2-3-3 Conditions of Utilization at Each Wharf

Utilization of wharves, by type, is analyzed below. The figures presented below are 1981 real values, unless otherwise specified.

(1) General cargo quays

Table 2-8 and Fig. 2-4(1) are based on conditions of utilization at each berth. According to this table and figure, the average number of ships moored annually at each berth is about 80, the average size ship is 10,100 DWT, the average volume of cargoes handled per ship is about 2,000 tons, and the average mooring time per ship is 90 hours. All of the general cargo quays, except for 9D and 9E, are 180 ~ 200 m long, and their present water depth is −10.5 m. In general, a quay used by 15,000 DWT ships is capable of handling a total of 200,000 tons of general cargoes per year (1,000 t/year for every meter of quay length).

A comparison of this standard capacity with the operation results from each quay shows that the standard is exceeded at 4B, 5B and 9B. This is because these berths handle cargoes such as container cargoes, automobiles, etc. for which there is high cargo handling efficiency. 1A, 1B and 3B also handle a relatively large cargo volume. Conversely, other quays at Callao Port handle cargo volumes smaller than their standard capacities This is due presumably to narrow aprons (2A – 2B), inconveniently located transit sheds and open storage yards (3A – 3B, 4A and 9A – 9C) and insufficient water depth (9D – 9E). These suspected deficiencies can be partially remedied, though not eliminated, by temporary make – shift measures. It seems, therefore, that to increase the volume of general cargoes handled at the existing facilities is hardly possible unless a redevelopment project is carried out.

Fig. 2-5 shows the distribution of numbers of ships according to length of time from entry to berthing. Fig 2-6 shows the distribution of numbers of ships according to mooring time. Fig. 2-7 shows the relation between the volume of cargoes handled per ship and mooring time. The number of ships requiring less than three hours from entry into the port until berthing represented 25% of the total. Whereas, the number of ships that took more than three hours represented 75%. It can be presumed from these values that waiting has already started in the case of general cargo ships. The mean value of mooring time in Fig. 1-6 is 90 hours. Since the per-ship volume of cargo handling is 2,000 tons on the average, the hourly volume of cargo handling is 44 tons. This value is for the average case where three gangs are used. Generally, the hourly volume of cargo handling at a modern port is said to be 15 ~ 20 tons. Compared with this, cargo handling efficiency at Callao Port is not necessarily adequate. This, as can be seen from Fig. 1-7, indicates that there is a great difference between individual ships in cargo handling efficiency and that cargo handling must be improved in some way.

(2) Mineral ore quays

As indicated in Table 2-8 and Fig. 2-4(2), the average number of ships annually moored per berth is about 110, the average ship size is about 10,700 DWT, the average volume of cargoes handled per ship is about 5,000 tons, and the average mooring time per ship is 69 hours.

The standard capacity of a mineral ore quay is considered to be 500,000 – 600,000 tons per year, assuming that no use is made of special cargo handling equipment. Berths 5C and 5D come close to meeting this standard capacity However, the cargo volume handled at 5E is smaller than expected, presumably due to the fact that the mineral yard behind the quay is small, and the fact that the quay is also partially used for the mooring of coast guard and other ships. It therefore seems that the capacity of these berths (5D, 5E and 5F) could in the future be increased if plans for more effective quay use are formulated and enacted, and if specialized mineral ore cargo handling equipment is installed.

(3) Petroleum quays

As indicated in Table 2-8 and Fig. 2-4(2), the average number of ships moored annually per berth is about 100, the average ship size is about 18,100 DWT, the average volume of cargoes handled per ship is about 8,900 tons, and the average mooring time per ship is 32 hours.

(4) Grain quays

As indicated in Table 2-8, the average number of ships moored per berth is 50, the average ship size is 17,600 DWT, the average volume of cargoes handled per ship is about 7,400 tons and the average mooring time per ship is 106 hours. But as can be seen from Fig. 2-4(2), while the three berths, 11A ~ 11C, supposedly form a grain wharf in reality, only Berth 11A is mainly in use. This is because only 11A is outfitted with specialized cargo handling equipment for grain. As a result, 11A handles about 80% of the grain cargo.

Fig. 2-8 shows the time that ships using the grain quay take from entry until berthing. Fig. 2-9 shows the distribution of numbers of ships according to mooring time. Fig. 2-10 shows the relation between the volume of cargoes handled per ship and mooring time. This figure shows that the per-ship volume of cargo handling is divided into two groups. That these are all grain ships in unlikely because of the per-ship volume of cargo handling of some ships is too small. Thus, the indication is that general cargo ships with small volumes of cargo handling also use Berths 11B and 11C. Therefore, we further analyze the actual utilization of 11A Berth which is the grain berth. Fig. 2-11 shows the relationships between ships that are unloading and the next ships, which are waiting for berth availability.

Careful observation of this figure reveals that two grain ships are sometimes simultaneously moored at Berth 11A. This seems to show that either data were erroneously recorded or that instances where the first ships had been shifted to other berths were not distinguished or were otherwise mishandled. Yet, it reflects that most grain ships wait in the offing of Callao Port for the grain wharf to be evacuated by previously arrived ships – which means that a state of ship waiting prevails. Thus, it can be said that the grain wharf is already being use to the full extent of its capacity.

Table 2-8(1) Performance of Cargo Handling at Callao Port in 1981

①	②	③	④	⑤	⑥		⑦	⑧	⑨	⑩	⑪
Type	Berth	Quay Length (m)	Number of Calling Ships	Average Ship Size (DWT)	Volume of Cargoes Handled (t)	Composition Ratio (%)	⑥/④ Average Cargo Volume per ship (t)	⑥/③ Cargo volume per-Quay-Length (t/m)	Mooring Time (hours)	⑨/④ Average Mooring Time Per-Ship (hours)	= ⑨ /8760 Berth Occupancy Ratio (%)
General cargo berths	1A	183	81	10,800	145,120 (176,212)	7.8	2,175	963	7,294	90	83.1
	1B	183	88	11,800	147,909 (179,001)	8.0	2,034	978	7,756	88	88 4
	2A	183	110	8,500	99,659 (130,751)	5.8	1,189	714	7,793	71	88.8
	2B	183	77	9,600	68,870 (99,962)	4.4	1,298	546	6,194	80	70.6
	3A	183	85	10,200	121,996 (153,088)	6.8	1,801	837	6,347	75	72.3
	3B	183	79	9,600	136,594 (167,686)	7.5	2,123	916	7,597	96	86.6
	4A	183	76	11,700	99,351 (130,443)	5.8	1,716	713	6,625	87	75.5
	4B	183	110	11,200	225,175 (256,267)	11.4	2,330	1,400	8,950	81	102.0
	9A	180	65	8,700	62,805 (93,897)	4 2	1,445	522	6,394	98	72.9
	9B	180	70	11,800	186,498 (217,590)	9.7	3,108	1,209	8,326	119	94.9
	9C	180	67	9,000	95,951 (127,043)	5.7	1,896	706	5,610	84	63.9
	9D	180	34	1,500	29,214 (60,306)	2.6	1,774	335	6,075	253	69.2
	9E	90	17	2,100	3,065 (34,157)	1 5	2,009	380	1,490	88	17.0
	5A	185	75	12,300	157,145 (188,237)	8.4	2,510	1,017	7,201	76	82.1
	5B	185	85	11,500	202,267 (233,360)	10.4	2,745	1,261	7,072	83	80.6
	Total	2,644	1,119	10,100	1,781,619 (2,248,000)	100.0	2,009	850	100,724	90	76.5
Mineral ore berths	5C	183	125	12,700	413,285 (575,428)	40.8	4,603	3,144	6,741	54	76.8
	5D	185	106	11,900	484,301 (646,444)	45.8	6,099	2,618	6,704	63	76.4
	5E	185	52	3,300	26,986 (189,128)	13.4	3,637	1,022	6,208	119	70.7
	Total	553	283	10,700	924,572 (1,411,000)	100.0	4,986	2,552	19,653	69	74.7
Petroleum berth	7A	262	125	17,800	563,233 (983,188)	52.6	7,866	3,753	4,243	34	48.4
	7B	262	84	18,600	466,858 (886,812)	47.4	10,557	3,385	2,472	29	28.2
	Total	524	209	18,100	1,030,091 (1,870,000)	100.0	8,947	3,569	6,715	32	38.3
Grain berths	11A	180	60	26,300	807,463 (852,333)	77.4	14,206	4,735	6,422	107	73.2
	11B	80	17	11,000	25,193 (70,063)	6.4	4,121	876	2,464	145	28.1
	11C	180	72	12,000	133,734 (178,604)	16.2	2,481	992	6,942	96	79.1
	Total	440	149	17,600	986,390 (1,101,000)	100.0	7,389	2,502	15,828	106	60.1
Grand total		4,161	1,760		4,702,672 (6,630,000)						

Note: 1. This table was made based on ENAPU's data concerning the daily use of Callao Port.
This table will be used for appraisal of the present conditions and future planning.
2 Suppositions for preparing Table 2-8(1) are shown in Table 2-8(2)

Table 2-8(2) Preconditions for Preparing Table 2-8(1)

No.	Item	Description
③	Quay length	Measured using Figure Plano General (scale 1:1,000, prepared in June 1982)
④	Number of calling ships	Counted at the quays where the ships were first berthed.
⑤	Average ships size (DWT)	According to Lloyd's Register of Shipping (1981 – 82). Mean values do not include the size of ships whose names, etc. cannot be confirmed.
⑥	Volume of cargoes handled	1) Supposing that all cargoes were handled at quays where the ships were first berthed. 2) Handled cargoes were assumed to be cargoes inherent to the berths. 3) There are differences in the total of ENAPU data for fee collection and ENAPU data added separately by ships. So, double level writing is used with partial corrections. 4) The figure at the top level shows the volume of cargo handling by berth from the data added separately by ships. 5) The figure in ( ) at the bottom level is what is obtained by dividing the difference between both data by the number of berths and adding this value to the separately added value, 4). 6) The composition ratio is based on the parenthesized volume of cargoes.
⑦	Average cargo volume per ship	Based on the parenthesized cargo volume.
⑨	Mooring time	1) Time from the ship's berthing till its leaving. 2) Total mooring time was counted at the berths that were first used even if ships later shifted over.
⑪	Berth occupancy ratio	8,760 hours are 365 days x 24 hours.

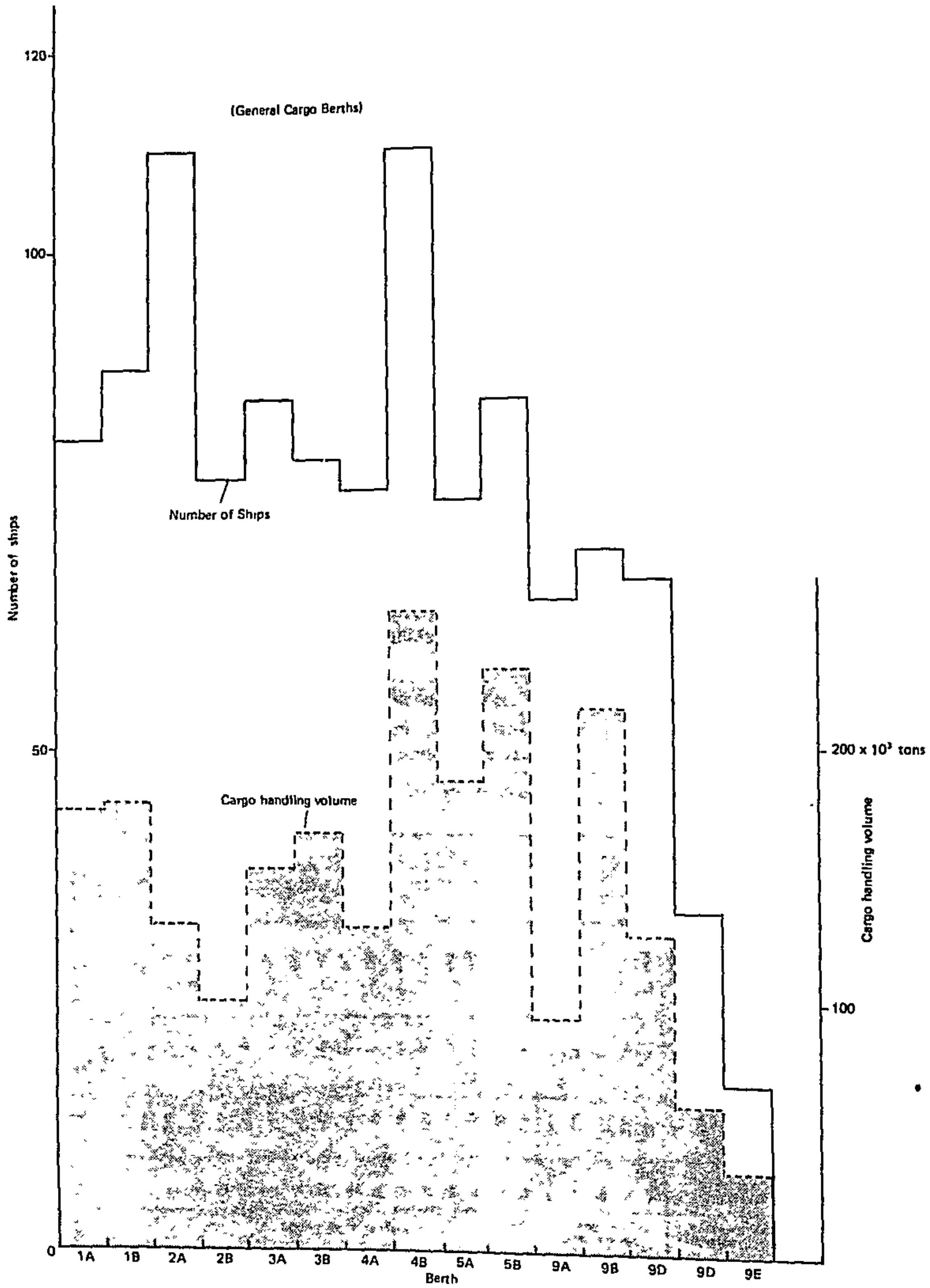


Fig. 2-4 (1) Operating Conditions at Berths (1981)

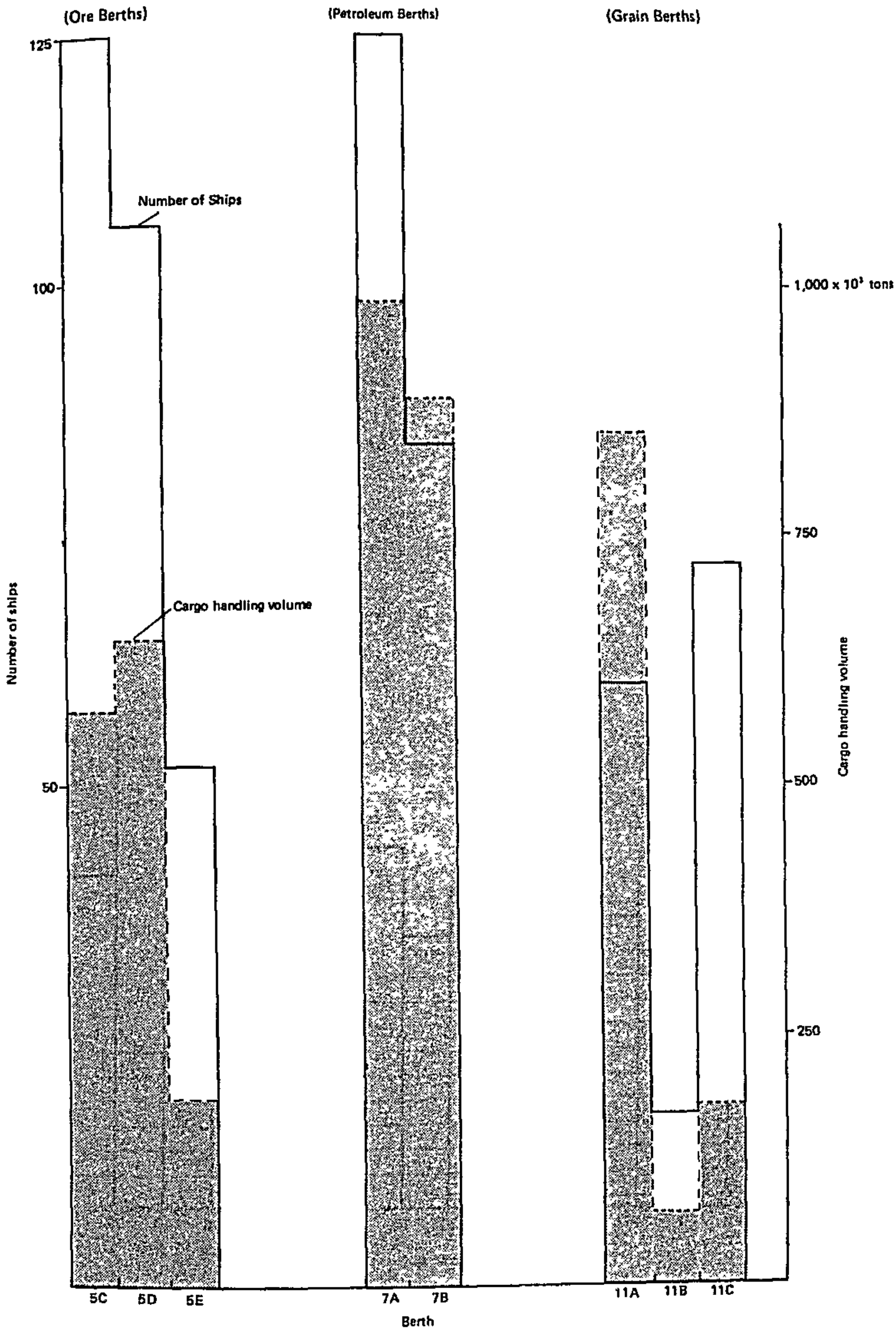


Fig. 2-4 (2) Operating Conditions at Berths

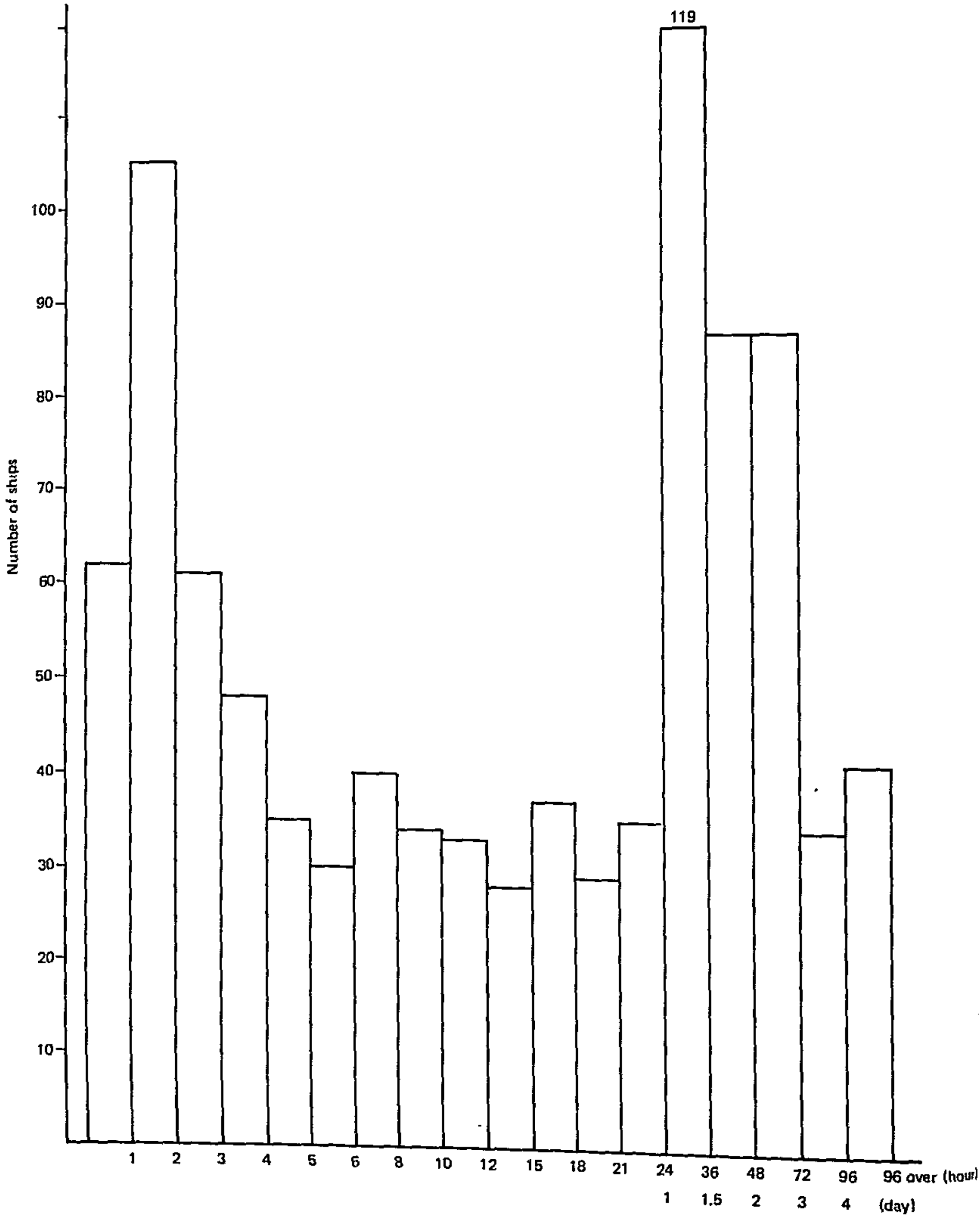


Fig. 2-5 Elapsed Time between Ship's Arrival and Berthing
(general cargo vessel, 1981)

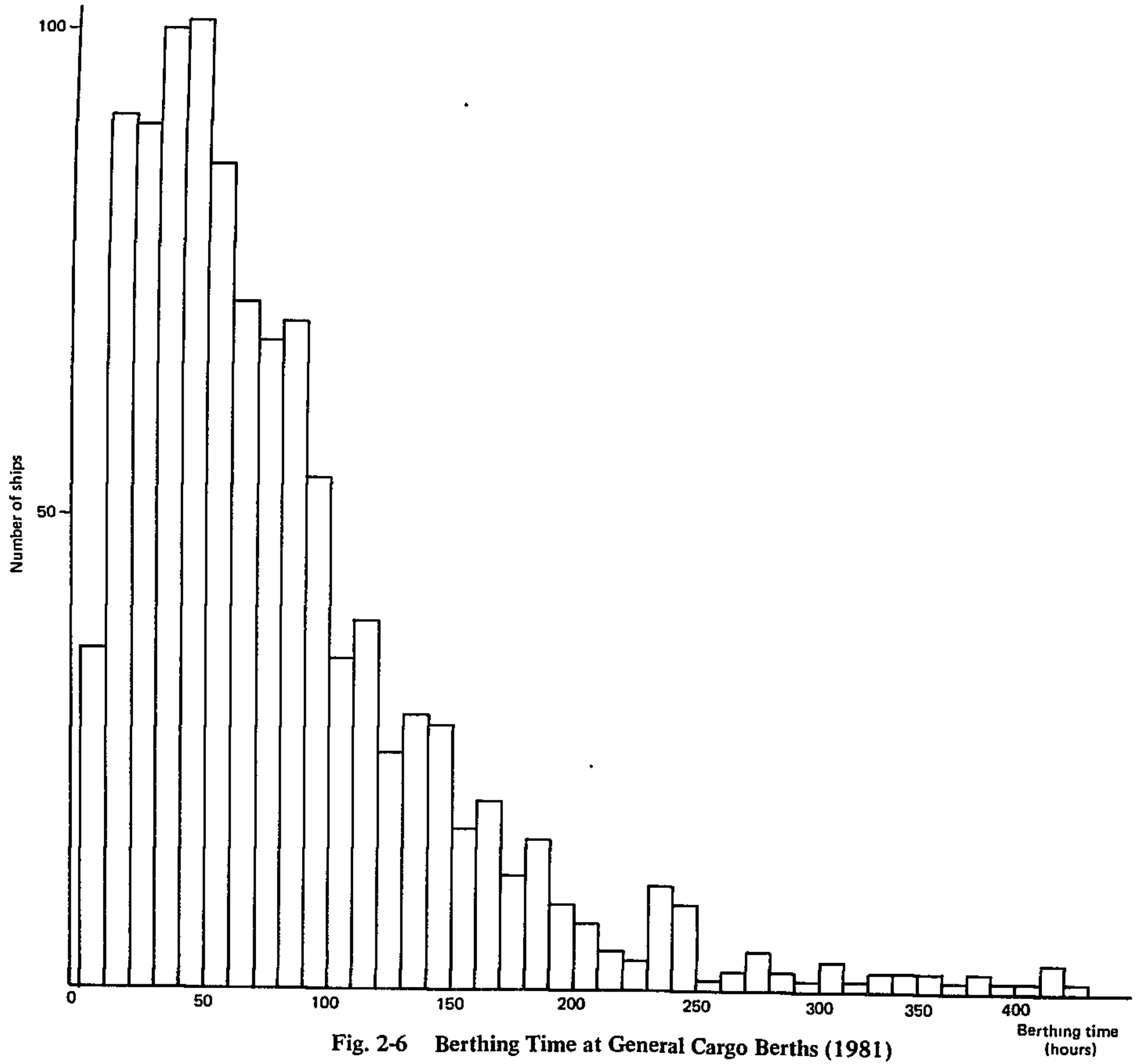


Fig. 2-6 Berthing Time at General Cargo Berths (1981)

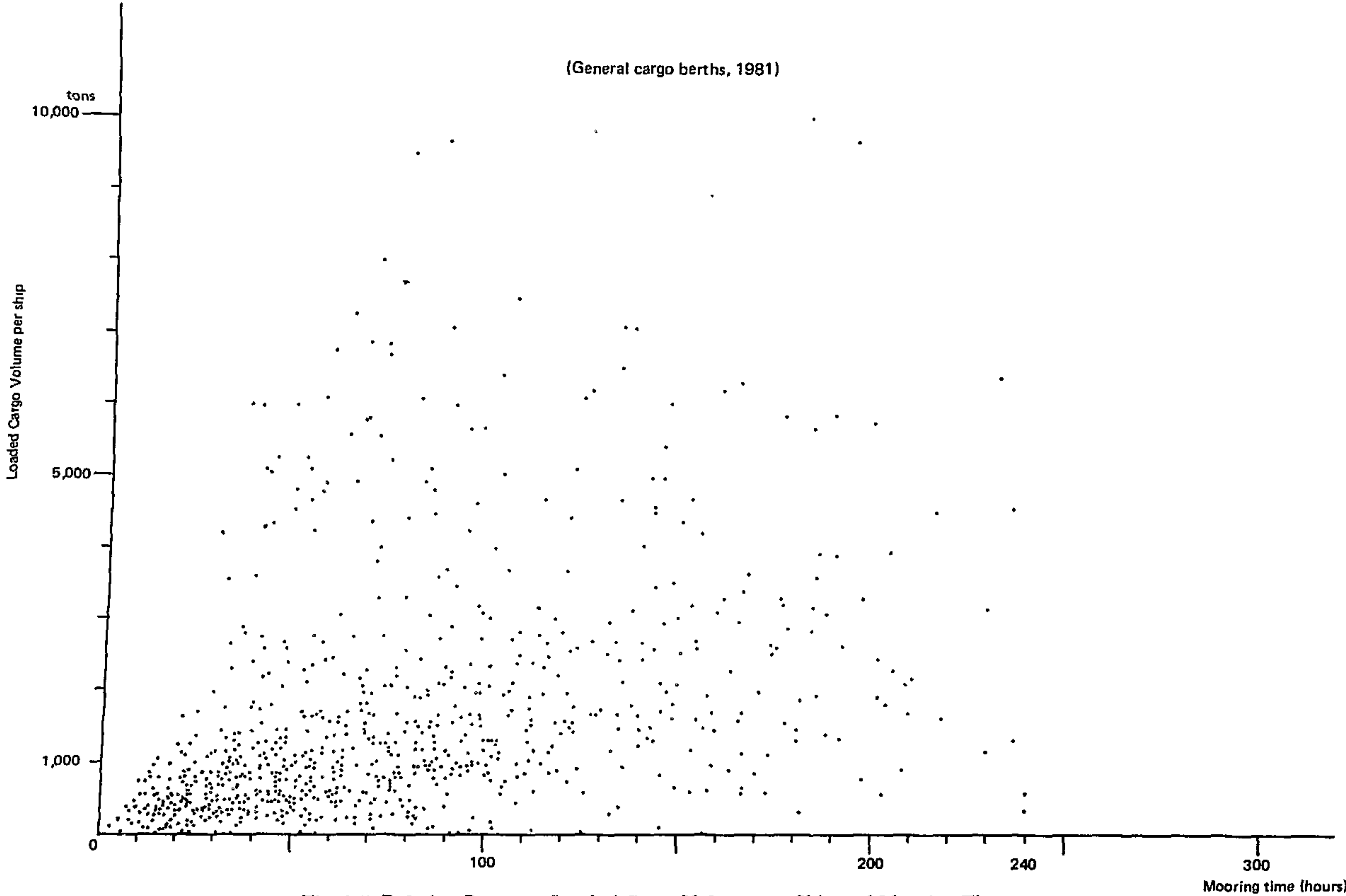


Fig. 2-7 Relation Between Loaded Cargo Volume per Ship and Mooring Time

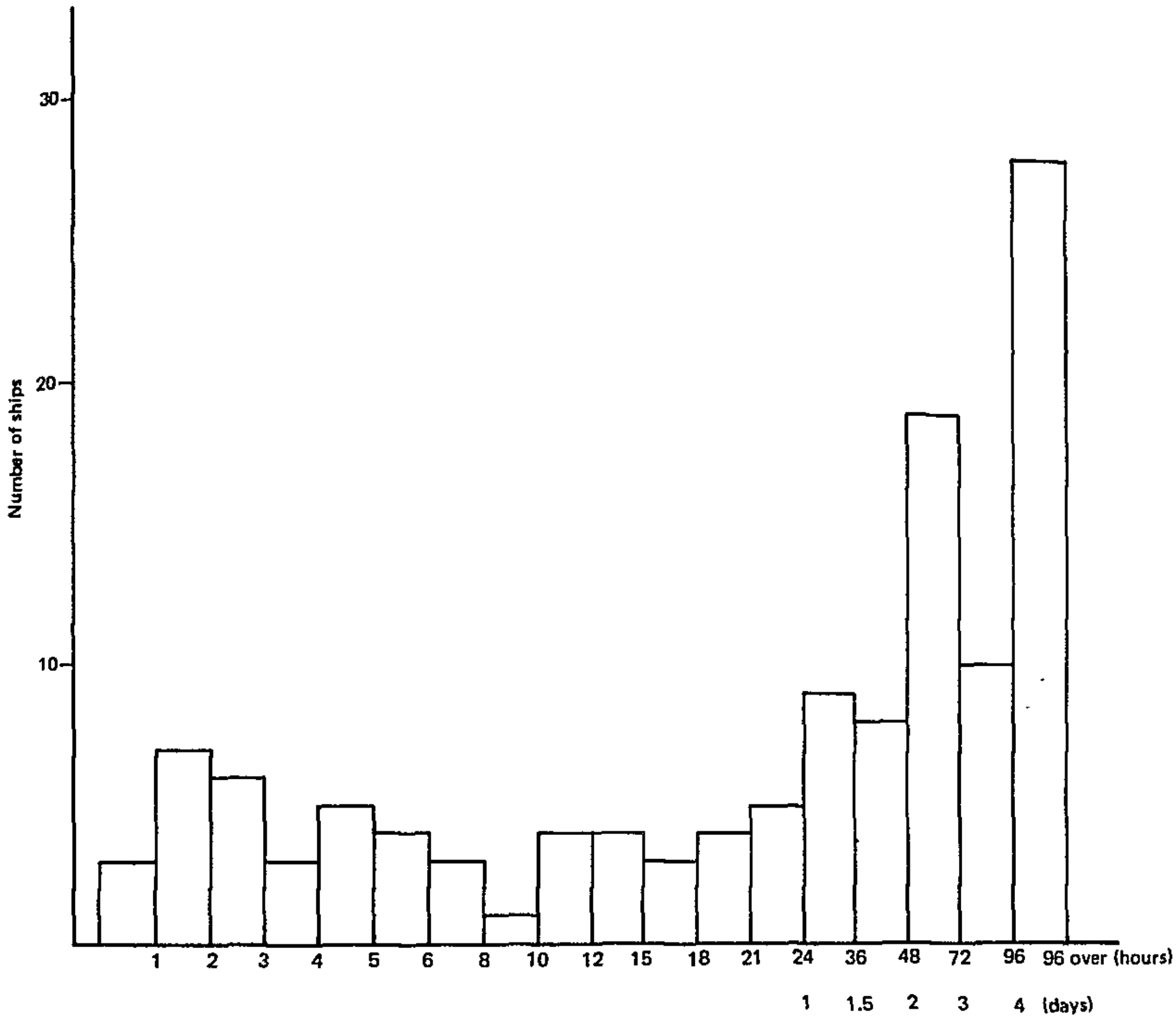


Fig. 2-8 Elapsed Time between Ship's Arrival and Berthing (grain ship, 1981)

