CHAPTER III.

PRESENT SITUATION AT THE PORT OF MANZANILLO

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1. Natural Conditions

1-1 Topographical and Geological Features

1-1-1 Topography and Geography

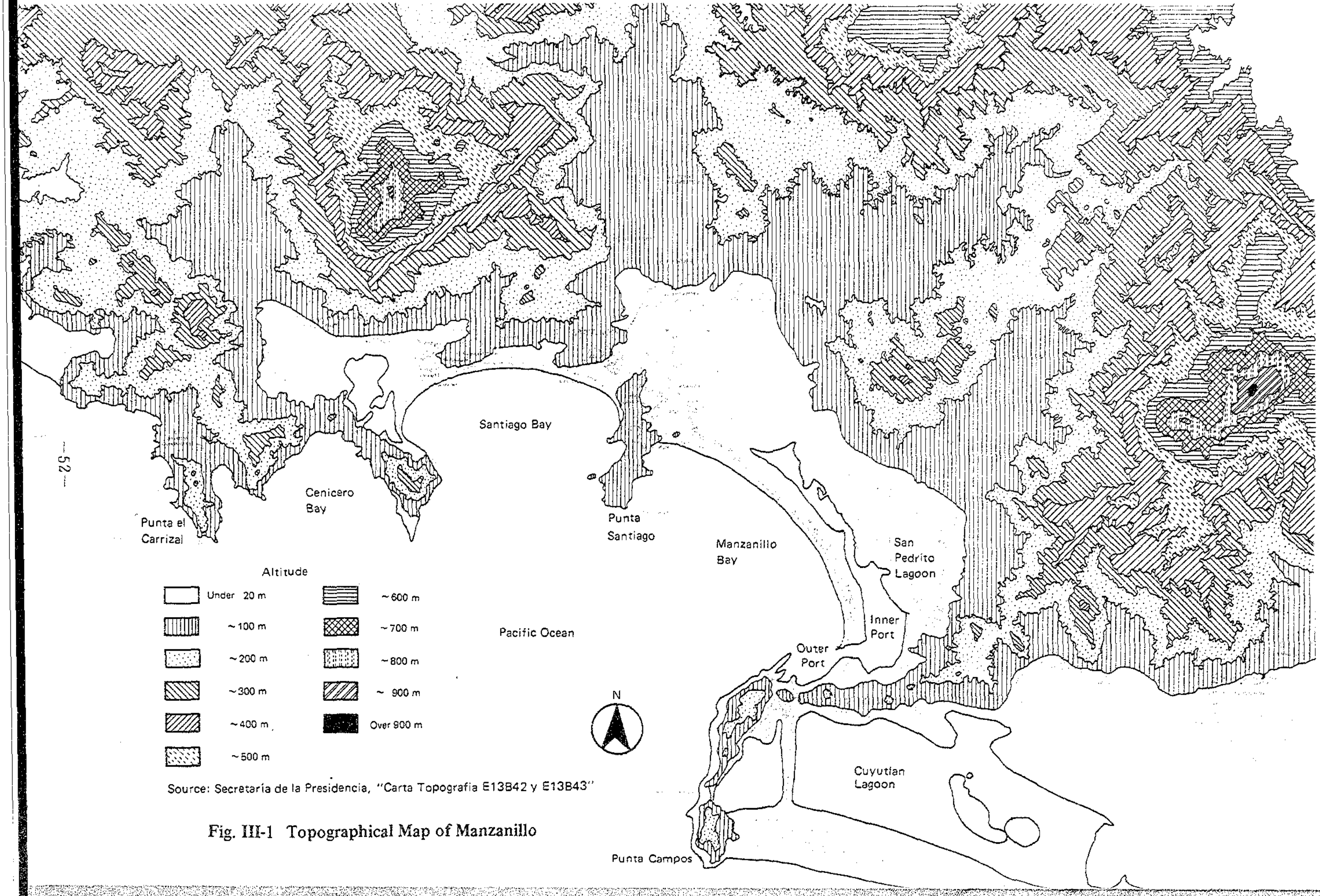
Fig. III-1 is a topographical map of the area in and around the port of Manzanillo, where a contour line at 20 m altitude is indicated. The coastal plains under 20 m in altitude lie in the areas behind the Cenicero and Santiago Bays, a total area of about 5 km^2, behind the Manzanillo Bay, about 20 km^2, and around the Cuyutlan Lagoon. As shown in Fig. III-1, there are lagoons and swampy areas in these plains, so the naturally benign areas are narrow and restricted.

With the exception of the gently sloped areas in the valleys, steeply sloped hills and highlands lie behind the area of 20 m altitude. In the areas between 20 m and 200 m altitude, the gradient is frequently more than 25% and rocks and weathered rock appear on the slopes. There are many precipices in this area.

As shown in Fig. III-1, the peninsular areas (Punta el Carrizal, the peninsula east of the Cenicero Bay, Punta Santiago and the city of Manzanillo itself) are highlands. This is one of the topographic features of this area. Highlands also extend from the steep hills and mountains behind the coastal plains. Coastal plains and plains between the hills and mountains may have been formed by the deposit of soil.

The other outstanding geographic feature of the area is that the urban portion of Manzanillo lies on a slope backed by hills on a peninsula between Manzanillo Bay and the Cuyutlan Lagoon. This peninsula extends from east to west having a width about 1 km with hills over 120 m high. The urban portion is concentrated on gentle slopes and along the coastline, and there is no room for further urban development in this immediate area.

The outer port of Manzanillo is certainly in one of the best natural locations for a port on the Pacific coast. The outer port is located in the south of Manzanillo Bay, and has abundant natural conditions: it faces a natural and calm bay, and the ocean current which goes up north along the western coastline can't affect it directly because the Punta Campos which lies southwest of the urban area shields the port. The outer port has been developed making use of these favorable conditions for a long time, and the urban area was probably developed along with the port and was concentrated in the narrow areas backed by hills.



Source: Secretaría de la Presidencia, "Carta Topografía E13B42 y E13B43"

Fig. III-1 Topographical Map of Manzanillo

Fig. III-2 is a topographical map of the outer and inner ports in 1972. This is presented here for the purpose of understanding the area before the recent port constructions. The outer port has only changed slightly since 1972. It utilizes its natural geographic shape without using any breakwaters.

On the other hand, the inner port has changed significantly. It is located along the south and east sides of the San Pedrito Lagoon, which is from 300 m to 800 m in width and about 5 km in length. As of Oct. 1984, 450 m and 600 m berths were completed, and part of the fishery port (1st stage) and a 600 m berth are under construction. From dredging, reclamation and construction work, the figure of the inner port is rapidly changing, year by year.

Due to the geographical limitations of the outer port, it would be difficult to extend the outer port beyond its current functions. Thus it is desirable to transfer port functions from the outer to the inner port. The area required for urban facilities and industries can be obtained by the development of the San Pedrito, Tapeixtles, and Cuyutlan Lagoons and the areas around them.

1-1-2 Geology

Fig. III-3 is a geological map of the area in and around the port of Manzanillo. The geology in this area can be classified as follows:

① Acid Intrusion, Plutonic Rock: Indication ▨
These are igneous rocks and are distributed over highlands, mountains and peninsulas – Punta el Carrizal, the peninsula east of the Cenicero Bay and Punta Santiago. Their geological age is classified as Cretaceous of Mesozic Era.

② Acid Intrusion, Volcanic Rock: Indication ░
These are also igneous rocks, and are distributed over the peninsular area behind the urban area of Manzanillo. Their geological age is classified as Teritiary of Mesozic Era.

③ Alluvial Deposit: Indication □
This alluvial soil is distributed over plains and valleys behind the Manzanillo and Santiago Bays. Its geological age is classified as Quaternary of Cainozoic Era, which is the most recent period. It is also partly distriuted over the northern coast of the Cuyutlan Lagoon.

④ Swampy Soil: Indication ░
This is distributed in and around the San Pedrito Lagoon. Its geological age is classified as the nearest Quaternary of Cainozoic Era.

One of the outstanding features in Manzanillo Port is that the geology in the inner port is different from that in the outer port. Swampy soil is distributed over the inner port, while Alluvial Deposit backed by Acid Intrusion, Volcanic Rock is distributed around the outer port. This difference should be considered for port planning and construction in Manzanillo Port.

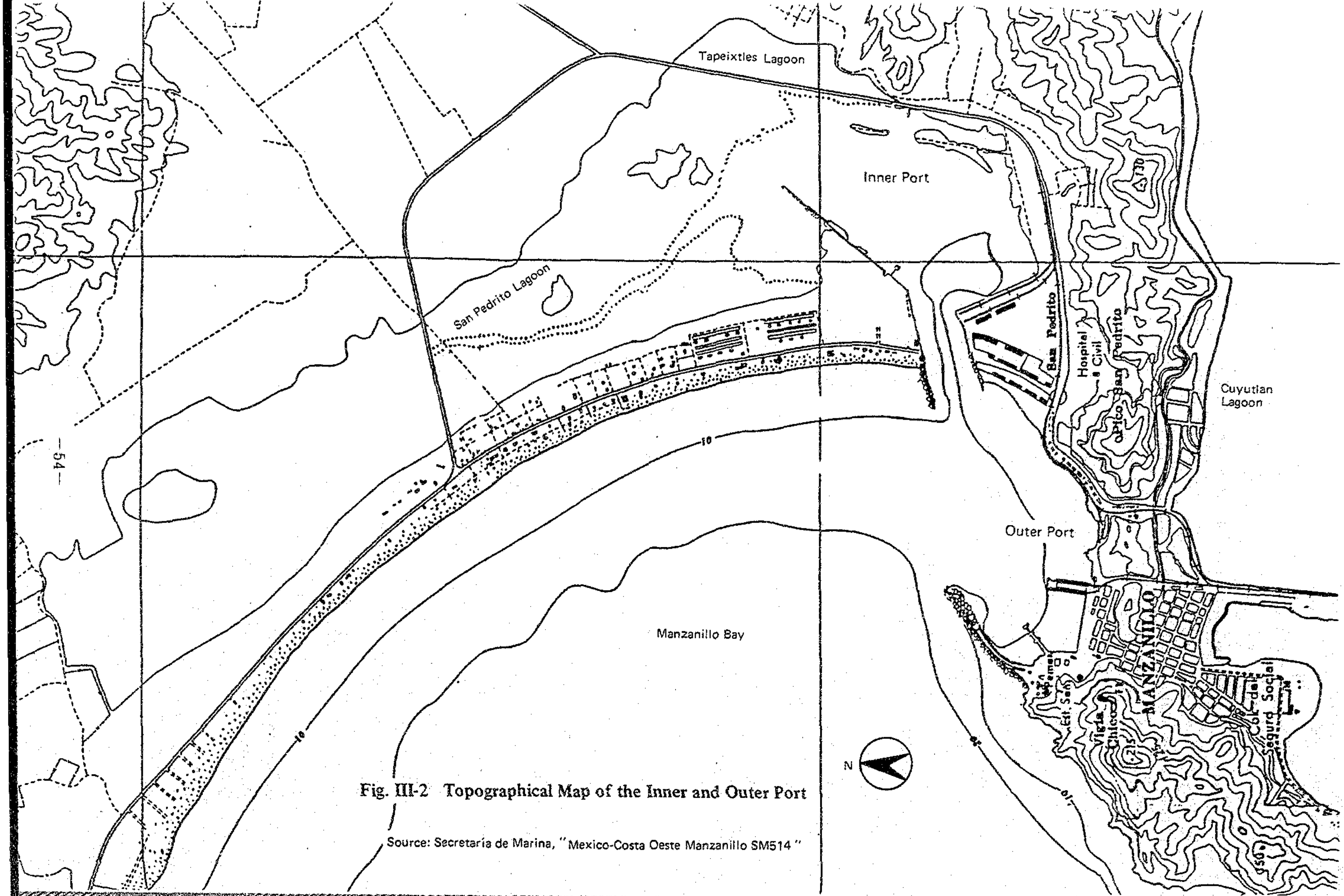
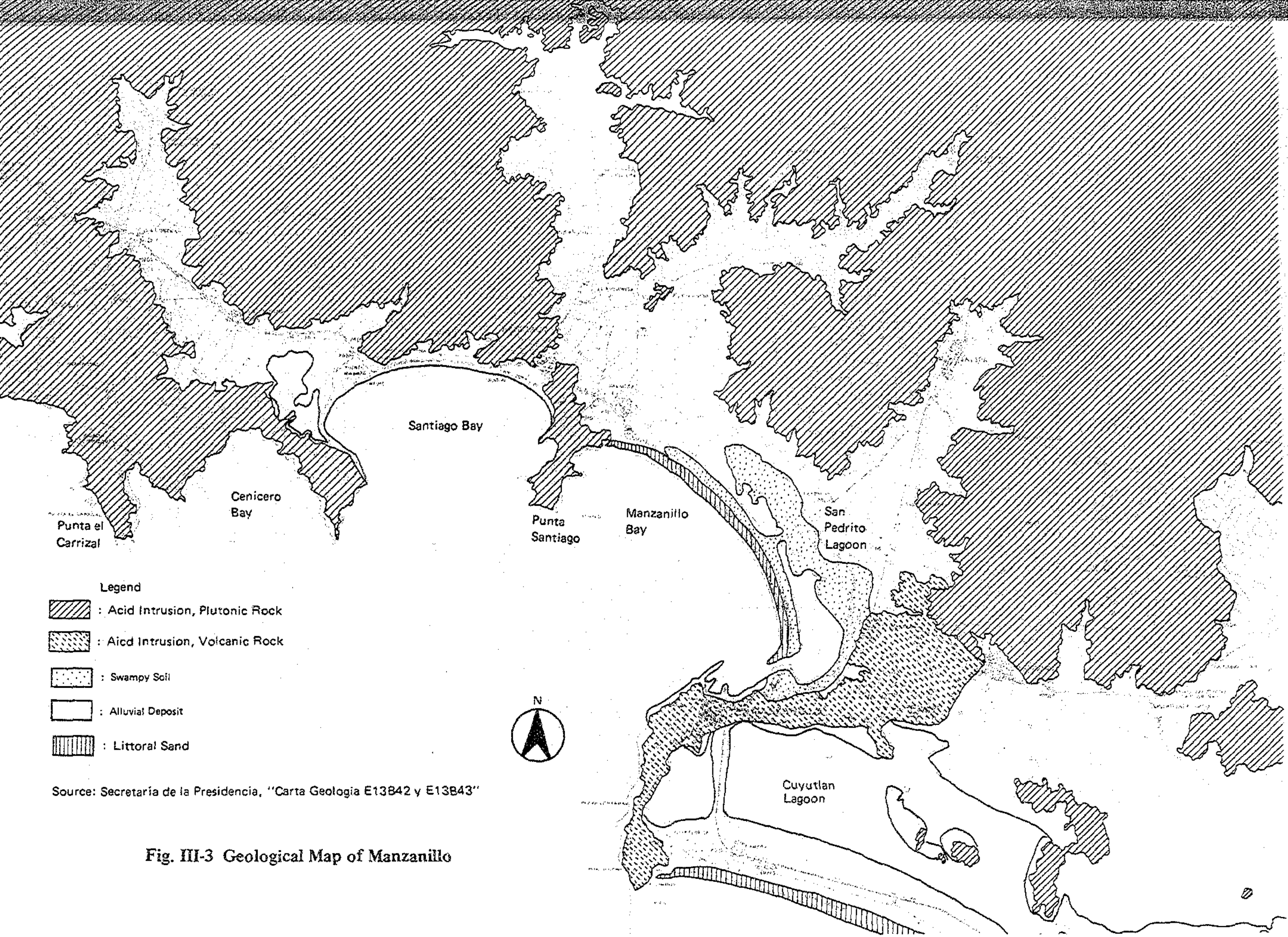


Fig. III-2 Topographical Map of the Inner and Outer Port

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



Source: Secretaría de la Presidencia, "Carta Geologia E13B42 y E13B43"

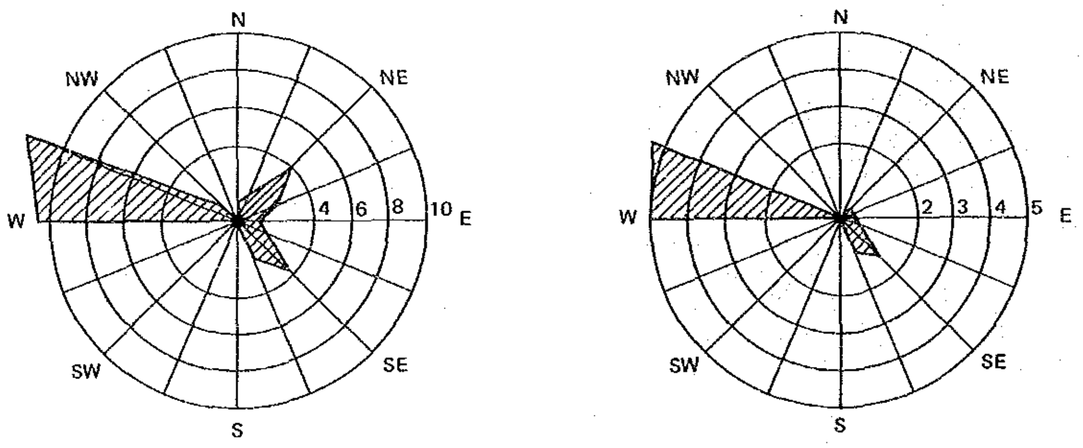
Fig. III-3 Geological Map of Manzanillo

1-2 Meteorological Conditions

As described in Chapter II, the climate around Manzanillo is classified as tropical savanna from Mazatlan to the southern border of the west coast. It has hot and humid weather and a lot of rain in summer, especially caused by cyclones.

1-2-1 Wind

Soft breezes from the Northwest to West predominate throughout the year. Sea winds from the SW are predominant in the daytime. Land winds blow at night but their direction and velocity are not fixed. Gales from the north sometimes blow off the land. Gales from the south caused by cyclones sometimes reach a wind speed of more than 15 m/sec. The wind diagram of Manzanillo from 1957 to 1962 is shown in Fig. III-4. From this figure it is clear that the winds from the W and WNW predominate at Manzanillo Port.



N $(x10^2)$

NV $(x10^3)$

Item	N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
N x10	11	15	38	22	11	14	37	21	1	0	1	5	107	121	9	3
NV x10	15	14	47	30	38	51	160	97	4	0	2	18	511	531	27	5

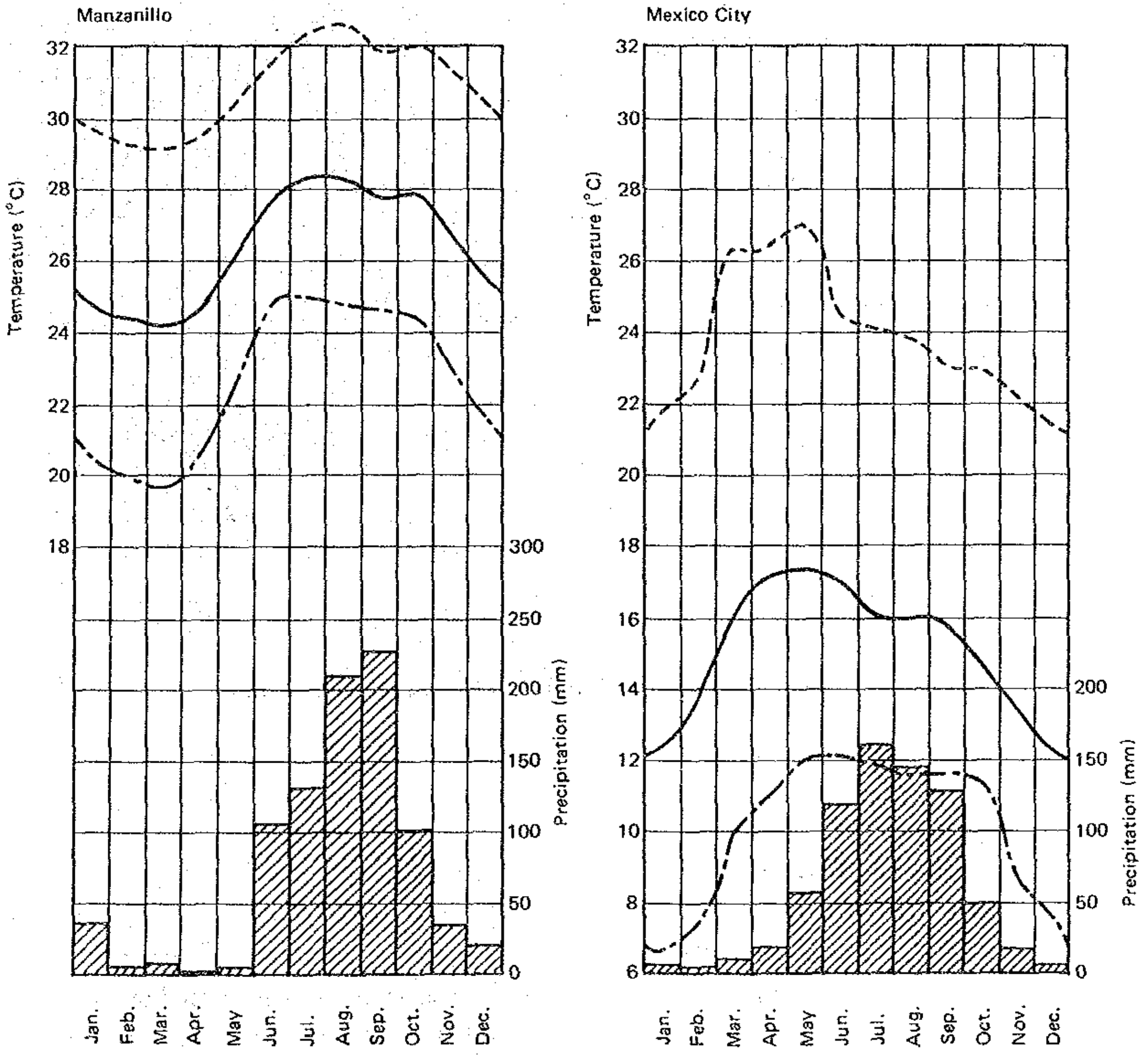
Note: Number of Total observation 6902
Calm 2751
Velocity (V) m/sec
N means number of observations.
NV means N x V.

Source: Secretaría de Marina, Estados en Manzanillo, Col., "Diagramas de Lenz", Sept. 1984

Fig. III-4 Wind Diagram

1-2-2 Precipitation

The mean annual rainfall at Manzanillo is about 900 mm. It rains heavily from June to October as shown in Fig. III-5 and the record rainfall in September during the last 20 years was more than 500 mm. The monthly rainfall from November to May is less than 40 mm. For the purpose of comparison, the rainfall at Mexico City is also shown in Fig. III-5. The distribution of mean annual rainfall in Colima is shown in Fig. III-6.



Notes: 1) Lines show the following:

——— Mean Temperature

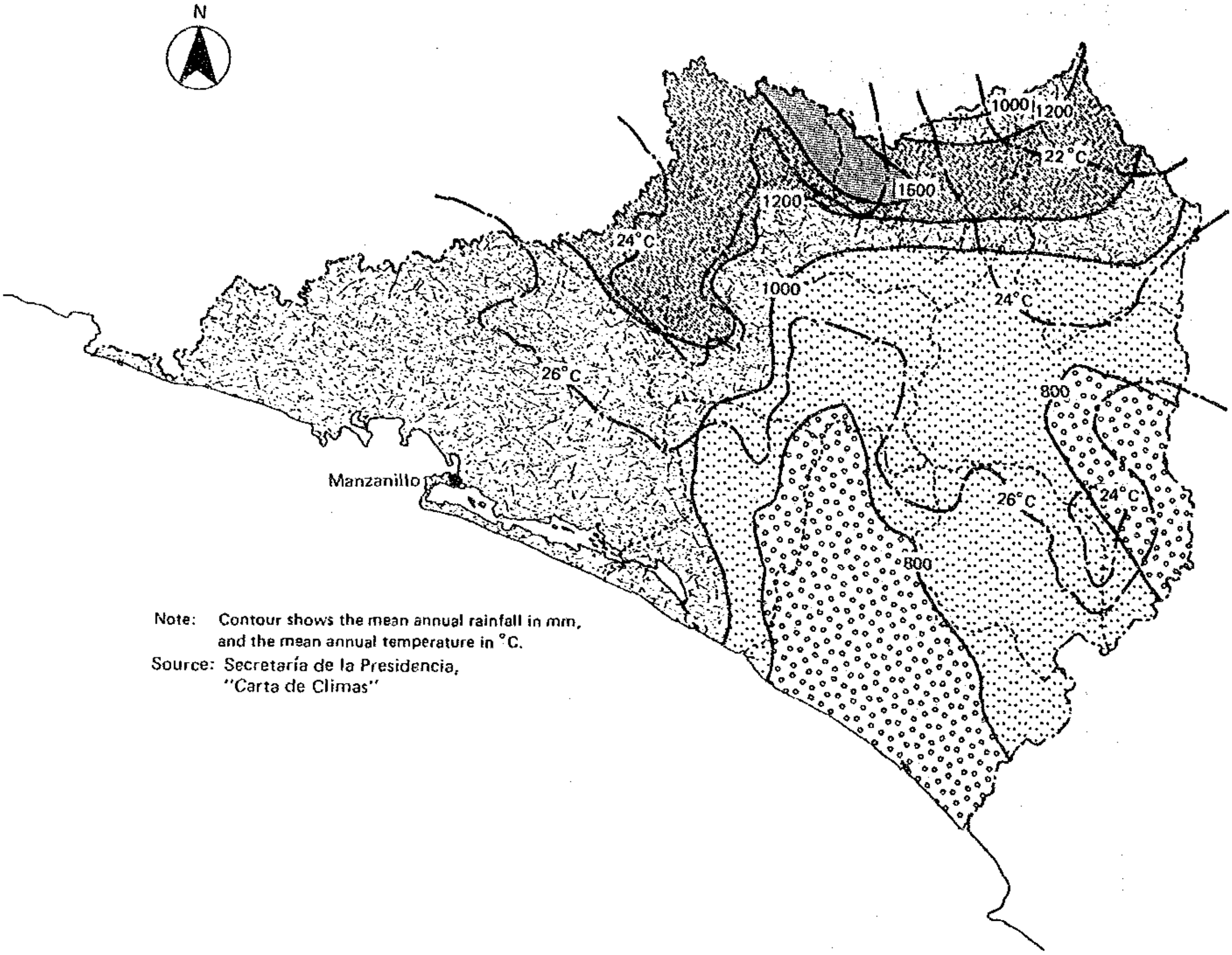
– – – – Monthly Average of Daily Maximum Temperature

—·—·— Monthly Average of Daily Minimum Temperature

2) For Manzanillo data, temperatures are based on 30 years observation from 1951 to 1980, and precipitation is based on 20 years observation from 1961 to 1980.

Source: Servicio Meteorologico Mexicano, (for Manzanillo data)
JICA, The Study on the Development Project of the Industrial Port of Tuxpan, Nov., 1983 (for Mexico City data)

Fig. III-5 Temperature and Precipitation at Manzanillo and Mexico City



Note: Contour shows the mean annual rainfall in mm, and the mean annual temperature in °C.
Source: Secretaría de la Presidencia, "Carta de Climas"

Fig. III-6 Distribution of Rainfall and Temperature in Colima

1-2-3 Temperature and Humidity

The average temperatures at Manzanillo and Mexico City are shown in Fig. III-5. Mean temperature at Manzanillo in July and August is 28.5°C and from December to April the mean is 25°C. The seasonal change of temperature at Manzanillo is small and the mean temperature at Manzanillo is fairly high when compared with that of Mexico City. The distribution of mean annual temperatures in Colima are shown in Fig. III-6.

The mean annual humidity is more than 75%. September shows the highest humidity, an average of 82%.

Manzanillo has, as described above, hot and humid weather all year round. Nevertheless, it feels rather comfortable in the dry season because of limited rainfall and cooler temperatures in the mornings and evenings.

1-3 Seismicity

During the period 1904 ~ 1952, more than 75% of the worlds' earthquake energy release has taken place in the narrow belt surrounding the Pacific Ocean. The west coast of Mexico is located in this belt. The region from central to southern Mexico and Gautemala is among the major seismic regions of the world (3.1% of the total world energy release). The records of major earthquakes and earthquake energy release in this area are shown in Table III-1 and Fig. III-7, respectively.

The Mesoamericana trench runs parallel to the shore about 70 km from the western coastline of this area as shown in Fig. III-7. The Cralion Fault runs east from the Revilla Gigedo Islands, passing through 19°N latitude, crossing Colima and connecting to the volcanoes in Jalisco and Michoacán.

The earthquakes in this area are mainly caused by the activities of the earth's crust at the volcanoes in Jalisco, Michoacán, in the Sierra Madre Occidental range, in the Revilla Gigedo Islands and along the Cralion Fault.

A rough zoning of earthquake probability in Mexico is shown in Fig. III-8. Manzanillo is included in zone 3 which has the highest probability of earthquake risk. The horizontal acceleration of earthquakes in this zone is estimated from 9 to 23% of gravity acceleration.

