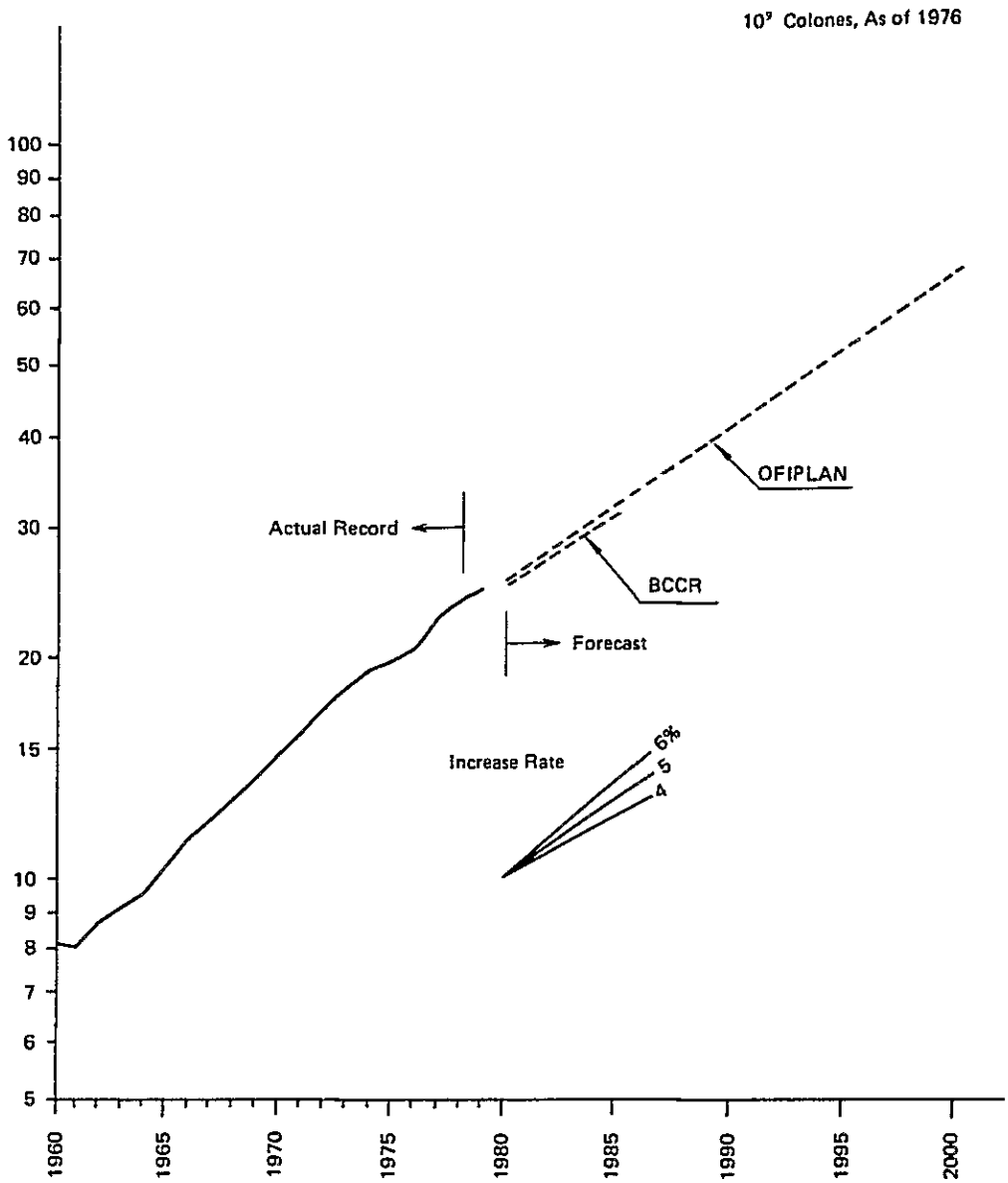
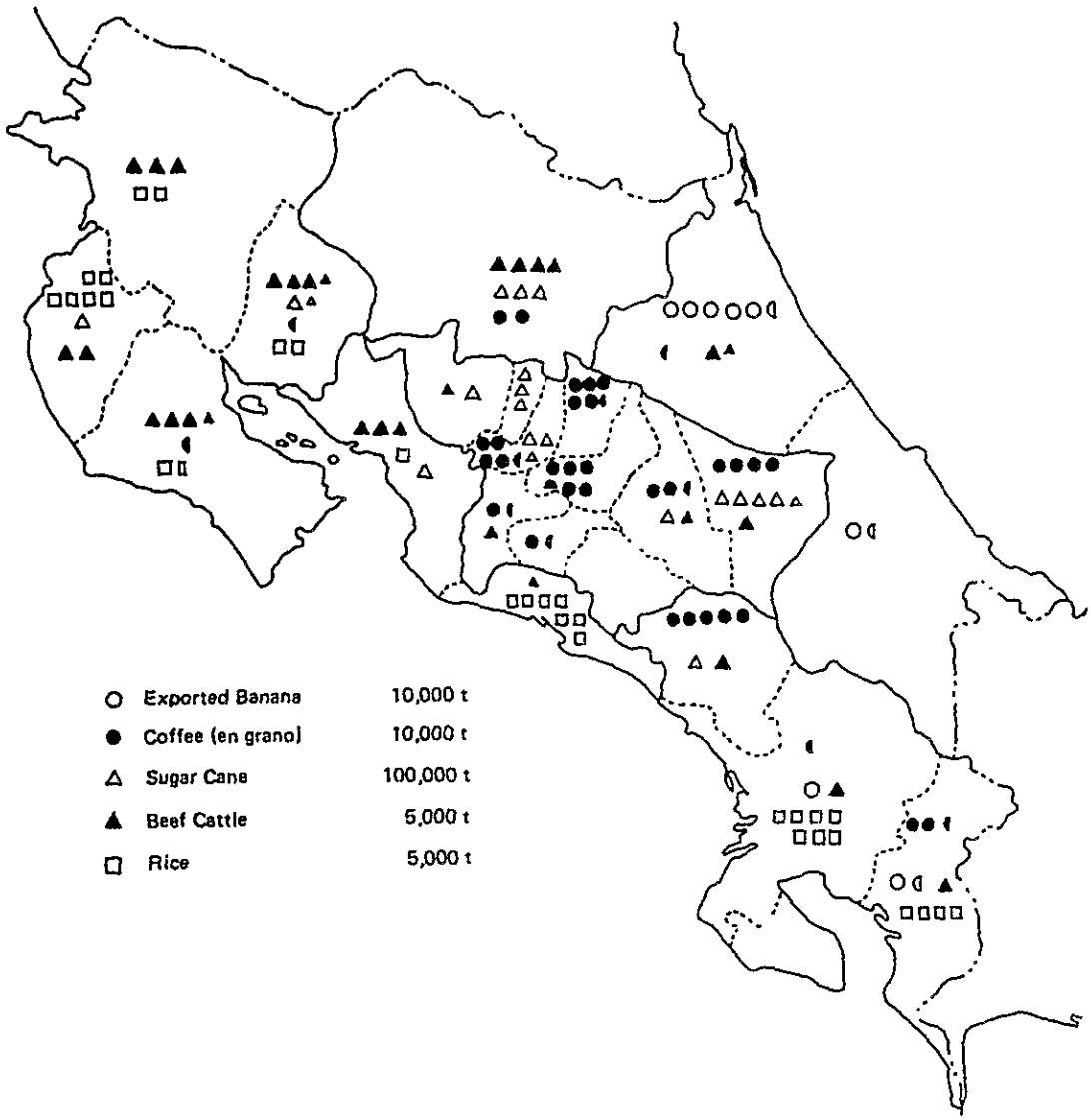


Fig. 2-3-1 Major Agricultural Production (1977)



② Goods in Self-sufficiency: The domestic production of chicken, eggs, milk and dairy products, maize (sorgo), beans (frijoles), fruit and vegetables is generally balanced with their domestic consumption and practically none is exported or imported.

③ Import Goods: Wheat is not produced in Costa Rica and all the needs are imported. It is imported from the U.S. A. and mostly shipped from New Orleans. Also, processed foods are imported in large quantities.

(2) Manufacturing Industries

Costa Rica does not abound in natural resources and its heavy industry is undeveloped.

All petroleum is imported from Venezuela and Crazao but RECOPE at Moin can refine only 13,000 to 14,000 barrels a day so the country imports approximately as much refined oil as crude oil.

The country is self-sufficient in cement. A new cement mill will be completed at Colorado in Guanacaste Province in the near future creating a temporary surplus that will probably be exported.

Costa Rica imports the raw materials for fertilizers from Gulf of Mexico ports and Vancouver and manufactures fertilizers at Fertica. Some of these products are exported to other countries in Central America and to Peru. Fertilizers are the most important of the nation's industrial products for export.

Plastics, metal industry products, chemicals and light industry products are also produced from imported raw materials and a part of the products are exported. However, these exports are small. They mostly go to other countries in Central America.

2-4. Trade Cargo Volume

Costa Rica uses three modes of transport – ports, land routes and air routes – for its foreign trade. Cargo shipped through seaports represents about 85% of the total trade volume. Trade by land with countries in Central America is included exports and imports through the ports of Nicaragua and Panama. Trade by air routes consists mostly of fresh food such as meat and fish.

The Statistical Yearbook (Anuario Estadistico de Costa Rica) issued by DGEC/MEIC gives statistics on port cargoes in greater detail than other sources. But for trade volume by item and by port "Cuadros Estadisticos sobre Sector Transportes 1978" by DGP/MOPT from the data of DGEC/MEIC is better. However, there are some numerical conflicts between the two documents.

Table 2-4-1 shows trade values in millions of U.S. dollars and trade weights of 1960–1977 by the Comercio Exterior de Costa Rica (DGEC/MEIC).

1960–1977 by the Comercio Exterior de Costa Rica (DGEC/MEIC).

Table 2-4-2 shows export and import values by trade partner regions, referred to from Anuario Estadistico de Costa Rica (DGEC/MEIC).

Table 2-4-3 shows export and import cargo vlume by port, issued by DGP/MOPT.

Table 2-4-1 Foreign Trade of Costa Rica 1960–1977

Year	Million $ C.A.			1000 tons	
	Export F.O.B.	Import C.I.F.	Difference	Export	Import
1960	85.8	110.4	-24.6	389.1	510.4
1961	84.2	107.2	-23.0	347.4	495.8
1962	93.0	113.3	-20.3	419.2	536.7
1963	95.0	123.8	-28.8	409.3	584.1
1964	113.9	138.6	-24.7	532.6	607.6
1965	111.8	178.2	-66.4	511.9	803.9
1966	135.5	178.5	-43.0	603.1	711.3
1967	143.8	190.7	-46.9	629.4	744.6
1968	170.8	213.9	-43.1	898.4	888.8
1969	189.7	245.1	-55.4	1,022.0	1,004.1
1970	231.2	329.1	-97.9	1,197.7	1,269.8
1971	225.4	349.7	-124.3	1,356.3	1,322.1
1972	280.9	372.8	-91.9	1,498.5	1,347.3
1973	344.5	455.3	-110.8	1,643.8	1,547.8
1974	440.3	719.7	-279.4	1,493.7	1,551.9
1975	493.3	693.9	-200.6	1,507.4	1,509.6
1976	592.9	770.4	-177.5	1,533.4	1,539.5
1977	828.2	1,021.4	-193.2	1,539.4	1,853.8

Source: Comercio Exterio de Costa Rica, 1977, DGEC

Table 2-4-2 Export and Import of Costa Rica in value (million US$)

Export (million $ US)

	1970	1971	1972	1973	1974	1975	1976	1977
N. America	99.0	94.8	114.0	117.7	141.8	211.2	238.9	255.6
C. America	53.5	56.3	63.2	85.7	122.7	124.1	150.6	197.0
Caribe	0.3	0.3	0.6	0.4	1.6	1.0	3.9	5.9
W. India	1.0	1.2	2.2	1.0	3.4	7.7	7.7	10.8
S. America	0.4	0.7	2.5	3.7	2.7	8.8	10.6	23.1
Europe	59.4	61.7	87.4	119.9	154.2	126.5	165.0	314.8
Asia	11.2	7.1	6.5	4.3	9.7	12.0	11.0	15.8
U.S.S.R.	6.3	2.3	3.2	8.9	1.6	–	2.8	2.8
Africa	0.0	0.2	0.6	2.4	1.9	1.6	1.2	1.4
Oceania	0.1	0.1	0.1	0.1	0.1	0.1	0.4	0.2
Provisiones Especiales	–	0.7	0.7	0.4	0.6	0.3	0.8	0.7
Total	231.2	225.4	280.9	344.5	440.3	493.3	592.9	828.2

Import (million $ US)

	1970	1971	1972	1973	1974	1975	1976	1977
N. America	121.1	126.8	140.2	179.2	285.0	280.9	302.5	382.1
C. America	72.5	81.0	86.1	94.7	132.5	131.3	156.6	184.6
Caribe	0.4	0.6	1.0	0.7	2.1	2.9	3.7	3.0
W. India	2.3	2.4	1.9	3.8	6.3	6.2	16.1	60.6
S. America	12.0	14.1	16.9	35.4	76.8	72.5	60.9	64.1
Europe	77.5	81.6	84.8	97.2	134.2	131.6	135.0	174.2
Asia	30.6	42.9	41.6	43.1	77.5	65.6	92.7	144.4
U.S.S.R.	0.0	0.0	0.0	0.3	1.6	1.3	0.5	0.6
Africa	0.2	0.1	0.1	0.2	0.1	0.2	0.2	0.4
Oceania	0.1	0.1	0.1	0.8	3.6	1.5	2.2	7.5
Total	316.7	349.7	372.8	455.3	719.7	694.0	770.4	1,021.4

Source: Anuario Estadistico de Costa Rica, 1974 and 1977, DGEC

Table 2-4-3 Import and Export by Ports

unit: 1000 metric tons

Year	Total		Limón		Puntarenas		Golfito	
	DES	EMB	DES	EMB	DES	EMB	DES	EMB
1970	1,033.2	1,120.2	559.6	615.9	390.2	152.5	83.4	351.8
1971	1,113.6	1,269.3	599.5	704.6	446.9	186.8	67.2	377.9
1972	1,117.9	1,389.0	649.2	826.9	392.1	164.5	76.6	397.6
1973	1,317.5	1,511.0	838.2	958.4	406.4	178.5	72.9	374.1
	(1,463.6)	(1,450.0)	(968.1)	(841.7)	(422.6)	(173.3)	(72.9)	(434.9)
1974	1,298.4	1,349.8	820.7	845.2	402 8	190.3	74.9	314.3
	(1,215.6)	(1,488.1)	(816.3)	(907.5)	(352.6)	(163.8)	(46.7)	(376.8)
1975	1,306.2	1,388.1	876.0	929.7	386.9	166.2	43.3	292.2
							(65.4)	
1976	1,400.0	1,407.3	923.3	859.1	411.2	189.0	65.5	359.2
1977	1,671.0	1,364.6	987.1	811.3	573.2	176.7	56.7	376.3
1978	1,918.5	1,379.1	1,207.7	899.7	655.6	163.9	55.2	315.5

Source: Cuadros Estadísticos sobre Sector Transportes, 1980
DGP/MOPT
( ) Annario Estadistico de Costa Rica, 1974–1977
DES : Desembarked
EMB : Embarked

2-5. Ports

Costa Rica has six ports: four on the Pacific side – Puntarenas, Punta Morales, Golfito and Caldera – and two on the Caribbean Sea side – Limon and Moin.

Of these, Puntarenas (in the future, Caldera) and Limon are public ports for foreign trade. Punta Morales and Golfito are exclusively used for sugar and bananas respectively, while Moin is exclusively for petroleum and bananas.

The port of Puntarenas has an L-shaped steel-pile pier constructed in 1929. However, this pier has become badly corroded after more than 50 years and is nearing the end of its usefulness moreover it does not structurally permit the modernization of cargo handling. Therefore, it will be abolished after the completion of the port of Caldera. However, the name of the port of Puntarenas will be retained for the goods landing place behind the port area and the FERTICA fertilizer plant facility, both of which will continue to be used.

The port of Limon is the largest in the nation in both scale of facilities and volume of cargo handled. It was originally constructed by a railway company in 1904 for the shipment of bananas and has been expanded and improved since 1968 when it became government property.

The main facilities of these ports are shown in Table 2-5-1 while the number of ships calling at them is shown in Table 2-5-2 and Fig. 2-5-1.

Table 2-5-1 Facilities of Main Ports

Name of port	Principal facilities	Remarks
Puntarenas	Steel-pile pier: 140 m long, 24 m wide Connecting bridge: 320 m long, 9 m wide No. 1 berth: 137 m long, -9.1 ~ 12.2 m deep No. 2 berth: 110 m long, -7.6 ~ 10.7 m deep Ancillary facilities: Railway sidings	Administration: INCOP Start of use: 1929
Punta Morales	Dolfin 1 berth: -12 ~ 14 m deep Ancillary facilities: Belt conveyors	Administration: INCOP Start of use: 1976 Exclusively for export of sugar
Golfito	Whart 2 berths: 276 m long, -7 ~ 10 m deep	Administration: Compañía Bananera de Costa Rica Privately owned
Limon	Muelle Metalico (steel-piled pier): 320 m long, 24 m wide Connecting bridge: 366 m long No 1 berth: 160 m long, -8.8 m deep No. 2 berth: 160 m long, -7.9 m deep No. 3 berth: 122 m long, -6.7 m deep Ancillary facilities: Railway sidings, belt conveyors for loading of bananas Muelle Nacional (steel-pilled pier). 156 m long, -6 ~ 7 m deep Ancillary facilities: Railway sidings Muelle Setenta (concrete-piled pier): 340 m long, 17 m wide 2 berths: -9 m deep 1 berth: -6 m deep Ancillary facilities: Railway sidings 20t crane Ro-Ro berth: -8 m deep Proyecto Aleman (concrete-piled open-type wharf): 360 m long, -11 m deep Ro-Ro berth (concrete-block wharf): 90 m long, -10 m deep	Administration: JAPDEVA Start of use: 1904 Under construction; to be completed in July 1981 Same as above
Moin	Petroleum unloading facility (mooring buoy) Crude oil berth (steel-piled open-type wharf): 200 m long, -14 m deep Ro-Ro berth: 30 m wide -12 m deep Banana handling berth (steel-piled open-type wharf). 400 m long, -12 m deep	Administration: RECOPE Start of use: Jan. 1979 Under construction; to be completed in July 1981

Table 2-5-2 Number of Calling Ships

	Pacific Ocean				Caribean Sea	Total
	Puntarenas	Golfito	Quepos	Sub-total	Limón, Moin	
1967	490	189	3	682	447	1129
1968	473	115	1	589	537	1126
1969	494	240	1	735	733	1468
1970	438	300	1	739	734	1473
1971	452	275	–	727	742	1469
1972	505	300	–	805	807	1612
1973	509	270	1	780	826	1606
1974	398	210	–	608	795	1403
1975	389	207	–	596	794	1390
1976	394	172	–	566	824	1390

Fig. 2-5-1 Number of Calling Ships by Ports (1967~1976)