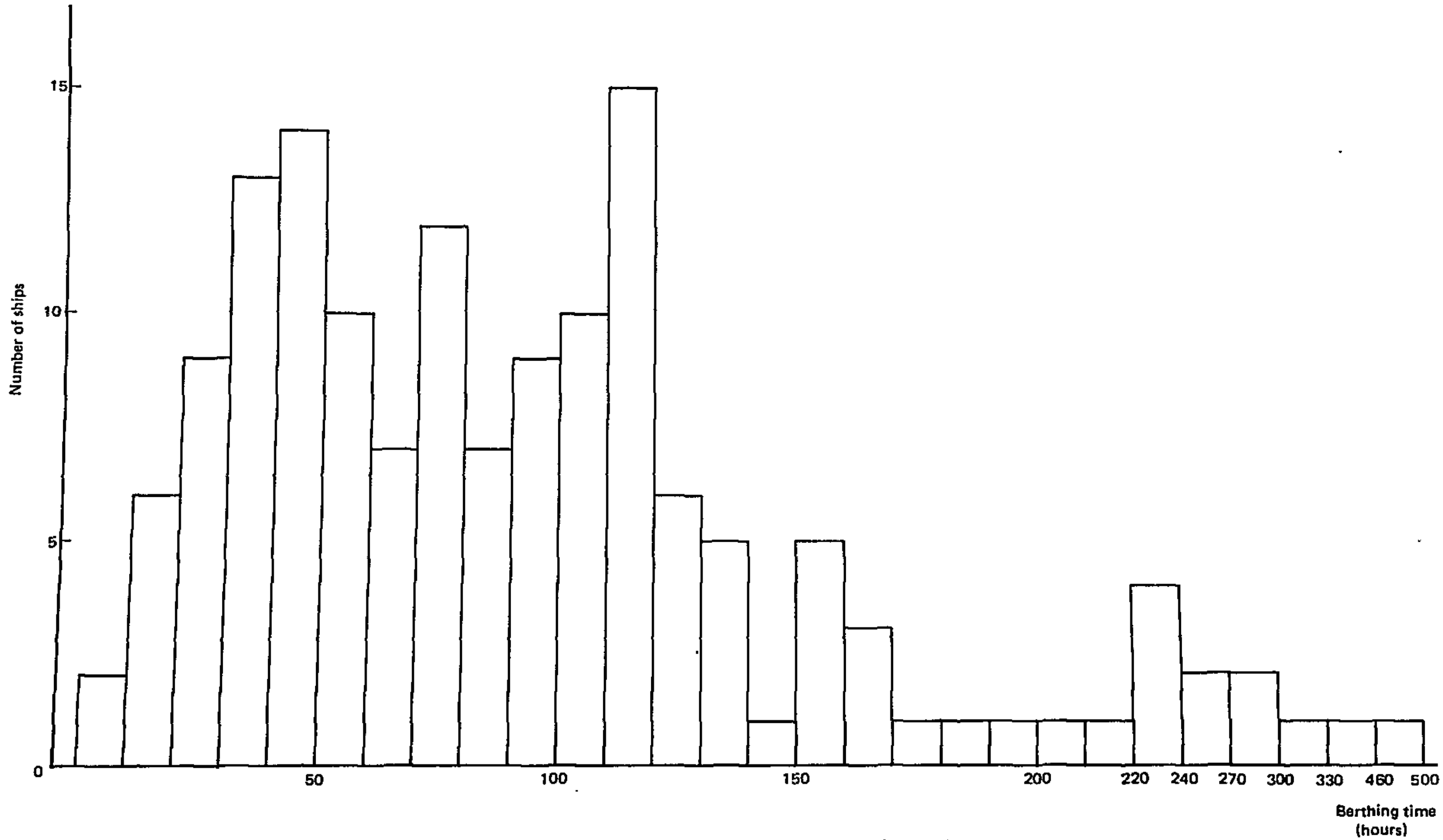


Fig. 2-9 Berthing Time at Grain Berths (1981)

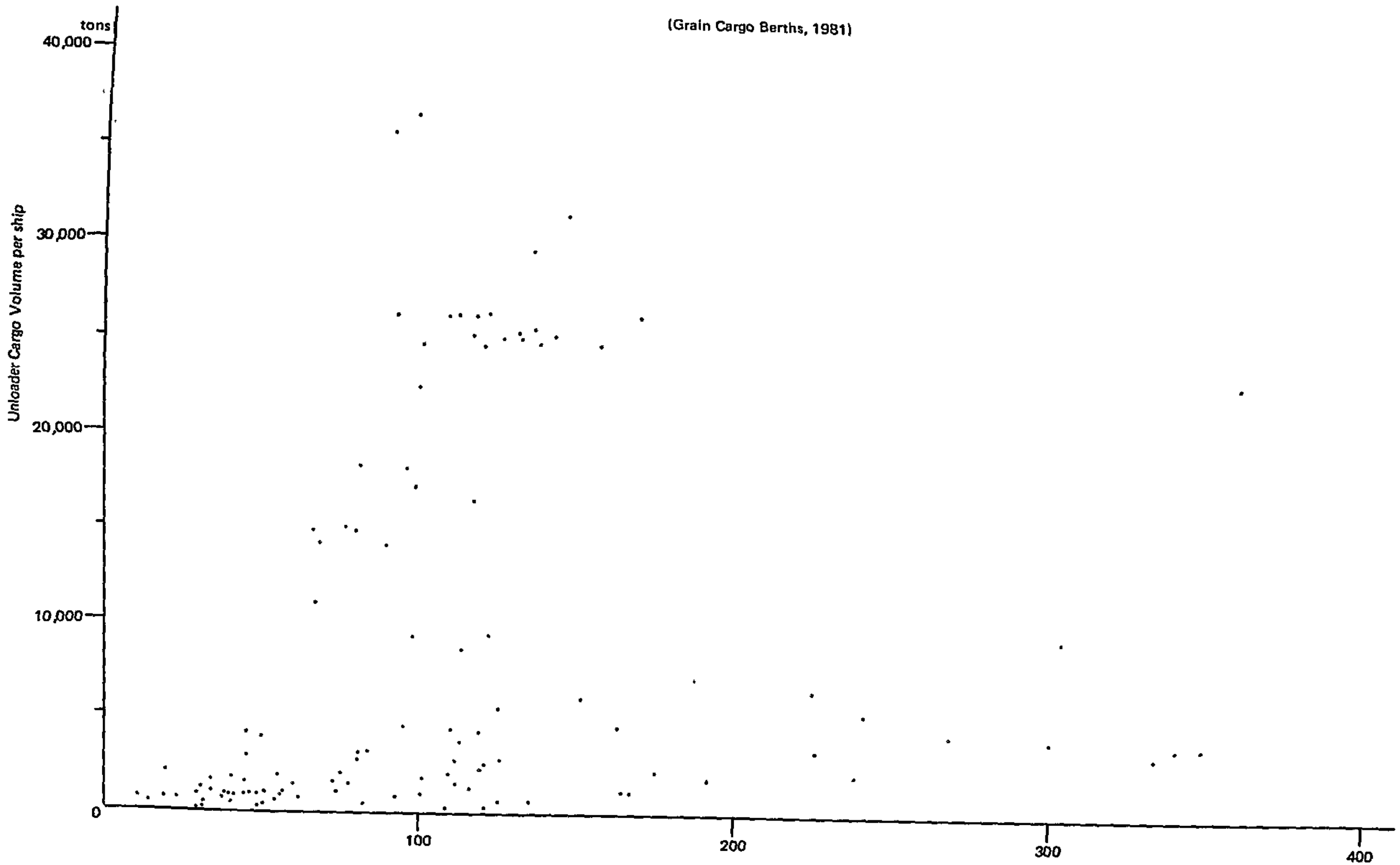
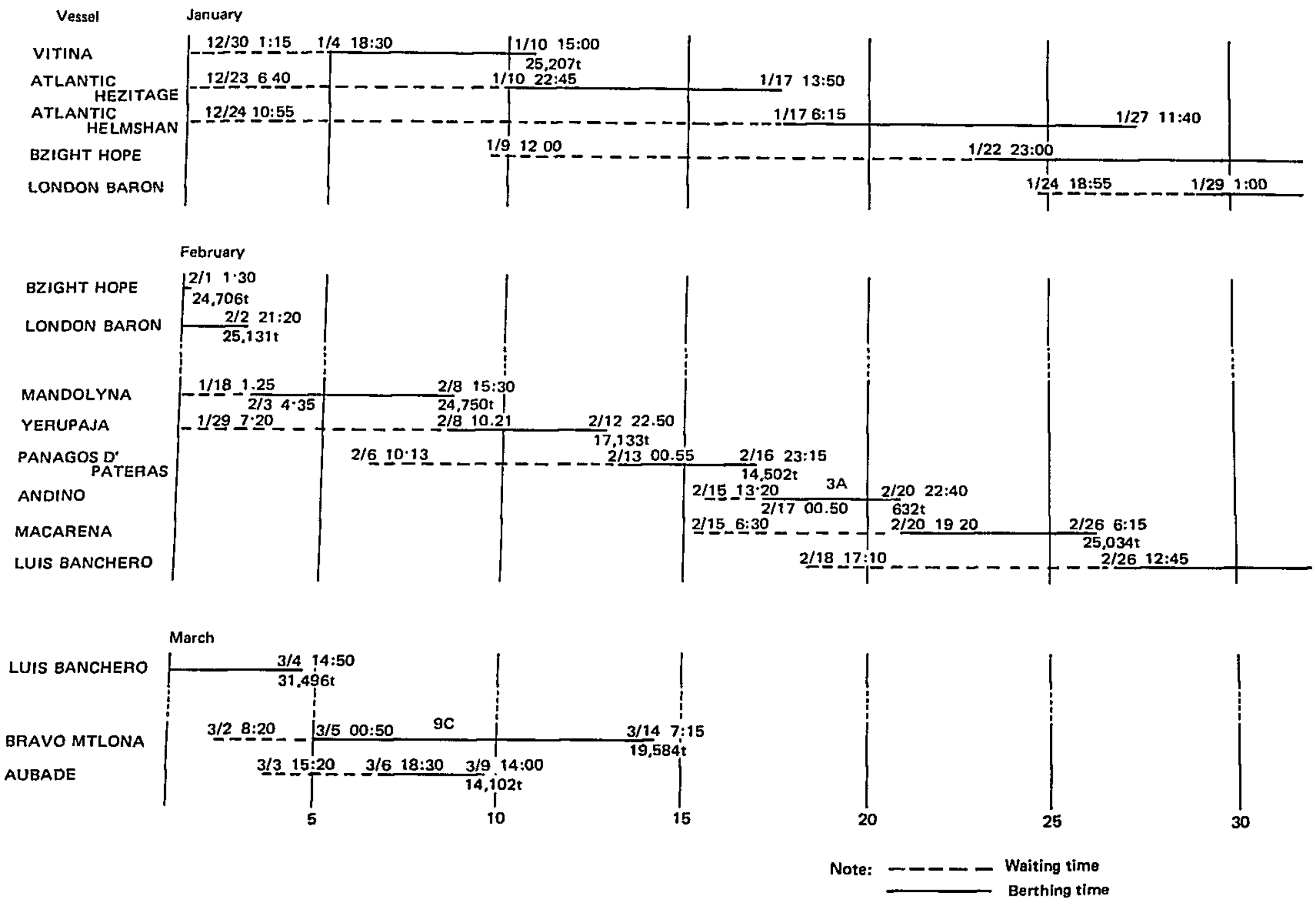
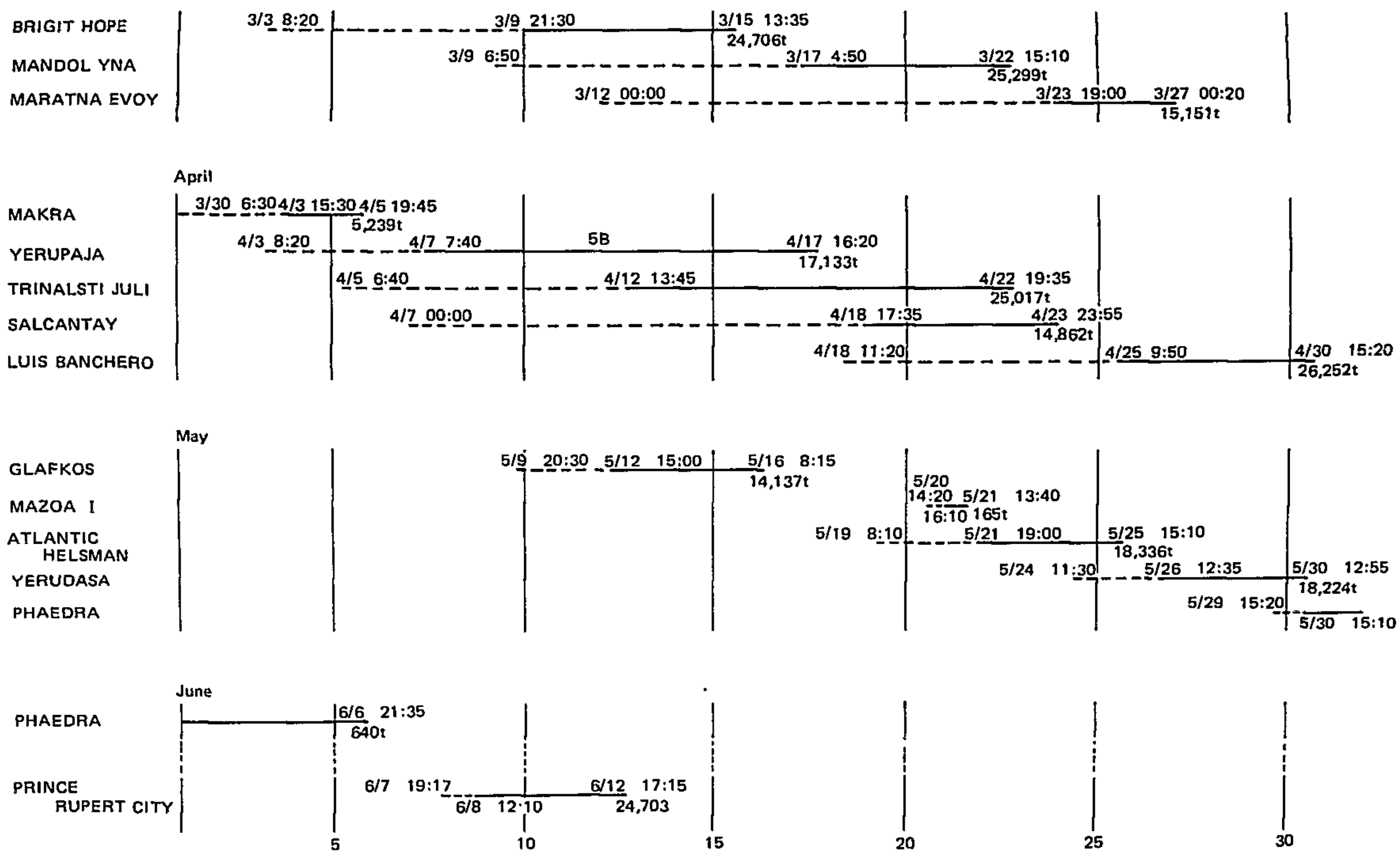


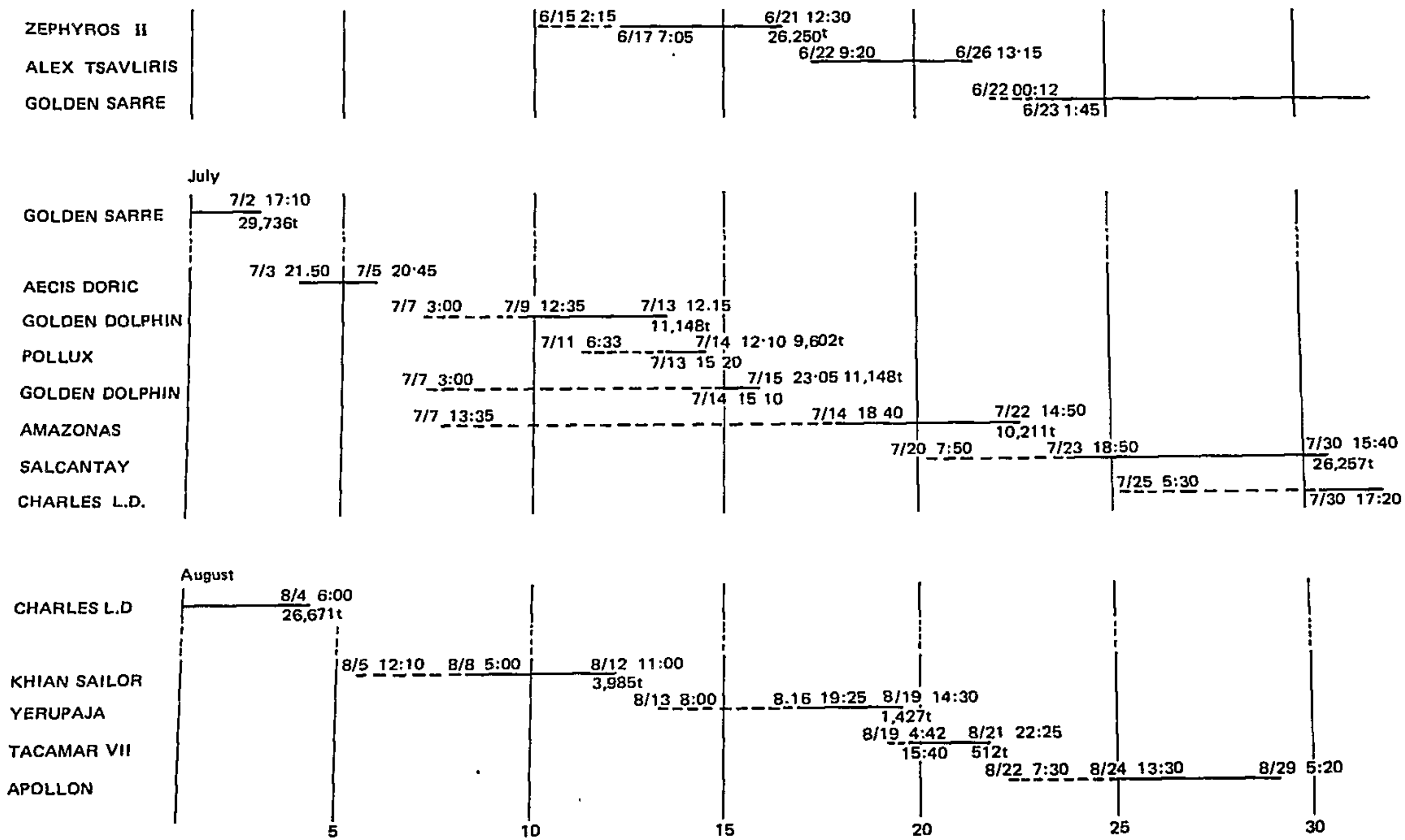
Fig. 2-10 Relation between Unloaded Cargo Volume per Ship and Mooring Time

Fig. 2-11 Waiting Time of Grain Ships





BRIGIT HOPE
MANDOL YNA
MARATNA EVOY
3/3 8:20
3/9 21:30
3/15 13:35
24,706t
3/9 6:50
3/17 4:50
3/22 15:10
25,299t
3/12 00:00
3/23 19:00
3/27 00:20
15,151t
April
MAKRA
YERUPAJA
TRINALSTI JULI
SALCANTAY
LUIS BANCHERO
3/30 6:30
4/3 15:30
4/5 19:45
5,239t
4/3 8:20
4/7 7:40
5B
4/17 16:20
17,133t
4/5 6:40
4/12 13:45
4/22 19:35
25,017t
4/7 00:00
4/18 17:35
4/23 23:55
14,862t
4/18 11:20
4/25 9:50
4/30 15:20
26,252t
May
GLAFKOS
MAZOA I
ATLANTIC HELSMAN
YERUDASA
PHAEDRA
5/9 20:30
5/12 15:00
5/16 8:15
14,137t
5/20 14:20
5/21 13:40
16:10
165t
5/19 8:10
5/21 19:00
5/25 15:10
18,336t
5/24 11:30
5/26 12:35
5/30 12:55
18,224t
5/29 15:20
5/30 15:10
June
PHAEDRA
PRINCE RUPERT CITY
6/6 21:35
640t
6/7 19:17
6/8 12·10
6/12 17:15
24,703
5
10
15
20
25
30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ALEX TSAVLIRIS
GOLDEN SARRE
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6/17 7:05
6/21 12:30
26,250t
6/22 9:20
6/26 13·15
6/22 00:12
6/23 1:45
July
GOLDEN SARRE
AECIS DORIC
GOLDEN DOLPHIN
POLLUX
GOLDEN DOLPHIN
AMAZONAS
SALCANTAY
CHARLES L.D.
7/2 17:10
29,736t
7/3 21.50
7/5 20·45
7/7 3:00
7/9 12:35
7/13 12.15
11,148t
7/11 6:33
7/14 12·10 9,602t
7/13 15 20
7/7 3:00
7/15 23·05 11,148t
7/14 15 10
7/7 13:35
7/14 18 40
7/22 14:50
10,211t
7/20 7:50
7/23 18:50
7/30 15:40
26,257t
7/25 5:30
7/30 17:20
August
CHARLES L.D
KHIAN SAILOR
YERUPAJA
TACAMAR VII
APOLLON
8/4 6:00
26,671t
8/5 12:10
8/8 5:00
8/12 11:00
3,985t
8/13 8:00
8.16 19:25
8/19 14:30
1,427t
8/19 4:42
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512t
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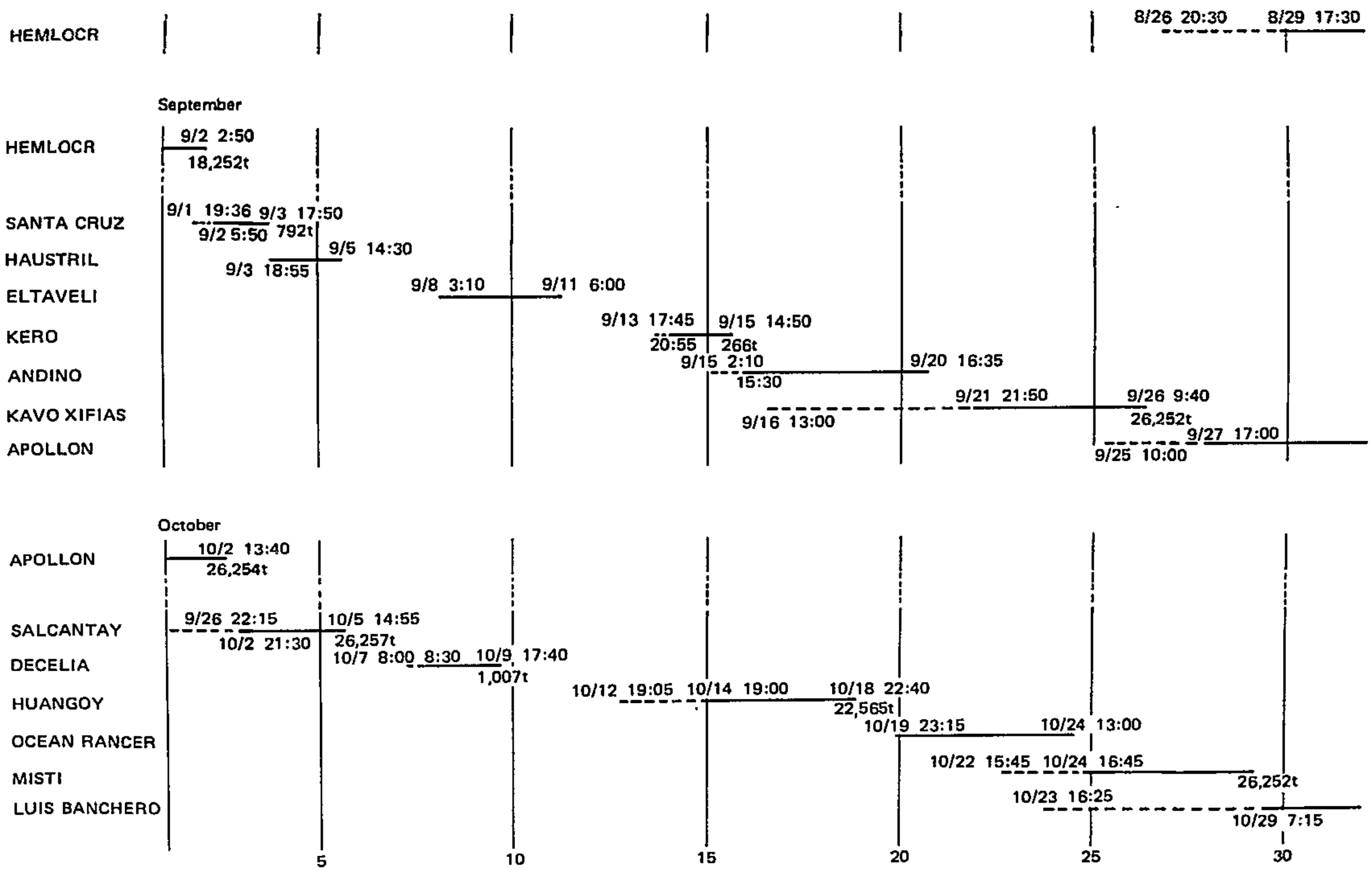
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8/29 17:30
September
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9/2 2:50
18,252t
SANTA CRUZ
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9/2 5:50
9/3 17:50
792t
HAUSTRIL
9/3 18:55
9/5 14:30
ELTAVELI
9/8 3:10
9/11 6:00
KERO
9/13 17:45
20:55
9/15 14:50
266t
ANDINO
9/15 2:10
15:30
9/20 16:35
KAVO XIFIAS
9/16 13:00
9/21 21:50
9/26 9:40
26,252t
APOLLON
9/25 10:00
9/27 17:00
October
APOLLON
10/2 13:40
26,254t
SALCANTAY
9/26 22:15
10/2 21:30
10/5 14:55
26,257t
DECELIA
10/7 8:00
8:30
10/9 17:40
1,007t
HUANGOY
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OCEAN RANCER
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10/24 13:00
MISTI
10/22 15:45
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15
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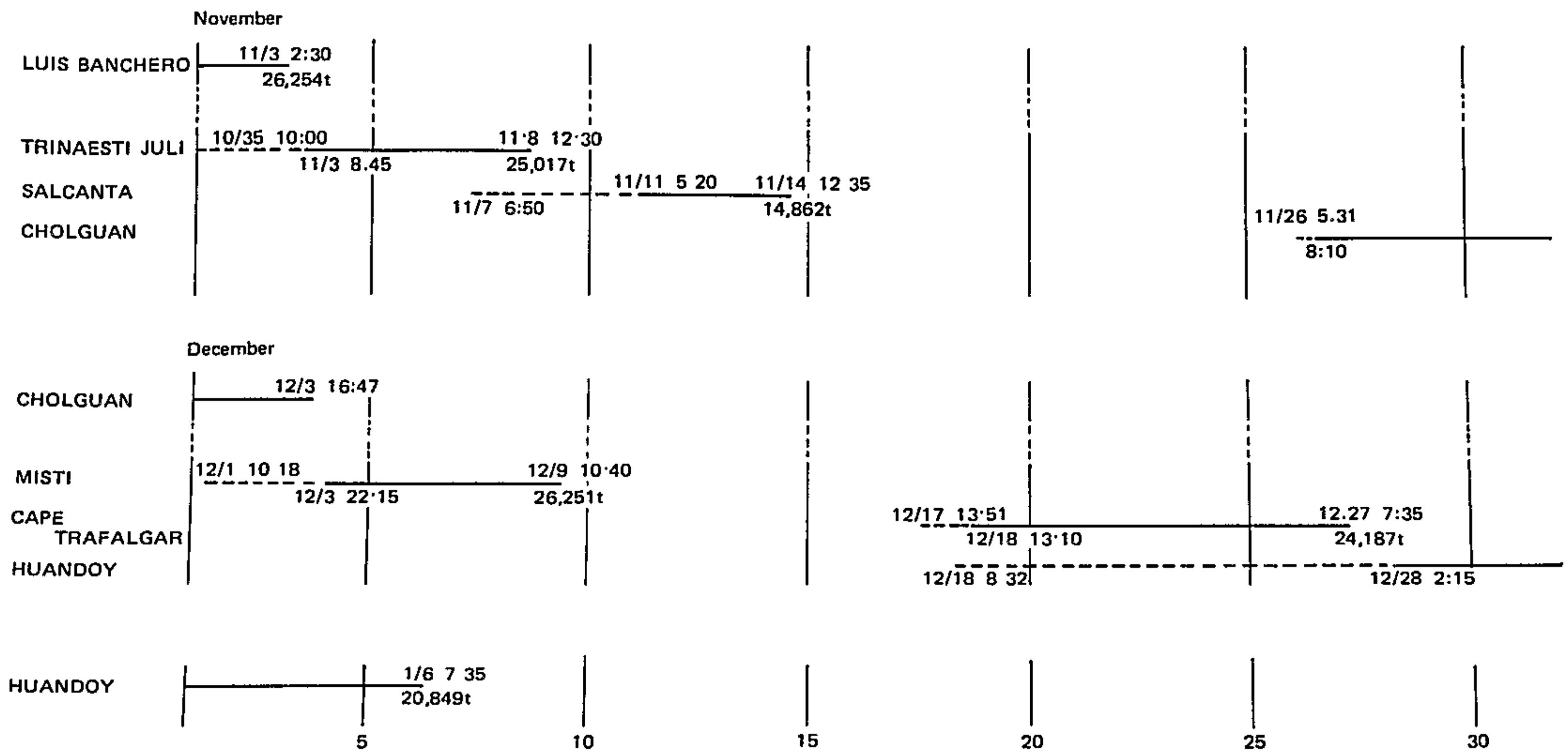

November
LUIS BANCHERO
11/3 2:30
26,254t
TRINAESTI JULI
10/35 10:00
11/3 8.45
11·8 12·30
25,017t
SALCANTA
11/7 6:50
11/11 5 20
11/14 12 35
14,862t
CHOLGUAN
11/26 5.31
8:10
December
CHOLGUAN
12/3 16:47
MISTI
12/1 10 18
12/3 22·15
12/9 10·40
26,251t
CAPE TRAFALGAR
12/17 13·51
12/18 13·10
12.27 7:35
24,187t
HUANDOY
12/18 8 32
12/28 2:15
HUANDOY
1/6 7 35
20,849t
5
10
15
20
25
30

2-4 System of Port Management and Operation

2-4-1 Port Administration

Port administration is under the jurisdiction of the Ministry of Transport and Communication, and the Water Transportation Bureau is in charge of ports, harbors and marine transportation. Duties of the Water Transportation Bureau are defined as below:

"It is their duty to plan, guide, coordinate, enforce and administer the businesses of marine, river and lake transportation and to construct corresponding basic facilities thereof". (Article 28 of the Cabinet Order No. 96 dated May 29, 1981)

The organizational structure of the water Transportation Bureau is shown in Figure 2-12.