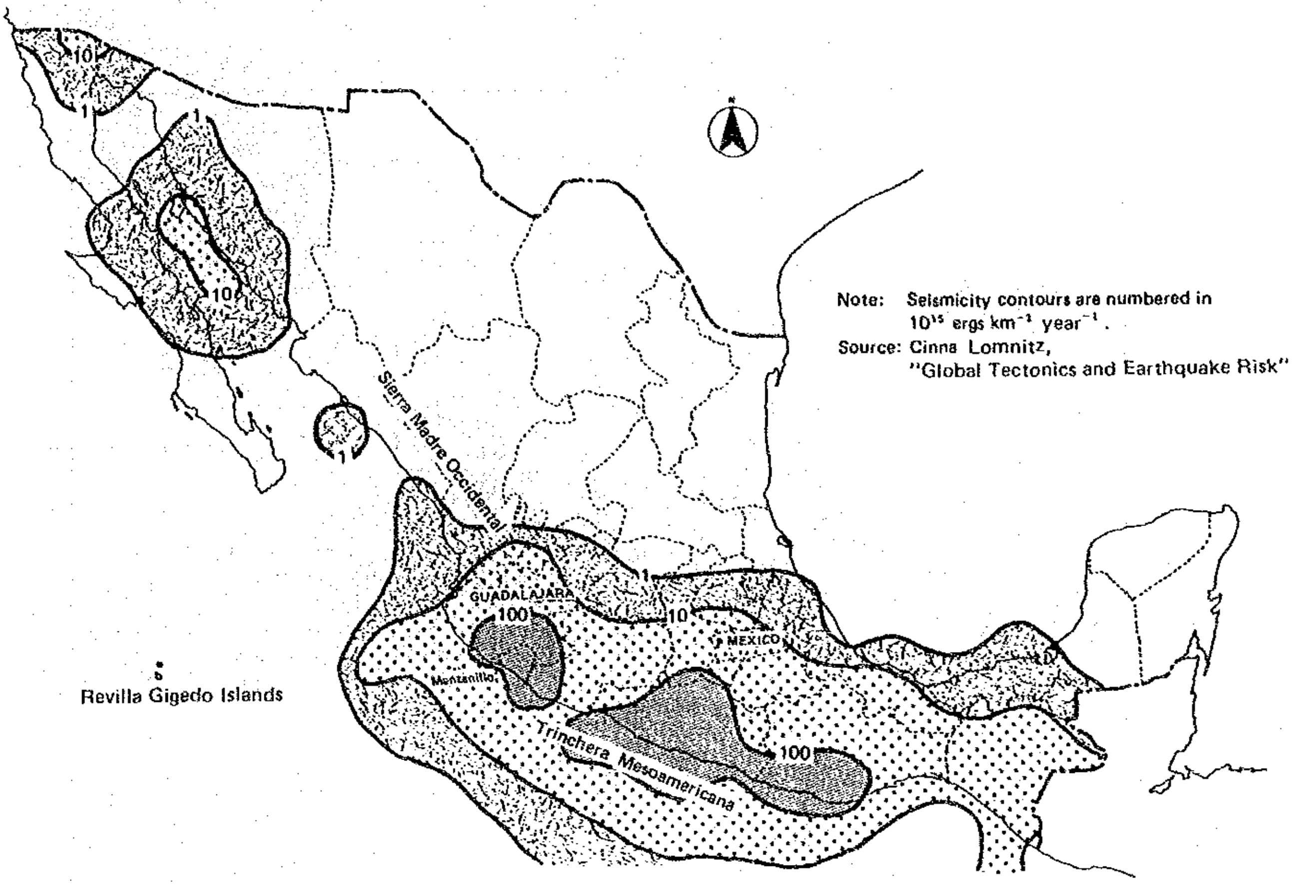
A rough estimate of the maximum horizontal acceleration of earthquakes is possible using the following two figures, if the magnitude and the distance from the epicenter of the earthquake are known. Fig. III-9 shows the damping of the maximum horizontal acceleration with the parameter of magnitude. Fig. III-10 shows the distribution of the earthquakes which occured around Manzanillo from 1911 to 1973. The most risky earthquakes in this area from this figure have a magnitude of 8.0 and a distance from the epicenter of 100 km. Thus, the maximum horizontal acceleration is estimated at about 0.15 g from Fig. III-9. This value is near the center of the 0.09 g ~ 0.23 g range described above.

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

Table III-1 Record of Main Earthquakes in Mexico and Guatemala

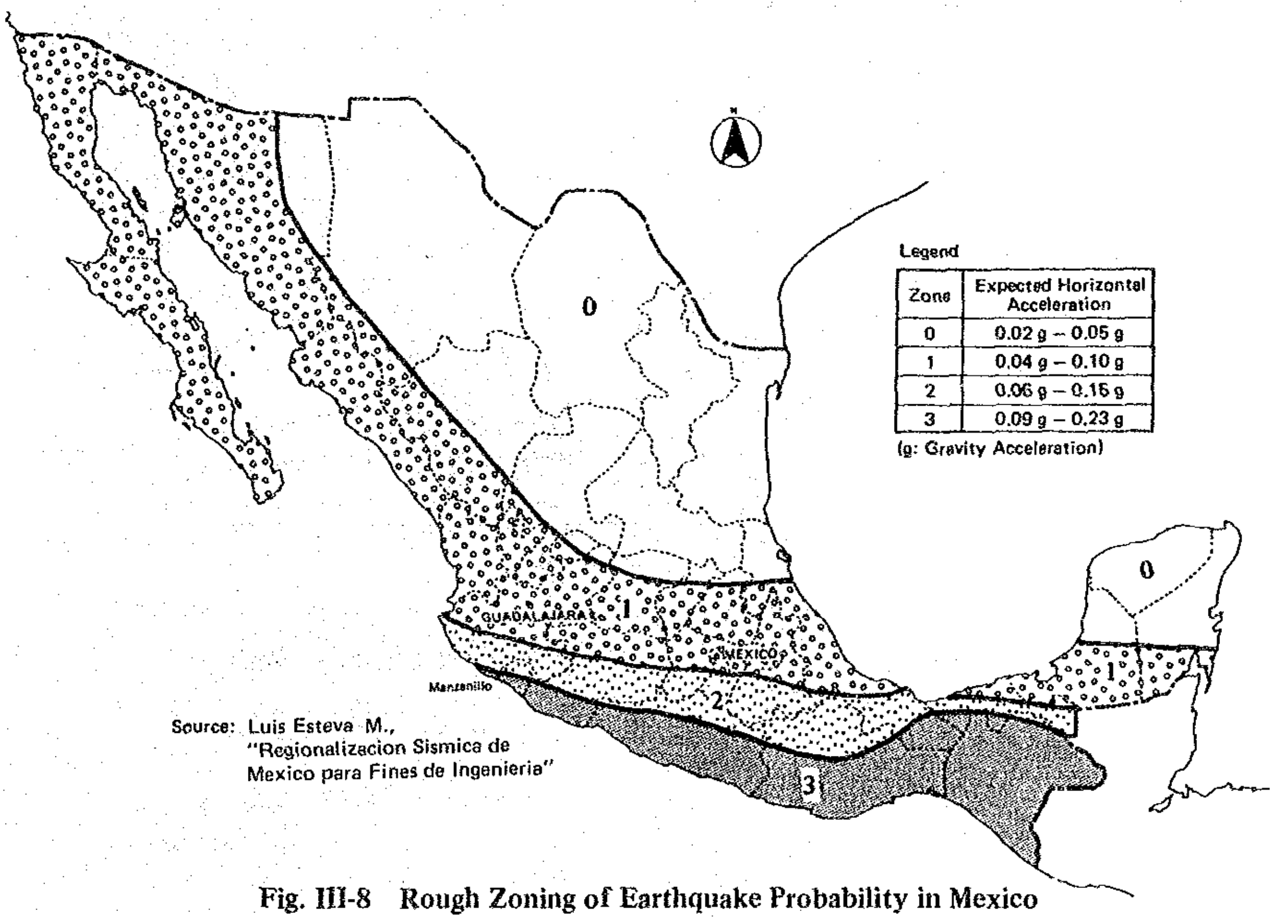
Date	Epicenter	Magnitude	Comments
1538	Mexico		
1542 Mar. 17	Mexico		
1568 Dec. 27	Cocula, Jalisco		
1573	Colima		
1575	Puebla		
1582	Mexico		
1586	Guatemala		
1603	Oaxaca		
1604 March	Oaxaca		
1608 Jan. 8	Oaxaca		
1611 Aug. 25	Mexico		very large
1619 Jan. 13	Oaxaca		
1622 May 6	Zacatecas		
1626	Puebla		
1655 Nov. 25	Oaxaca		
1662 Jun. 7	Oaxaca		
1667 Jul. 30	Puebla		
1697 Feb. 25	Acapulco, Guerrero		
1701 Dec. 21	Oaxaca		destructive
1711 Aug. 16	Mexico, Colima, Guadalajara		several dead
1727 Mar. 10	Oaxaca		
1739 Jul. 14	Colima		
1749	Mexico		
1750	Mexico		
1754 Sep. 1	Acapulco, Guerrero		tsunami
1773 Jul. 29	Guatemala		100 dead, capital city moved to present site
1784 Mar. 28	Acapulco		tsunami (12 ft), several dead
1801 Oct. 5	Oaxaca		7 dead
1806 Mar. 25	Jalisco		many dead
1818 May 31	Mexico, Colima		
1820 May 9	Acapulco		tsunami
1830 Apr. 1	Guatemala		
1838	Veracruz		tsunami
1845 Apr. 7	Acapulco	about 7	tsunami
1852 May 17	Amatitlan, Guatemala		
1854 Apr. 15	Guatemala		
1858 Jun. 19	Michoacān	about 7	
1862 Dec. 19	Antigua, Guatemala		
1864 Oct. 3	Puebla		
1870 May 11	Oaxaca	about 7	
1872 Mar. 27	Oaxaca		
1874 Sep. 18	Guatemala		
1875 Feb. 11	Zapopan, Jalisco	7.5	
1882 Jul. 19	Puebla		
1897 Jun. 5	Oaxaca	7	
1899 Jan. 29	Oaxaca	8.9	
1990 Jan. 19	Jalisco		
1902 Jan. 16	Guerrero	7	
1902 Apr. 19	Quezaltenango, Guatemala	8.3	many dead
1902 Sep. 23	Chiapas	7.8	
1903 Jan. 14	Oaxaca	8.3	
1907 Apr. 15	Acapulco	8.3	
1908 Mar. 26	Guerrero	7.5	
1909 Jul. 31	Guerrero	7 3/4, 7	
1909 Sep. 5	Guerrero	6.6	
1909 Oct. 31	Guerrero	7	
1910 May 31	Guerrero	6.5	
1911 Feb. 3	Oaxaca	7.25	
1911 Jun. 7	Jalisco	8	45 dead, damage in Mexico City
1911 Aug. 27	Oaxaca	6.7	
1911 Dec. 16	off Guerrero	7	
1912 Nov. 14	Acambay, Jalisco	7	
1918 Jan. 3	Guatemala		destructive in Guatemala City; several dead
1919 Apr. 17	Guatemala	7.0	
1920 Jan. 3	Oxochoacān, Puebla		
1920 Apr. 19	Jalapa, Veracruz	about 6	
1928 Feb. 9	Oaxaca	7.7	
1928 Mar. 21	Oaxaca	7.5	
1928 Apr. 16	Oaxaca	7.7	
1928 Jun. 17	Oaxaca	7.9	
1931 Jan. 15	Oaxaca	7.9	
1932 Jun. 18	Jalisco	7.9	tsunami
1932 Jun. 22	Colima	7.9	tsunami
1936 Dec. 14	Tuxtla Gutiérrez, Chiapas		
1941 Apr. 15	Guerrero	7.0	
1942 Aug. 6	Guatemala	7.9	
1943 Feb. 20	Paricutín, Michoacán		volcanic eruption
1943 Feb. 22	Guerrero	7.5	damage in Mexico City
1948 Dec. 4	Islas Marias	7 1/4	
1954 Feb. 5	Chiapas	6 1/4	
1956 Nov. 9	Tehuantepec		
1957 Jul. 28	Guerrero	7 1/2	several dead, damage in Mexico City
1959 May 24	Oaxaca	6.8	
1959 Aug. 26	Veracruz	6.5	
1962 May 11	Acapulco	6.7	
1962 May 19	Acapulco	6.5	
1962 Nov. 30	Guerrero	5.5	local damage
1964 Jul. 6	Guerrero	6.5	
1965 Dec. 9	off Guerrero	6.8	
1967 Mar. 11	Veracruz	5.5	damage
1968 Aug. 2	Oaxaca	6.5	damage
1968 Sep. 25	Chiapas	6	
1970 Apr. 29	Chiapas	6.3	
1973 Jan. 30	Michoacān-Colima	7.7	56 dead
1973 Aug. 28	Puebla-Veracruz	7.1	100 km depth; 600 dead

Source: Cinna Lomnitz, "Global Tectonics and Earthquake Risk"



Note: Seismicity contours are numbered in 10^{15} ergs km^{-2} $year^{-1}$.
Source: Cinna Lomnitz,
"Global Tectonics and Earthquake Risk"

Fig. III-7 Seismicity of Mexico



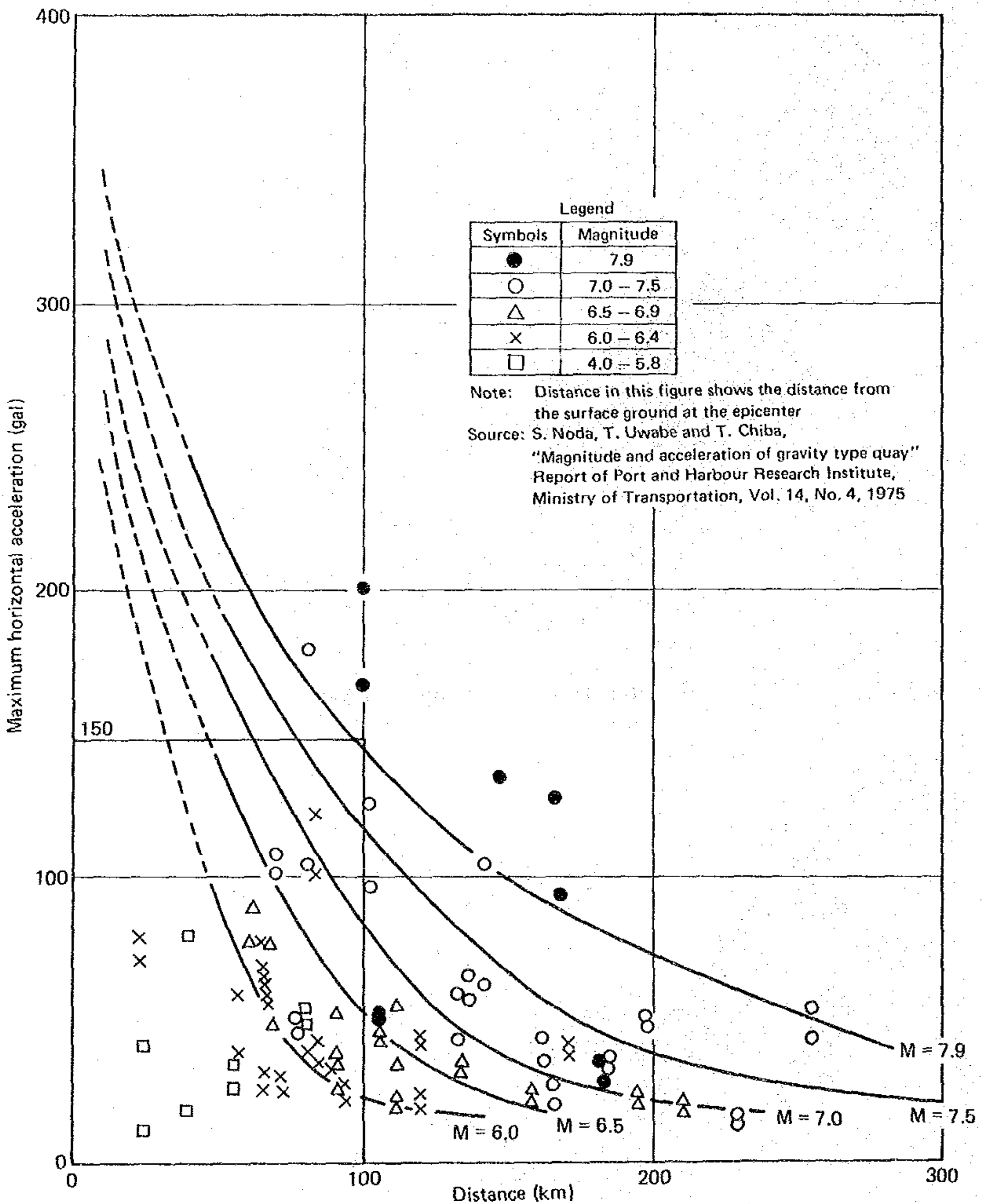
Legend

Zone	Expected Horizontal Acceleration
0	0.02 g – 0.05 g
1	0.04 g – 0.10 g
2	0.06 g – 0.15 g
3	0.09 g – 0.23 g

(g: Gravity Acceleration)

Source: Luis Esteva M.,
"Regionalizacion Sismica de
Mexico para Fines de Ingenieria"

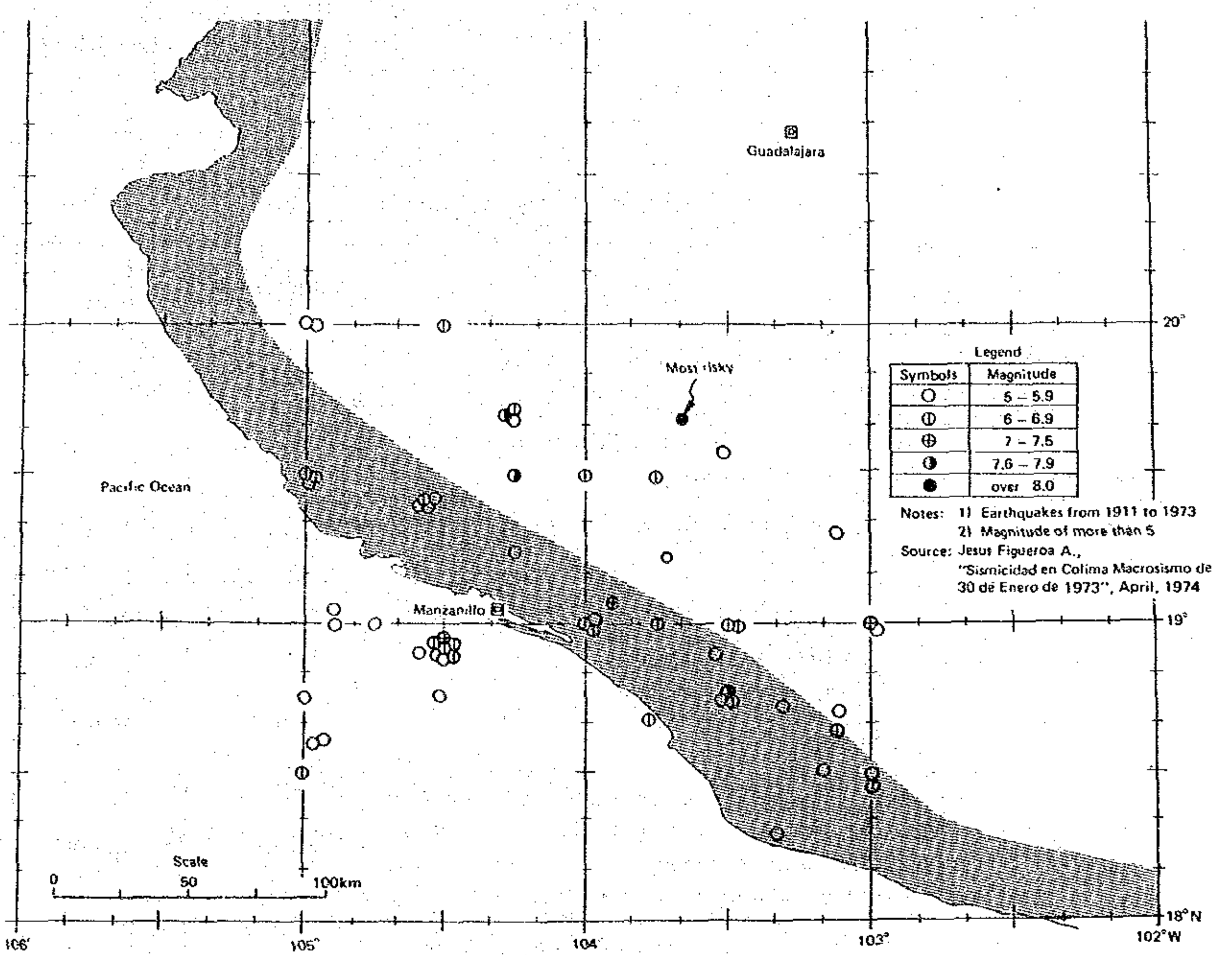
Fig. III-8 Rough Zoning of Earthquake Probability in Mexico



Note: Distance in this figure shows the distance from the surface ground at the epicenter

Source: S. Noda, T. Uwabe and T. Chiba, "Magnitude and acceleration of gravity type quay" Report of Port and Harbour Research Institute, Ministry of Transportation, Vol. 14, No. 4, 1975

Fig. III-9 Damping of Maximum Horizontal Acceleration



Notes: 1) Earthquakes from 1911 to 1973
2) Magnitude of more than 5
Source: Jesus Figueroa A., "Sismicidad en Colima Macrosismo del 30 de Enero de 1973", April, 1974

Fig. III-10 Distribution of Main Earthquakes around Manzanillo

1-4 Oceanographical Conditions

1-4-1 Tide

The tide at Manzanillo Port is described in the tide table published by UNAM. The tides and the definition of the tides are shown in Table III–2. The 4 major components of the tide are as follows:

Principal Lunar Semidiurnal Component, M_2;	0.145 m
Principal Solar Semidiurnal Component, S_2;	0.168 m
Luni-solar Diurnal Component, K_1;	0.163 m
Principal Lunar Diurnal Component, O_1;	0.119 m

The tide at Manzanillo Port is a mixed type of diurnal and semidiurnal tide. Mean lowest low water level is chosen as the datum level for the water deptch chart, port structures and port construction work. The following factors must be considered for the design of port structures:

① There is no definition of mean high and low spring and neap tides.

② The clearance of the mean sea level from the datum level does not coincide with the sum of the 4 major components of tide.

Table III-2 Tide at Manzanillo Port

Name of Tide	Definition	Abbreviation	Tide Level (m)
Pleamar máxima registrada	Maximum tide level in the past, which includes astronomical and meteorological tide	–	0.848
Nivel de pleamar media superior	Average of daily high water; higher one is chosen if there are two high tides in a day	MHHW	0.333
Nivel de pleamar media	Average of daily high water; all of the high water is included	MHW	0.272
Nivel medio del mar	Average water level measured at regular intervals	–	±0.000
Nivel de media marea	Average of MHW and MLW	MTL	+0.005
Nivel de bajamar media	Average of daily low water; all of the low water is included	MLW	-0.264
Nivel de bajamar media inferior	Average of daily low water; lower one is chosen if there are two low waters in a day. This level is chosen as the datum level of chart, port structures and port construction work	MLLW	-0.398
Bajamar mínimum registrada	Minimum tide level in the past, which includes astronomical and meteorological tide	–	-0.889
Altura mínima registrada	Minimum water level causes by tsunami	–	-0.919

1-4-2 Ocean and Tidal Current

The seasonal currents from southern California to the west coast of Mexico are shown in Fig. III-11. The cool southward current along the California Peninsula is called the California Current. This current is usually gentle and greatly influenced by occasional winds. After flowing along the California Peninsula, the southerly current changes its direction to the southwest and passes into the North Equatorial Current. On the other hand, the warm northward current along the Mexican west coast is derived from the Equatorial Counter Current. The confluence of these two currents goes south in winter and returns north in summer influenced by the movement of the ITCZ described above. In winter, the portion of the California Current which flows south as far as Acapulco is called the Mexican Current. In summer, the Equatorial Counter Current, which changes its direction to the north of northwest, flows north along the Mexican west coast. Therefore, offshore of Manzanillo, the northward current is predominant in summer and the southward current is predominant in winter.

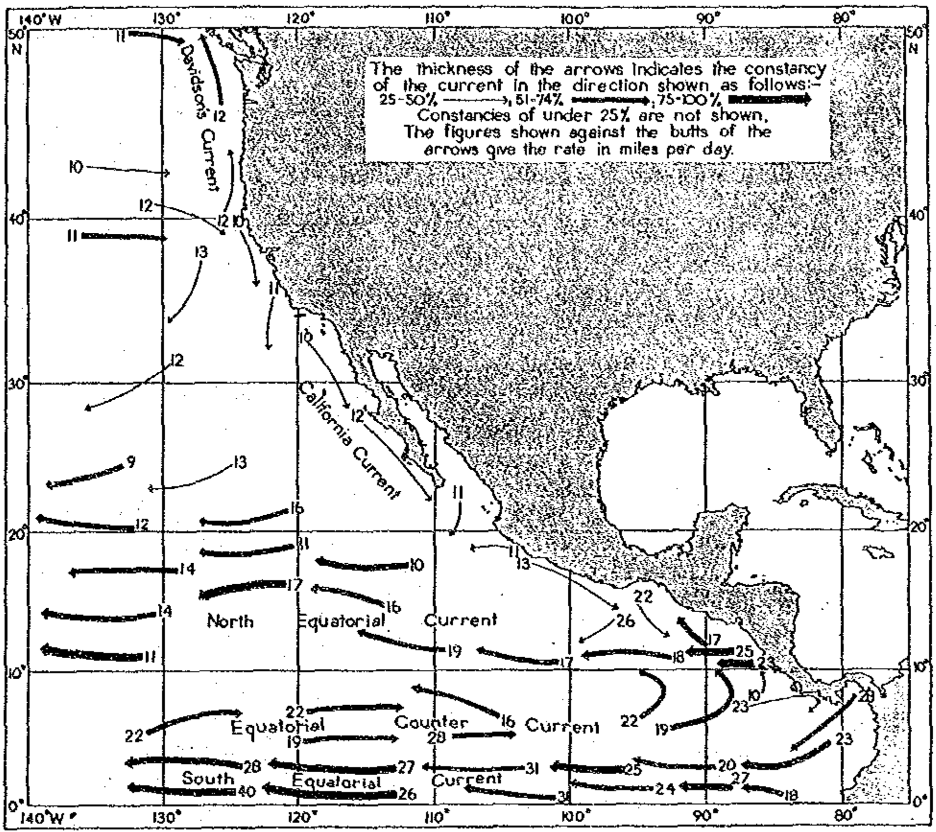


Fig. III-11 (a) Predominating Currents in December, January and February

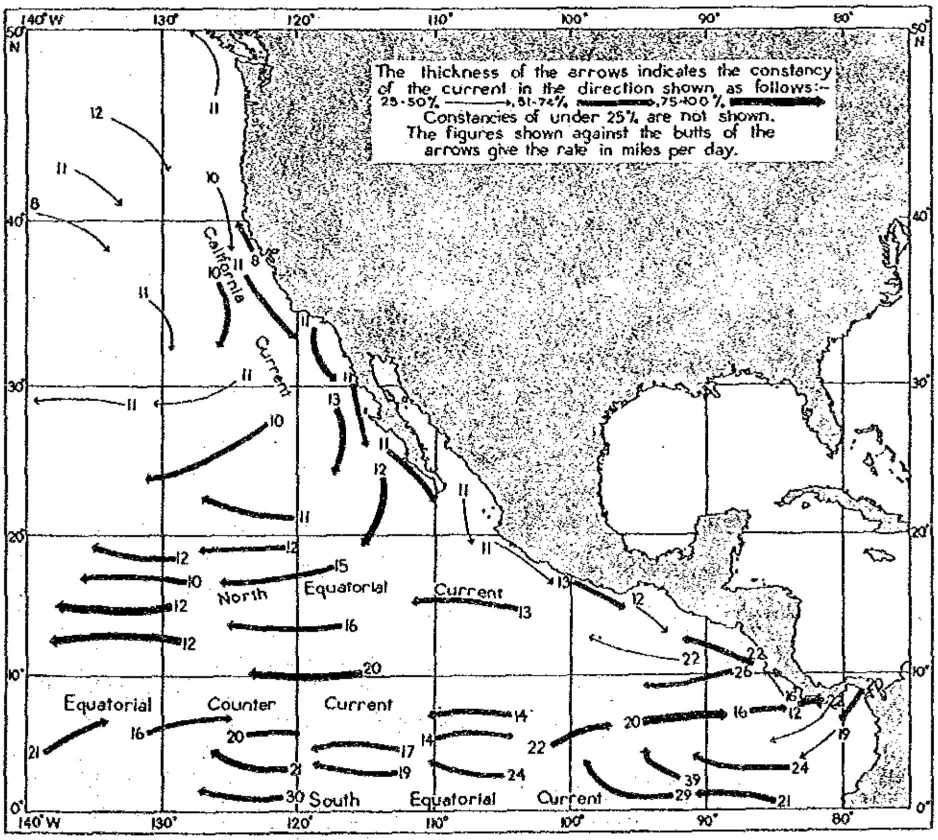


Fig. III-1 1(b) Predominating Currents in March, April and May

Source: Hydrographic Department, Lords Commissioners of the Admiralty, "West Coasts of Central America and United States Pilot"

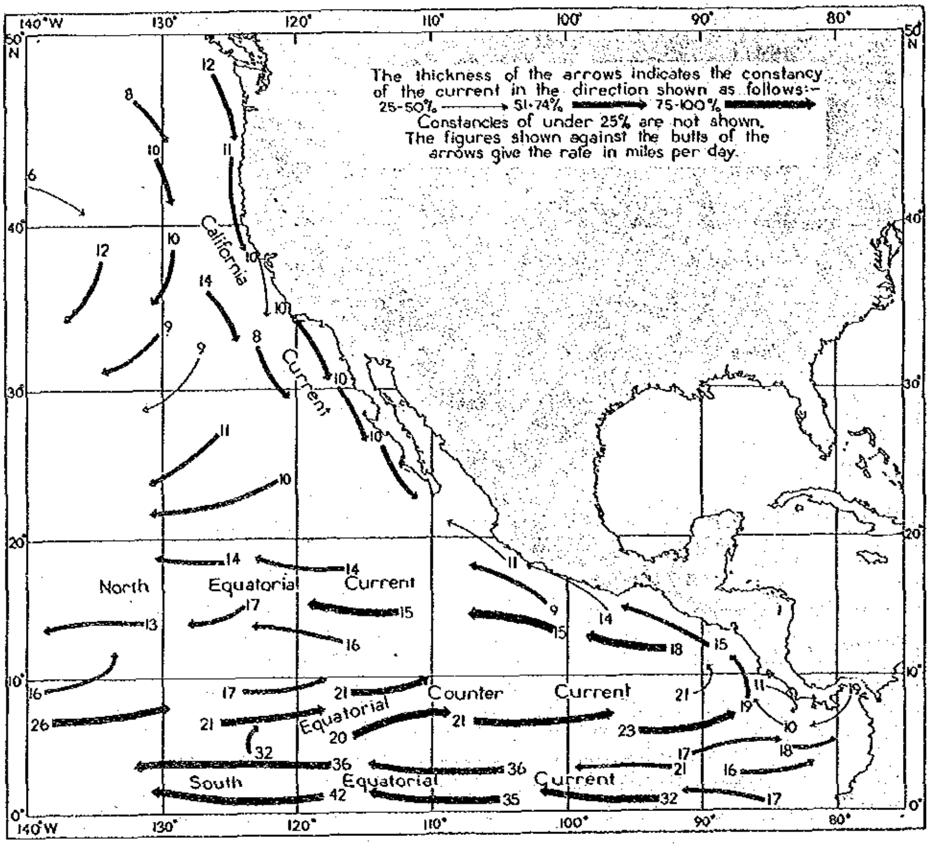


Fig. III-11 (c) Predominating Currents in June, July and August

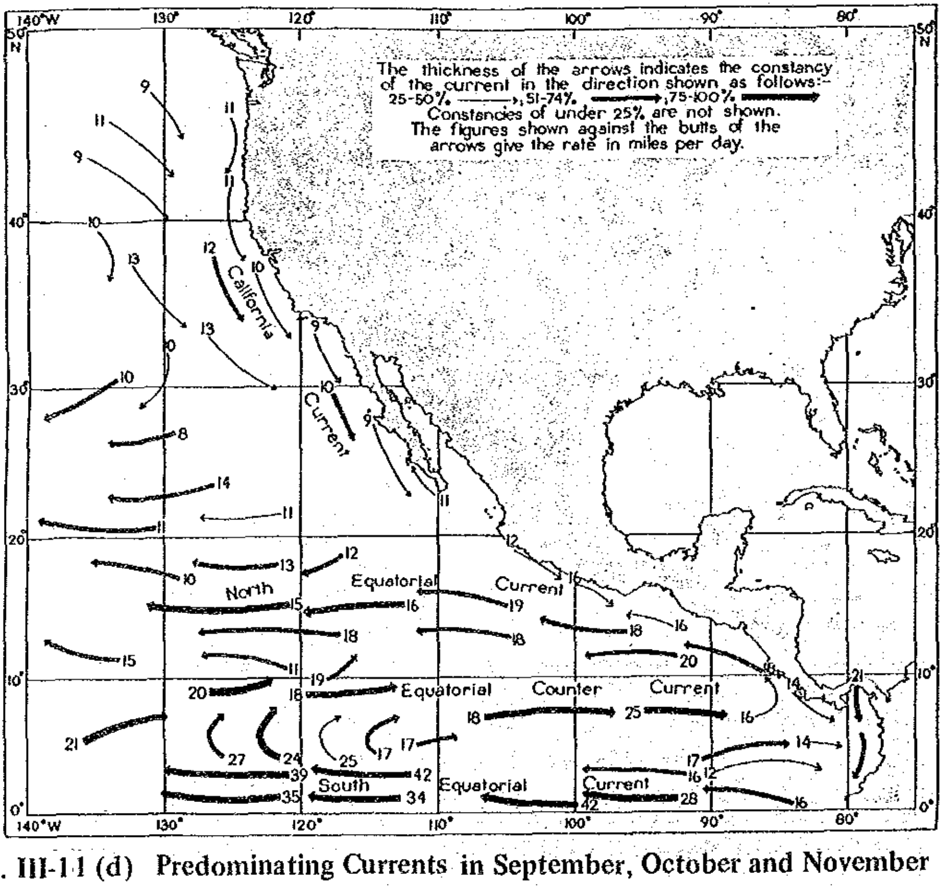


Fig. III-11 (d) Predominating Currents in September, October and November

Source: Hydrographic Department, Lords Commissioners of the Admiralty, "West Coasts of Central America and United States Pilot"

Incidentally, the sea area around the California Peninsula is well known as an abundant fishing region.