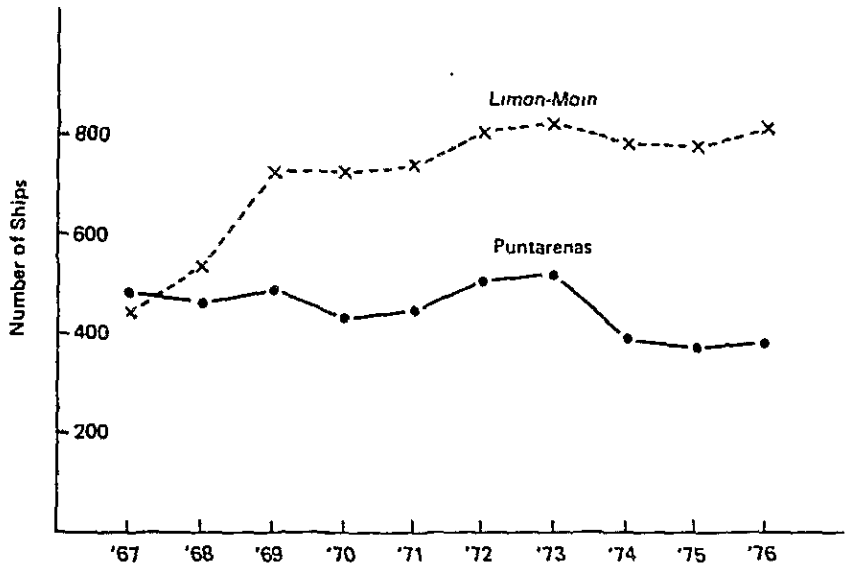
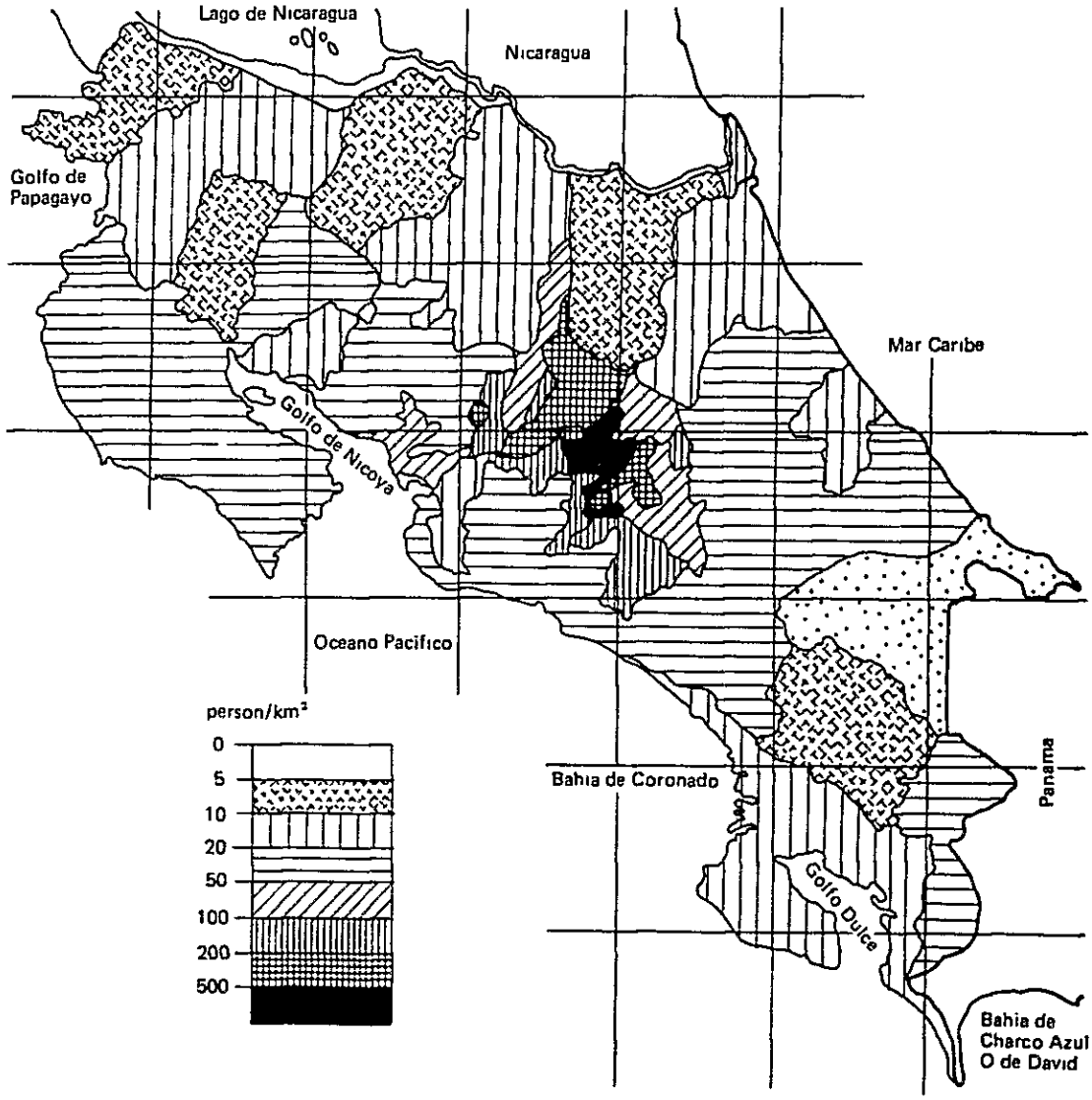


Fig. A2-1-1 Population Density by Canton (1977)



Source Anuario estadistico de Costa Rica 1977

Fig. A2-1-2 Population Pyramid (OFIPLAN)

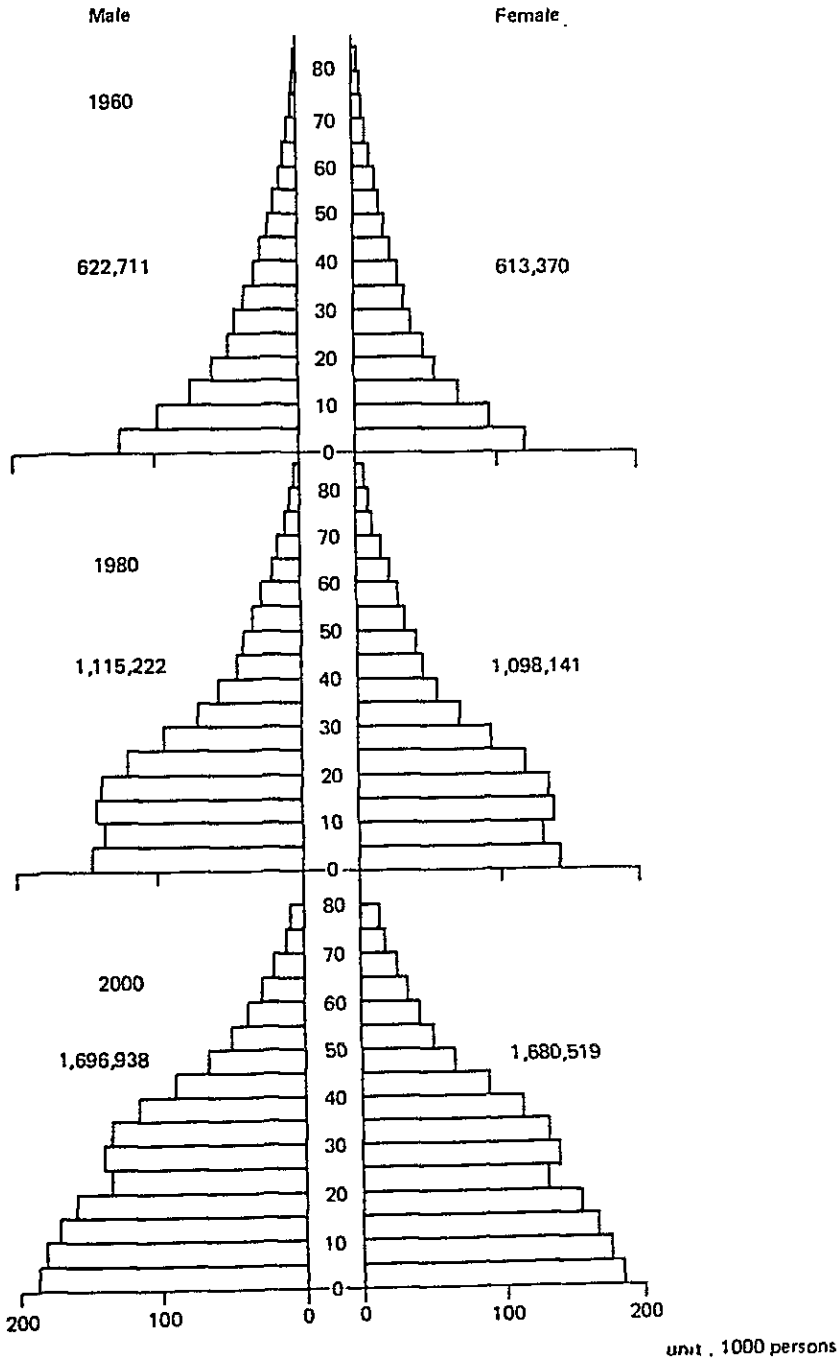


Table A2-2-1 Forecast of Gross Domestic Product of Costa Rica

OFIPLAN (10^6 colones of 1976)

1976	20,675.6
1980	25,318.6
1982	27,907.8
1985	32,250.6
1990	40,978.4
1995	51,989.0

BCCR (10^6 colones of 1966 → 1976)

1980	9,582.3 →	25,124
1981	9,861.8	25,857
1982	10,374.1	27,200
1983	10,875.0	28,513
1984	11,333.2	29,715
1985	11,786.6	30,904

DGP/SYSTAN (income, 10^6 colones of 1976)

1973	17,884
1978	23,551
1980	25,413
1985	32,135
1990	40,731
1995	51,756
2000	65,942

CHAPTER 3
PRESENT SITUATION OF THE PORT OF PUNTARENAS

CHAPTER 3. PRESENT SITUATION OF THE PORT OF PUNTARENAS

3-1 Management of the Port

3-1-1 Management System of Ports and Harbors in Costa Rica

The DGOP (Directorate General of Port Works), MOPT is responsible for the planning and construction of port facilities, while the port authority, INCOP and JAPDEVA are responsible for the management of completed port facilities. Such planning, however, is not wholly made by the DGOP, MOPT. The estimation of cargo volume, serving as a basis for deciding the size of the facility, is computed by the DGP (Directorate General of Planning), MOPT. Further, the DGTA (Directorate General of Transports by Water), MOPT is involved with such management too. The composition and level for tariffs are determined by the three parties of DGP, MOPT, DGET (Dirreción General de Estudios Técnicos) of MOPT in addition to DGTA of MOPT.

As a coordinating organ of national organs concerned with ports and harbors, there is the Consejo Portuario Nacional.

Duties and responsibilities of the Consejo are as follows:

a) To prepare a detailed report on port facilities currently being used;
b) To map out such matters as cost, means of procuring funds, and public agencies capable of being responsible for construction in connection with works for recovering port facilities;
c) To prepare a report on the performance situation of currently proceeding port projects;
d) To make a survey on the reorganization of the port management system;
e) To supervise the matters determined by the Consejo so that they are fulfilled within the specified terms.

Members of the Consejo are the following 6 persons:

Minister of MOPT President
Deputy Minister of Finance
Representative of INCOP
" JAPDEVA
" RECOPE
" FECOSA

The Consejo shall designate the Director, Port and River Works, MOPT as the Chief Secretary, and will meet at least once a week. Matters decided upon by the Consejo may be enforced, unless they are opposed by the Government.

The organization chart of MOPT is as shown in Fig. 3-1-1. The Comisión Asesora Portuaria Nacional appearing in the Figure is a different organ from the Consejo Portuaria Nacional mentioned above, but is an advisory organ to the Minister which hears opinions from wider sources including non-Governmental organizations within its membership.

The Port of Puntarenas and the Port of Limon, which are the major ports of Costa Rica, are respectively managed by INCOP and JAPDEVA, which are their port authorities. These port authorities are supervised by DGTA, MOPT, though indirectly via the Consejo.

3-1-2 INCOP

The INCOP which manages the Port of Puntarenas is a port authority established by Law No. 1721 of 28 Dec. 1953 as amended later by Law No. 4964 of Mar. 1972. Until sometime previously, it also had managed the railroad between Puntarenas and San José in addition to the Port, but at present, the railway division has been separated leaving port management only. Law No. 4964 provides that the INCOP is "an autonomous organ of public nature vested with corporate status and holds its own assets" in order to perform efficient port operation.

The organization chart of the INCOP is as shown in Fig. 3-1-2. As the supreme decision making organ, there is the JUNTA DIRECTIVA (Managing Commission). The PRESIDENCIA EJECTIVA (Governor) is appointed by the President of Costa Rica. The number of employees is 910 in total, including 250 staff members and 660 laborers (temporary laborers included). Table 3-1-1 shows its breakdown.

Though the INCOP is a public organization affiliated with the Government, it adopts the business accounting system. According to the abovementioned Law No. 4964, the INCOP may be financed by foreign sources through Government authorization for constructing new ports. And the payment of such principal and interest shall be defrayed from the profit obtained through the port management.

3-1-3 Management of the Port of Puntarenas

The scope of the major lines of business of the INCOP which manages the Port of Puntarenas are as follows:

Pilotage service
Tug-boat service
Berthing assistance service
Water supply
Port transportation
Storage
Cargo handling: on ship/on quay

The Port of Puntarenas consists of an L-shaped steel-pile jetty, on which 6 railroad tracks are laid to handle in-bound and out-bound cargoes.

Ordinary hours of loading-unloading are 5AM-7PM, but the port may operate for 24 hours.

One gang consists of 22 persons. Eight gangs may ordinarily be mobilized.

The tariffs of the Port are shown in Table 3-1-2. The actual revenue of tariff by item in the past 3 years are shown in Table 3-1-3.

Fig. 3-1-1 Organization Chart of MOPT

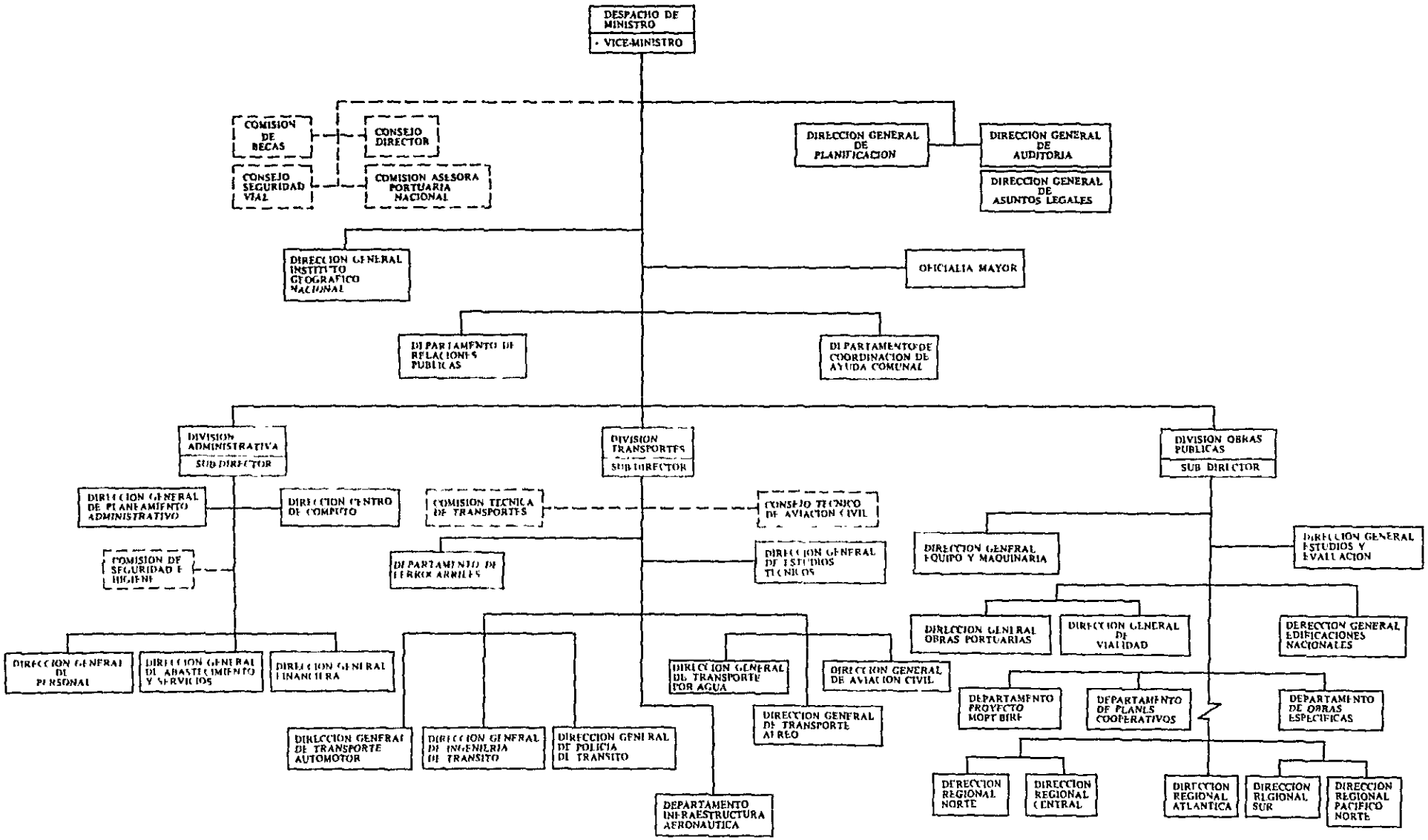


Fig. 3-1-2 Organization Chart of INCOP

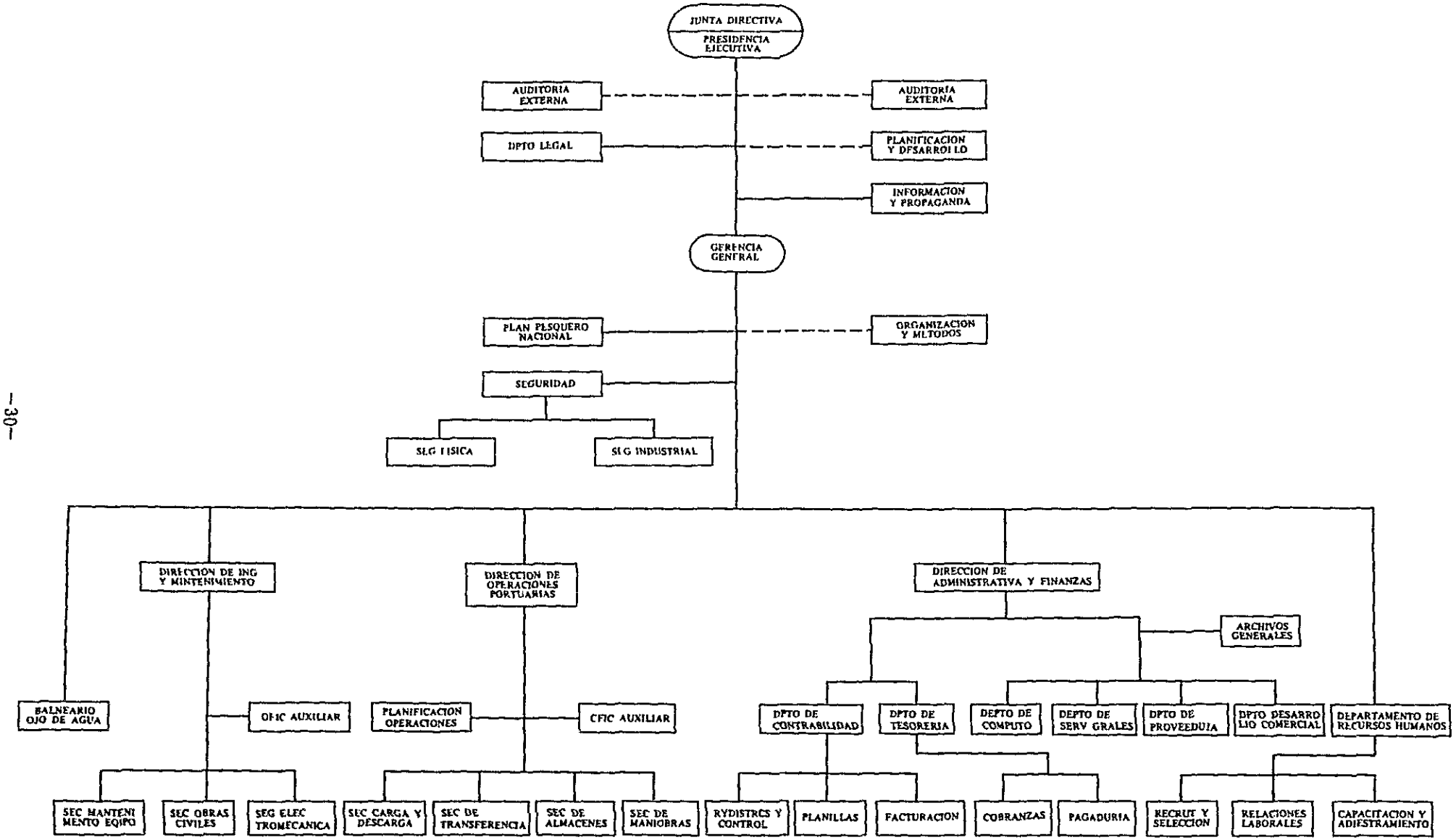


Table 3-1-1 Labour Force of the Port of Puntarenas

	Permanent	Casual	Total
ABROAD STEVEDORES	176	–	176
STOREROOM STEVEDORES	55	–	55
CASUAL STEVEDORES	–	186	186
OTHER PORT WORKERS	36	86	122
CARGO OFFICIALS	4	15	19
WATER CARRIERS	25	–	25
CHECKERS AND INSPECTORS	46	31	77
TOTAL	342	318	660
ADMINISTRATIVE PERSONNEL	250	–	250
TOTALS	592	318	910

source. INCOP

Table 3-1-2 Puntarenas Port Service Tariff

1. Wharfage

a) Loading
¢34/ton for export merchandise, when transit shed is not used.

b) Unloading
For every ton unloaded of imported merchandise of any kind, except motor vehicles:

General cargo	¢69.00
Bulk grain	40.00
Vehicles	1% of C.I.F. value

2. Light house service

¢265 per vessel up to 5,000 ton (dead weight) and ¢50 up for every (1,000) ton in excess.