The management and operation of public port facilities are carried out by Empresa National de Puertos S.A., ENAPU S.A..

2-4-2 ENAPU S.A.

(1) Purposes of establishment

ENAPU-PERU was established on January 1, 1970 under the Cabinet Order No. 18027 as a public business entity of authorities within the Transport and Communication sector. It operates 23 ports (18 terminals) including Callao Port as an operating body of ports and harbors with autonomy in operation and management and financial self-sufficiency. The public corporation was reorganized as Peru National Port Company Ltd., i.e., ENAPU S.A. under the Cabinet Order No. 98 dated May 29, 1981 and has come to be controlled by said Cabinet Order, the Law for Merchantile Companies and Code of Commerce.

The purposes of ENAPU are to administer, operate, coordinate, maintain and also to construct, upon approval, terminals and wharves of the Republic on sea, rivers and lakes. In carrying out these purposes, ENAPU cooperates with economical, financial, technical and administrative organizations and follows the policies, purpose and objectives which are approved by the Ministry of Transport and Communication. The organization, bureaus and management of ENAPU S.A. are under the authority of the general meeting of stockholders, the Board of Directors and the President. The organization structure of ENAPU is shown in Fig. 2-13.

The Board of Directors is composed of 8 members. 2 of them represent the Ministry of Transport and Communication; 1 the President's Office; 1 the Ministry of Economy, Finance and Commerce; 1 the Ministry of Agriculture; 1 the Navy; 1 the Ministry of Energy and Mining; and 1 the workers of ENAPU. The responsibilities entrusted to the Board of Directors are laid down in the Laws for Merchantile Companies. The chairman of the Board of Directors may become a member of the general meeting of stockholders. A director representing workers is selected by vote of the employees of ENAPU S.A. Other directors are chosen by the general meeting of stockholders.

He duly represents ENAPU S.A., The president acts as an agent for the Board of Directors, guides, coordinates and administers the business of ENAPU. He is appointed and dismissed by the Board of Directors. The president may become a member of the Board of Directors.

(2) Capital etc.

The capital is 40 billion soles fully paid by the central Government. It consists of 40 million shares at 1,000 soles per share. Representative shares of paid-in capital are issued in the name of the Government and are entrusted to the management of La Corporacion Financiera de Desarrollo (COFIDE).

The fiscal year starts on January 1 and ends on December 31 of each year. In accordance with the tax system of private companies, it is subject to audit by 1 certified public accountant working in ENAPU appointed by the Board of Audit of the Republic. It may raise funds from local and foreign financial institutions in addition to the loans received from the Government financial institution.

Compilation, approval, execution and administration of budget and financial conditions of ENAPU S.A. are subject to provisions of Cabinet Orders, Laws for Merchantile Companies and Code of Commerce.

(3) Port Services

General port services are provided except for stevedoring on board.

Shipping services include:

a. Towage services such as berthing and unberthing.
b. Mooring to buoys.
c. Cargo transfer between holds.
d. Transfer of cargo.
e. Pilot services.
f. Water supply.

Cargo handling services include:

a. Loading/unloading at wharves (coastal stevedoring).
b. Cargo handling inside transit sheds.
c. Cargo storage services.
d. Railway and truck transportation inside the port.

Other services include renting facilities, equipment, and weight measurement. Services provided by other sources than the ENAPU S.A. include stevedoring on board which is provided by the Union under the authority of the Coordination Committee for Maritime Labour (CCTM) of the Navy. The working hours are based on 24 hours and 3 shifts/day operation, namely, 7:00 to 16:00, 17:00 to 24:00 and 1:00 to 6:00 hour-shifts.

The working days are 364 days/year except for may Day, May 1. ENAPU S.A. is responsible for the security of port facilities inside the port area and Maritime Safety Agency is responsible for marine cargo.

(4) Port tariffs

These are classified into 4 types as shown below:

a. Tariffs for services and conveniences rendered for ships.
b. Tariffs for services and conveniences for cargo.
c. Tariffs for services and conveniences for storage.
d. Tariffs for special services and conveniences such as the use of ships and equipment.

Port tariff was revised on March 31, 1982.

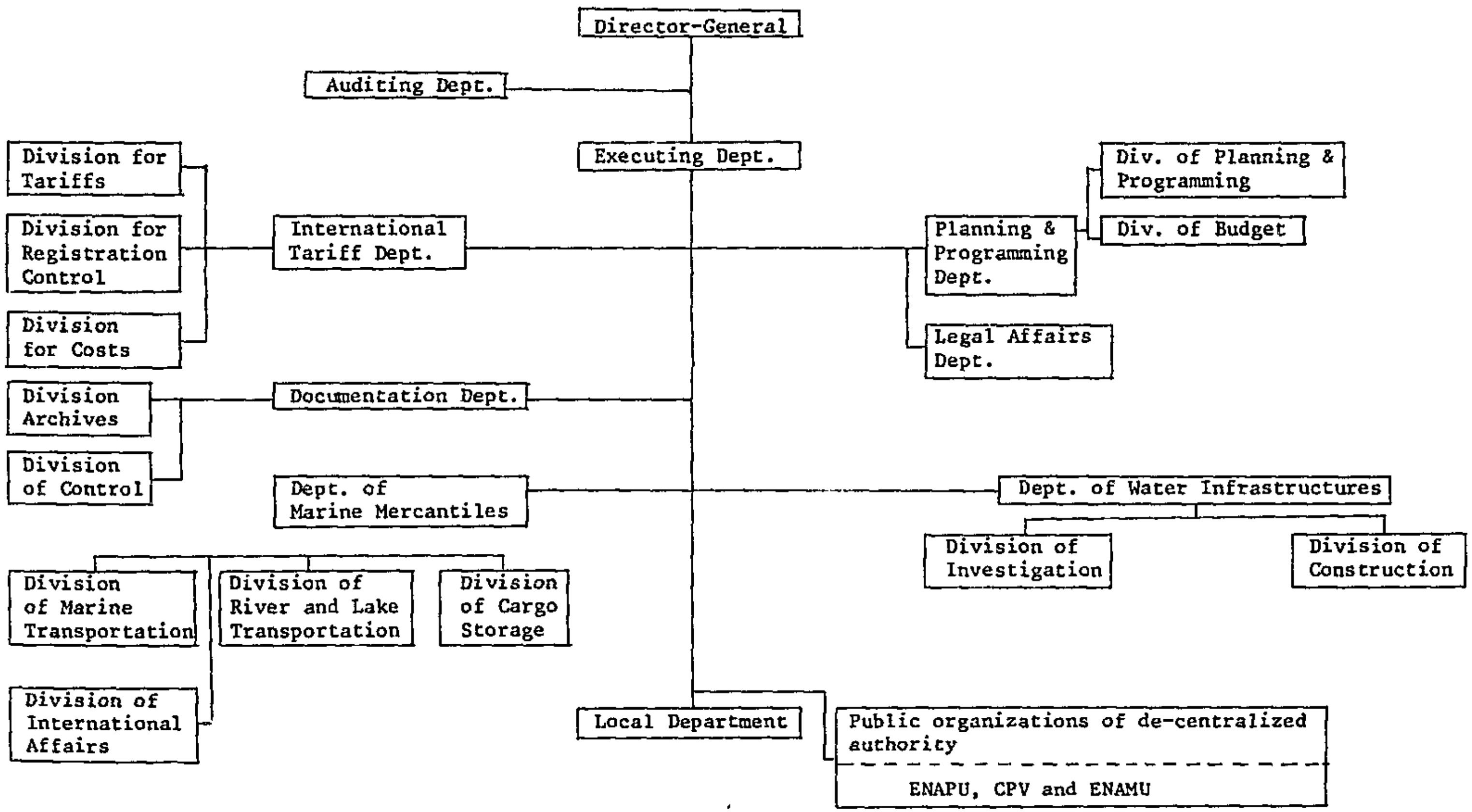


Fig. 2-12 Organization Structure for Water Transportation Bureau

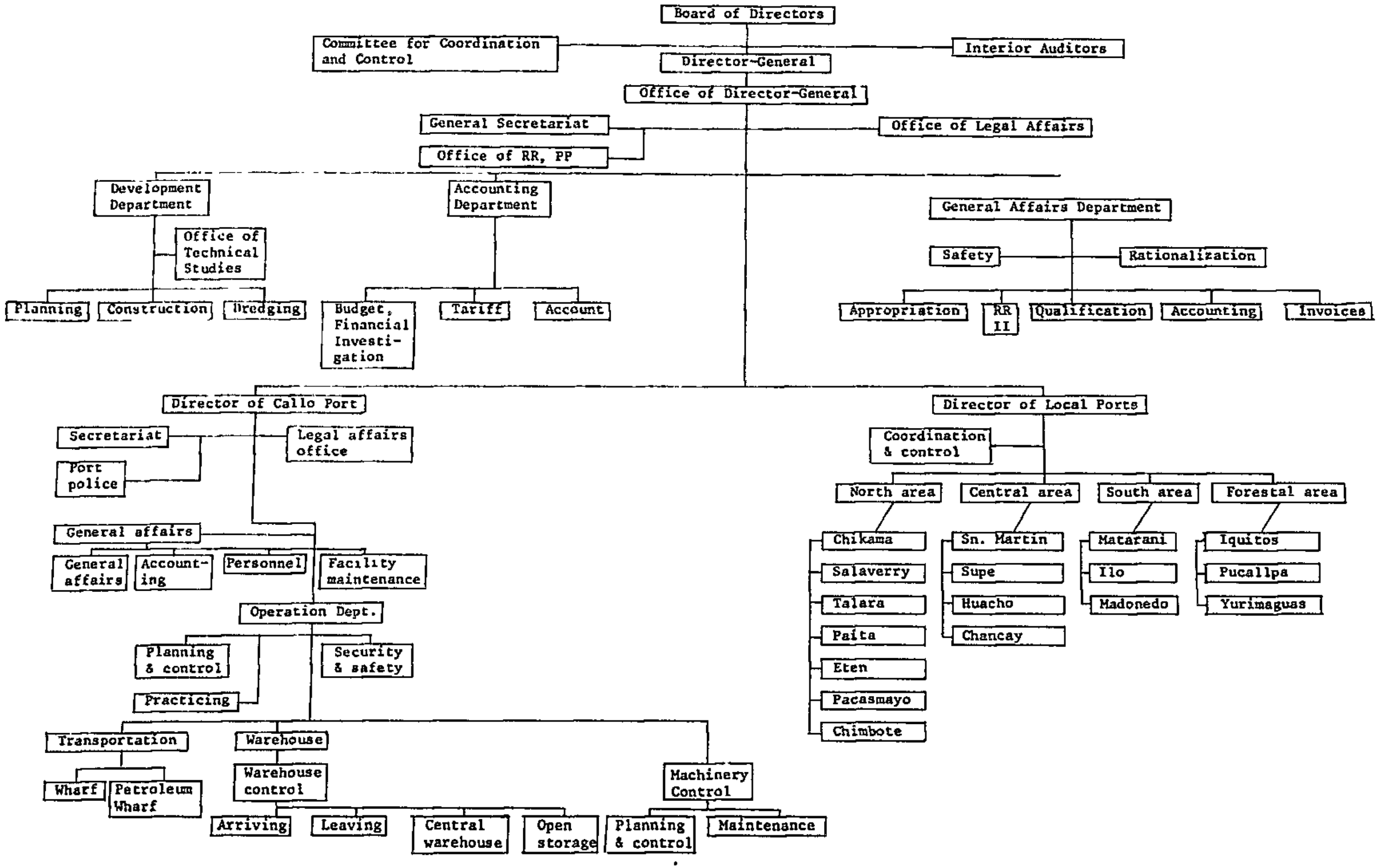


Fig. 2-13 Organization Structure of ENAPU S.A.

Table 2-9 Number of Staff at ENAPU S.A. (as of July, 1982)

	Full Time									Part-time	Total
	Gen. affrs	Operation	Account	Personnel	Appropriation	Technology	Safety	Others	Total		
Headquarters	158	9	32	65	36	26	24	30	380	110	490
Callo Port	44	1,486	127	124	51	362	126	-	2,320	177	2,497
Salaverry "	7	89	26	40	9	31	36	-	238	6	244
Chimbote "	5	55	18	12	8	23	33	-	154	3	157
Matarani "	7	142	33	18	11	57	50	-	318	71	389
San Martin	6	54	15	14	3	21	19	-	132	5	137
Talara "	3	40	7	3	2	3	16	-	74	21	95
Iquitos "	9	77	18	8	5	21	30	-	168	4	172
Paita "	6	55	13	8	3	23	21	-	129	20	149
Ilo "	5	24	8	5	4	4	19	-	69	11	80
Supe "	3	15	4	2	1	9	9	-	43	2	45
Huacho "	5	11	4	1	-	8	9	-	38	-	38
Chancay "	2	5	2	-	-	1	5	-	15	2	17
Chikama "	1	3	-	-	-	2	1	-	7	-	7
Sacasmayo "	3	12	6	1	4	10	9	-	45	3	48
Pucallpa "	2	-	-	-	-	-	-	-	2	63	65
Puerto Madonado "	1	2	-	-	-	-	-	-	3	2	5
Eten "	-	-	-	1	-	-	-	-	1	1	2
Yurimagnas "	-	-	-	-	-	-	-	-	-	27	27
Total	267	2,079	313	302	137	601	407	30	4,136	528	4,664

2-4-3 Port Cargo Handling

The Coordination Committee for Maritime Labour (CCTM, Comision Controladora del Trabajo Maritimo) is deeply concerned with cargo handling at Callao Port. The CCTM belongs to the Naval Ministry and engages mainly in finding jobs for maritime workers.

Stevedoring at the port is performed by workers provided by the CCTM at the request of shipping companies or agencies. The ENAPU is not involved in stevedoring at all. Instead, it conducts land transportation (coastal stevedoring) between the wharf and the transit shed or the open storage yard, using workers provided by the CCTM.

Needless to say, port cargo handling should be conducted under an integrated, responsible system but at this port, responsibility is divided into two, as stated above. This presumably is a factor causing inefficiency of cargo handling and damage to cargoes being handled.

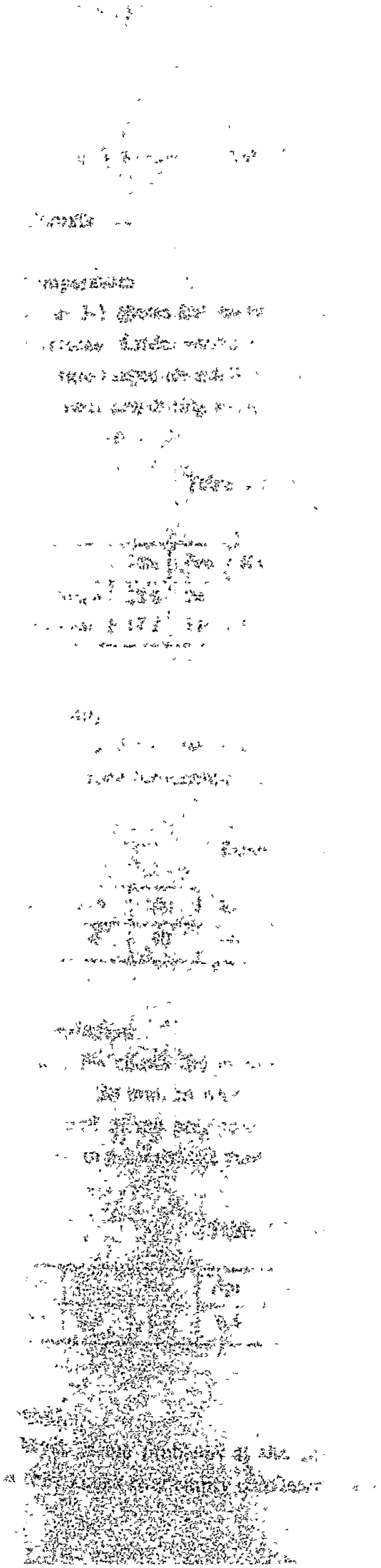
Workers registered with the CCTM include stevedores (estibadores), rigger gangs (maniobristas), tally men (tarjadores) and workers handling pallets and wagons (parih-vag.). Callao Port has more than 2,100 registered workers: regular workers and auxiliary workers. And work is assigned to these workers in the order of their registration numbers.

The CCTM has a unique tariff. The cost of stevedoring is paid by the shipping company or the agency to the CCTM and the cost of coastal stevedoring is paid by the ENAPU to the CCTM – both in accordance with the tariff.

As to coastal stevedoring, the transit sheds on the wharves are not being effectively used and most cargoes are temporarily kept in the open storage yards. The relatively long distance between the open storage yards and the wharves and the deteriorated road pavement make efficient and economical transportation difficult.

The working time is eight hours a shift (8:30 – 17:30) but work is actually performed for only about five hours.

Container cargo handling basically follows the same form of cargo handling as other cargoes: Namely, responsibility for container cargo handling is divided into two between stevedoring and coastal stevedoring. This is likely to greatly hamper the execution of full developed container transportation. Customs clearance for container cargoes is handled by the customhouse (aduana). At Callao Port, bonded transportation out of the harbor is not approved and customs clearance examination for FCL takes place in the harbor itself. This examination is not so strict that all containers have to be uncreated.



CHAPTER 3
Natural Condition

CHAPTER 3. NATURAL CONDITIONS

3-1 Climate

(1) Temperature

Table 3-1 shows the monthly averages of the daily maximum temperatures and minimum temperatures. Little variation in temperature is noted throughout the year and the daily temperature ranges are small. Temperatures are relatively high during summer (November – May) and relatively low during winter (June – October).

Table 3-1 Maximum and Minimum Temperatures (monthly average) (°C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Maximum	23.0	24.2	23.5	22.5	21.5	19.0	28.6	18.4	18.6	19.2	20.2	21.6
Minimum	17.2	17.6	19.0	15.7	16.5	15.1	14.6	14.5	14.8	14.2	14.6	16.0

(2) Humidity

Table 3-2 shows the monthly average humidity recorded at La Punta. High humidity of 83 – 90% is recorded throughout the year.

Table 3-2 Monthly Average Humidity (%)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
88	86	90	90	83	88	90	89	89	87	86	86

(3) Precipitation

Table 3-3 shows the monthly precipitation at La Punta. Yearly precipitation is very low, about 10 – 20 mm. In winter (June – September) drizzling rains are often noted, but they are not counted in the precipitation figures. The drizzling rains damage bagged goods and rolled paper, etc. in open storage yards.

Table 3-3 Monthly Total Precipitation (mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
0.5	0.4	0.4	0.5	1.1	3.6	1.5	7.6	2.3	0.4	0.1	0.3

(4) Wind

Winds create problems at the container terminals when the wind velocity becomes so high that they knock over empty containers stacked in the yard.

The minimum wind velocity which causes damage varies according to wind directions but the following gives a general guideline.

When containers are wet and slippery, a wind velocity of over 15 – 16 m/s will cause the containers to slide.

A wind velocity of over 20 m/s will create the possibility of falling containers.

Table 3-4 presents the monthly maximum wind velocities and wind directions taken from survey data at La Punta for the 30 years from 1944 to 1974.

According to Table 3-4, the maximum wind velocity over these 30 years was 15 m/s followed by 11 m/s.

Therefore, when planning container terminals at Callao, the possibility of shifting of empty containers by strong winds is small.

Table 3-4 Maximum Wind Velocity and Direction 1944 – 1974 (m/s)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
10(SE) 10(SSW)	8(ESE)	10(SE)	15(ENE)	11(SE)	10(SSE)	11(SSE) 11(NW)	11(NE)	10(NE)	10(SSE)	9(SSE)	8(SSE) 8(SE) 8(SSW)

(5) Visibility

Visibility is one of the factors that affects the deployment of ships in the channels. Depending on the congestion of a port and the traffic of small vessels, most ports restrict entry of ships into the channels at visibility less of than 1 km. Table 3-5 shows the number of days for each month when minimum visibility becomes less than 1 km according to the survey made by the Dirección de Hidrografia y Navegación in 1980 and 1981.

In both 1980 and 1981, poor visibility is noted from December to May and good visibility is recorded from June to November. Visibility of less than 1 km is recorded for 21 days in 1980 and 23 days in 1981.

It must be noted, however, that these days simply indicate the number of days of poor visibility but not the number of days when the actual deployment of ships in the channels was restricted.

Table 3-5 Number of Days of Minimum Visibility less than 1 km

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1980	2	5	0	5	8	0	0	0	0	1	0	0
1981	11	1	4	2	0	0	0	0	0	0	1	4

3-2 Sea Conditions

3-2-1 Waves

(1) Deepwater waves

During the Study of the Construction for the Fishing Port in Ventanilla, located about 20 km north of Callao, a survey* was made that includes a study of the waves in the Callao area. Both Callao Port and the construction site of Ventanilla fishing port are located on an unbroken length of bow-shaped coast line. Because the distance is only about 20 km between the two locations, deepwater wave direction, deepwater wave height and the period for Callao Port may be considered similar to those for Ventanilla fishing port.

At Ventanilla, a wave observation was made at a water depth of −18.0 m from June, 1977 to February, 1979 using Wave Rider Buoy. Table 3-6 shows the monthly average significant wave height, the significant wave period, and the maximum significant wave height for each month according to this observation.

The following conclusions are drawn from Table 3-6.

1 Wave height is large in winter, from May through August, and in summer, from November through February.

2 Maximum significant wave height is especially large in May and June and small in December and January.

3 Wave period is usually between 10 and 14 seconds, while a period over 14 sec or under 8 sec, is rarely observed.

Wave directions are not specially given in the results of the survey but in the study of design wave height at Ventanilla fishing port, S and SW directions were examined. This is because the wave directions of S and SW are considered the most likely to occur.

Table 3-6 Monthly Average Significant Waves and the Maximum Significant Wave Height

	Average Significant Wave Height and Standard Deviation			Average Wave Period and Standard Deviation			Maximum Significant Wave Height	
	$\bar{H}$(m)	$\pm\sigma$(m)	($H\pm\sigma$)(m)	$\bar{T}$ (sec)	$\pm\sigma$(sec)	($T\pm\sigma$)(sec)	$(H_{\frac{1}{3}})_{max}$ (m)	T (sec)
Jan.	0.99	0.17	0.82 - 1.16	11.44	1.54	9.9 - 13.0	1.19	13.5
Feb.	1.10	0.23	0.87 - 1.33	11.60	1.28	10.3 - 12.9	1.55	12.5
Mar.	1.18	0.27	0.91 - 1.45	11.40	1.19	10.2 - 12.6	1.89	12.5
Apr.	1.16	0.30	0.86 - 1.46	12.10	1.81	10.3 - 13.9	1.80	13.0
May	1.30	0.56	0.74 - 1.86	10.80	1.52	9.3 - 12.3	3.41	13.8
Jun.	1.51	0.61	0.90 - 2.12	11.70	2.02	9.7 - 13.7	3.15	13.5
Jul.	1.24	0.34	1.24 - 1.58	11.20	1.11	10.1 - 12.3	2.24	12.8
Aug.	1.16	0.33	0.82 - 1.49	10.56	2.60	8.0 - 13.2	2.23	13.4
Sep.	0.88	0.13	0.75 - 1.01	9.30	0.60	9.2 - 9.9	1.98	13.4
Oct.	Not Available							
Nov.	0.93	0.27	0.66 - 1.20	11.10	0.43	9.7 - 12.5	1.94	13.4
Dec.	0.82	0.24	0.58 - 1.06	11.10	1.25	9.9 - 12.4	1.62	13.2

* The Study of the Construction for the Fishing Port in Ventanilla, August 1979

Fig. 3-1 shows the probability of wave occurrence off the Supe and Huacho areas (located about 135 km north of Callao) as given in the feasibility study report* for the construction of a jetty for loading minerals.

According to this, the wave directions are concentrated in the S, SW and SE, while other directions show a probability of less than 1%. Since the SE direction faces the sea and the wave height is considered to be small, it may be omitted.

A significant deepwater wave height of 3.85 m is used as the design deepwater wave height in the Ventanilla area, and was calculated from the maximum significant wave height obtained during the survey period.

Fig. 3-2 shows the distribution frequency of significant deepwater wave height (by period) in the Supe and Huacho areas. It shows that significant wave heights of over 4 m very rarely occur.

From the above, the following dimensions of deepwater waves are assumed for the study of Callao Port.

Period . . . . . 10 sec. and 14 sec.