Tidal current around Manzanillo Port is weak. Generally, along any continental coast facing a large ocean, especially if the coast is steap and there is little impediment to the free movement of the water, the tidal current will be weak. It is only when the flow of water is constrained to follow relatively shallow and narrow channels in gulfs, river estuaries, and passages between islands, that tidal currents become rapid. Along the greater part of the western coast of Central America, which is fairly steep and free from major obstructions to the water flow, the tidal streams are therefore weak and negligible compared with the currents described above.

The sea current between the Manzanillo coast and about 30 km offshore cannot be easily grasped because:

① Ocean current changes its direction seasonly.

② Eddies and turbulences appear at the confluence and change their locations year by year.

③ The configuration of the sea bottom and coastline influence the flow in shallow areas less than 200 m deep.

④ Up-welling occurs when there are straight coastlines and winds blow parallel to the coast. This often occurs along the western coastline including the areas offshore from Manzanillo.

However, it can be concluded that the sea streams off Manzanillo Port are fairly weak because there is no factor which reveals the existence of strong currents.

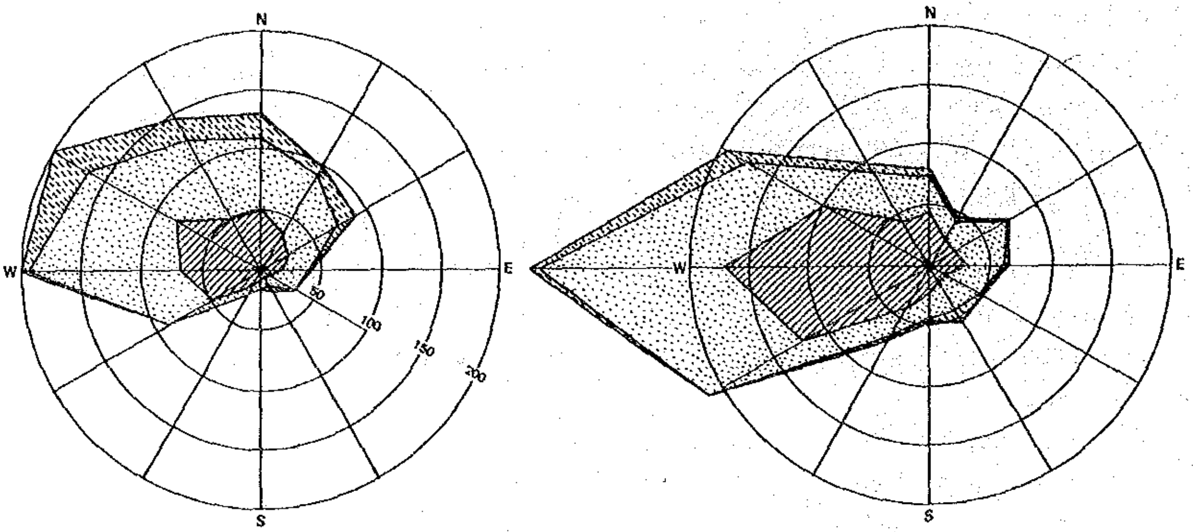
1-4-3 Waves

(1) The general characteristics of the waves offshore Manzanillo

A mean annual wave height of 1.12 m and ceaseless wind waves and swells are shown in the observation data from the U.S.A.

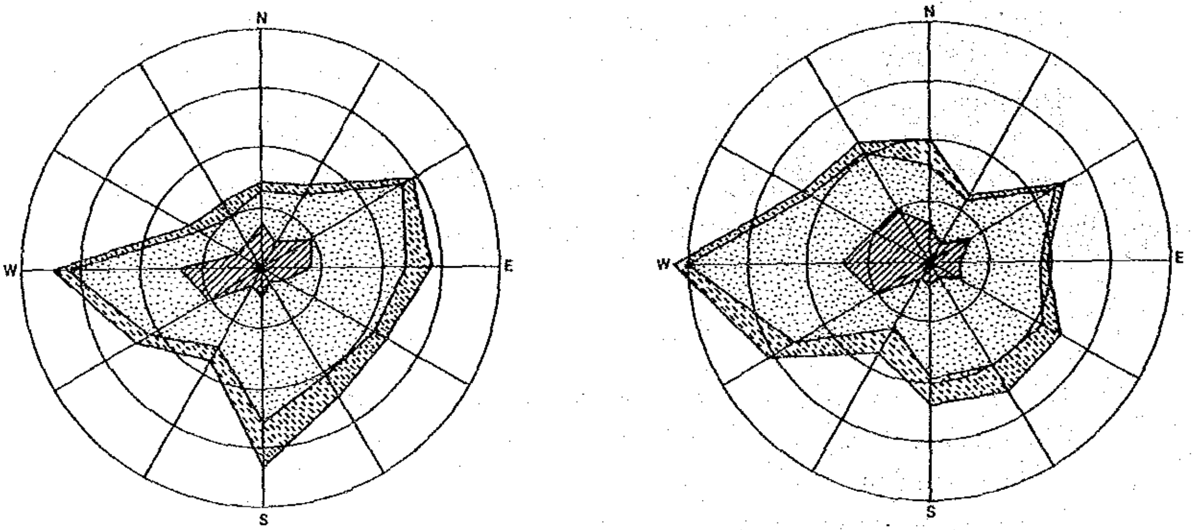
The frequency of wave occurrence in this area is shown seasonally in Fig. III-12(a), (b). Fig. III-12(a) shows that waves less than 2.75 m high which come from the W are predominant all year around, and that there is a relative increase of waves from the S in the summer season. Fig. III-12(b) shows that waves more than 2.75 m high which come from the N and NNW are predominant in the winter season, and those from the S and SW are predominant in the summer season. The latter occur in conjunction with cyclones.

The relation between wave height and period which occurs in this area is shown in Table III-3.



December — February

March — May

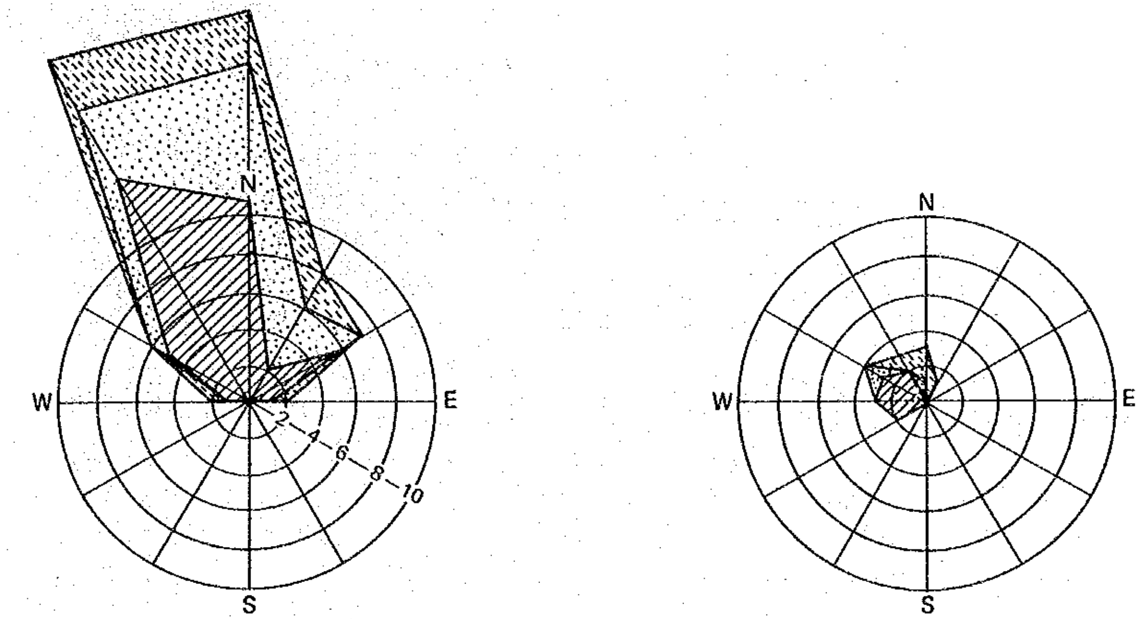


June — August

September — November

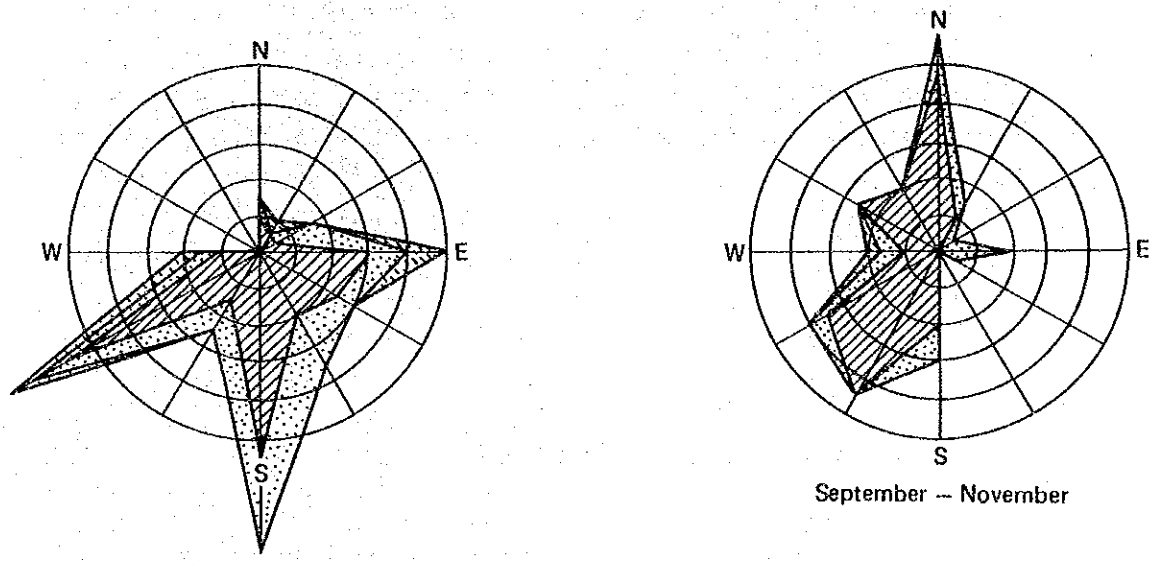
Notes: 1) The number in this figure shows the wave occurence.
2) Largest rose H ≦ 2.75 m
Middle rose H ≦ 1.75 m
Smallest rose H ≦ 0.75 m
Source: N. Hogben, F.E. Lumb, "Ocean Wave Statistics"

Fig. III-12(a) Wave Height Rose



December – February

March – May



September – November

June – August

Notes: 1) The number in this figure shows the wave occurence.
2) Largest rose 2.75 m < H
Middle rose 2.75 < H ≦ 4.75 m
Smallest rose 2.75 < H ≦ 3.75 m

Source: N. Hogben, F.E. Lumb, "Ocean Wave Statistics"

Fig. III-12(b) Wave Height Rose

Table III-3 Relation between Wave Height and Wave Period

Wave Height Code	Wave Period Code X	2	3	4	5	6	7	8	9	0	1	Total
00	729	671	12		2		2	1		8	13	1438
01	40	1013	104	36	11	2	1	2			50	1259
02	54	1068	479	129	32	14	6	2		4	11	1799
03	17	552	479	160	69	17	8	1		2		1105
04	8	55	164	89	44	21	2					383
05	1	13	46	62	22	4	1	2	1			152
06	2	2	29	35	19	13	1					101
07		1	16	13	6	4	3	1				44
08			4	8	8	2						22
09	1		3	9	6	4	2	1				26
10		1	1	1	2							5
11	1	1	1									3
12	1	1	1	2	1							6
13			1	2		1						4
14			1									1
15				2	1							3
16				1								1
Total	854	3178	1341	549	223	82	26	10	1	14	74	6352

Wave Height Code	Wave Height Feet	Wave Height Meter	Wave Period Code	Wave Period Seconds
00	1	0.25	X	Calm or period undetermined
01	1.5	0.5		
02	3	1	2	5 or less
03	5	1.5	3	6 or 7
04	6.5	2	4	8 or 9
05	8	2.5	5	10 or 11
06	9.5	3	6	12 or 13
07	11	3.5	7	14 or 15
08	13	4	8	16 or 17
09	14	4.5	9	18 or 19
10	16	5	0	20 or 21
11	17.5	5.5	1	over 21
12	19	6		
13	21	6.5		
14	22.5	7		
15	24	7.5		
16	25.5	8		
17	27	8.5		
18	29	9		
19	30.5	9.5		
90	33	10		
91	36	11		
92	39	12		
93	43	13		
94	46	14		
95	49	15		
96	52	16		
97	56	17		
98	59	18		
99	62	19		

Source: N. Hogben, F.E. Lumb, "Ocean Wave Statistics"

From this table, it can be seen that waves of all different heights exhibit a wide distribution of periods. This shows the existence of both wind waves and swells.

(2) Estimation of offshore waves caused by the cyclones at Manzanillo

It is very important for port planning to predict the waves caused by cyclones which attack this area mainly in summer and autumn.

One cyclone is chosen for estimating the waves. This cyclone passes through the typical course and we have values for central pressure, the velocity of the cyclone, and the maximum wind speed around the cyclone's center. The calculations for wave estimation are executed using a computer. The calculation program employs Myer's pressure distribution equation as a model for the cyclone and Wilson's equation for the growth of significant waves. The cyclone model is hurricane "Norman" which attacked this area on 1st to 3rd, September, 1978. More detailed data such as the distance and depression of pressures between the site for estimation and the cyclone center are needed for an accurate estimate. These are replaced with standard values because the actual data are unavailable. The computed area and the course of the hurricane "Norman" are shown in Fig. III-13.

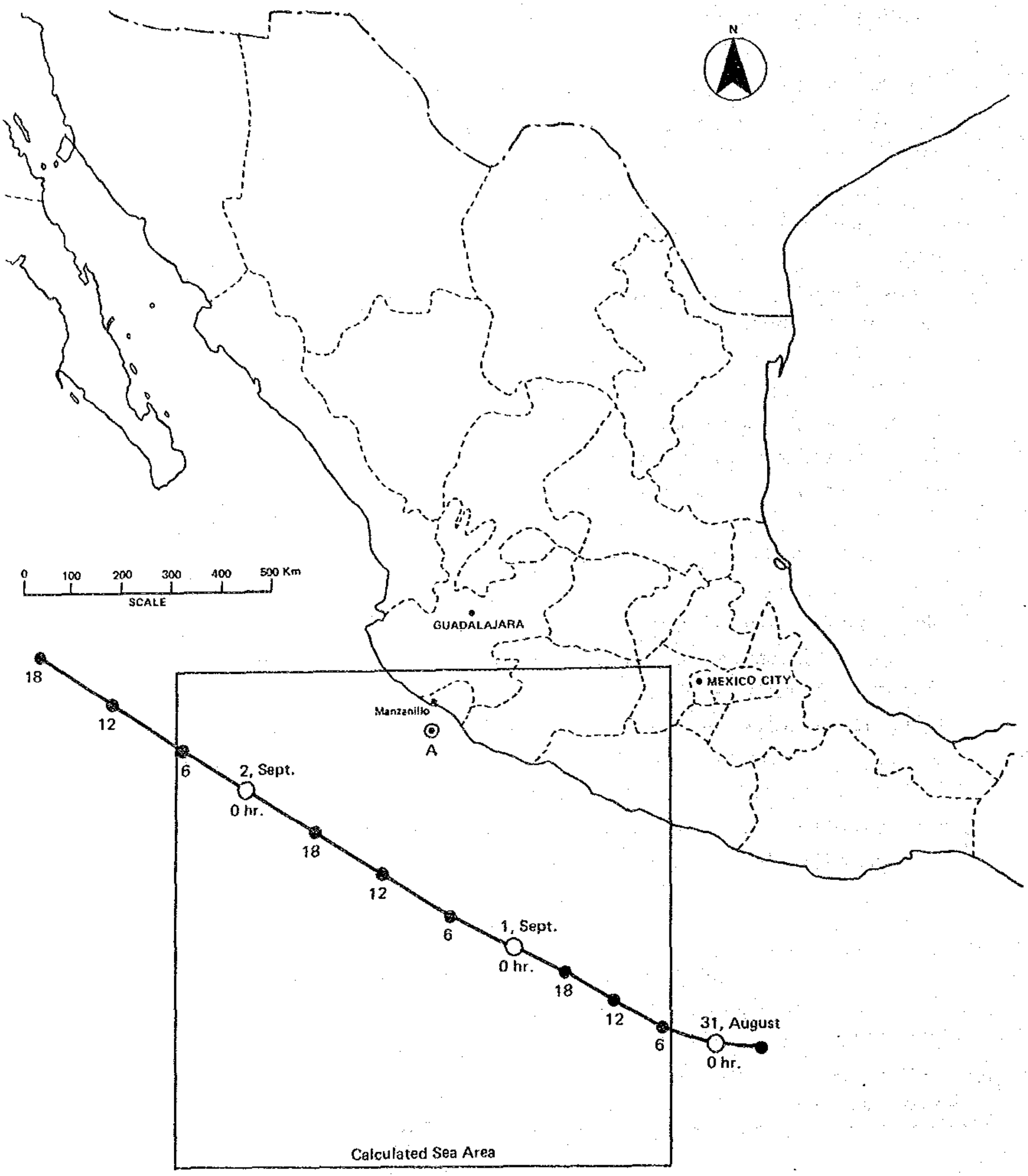
The results of the estimation are shown in Fig. III-14 ~ III-18 and Table III-4. Fig. III-14 ~ III-16 show the wave height, period, and direction on September 2nd. As only significant changes are shown, separate height figures drawn for 4:00, 8:00, and 12:00; period is only shown at 8:00, and direction is shown at 4:00 and 8:00.

Fig. III-17 shows the growth and decline of significant wave height and period with the lapse of time at A point in Fig. III-13. It can be seen from this figure that the wave height at A point which is located south of Manzanillo reaches a Maximum at 8:00 on 2nd, September. The wave direction, significant wave height and period at that time are SE, $H_{1/3}$ = 4.23 m, and $T_{1/3}$ = 8.34 sec, respectively. The rapid decline of wave height after passing through hurricanes can also be seen from this figure.

Table III-4 shows the maximum significant wave height and period in each direction.

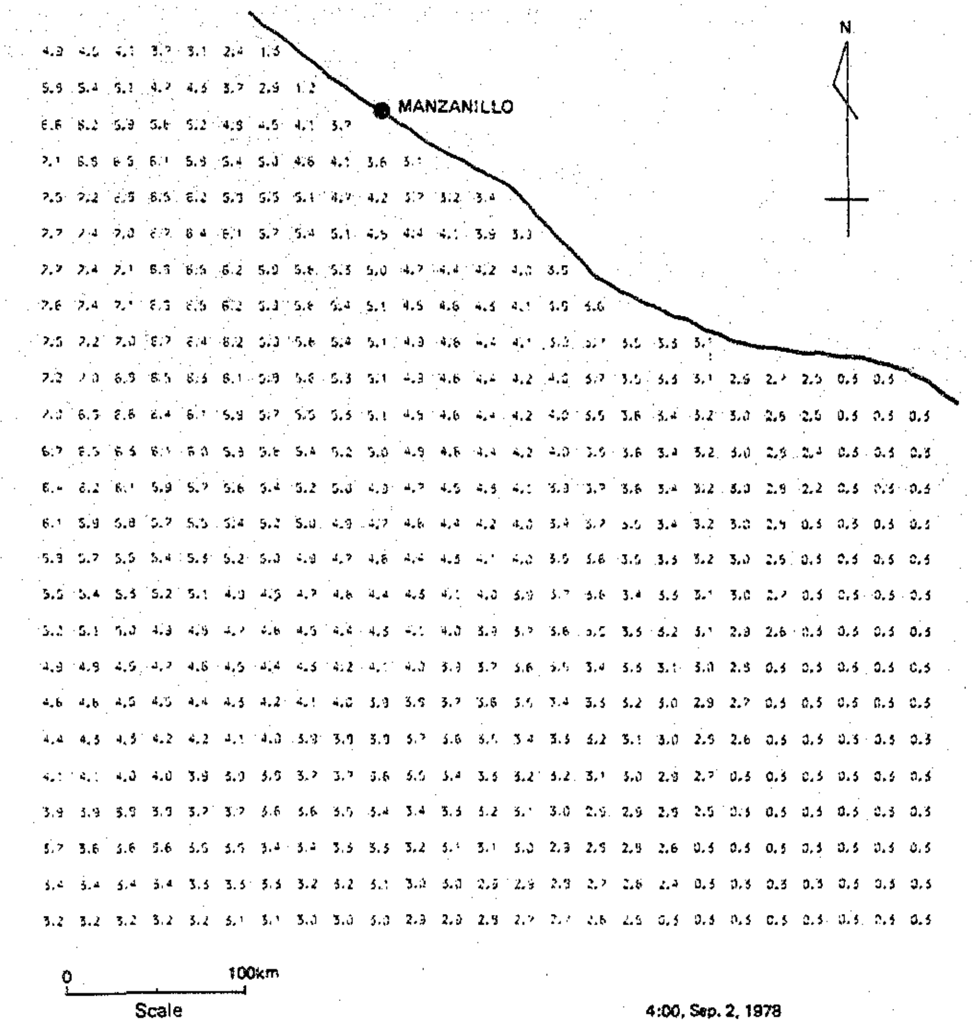
Table III-4 Maximum Waves in Each Direction

Wave Direction	NE	ENE	E	ESE	SE	Total
Wave Height (m)	0.82	1.53	1.99	2.77	4.23	4.23
Wave Period (sec)	3.29	4.33	4.85	5.98	8.34	8.34



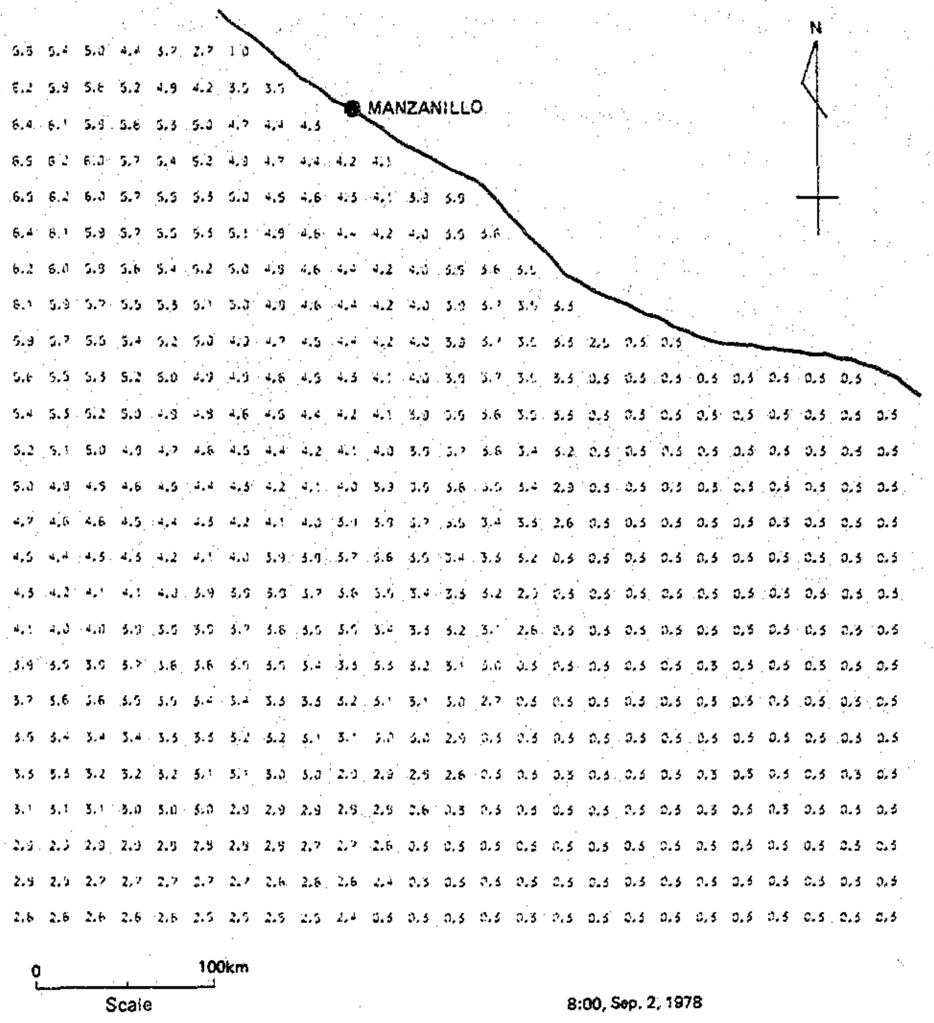
Note: Estimated waves are located at point A.
Source: SARH, "Trayectorias Ciclónicas, 1960 – 1980"

Fig. III-13 Course of the Hurricane 'Norman' and the Calculated Area



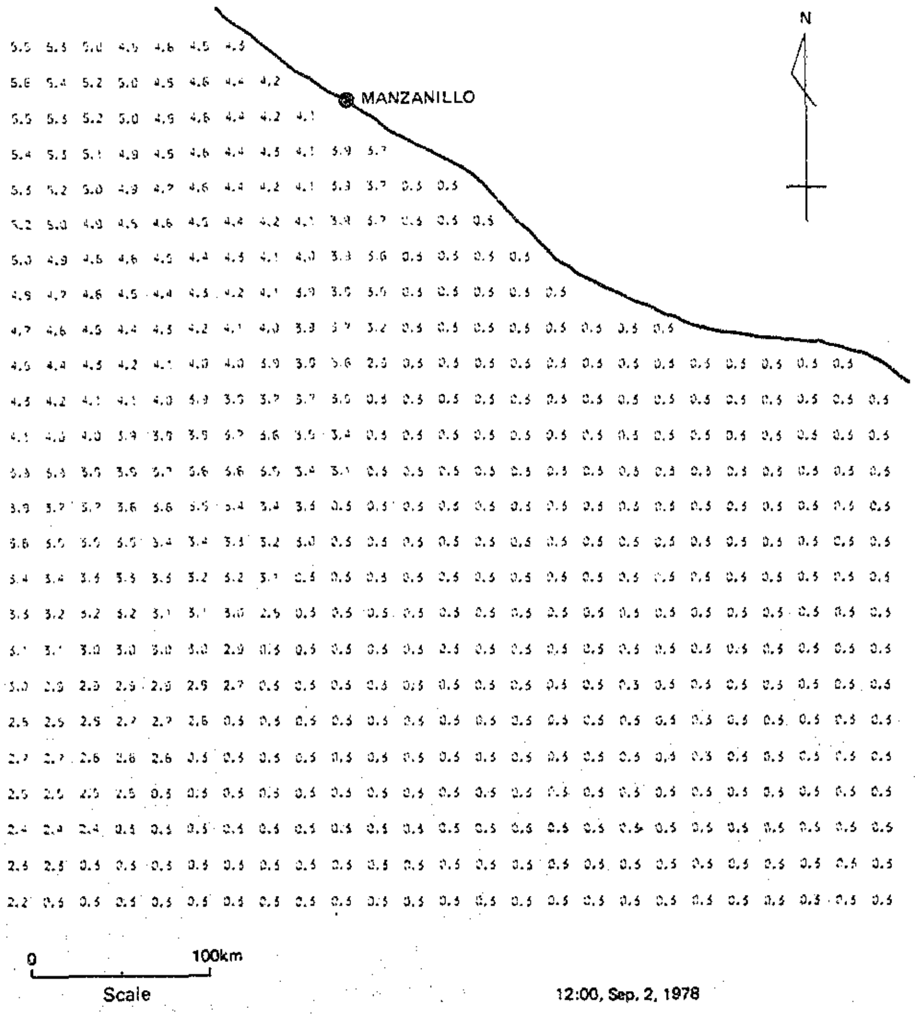
4:00, Sep. 2, 1978

Fig. III-14 (a) Distribution of Wave Heights ("Norman")