3. Pilotage
¢250 per vessel plus ¢330 per hour for vigilance.

4. Line handling

¢100 per vessel. Vigilance is charged in tariff 3.

5. Dockage

¢0.20 per ton of vessel each day. One day's minimum charge will be ¢100 and maximum ¢600. This tariff shall be charged from the moment the vessel has been tied to the Pier.

6. Port due

Every vessel shall pay:

Less than 50 G/T							¢76	per vessel
More than		50	but	less	than	250 G/T	109	" "
"	"	250	"	"	"	500 G/T	185	" "
"	"	500	"	"	"	1000 G/T	294	" "
"	"	1000	"	"	"	5000 G/T	570	" "
"	"	5000	"	"	"		760	" "

7. Accessories for loading/unloading

For the lease of accessories, each vessel shall pay:

Rope	¢55/per day
Steel wire rope	45
"Chinguillos"	25
Cement board	20
Steel sling	20
Car accessories	20
Red Cargo saver	20
Car "Chinguillos"	25
Rope sling	15
General cargo disc	15
Hook	15
Gang plank	20

8. Mooring Buoy

For this service ¢50 per day per vessel

9. Boat Services

For this service the charge is ¢100 per hour

10. Water supply

¢10.00 per metric ton

11. Vessel's vigilance

All vessels shall be protected. INCOP will appoint guards with a minimum of 1 man/per hatch. Guard may be appointed for vessels awaiting mooring or arriving for fuel or foodstuffs.

Fees are:

Day hour per man	¢ 11.10
" " extra per man	16.65
Night " per man	14.76
" " extra per man	22.00
" " double per man	29.26

Day time starts of 06:00 Hrs. Night time at 20:00 Hrs. Extra hours are 8 during day time and 6 during the night.

Sundays and holidays the hour is payed for the double of its rate.

12. Stevedore's service fee (on board and on pier) (Loading and Unloading)

Shipping companies shall pay:

General Cargo	¢78.40 per ton
Bags	78.40
Grain	34
Cattle (live stock) only on pier.	53.50 per ton

When vessel cannot moor within less than 1.5 Km from the Pier due to her draft, the tariffs due to loading and unloading will have an special charge of 50%.

13. Storage in the Warehouses on Jetty

The first 12 days the storage will be free of charge. From that time on:

General cargo:	¢0.10 per day per 100 Kg during first month. ¢0.30 per day per 100 Kg during second month plus 2% of CIF value of merchandise. From the first day of the third month the CIF percentage goes up to 4%.
Liquors, wine, beer:	Similar to General cargo, but CIF percentage goes to 10% after the second month.
Flammable and rusting merchandise:	¢0.40 per kg

14. Use of Railway Platform

INCOP will charge for this service:

Pickups	¢1.00
3 axles's truck (3–5 ton)	2.50
3 axles's truck (5–10 ton)	5.00
Trucks of more than 10 ton	1.00 per ton

15. Barges' mooring on Barge's pier

There is a charge of ¢10.00 per day per barge belonging to any private company. All barges shall depart as soon as the loading/unloading is over.

16. Tug-boat service

INCOP will charge ¢1,551.90 per this service to each vessel, for mooring and sailing operations. For other services within the harbour it will be ¢1,052 per hour from Monday to Saturday and ¢1,546 when it is on Sundays or Holidays.

Minimum charge will be two hours.

17. Crane and fork-lift services

Crane	12 – 25 ton	¢200.00 per hour
"	6 – 11 ton	150
"	less than 6 ton	125
Forklift of	6 ton	125
"	3 ton	100
"	2 ton	50

When the required machinery is not available, the next bigger will be lend.

When these machinery is used outside the Jetty, a charge of ¢5.00 per kilometer will be additionally charged.

18. Oil derivates supply on Pier

All Fuel companies shall pay ¢20.00 per 1,000 Kg of diesel or any other petroleum derivates supplied to vessels, loaded or unloaded through the Pier, be it through pipeline, tank-car or any other mean.

19. Merchandise on transit

For every ton of this type of merchandise INCOP will charge ¢69 for both loading and unloading.

The same fee will be collected in the case that such merchandise be only unloaded and loaded through other means.

Table 3-1-3 Detail of Revenue

(in ¢ 1,000)

Item	1977		1978		1979	
	Revenue	Ratio	Revenue	Ratio	Revenue	Ratio
Wharfage	20,128	36	19,708	32	22,716	35
Loading and Unloading	21,632	38	23,585	39	24,002	37
Bouys and Lighthouse Dues	292	–	227	–	189	–
Dockage	477	1	497	1	458	1
Pilotage, Tugs & Handling Lines	1,595	3	1,747	3	3,941	6
Cargo Demurrage	6,576	12	7,532	12	7,625	12
Port Dues	338	–	318	–	263	–
Rental of Equipment	1,568	3	2,905	5	1,619	3
Other Revenues	3,752	7	4,229	8	3,519	6
Total	56,358	100%	60,748	100%	64,332	100%

Source: INCOP

3-2 Port Facilities

Main facilities of the port of Puntarenas are the national pier (Muelle Nacional) consisting mainly of two berths for large vessels and the municipal pier (Muelle Municipal) consisting mainly of facilities for small coastal ships. The national pier (Muelle Nacional) protrudes from the approximate center of the urban area of Puntarenas, at a point 2.3 km from the tip of the Peninsula of Puntarenas on the south side of the peninsula. The municipal pier faces El Estero on the north side of the Peninsula of Puntarenas and is located symmetrically to the national pier. Besides, there are some small craft berths on the side of El Estero in the eastern suburbs of Puntarenas.

The plane configuration of the national pier is a reverse L-shape and two berths are provided from the solid angle to the tip. The berth on the south side has a length of 137m and a water depth of −9.1m ~ −12.2m. While the berth on the north side has a length of 110m and a water depth of −7.6m ~ −10.7m.

These water depths are retained in spite of the fact that no maintenance dredging has been carried out there in the past. There are two buoys off each berth to moor ships by exclusive cables so that the ships may not directly contact the wharf. The wharf has six railway tracks, thereby only permitting freight cars to be directly loaded.

This steel pile pier was constructed around 1929. After the lapse of more than 50 years since its construction, it is badly corroded and may soon be unserviceable.

3-3 Utilization of the Port of Puntarenas

During the calendar year of 1979, 254 ocean-going ships called at the port of Puntarenas and the volume of cargoes handled there was 380,474 tons (import: 354,401 tons, export: 26,073 tons) while 4 called at Punta Morales with 62,245 tons (export only) and 52 called at Fertica with 178,400 tons (import: 142,424 tons, export: 35,976 tons).

Of the 254 ships that called at the port of Puntarenas, cargo handling at quaywall accounted for 99, offshore cargo handling accounted for 101, cargo handling at quaywall after offshore cargo handling accounted for 46 and "unknown" accounted for 8. Fig. 3-3-1 shows the cargo volume per ship for the 246 ships other than the "unknown" 8.

The per-ship average time of cargo handling was 90.7 hours for cargo handling at quaywall and 62.6 hours for offshore cargo handling and 85.6 hours for offshore cargo handling plus cargo handling at quaywall, it was 31.7 hours for offshore handling and 53.9 hours for quaywall handling. The per-hours average speed of cargo handling was 19.27 tons for quaywall handling, 11.60 tons for offshore handling and 21.62 tons for offshore handling plus quaywall handling. The frequency of cargo handling speed and handled cargo are shown in Fig. 3-3-2 and the relations between handled cargo and loading speed are shown in Fig. 3-3-3.

Fig. 3-3-1 Cargo Volume per Ship, Import & Export
(Puntarenas, 1979)

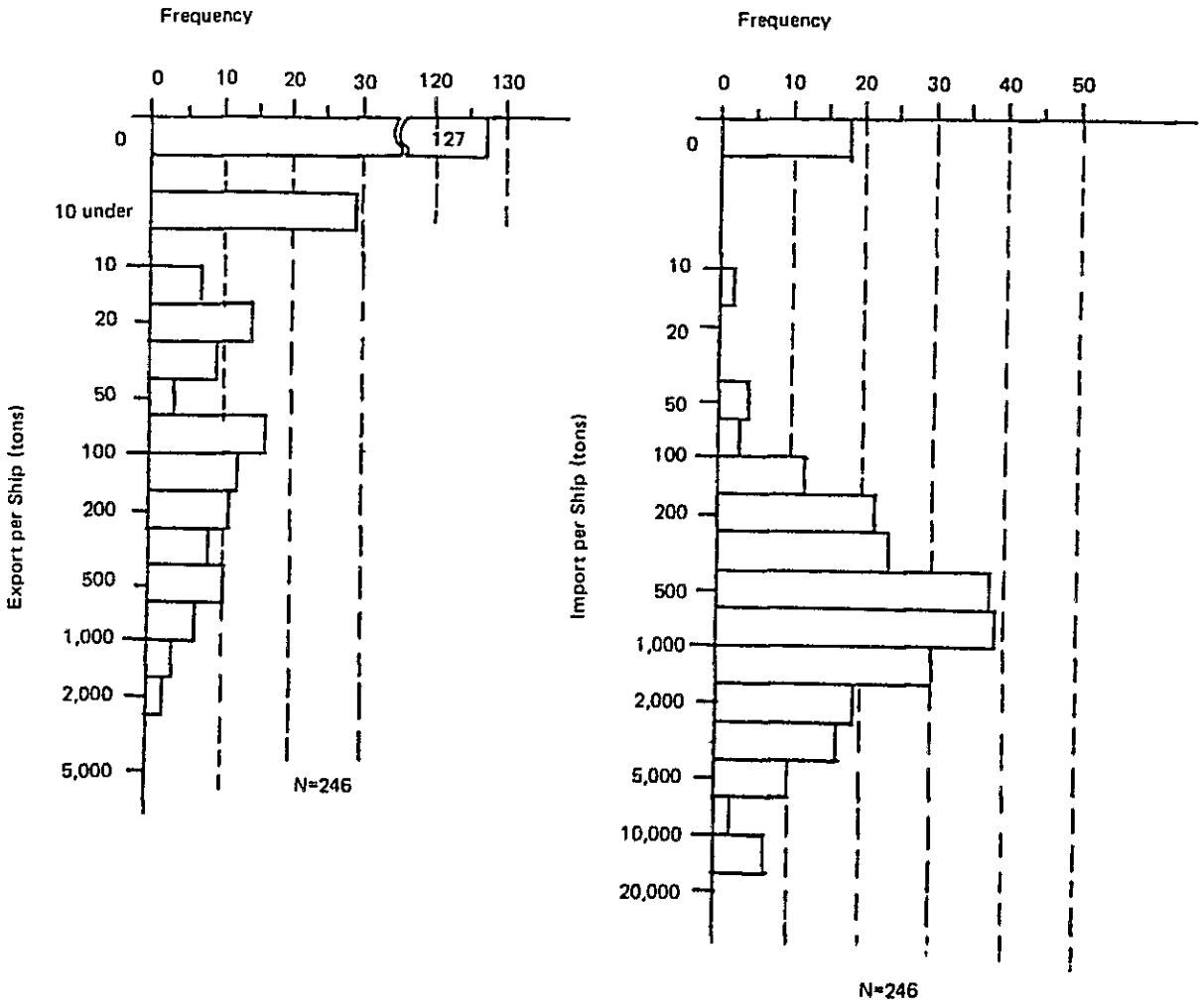


Fig. 3-3-2 Frequency of Handling Speed and Handled Cargo
(Puntarenas, 1979)

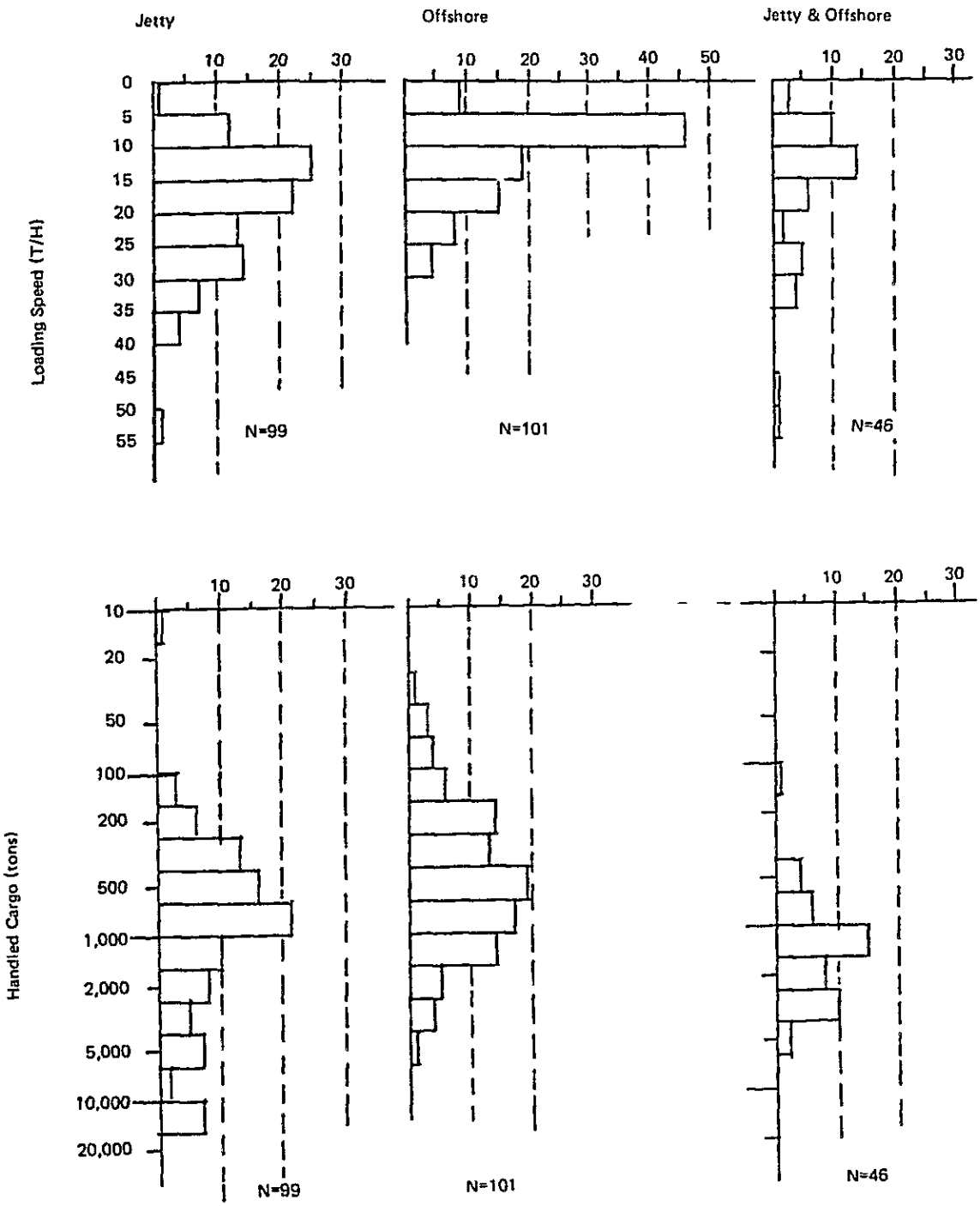
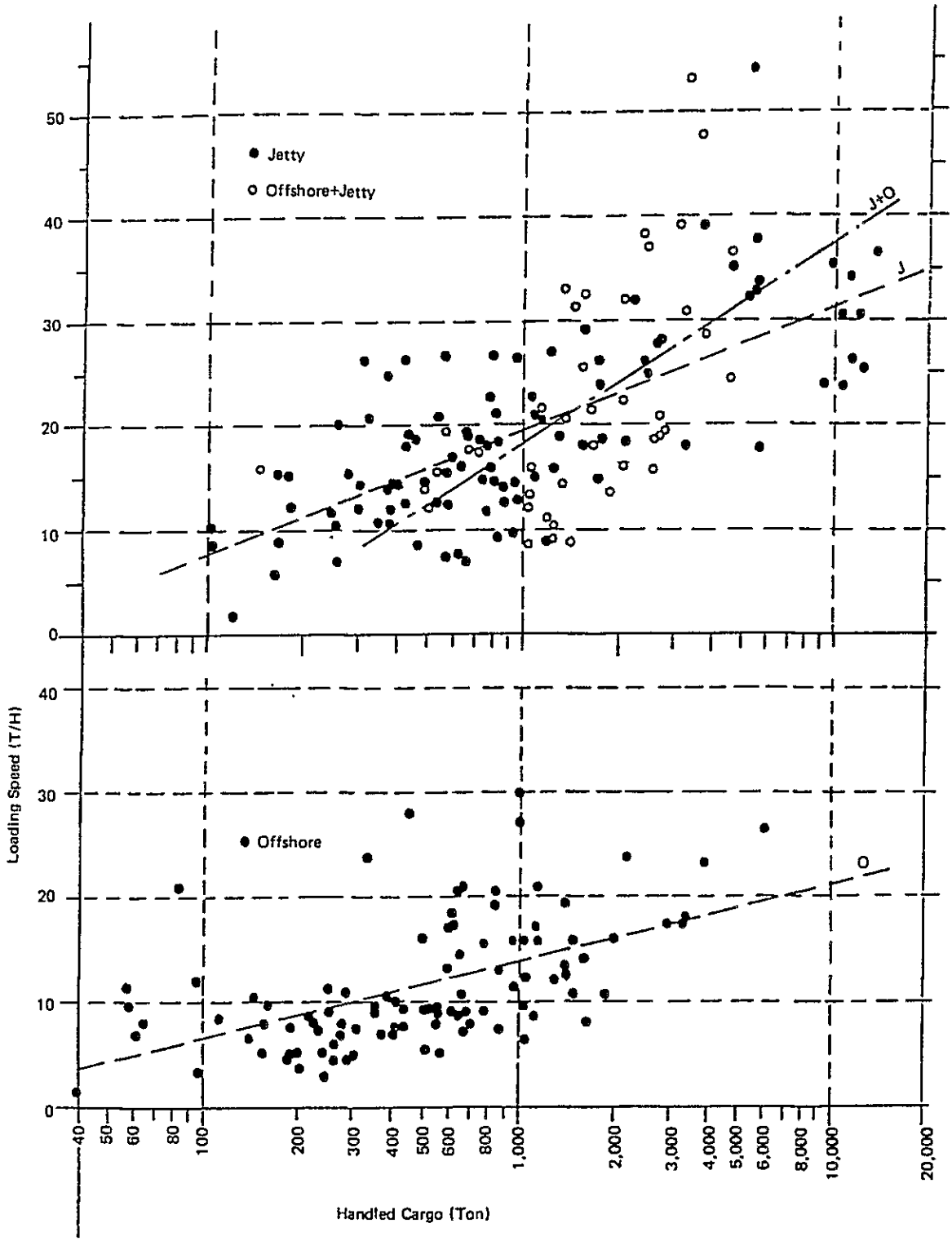


Fig. 3-3-3 Relations between Handled Cargo and Loading Speed



CHAPTER 4
LOCATIONAL CONDITIONS OF THE PORT OF CALDERA

CHAPTER 4 LOCATIONAL CONDITIONS OF THE PORT OF CALDERA

4-1 Geographical Conditions

The Port of Caldera is situated approx. 30km southeast of Puntarenas, and is in the Gulf of Nicoya as is the Port of Puntarenas. It is close to the Central Plateau and is about one and a half hours from San José, the Capital of Costa Rica.