Wave directions . . . . . S and SW

* Feasibility Study for Port Development in the Norte Chico Region, Livesey, Henderson & Partners, 1972 April

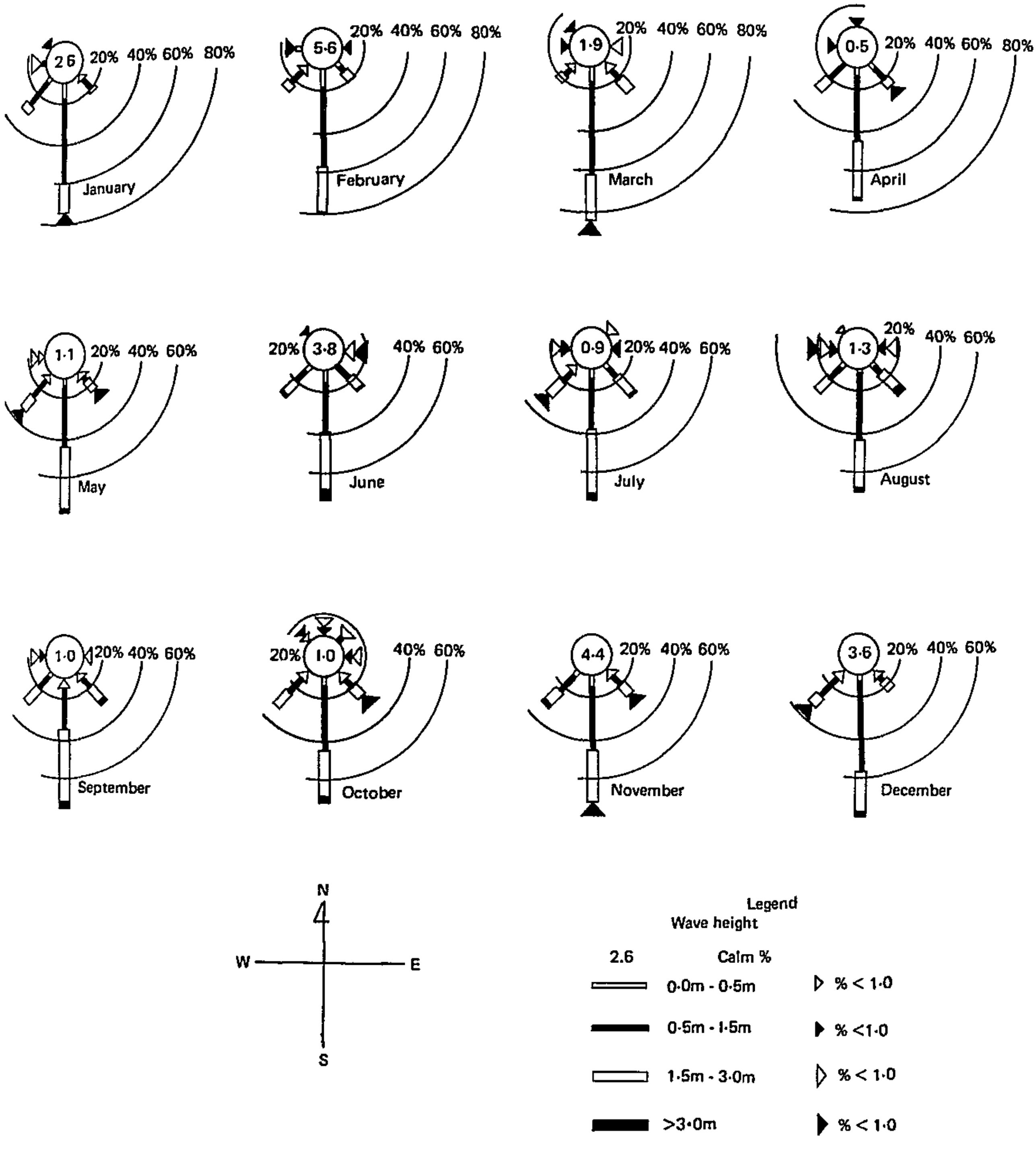


Fig. 3-1 Probability of Occurrence of Wave Directions Off Supe and Huacho

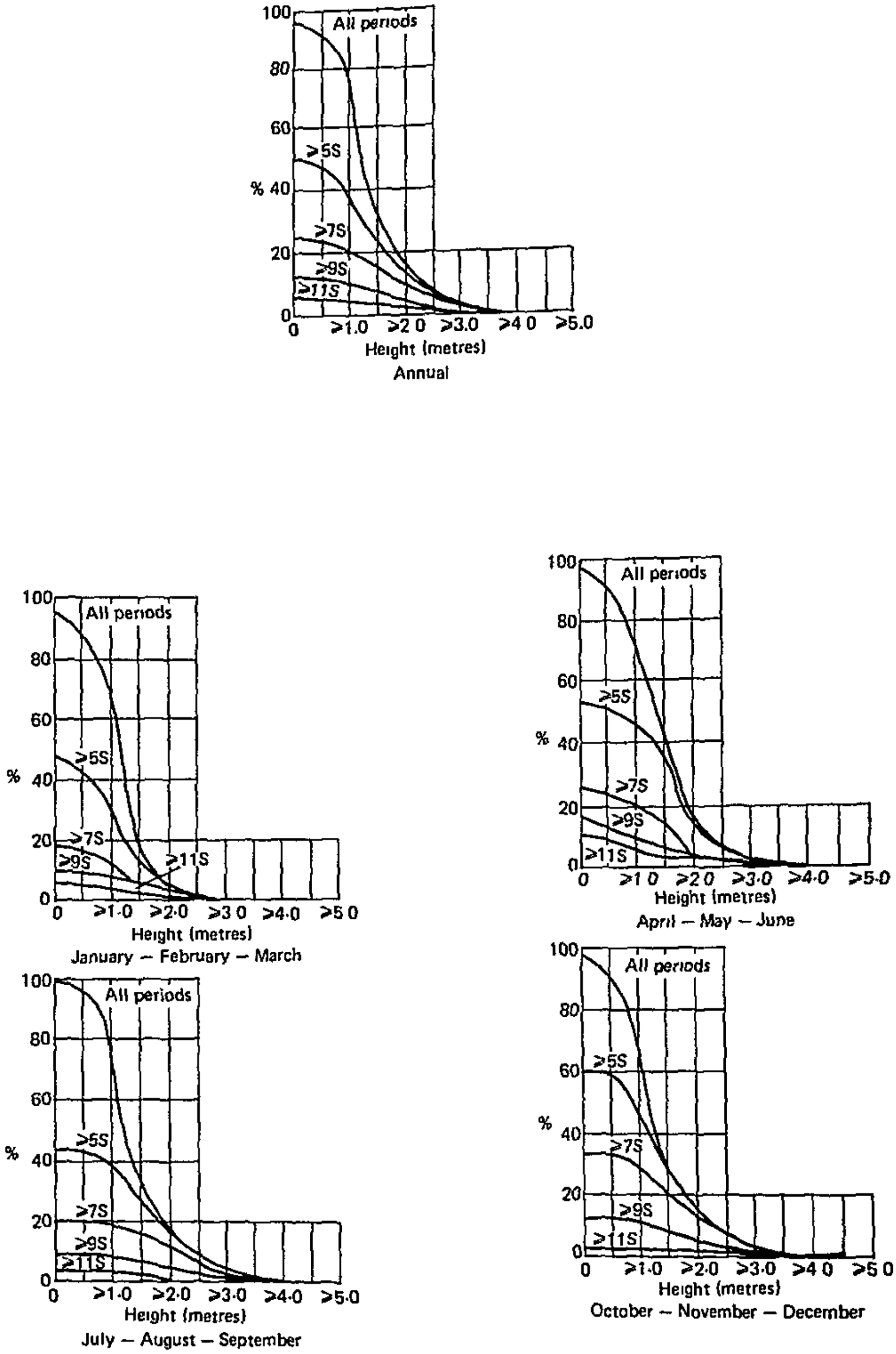


Fig. 3-2 Distribution of Frequency of Significant Wave Height

(2) Study of Design Waves at the Location of Callao Port

For obtaining dimensions of design waves at Callao Port, it is necessary to study the effect of wave interception (diffraction of waves) created by San Lorenzo Island and effect of wave refraction.

Topography around Callao Port is very complicated due to the effect of Tombolo which will be mentioned in 3-2-4 "Coastal Topography and bottom sediments". Usually both hydraulic model experiment and mathematical calculation are used for estimating design wave heights in an area of such complicated topography. However, only a mathematical calculation is taken up in this report, because the calculation is judged to be good enough for the determination of the wave dimensions which are needed for the execution of the master plan study.

These considerations should be kept in mind while examining the following calculations.

Fig. 3-3 shows the relation between the locations of Sun Lorenzo Island and Callao Port and directions of the prevailing waves.

Water depth on the seaward side of San Lorenzo Island is $-20 \sim -30$ m, and drops off sharply further out. With such water depth, wave directions are not changed greatly by refraction. So, it is assumed that at the location of the island the wave directions of S and SW are still predominant.

From Fig. 3-3, it is expected that waves from the southwest, diffracted at the western end of San Lorenzo Island, will apparently give larger wave height at the location of Callao Port than those from the south.

On the other hand, waves diffracted at the eastern end of San Lorenzo Island will be larger at Callao Port for S directions than for SW directions.

Fig. 3-4 shows the diffraction coefficients of waves from southerly directions with a 14 sec. period. Compared with waves from southerly direction with a 10 sec. period, the former waves give a larger diffraction coefficient.

Since calculations have been done for regular waves, diffraction coefficients vary over a wide rage.

From this result, the diffraction coefficient at the planned location of the new wharves is determined as 0.40. Because this coefficient will be used for design purposes, a value on safe side should be taken.

Calculations are made for the refraction coefficient of waves from southerly directions reaching the planned site of construction. The refraction coefficient of waves from Southerly direction, with a 14 sec. period coming through the area east of San Lorenzo Island is used as the approximate value.

The result is given as Kr = 0.58. However, since it is difficult to take the effects of the shallow waters off La Punta fully into account, the estimate is made on the safe side.

The shoaling coefficient is obtained as Ks = 1.86. Therefore, the design wave height for southerly directions is $H_d = 3.85 \text{ m} \times 0.40 \times 0.58 \times 1.86 = 1.66 \text{ m}$.

Fig. 3-5 shows the diffraction coefficients of waves from the SW directions with a 14 Sec. period. From this, the diffraction coefficient K_d at the planned site of the wharves is found to be 0.10.

Since this calculation of diffraction is made for regular waves, K_d may be somewhat on the risky side.

On the other hand, the product of the refraction coefficient Kr and the shoaling coefficient Ks becomes 1.30.

Therefore, design wave height for the SW direction will be H_d = 3.85 m x 0.10 x 1.30 = 0.50 m.

Taking the larger of the two design wave heights, S direction 1.66 m and SW direction 0.50 m, the design wave height at the site of the wharves was determined as 1.66 m.

(3) Wave observation done between August and October, 1982

Table 3-7 shows the frequency distribution of significant wave height and period which was calculated after the wave observation done by the Japanese Study Team between August and October, 1982.

The following can be noticed:

1 Significant wave period ranges between 9 and 19 sec. This means swell is predominant. The most frequent period is 12 – 15 sec. which gives a similar result as Table 3-6.

2 The maximum significant wave height observed during the observation period was 1.28 m. According to Fig. 3-4, the diffraction coefficient K_d at the wave observation point is about 0.40. Therefore, the design wave height at this point is

$$H = 3.85\ m \times 0.40 \times 0.58 \times 1.86 = 1.66\ m$$

When it is taken into consideration that the period between August and October includes the time when wave heights are largest, the result of the wave observation, that the maximum significant wave height is 1.28 m, when compared to the design wave height of 1.66 m, verifies this way of determining the design wave height.

Table 3-7 Frequency Distribution of Significant Wave Height and Period (Off Callao Port, h ≑ –20 m)

$H_{1/3}$ (m) \ $T_{1/3}$ (sec)	9-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	TOTAL
0.20 - 0.39			3	16	22	11	2	1			55
0.40 - 0.59	1	20	42	153	120	67	31	21	7	1	463
0.60 - 0.79		2	20	55	103	91	47	26	3	5	352
0.80 - 0.99			1	5	18	16	22	4	1		67
1.00 - 1.19					1	2	2				5
1.20 - 1.39						2					2
TOTAL	1	22	66	229	264	189	104	52	11	6	944

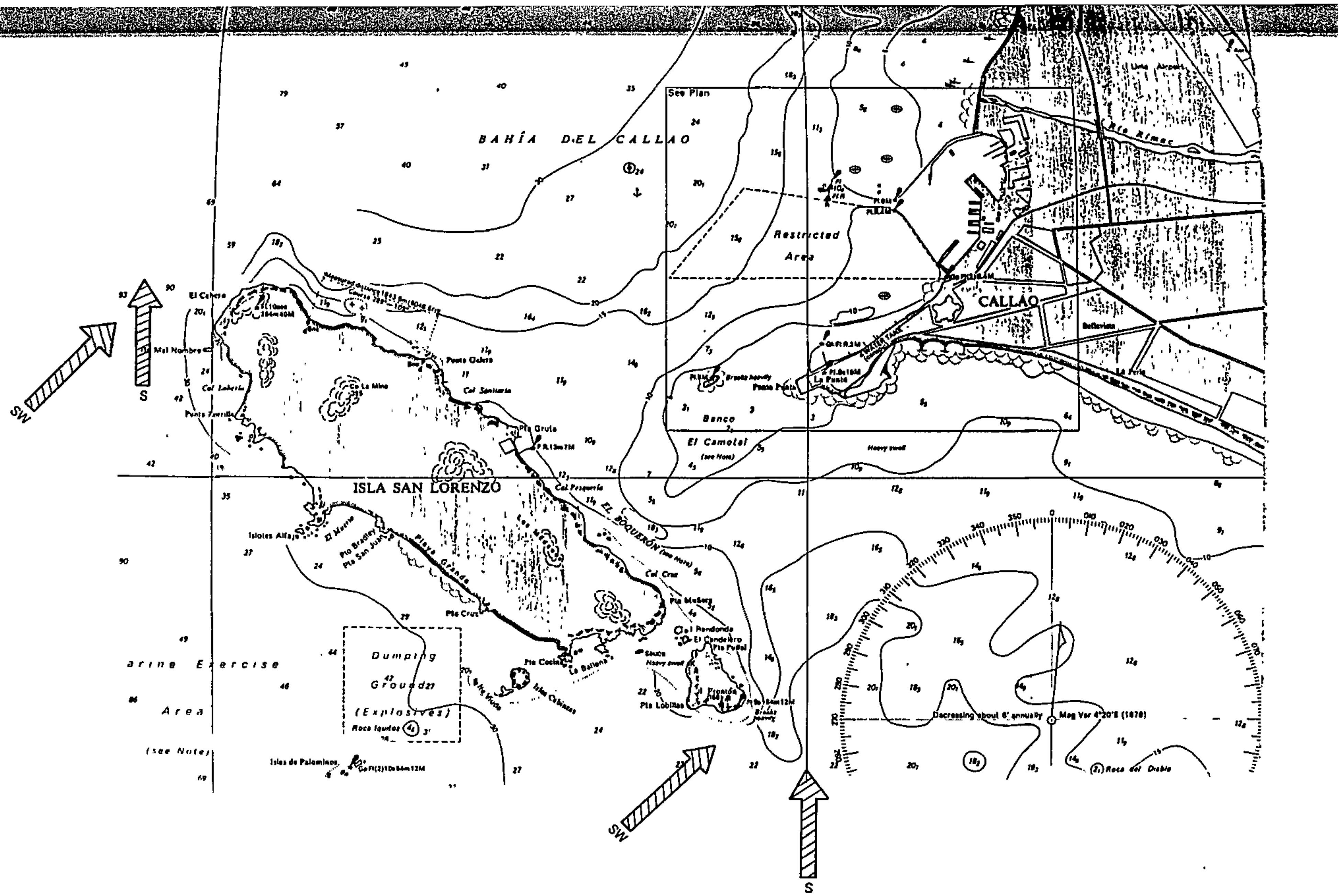


Fig. 3-3 San Lorenzo Island, Callao Port and Directions of Prevailing Waves

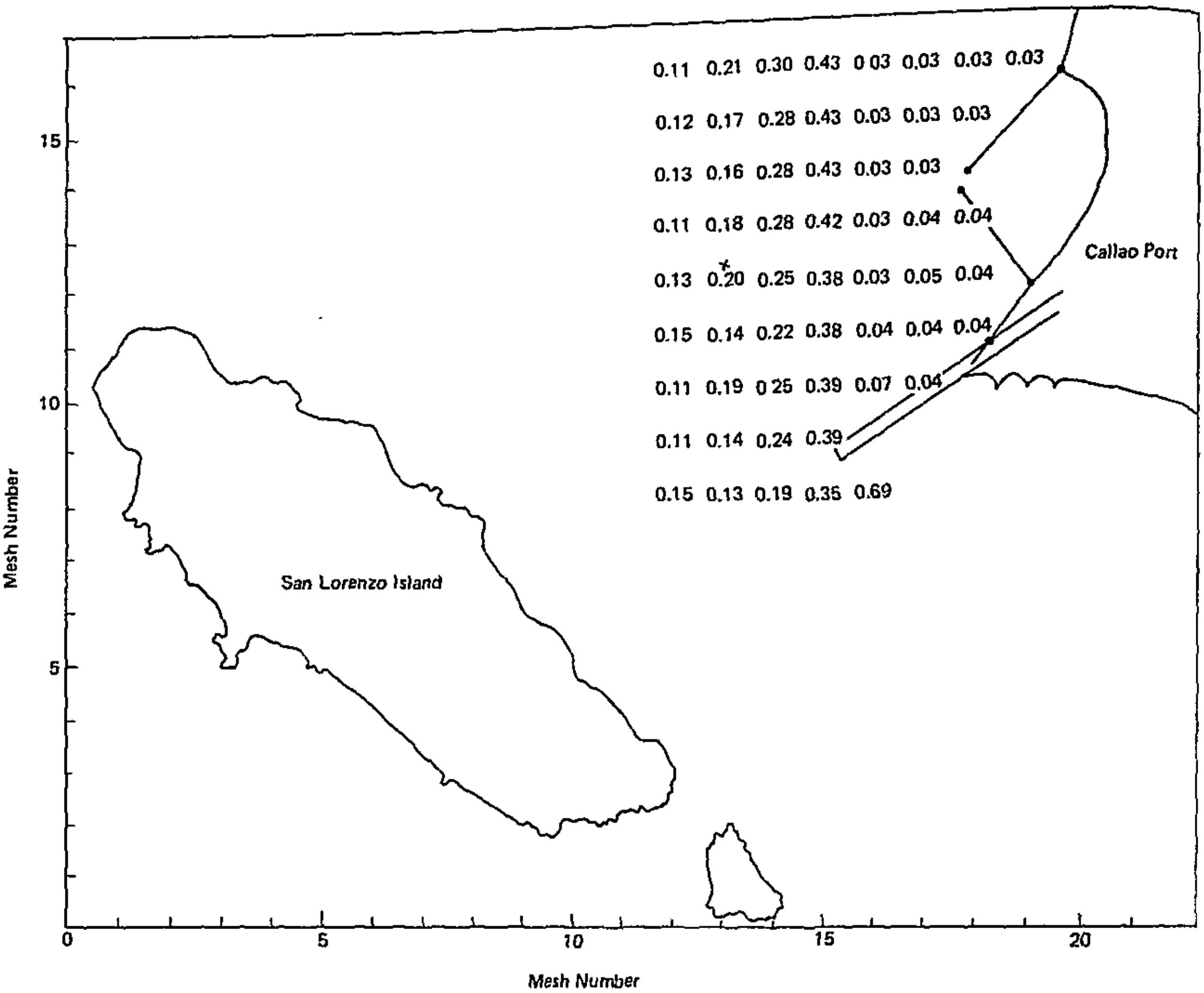


Fig. 3-4 Distribution of Diffraction Coefficients Around Callao Port

(Wave Direction S, Period 14 Sec.)

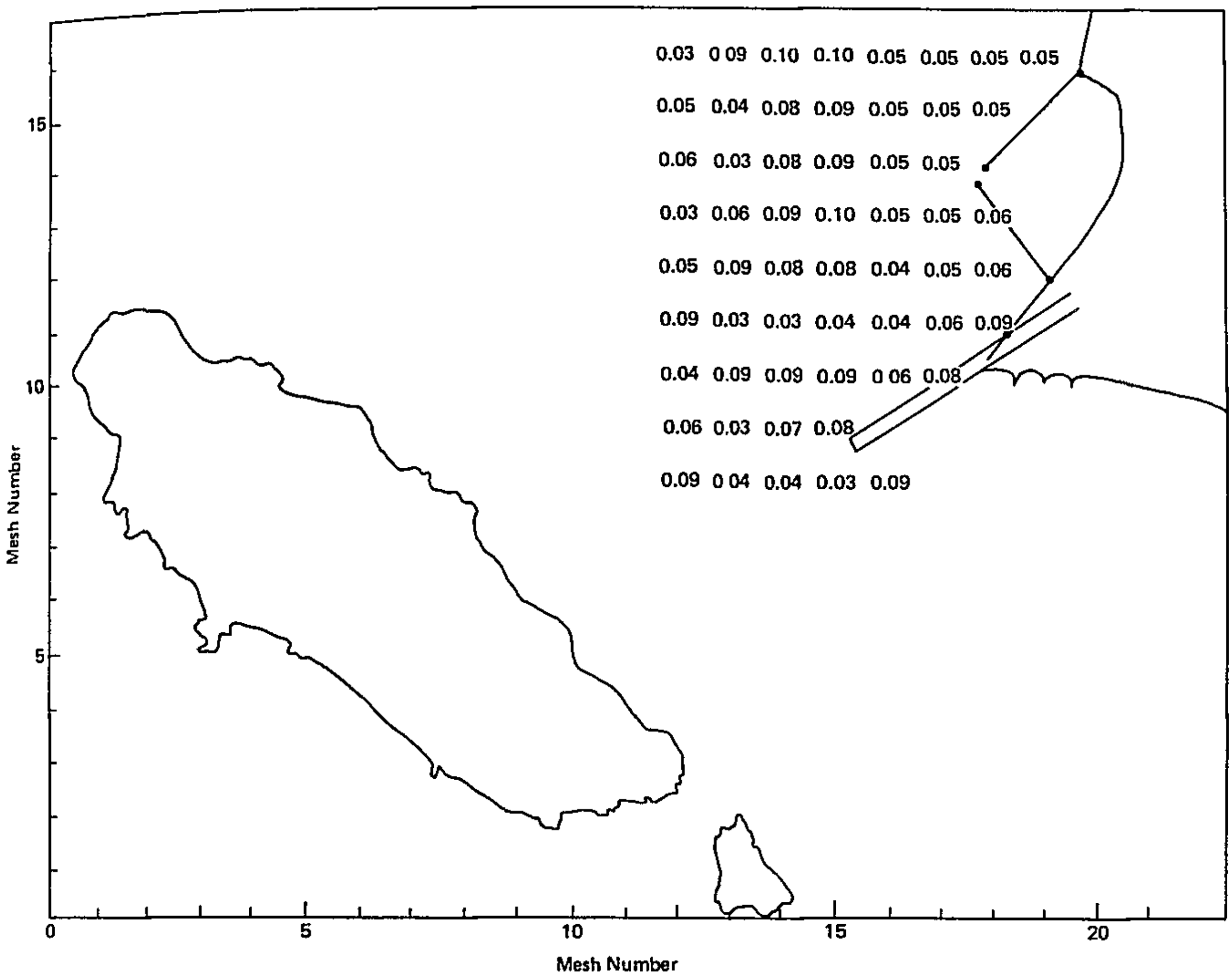


Fig. 3-5 Distribution of Diffraction Coefficients Around Callao Port
(Wave Direction SW, Period 14 Sec.)

3-2-2 Current

Fig. 3-6 shows the result of current observation done by the Dirección de Hidrografia y Navegación. According to this, the current runs to the south and north and the maximum current speed is 0.08 m/s.

Fig. 3-7 shows the result of current observation done by the Japanese Study Team. The vectors connecting 0 point with points on the hodograph give current velocities and directions. "Upper Layer" means the observation was done at 2 m below the water surface and "Lower Layer" shows it was done at 2 m above the sea bottom.

The following can be noted.

① There is northward permanent uni-directional current at each observation point. This is a current which is influenced by the northward ocean current off Peru.

② The maximum velocity is approximately 15 cm/sec.

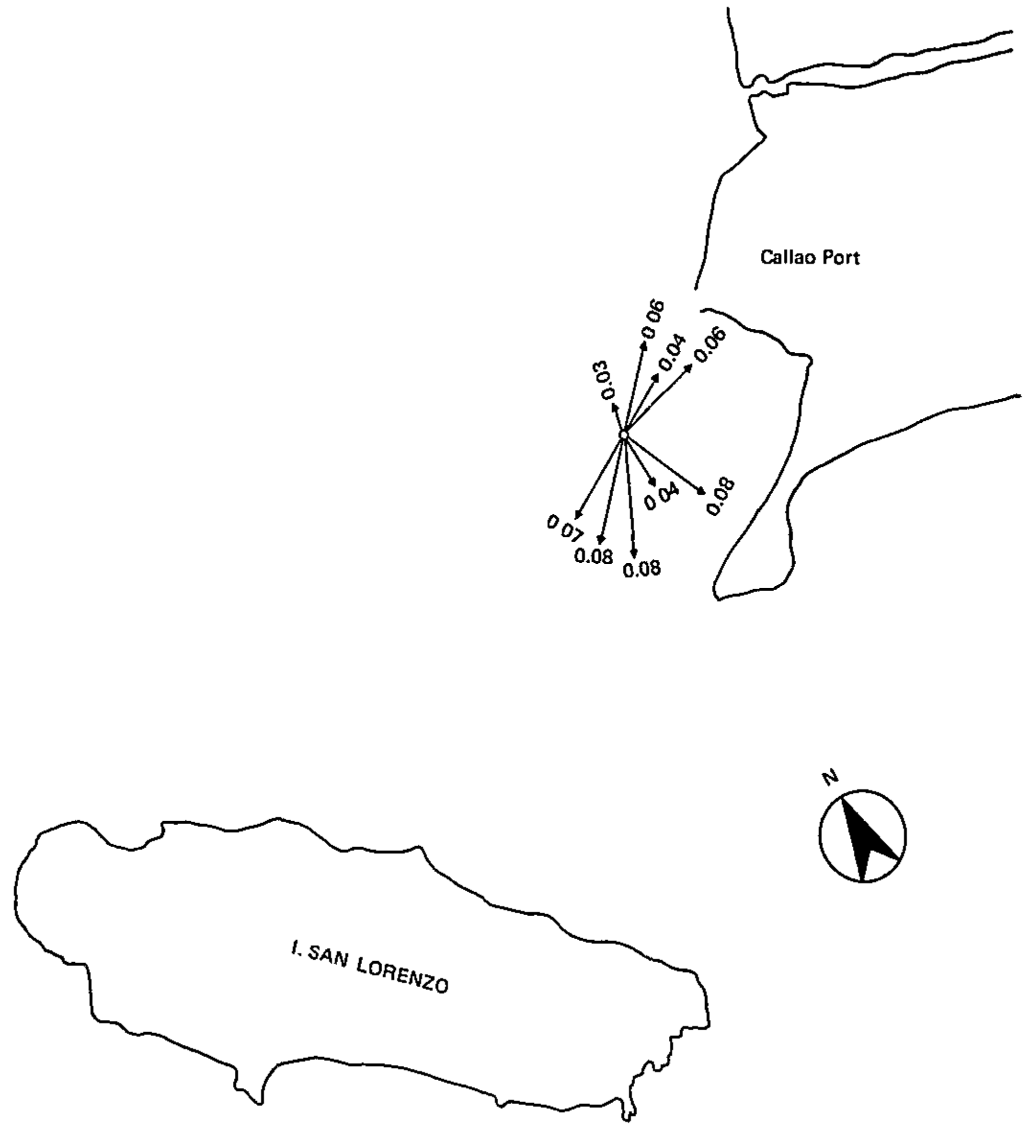


Fig. 3-6 Current Off The Port of Callao (Unit m/s)

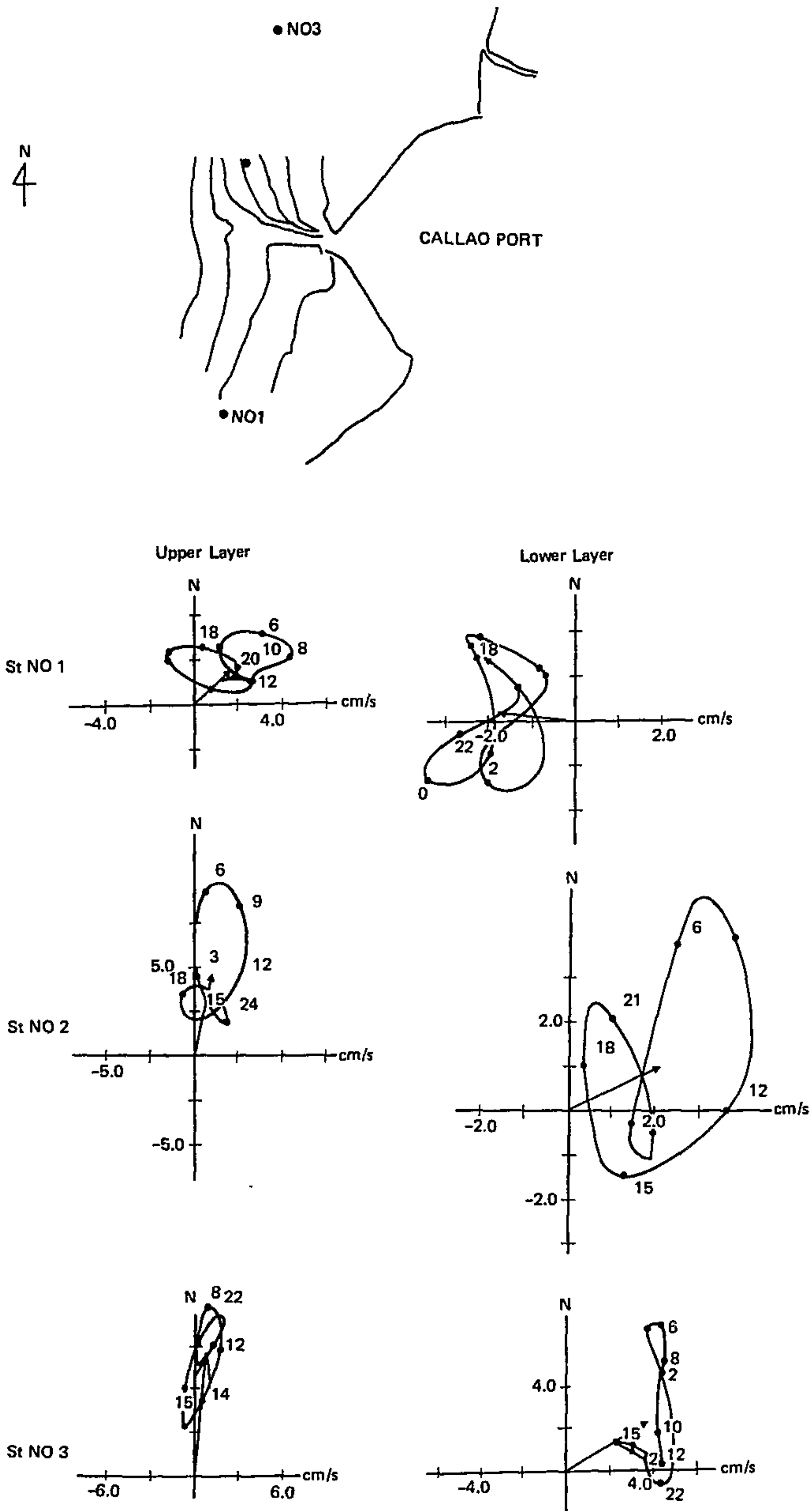


Fig. 3-7 Current Observed by The Japanese Study Team in 1982

3-2-3 Tide

According to ENAPU, HWL at Callao Port is 0.9 m and LWL is −0.05 m. On the other hand, the American chart shows LWL 0.0 m, MSL +0.518 m and HWL +1.036 m.