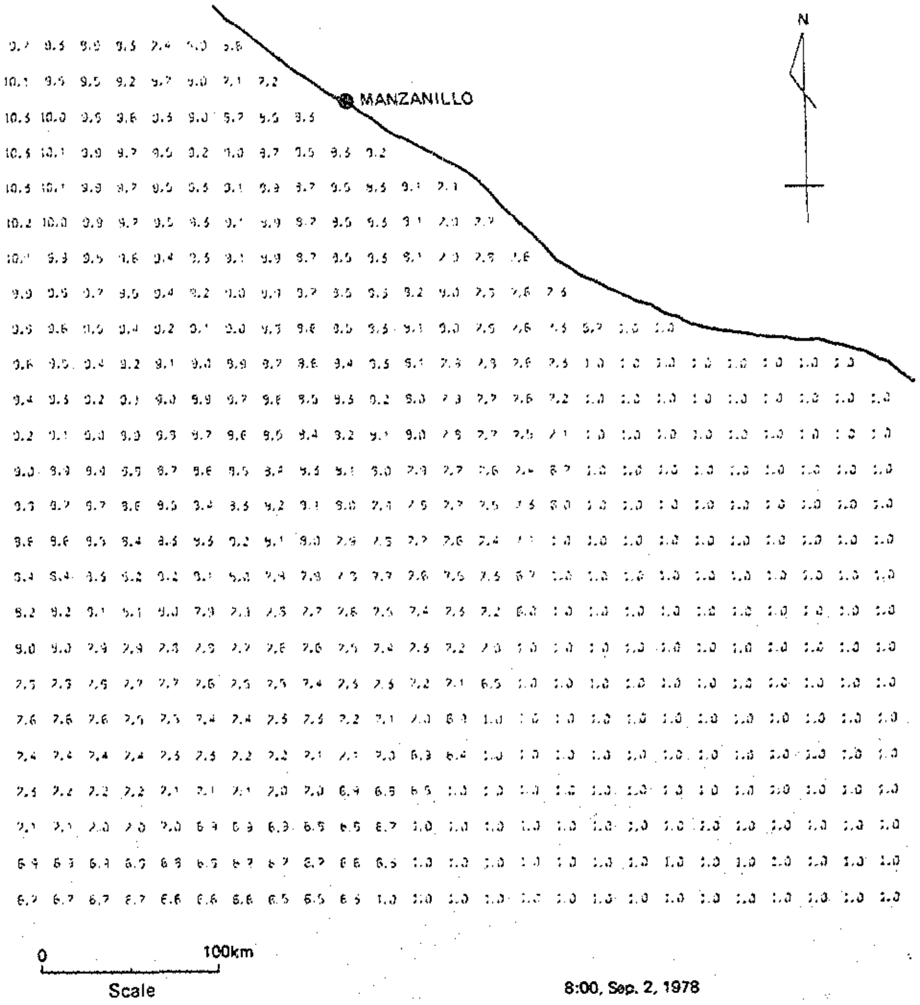
8:00, Sep. 2, 1978

Fig. III-14 (b) Distribution of Wave Heights ("Norman")



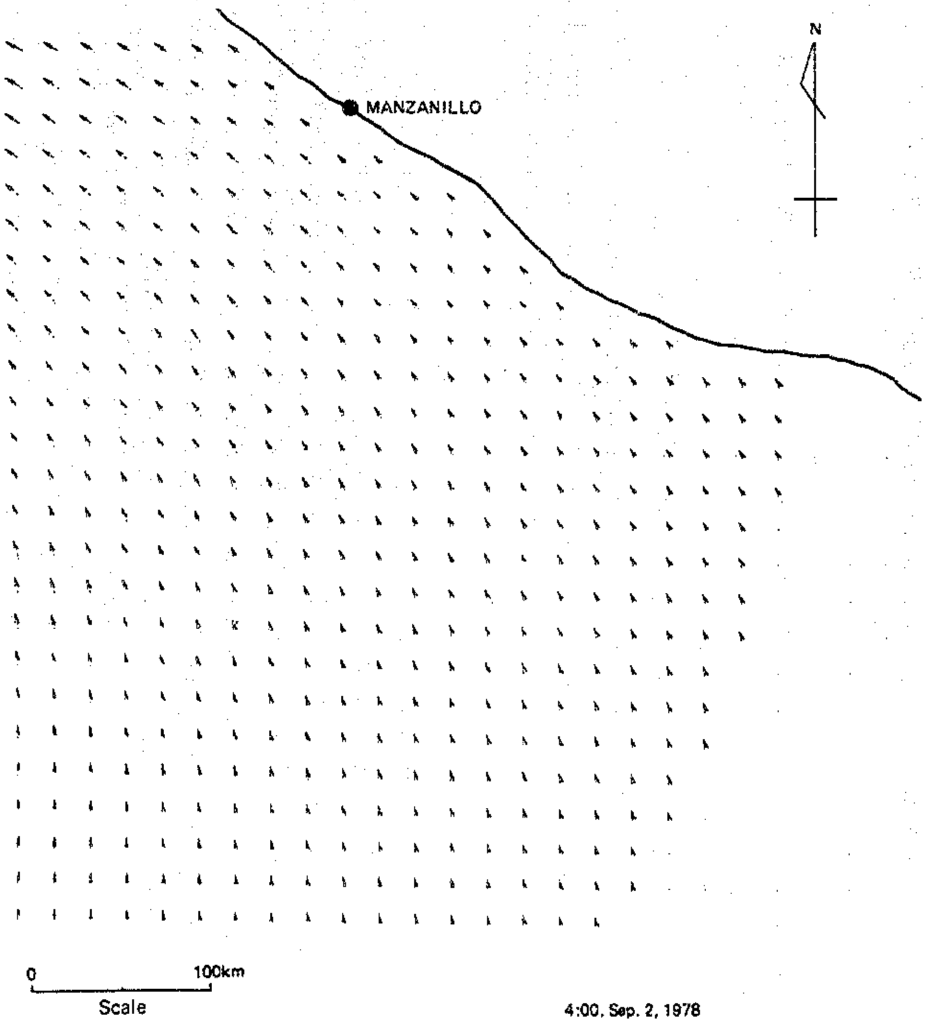
12:00, Sep. 2, 1978

Fig. III-14 (c) Distribution of Wave Heights ("Norman")



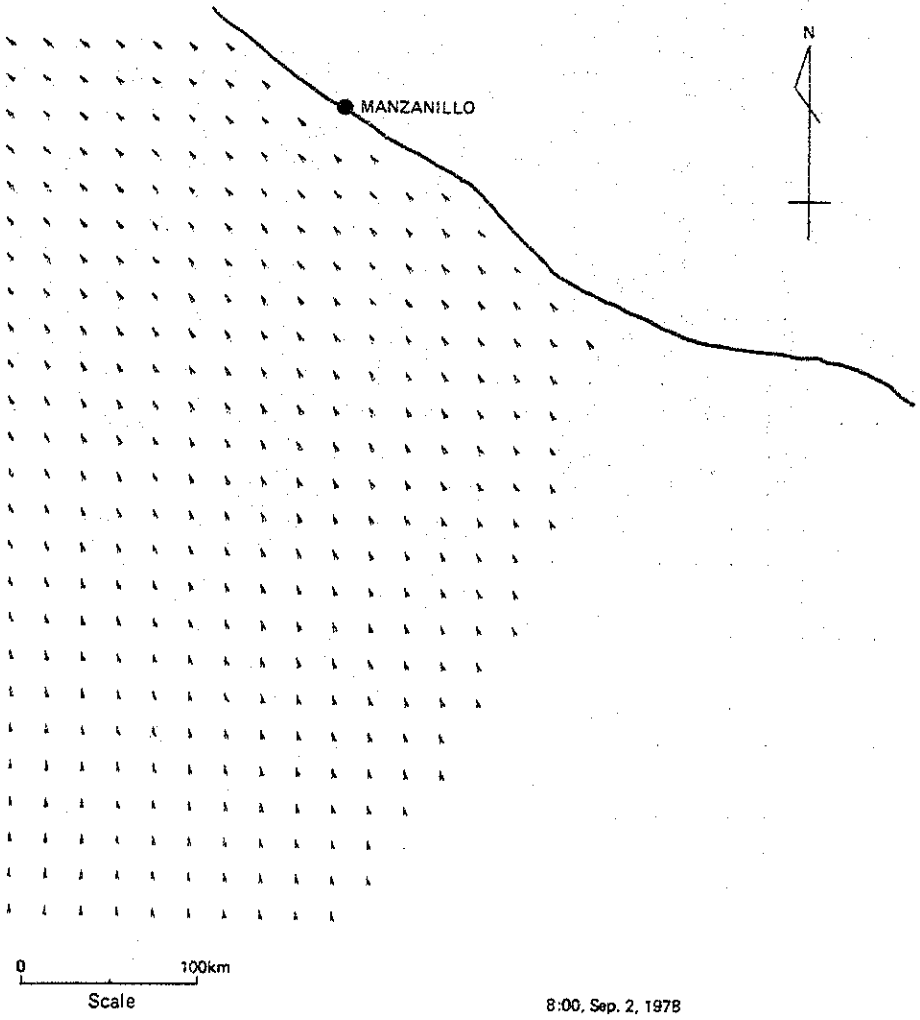
8:00, Sep. 2, 1978

Fig. III-15 Distribution of Wave Periods ("Norman")



4:00, Sep. 2, 1978

Fig. III-16 (a) Distribution of Wave Directions ("Norman")



8:00, Sep. 2, 1978

Fig. III-16 (b) Distribution of Wave Directions ("Norman")

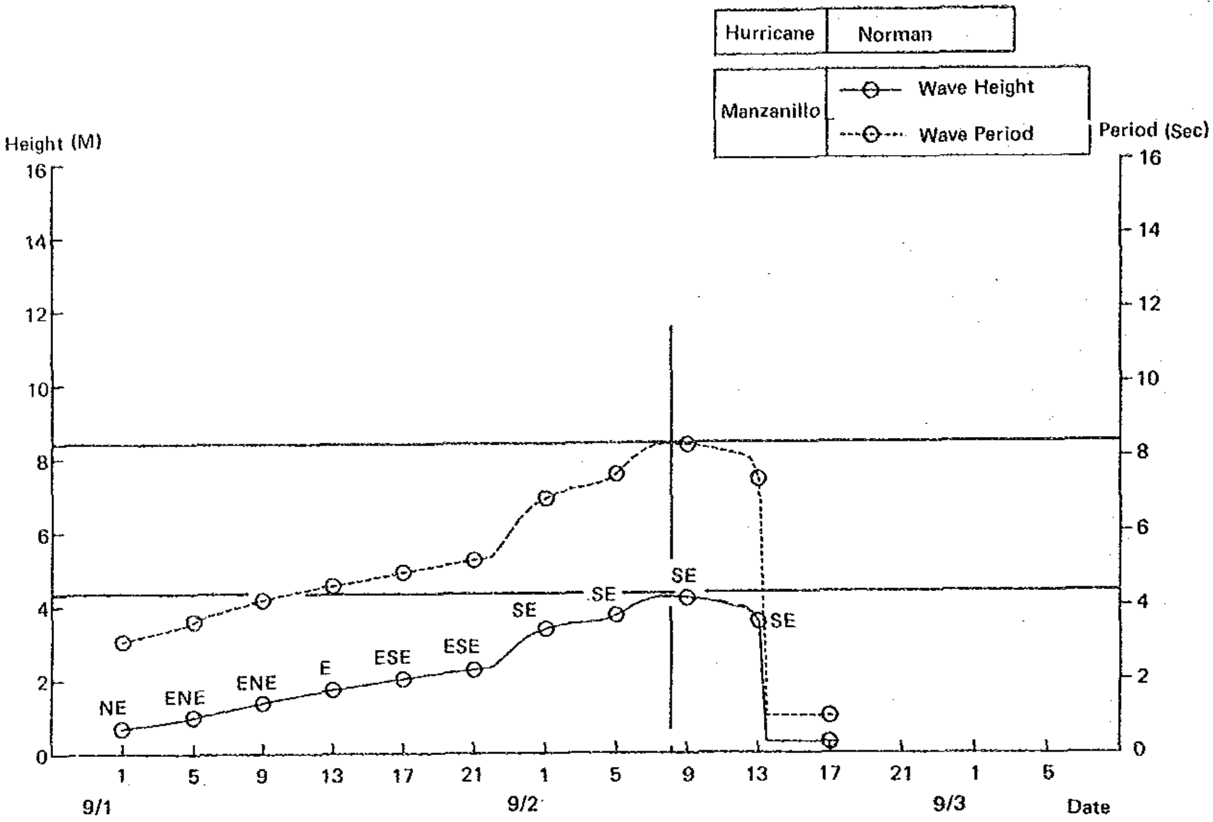


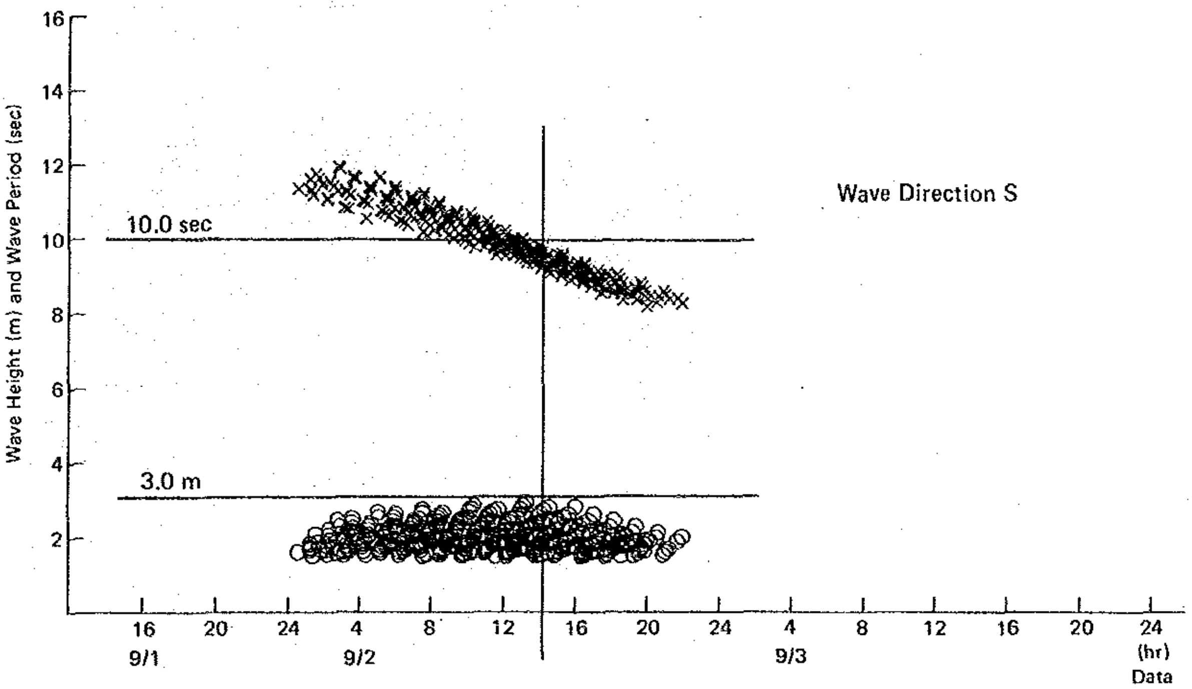
Fig. III-17 Wave Heights and Periods Versus Time ("Norman": Wind Waves)

It can be seen from this table that the wave directions S, SW, W, NW and N never occur in the case of hurricanes such as "Norman", and the maximum waves off Manzanillo come from the southeast.

Fig. III-18 shows the calculated swells reaching point A which come from the S and SW. Bretshneider's equation is used to calculate the swells. This figure shows that swells from the S have a significant wave height and period of 3.0 m and 10 sec, and that those from the SW reach 1.5 m and 10 sec. Swells reach their maximum 6 hours later than wind waves at point A.

(3) Waves which reach Manzanillo Port

The bathymetric contour of Manzanillo Bay is shown in Fig. III-19. Wind waves from the W and WNW can reach the breakwater at the outer port of Manzanillo directly without being screened by the cape and land as shown in this figure. The waves from the WNW bring more severe conditions to Manzanillo Port than those from the W. Waves of 1.75 ~ 2.75 m in wave height from the WNW occur several times a year as shown in Fig. III-12(a). These waves have a period of 6 ~ 10 sec as shown in Table III-3.



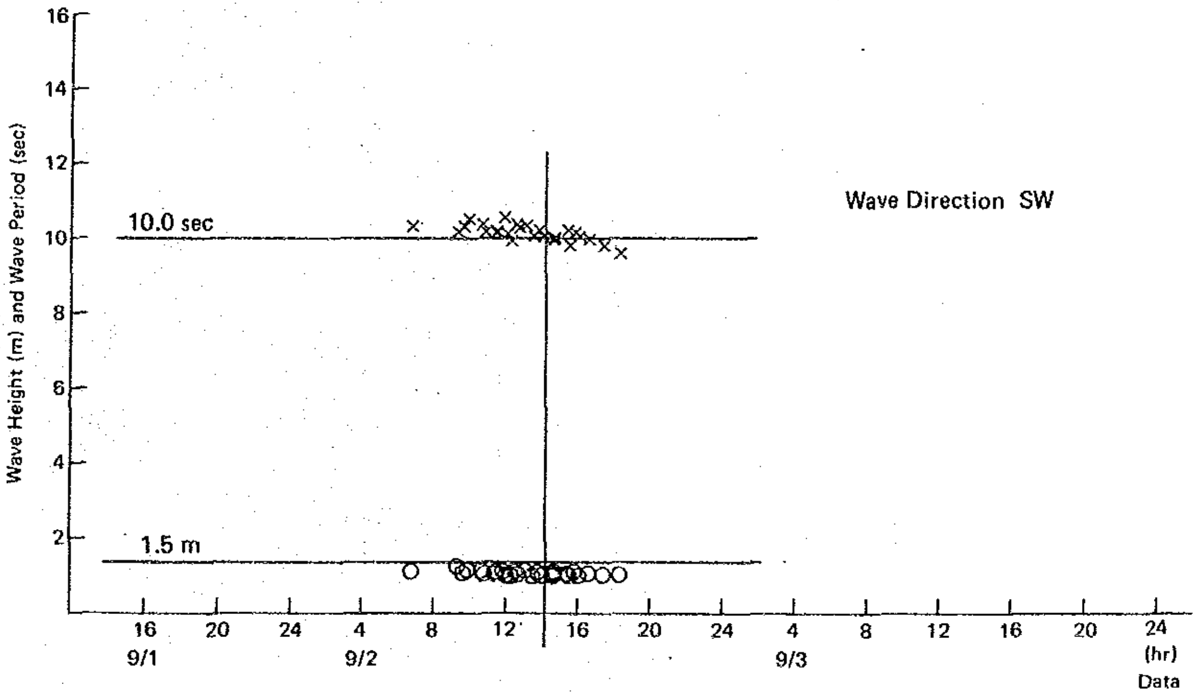
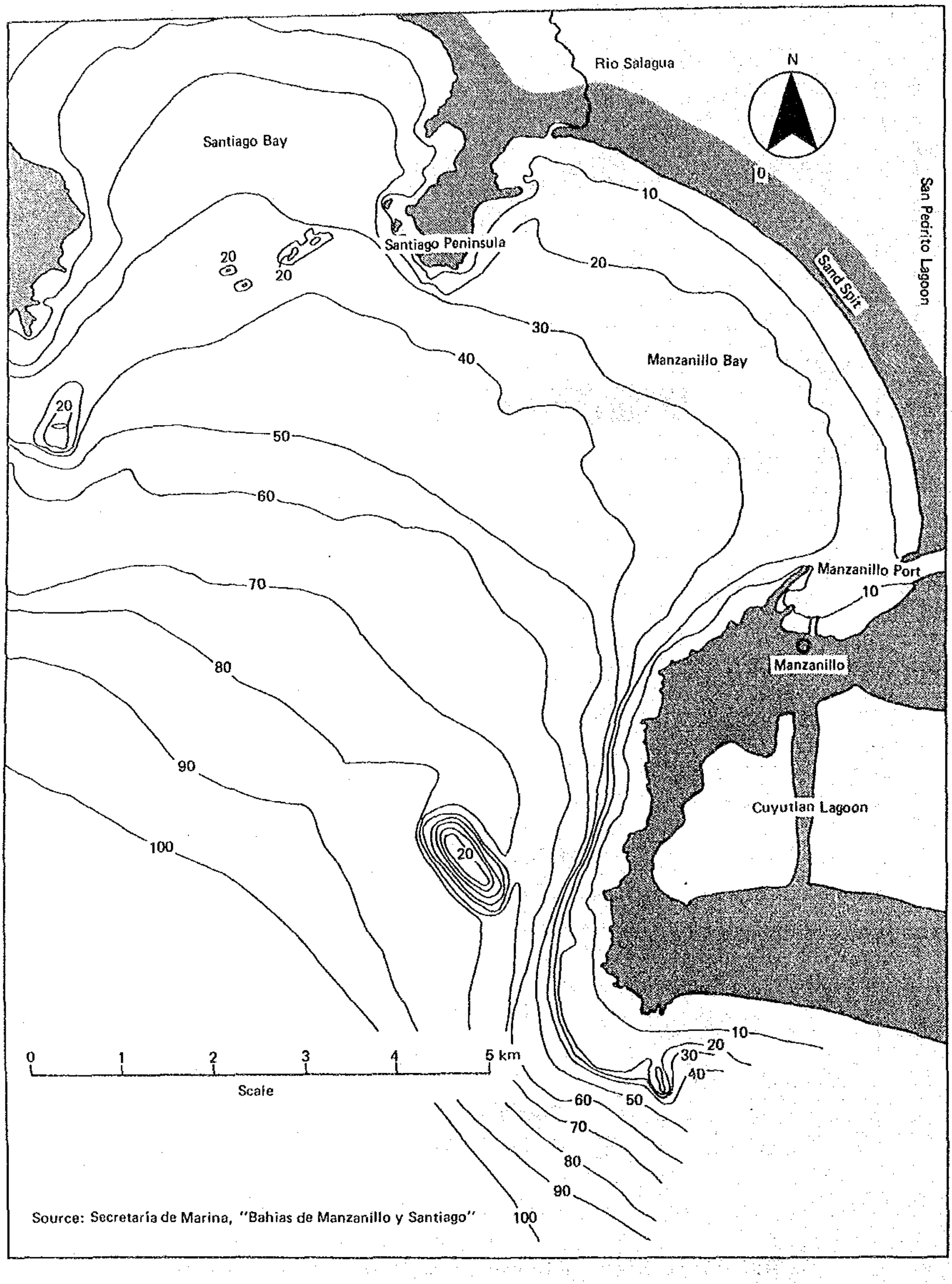


Fig. III-18 Wave Height and Periods Versus Time ("Norman": S wells)



Source: Secretaría de Marina, "Bahias de Manzanillo y Santiago"

Fig. III-19 Bathymetric Contour of Manzanillo Bay

The wind waves from the SW caused by cyclones are fairly large. However, these waves are screened by the cape and land. Therefore, large waves from this direction will never reach Manzanillo Port. Thus, to estimate the waves at Manzanillo Port, it is only necessary to consider the wind waves from the WNW and the swells from the S and SW which are also caused by cyclones.

The calculation of wave deformation in shallow water is executed using a computer. The calculation method is to resolve the wave energy balance equation numerically under reasonable boundary conditions.

The wind wave and swell conditions are as follows:

	Wave direction	Wave height	Wave period
① Wind waves	WNW	$H_{1/3} = 2.75$ m	$T_{1/3} = 10.0$ sec.
② Swells	S	$H_{1/3} = 3.0$ m	$T_{1/3} = 10.0$ sec.
	SW	$H_{1/3} = 1.5$ m	$T_{1/3} = 10.0$ sec.

Irregular waves usually have a kind of spectral band of wave periods and directions. The Bretschneider Mitsuyasu frequency spectrum and the Mitsuyasu directional distribution function are chosen for the calculation.

The calculation results are shown in Fig. III-20 ~ III-23. Fig. III–20 shows the height of wind waves in shallow areas as a percentage of the height of offshore waves for all the calculated latticed points. Fig. III-21 shows the wave directions at the same points. Fig. III-22(a), (b) and Fig. III-23(a), (b) show the same results of swells from the S and SW.

Based on these figures and the offshore wave conditions, the waves at Manzanillo Port are estimated as shown in Table III-5.

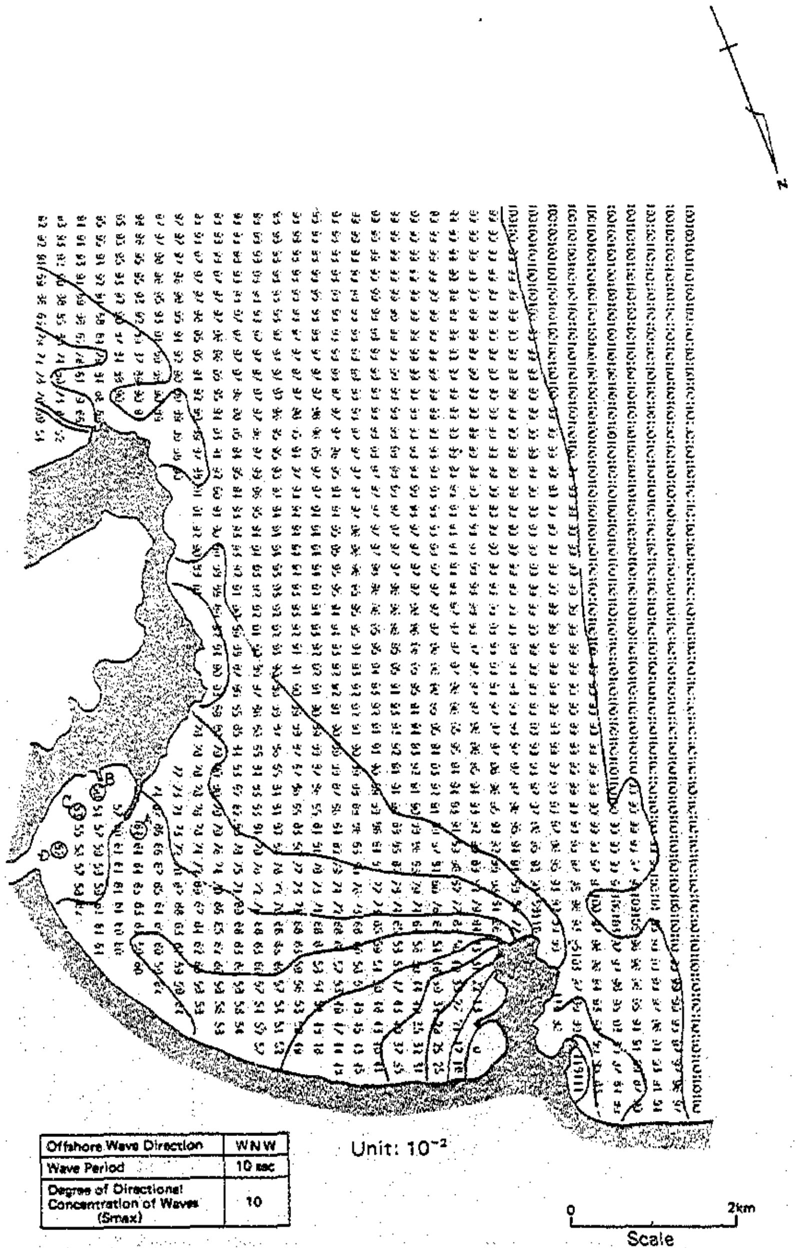
Table III-5 Estimated Waves at Manzanillo Port

Location		Wind Waves from WNW		Swells from S		Swells from SW	
		Direction	Height (cm)	Direction	Height (cm)	Direction	Height (cm)
A	Top of the Breakwater	N60°W	176	S71°W	48	S73°W	63
B	Top of the Old Wharf in the Outer Port	–	138	–	15	–	18
C	Beach in the Outer Port	–	146	–	12	–	20
D	Entrance of the Inner Port	S85°W	143	S86°W	39	N87°W	63

Notes: 1) The offshore wave conditions:

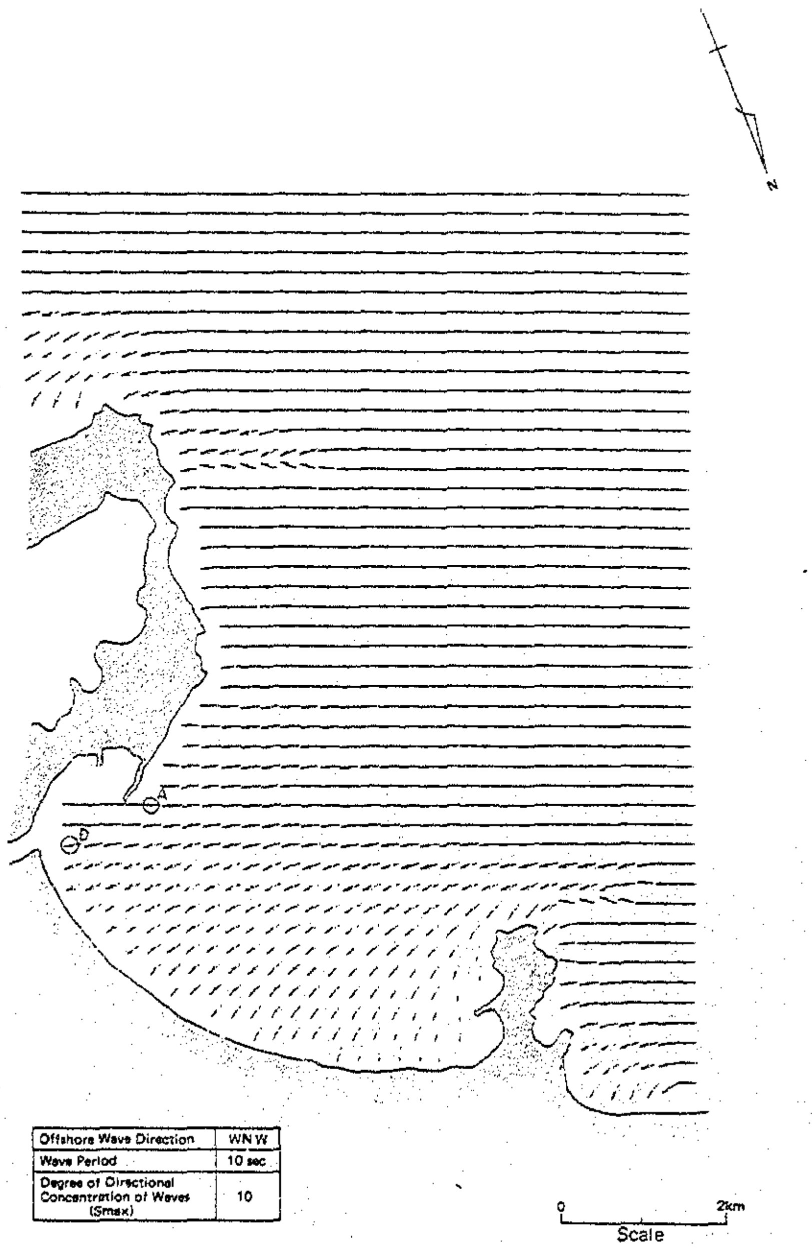
Wind Waves from WNW H_0⅓ = 2.75m, T⅓ = 10.0 sec.
Swells from S H_0⅓ = 3.0 m, T⅓ = 10.0 sec.
Swells from SW H_0⅓ = 1.5 m, T⅓ = 10.0 sec.