Costa Rica's foreign trade occurs not only with Central American countries but also South and North American countries, Japan and many countries in Europe. Because of her long and narrow shape, stretching in a north to south direction, prolonged land transport distances, insufficient land transport facilities, and so forth, approx. 85% of her trade is dependent upon maritime transport. As gateways for this transport, there are currently the three ports of Puntarenas, Limon and Golfito, through which almost all of her maritime transport is handled.

The Port of Puntarenas has served as the sole public port for foreign trade on the Pacific coast of Costa Rica. The Port of Caldera will in the future take the largest share of this trade. So far as highways are concerned, these ports will be connected by the Inter-American highway when the Caldera-El Roble-Esparta road currently under construction is opened. The Inter-American Highway is a major trunk line coming from the Nicaraguan border in the north, through the Pacific coast, the Central Plateau and the Mountain District, re-entering the Pacific Coast region, and reaching Panama. In addition a highway connecting Caldera to San José, the capital. is scheduled to be completed in 1985 to further shorten the driving time between the two cities. (See: Fig. 4-1-1, Road Network Map in Costa Rica)

In regard to railroads, these ports will be connected with the San José-Puntarenas railroad leading to San José when the planned Caldera-Salinas line is completed. (See: Fig. 4-1-2, Railroad Network Map in Costa Rica)

Though Puntarenas fulfills its role as the central city of the district, it has been developed on a sand spit surrounded on three sides by sea. The whole area of the sand spit is now fully urbanized, leaving less and less space. On the other hand, Caldera has ample space for long term expansion.

Fig. 4-1-1 Road Network Map in Costa Rica

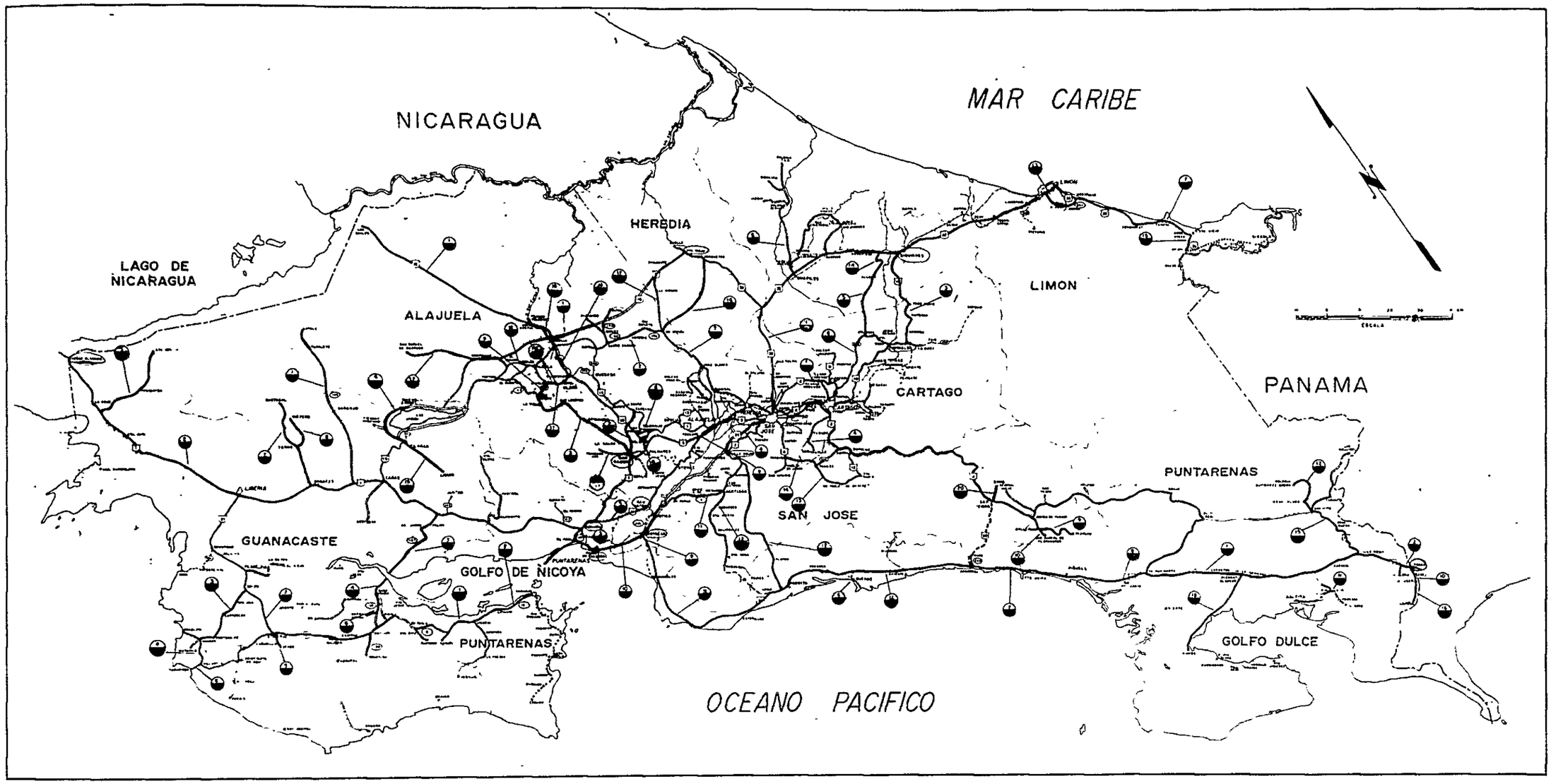
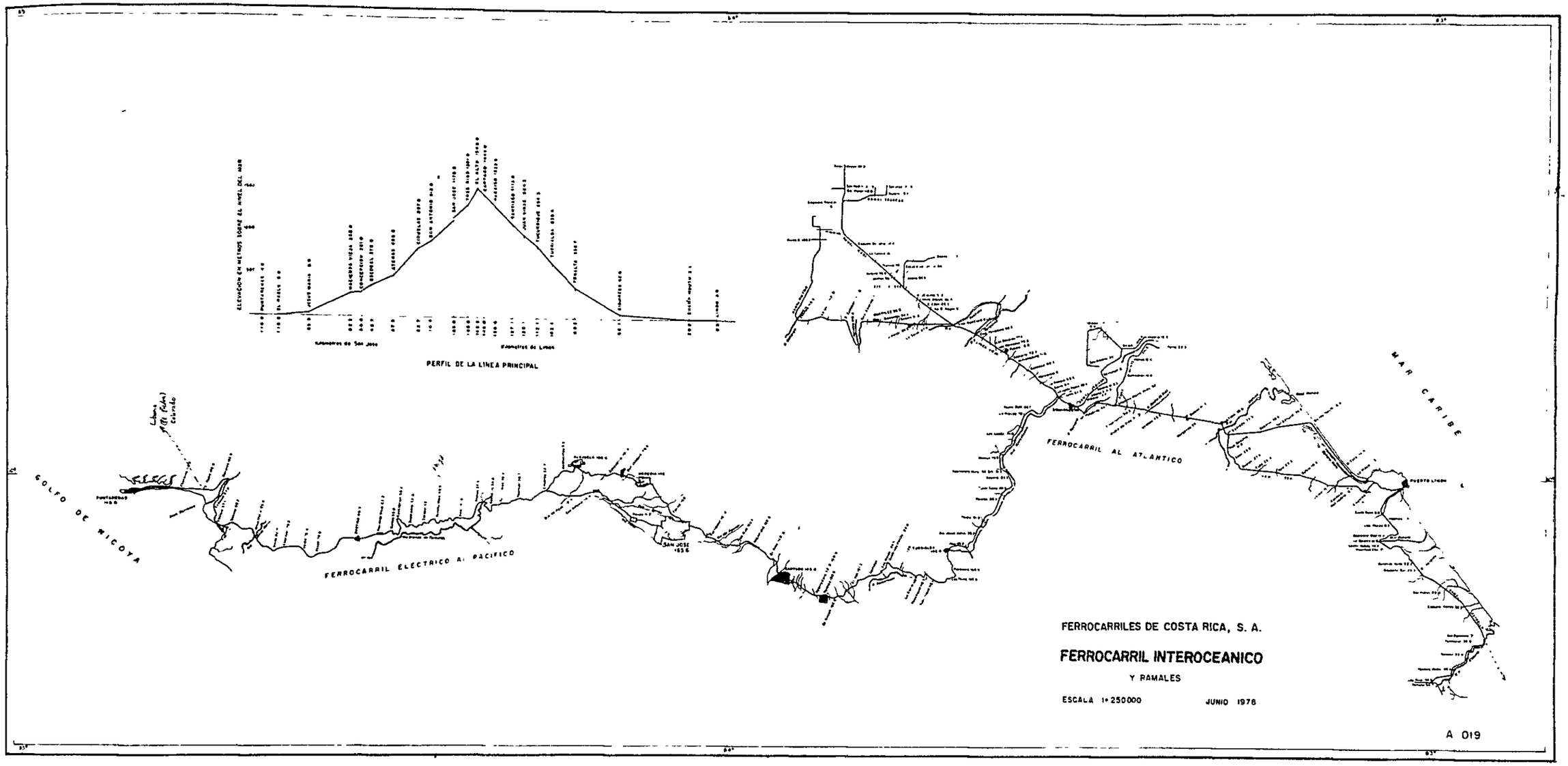


Fig. 4-1-2 Railroad Network Map in Costa Rica



4-2 Natural Conditions

4-2-1 Wind

Data collected at the Chacarita Airport weather station, Puntarenas, is appropriate for ascertaining wind conditions at the project site. Fig. 4-2-1 shows the percentage of the wind direction and the wind speed from 1970 to 1971, using the data from this station.

At night time from about 7 p.m. to about 7 a.m., prevailing wind directions are N to E. Some land breezes and trade winds come mostly in the same directions.

In the daytime S to SW winds prevail; sea breezes and equatorial west winds. In the dry season from November to April, there are sea breezes. In the rainy season there are equatorial west winds and sea breezes. After sea breezes stop at sunset, equatorial west winds begin to blow, which often blow continually until midnight.

The diagram of the prevailing wind change in directions by months by hours are shown in Fig. 4-2-2. It indicates that N to E winds prevail by night, and S to SW winds prevail by day, SE winds sometimes prevail around sunset.

The diagram of wind change in speed is shown in Fig. 4-2-2 which represents mean wind speed in km/hour. According to this figure, the wind speed is high by day and low by night. It is marked that the wind speed during the daytime in February is so high.

4-2-2 Precipitation

The map of precipitation of Costa Rica is shown in Fig. 4-2-3. It shows the mean annual precipitation from 1954 to 1973. The precipitation at the coast of the Gulf of Nicoya is about 1,600 mm and is the lowest in Costa Rica.

The mean monthly precipitation at Puntarenas for 20 years from 1959 to 1979 are shown in Table 4-2-1. The mean annual precipitation for this period was 1,556 mm. The maximum value was 2,080 mm in 1972 and the minimum value was 1,072 mm in 1964. The rainy season is usually the period from April to November while the dry season is from December to March. There is a remarkable difference between the two seasons. In the rainy season it rains especially hard from August to October and generally from afternoon to evening. In the dry season there is almost no rainfall, particulary in January.

4-2-3 Temperature

In Cost Rica, the variation of temperature through the year is relatively low and the mean temperature in the central plateau is about 10°C lower than in the coastal areas. Fig. 4-2-4 shows that the distribution of mean temperature in the Pacific and Caribbean Sea coasts is 24 to 27°C. Table 4-2-2 indicates the mean temperatures at Puntarenas from 1961 to 1978 According to the table, the temperature is high from March to April and low from September to November, and the difference between these temperatures is only about 2°C.

Table 4-2-2 Mean Temperatures at Puntarenas (°C)

	J	F	M	A	M	J	J	A	S	O	N	D	Means
Maxima	34.0	34.4	35.3	34.6	33.2	32.3	32.4	32.5	32 1	31.6	31.9	32.7	33 1
Minima	22.0	22.4	23.0	23 6	23.8	23.3	23.1	22.9	22.9	22 9	22.5	21.9	22.9
Means	27.0	28.0	28.7	28 7	27.9	27.1	27 1	26 9	26.6	26.6	26.7	27.0	27.4

Fig. 4-2-1 Frequency of Wind Direction & Wind Speed

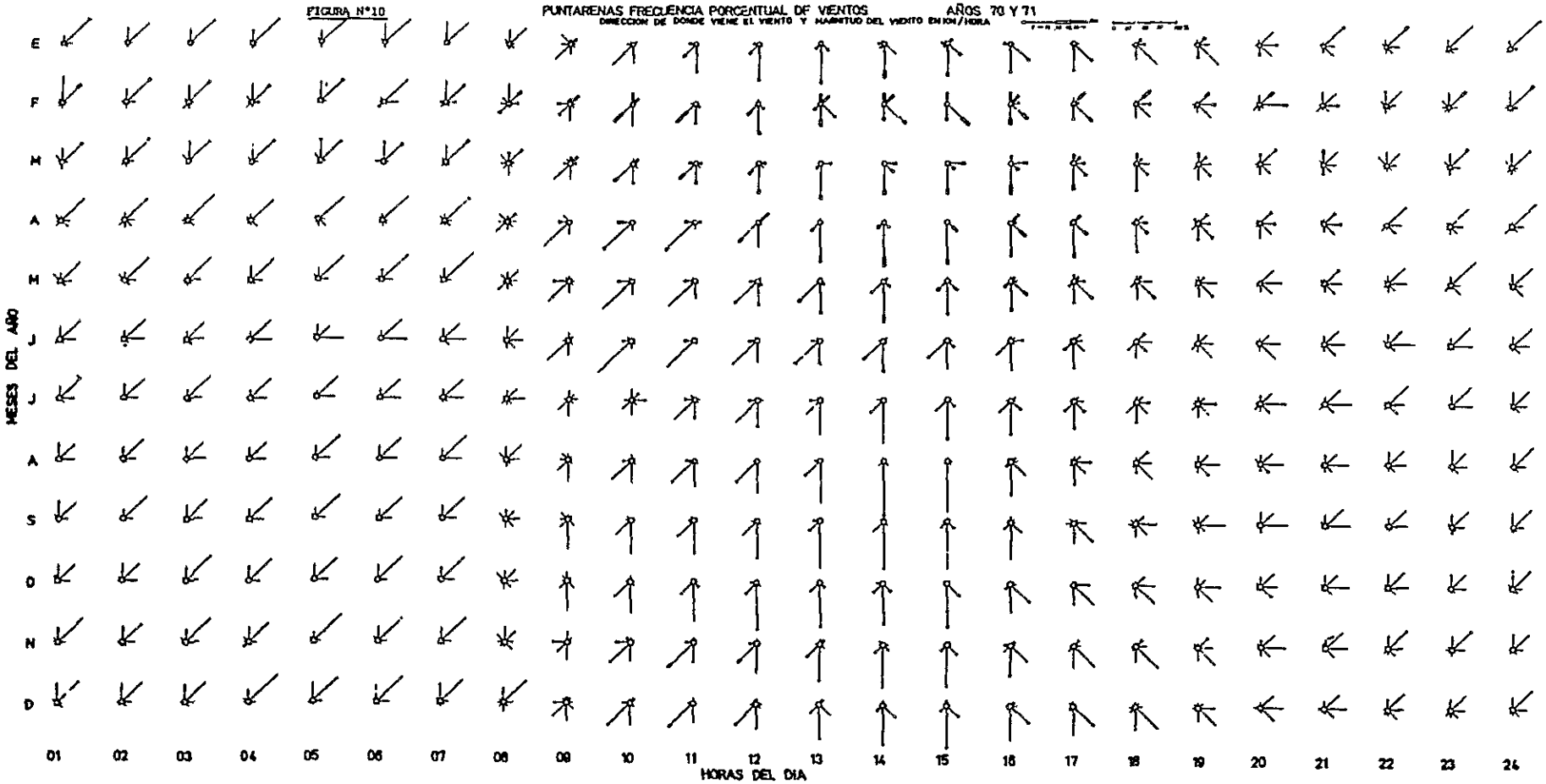


Fig. 4-2-2 Frequency of Prevailing Wind

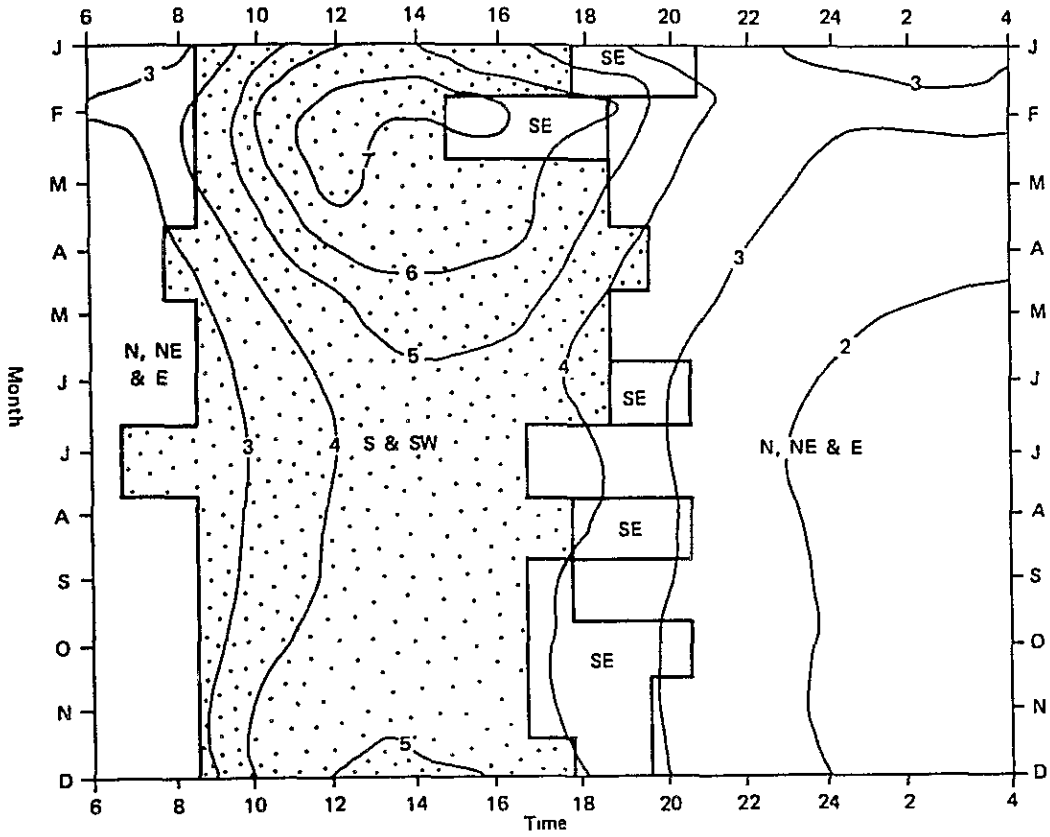


Fig. 4-2-3 Mean Annual Precipitation
(1954–1973)