The datum level for the survey chart made by the Japanese Study Team is same as LWL of the American chart. HWL is a factor which influences the crown height of the wharves, and the difference in HWL of 0.136 between ENAPU's level and the American chart level is too small to affect this.

3-2-4 Coastal topography and bottom sediments

(1) Coastal Topography

As discussed in the section 3-2-1 "Waves", the predominant deepwater waves reaching the coast around Callao are swells from the S and SW directions. Therefore, the waves hitting the coast have directions inclining towards south and they create the littoral sand drift from south to north which generally appears on the coast of Peru.

Callao and Lima areas are situated on the tombolo formed behind San Lorenzo Island. This tombolo and the related sea bottom topography seem to have been created by sand and mud shifted from the unsheltered area to the area sheltered by San Lorenzo Island over a period of many years.

The sea bottom topography constructing a part of this tombolo is a shoal off La Punta extending toward San Lorenzo Island. Off the rivermouth of the Rio Rimac, sediments discharged from the river are deposited and the shoal extends in a circular shape.

(2) Bottom sediments

The results of the bottom sediments survey done by the Japanese Study Team are given in Figs. 3-8 and 3-9.

Fig. 3-8 gives the distribution of median diameter d_{50} and Fig. 3-9 gives the distribution of sieve analysis coefficient So. On the northern coast of the north breakwater, sediments are sampled near both the low tide mark and the high tide mark.

The former is shown on the sea side of the shoreline and the latter is on the land side of the shoreline in Figs. 3-8 and 3-9.

The following are noted as the characteristics of bottom sediments around Callao Port.

① Uniform fine sands make up the beach on the northside of the north breakwater.

② Off the Rio Rimack, bottom sediments are constituted by comparatively course uniform silt ($d_{50} \doteqdot 0.05$ mm).

③ Bottom sediments near the approach channel and inside the port are constituted by fine silt ($d_{50} \doteqdot 0.005$ mm) with large sieve analysis coefficient (comparatively wide distribution range).

④ Bottom sediments to the south of the south breakwater are silt, and d_{50} there is somewhat larger than d_{50} of bottom sediments near the approach channel.

Fig. 3-10 shows the distribution of types of bottom sediments extending south from Callao Port to San Lorenzo Island which was obtained from the Dirección de Hidrografia y Navegación de la Marina. The following are noted:

① Bottom sediments to the southwest of Callao Port extending from Callao Port to San Lorenzo Island are mud, known as Black Mud. This conforms with the data given in Figs. 3-8 and 3-9. Sediments on the beach between Callao Port and La Punta are gravel.

② Bottom sediments in the area between La Punta and San Lorenzo Island are comprised of gravel, mud, muddy sand and sand, etc.

③ The waters east of La Punta are not sheltered by the island and bottom sediments there are comprised of sand and muddy sand.

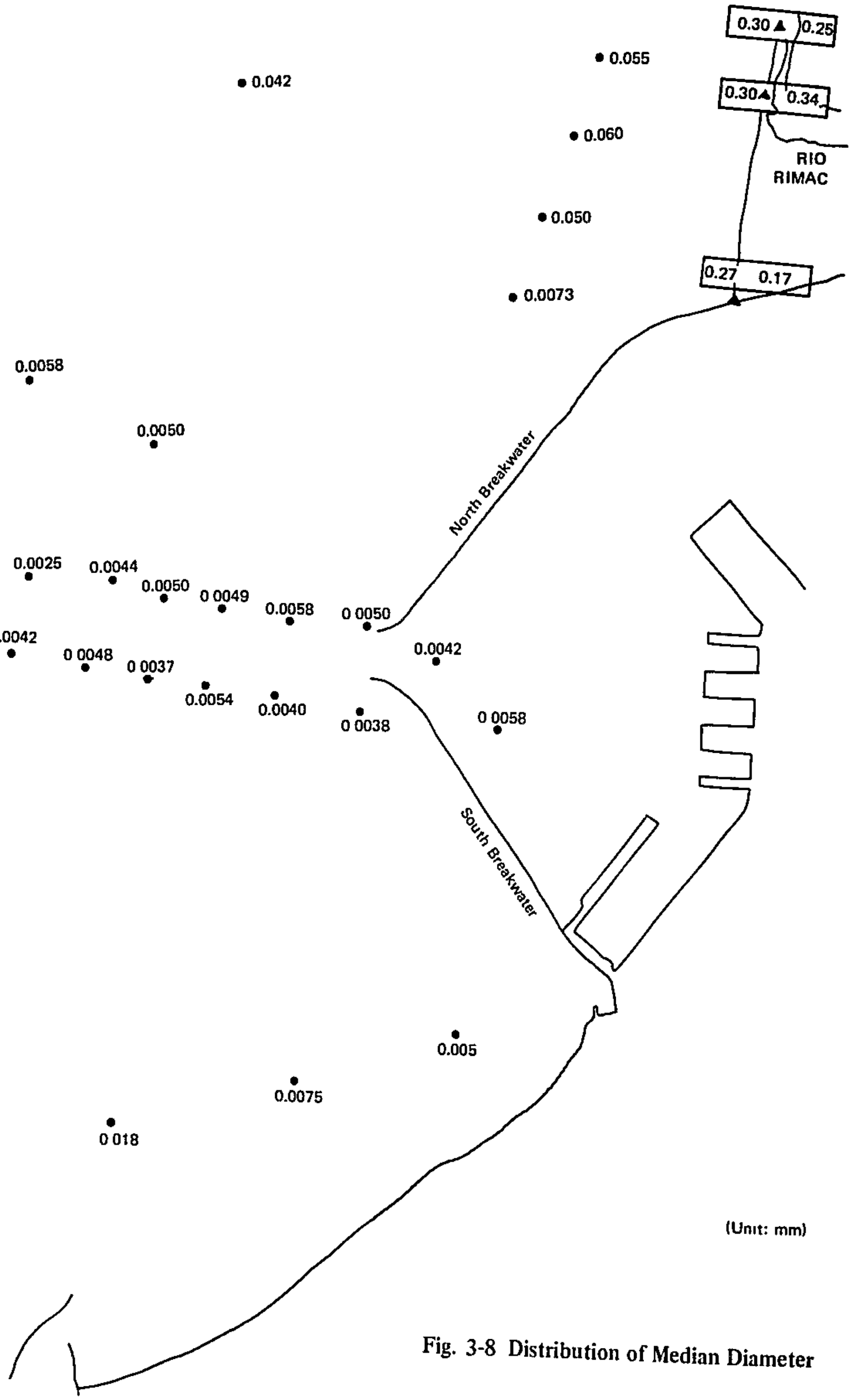


Fig. 3-8 Distribution of Median Diameter

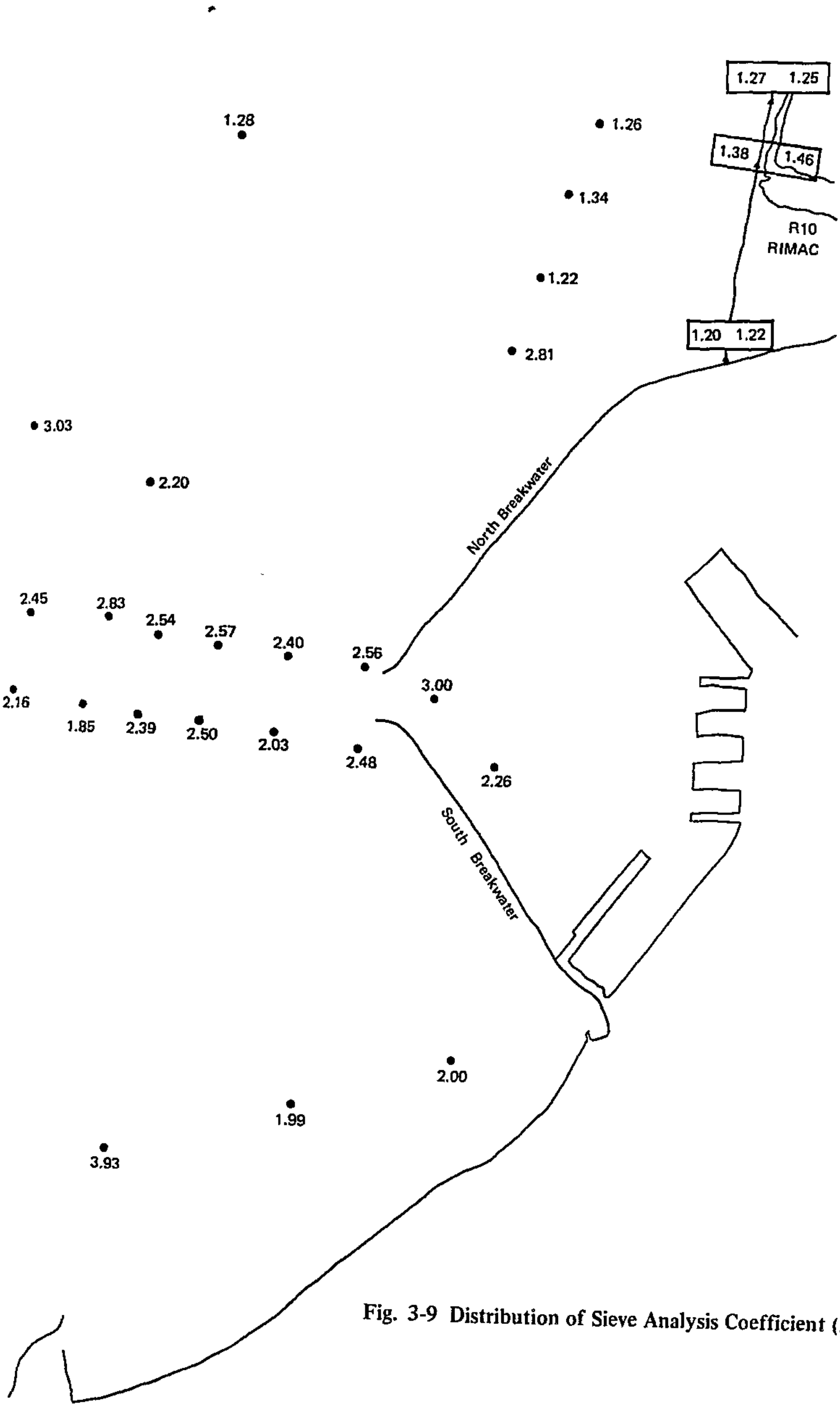


Fig. 3-9 Distribution of Sieve Analysis Coefficient (So).

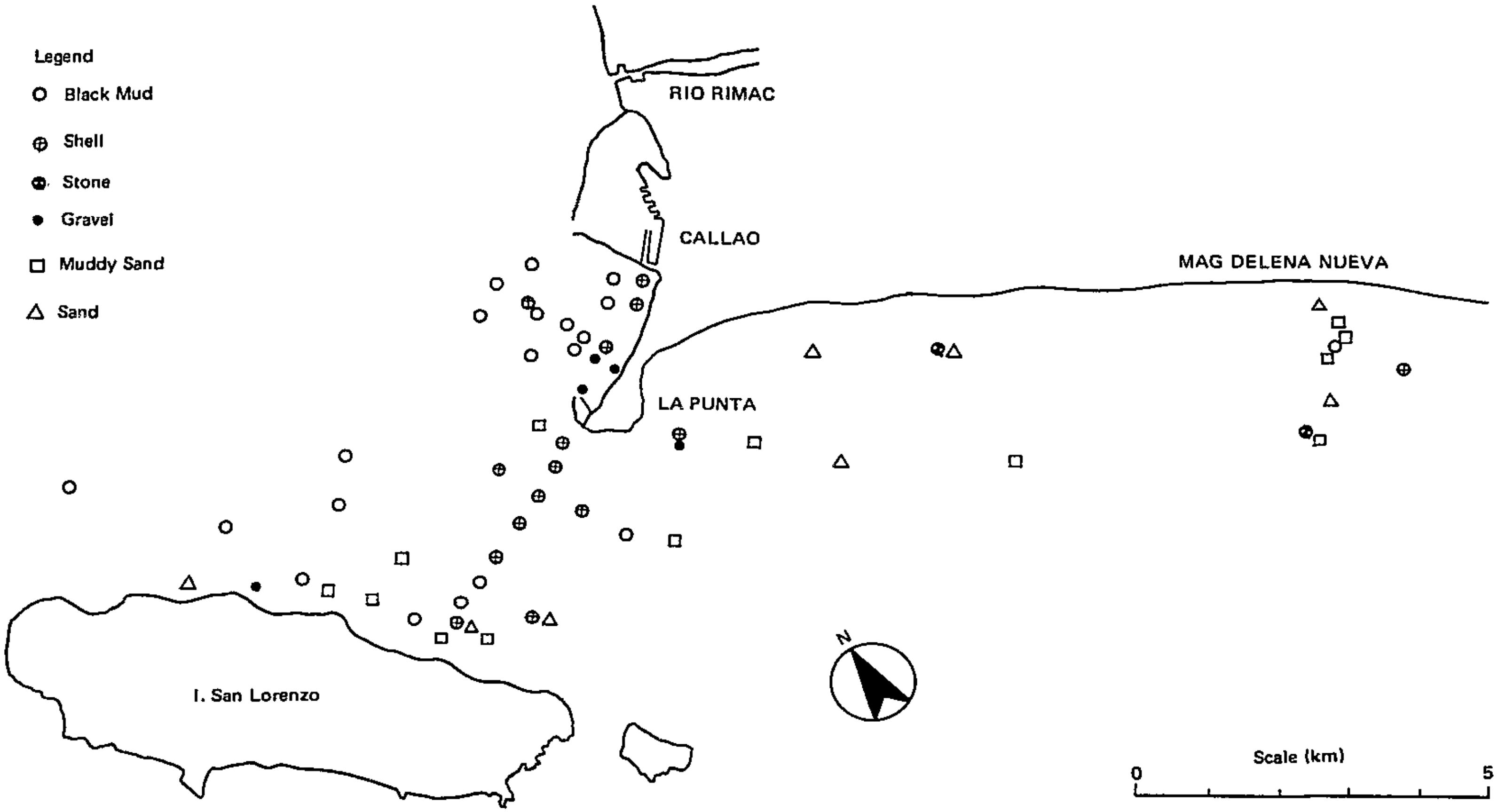


Fig. 3-10 Distribution of Bottom Sediments

3-3 Soil Conditions

3-3-1 Soil Survey Data

Soil surveys carried out by ENAPU in 1923 and 1956 cover nearly the entire area of Callao Port, and the area between wharf No. 9 and wharf No. 10 was surveyed in 1970. However, sufficient data could not be obtained from the survey in 1923 to determine the soil properties. Fig. 3-11 shows locations of test borings in 1956. The penetration test is a method where the number of blows of a 300 lb hammer falling 14 inches required to drive split samplers of 2 or 3 inches diameter by 6 inches into the soil is counted. Soil characteristics are described, but the data of laboratory tests were not available. Boring logs of the soil survey are shown in Figs. 3-12 ~ 3-17.

Fig. 3-18 shows locations of soil survey in 1970. The survey method is based on A.S.T.M.. Results of standard penetration tests, grain size distribution tests, liquid limit, and plastic limit are recorded. Figs. 3-19 ~ 3-21 show the above data.

The above soil survey data gives merely an outline of the soil layers and is not sufficient for design purposes.

In 1982, the Japanese study Team carried out a soil survey for the port development project at locations indicated in Fig. 3-22. The details are reported in the "Natural Condition Survey Report for the Study on the Development Project for the Port of Callao" prepared in December, 1982.

3-3-2 Outline of Strata

The outline of the strata was estimated mainly based on the soil survey carried out in 1982. In the area between wharf No. 9 and wharf No. 10, and the area around the north breakwater, the strata were estimated from the data of the soil surveys carried out in 1956 and 1970.

The soil profiles are shown in Fig. 3-23 ~ 3-28.

The soil around the port of Callao is composed of Mesozoic sedimentary rocks covered with a diluvium and alluvium of the Quarternary period of the Cenozoic era. The Mesozoic sedimentary rocks are exposed on the hills and cliffs. The upper layer of the alluvium (Au) is very soft organic clay (N=0), with a thickness of 2 m at the seaward end of the wharf No. 5 and about 9 m around the south breakwater.

The lower alluvium stratum (Al) is composed of silty clay and silt layers containing more sand than the upper layers. There is a thin layer of fine sand in this Al-layer. The layers also are very soft (N=0~1). The thickness of the stratum is about 9 m at P-1 and P-6 on the sea side, decreasing towards the shore side, reaching about 3 m at P-7.

Under the above mentioned alluvial stratum, there is a diluvium stratum of sand and gravel (N>50), which will be the bearing stratum of the structures. This stratum is inclining, deeper on the offshore side.

According to the soil profile shown in Fig. 3-24 this stratum is found at a depth of −10 m at PS-3 (in the survey carried out in 1970), at a depth of −26 m at P-6. The same tendency is found on the outer side of the port. Fig. 3-29 shows the distribution of the depths of the bearing strata.

According to the data at Nos. 23, 24 and 25 borings of the soil survey is 1956, the bearing stratum is found at about −16 m near the shore-side end of the north breakwater, becoming deeper on the offshore side, and −24 m at No. 23. There is a very soft clayey layer between this bearing stratum and the sea bottom surface.

The presence of this soft alluvium at the project site causes a problem. For the construction of wharves and revetments it is advisable to replace this stratum with sand of good quality or to improve the bearing stratum. At the reclamation site of the container yard, it is necessary to make a plan for dealing with ground subsidence because the project is an urgent one and the maintenance after the completion should be as easy as possible.

At the grain berth site between wharf Nos. 9 and 10, a soil survey was carried out in 1970.

The soil profiles are shown in Figs. 3-19 ~ 3-21.

Fig. 3-19 shows the stratum along the proposed face line of the wharf. The stratum is divided into 4 layers. The upper clay layer is very soft, located between the sea bottom and the −10 m depth. At PS-1 the layer is locally deep, being at −13 m. The lower clay layer is of clay including more sand, located at −13 m to −14.5 m of depth, between PS-1 and wharf No. 9. This layer does not exist between PS-1 and wharf No. 10. The stratum beneath the above mentioned layer is a sand layer of medium density touching the bearing stratum.

The thickness is about 1 to 3 m.

The bearing stratum of sand and gravel is usually found at −16 m of depth, but it is at a −11 m depth near wharf No. 10. The stone-pitched quaywall of wharf No. 10 is supported by this stratum.

According to Figs. 3-20 ~ 3-21 these layers exist along the line parallel to wharf No. 9.

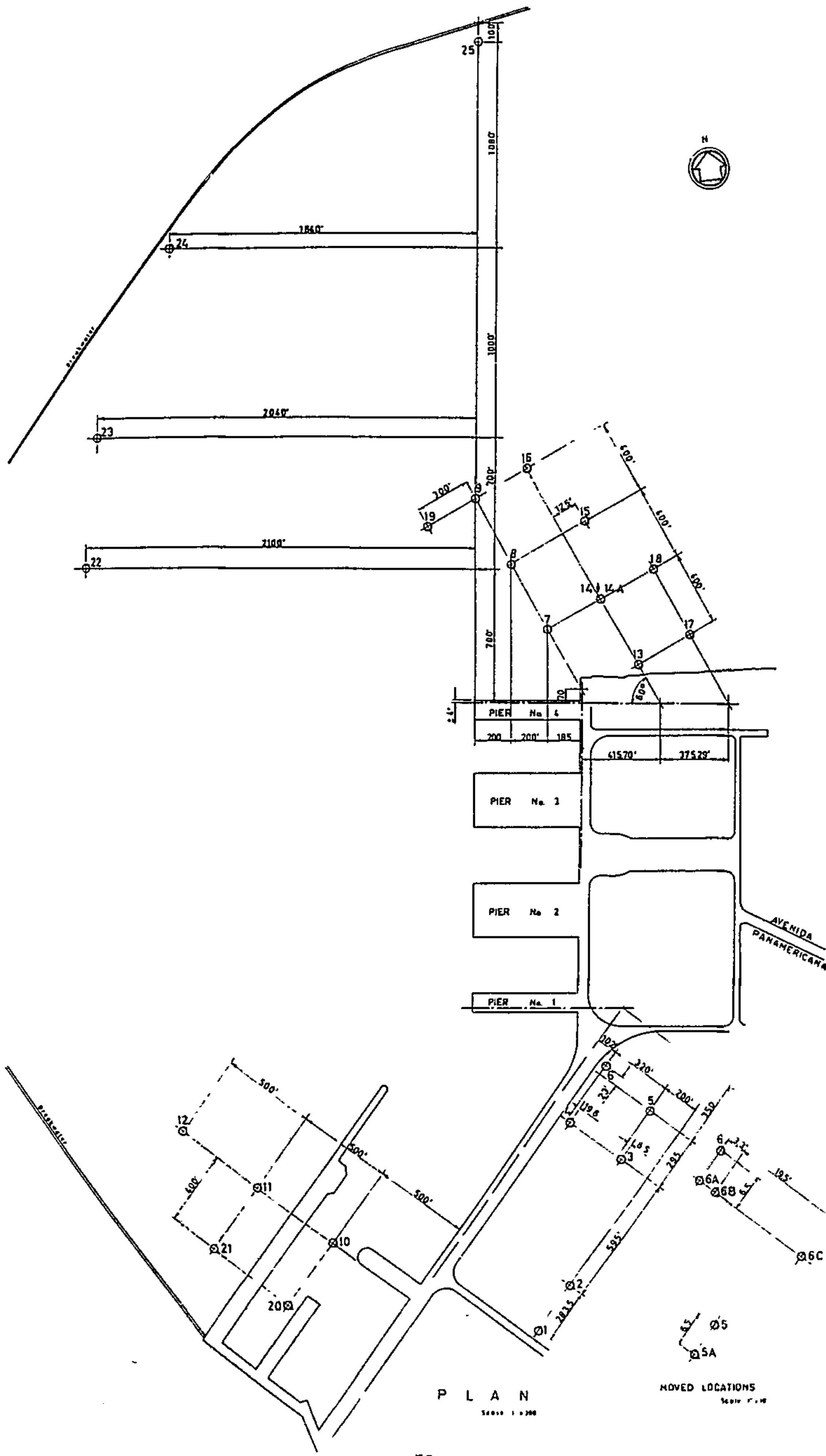


Fig. 3-11 LOCATION OF BORING (By ENAPU in 1956)

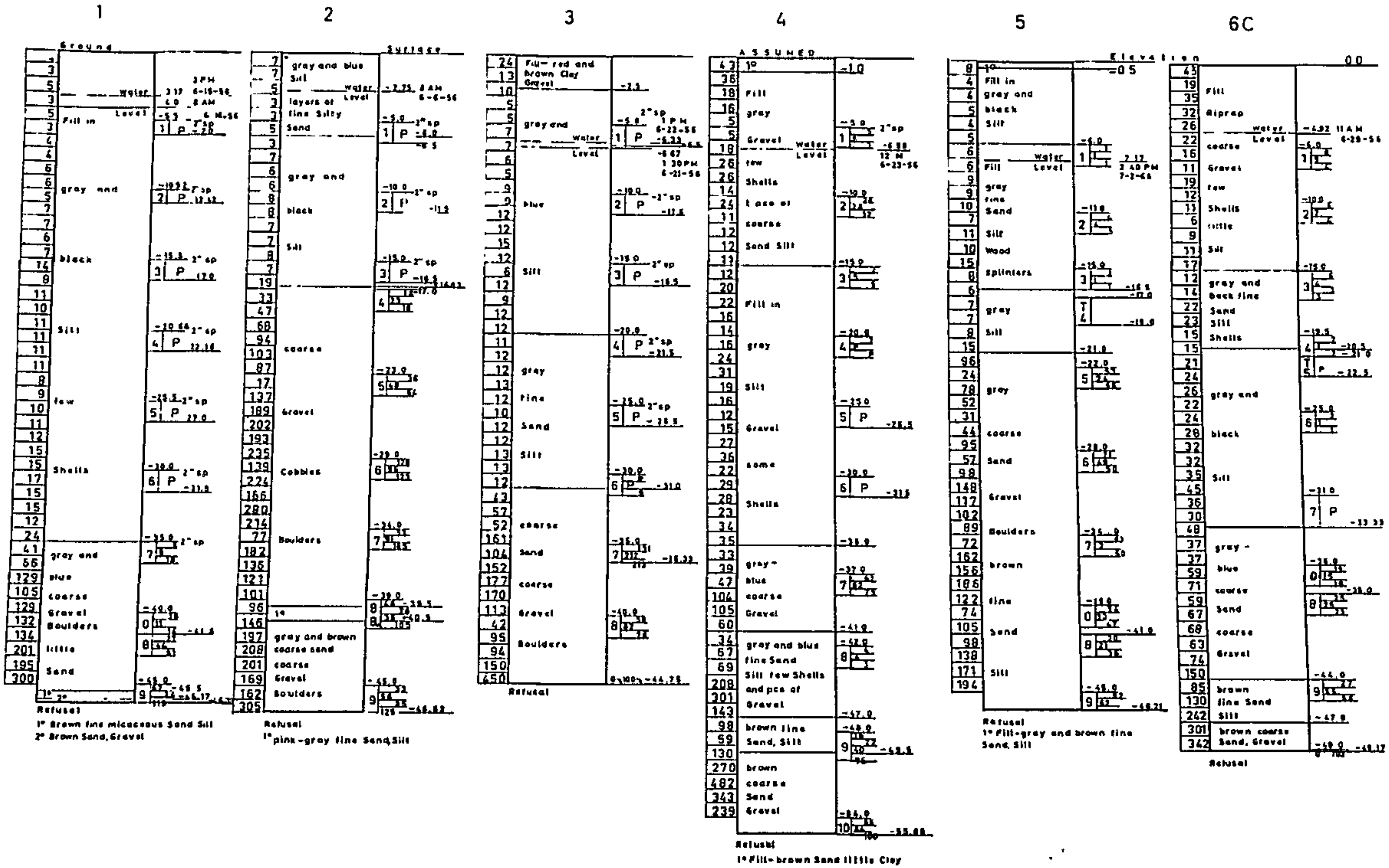
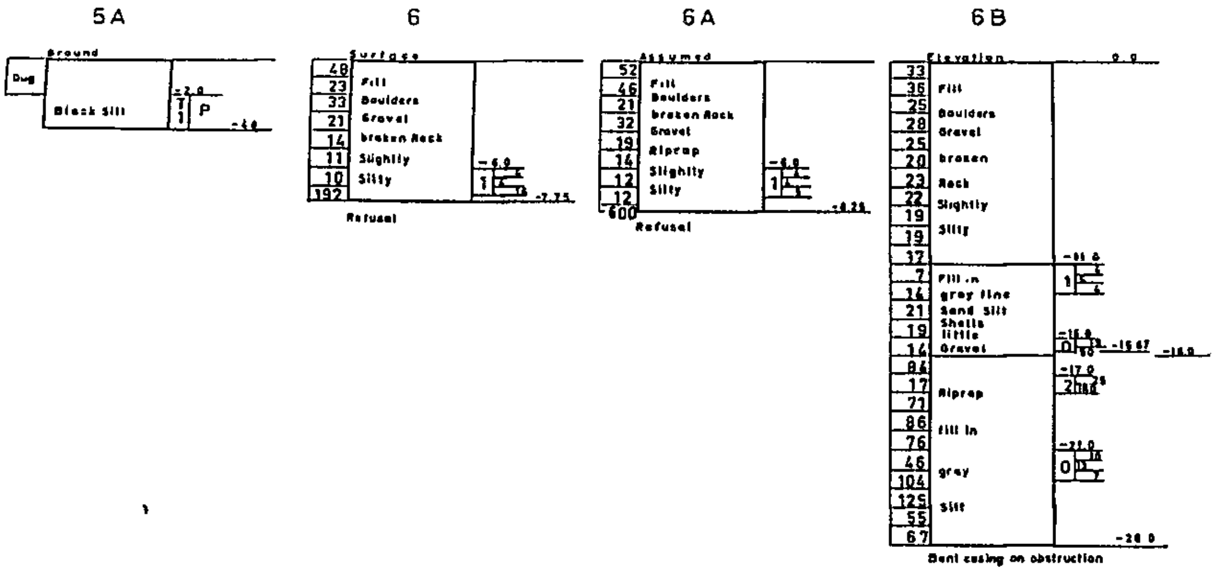


Fig. 3-12 BORING LOG
(By ENAPU in 1956)



ACTUAL GROUND ELEVATION above M.L.W		
BORING No.	ELEVATION IN FEET	ELEVATION IN METERS
1	+ 5.16	+ 1.579
2	+ 5.25	+ 1.601
3	+ 9.16	+ 2.800
4	+ 9.49	+ 2.890
5	+ 9.49	+ 2.880
5A	+ 9.45	+ 2.880
6	+ 9.38	+ 2.860
6A	+ 9.38	+ 2.860
6B	+ 9.38	+ 2.860
6C	+ 9.38	+ 2.860

NOTES

A is elevation of botton of sampler at start of penetration

B is number of sample "O" here, no sample recovered "T," piston sampler used

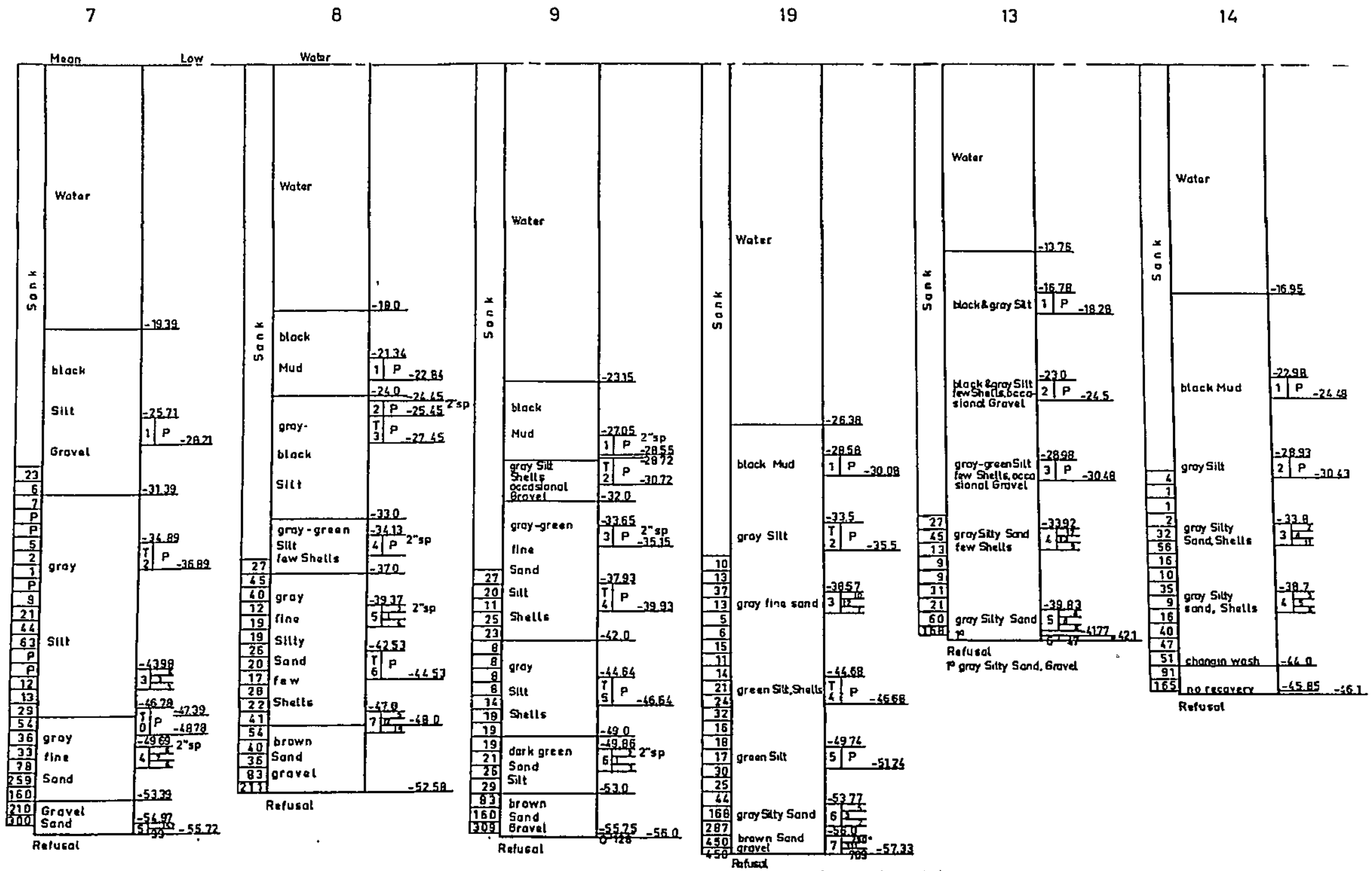
C is number of blows of 300-lb hammer falling 14 inches taken to drive 3- in split sampler (unless tube sample is shown in space B or notation "2"sp" after sample marks use of 2-in split sampler) All penetration increments are 6 inches except those bottom ones where bottom elevation is given and shows drive to have stopped short of 6-inches When weight of rods and/or hammer and crew caused penetration, and when tube of piston sampler was pressed in, "P" is shown here For all samples where no driving at all was done a bottom elevation shows

At left of sections is number of blows of 300-lb hammer falling 20 inches taken to drive 3-1/2-in casing each foot, and odd distance shown to refusal

All land borings and attempts this sheet, water borings 11. As boringns were added and numbers are not in sequence, sections arranged as grouped in plan

ELEVATION IS INDICATED IN FEET

Fig. 3-13 BORING LOG
(By ENAPU in 1956)



*after failure of 3"sampler to penetrate and recover sample, open-end A-rod was used. After taking sample casing was driven to -57.33, where 200 additional blows on rods, also on casing, caused no further penetration.