2) Locations A to D are shown in Fig. III-20 ~ III-23.



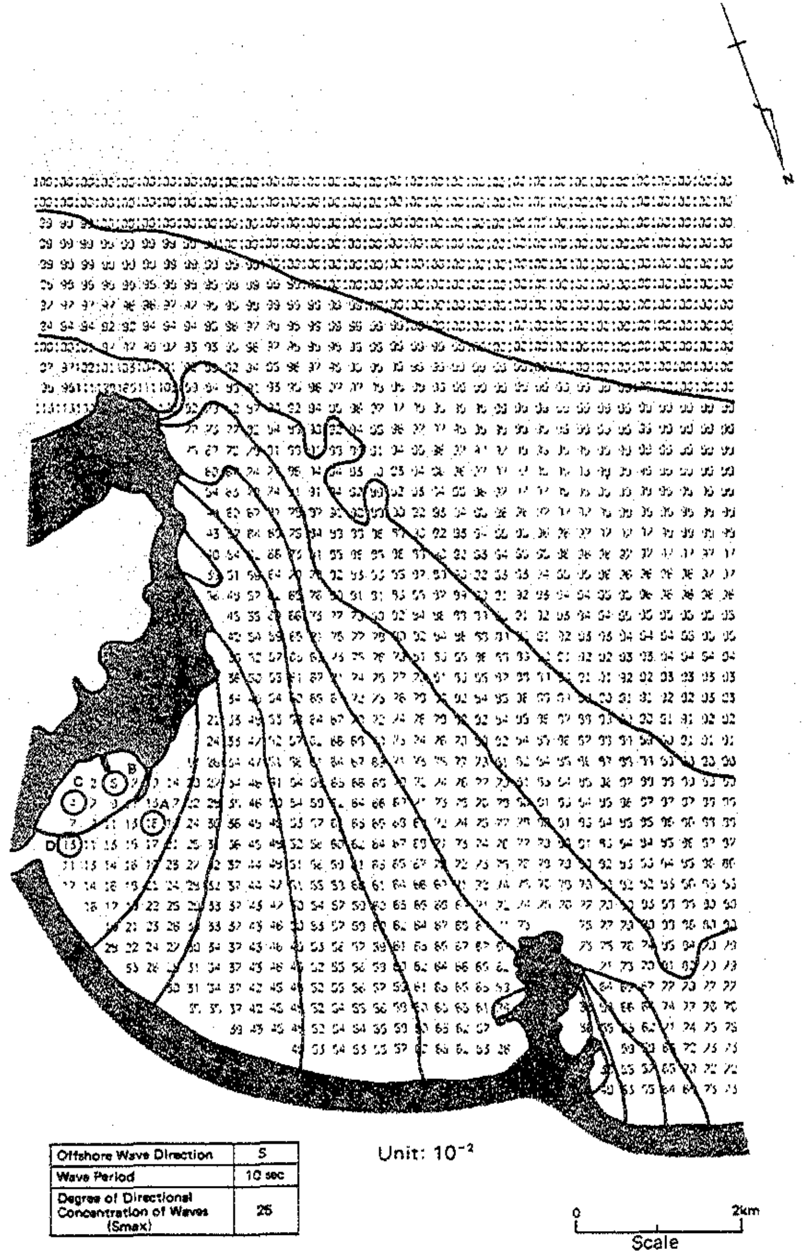
Offshore Wave Direction	WNW
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	10

Fig. III-20 Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (WNW)



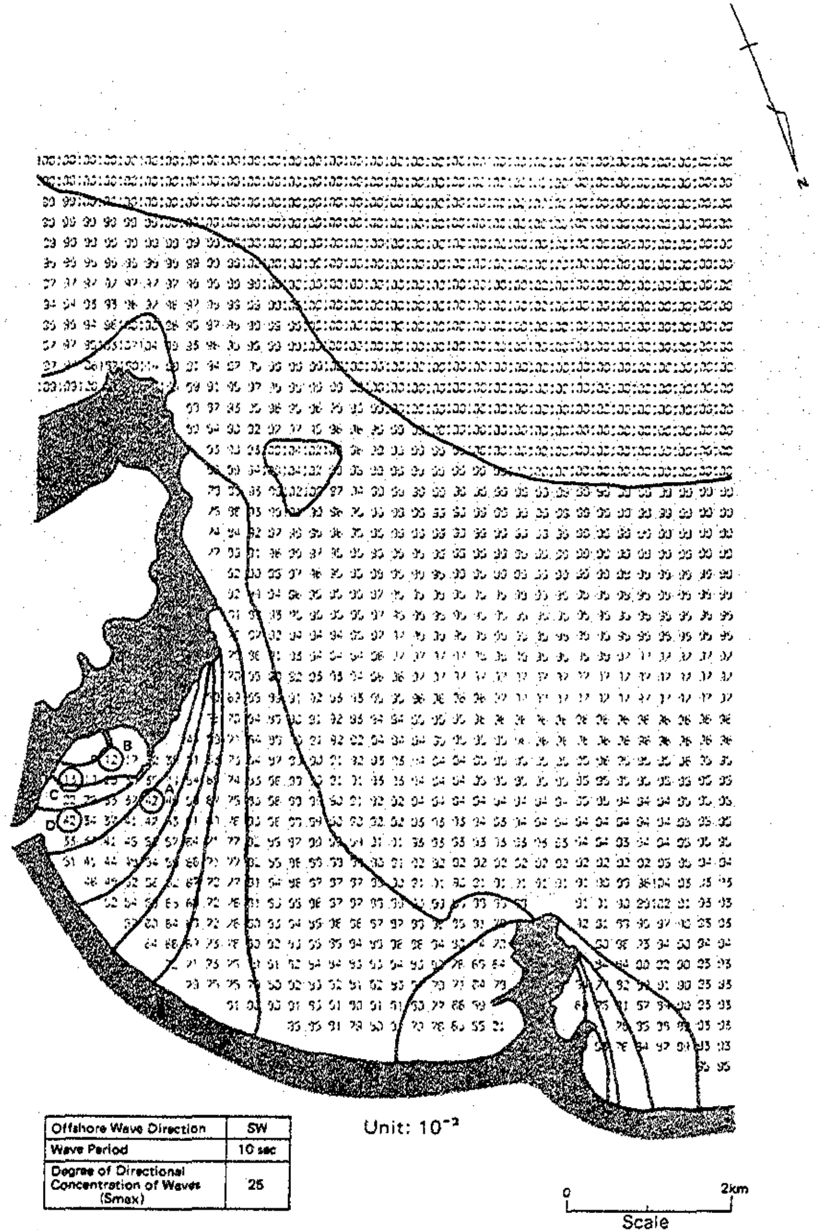
Offshore Wave Direction	WNW
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	10

Fig. III-21 Calculated Wave Direction (WNW)



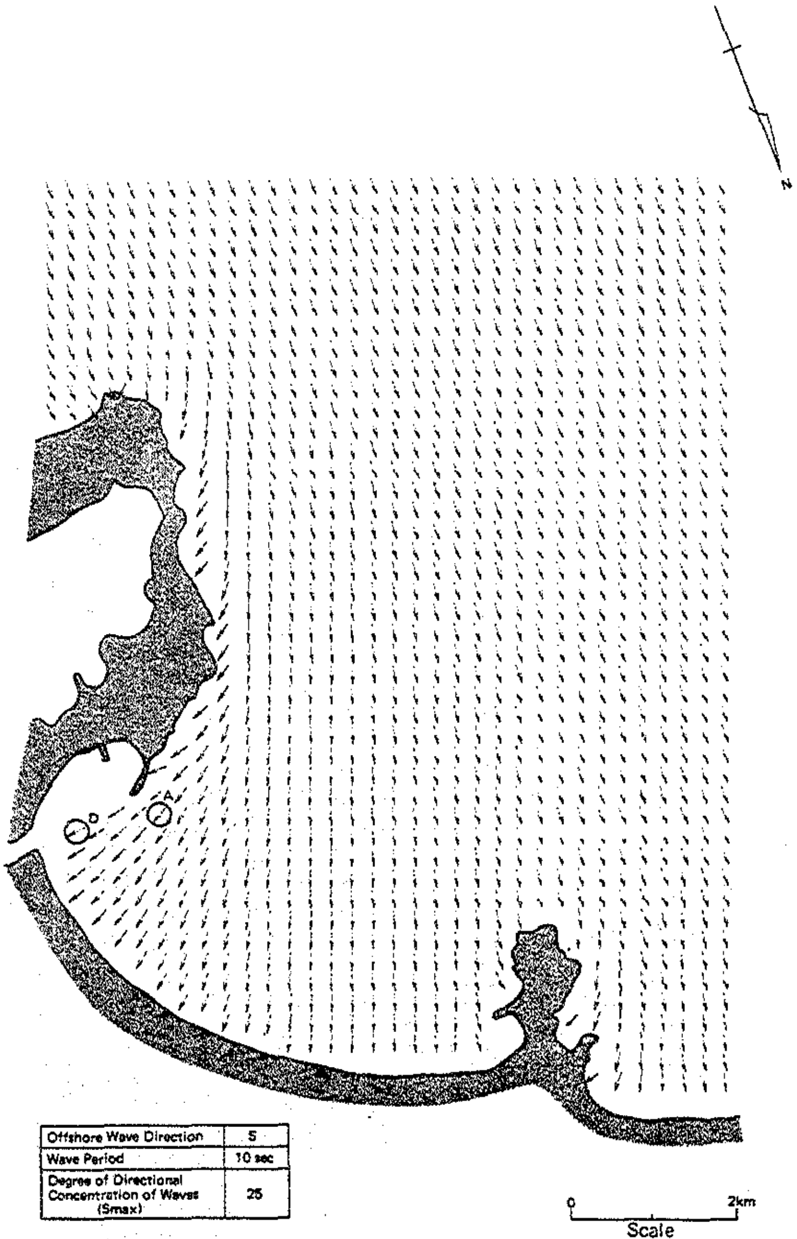
Offshore Wave Direction	S
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	25

Fig. III-22 (a) Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (S)



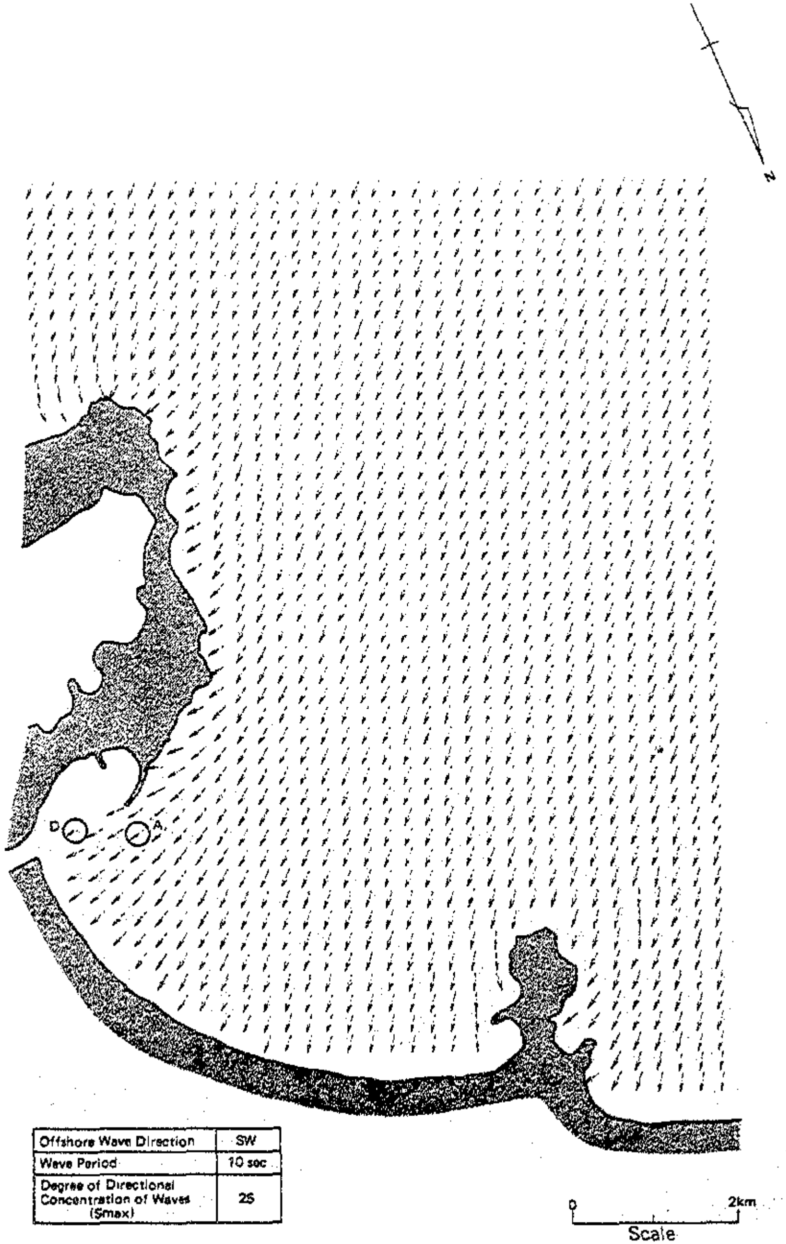
Offshore Wave Direction	SW
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	25

Fig. III-22 (b) Height of Waves in Shallow Areas as a Percentage of the Height of Offshore Waves (SW)



Offshore Wave Direction	S
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	25

Fig. III-23 (a) Calculated Wave Direction (S)



Offshore Wave Direction	SW
Wave Period	10 sec
Degree of Directional Concentration of Waves (Smax)	25

Fig. III-23 (b) Calculated Wave Direction (SW)

(4) Waves in the Inner Port of Manzanillo

The wave height distribution in the Inner Port is calculated using a computer, based on the wave conditions at the entrance of the Inner Port. The wave conditions at the port entrance are shown in Table III-5 with a significant wave height and period of 1.43 m and 10 sec. The future faceline of the wharves and piers is chosen for the calculation. It is based on the Master Plan described in Chapter VII.

Fig. III-24 shows the calculation result. This figure shows sufficient calmness in the Inner Port.

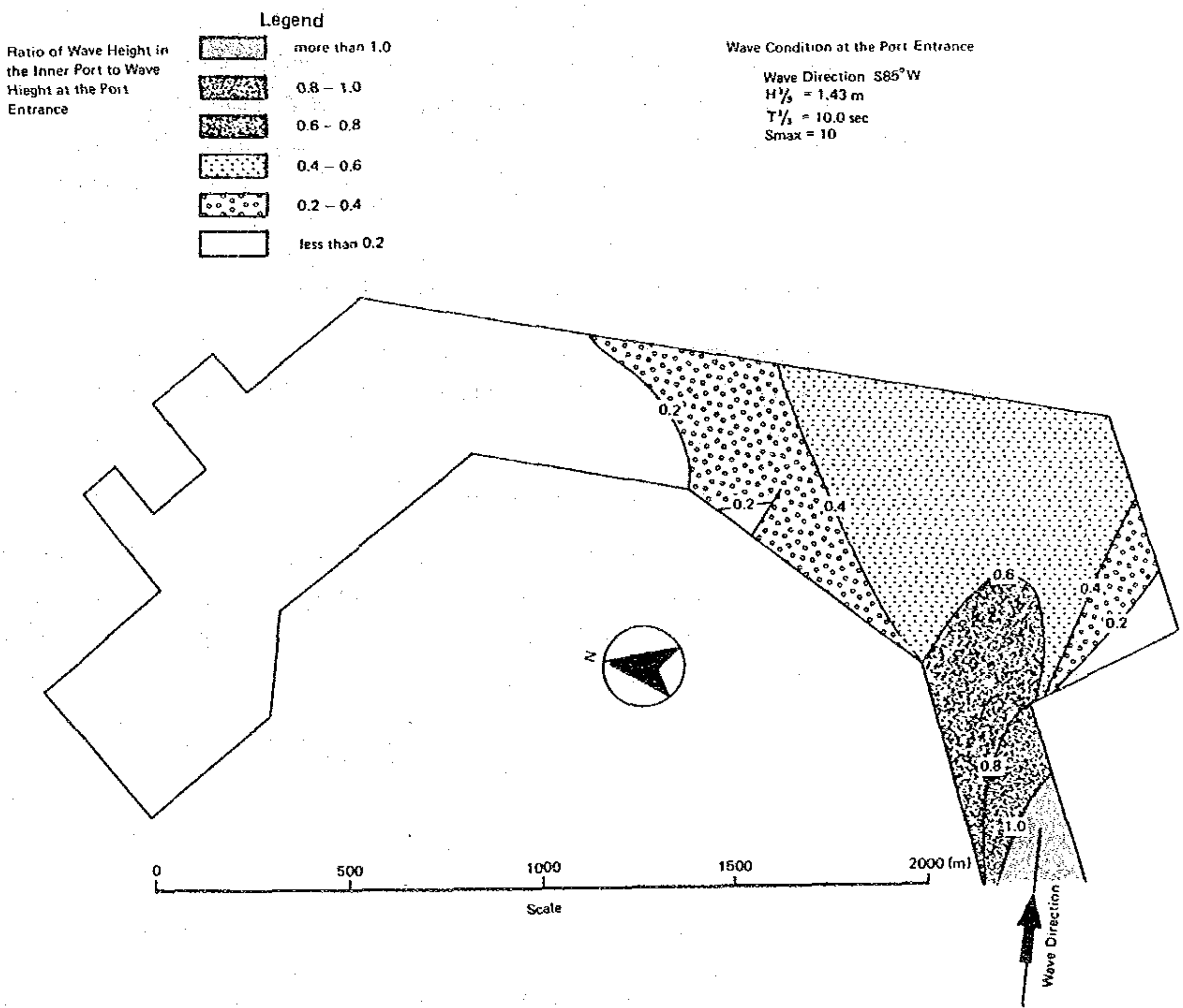


Fig. III-24 Calmness in the Inner Port

1-4-4 Storm Surge

The water level fluctuations by storm surge at the port of Manzanillo caused by the hurricane "Norman" are roughly analyzed.

Storm surge is mainly caused by the depression of atmospheric pressure and the wind-induced surface current. If the total water level fluctuation(ζ) is divided into two, the water fluctuation by the depression of atmospheric pressure (ζs) and the fluctuation caused by the wind-induced surface current (ζw), then

$$\zeta = \zeta s + \zeta w$$

ζs can be given statically as follows:

$$\zeta s\ (\mathrm{cm}) = 0.991\ \triangle P\ (\mathrm{mb})$$

The depression ($\triangle P$) of hurricane "Norman" is estimated 16 mb, and therefore,

$$\zeta s = 0.991 \times 16 = 15.9\ (\mathrm{cm})$$

ζw can be calculated using a cross sectional model along the wind direction. The conditions for the calculation are given based on the records of hurricane "Norman" and its wave estimation results described before as follows:

The moving velocity of the cyclone	$V = 30$ km/hr
The radius of the cyclone	$r_o = 1/a = 100$ km
The wind velocity at Manzanillo	$U = 18$ m/sec

Fig. III-25 shows the calculation result of water surface changes over time. From this figure we see that water level converges toward a constant value of 44.9 cm. The total water level fluctuation is therefore estimated.

$$\zeta = \zeta s + \zeta w = 15.9 + 44.9 = 60.8\ (\mathrm{cm})$$

As this result is obtained based upon some assumptions, there may be some difference between the estimated and actual wave fluctuations at Manzanillo Port caused by hurricane "Norman". However, the estimate can be considered as one of the typical instances to predict the future probability of water level fluctuation at Manzanillo Port.

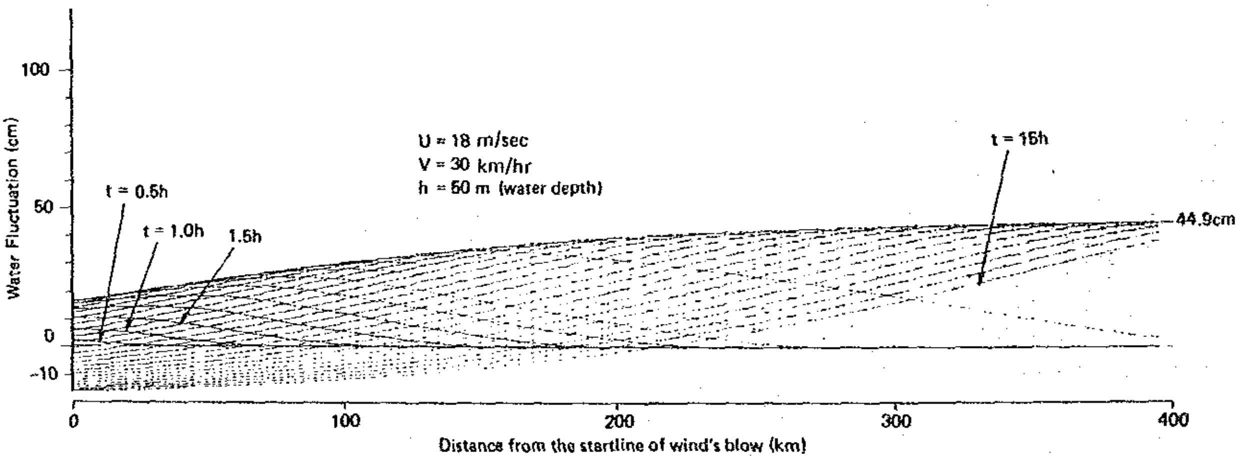


Fig. III-25 Water Surface Changes by the Wind-Induced Surface Current

1-4-5 Littoral Drift

The outline of Manzanillo Bay is shown in Fig. III-19 as described before. The long sand spit which well protects the Inner Port (San Pedrito Lagoon) is located in the inner part of the bay. The bottom slope of the bay is fairly steep with a ratio of 1/60 between the coastline and the area 40 m deep. Further out, in areas over 40 m deep, the slope is more gradual. The bay can only be influenced by waves from the W to SW because of its geographical conditions. There is a small river named "Salagua" which is one of the source of sand supply.

The wave refraction in shallow water from the two directions of W and SW is shown in Fig. III-26. It can be easily seen from this figure that the probability of sand transportation to the mouth of the Inner Port caused by waves from the SW is small, and on the contrary, that from the W is fairly high. As analysed before, waves from the W are usually small and typical cyclones never cause wind waves and swells from the W, therefore it can be concluded that serious trouble from the shoaling of the port of Manzanillo and the channel will not take place. The same conclusion was found in the other study executed by the Japanese study team in 1973. The fact that dredging of the Inner Port entrance channel for the maintenance of depth has not been needed since 1973 also supports this conclusion.

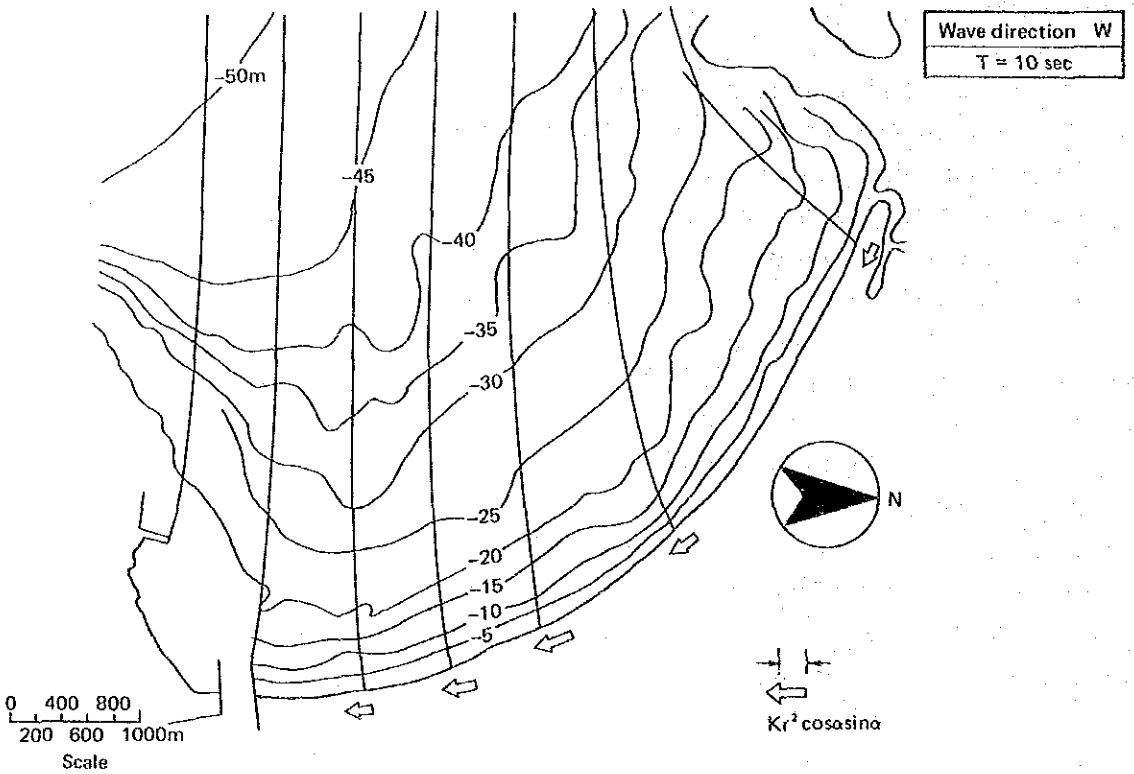


Fig. III-26 (a) Wave Refraction at Manzanillo Bay

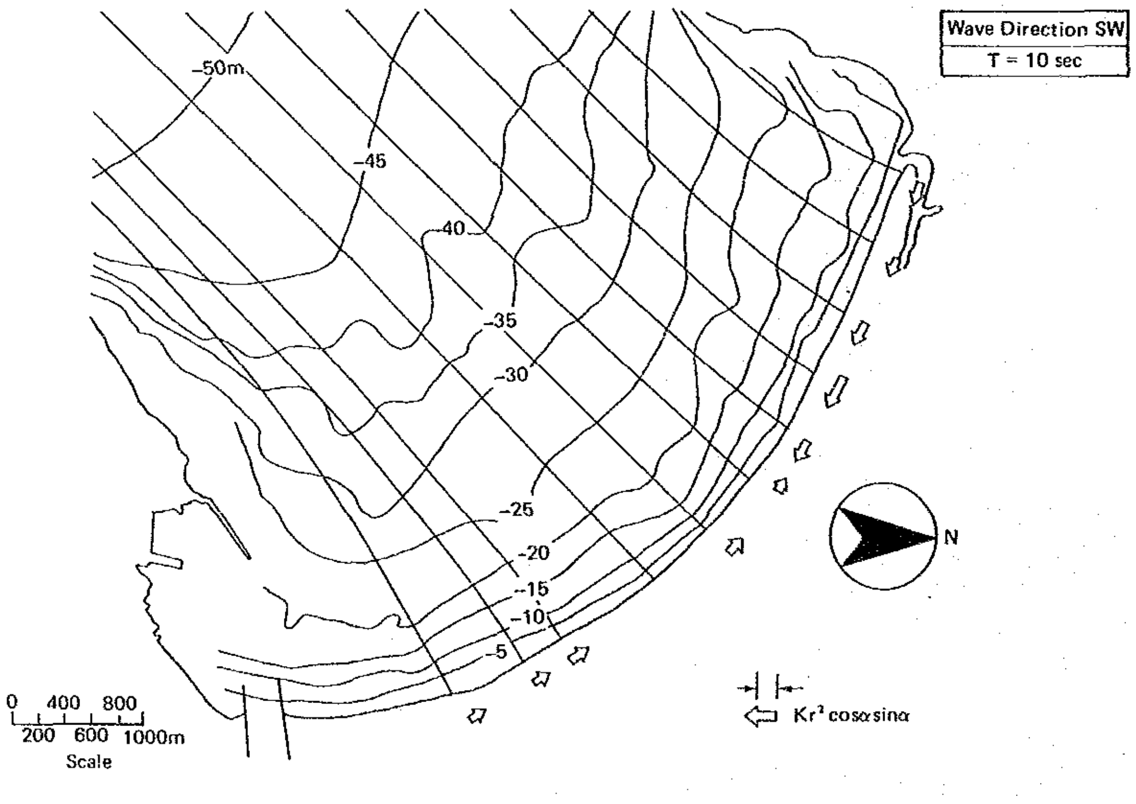


Fig. III-26 (b) Wave Refraction at Manzanillo Bay

Note: ⇦ shows the direction of sand transport.
Source: OTCA, "Study of Port Construction Planning, The United Mexican States", January, 1973

1-4-6 Tsunami

The main tsunami which have attacked Manzanillo Port are listed in Table III-6. It can be seen from this table that tsunami over 1.0 m in wave height attacked Manzanillo Port twice in the last 30 years. Fig. III-27 shows the records of water level changes caused by the tsunami at Manzanillo Port. These figures show that the maximum amplitudes and periods of tsunami caused by the Alaskan earthquake in March, 1964, and the earthquake in Colima in January, 1973 are 1.1 m, 30 ~ 40 minutes and 1.2 m, 50 minutes, respectively.