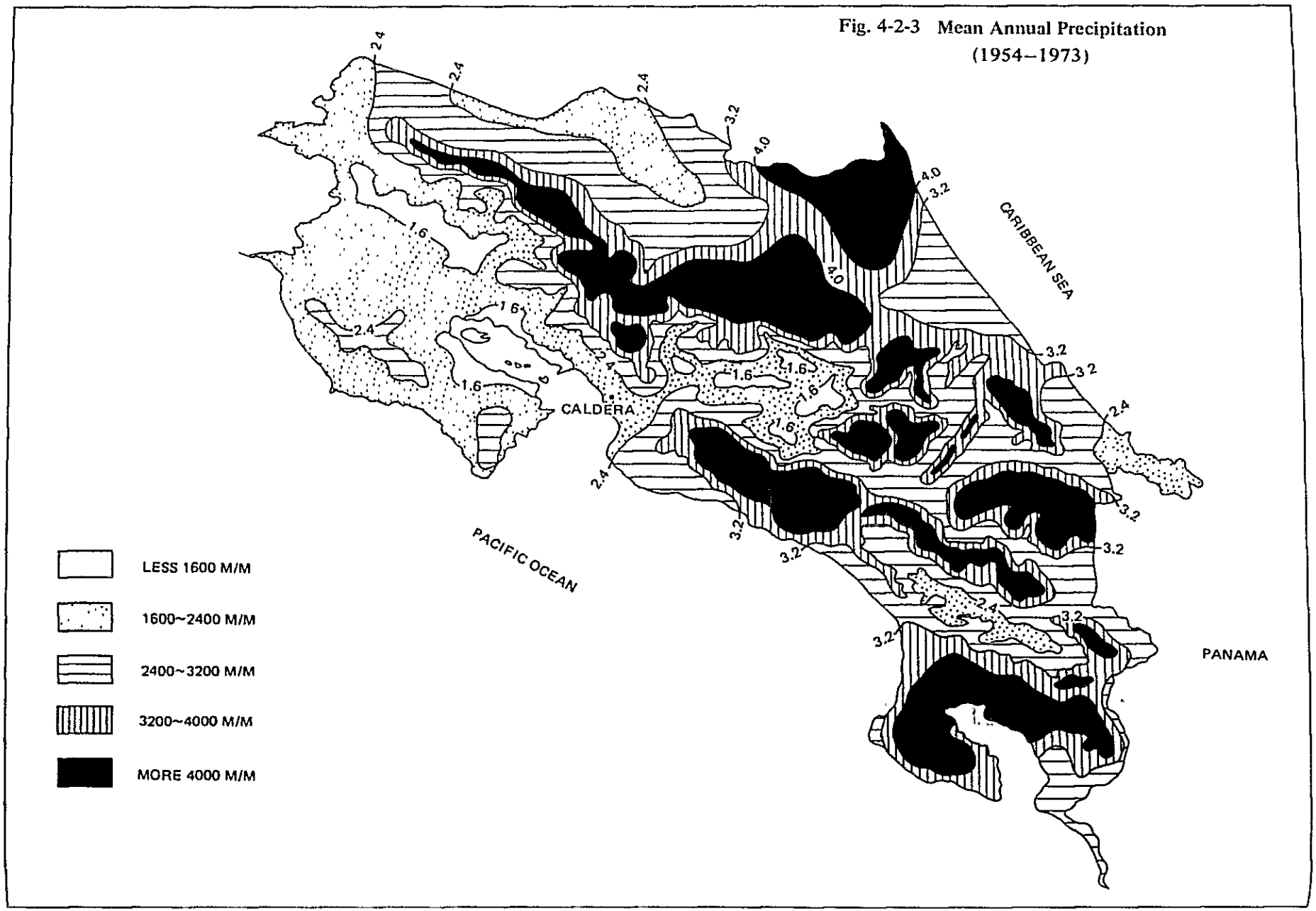
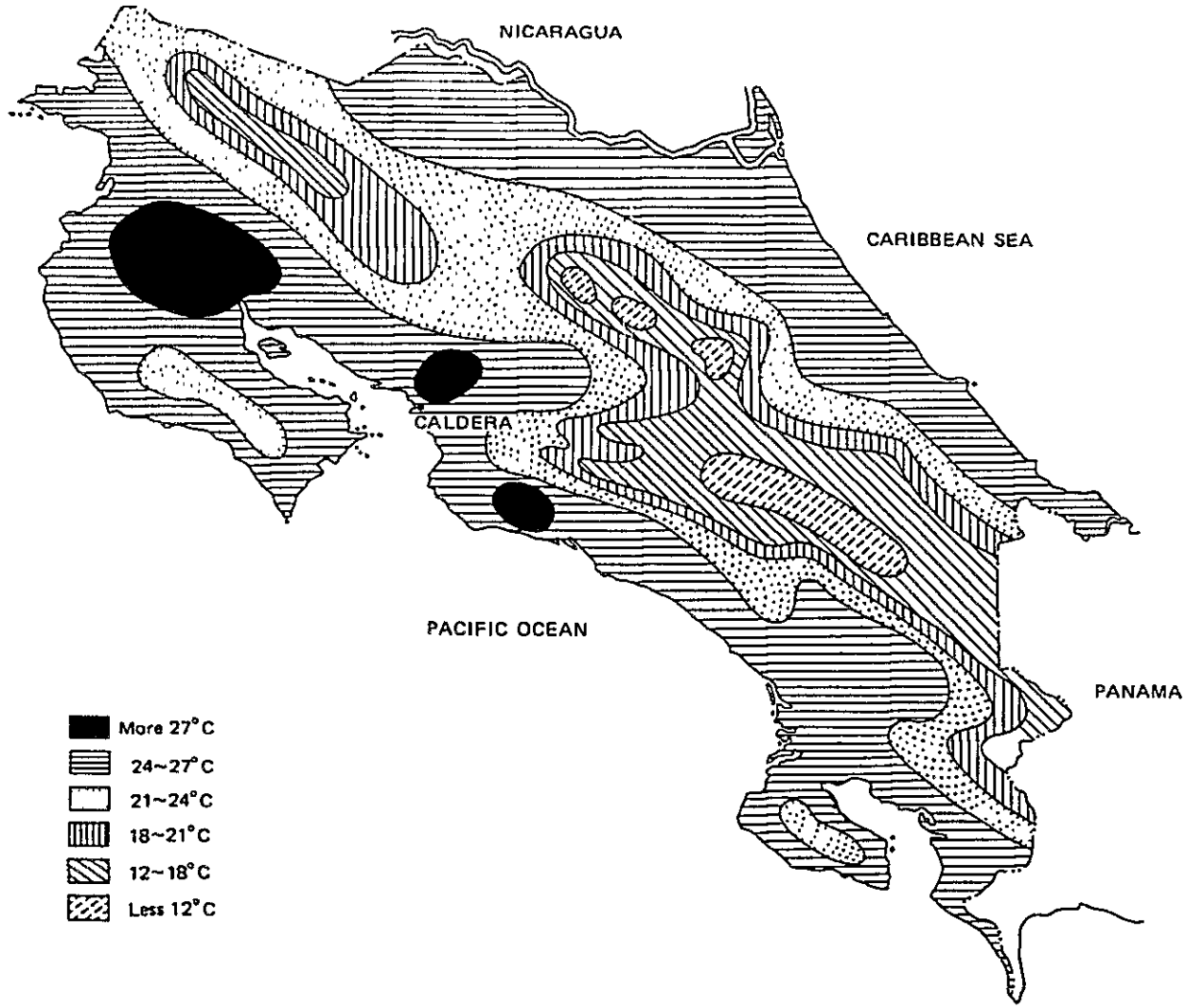


Table 4-2-1 Mean Monthly Precipitation at Puntarenas
(1959 – 1979)

Lat. 09 58 Long. 84 50

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1959	9.0	0.0	0.0	16.2	44.0	133.5	135.1	173.6	181.3	208.4	181.2	0.0	1083.0
1960	0.4	102.2	3.1	17.6	137.6	79.6	196.0	284.6	316.2	557.7	46.3	00.0	1741.3
1961	0.0	0.0	4.1	29.8	15.4	130.4	333.7	127.1	302.4	154.7	181.1	15.5	1294.2
1962	0.0	0.0	16.2	32.3	188.6	401.2	172.8	83.4	124.1	200.8	58.0	13.0	1290.9
1963	4.1	6.7	0.0	81.0	66.2	188.0	148.4	109.5	363.3	283.9	170.0	0.0	1378.4
1964	0.0	0.0	0.0	0.0	93.9	320.2	251.6	209.6	–	–	59.2	56.5	1072.0
1965	0.0	0.0	0.0	0.0	105.0	166.7	158.8	198.8	286.1	73.7	72.5	19.5	1080.6
1966	0.0	0.0	34.5	88.9	343.0	312.5	122.4	219.0	122.3	417.2	42.1	17.9	1630.9
1967	0.9	14.5	0.0	0.0	39.0	248.2	266.5	90.6	372.1	191.8	29.6	98.3	1440.4
1969	2.5	0.0	1.2	12.0	134.8	253.1	124.6	364.6	319.0	357.7	280.5	0.3	1820.3
1970	13.0	2.9	29.8	43.8	167.6	147.6	417.3	321.2	269.5	418.2	38.5	61.0	1930.4
1971	0.3	1.3	13.6	95.8	448.7	203.5	53.3	317.6	455.1	178.5	83.4	1.9	1853.0
1972	35.3	0.0	0.9	29.6	289.6	140.6	81.8	384.9	469.2	330.4	208.5	108.8	2079.0
1973	0.0	-	1.5	18.6	307.4	266.7	166.7	497.1	403.3	290.3	77.1	0.0	2028.7
1974	0.0	0.0	11.4	39.7	133.2	197.8	136.3	267.6	587.1	213.1	9.3	9.5	1605.0
1975	0.0	1.4	16.5	0.0	108.3	168.8	224.9	334.3	374.3	163.3	239.7	17.0	1648.5
1976	0.0	0.0	0.0	2.6	157.6	376.4	33.6	142.3	165.7	237.7	176.3	0.8	1293.0
1977	0.0	0.0	0.0	15.5	61.6	261.7	117.8	181.9	313.0	199.6	185.1	10.9	1347.1
1978	0.0	0.0	0.0	10.3	220.4	141.7	206.7	255.1	195.9	309.1	49.3	50.0	1488.5
1979	0.0	0.0	0.0	41.3	158.8	321.7	116.5	621.8	341.5	366.9	84.1	14.8	2067.4
Mean	3.3	6.5	6.6	30.7	161.1	223.0	173.2	259.2	298.1	257.7	112.1	24.8	1556.3

Fig. 4-2-4 Mean Annual Temperature



4-2-4 Waves

(1) Wave observation at the Port of Caldera

Wave observation at the Port of Caldera has been in effect since June 15, 1978, by an ultrasonic wave height meter (product of Kaijo Denki Co., Japan) installed at a water depth of 15 m, 1.8 km offshore. It automatically indicates significant waves by a singificant wave meter with which in was provided in July 1980.

Table 4-2-3 is a correlation frequency table for the correlation between wave height and wave period prepared on the basis of observation results recorded during the three years from June 15, 1978 until June 11, 1981 while Fig. 4-2-5 is a chart of unsurpassed wave height and period occurrence probabilities.

Table 4-2-4 mentions, in the order of wave height, waves with maximum $H1/3$ of more than 1.5 m picked up from these wave observation records. Probable wave heights corresponding to reappearance periods determined by applying the Weibull distribution to the appearance probabilities of high waves from Table 4-2-4 are shown in Fig. 4-2-6. Periods corresponding to these maximum $H1/3$ are plotted in Fig. 4-2-7. From these, the wave heights and periods of high waves by periods of reappearance are as follows:

Reappearance period (year)	$H1/3$ (m)	$T1/3$ (sec)
10	3.7	17.8
20	4.1	18.2
30	4.3	18.4
40	4.5	18.6
50	4.6	18.7

(2) High Waves of May 1981

The Port of Caldera was struck by high waves twice: May 6 and 21, 1981 and the rubble mound breakwater was partially destroyed by them. According to records by the ultrasonic wave height meter, those high waves showed the following values:

May 6, 1981	Hmax = 3.98 m	Tmax = 20.0 sec
	$H1/3$ = 2.74 m	$T1/3$ = 17.4 sec
May 21	Hmax = 5.44 m	Tmax = 16.9 sec
	$H1/3$ = 3.55 m	$T1/3$ = 17.9 sec

The wave height on May 21 is the largest of all past observed values and is much larger than $H1/3$ = 3.0 m, the breakwater design wave height under the First Stage Project. This high wave was caused as follows:

This high wave was a very long swell with a period of 17~18 sec and presumably originated at a distant point in the Pacific Ocean. So, we obtained weather charts prepared by the Ocean Routes, Inc. for the Pacific area from lat. 30°N to lat. 60°S. These weather charts carry isobars drawn by the meteorologists of the U.S. headquarters of the Ocean Routes, Inc., based on data from the analysis and forecasting of sea winds and waves by the U.S. Navy Fleet Numerical Oceanography Center and its data for ship information.

Table 4-2-3 Frequency of Significant Waves ($H_{1/3}$, $T_{1/3}$)

From June 15, 1978
To · June 11, 1981

PERIODO (SEC) T 1/3 / HEIGHT (M) H 1/3	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	>16	TOTAL	%
	0 a 1 4	1 5 a 2 4	2.5 a 3 4	3.5 a 4.4	4.5 a 5 4	5.5 a 6.4	6.5 a 7 4	7.5 a 8.4	8 5 a 9.4	9.5 a 10 4	10.5 a 11.4	11.5 a 12.4	12.5 a 13.4	13.5 a 14.4	14.5 a 15.4	15.5 a 16.4			
0 a 0.5						2 (0.1)	17 (0.5)	21 (0 6)	36 (1 1)	58 (1 8)	110 (3.4)	118 (3 6)	119 (3.6)	86 (2.6)	34 (1.0)	24 (0.7)	14 (0.4)	639	19.73
a 1 0						8 (0 2)	30 (0 9)	96 (3.0)	143 (4.4)	220 (6.8)	301 (9.3)	341 (10.5)	362 (11.1)	337 (10 4)	177 (5.5)	58 (1.8)	32 (1.0)	2105	65.01 (84.74)
a 1.5				1 (0)	1 (0)		1 (0)	3 (0 1)	13 (0 4)	17 (0.5)	21 (0 6)	19 (0.6)	372 (2.2)	100 (3.1)	71 (2.2)	35 (1.1)	31 (0.1)	385	11.89 (96.63)
a 2 0			1 (0)					1 (0)	2 (0 1)	1 (0)	1 (0)	2 (0 1)	3 (1.3)	7 (0 2)	17 (0 5)	23 (0.7)	15 (0.1)	73	2.25 (98.88)
a 2.5														1 (0)	8 (0.2)	9 (0 3)	5 (0.1)	23	0 71 (99.59)
a 3 0																1 (0)	9 (0.3)	10	0.31 (99.9)
a 3.5																1 (0)	1 (0)	2	0.06 (99.76)
a 4 0																	1 (0)	1 1	0 03 (99 76)
a 4.5																			
a 5 0																			
a 5.5																			
a 6 0																			
> 6 0																			
TOTAL			1	1	1	10	48	121	194	296	433	480	556	531	307	151	108	3238	
			0	0	0	0 31	1 42	3.74	5.79	9.14	13 37	14 82	17 17 (11.02)	16.40 (52.42)	4.48 (91.9)	4 66 (96.56)	3.34		

Fig. 4-2-5 Percentage Excess of $H_{1/3}$ and $T_{1/3}$

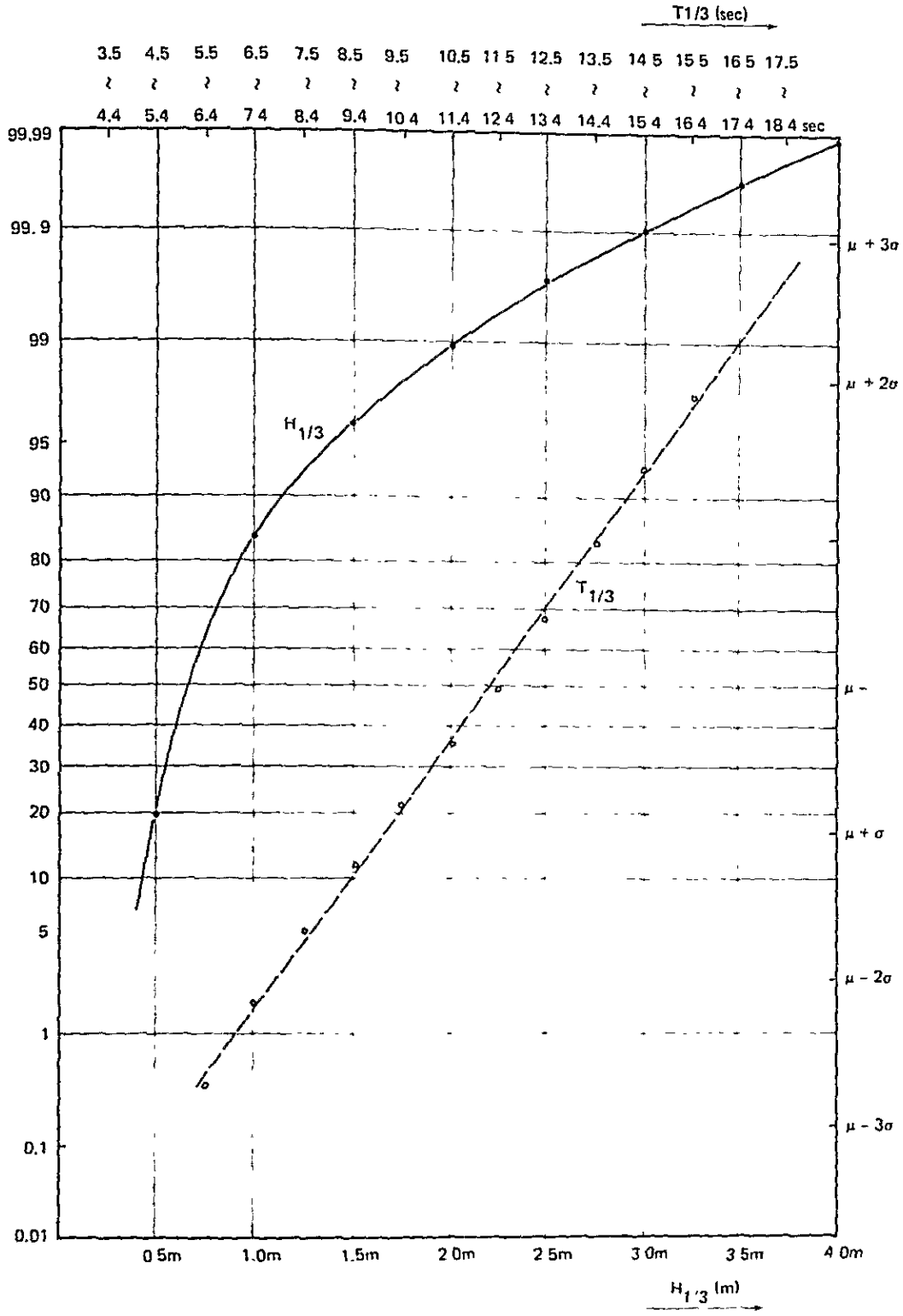


Table 4-2-4 List of the Maximum Significant Wave Heights in a Group of the Large Waves (H1/3, higher than 1.5m, are selected)