Fig. 3-14 BORING LOG
(By ENAPU in 1956)

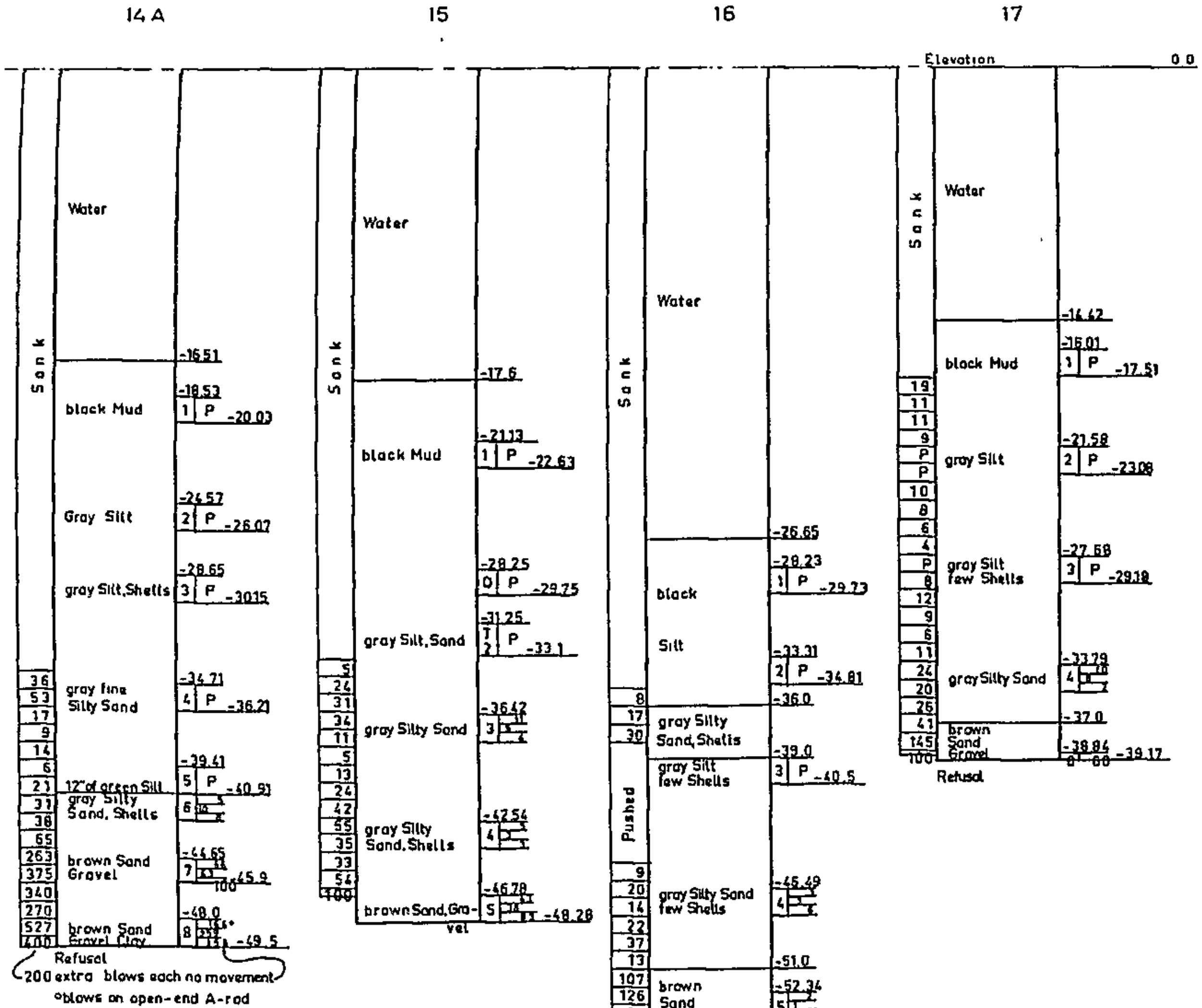


Fig. 3-15 BORING LOG
(By ENAPU in 1956)

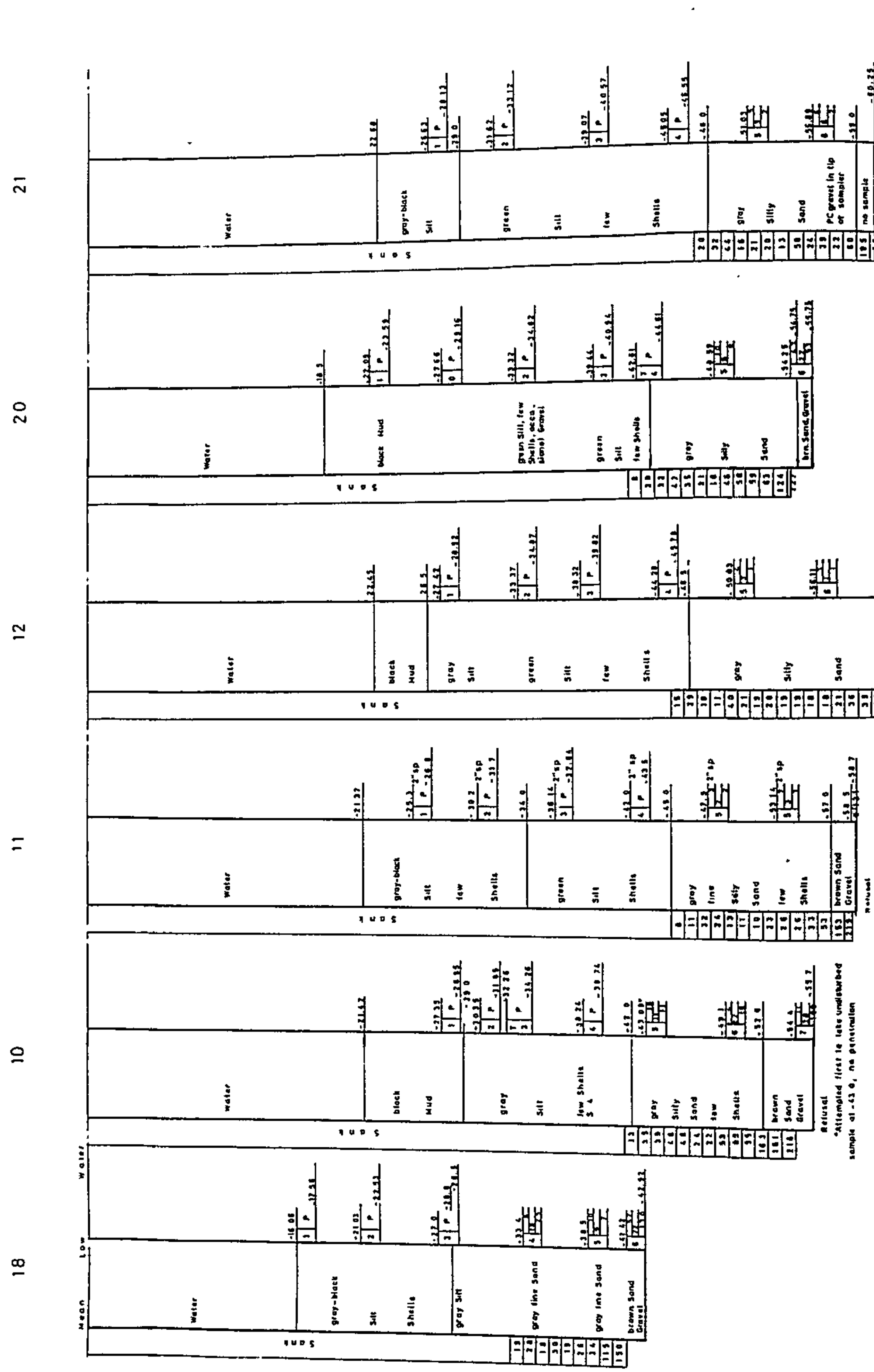


Fig. 3-16 BORING LOG
(By ENAPU in 1956)

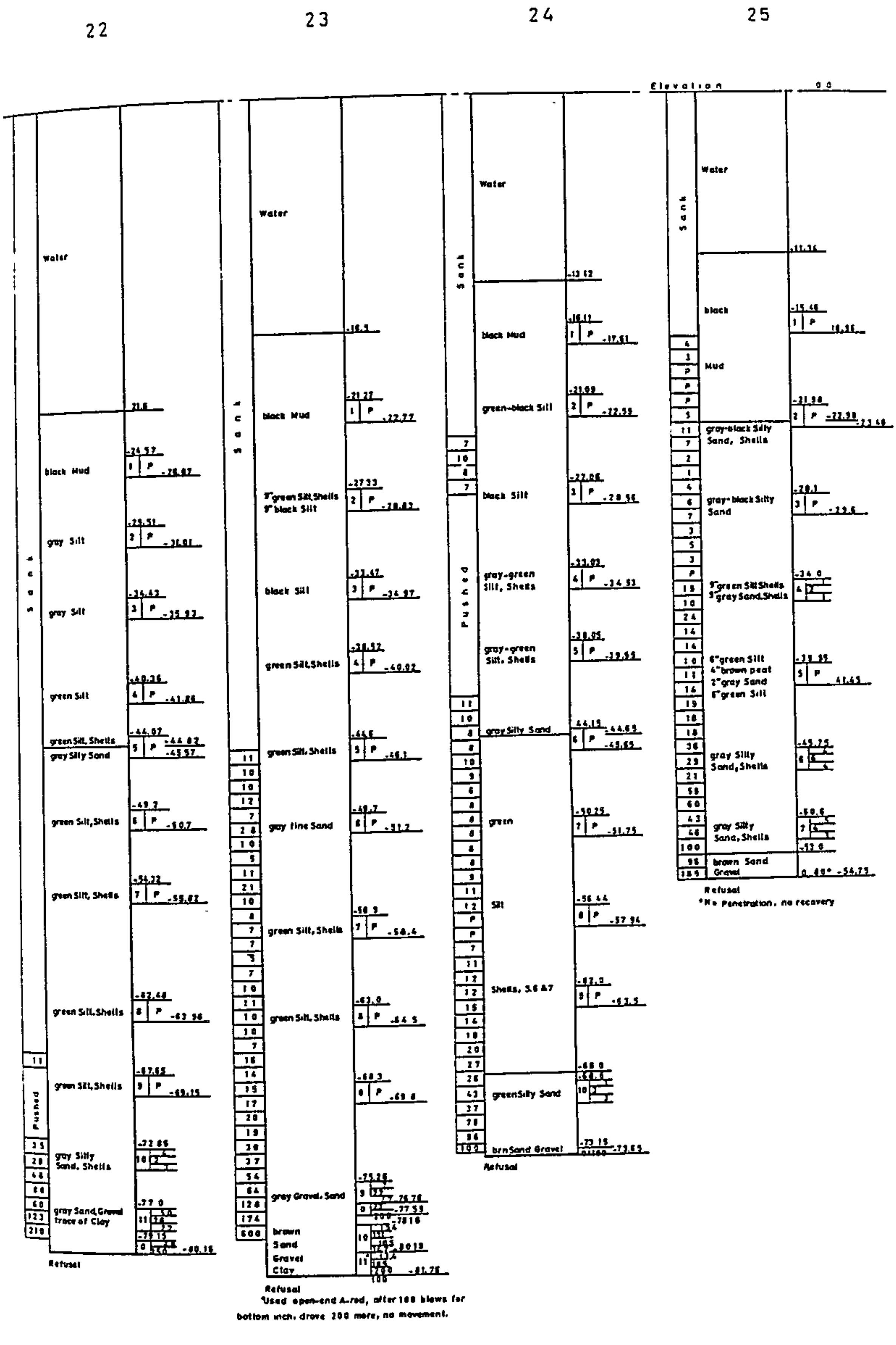


Fig. 3-17 BORING LOG
(By ENAPU in 1956)

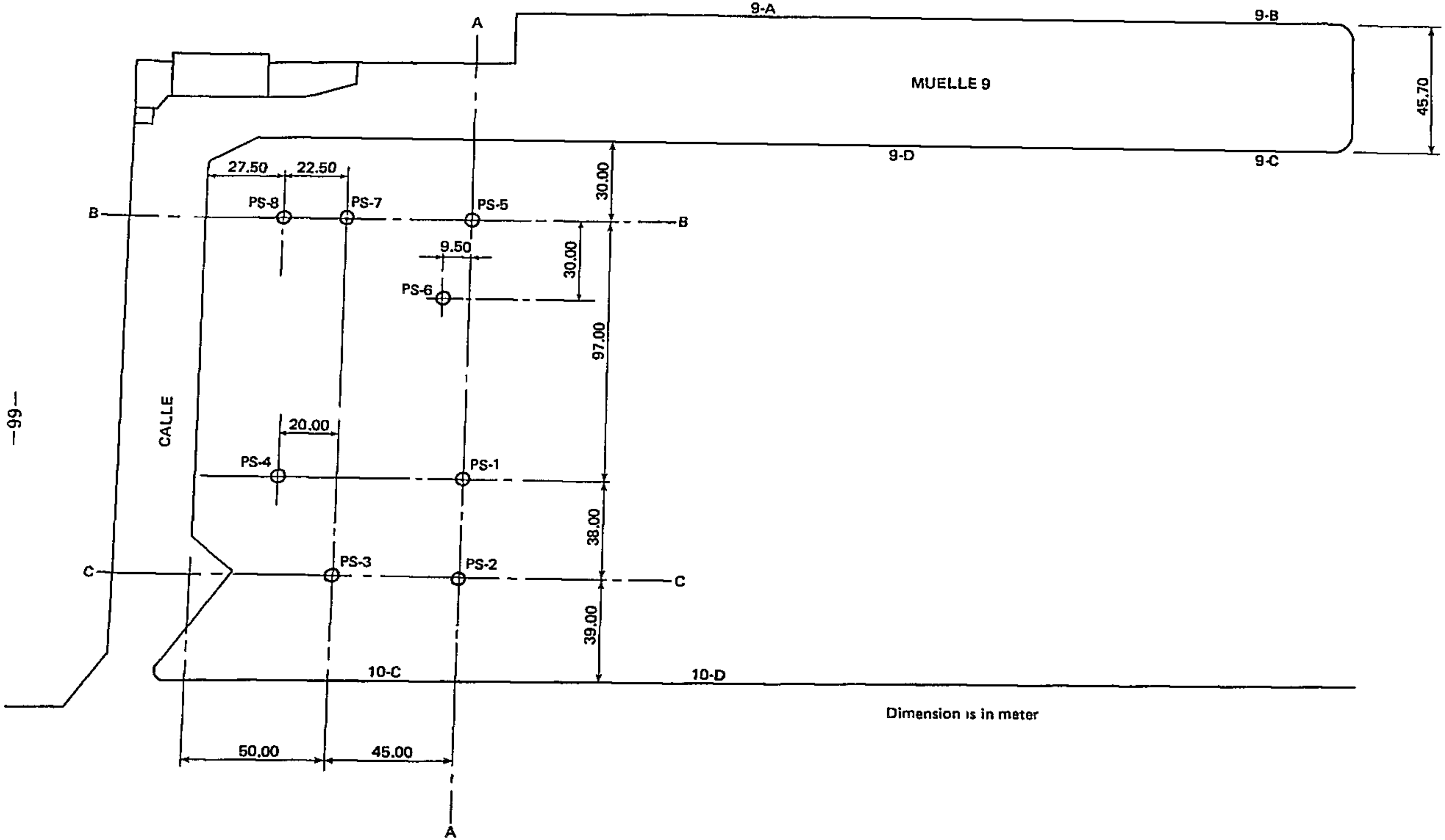


Fig. 3-18 Location of Boring (Carried out by ENAPU In 1970)

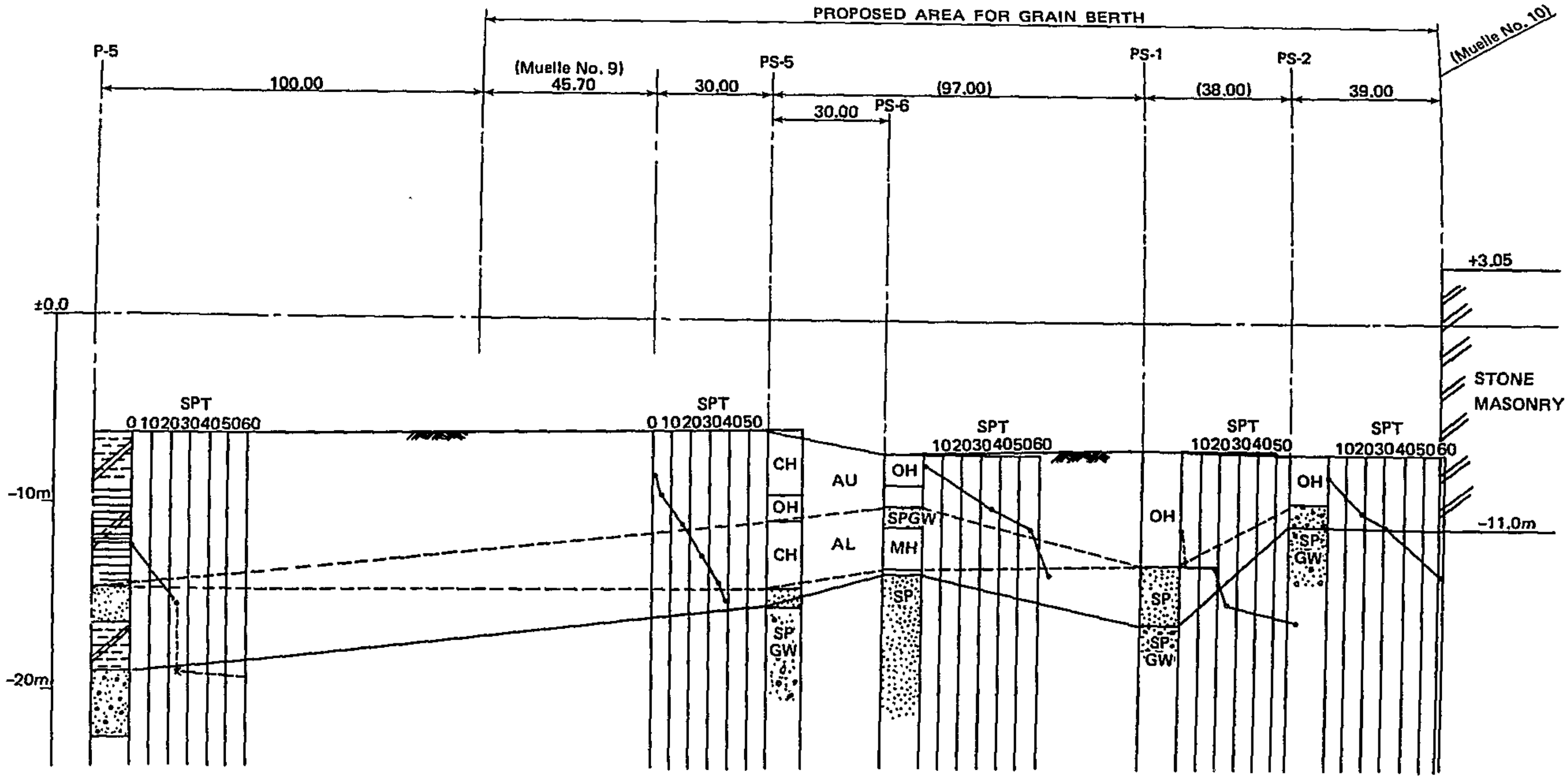


Fig. 3-19 Soil Layer Differentiation Profile A-A for Grain Berth

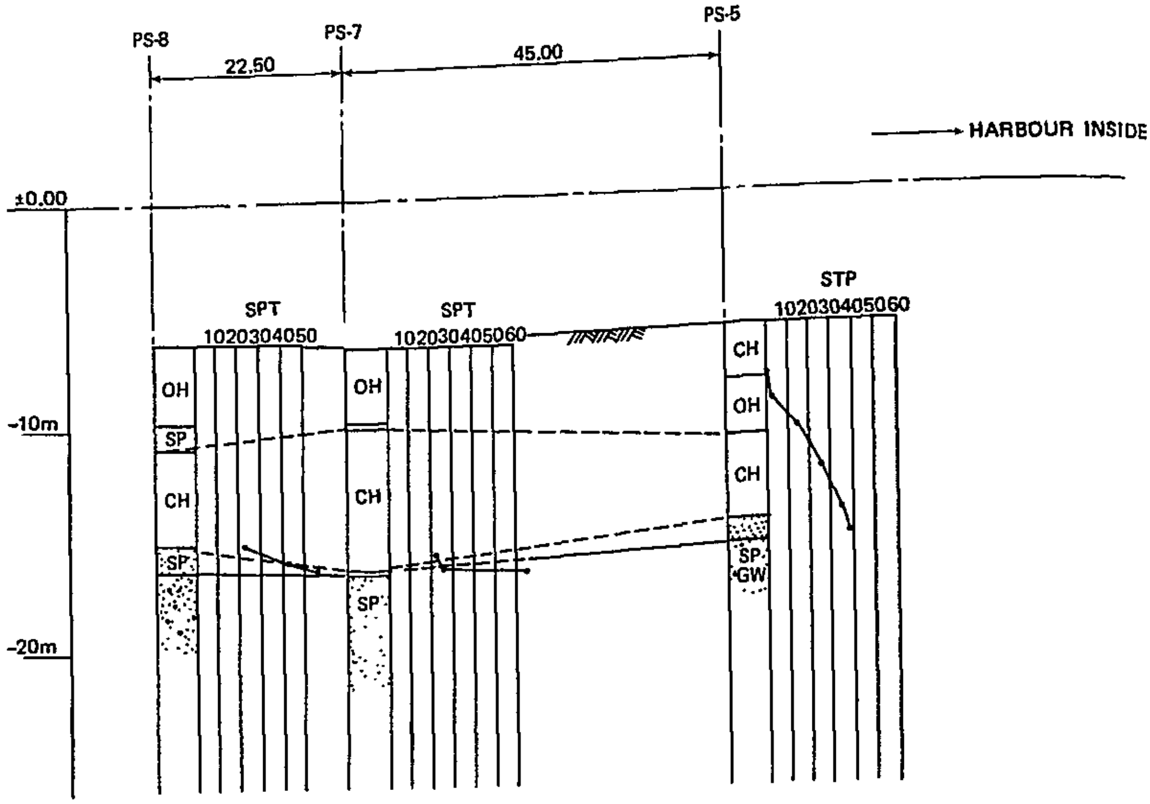


Fig. 3-20 Soil Layer Differentiation Profile B-B for Grain Berth

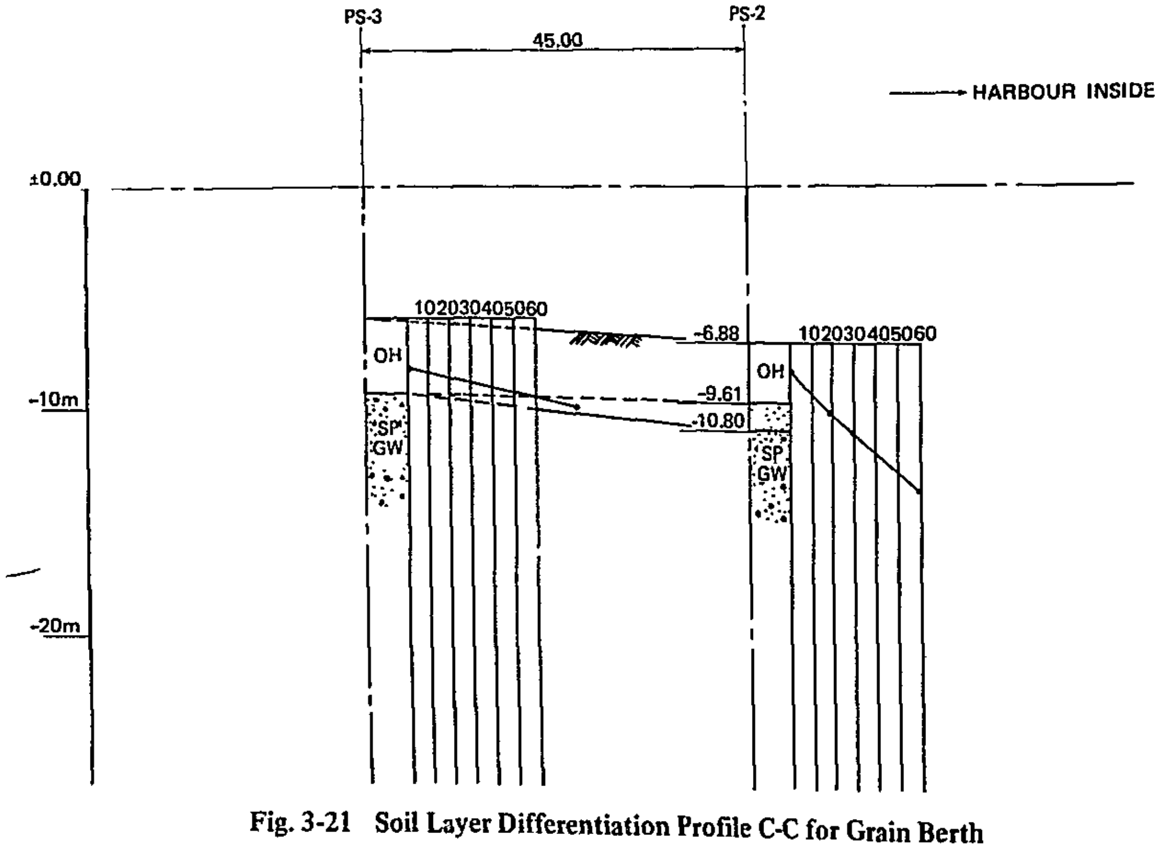


Fig. 3-21 Soil Layer Differentiation Profile C-C for Grain Berth

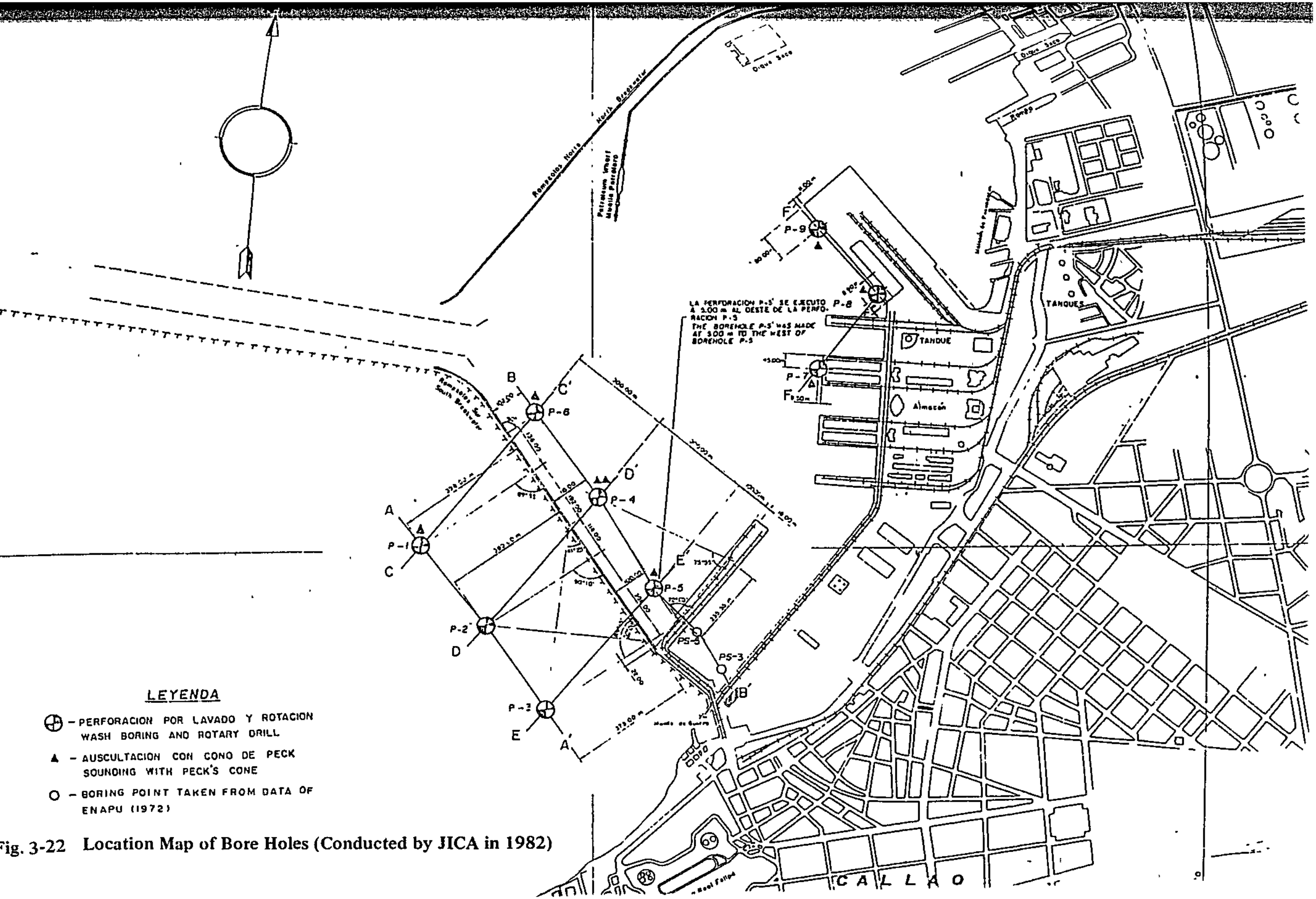


Fig. 3-22 Location Map of Bore Holes (Conducted by JICA in 1982)