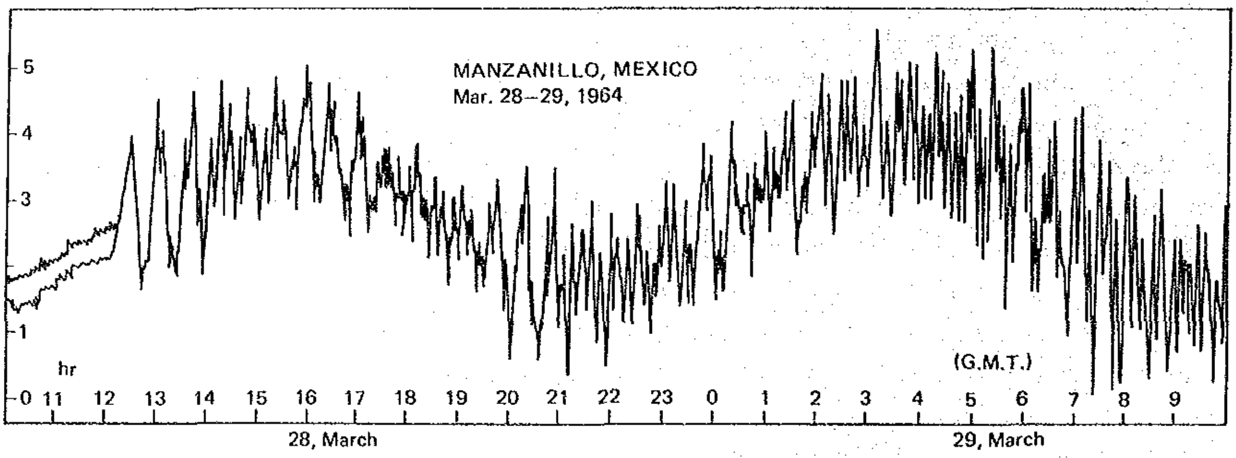
Fig. III-28 shows the estimation of the probabilities of tsunami occurrence on the west coast of Mexico based on the experienced tsunami. It can be seen from this projection that tsunami which have a wave height of 2 m may come twice in 50 years. Of course, actual wave height of tsunami changes locally by the geography at the sites.

The most preferential countermeasures to tsunami are to forecast their occurrence, to inform all of the inhabitants, and to give them refuge. This is a basic precept learned from many historical experiences. This must be considered when planning port and urban development.

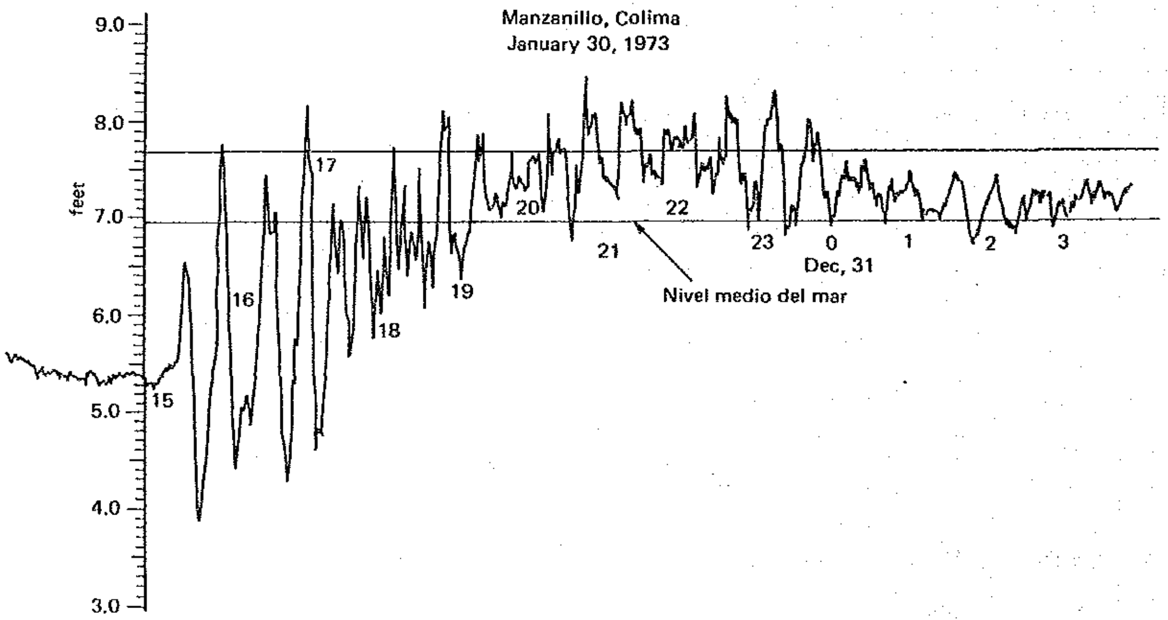
Table III-6 Major Tsunami at Manzanillo Port

Year	Month	Date	Magnitude of Earthquake	Location of Epicenter	Brief Description
1932	June	3	7.8	19.5°N, 104.25°W	
1932	June	18	7.8	18.767°N, 103.5°W	Tsunami occured at Manzanillo and other places.
1932	June	22	7.0	18.9°N, 104.5°W	Tsunami attacked Cuyutlan. Tsunami was observed at Manzanillo, Tecoman and other places.
1957	March	9	7.8	51°N, 176.5°W	Tsunami was caused by an earthquake in Andreanof. Hawaii had damage.
1960	May	22	8.3	38°S, 73.5°W	Tsunami was caused by an earthquake in Chile. Hawaii and Japan had much damage.
1964	March	28	8.4	61.04°N, 147.3°W	Tsunami was caused by an earthquake in Alaska. Many ports and islands around the Pacific coast had much damage. The amplitude of the tsunami was 3.9 feet.
1973	January	30	7.0	18°N, 103.3°W	Earthquake originated in Colima State. The maximum amplitude of the tsunami was 4 feet. Fortunately, serious damage did not occur because the water level was low at that time.

Source: Jesus Figueroa A., "Sismicidad en Colima Macrosismo del 30 de Enero de 1973", April, 1974, UNAM

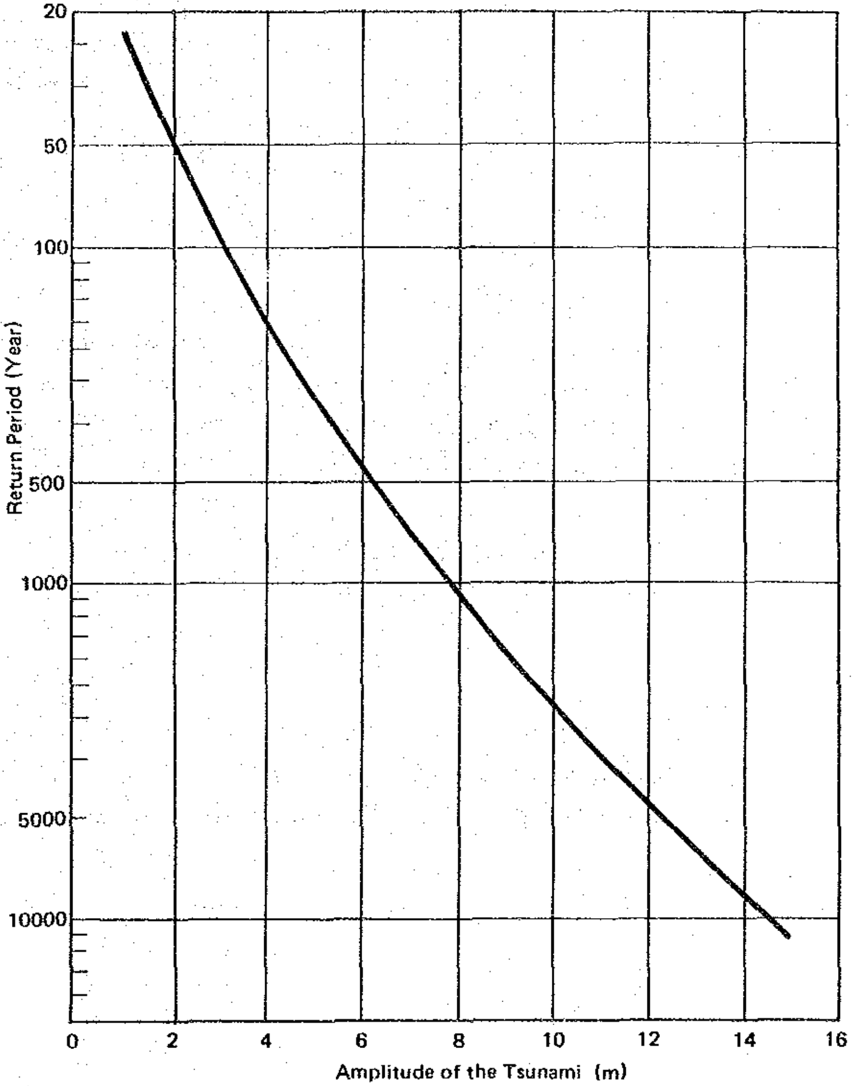


Note: G.M.T. means Greenwich Mean Time
Source: M.C. Salvador Farreras S., "Tsunamis en la Costa Occidental de Mexico".



Source: Jesus Figueroa A., "Sismicidad en Colima Macrosismo del 30 de Enero de 1973"

Fig. III-27 Wave Records of Tsunami



Note: Amplitude means the distance from top to bottom of the wave

Source: Augusto G. Villarreal, Octavio A. Rascon, "Estudio Estadistico de los Tsunamis Observados en la Costa Mexicana del Pacifico", January, 1974, UNAM

Fig. III-28 Probability of Tsunami Occurence

1-5 Soil Conditions

Soil conditions in the inner port are discussed in this section from an engineering point of view. As described above, the soil conditions of the inner and outer port seem to be different. However, detailed soil data of the outer port have not yet been obtained.

1-5-1 Locations of Borings and Survey Items

The locations of borings and zone classification, from A to G, are shown in Fig. III-29. Zones A to F are in the San Pedrito Lagoon and Zone G is in the Tapeixtles Lagoon.

Zone A includes the recently constructed 600 m long berth, Zone B includes the 600 m long berth now under construction and the planned extension area, Zones C and E include the channel, Zone D includes naval area, Zone F includes the fishery port and Zone G includes Tapeixtles Lagoon.

Samples from 138 points of boring have been collected to date, and for the 133 points of boring that can be classified into these zones, the boring numbers, and the existence of data for soil profiles, Standard Penetration Tests (S.P.T.) and the boring locations are shown in Table III-7, List of Boring Data.

76 points of boring have complete data for the soil profiles, S.P.T. and the locations. Furthermore, the natural water content, and the liquid and the plastic limit for the organic soil covering the entire area, as well as the grain size distribution for sand have been obtained.

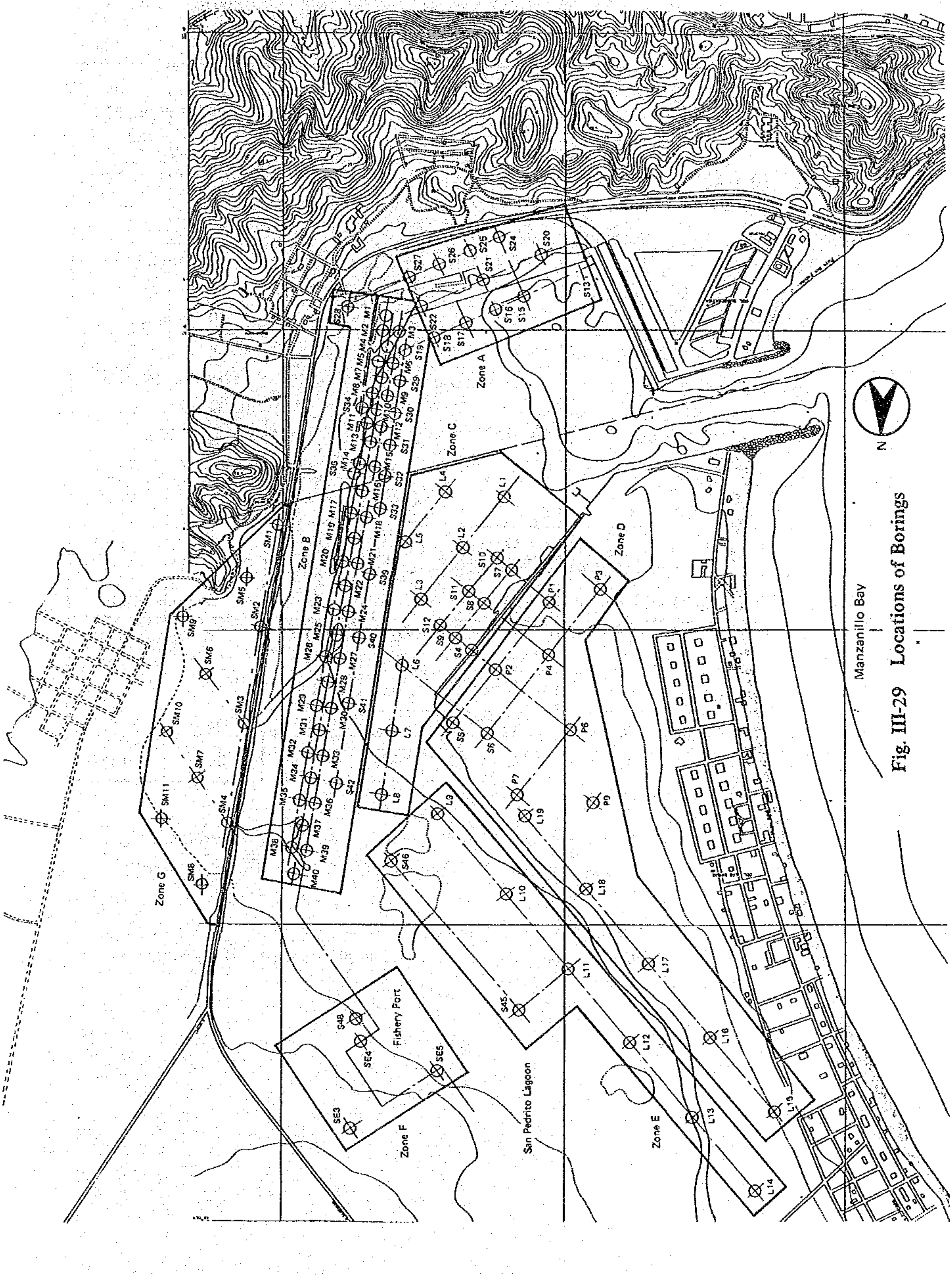


Fig. III-29 Locations of Borings

Table III-7 List of Boring Data

Zone	Boring No.	Existence of Data			Number of Boring	
		Soil Profile	*1 S.P.T.	Location		
A	S-13, 15, 17, 20, 21, 22, 24, 26	○	○	○	8	12
	S-16, 18, 25, 27	○	X	○	4	
B	S-19, 28, 29, 31, 33, 34, 35, 39, 40, 41	○	○	○	10	62
	S-23, 30, 36, 37, 38, 42, 47	○	X	○	7	
	M-1 ~ 40	○	○	○	40	
	A, B, C, D, E	○	○	X	5	
C	S-4, 7, 8, 9, 10, 11, 12	○	○	○	7	15
	L-1, 2, 3, 4, 5, 6, 7, 8	○	X	○	8	
D	S-5, 6	○	○	○	2	14
	P-1, 2, 3, 4, 6, 7, 9	○	○	○	7	
	L-15, 16, 17, 18, 19	○	X	○	5	
E	S-45, 46	○	○	○	2	10
	S-43, 44	○	X	○	2	
	L-9, 10, 11, 12, 13, 14	○	X	○	6	
F	S-48	○	Δ*2	○	1	9
	SE-3, 4, 5	○	Δ*2	○	3	
	SE-1, 2, 6, 8, 16	○	X	X	5	
G	SM-1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11	○	X	○	11	11
					Total	133

Note: ○ Yes X No. Δ Partial

*1: The Standard Penetration Test.

*2: Lack of Data Table

1-5-2 Soil Profile

Soil profiles were made for sections ①to ⑨in the inner port (see Fig. III-30). The profile of section ① - ① is presented in Fig. III-31 as a typical profile. The other profiles are shown in Appendix 1.

With the exception of boring points numbered SE- and SM-, the boring data may be classified into two groups chronologically. The 69 points numbered S-, P- and L- were bored in 1972, and the other 45 points numbered M- and A to E were bored late in 1983. There are some differences between the two groups. The main features of the soil profile are presented here. Further details are described in Appendix 1.

(1) Soil map

In this area, that is the San Pedrito and Tapeixtles Lagoons, the ground conditions from the surface down consist of the following 4 types of soil:

① Soft organic soil or clayey soil layer

This soft layer covers the entire area of the San Pedrito and Tapeixtles Lagoons, as a surface layer. And as shown in Table III-8, this layer is very soft and its unconfined strength is less than 1.0 t/m^2.

Table III-8 Characteristics of Surface Layer

Natural Water Content	163% ~ 400%
Plastic Limit	80% ~ 180%
Liquid Limit	250% ~ 350%
N-value	Almost 0

Note: Data obtained from samples from the San Pedrito Lagoon.

As shown in Table III-8, the range of natural water content includes, and is broader than the liquid limit. This means that this soil layer is very soft.

② Clayey sand or sandy clay layer

This layer lies under the organic soil or clayey soil layer, but doesn't cover the entire area. The layer has a variety of characteristics, as observed in individual sections.

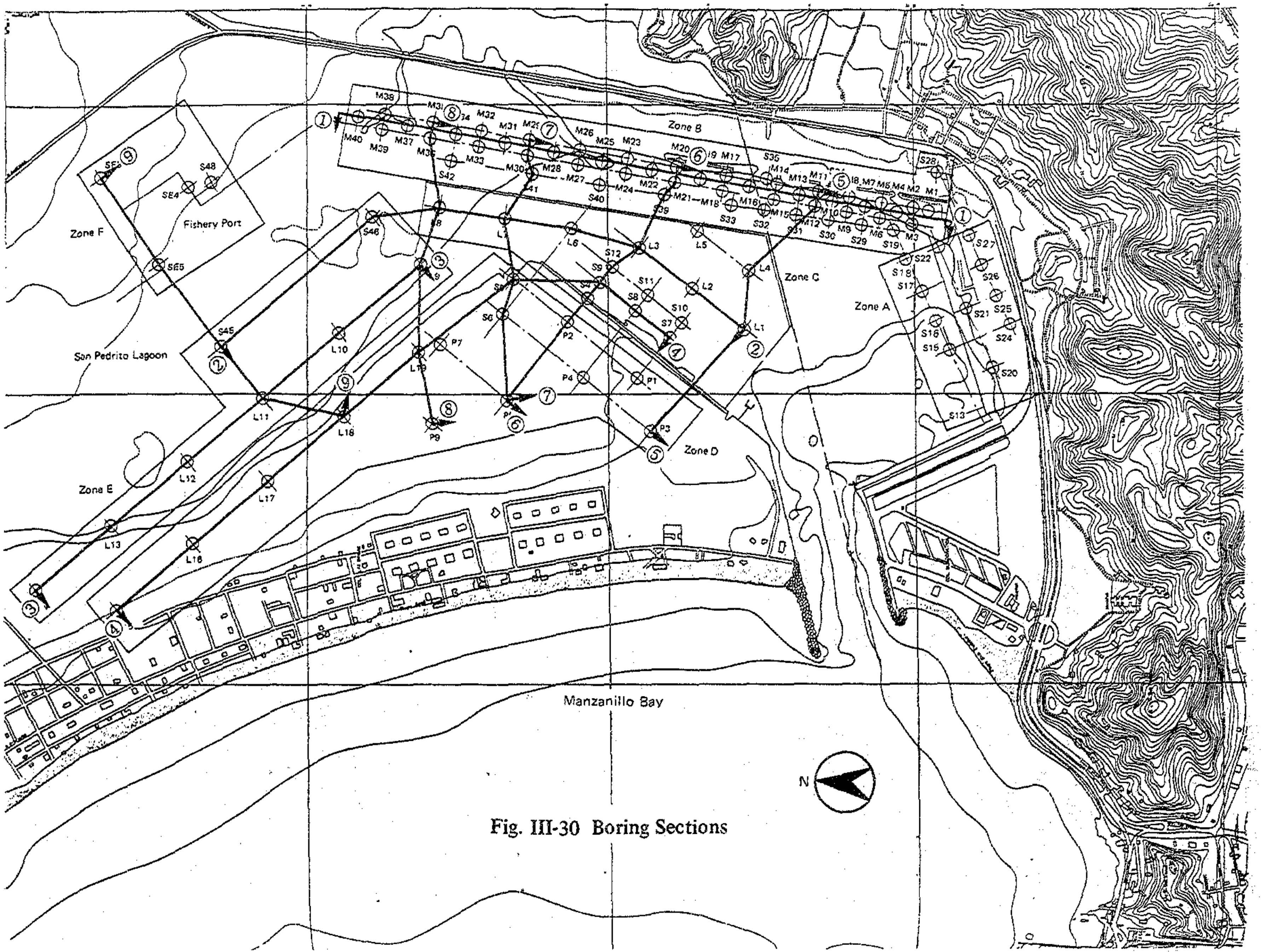


Fig. III-30 Boring Sections

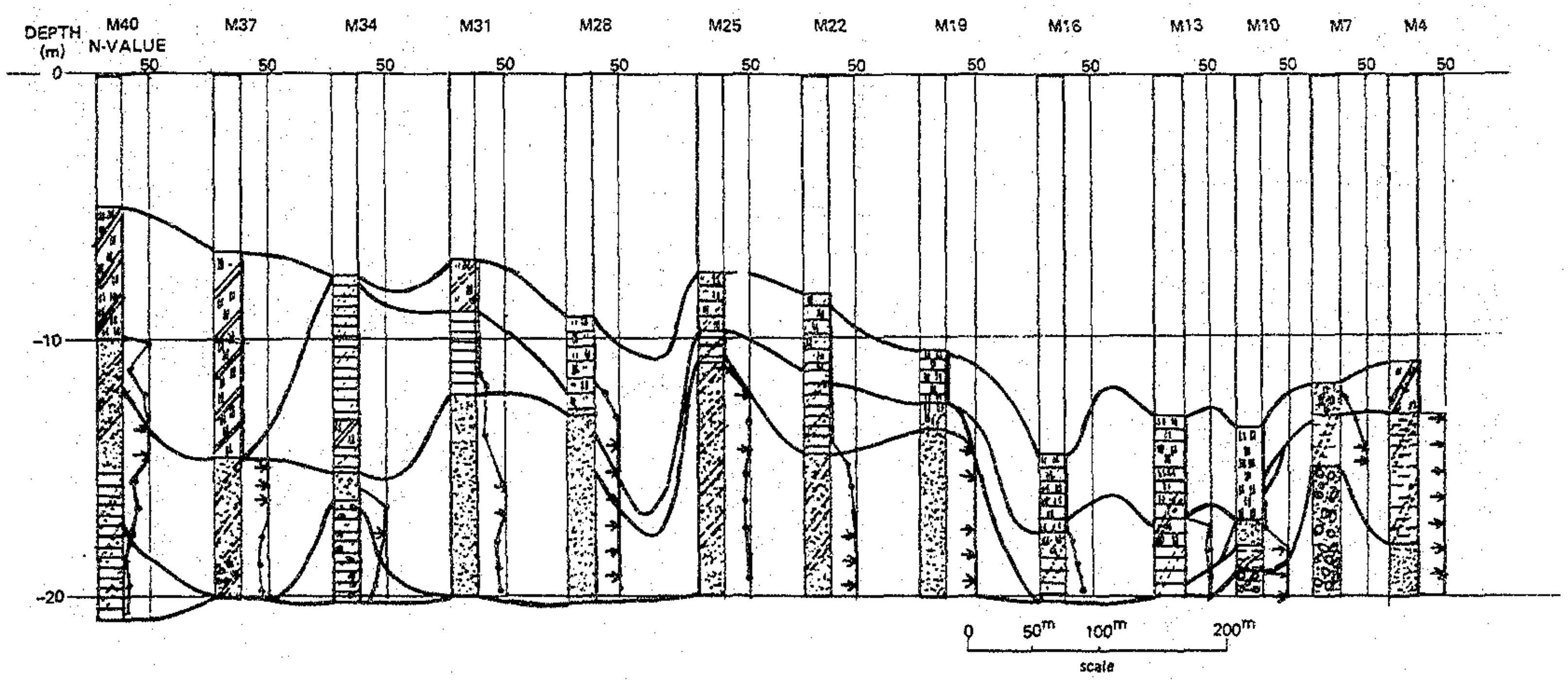


Fig. III-31 Soil Profile, Section ① - ①

③ Sandy soil layer

This layer lies under the entire area, and its characteristics are shown in Table III-9.

Table III-9 Characteristics of Sandy Soil Layer

Sand Fraction	98% ~ 90%
D_{10}	0.2 mm ~ 0.4 mm
D_{60}	0.5 mm ~ 0.9 mm
Uc (D_{60}/D_{10})	1.0 ~ 3.5
N-value	over 50

Note: Data obtained from samples from the San Pedrito Lagoon.

Its coefficient of uniformity, Uc, ranges from 1.0 to 3.5. This means that the grain-size distribution doesn't have a wide range.

④ Complex layer of sandy, silty and clayey soils

This layer consists of thin layers of sandy, silty and clayey soils, and may underline the entire area. However this can not be confirmed as data for this layer is only available for those borings numbered S-. Further, the soil data for this layer in the Tapeixtles Lagoon has not been obtained.

(2) Soil profile features

The San Pedrito and Tapeixtles Lagoons have a similar soil profile. They may have been one lagoon, and become divided into two lagoons by the man-made road.

The features of each lagoon are shown as follows:

1) San Pedrito Lagoon

For the soil profiles in the longitudinal direction (North to South) of the San Pedrito Lagoon (sections①to④), the soft organic soil or clayey soil layer lies around −10 m in average depth. However, in the middle-portion of section①, the maximum depth of the soft layer is about −17 m at M-16.

The thickness of the sand layer, which is one of the most important layers as the bearing stratum for foundations, decreases to the northeast in the San Pedrito Lagoon and south of Zone F. The minimum thickness of the sand layer is 1.6 m at S-45. Furthermore, the thickness of the sand layer can not be obtained with the exception of borings S-5, 7, 8, 9, 45 and 46, because the borings were shallow, stopping in the middle of this sand layer, about 20 m deep.

For the soil profiles in the transverse direction (East to West) of the San Pedrito Lagoon (section⑤to⑨), the thickness of the soft organic soil or clayey soil layer increases to the northeast and is thickner within longitudinal section①.

The water is deepest in the area near the 600 m berth which is currently under construction, probably because this area may have been dredged for the construction project.

The thickness of the sand layer decreases to the northeast, and a soft layer underlies part of the sand layer.

2) Tapeixtles Lagoon

The soil profile in the Tapeixtles Lagoon is almost the same as in the San Pedrito Lagoon. In this lagoon, the soft organic soil or clayey soil lies around −10 m in depth, too.

Determining the bearing stratum for foundations here is also difficult because the borings were shallow.

1-5-3 Evaluation of Soil Conditions

From all of the boring data, the soil conditions in the inner port and in the San Pedrito and Tapeixtles Lagoons can be simplified as shown in Fig. III-32.

The distribution of soil can be classified into four types as follows:

① Soft Organic Soil or Clay

This organic soil or clay underlies the entire area from 5 m to 20 m in depth. From the engineering point of view, this soil is not useful, and has to be removed or ignored.

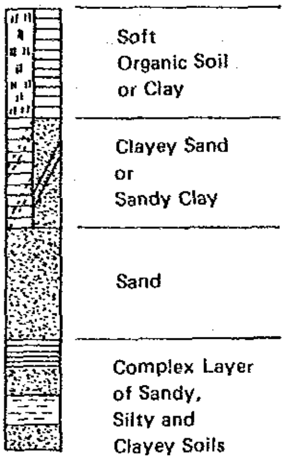


Fig. III-32 Typical Soil Conditions in San Pedrito Lagoon

② Clayey Sand or Sandy Clay

This layer underlies most of the area and its thickness ranges from 0 m to about 10 m. This soil has various mechanical characteristics from soft to stiff soil. Therefore, each specific area of the soil has to be examined and it must be determined if it is useful or not from the engineering point of view.

③ Sand

This sand layer underlies almost the entire area and has enough bearing capacity for the foundations of habour structures. But, the thickness of this layer is less than 2 m with an N-value smaller than 30 in the northeast portion of the San Pedrito Lagoon, and thus in this area the sand layer can not be considered as a bearing stratum.

Also the depth of this sand layer in the Tapeixtles Lagoon can not be determined, because the borings were too shallow.

④ Complex Layer of Sandy, Silty and Clayey Soils

This complex layer underlies almost the entire area beneath the sand layer. Generally it has enough bearing capacity for the foundations of habour structures with the exception of the southwestern portion of the San Pedrito Lagoon.

As a whole, the depths of collected boring data are insufficient, and the true depth and thickness of this layer, which is one of the most important layers as the bearing stratum for foundations, can not be determined from available data. Deeper borings may be necessary before important structures are planned and designed.

When filling the area behind wharves, the surface soft organic soil or clayey soil shall be removed for stability and as a countermeasure against subsidence. Furthermore, when the sand in ③ is used as a reclaimed material, it must be compacted. There is a possibility that the loose sand layer may undergo liquifaction during an earthquake, because the grain-size distribution doesn't have a wide range as shown in 1-5-2.