Order	Observed Year M D.	Time	$H'_{1/3}$ (m)	$T'_{1/3}$ (sec)	Hmax (m)	Tmax (sec)	$H'_{1/10}$ (m)	$T'_{1/10}$ (sec)	Hmean (m)	Tmean (sec)
1	1981. 5 21	16	3.55	17 9	5 44	16.9	4.17	17.8	2.19	15.1
2	78 6.20	8	3 00	16.8	4.60	17.0	3.80	17.0		
3	81 5 6	18	2 74	17.4	3.98	20.0	3 43	16.7	1.58	12.0
4	80.11	8	2.53	17.1	3 36	17.7	2 95	17.6	1.55	12.5
5	80.10 16	22	2 22	17.1	3.55	18 1	3 11	17.3	1 30	12.4
6	78 9 18	2	2 10	8 9	3 70	9 0	2.10	8 9		
7	78 10 3	16	2 00	16 0	3 00	15 0	2.50	16.0		
8	79. 8 7	16	2 00	18.2	2 50	20.0	2.30	19.0		
9	81 3 21	18	2.00	15 7	2.48	14 3	2.29	15.5	1 21	13 0
10	78. 8 6	4	1 90	14.5	3.20	14.0	2.40	14.5		
11	79 5 20	24	1 90	16 0	2 50	17 0	2.30	16.0	1.30	15.0
12	79 9. 7	16	1.80	15 4	2 70	18.0	2.30	16.0	1.10	12.2
13	79 8 4	8	1 70	16.0	2.60	16.0	2.10	16 2	1.10	14.0
14	78 9.12	20	1.60	15 0	2 70	14.0	2.00	15.4		
15	80 9 11	22	1.51	11.7	2 06	11.5	1.82	11.8	0.97	9.7
16	78.10 15	4	1.50	14 0	1.90	16.0	1.70	15 0		
17	80 10.26	4	1.50	13.8	2 40	13.9	1.88	14.4	0.96	10.9

Fig. 4-2-6 Probability Significant Wave Height in Various Return Periods

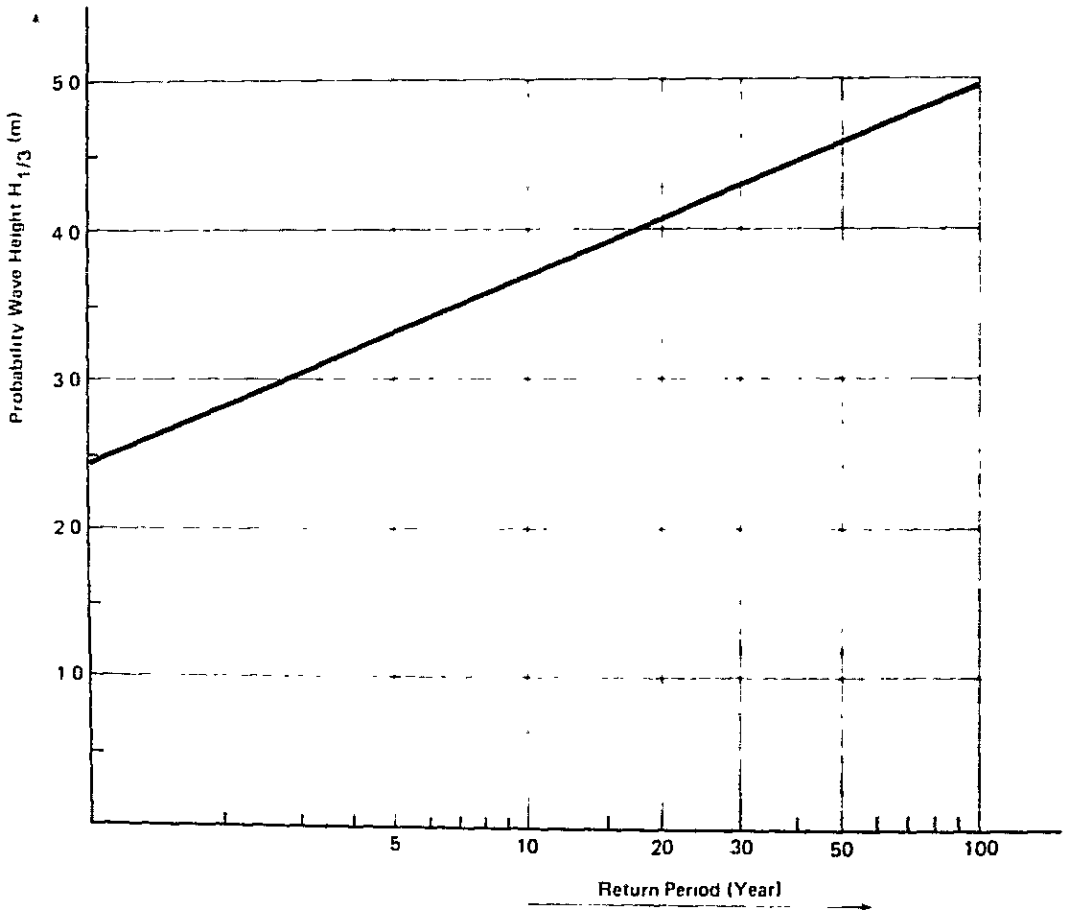
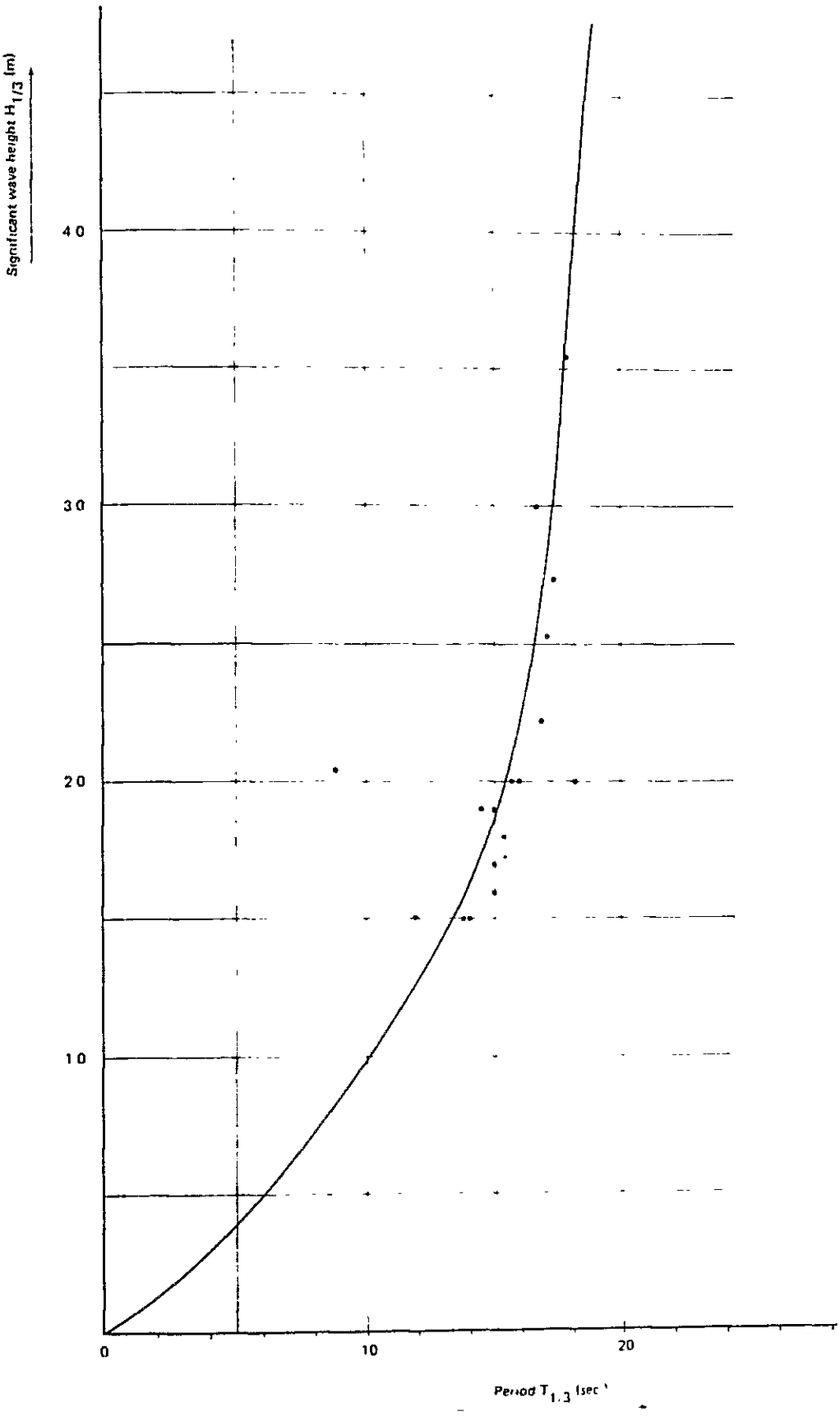


Fig. 4-2-7 Relation between $H_{1/3}$ and $T_{1/3}$



The presumed origin of the high wave of May 6 was with strong winds that continued from April 27 until May 1 in the waters of lat. 47°~60°S and long. 140°~165°W to the east of New Zealand. Fig. 4-2-8 shows the area within ±30° of the direction of winds proceeding toward Nicoya Bay at velocities of more than 20 m/sec, as determined from the weather charts. The details of this wind field are:

Fetch	: 1,500 km
Decay distance	
(from wind field to Nicoya Bay)	. 8,700 km
Width of wind field	: 840 km
Average wind velocity	. 22 m/sec
Wind duration	: 90 hrs

The value of the swell is presumed by the Bretschneider method after determining the generated wave from these by the SMB method as follows:

Wave generated in wind field	.	$H_{1/3}$ = 9.8 m	$T_{1/3}$ = 13.2 sec
Swell reaching Nicoya Bay	:	$H_{1/3}$ = 2.5 m	$T_{1/3}$ = 17.4 sec
Time taken to reach	:	178 hours (7.4 days)	

The highest wave at the Port of Caldera occurred at 1800 hrs on May 6 and this wave is believed to have left its area of origin at midnight on April 29. Its presumed direction toward Nicoya Bay was N210°.

The high wave of May 21 is thought to have originated, based on data from weather charts, in the field of strong southwesterly winds between the very high pressure that slowly proceeded east over the sea to the east of New Zealand from about May 6 and soon turned toward southeast and the very low pressure that stayed and developed from May 13 in the seas west or Chile. From May 13, this wind field appeared in the waters to the east at a somewhat higher latitude from that of May 13 (see Fig. 4-2-9) with the following data:

Fetch	:	3,000 km
Decay distance	:	6,800 km
Average wind velocity	:	22 m/sec
Wind duration	:	90 hrs

The values of the wave generated in this wind field and the swell are presumed to be as follows:

Wave generated in wind field	:	$H_{1/3}$ = 11.0 m	$T_{1/3}$ = 14.6 sec
Swell in Nicoya Bay	:	$H_{1/3}$ = 4.3 m	$T_{1/3}$ = 18.5 sec
Time taken to reach	:	131 hours (5.5 days)	

Fig. 4-2-8 Estimated Wave Generating Area for High Swell of May 6, 1981

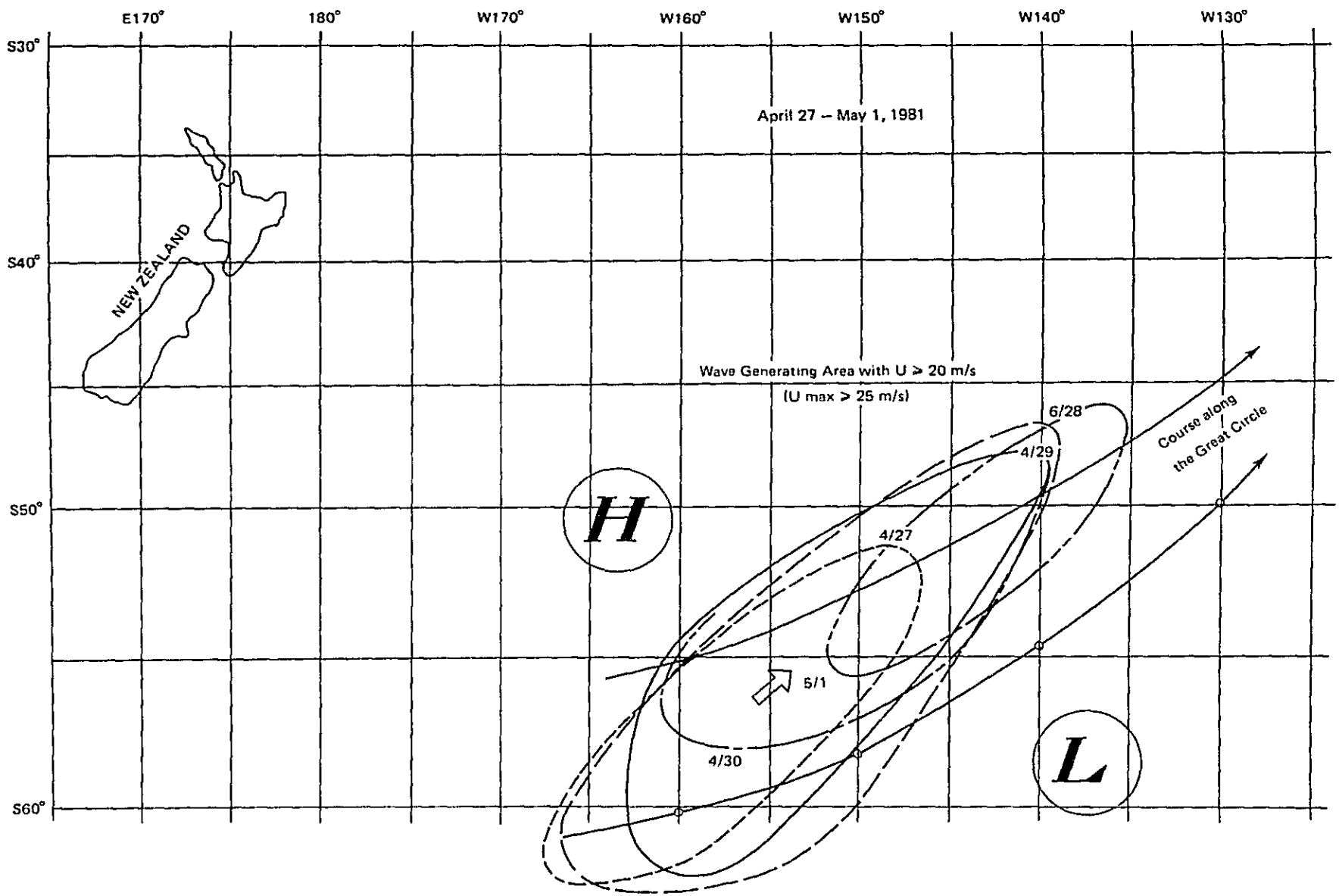
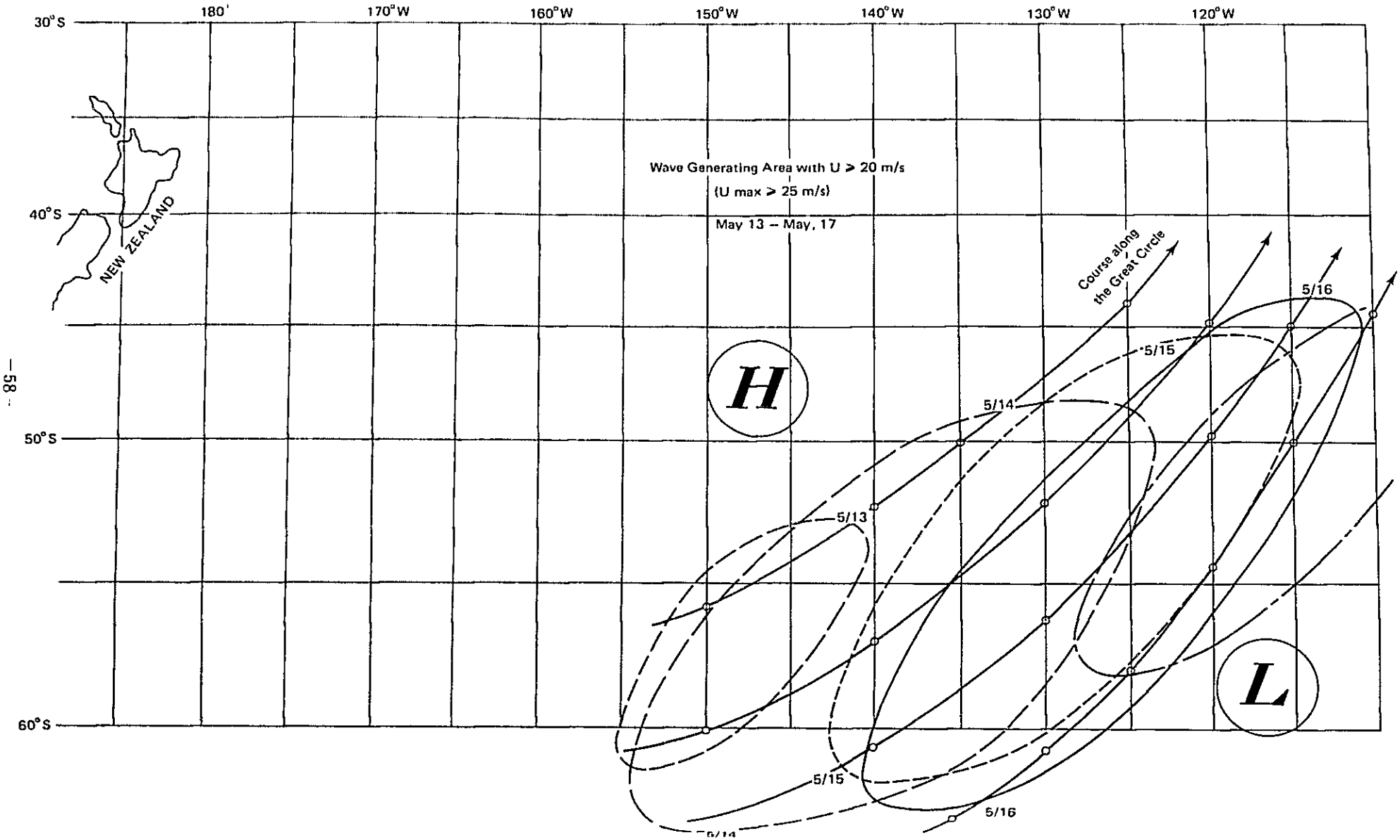


Fig. 4-2-9 Estimated Wave Generating Area for High Swell of May 21, 1981



Thus long-period swells affecting the Port of Caldera are presumed to be waves generated in the long-distance wind field formed along the atmospheric pressure slope between extensive high and low pressures in the waters of lat. 50°~60°S and long. 120°~160°W and propagated over a distance of 7,000~9,000 km. Characteristically, swells from a great distance such as this, have a narrow dispersion width of wave direction and behave somewhat similarly to regular waves. Their dispersion width of wave direction is indeed small and presumed to be only about ±10°, as can be seen from the fact that the main wave directions of the high waves of May 6 and 21 were N210° and N205°.