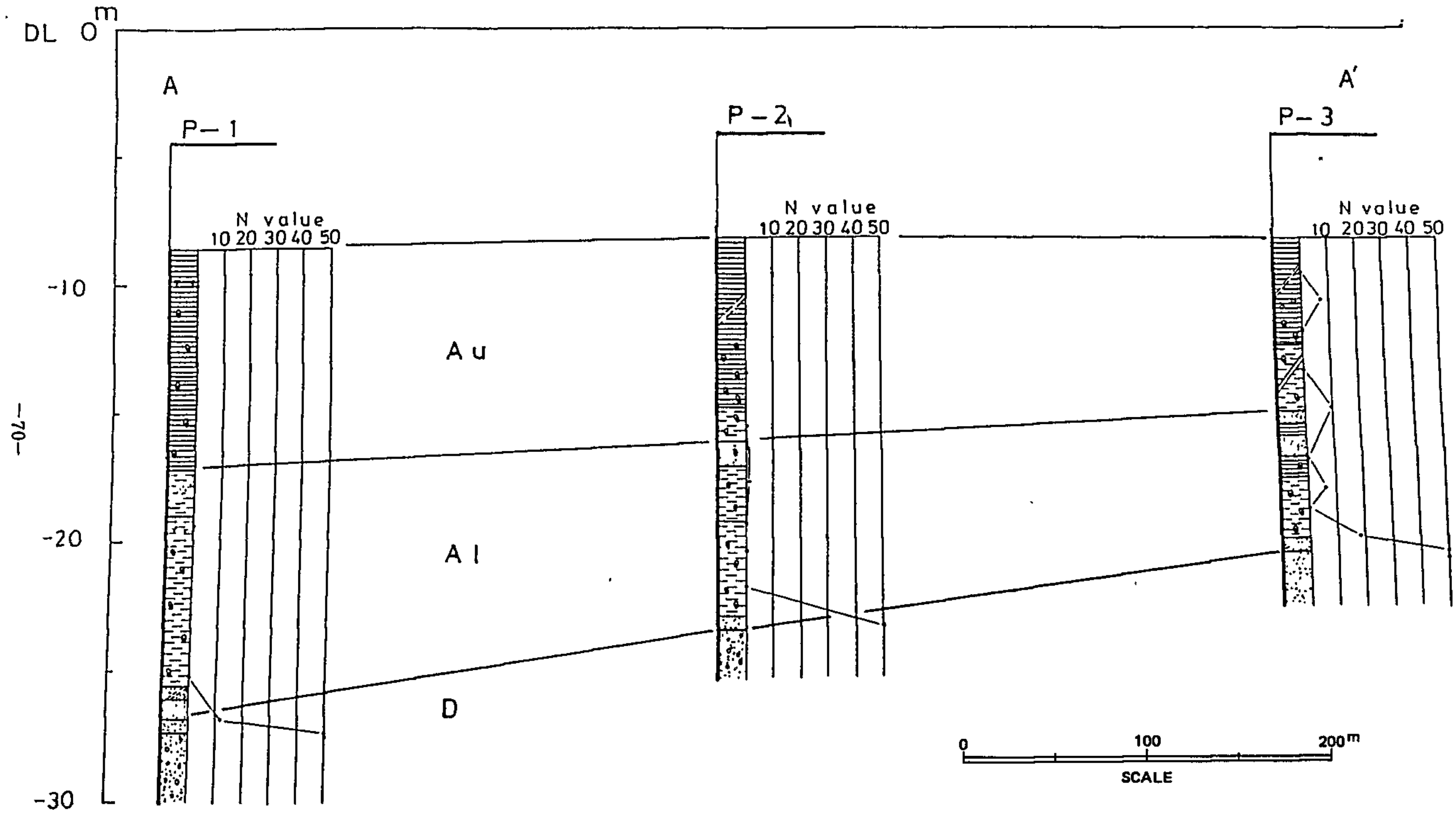


Fig. 3-23 Layer Differentiation Profile A-A'

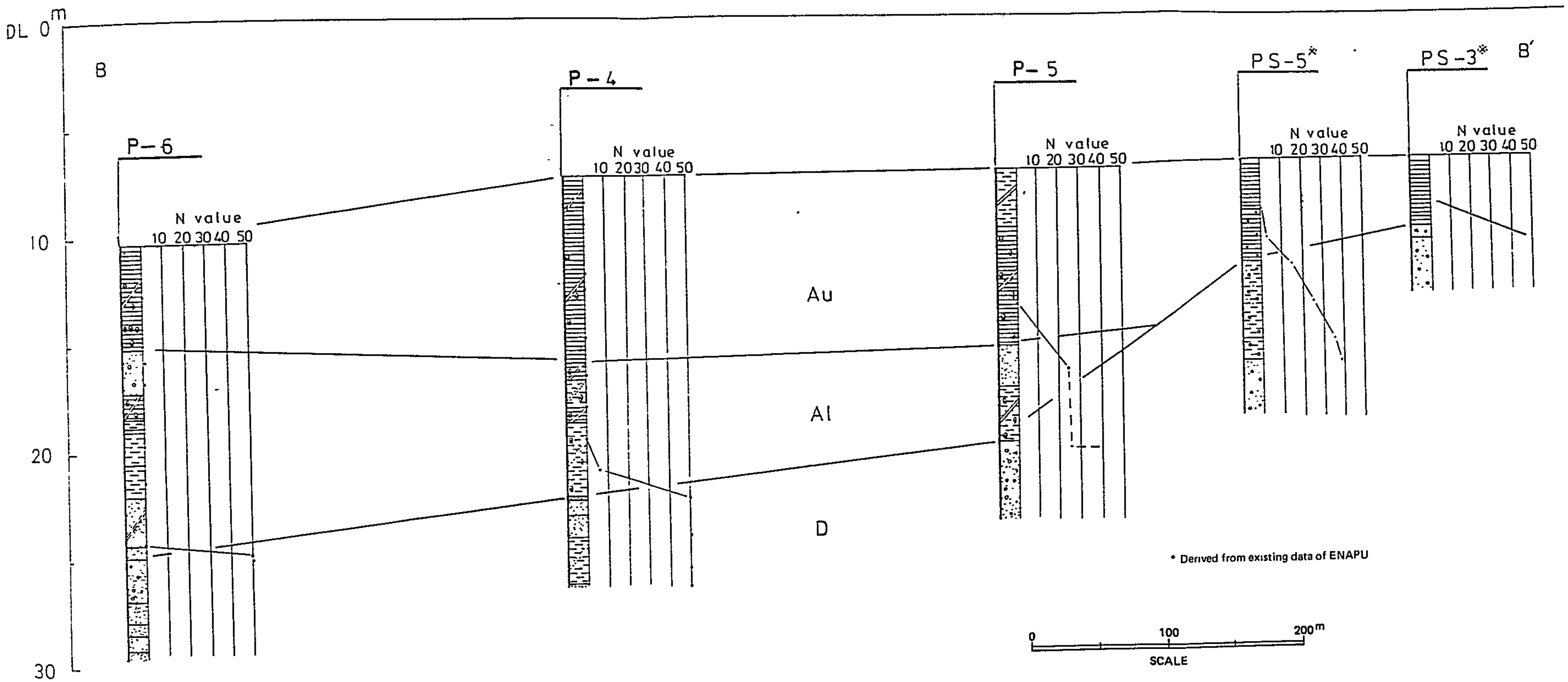
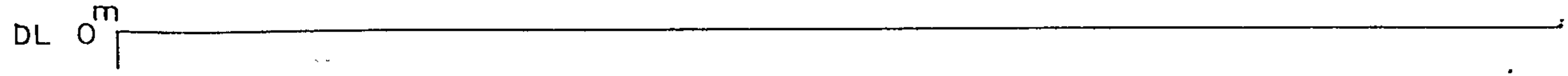


Fig. 3-24 Layer Differentiation Profile B-B'


DL
O
m

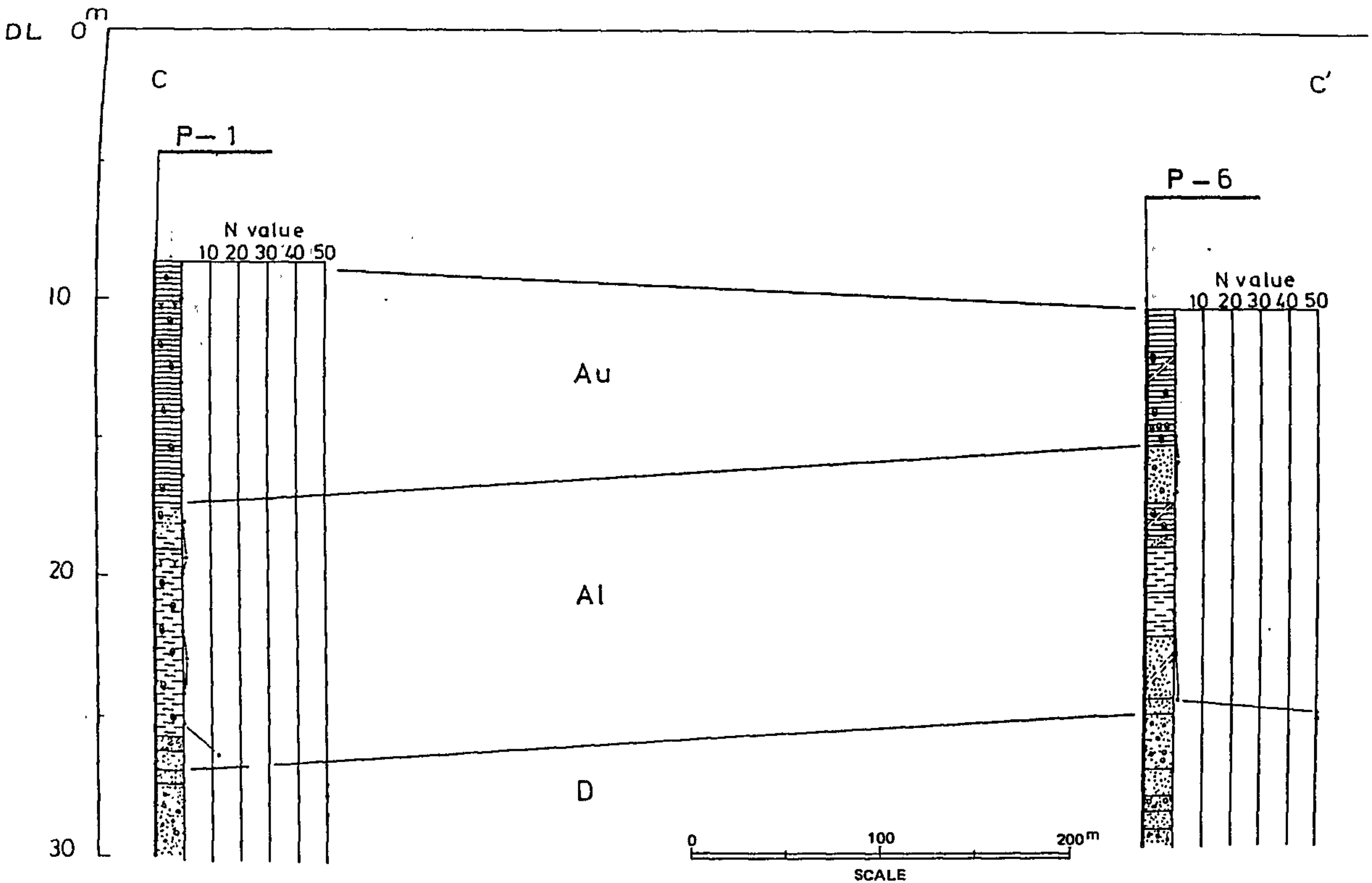


Fig. 3-25 Layer Differentiation Profile C-C′

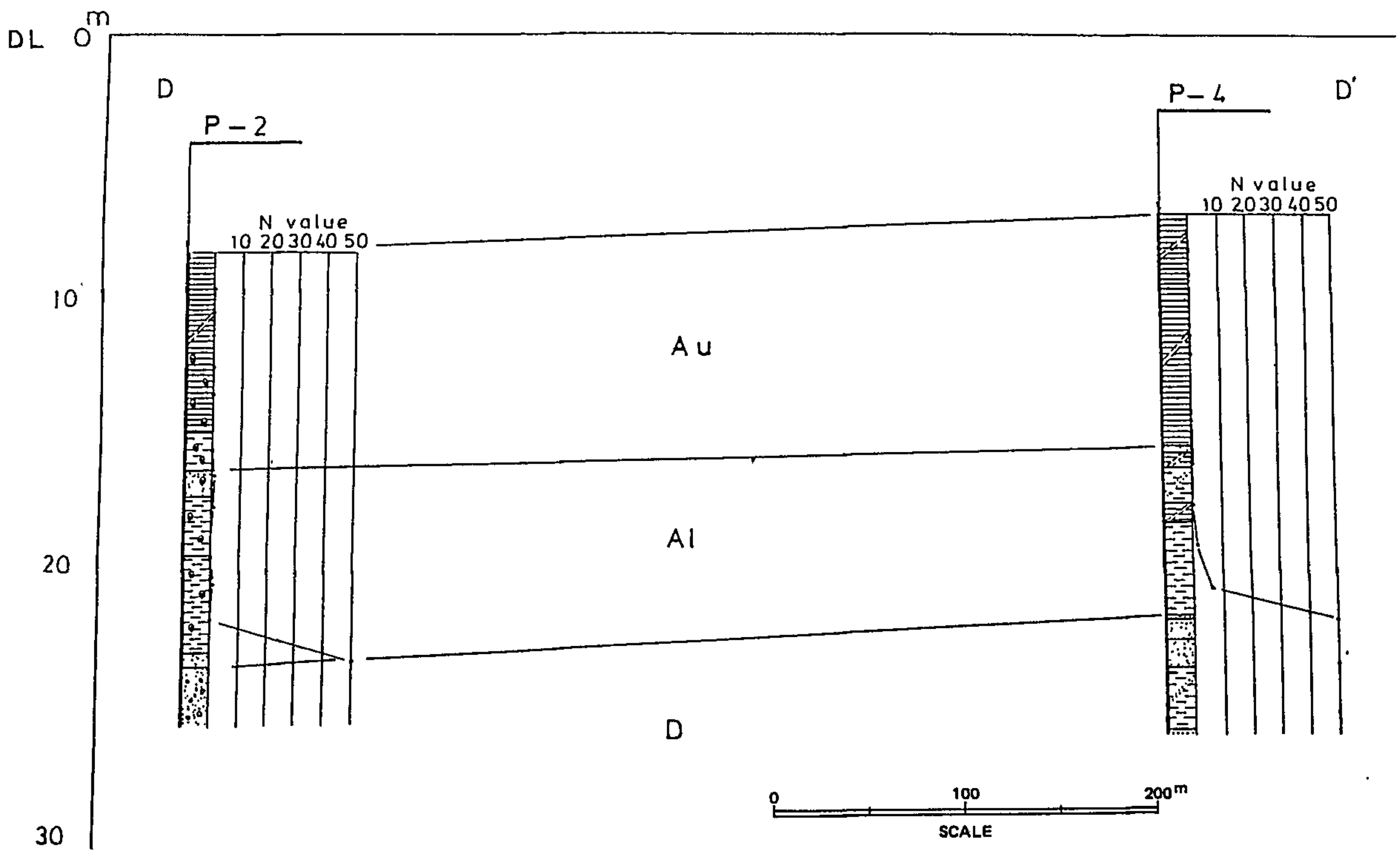


Fig. 3-26 Layer Differentiation Profile D-D'

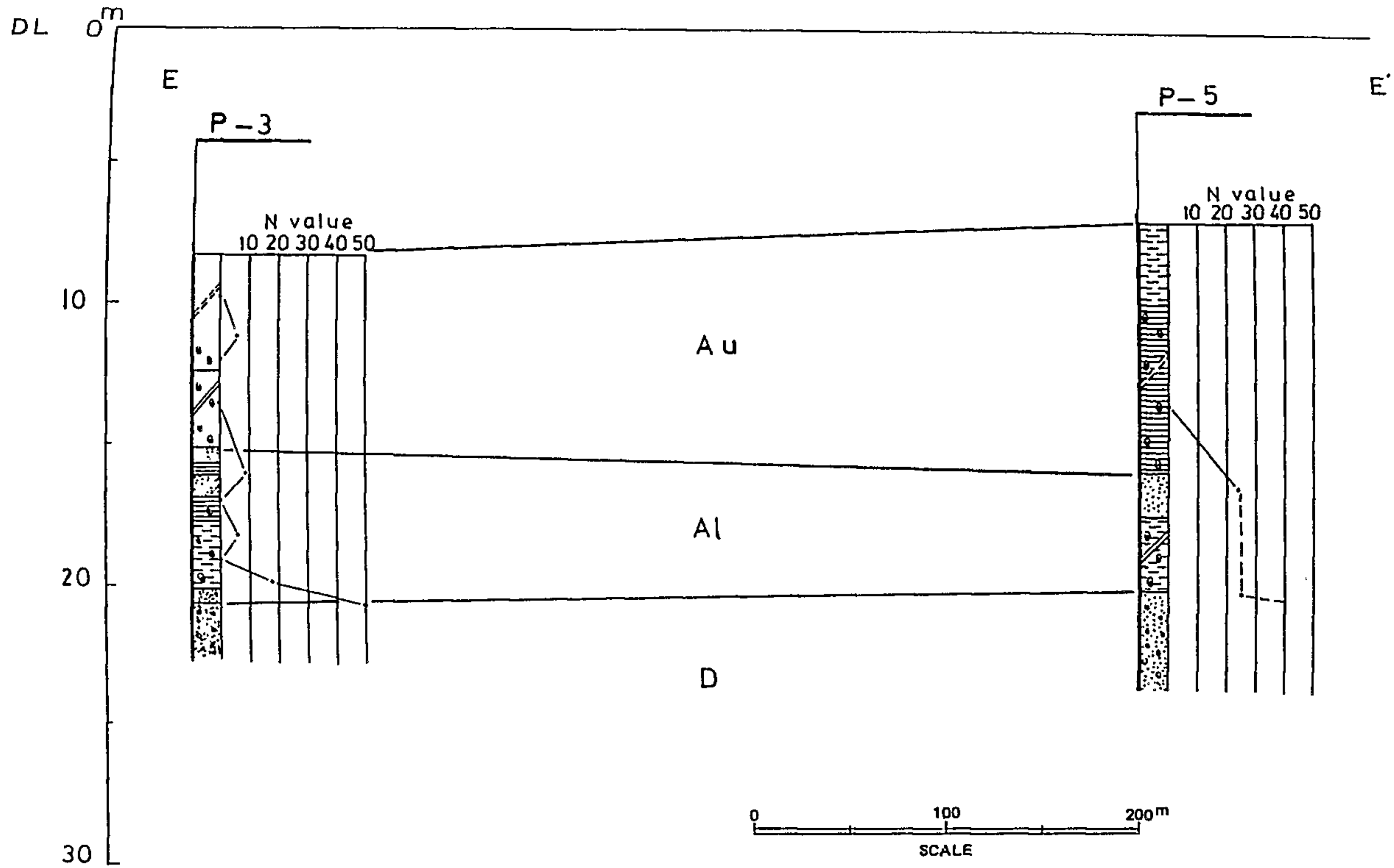


Fig. 3-27 Layer Differentiation Profile E-E'

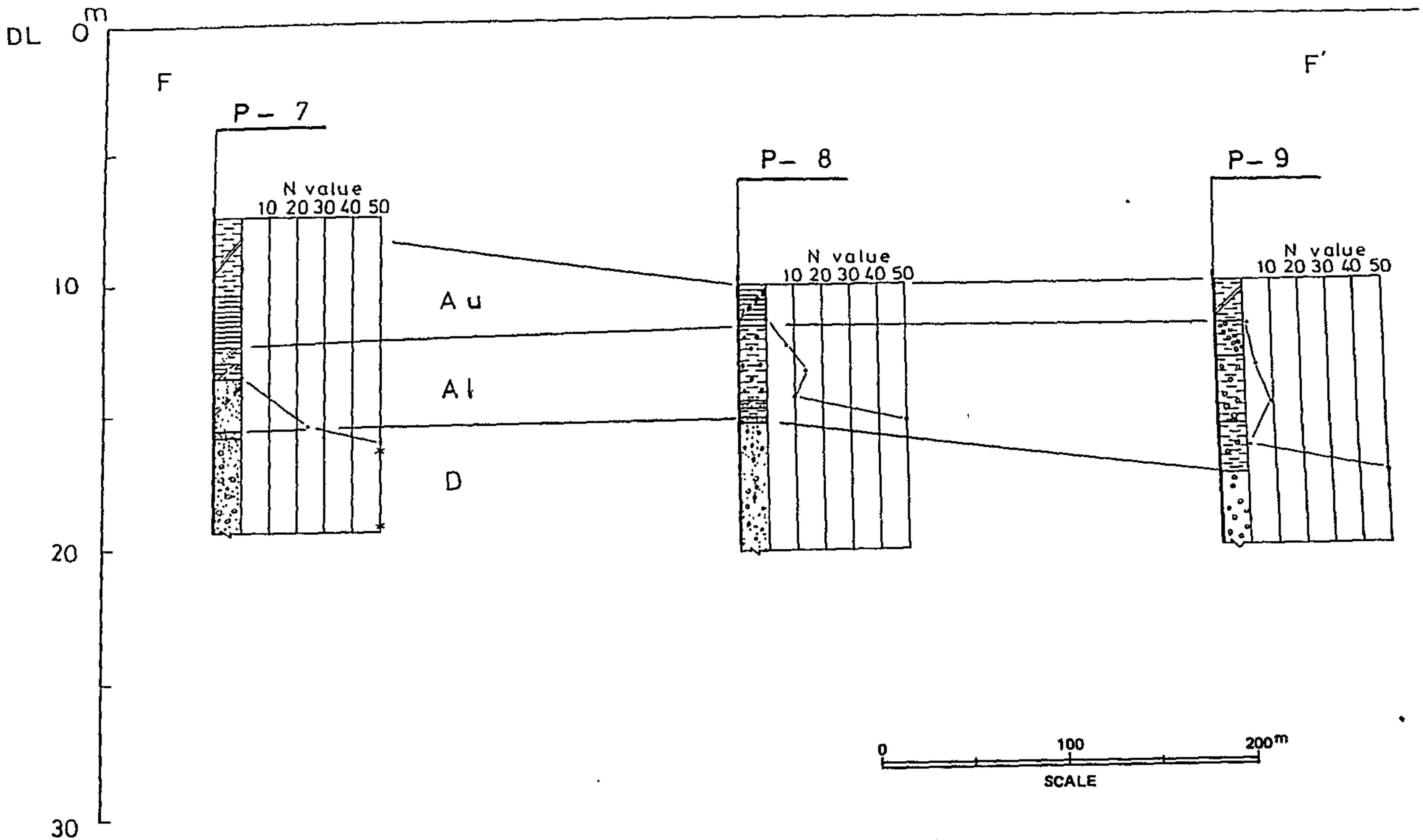
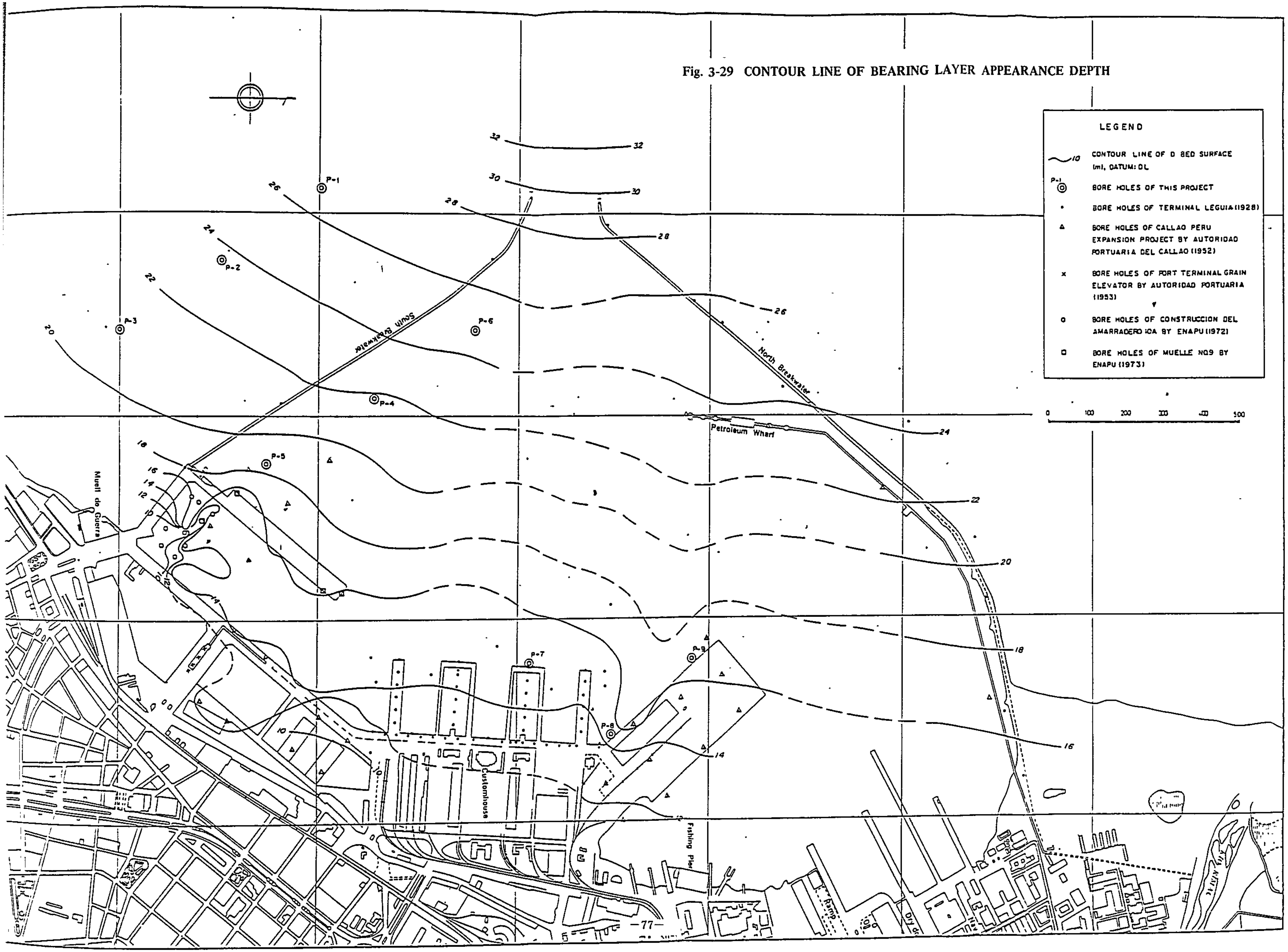
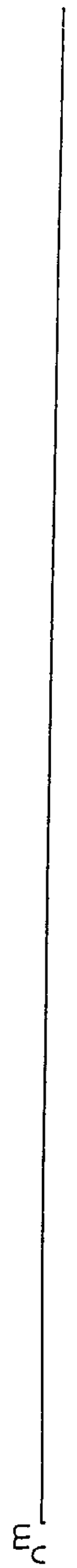


Fig. 3-28 Layer Diffrentiation Profile F-F′

Fig. 3-29 CONTOUR LINE OF BEARING LAYER APPEARANCE DEPTH





3-3-3 Parameters of soils at the Project Site

The soil parameters of the alluvial clay stratum were studied based on the laboratory test data of the soil survey in 1982.