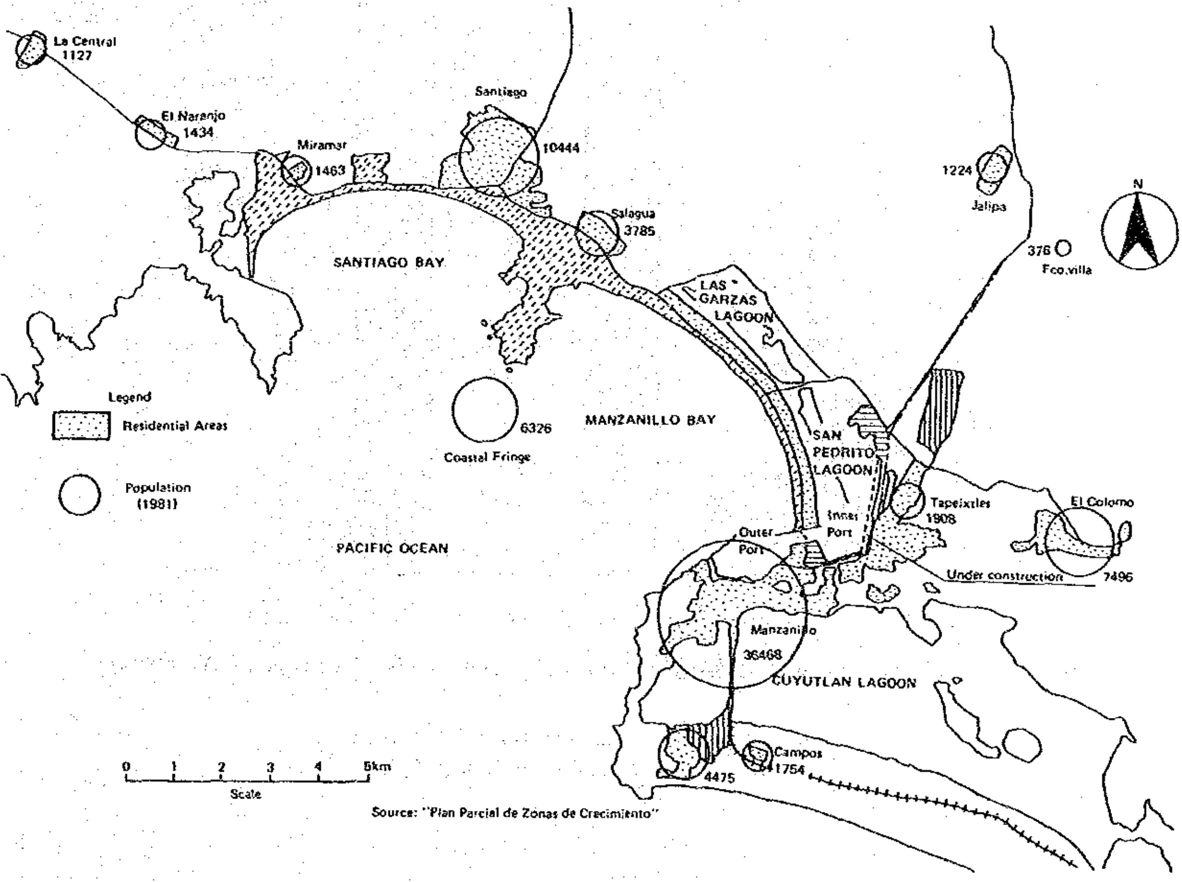
2. Manzanillo City

In this section, the area around Manzanillo will be examined generally in respect to population, economic activity, transportation, land use and urban facilities.

2-1 Population

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

The area around Manzanillo Bay and Santiago Bay is called the Manzanillo Metropolitan Zone, and the distribution of population (1981) in the Manzanillo Metropolitan Zone is shown in Fig. III-33.



Source: "Plan Parcial de Zonas de Crecimiento"

Fig. III-33 The Distribution of Population

2-2 Socio-Economic Activities

2-2-1 Sectoral Distribution of Economic Activity

The sectoral distribution of economic activity in Colima State and the Municipality of Manzanillo is shown in Fig. III-34.

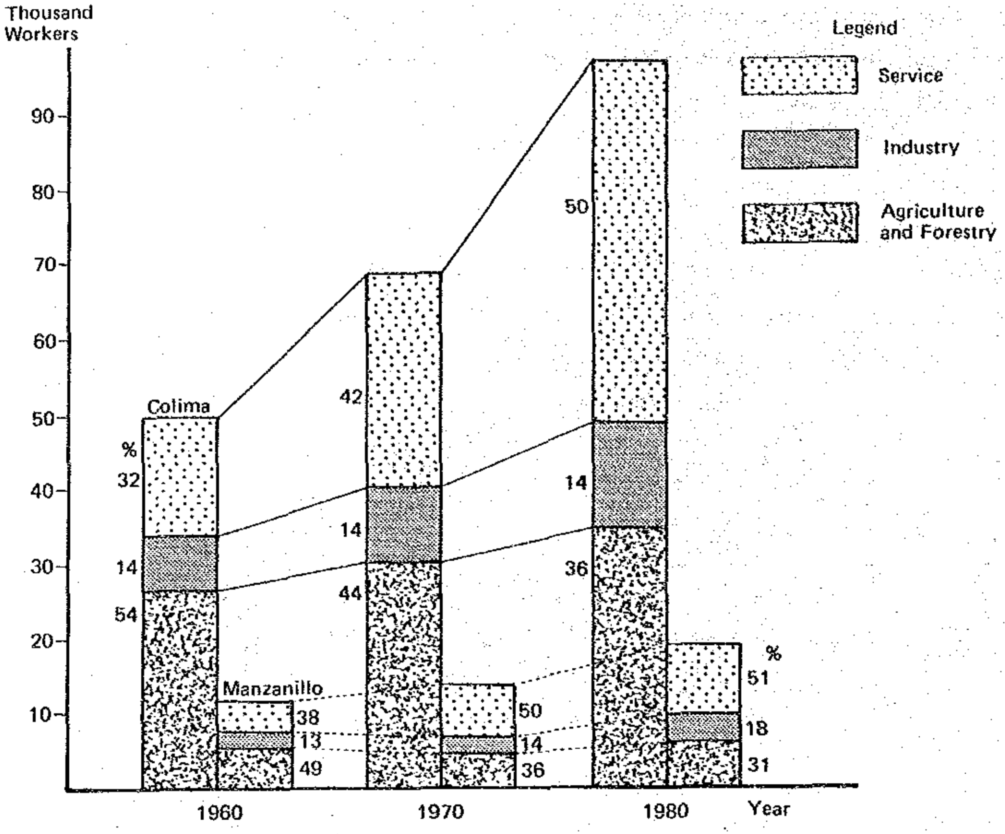


Fig. III-34 Sectoral Distribution of Economic Activity (By Number of Workers)

Source: SARH, "VIII y IX Censos Generales de Población"
"Datos estimados por la Residencia de Planeación"

2-2-2 Socio-Economic Activity

(1) Agriculture, stock raising, and forestry

In 1980, agriculture, stock raising and forestry in Colima State is as follows:

Agriculture	
Useable Land	170,000 ha
Under Cultivation	121,464 ha
Irrigated	63,001 ha
Seasonal	58,463 ha
Stock raising	
Cattle	235,341
Pigs	71,917
Goat	37,237
Milk cows	24,487
Fowl	610,558
Beehives	57,600
Forestry	
Forested Area	200,891 ha
Useable Area	105,000 ha
Commercially Feasible Area	24,850 ha
Grove Surface (bush, oak, mangrove, etc.)	80,150 ha

Source: SARH, "Jefatura del Programa Agrícola, Ganadero y Forestal Residencia de Planeación"

The supply and demand of primary agricultural products in Colima State (1980) is shown in Table III-10.

Table III-10 Supply and Demand of Primary Agricultural Products in Colima State (1980)

(Unit: t)

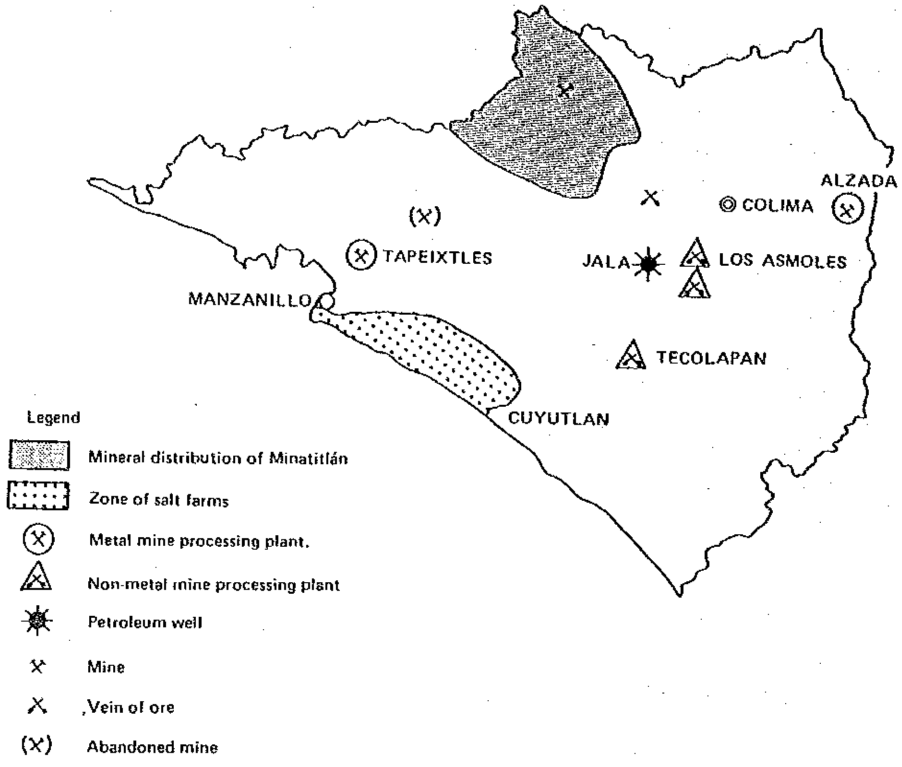
Kind of Product	Supply	Demand	To Other States	From Other States
Maize	75,780	62,442	13,338	
Sorghum	13,953	25,021		11,068
Rice	15,541	1,044	14,497	
Sesame	523	519	4	
Coconut	8,945	819	8,126	
Lemon	72,705	778	71,927	
Banana	81,751	6,189	75,562	
Sugar Cane	40,684	14,947	25,737	

Source: Estimaciones Realizadas la Residencia de Planeación – Consumos Aparente, publicados por la subsecretaria de Agricultura y Operación. Dirección General de Economía Agrícola, SARH

(2) Industry

1) Mineral resources

The distribution of mineral resources in Colima State is shown in Fig. III-35.



Source: SPP, "Síntesis Geográfica de Colima"

Fig. III-35 Distribution of Mineral Resources in Colima State

In relation to Manzanillo, the "Peña Colorada" in Tapeixtles that produces iron pellets and the salt farms around Cuyutlan Lagoon are important.

a) Salt

The output of salt in Cuyutlan Lagoon is shown in Table III-11.

Table III-11 Output of Salt in Cuyutlan Lagoon

(Unit: t)

	1974	1975	1976	1977	1978	1979	1980	1981
Output	4,776	3,519	3,878	4,979	4,828	–	13,466	21,868

Note: – indicates no available data.
Source: DGFF, SARH
Dirección de Agroindestrias, SARH.

b) Iron pellets

"Peña Colorada" has two plants which produce iron pellets with an output of 2,397,000 tons and a value of 1,851,152,000 pesos in 1980.

2-3 Transportation

Ports, roads, railways and airports are discussed here. The existing transportation network in Colima State is shown in Fig. III-36.

2-3-1 Ports

The port of Manzanillo is located on the coast in the northwest part of Colima State. In recent years new facilities have been under construction. The port of Manzanillo is one of the most important commercial ports on the Pacific coast.

The Port can be roughly divided into two regions called the outer and inner ports.

The details of the Port are described in Chapter III Section 3.

2-3-2 Roads

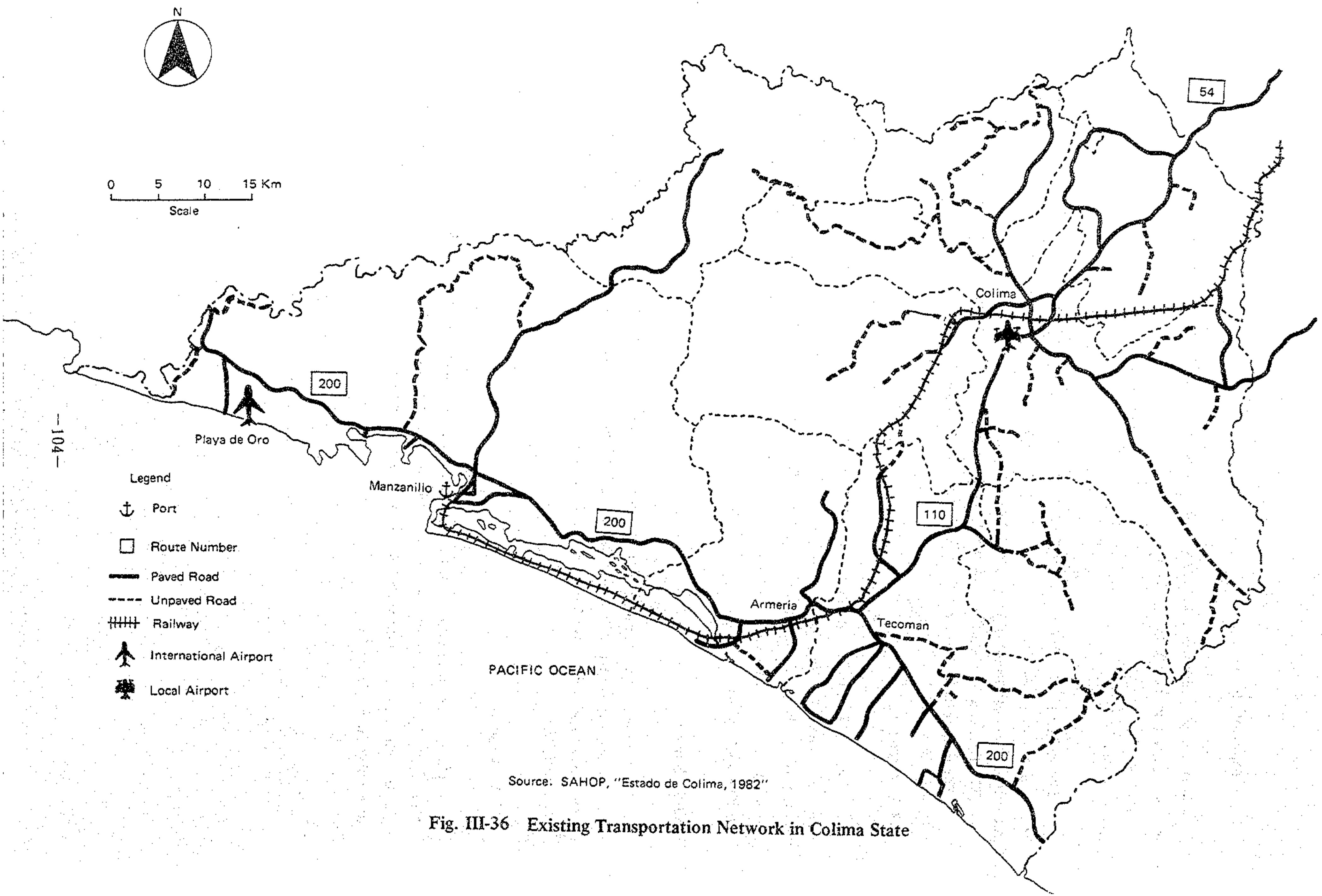
Colima, Tecoman, Armeria, and Manzanillo are connected to one another by two-lane national roads, but the roads connecting with other cities are in poor condition. The only main road through Manzanillo City is route MEX-200 connecting with the other cities on the Pacific coast. In recent years a four-lane national road (Manzanillo ~ Colima ~ Guadalajara) has been under construction.

2-3-3 Railways

The railway (Manzanillo ~ Colima ~ Guadalajara) is mainly used for transporting port cargoes and the iron pellets made in "Peña Colorada". The city area facing the outer port to the north and backed by hills to the west is divided by the railway, and this interferes somewhat with daily activities.

2-3-4 Airports

There is an international airport in "Playa de Oro" which is about 50 km west of the city of Manzanillo by road. The runaway is 2,200 m in length and 45 m in width. The airplanes which use the runaway are mainly DC-9s and B-727s. The daily schedule flights to and from this airport are shown in Table III-12.



Source: SAHOP, "Estado de Colima, 1982"

Fig. III-36 Existing Transportation Network in Colima State

Table III-12 Daily scheduled flights at Manzanillo International Airport

City (to/from)	Number of Times
Mexico City	4
Guadalajara	2
Los Angeles	1

2-4 Land Use

The present conditions of land use in Colima State are shown in Table III-13.

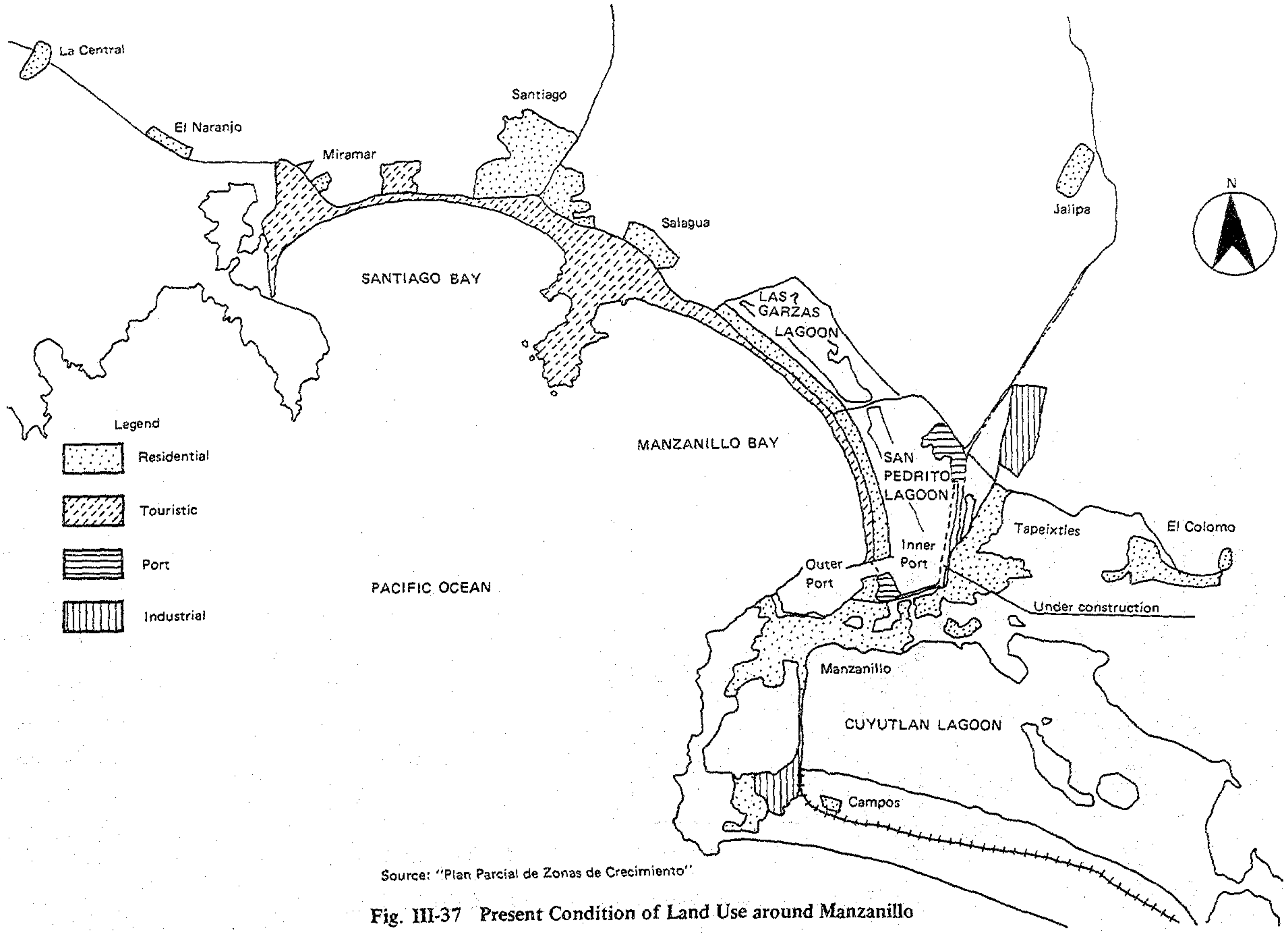
Table III-13 The Present Conditions of Land Use in Colima State

Item	Surface (ha)	%
Agricultural Land	170,000	31
Pasture	164,365	30
Forest	200,891	37
Other	10,244	2
Total	545,500	100

Source: SARH, "Agropecuarios y Forestales y Estimaciones Realizadas per la Residencia de Planeación"

The built-up area in the Manzanillo Metropolitan Zone is estimated at 1,760 ha, of which 60% are residential, 25% are touristic and 15% are industrial and port, and the distribution of land use is shown in Fig. III-37.

The Las Garzas Lagoon which is named after "herons" lies to the north of the San Pedrito Lagoon. The Lagoon is surrounded by coconut palms and mangroves. Many kinds of birds usually rest in this beautiful lagoon. The government of Colima State recently designated the lagoon a natural environmental conservation area. The fine surroundings seem to be well kept.



Source: "Plan Parcial de Zonas de Crecimiento"

Fig. III-37 Present Condition of Land Use around Manzanillo

2-5 Urban Facilities

Fundamental urban facilities which are necessary for functional and comfortable urban activities are discussed here from a general point of view.

2-5-1 Potable Water and Drainage

(1) Potable water

The supplying of potable water for the city of Manzanillo was introduced in 1934 and actually comes from 5 profound wells located on Tapeixtles public land, north of the City. The wells provide 416 ℓ/second, and water is stored in a regulator tank with a capacity of 1,400 m^3.

The main water service is complemented with a well located in Salagua, that distributes, by gravity, 108 ℓ/second. With this, the total supply for the city is 524 ℓ/second.

In response to increased population and water demand, 4 more wells are being drilled, and a new project will bring 500 ℓ/second from the Armeria River.

(2) Sewage and drainage

The municipal sewage system in the city of Manzanillo serves 6,653 landed properties, benefitting 40,413 inhabitants (July, 1982).

The system functions with asbestos piping 8" in diameter that discharges into a pumping drain and from these passes to a well from which it is sent by gravity to the ocean. This system only exists in the oldest urban zone. It was observed that during the rainy season the pumpint system was deficient in its discharging.

The sewage from the area adjacent to the oldest urban zone discharges directly into the Cuyutlan Lagoon without any treatment. Recent settlements of such as Las Brisas, Salagua and ISSSTE discharge their waters into septic tanks and then to absorbing wells.

Finally, there are zones that have no sewage service whatsoever. However, one project to be carried out in the near future will provide for treatment of the sewage that discharges directly to the Cuyutlan Lagoon and for remaking the sewerage.

2-5-2 Energy Supply

(1) Electric energy

The electric energy service is provided by CFE through a thermoelectric plant situated south of the city of Manzanillo with a capacity of 1,200 MW (300MW x 4). Another plant with a capacity of 700 MW (350 MW x 2) is under construction, and is going to be completed in December 1987 and June 1988. This system will satisfy the present and future demand of the development area.

Four sub-stations provide electricity with capacities as follows:

Name	Transformation (kv)		Capacity (MVA)
	From	To	
El Colomo	69	13.8	15
Tapeixtles	69	13.8	20
Salagua	69	13.8	14.375
Miramar	69	13.8	12

(2) Fuel

Manzanillo has two gas stations that supply fuel. They are "Servicio León" and "La Moderna".

2-5-3 Communication facilities

The communication facilities are as follows:

① Telephone

"Teléfonos de México" provides service through as automatic exchange in the city of Manzanillo. There were 2,700 telephone numbers in 1978.

② Telecommunications

The city of Manzanillo has one microwave telecommunication station that serves the telegraph administration. The Secretaría de Marina has for its exclusive use one wireless communication system.

③ Post offices

The Secretaría de Comunicaciones y Transportes controls the service through one Mail Administration Center located in the city of Manzanillo.

④ Broadcasting

Two broadcasting stations, XEGS and XEAL, operate in the city of Manzanillo with 1 kw of power. There is also one maritime radiocommunication station, XFM.

2-5-4 Other Facilities

(1) Educational facilities

To assist the student population, the city of Manzanillo has pre-school education, primary school, high school, technical high school, and the Superior School of Marine Sciences connected with the University of Colima.

Of all the educational institutions, only the University of Colima, the educative centers CET del Mar, and Technical High School No.4 give teaching concerning fishing.

(2) Medical services

The medical installations in the city of Manzanillo are as follows:

IMSS:	Zone Hospital and Family Medicine Unit
SSA:	Health Center "A", Civil Hospital and Sanitary Unit
ISSSTE:	General Hospital

SM:	Nursery No. 5 of the Pacific
Red Cross:	First Aid

Clinic services and private doctors.

(3) Public administration

The public administrative offices in Manzanillo are listed in Table III-14.

Table III-14 The Public Administrative Offices in Manzanillo

Public Administration	Number of Offices
Secretaría de Comunicaciones y Transportes	9
Secretaría de Marina	6
Secretaría de Agricultura y Recursos Hidráulicos	4
Secretaría de Hacienda y Crédito Público	3
Secretaría de Desarrollo Urbano y Ecologia	2
Secretaría de Gobernación	2
Secretaría de Salubridad y Asistencia	2
Secretaría de Pesca	1
Secretaría de Turismo	1
Secretaría de Educación Publica	1
Colima State	13
Total	44

3. Port Facilities

The existing port facilities in the port of Manzanillo are shown in Fig. III-38. Mooring facilities are located in both the outer and inner ports:

Outer port	This port is an old commercial port developed behind Chiquita del Viejo Cape.
Inner port	This port has been recently developed utilizing the San Pedrito Lagoon which is located to the northeast of the outer port. Most of the port construction investment after 1970 were used to develop this port.

The inner port can be divided into the commercial port and fishery port.

3-1 Commercial Port

3-1-1 Commercial Port Facilities

Mooring facilities are generally classified by water depth into two categories. One is for large ships with a water depth of 4.5 m or more (hereinafter referred to as "large facilities"), and the other is for small ships with a water depth of less than 4.5 m (hereinafter referred to as "small facilities").

Table III-15 and III-16 show the dimensions of large and small facilities in the port of Manzanillo.

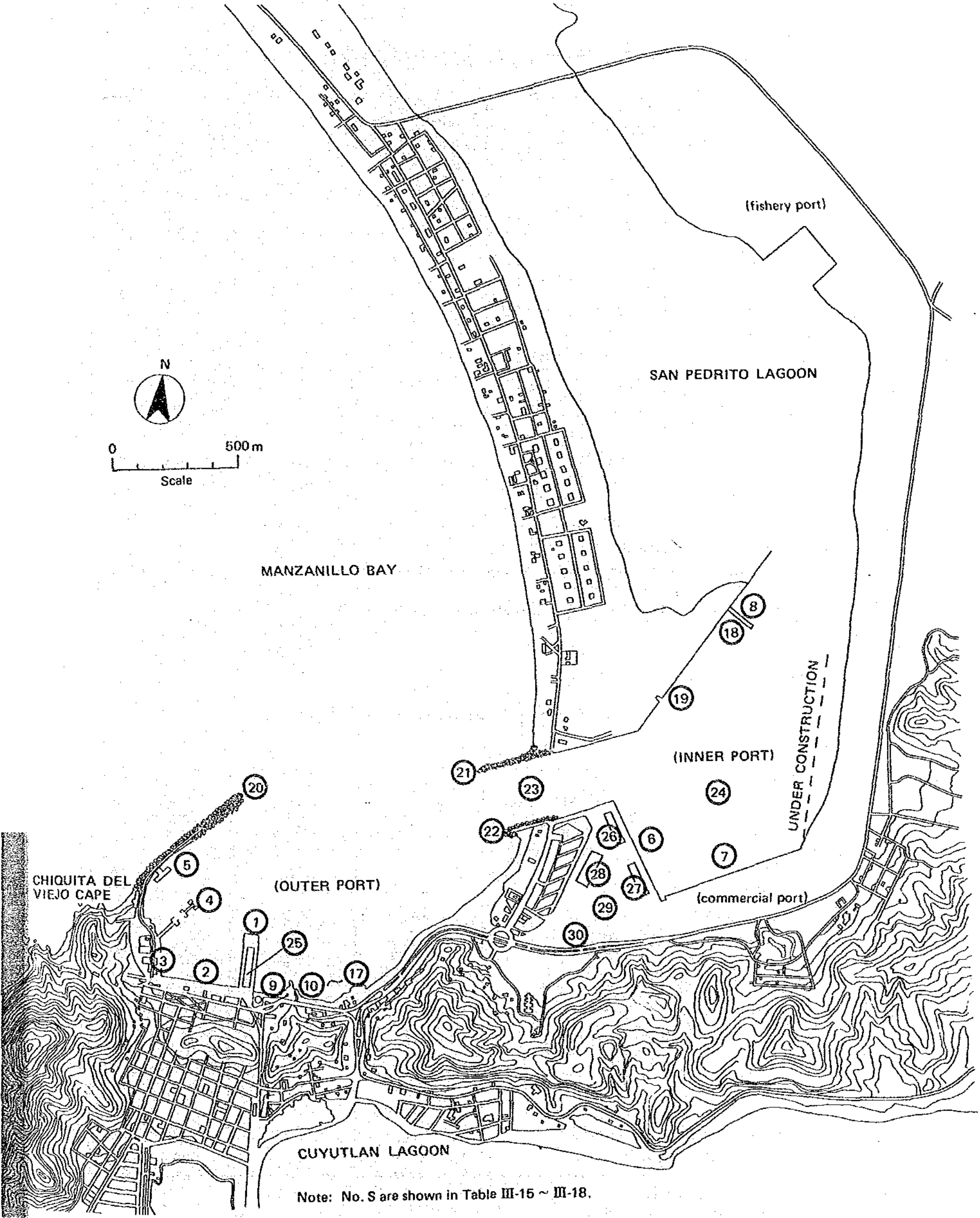
As for large facilities, there are 10 public berths and 3 private berths excluding the naval facilities, and the total length of these berths is about 2,200 m.