(3) Calculation of Refraction of Waves Affecting the Port of Caldera

Waves affecting the Port of Caldera are swells with long periods of 16~18 sec and subject to refraction from a water depth of about 200 m. It is, therefore, desirable to calculate their refraction from outside the mouth of Nicoya Bay but, for the convenience of calculation, we used the area of about 40 km north to south and about 50 km east to west on the north side of lat. 9°36'N and calculated by a computer program based on the wave direction line method as regular waves. The calculation covered 42 cases representing the entire combinations of the following wave directions and periods, as indicated in Figs. A4-2-1 ~ A4-2-42

Wind direction	SSE (N157.5°)	S (N180°)	S·SSW (N191.3°)	SSW (N202.5°)	SSW·SW (N213.8°)	SW (N225°)
Period	8 sec	10 sec	12 sec	14 sec	16 sec	20 sec

The refraction coefficients for the vicinity of the point of installation of the wave height meter at the Port of Caldera obtained from these refraction charts are shown in Table 4-2-5. Also, areas where waves are liable to concentrate are, by wave directions, as follows.

Table 4-2-5 Refraction Coefficient

Direction / Period	157.5° SSE	180° S	191.3° S·SSW	202.5° SSW	213.8° SSW·SW	225° SW
8 (s)	–	0.87	1.0	0.84	0.67	0.33
10	0.3	1.00	1.0	0.82	0.42	0.16
12	0.4	0.91	0.8	0.88	0.35	<0.15
14	0.55	0.88	0.6	0.79	0.25	〃
16	0.65	0.84	0.83	0.75	0.20	〃
18	0.7	1.34	1.33	0.77	0.17	〃
20	0.3	1.27	1.41	0.75	0.15	〃

SSE	(N157.5°)	:	Vicinity of the Port of Puntarenas
S	(N180°)	:	Rather evenly distributed
S·SSW	(N191.3°)	:	Caldera beach north of Cape Carballos
SSW	(N202.5°)	:	South side of Cape Caldera
SSW·SW	(N213.8°)	:	From south side of Cape Caldera to Tirives beach
SW	(N225°)	:	Rather evenly distributed

At the construction site of the Port of Caldera, S·SSW long-period waves after tend to concentrate but this tendency is not remarkable and the site has relatively calm waters for this coast.

The direction of incident waves at the Port of Caldera is first measured on the line extending due west from the southern tip of Plaja Icaco, using the refraction charts of Figs. A4-2-1~A4-2-42. Then, the angle of incidence of waves is measured by preparing refraction charts with a larger reduced scale from this line toward the Port of Caldera. Table 4-2-6 shows wave directions on the line extended due west from Plaja Icaco. The angle of incidence on the line of the breakwater was measured by preparing refraction charts Figs. A4-2-43~A4-2-48 for 12 dec, 16 sec and 20 sec, periods for S·SSW and SSW included in these wave directions. The results for these computations for, the directions of incident waves into the Port of Caldera are shown in Table 4-2-7. Waves from SSW·SW have a larger angle of incidence than waves from SSW but, because of their extremely small refraction coefficient, they affect harbor wave height and other factors less than SSW waves.

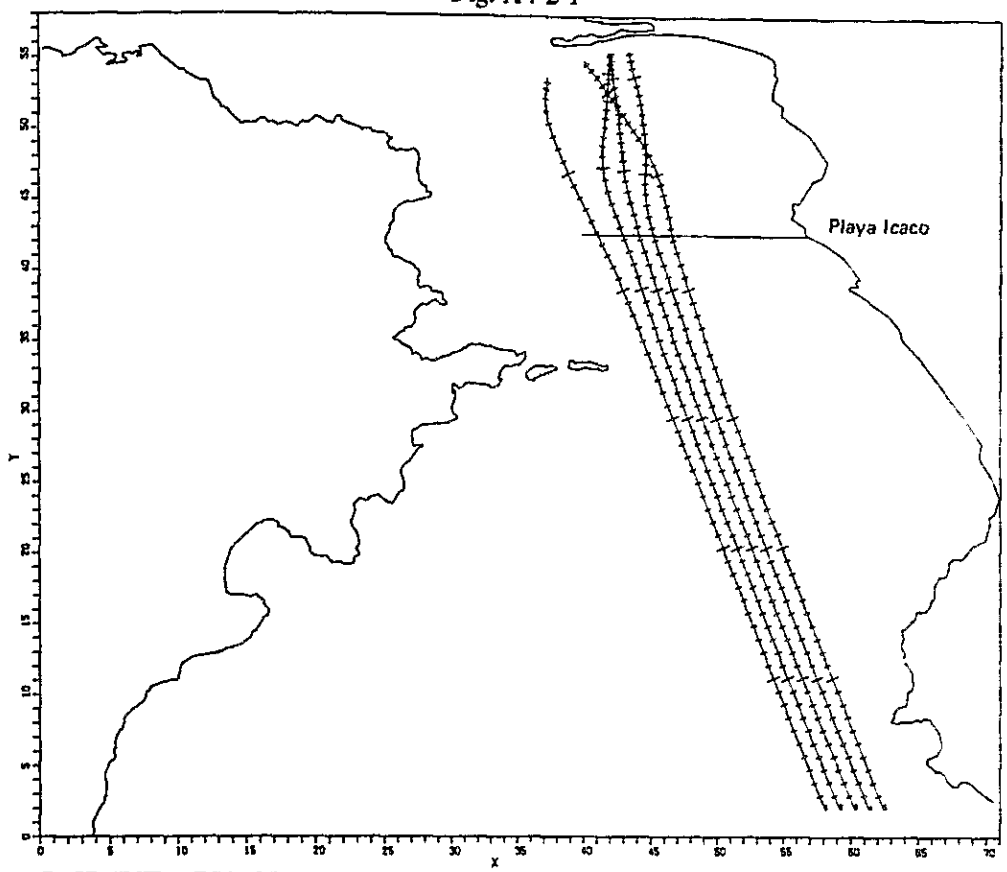
Table 4-2-6 Wave Direction

Direction / Period	157.5° SSE	180° S	191.3° S·SSW	202.5° SSW	213.8° SSW·SW	225° SW
8 (S)	*	182°	193°	205°	216°	*
10	*	183°	195°	208°	217°	*
12	*	185°	196°	210°	217°	*
14	*	186°	198°	211°	217°	*
16	177	189°	199°	212°	218°	*
18	180	191°	202°	214°	219°	*
20	180	193°	204°	215°	219°	*

Table 4-2-7 Incident Wave Direction to the Port of Caldera

Direction / Period	191.3° S·SSW	202.5° SSW
12	220°	224°
16	223°	(233°) 228°
20	225°	(233°) 229°

Refraction Chart
Fig. A4-2-1



GLID INT = 750 (M) SSE T = 8s

Fig. A4-2-2

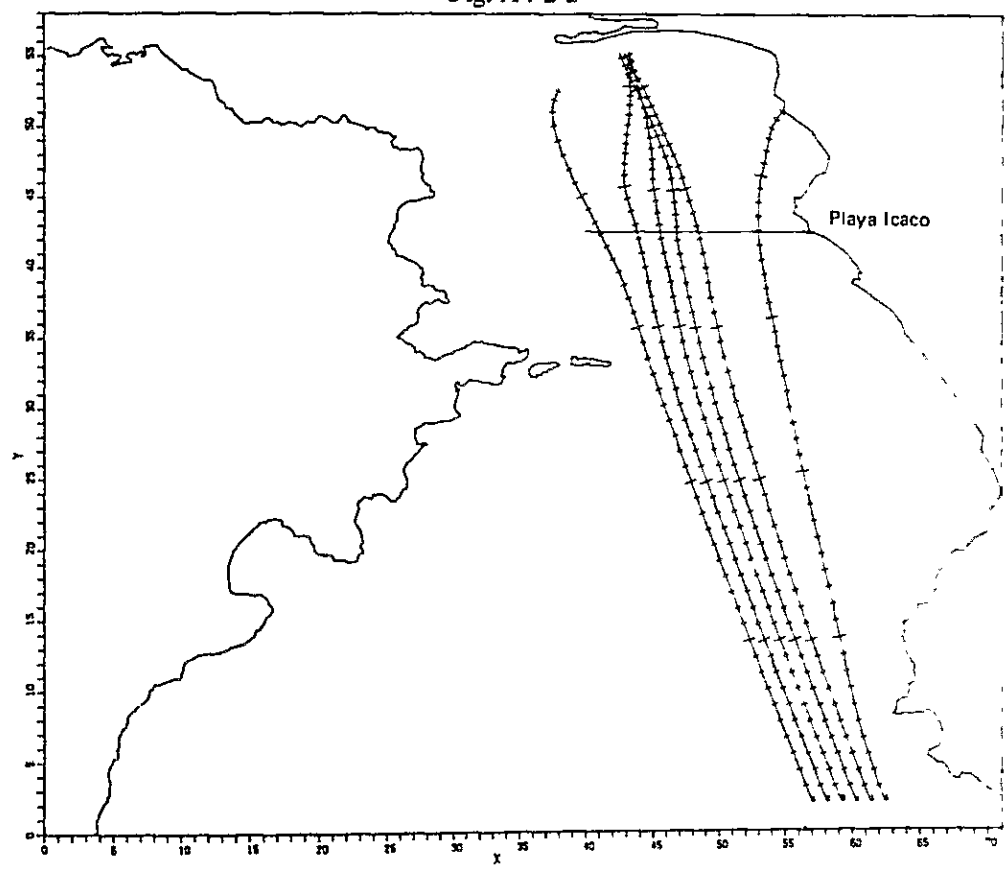


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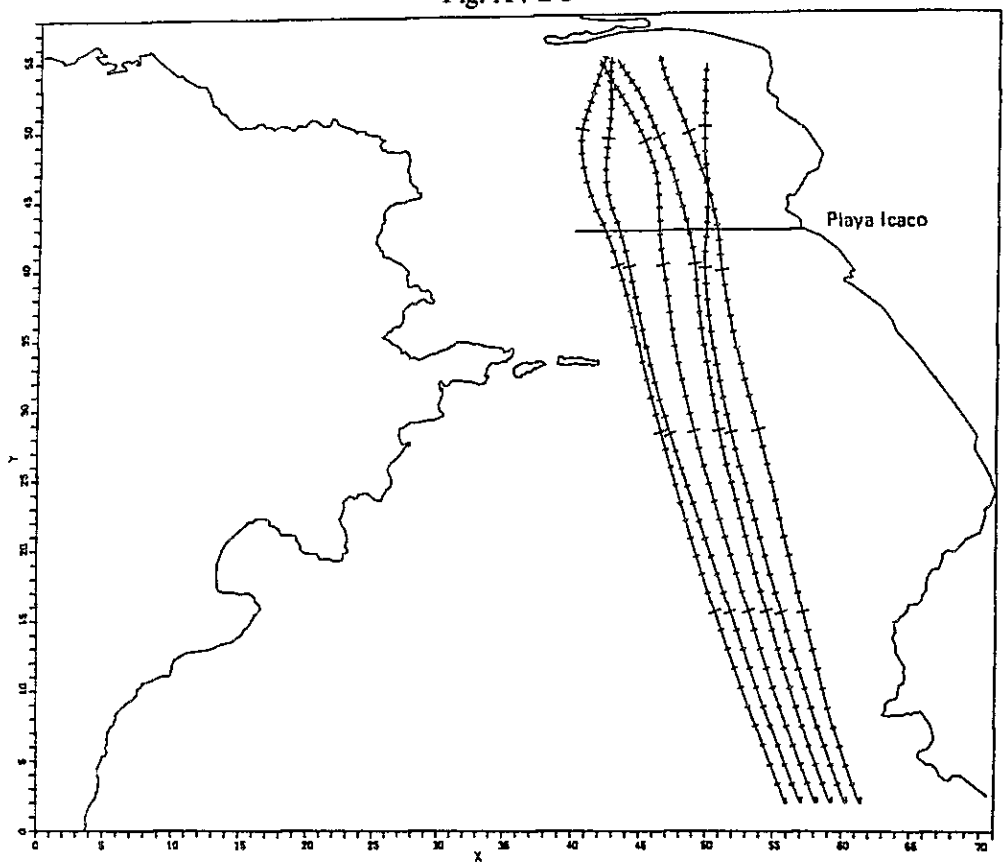
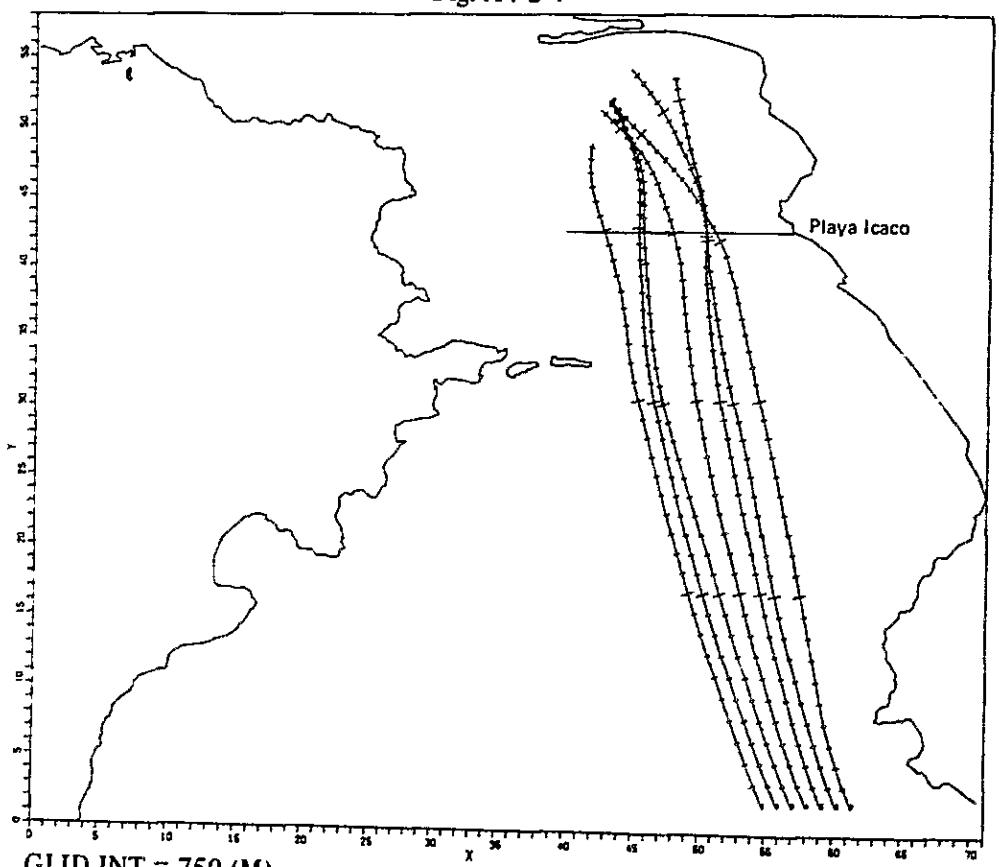
Fig. A4-2-3



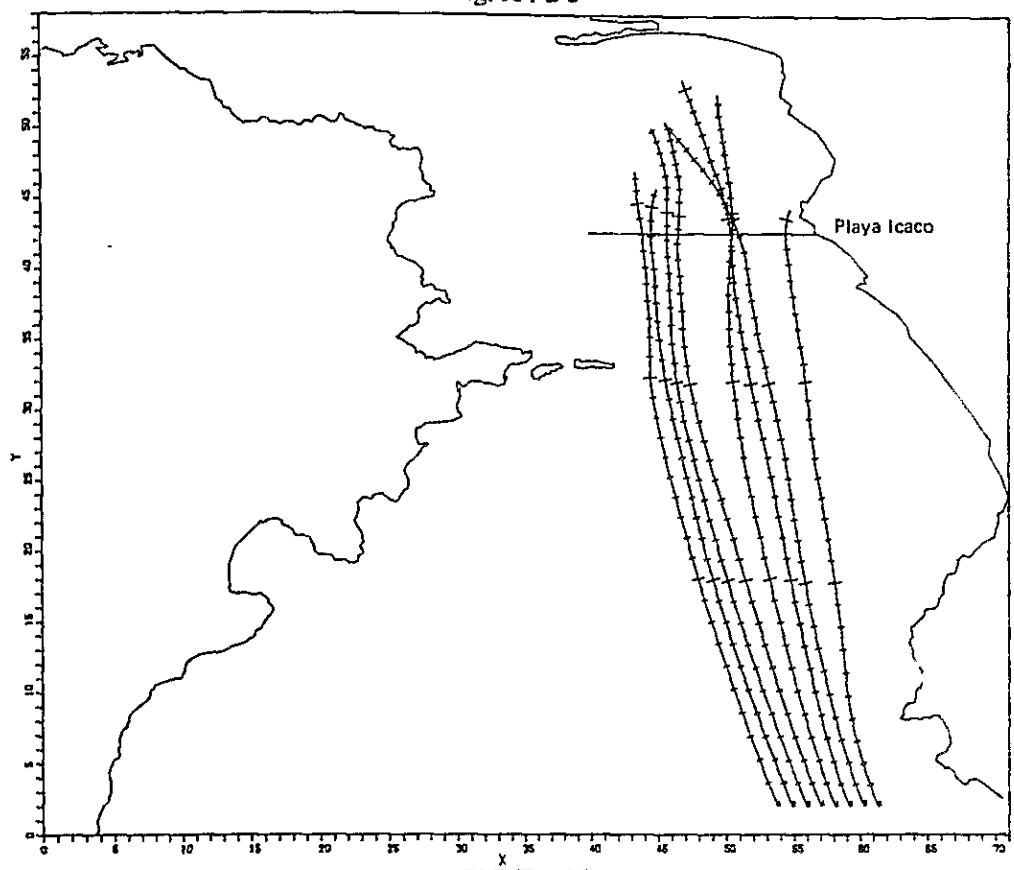
GLID INT = 750 (M) SSE T = 12s

Fig. A4-2-4



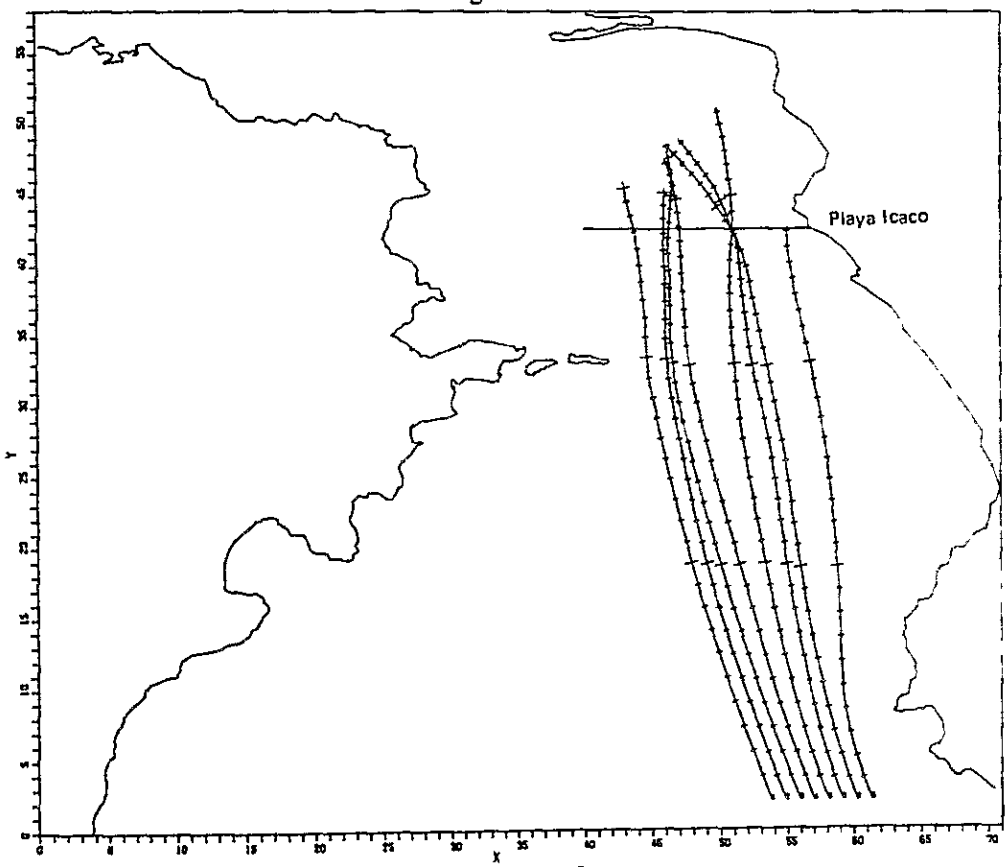
GLID INT = 750 (M) SSE T = 14s

Fig. A4-2-5



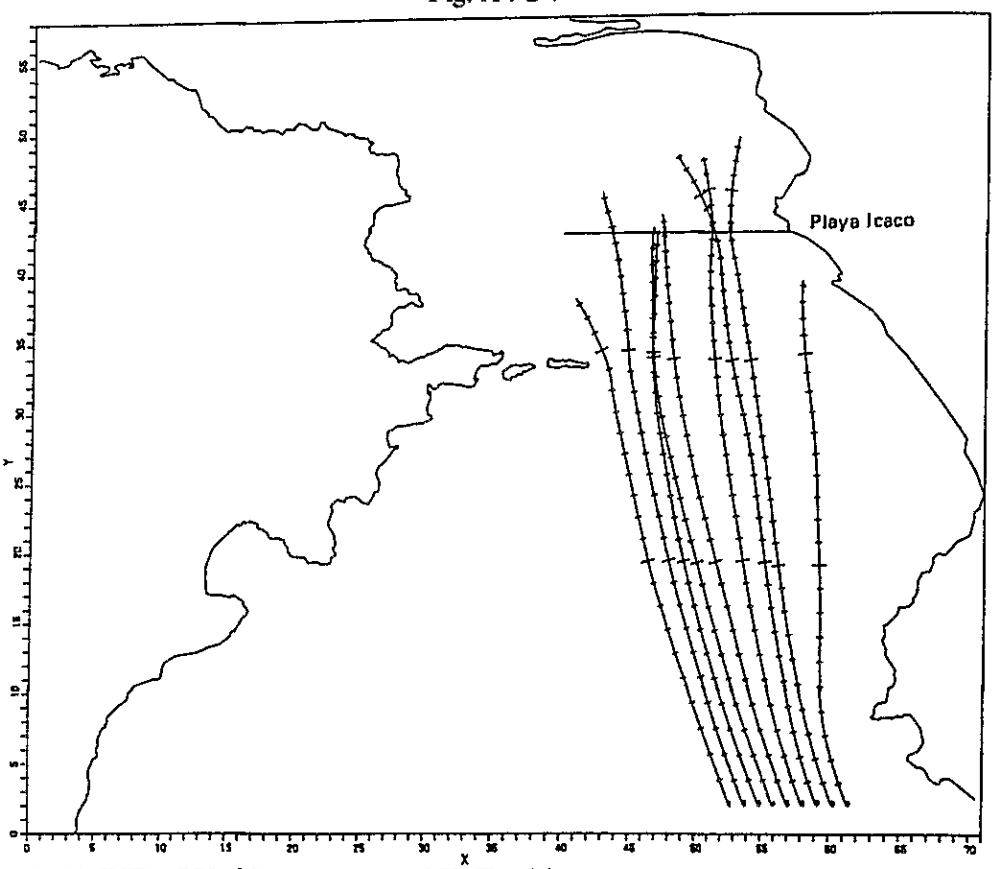
GLID INT = 750 (M) SSE T = 16s

Fig. A4-2-6



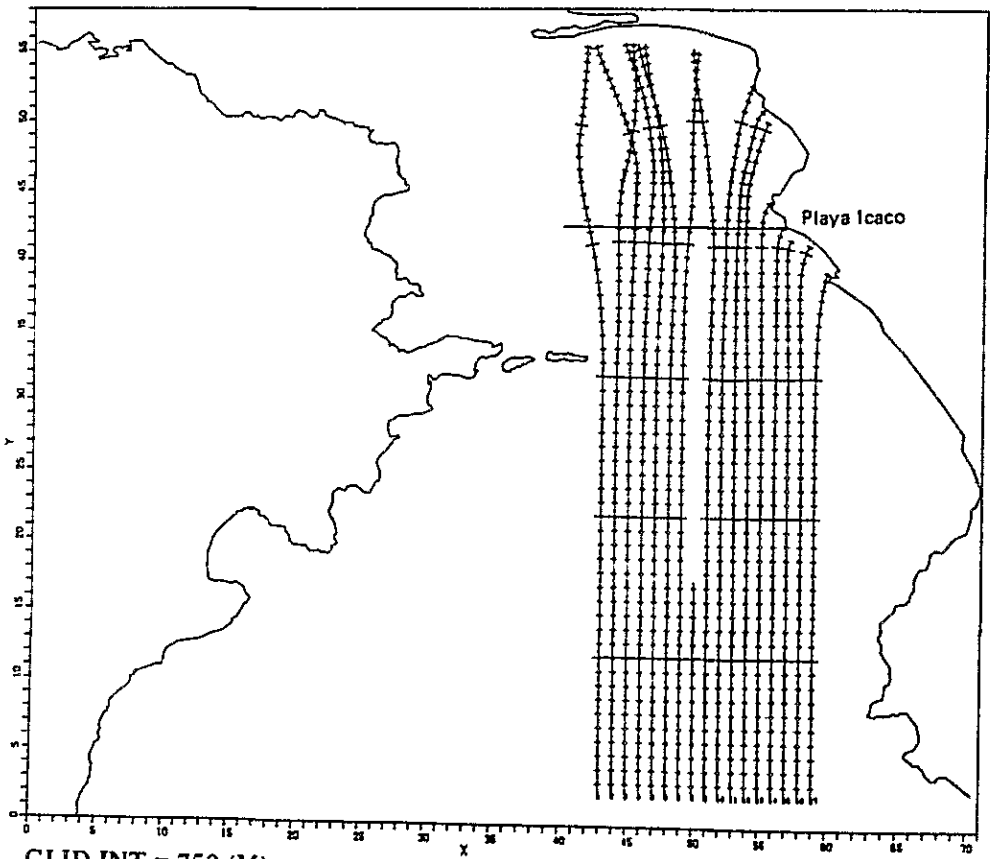
GLID INT = 750 (M) SSE T = 18s

Fig. A4-2-7



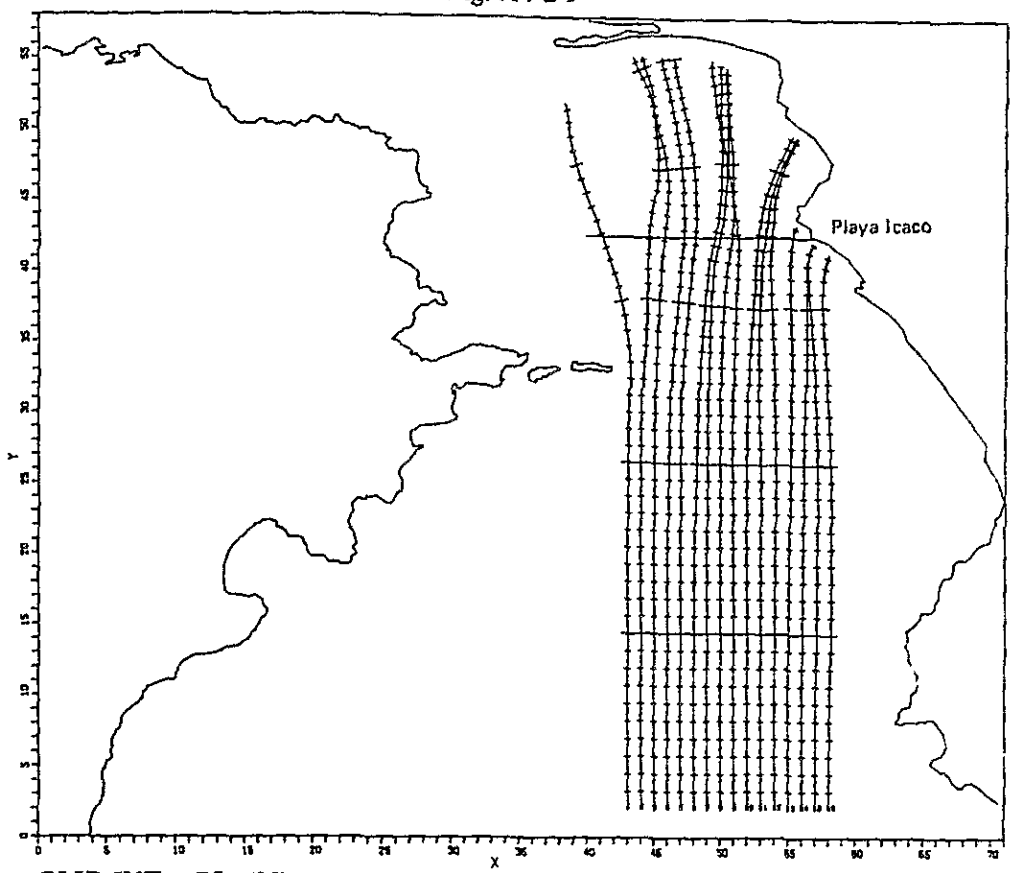
GLID INT = 750 (M)　　SSE T = 20s

Fig. A4-2-8



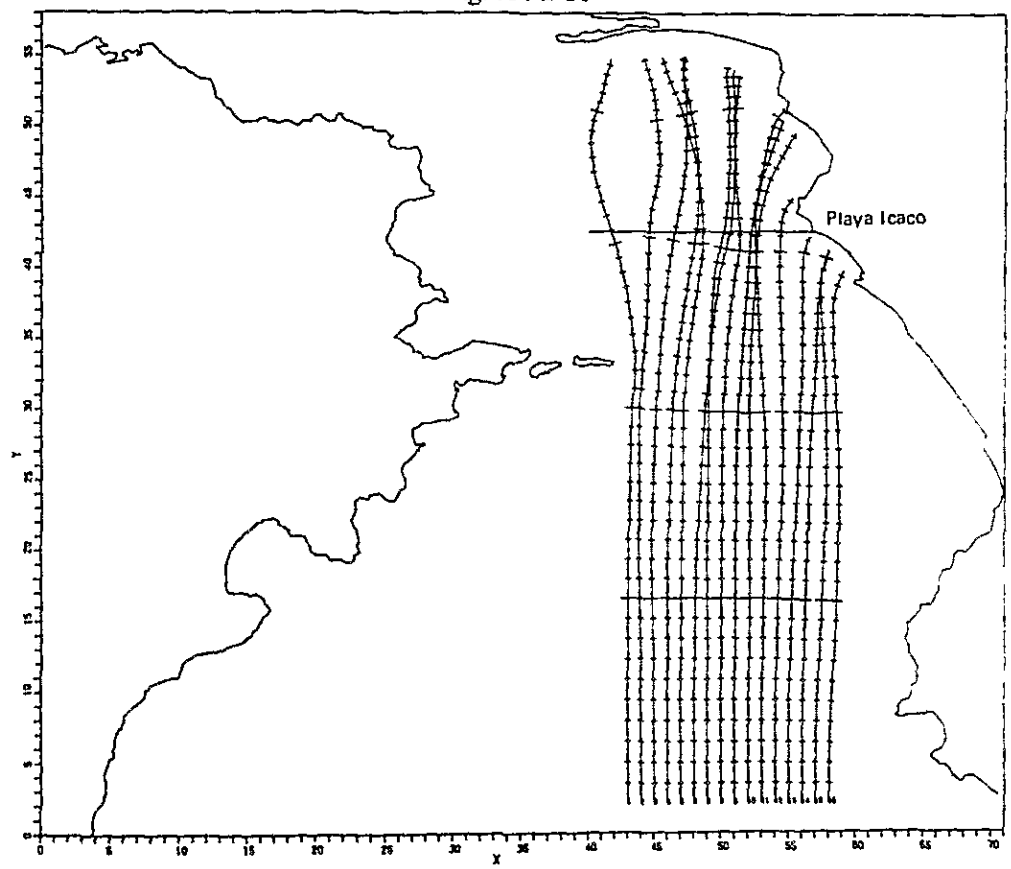
GLID INT = 750 (M)　　S T = 8s

Fig. A4-2-9



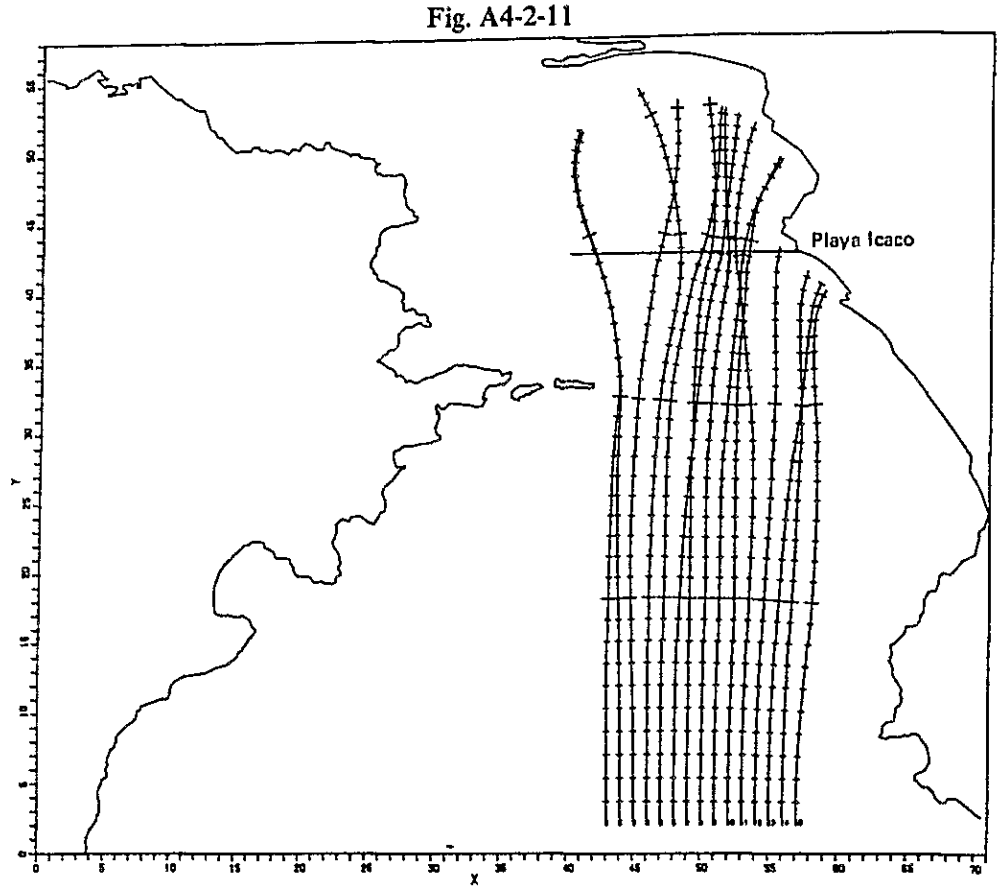
GLID INT = 750 (M) S T = 10s

Fig. A4-2-10



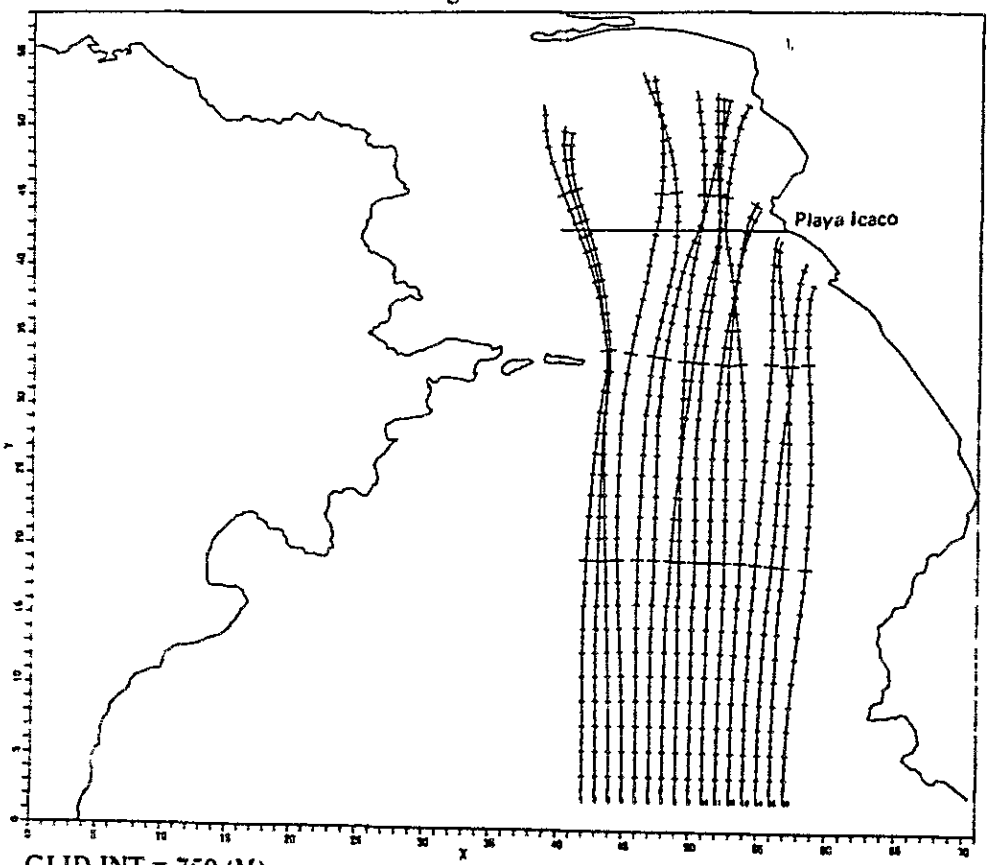
GLID INT = 750 (M) S T = 12s

Fig. A4-2-11



GLID INT = 750 (M) S T = 14s

Fig. A4-2-12



GLID INT = 750 (M) S T = 16s