Among the public berths, "Muelle Fiscal" in the outer port has been used for more than thirty years, since 1952. As a result, this wharf has become obsolete. All of the private berths are oil berths of PEMEX, and these are located in the outer port. Most of small facilities are located in the outer port, and the total length of these berths is about 270 m.

In addition, a new large berth (location is underlined in Fig. III-38) is under construction in the inner port, and is planned to have a depth of 12 m.

Table III-17 shows the dimensions of the breakwater, channel and turning basin. The capacity of main storage facilities in the commercial port are shown in Table III-18.

Principal cargo handling machines used in the public berths are listed in Table III-19.



Note: No. S are shown in Table III-15 ~ III-18.

Fig. III-38 Existing Port Facilities in the Port of Manzanillo

Table III-15 Mooring Facilities (Large Facilities)

No.	Name of Facility	Length of Berth (m)	Water Depth of Berths (m)	Number of Berths	Structural Type	Year Constructed	Public or Private
	(Outer Port)						
①	Muelle Fiscal	512	11.4	3	Open-type Wharf	1946~1952	Public
②	Malecón Miguel Alemán				Concrete Block	1952	
	(Muelle de la Armada)	(100)	5.0~7.0	–			–
	(Muelle de Cabotaje)	110	5.0~7.0	1			Public
③	Malecón de la X Zona Naval	(159)	5.0~7.0	–	–	–	–
④	Muelle de PEMEX	440	13.4	2	Dolphin	1965	Private
⑤	Muelle de PEMEX	100	14.0	1	Sea Berth	1982	Private
	(Inner Port)						
⑥	Muelle de Altura	450	11.4	3	Open-type Wharf	1967~1969	Public
⑦	Muelle de Altura	600	12.0*	3	〃	1983	Public
⑧	Muelle de la Armada	(260)	5.0~7.0*	–	–	–	–

Note: 1) – indicates no available data.
2) *: According to local office of department of marine works, SCT.
Source: 1) DGOM, Catastro Portuario 1982"
2) DGODP, "Sistema Estadístico Operacional Indicadores de Rendimiento 1983"

Table III-16 Mooring Facilities (Small Facilities)

No.	Name of Facility	Length of Berths (m)	Water Depth of Berths (m)	Year Constructed
	(Outer Port)			
⑨	Atracadero de Turismo	2.5	–	1940
⑩	Muelle de Pilotía	1.85	4.0	–
⑪	Atracadero para lanchas Turísticas	1.2	4.0	–
⑫	Muelle de la Fábrica de Hielo	41.5	2.5	–
⑬	Muelle Sr. Vázquez Arroyo	1.5	2.5	–
⑭	Muelle de los Astilleros de Jaramillo y Rosas	1.5	2.5	1970 approx.
⑮	Muelle Cooperativa Independencia	5.8	2.5	〃
⑯	Muello Cooperativa Mazatlán	4.55	2.5	〃
⑰	Muelle de la Unión de Lancheros	40.0	2.5	–
	(Inner Port)			
⑱	Muelle para Lanchas de la Armada	7.4	2.5	1979
⑲	Muelle del Club Náutico	168.8	2.5	1970 approx.

Note: – indicates no available data.
Source: DGOM, "Catastro Portuario 1982"

Table III-17 Other Port Facilities (Breakwater, Channel and Turning Basin)

No.	Name of Facility	Length (m)	Width (m)	Depth (m)	Crown Height (m)	Area (ha)	Year Constructed
⑳	Breakwater	700	7 (crown)	–	3.0	–	1960
㉑	North Breakwater	300	7 (crown)	–	3.0	–	1964 ~ 1965
㉒	South Breakwater	100	7 (crown)	–	3.0	–	1964 ~ 1965
㉓	Access Channel	600	100 (bottom)	14	–	–	–
㉔	Turning Basin	–	–	12	–	18	–

Note: – indicates no available data.
Source: DGOM, "Catastro Portuario 1982"

Table III-18 Capacity of Main Storage Facilities

No.	Name of Facility	Total Area (m^2)	Net Space (m^2)
	Warehouse and Transit Shed		
㉕	Outer Port 1.	4,995	2,820
㉖	Inner Port 1.	3,708	2,004
㉗	2.	3,381	1,999
㉘	3.	6,412	3,488
	Yard		
㉙	Stock Yard	35,307	24,715
㉚	Container Yard	63,587	44,511

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

Table III-19 Principal Cargo Handling Machines

Machine	Number	Capacity
Forklifts	59	2 ~ 7.5 t
Forklifts (large size)	3	15 t
Mobile Cranes	6	10 ~ 20 t
Mobile Crane (large size)	1	70 t
Shovel Loaders	15	1 ~ 2.5 t
Tractors	21	2 ~ 2.5 t
Tractors (large size)	4	15 ~ 20 t
Flat Chassis	87	1.5 ~ 6 t
	10	20' container
	7	40' container
Suction Unloaders	5	120 t/hr
Hoppers (for grain unloading)	6	30 t
Tug Boat	1	1,500 HP

Source: Servicios Portuarios de Manzanillo, S.A. de C.V.

3-1-2 Other Facilities

(1) Fuel supply facilities

The fuel supply facilities in the outer port operated by PEMEX supply fuel for ships. As the commercial functions will be moved to the inner port, "Servicios Poltuarios de Manzanillo" has a plan to supply fuel to ships in the inner port. As part of this plan, "Servicios Portuarios de Manzanillo" has completed, but has not yet begun operating, two tanks in the corner of the container yard as follows:

Fuel tank (Diesel)	10,000 bls (≒ 1,590 kℓ)
Fuel tank (Combustible)	10,000 bls (≒ 1,590 kℓ)

(2) Aids to navigation

In general, the navigation of vessels approaching Manzanillo Port is not particularly difficult. The coastline near Manzanillo Port has suitable geographic features, and there are no harmful obstacles in the approach area. Furthermore, harbor pilots board incoming vessels three-quarters of a mile off the breakwater.

The aids to navigation that are currently located in Manzanillo Port are shown in Table III-20 and Fig. III-39.

There are other light beacons at the PEMEX wharf ⑫, and at the wharf in the outer port ⑬, too.

Table III-20 Aids to Navigation

Aid	Color	*Location	*Symbol
Lighthouse	White	Punta Campos	–
Lighted Mark	White	①	
	Green	②	
	Red	③	
Lighted Buoy	Green	④, ⑥	 
	Red	⑤, ⑦	 
Buoy	Green	⑧	
Leading Light	White	⑩ (Front)	
		⑪ (Rear)	

Note: * The location of aids are shown by the symbol in Fig. III-39.
Source: DGOM, "Catastro Portuario 1982"

3-2 Fishery Port

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

Furthermore, about 17 ha of land reclamation have been completed in accordance with first stage plan as part of the new fishery port.

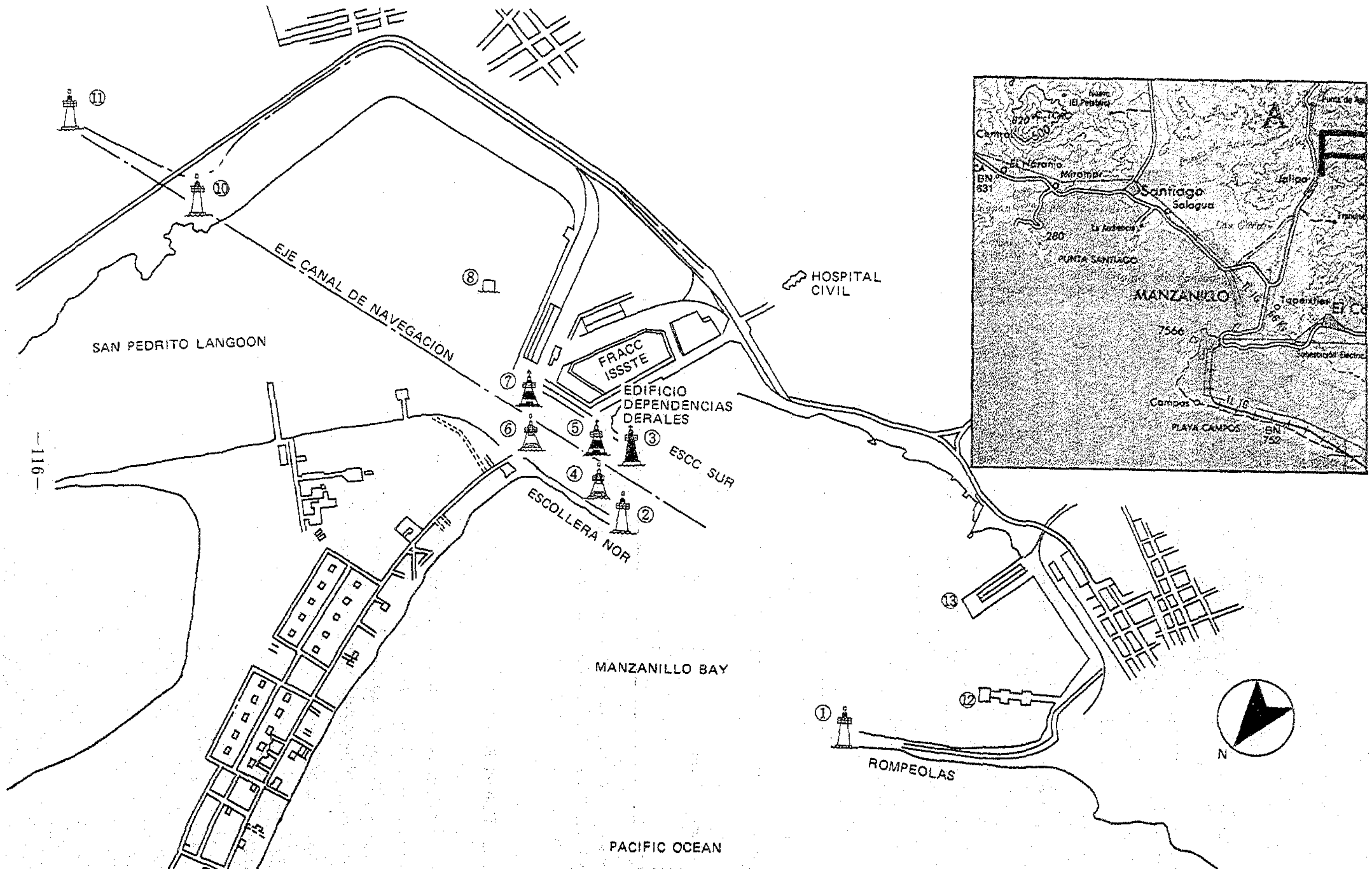


Fig. III-39 Aids to Navigation in Manzanillo Port

4. Cargo and Vessel Movement

4-1 Handling Volume and Commodities

4,025 thousand tons of cargo including 871 thousand tons of foreign trade were handled at the port of Manzanillo in 1983. Table III-21 and Fig. III-40 show the volume of cargo handled in the last eight years.

The total volume was increasing favorably until 1980, but dropped sharply in 1981, a 25% decrease from the previous year, due to a sharp decrease in domestic cargo. However, since 1981 cargo volume has grown rapidly at an average annual growth rate of 30%. The expansion is primarily due to the increase of petroleum cargo for domestic trade. The handling volume of foreign trade cargo has been decreasing since 1981.

The majority of petroleum and its derivatives cargo is handled at the facilities of PEMEX located in the outer port, and the other cargoes are handled at the public wharves.

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

Table III-21 Volume of Cargo Handled at Manzanillo Port

(Unit: '000 t)

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

Note: Figures in parentheses show the volume except for petroleum and its derivatives.
Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Carga y Buques"

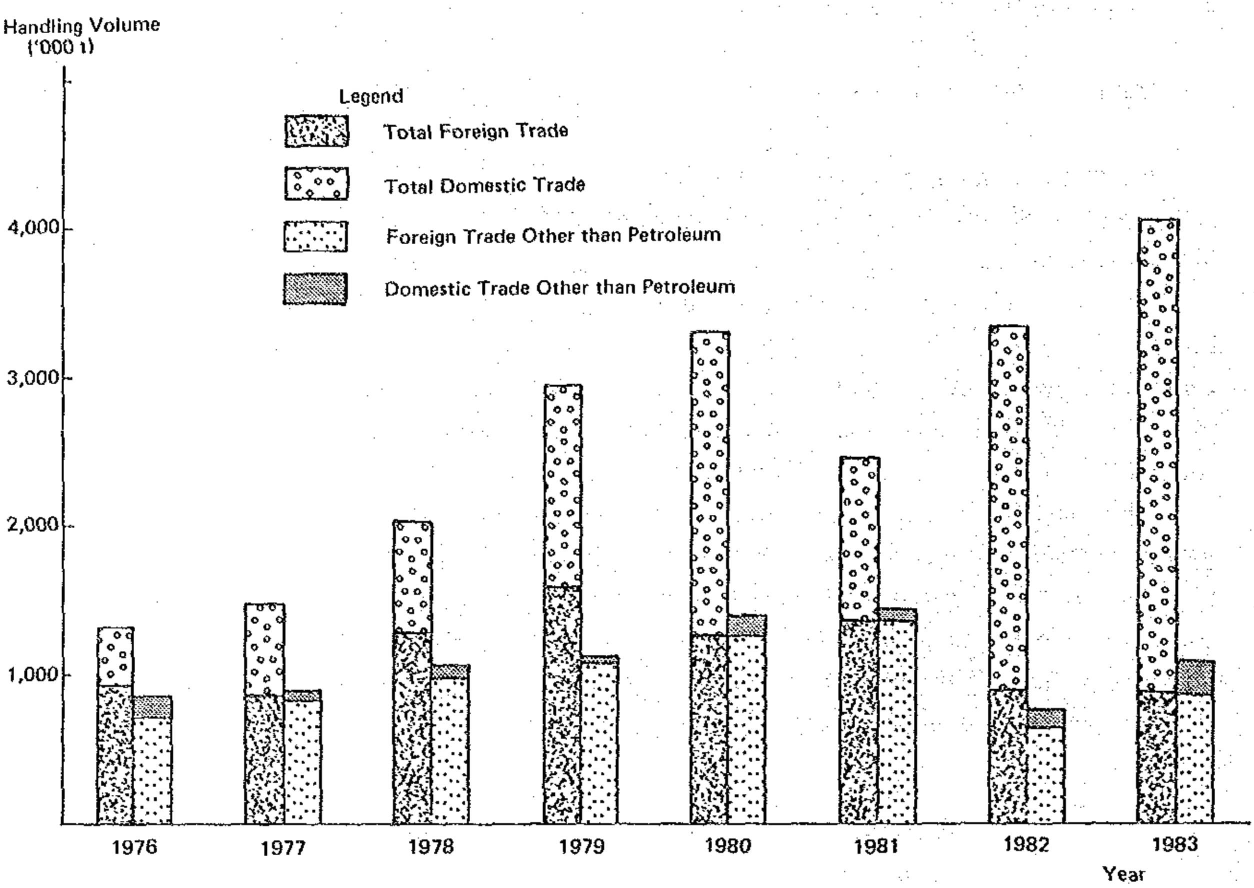


Fig. III-40 Cargo Handling Volume at Manzanillo Port

The volume of cargoes by major items are shown in Tables III-22 and III-23. As for foreign trade cargoes, imported agricultural bulk cargo takes a big share, 63% of total foreign trade volume, and imported general cargo accounts for 20% of total foreign trade. On the other hand, petroleum and its derivatives is the most important item for domestic trade, amounting to 92% of total domestic cargo volume.

The principal commodities of foreign trade cargo in 1983, as shown in Table III-24, include exports of metallic zinc, lead, ammonium sulfate and sodium sulfate and imports of maize, sorghum, sugar and steel plate.

Table III-22 Volume of Foreign Trade Cargo by Major Items

(Unit: '000 t)

Year	General Cargo		Agricultural Bulk		Mineral Bulk		Petroleum and Its Derivatives		Other Liquid		Perishables	
	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import	Export	Import
1976	61	306	–	211	5	148	–	111	34	7	–	–
1977	66	199	–	260	7	240	1	61	37	–	–	–
1978	97	212	–	476	11	116	–	304	64	–	–	–
1979	97	204	–	508	–	201	–	504	61	1	–	–
1980	100	404	–	731	–	104	–	–	10	1	–	–
1981	75	405	–	731	–	123	–	1	13	–	–	–
1982	40	269	–	190	–	106	–	260	22	6	–	–
1983	76	179	–	553	–	42	–	17	–	4	1	–

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

Table III-23 Volume of Domestic Trade Cargo by Major Items

(Unit: '000 t)

Year	General Cargo		Agricultural Bulk		Mineral Bulk		Petroleum and Its Derivatives		Other Liquid		Perishables	
	Out	In	Out	In	Out	In	Out	In	Out	In	Out	In
1976	–	59	–	20	2	–	136	202	–	–	–	–
1977	–	67	–	–	–	4	233	279	–	–	–	–
1978	–	72	–	7	–	–	299	354	–	–	–	–
1979	–	49	–	–	–	–	549	751	–	–	–	–
1980	23	43	–	–	–	73	490	1,303	–	–	–	–
1981	40	16	–	–	–	22	124	874	–	–	–	–
1982	23	20	–	–	–	81	484	1,813	–	–	–	–
1983	43	1	–	–	–	192	553	2,368	–	–	–	–

Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Cargo y Beques"

Table III-24 Principal Commodites for Foreign Trade (1983)

(Unit: t)

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

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

At Manzanillo Port, container cargoes are handled by a 70 t capacity mobil crane and/or by ship derricks. Table III-25 shows the volume of container cargoes in the last five years.

Table III-25 Container Cargo at Manzanillo Port

(Unit: t, %, TEU)

Year	Cargo Volume			Percent of General Cargo			Total Number of Containers
	Export	Import	Total	Export	Import	Total	
1979	7,091	1,329	8,420	7.3	0.7	2.8	964
1980	19,280	23,758	43,038	19.2	5.9	8.5	4,834
1981	22,282	36,806	59,088	25.6	9.1	12.3	6,785
1982	7,788	6,564	14,352	19.6	2.4	4.6	1,538
1983	21,580	1,307	22,887	28.5	0.7	9.0	1,650

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

The total volume of container cargoes reached about 59 thousand tons in 1981. The volume of container cargoes dropped in 1982 because the navigation company which had operated a container ship service between the west coast of U.S.A. and Manzanillo Port changed its port of call to Lázaro Cárdenas in 1982. Nevertheless, the volume of container cargoes recovered somewhat in 1983, reaching about 23 thousand tons, or 9% of general cargo.

The principal commodities of containerized cargo are auto parts, electric articles, machinery parts and chemical industrial products.

4-2 Trading Counterparts and Vessel Movement

Table III-26 shows the major foreign trading counterparts for the port of Manzanillo. The principal destinations are Japan, the other Asian countries, and South and Central America. On the other hand, over 70% of the imported cargo comes from U.S.A.

Table III-26 Export and Import by Nation (1983)

(Unit: t)

Export			Import		
Nation	Tonnage	%	Nation	Tonnage	%
Japan	24,154	31.53	U.S.A.	566,021	71.21
China	11,464	14.96	Japan	55,144	6.94
Colombia	10,186	13.30	Korea	38,357	4.83
Thailand	9,039	11.80	France	32,725	4.12
Costa Rica	4,727	6.17	Canada	24,197	3.04
Korea	4,065	5.32	Philippines	23,353	2.94
Chile	2,572	3.36	Spain	21,474	2.70

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

Table III-27 shows the number of vessels calling at Manzanillo Port. 175 ocean going vessels and 226 vessels for domestic trade called in 1983.

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

The port of Manzanillo is the most important liner port on the Pacific coast of Mexico. At present 13 navigation companies use Manzanillo Port as a calling port for their liner services connecting with Japan, the Far East, Central and South America, the Caribbean Sea, and the west coast of U.S.A.

Table III-27 Number of Vessels

Type of Vessel	General Cargo			Agricultural Bulk			Mineral Bulk			Oil Tankers			Other Liquid			Total		
Year	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total	Foreign	Domestic	Total
1979	205	23	228	27	–	27	12	–	12	23	117	140	6	–	6	273	140	413
1980	212	48	260	38	–	38	7	9	16	–	171	171	2	–	2	259	228	487
1981	189	35	224	37	–	37	9	2	11	1	154	155	1	–	1	237	191	428
1982	146	22	168	10	–	10	5	6	11	14	187	201	3	–	3	178	215	393
1983	144	16	160	27	–	27	2	11	13	1	199	200	1	–	1	175	226	401

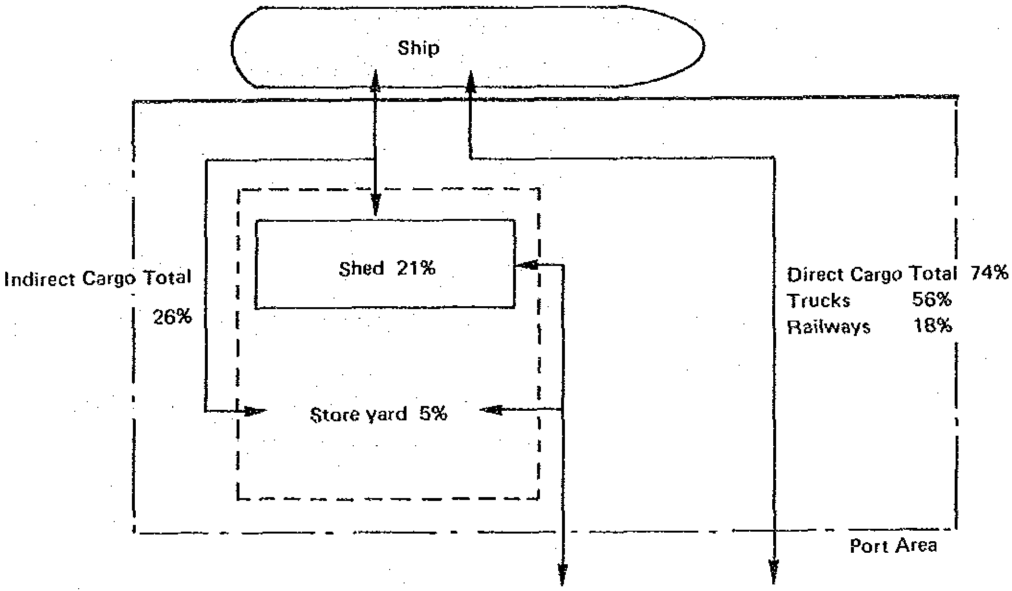
Source: DGODP, "Estadísticas del Movimiento Portuario Nacional de Carga y Buques"

4-3 Cargo Flow in the Port Area

The modal split of cargo traffic at the public wharves of Manzanillo Port is shown in Fig. III-41. As shown in this figure, 74% of total discharging/loading cargo is moved to and from ship side directly by trucks and railways and the rest passes through store yards or sheds.

The majority of agricultural bulk cargoes are loaded and unloaded at ship side by trucks.

As for inland transportation to and from the port of Manzanillo, 80% of the imported cargo is transported by truck and 20% by railway, and for exported cargo 45% is transported by truck and 55% by railway.



Note: Average 1981 and 1982
Source: DGODP

Fig. III-41 Modal Split of Cargo Traffic

5. Administration and Operation

5-1 Administration

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

① Comisión Nacional Coordinadora de Puertos, SCT: coordinates the port development plan in line with the national policy, and takes responsibility for control of "Servicios Portuarios".

② Dirección General de Obras Maritimas, SCT: designs, constructs and maintains dredging work and the port facilities such as breakwaters, quaywalls, transit sheds, and warehouses except movable handling machines. These port facilities are constructed with governmental funds and are owned by the government.

③ Dirección General de Operación y Desarrollo Portuario, SCT: supervises port operations and takes responsibility for keeping port statistics.

④ Servicios Portuarios de Manzanillo, S.A. de C.V.: is a special corporation mostly financed by governmental funds and under a quite general overall supervision by CNCP.

"Servicios Portuarios" provides major port services and operates cargo handling using the stevedoring union by contract, and also takes responsibility for small repairs and maintenance work of port facilities.

Fig. III-42 shows an organizational chart of "Servicios Portuarios de Manzanillo, S.A. de C.V.", and Table III-28 shows the principal port services provided at Manzanillo Port.

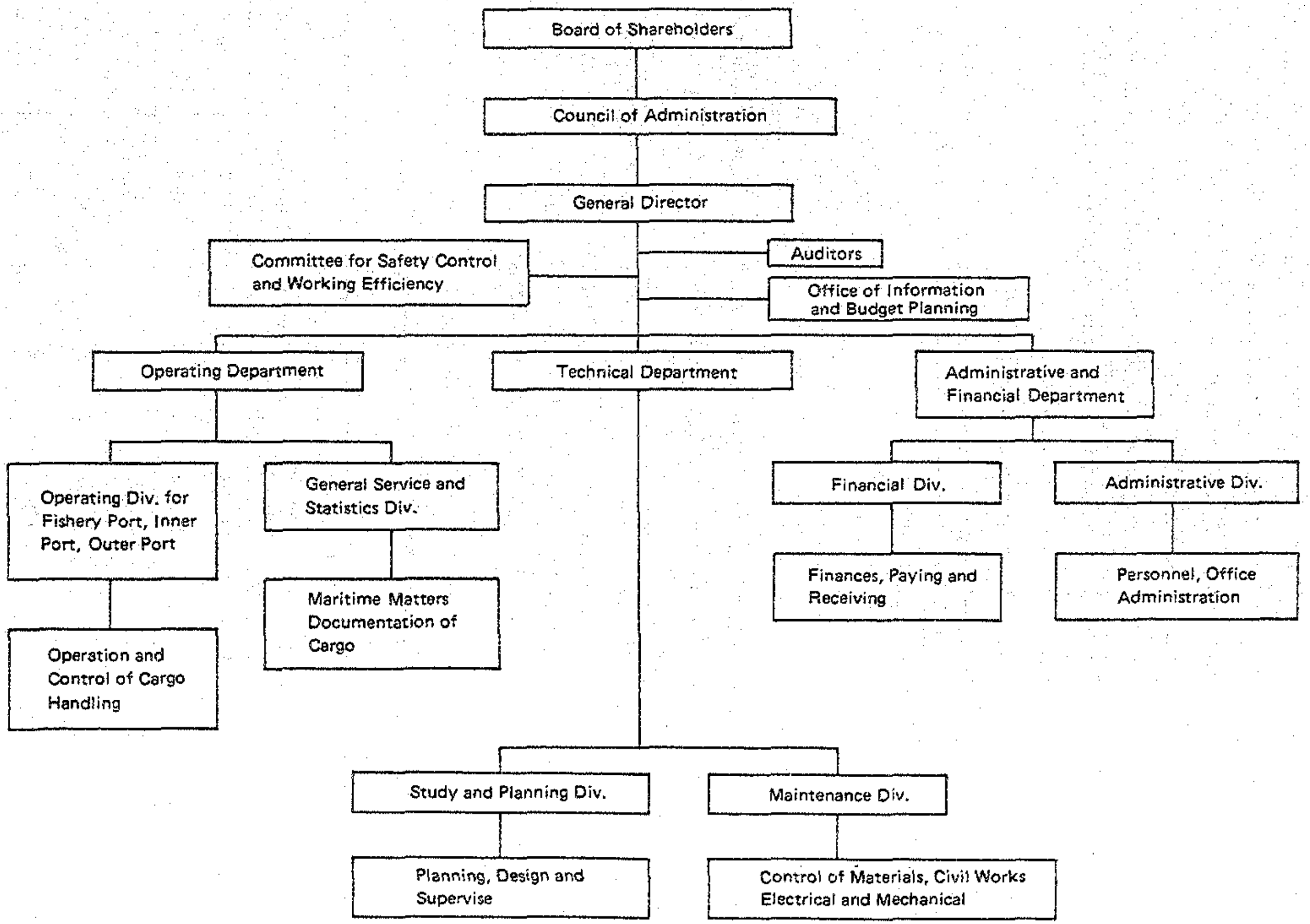


Fig. III-42 Organizational Chart of "Servicios Portuarios de Manzanillo, S.A. de C.V."

Table III-28 Principal Port Services Provided at Manzanillo

Type of Service	Concession Holder
Pilotage	Sindicato Nacional de Pilots de Puerto
Lighterage	Sindicato de Lancheros del Puerto de Manzanillo
Wharfage	Servicios Portuarios de Manzanillo
Towage	Servicios Portuarios de Manzanillo
Bunkering	PEMEX; this concession will be given to Servicios Portuarios in a few years
Water Supply	Servicios Portuarios de Manzanillo; Agua y Alcantarillado de Manzanillo
Fumigation	Servicios Portuarios de Manzanillo
Cargo Handling	Servicios Portuarios de Manzanillo
Storage	Servicios Portuarios de Manzanillo

Source: DGODP Superintendent

5-2 Operation

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

About 360 regular longshoremen are working in the port of Manzanillo. Handling of general cargo is operated by two gangs, with an average of 10 longshoremen in each gang using ship cranes and/or cargo handling equipment which is provided by "Servicios Portuarios".

Table III-29 shows the average working efficiency by type of cargo in 1983.

Table III-29 Working Efficiency by Type of Cargo (1983)

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

Note: These figures indicate the working efficiency during actual operational time.
Source: DGODP, "Sistema Estadístico Operacional Indicadores de Rendimiento 1983"

5-3 Port Dues

As for port investment, the basic port facilities such as civil structures, storage facilities and cranes installed on quaywalls are constructed by the federal government. Cargo handling equipment, the tug boat and other movable machines are provided by "Servicios Portuarios".

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

To reform tariffs of port charges, it is necessary to obtain the permission of the federal government, Dirección General de Tarifas, SCT.

The main port dues/charges in effect at Manzanillo Port are summarized in Table III-30.

Table III-30 Main Port Dues/Charges

Kinds	Application
① Port Dues	Tariff x tonnage (G/T) of ship
② Charge for Use of Quaywall	Tariff x hours x occupied length of quaywall by ship
③ Charge for Use of Wharf	Tariff x cargo ton
④ Charge for Use of Storage Facilities	Tariff x day x cargo ton
⑤ Concession Charge	Tariff x number of installations Tariff x land value
⑥ Towage	Tariff per ship
⑦ Mooring Charge	Tariff per ship
⑧ Fumigation	Tariff x m^3
⑨ Water Supply	Tariff x m^3
⑩ Cargo Handling Charge	Tariff x cargo ton or unit

Note: Dues/Charges No. ① ~ ⑤ are paid to the federal government.