P-1 ~ P-6 are sites of soil surveying.

Fig. 3-30 shows the vertical distribution of the weight per unit volume of soil.

According to this figure, γt_1 is 1.45 t/m^3 between the soil surface and the depth of 8 m.

γt_2 is 1.55 t/m^3 at depths greater than 8 m.

Fig. 3-31 shows the vertical distribution of unconfined compression strengths.

They are distributed between the chain-dot line and the dotted line. Therefore, the values indicated by the solid line will be taken as the average values. If C is equal to qu/2, the equation giving Cohension C will be C (t/m^2) = 0.55 + 0.15Z (g/m^2)

Fig. 3-32 shows preconsolidation stresses.

Assuming the cohesion is 0 at the surface of the earth, the effective overburden pressure is shown by the solid line, in Fig. 3-32. This effective overburden pressure nearly agrees with the preconsolidation stresses. The tendency of cohesion to increase with depth is almost the same as that of the consolidation load.

C/P of this clay was about 0.3. The results of the unconfined compression tests vary widely. However, when the average values are adopted, the figures show the normal trend of clay soil.

Values of the coefficient of volume compressibility Mv and coefficient of consolidation Cv will be examined as follows.

According to the soil profile, a thin sand layer exists at a depth of approximately −15 m, and layers beneath this sand layer consist of clay containing more silt and fine sand than the upper layers. Therefore, Mv and Cv will be calculated for upper clay layer (shallower than −15 m) and lower clay layer (deeper than −15 m), respectively.

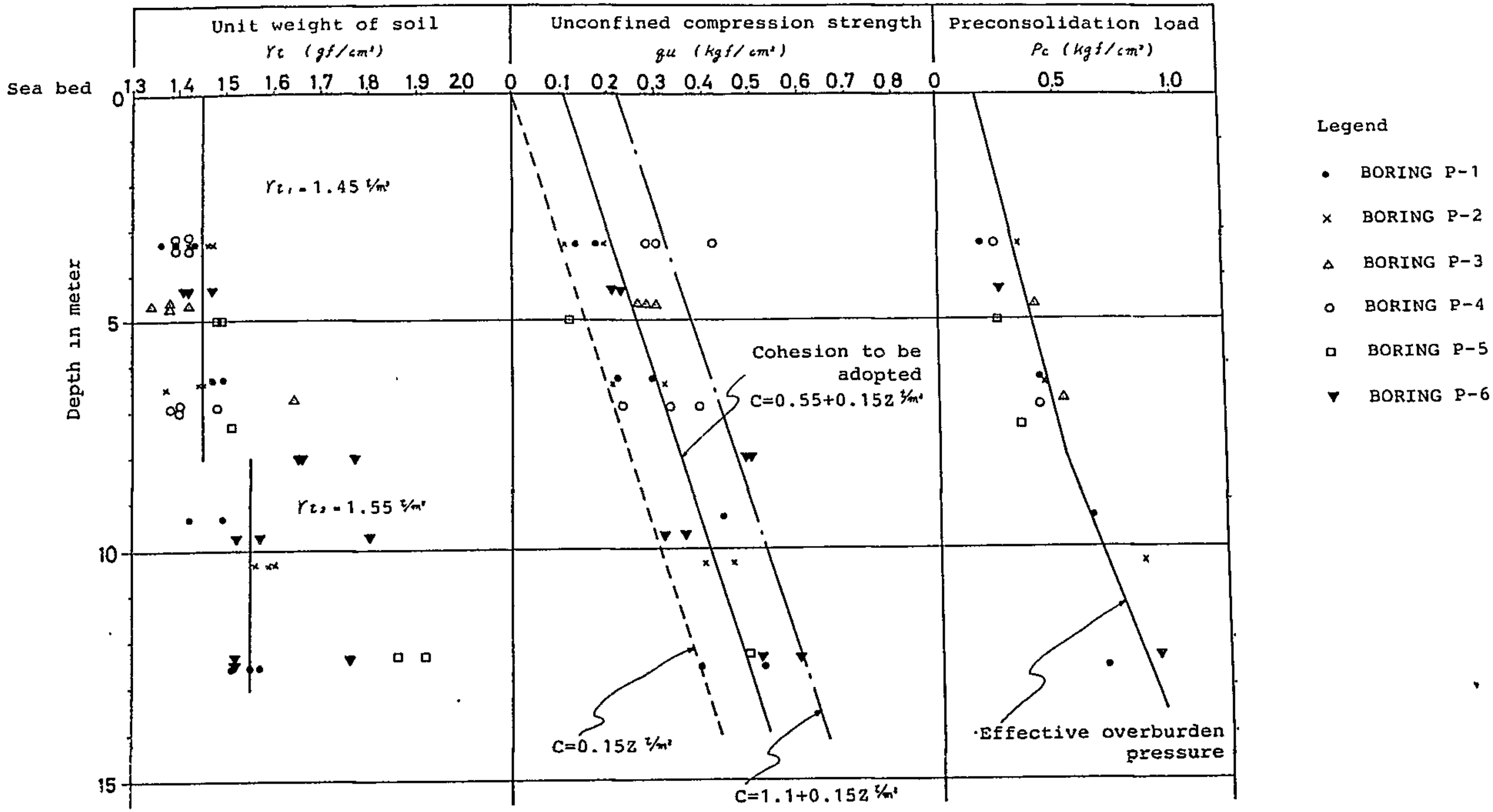
Fig. 3-33 shows Cv of the upper clay layer. According to this, the data varies considerably. However, the average value indicated by the solid line was taken. Fig. 3-34 shows Cv of the lower clay layer. Values shown by the solid line are adopted.

Figs. 3-35 and 3-36 show Mv of the upper clay layer and the lower clay layer respectively. Solid lines are the values assumed for design purposes.

Fig. 3-30 Weight of Unit Volume of Soil

Fig. 3-31 Unconfined Compression Strength

Fig. 3-32 Pre Consolidation Load



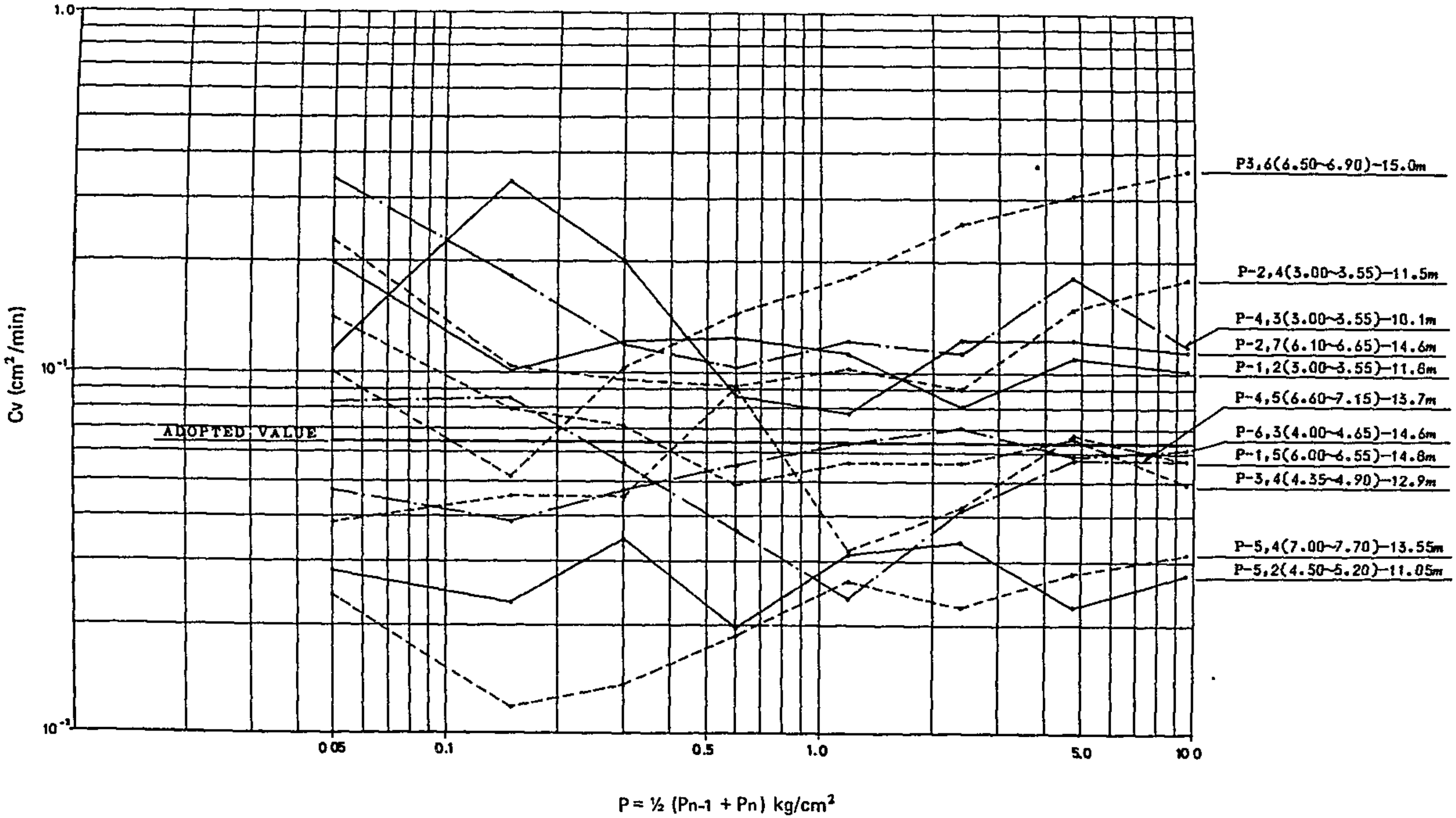


Fig. 3-33 Cv (Above – 15m C.D.L.)

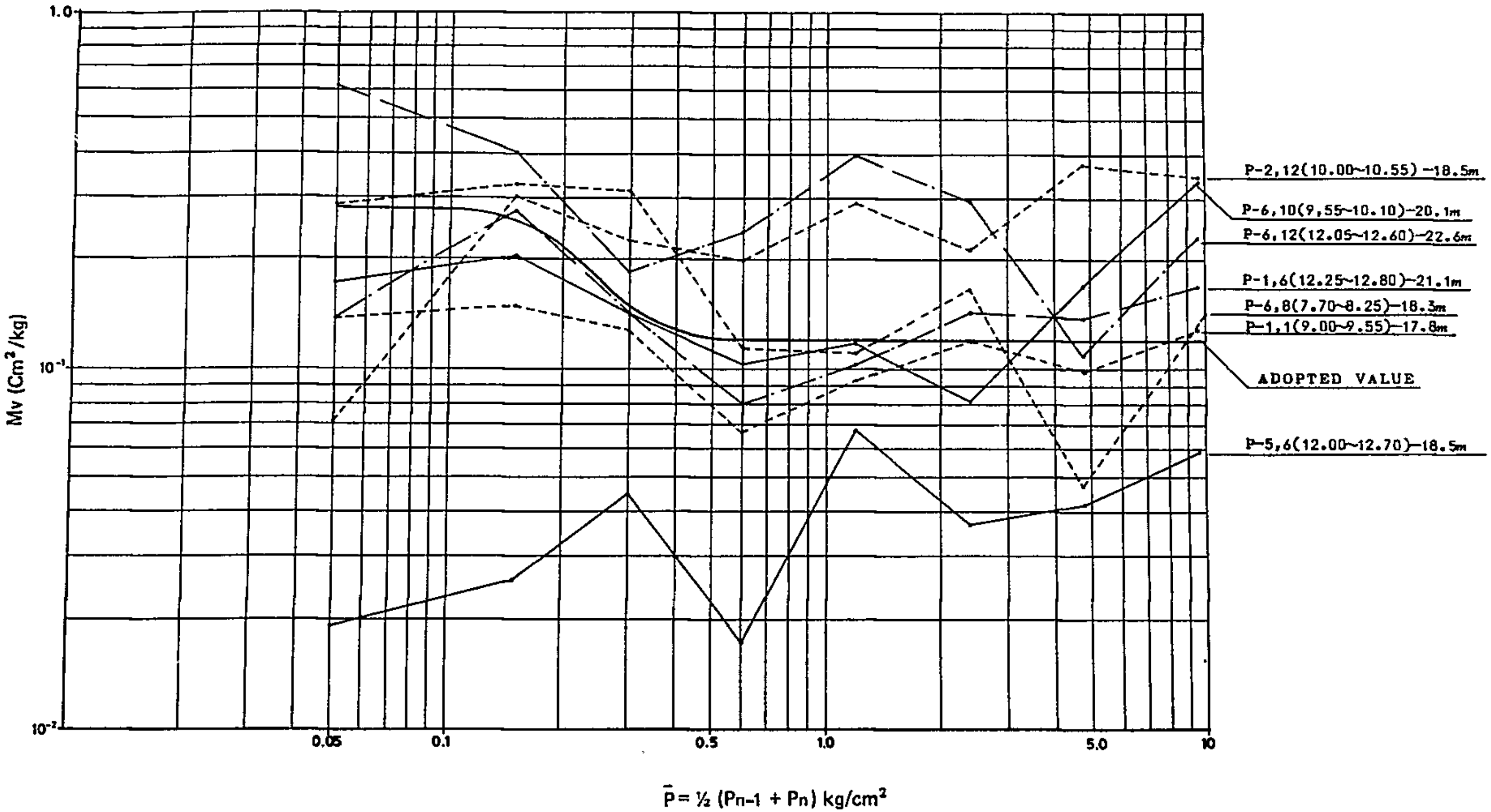


Fig. 3-34 Cv (Below – 15m C.D.L.)

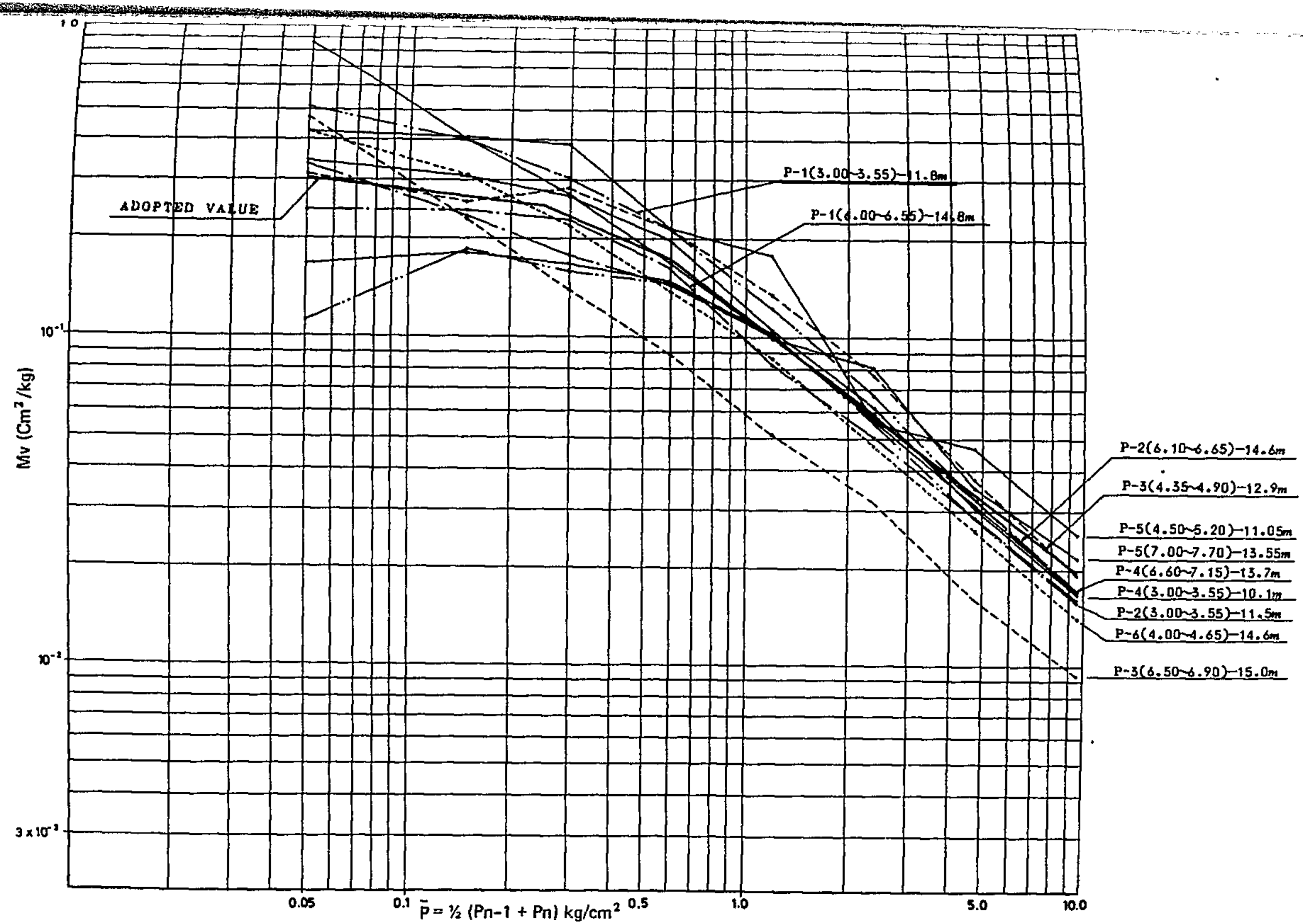


Fig. 3-35 Mv (Above -15.0m C.D.L.)

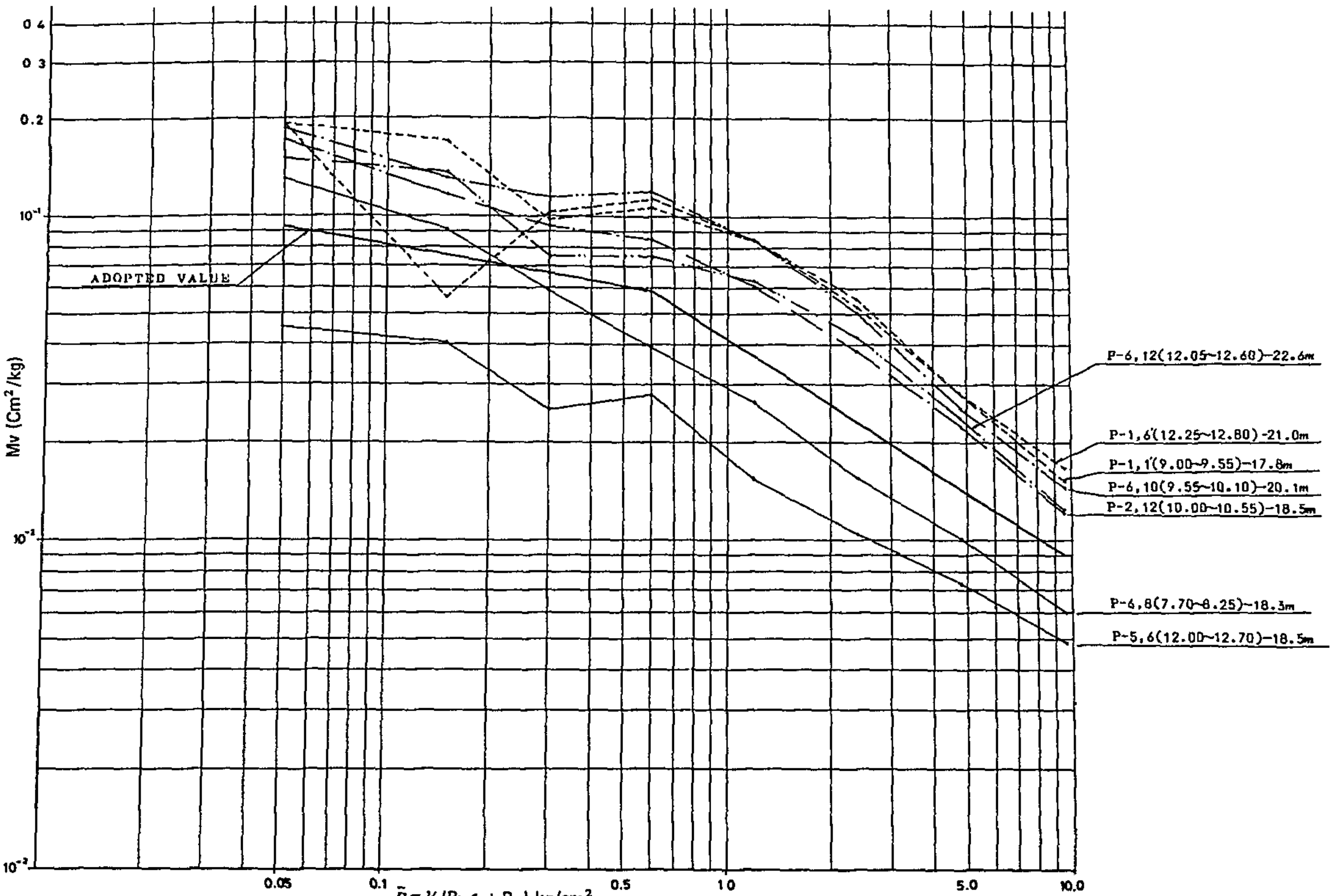


Fig. 3-36 Mv (Below −15m C.D.L.)

3-4 Earthquakes

3-4-1 Earthquakes in Peru

Peru is located on the active structural seismic belt on the Coast where the 'NASCA' plate slips beneath the continental plate of South America and is very famous for many earthquakes.

Earthquakes in Peru mostly occur on the coastal fault, the Ancash-Satipo fault, and on the faults of the eastern, central and northeastern parts. Major earthquakes which occurred in Peru from 1940 to 1973 are shown below as a reference.

SISMOS DE MAYOR INTENSIDAD OCURRIDOS EN EL PERU
(1940 – 1973)

Lima	VIII M.M	1940	1600 muertos
Slhuas	VIII	1946	
Satipo	IX	1947	
Cuzco	VII	1950	
Tumbes	VIII	1953	
Arequipa	VIII	1958	22 muertos
Arequipa	VII	1960	63 muertos
Huacho	VIII	1966	130 muertos
Ancash	VIII	1970	70000 muertos

(By the revised 'MELCALI' method)

'Norma de Diseno Sismico' of Peru was incorporated into 'Reglamento Nacional de Construccions' in 1970 after its draft was revised at the 1st seismology and seismic engineering conference held in Chili in 1963.

The regulation is continuously reviewed for revision. In the regulation (Reglamento), according to potentials and size of earthquakes (SISMICIDAD) the total area of Peru is divided into 3 zones as shown in the map and design seismic intensity is decided for each zone.

Port Callao is located in ZONA 1 which has the largest coefficient.

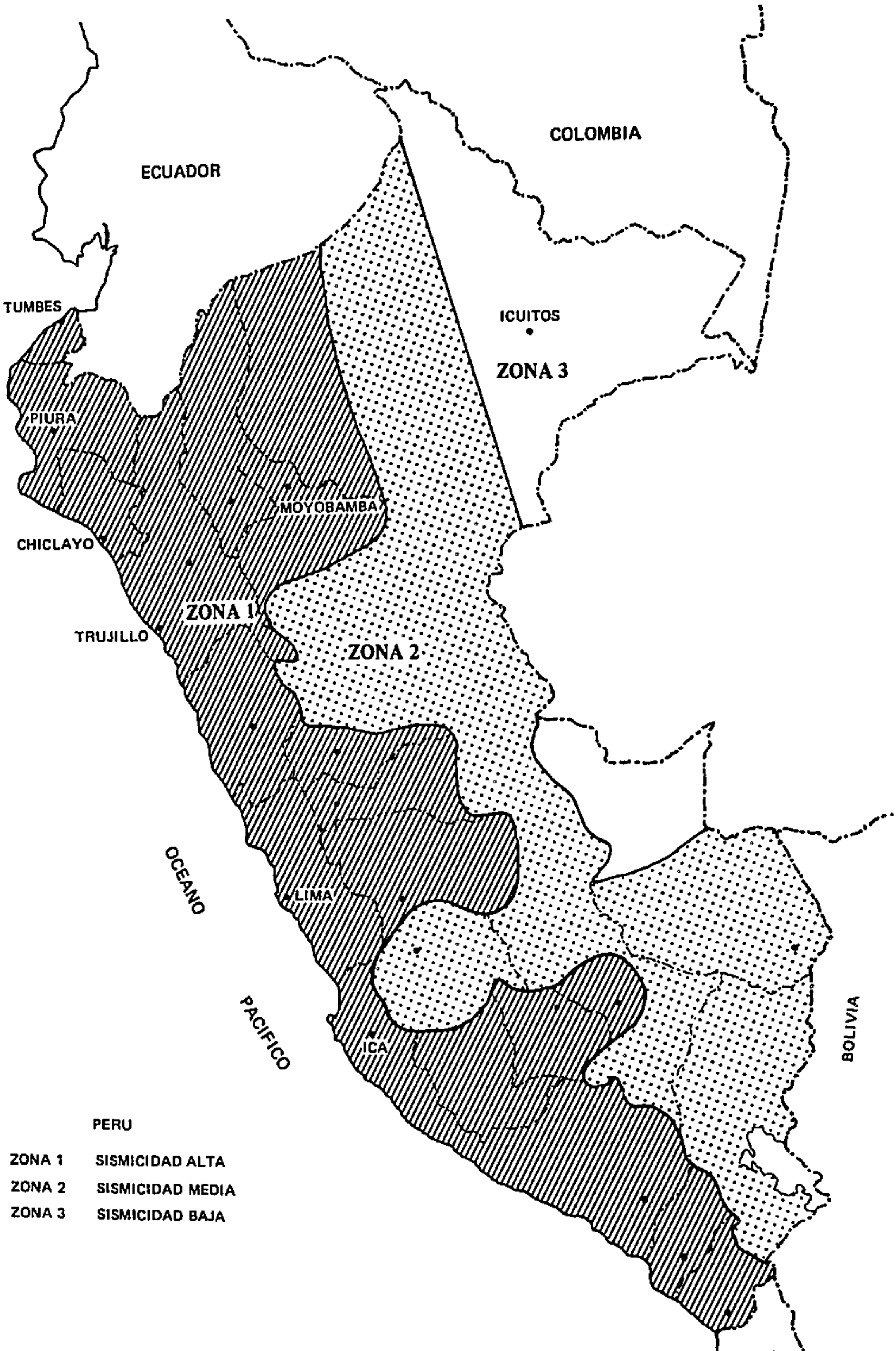


Fig. 3-37 Seismic Zone

3-4-2 Seismic Coefficient

Seismic coefficient is determined according to 'REGLAMENTO NACIONAL DE CONSTRUCCIONES' Oficina de Investigación y Normalización, MINISTERIO DE VIVIENDIA Y CONSTRUCCION. According to the above regulation, horizontal seismic force is determined by the following formula.

$$H = \frac{Z \times U \times S \times C \times P}{Rd} \quad .... (1)$$

where, Z: Regional factor
U: Coefficient of importance
S: Factor for subsoil conditions
C: Seismic coefficient
Rd: Ductility
P: Weight of buildings

(1) Regional factor

It is determined by areas where structures are located.

Callao Port belongs to Zone 1 and $Z = 1.0$.

(2) Coefficient of importance (U)

It is determined according to the classification of buildings and the port belongs to Category B.

Therefore, $U = 1.3$.

(3) Factor for subsoil conditions (S)

It is determined according to the nature of the subsoil of the foundation. The ground around Callao Port belongs to Category III and $S = 1.4$.

(4) Seismic coefficient (C)

It is calculated by the following formula

$$C = \frac{0.8}{T/Ts + 1.0}$$

where, T: Fundamental vibration period of buildings
Ts: Predominant vibration period of ground

The range of C and Ts is

$$0.16 < C < 0.40$$
$$0.3 < Ts < 0.9$$

Since the fundamental vibration period of buildings greatly differs according to the type of structure and the ground also differs according to location, value of C has been taken as the maximum allowable value to be applied to any location inside the port and to any type of structure.

$C = 0.40$

5) Ductility (Factor de ductlidad) (Rd)

for port, $Rd = 5.0$ is used.

6) Seismic coefficient (Kh)

Using the above mentioned coefficients, seismic horizontal force is calculated as follows:

$$H = \frac{1.0 \times 1.3 \times 1.4 \times 0.40}{5.0} \times P$$
$$= 0.15\,P$$

In the original design of No. 5 wharf, seismic coefficient Kh = 0.133 is used. However, considering the damage of No. 5 wharf, for a new design Kh = 0.15 may be appropriate to be on the safe side. Vertical force is not considered.

Fig. 3-38* shows distribution of seismic acceleration on ground surface for return period Tr = 100 years in Peru.

Acceleration at Lima area is 100 gal, and an area of 150 gal exists immediate north of Lima area. Therefore it is advised that 150 gal is taken as adopted value to be on the safe side.

Design seismic coefficient can be calculated by the following equation:

$K_h = \alpha_h/G$

where, K_h: Design seismic coefficient

α_h: Maximum acceleration (gal)

g: Acceleration due to gravity (980 cm/sec)

So, $K_h = 0.15$

* Report of the Building Research Institute No. 88, 1980 February, Building Research Institute, Japan.

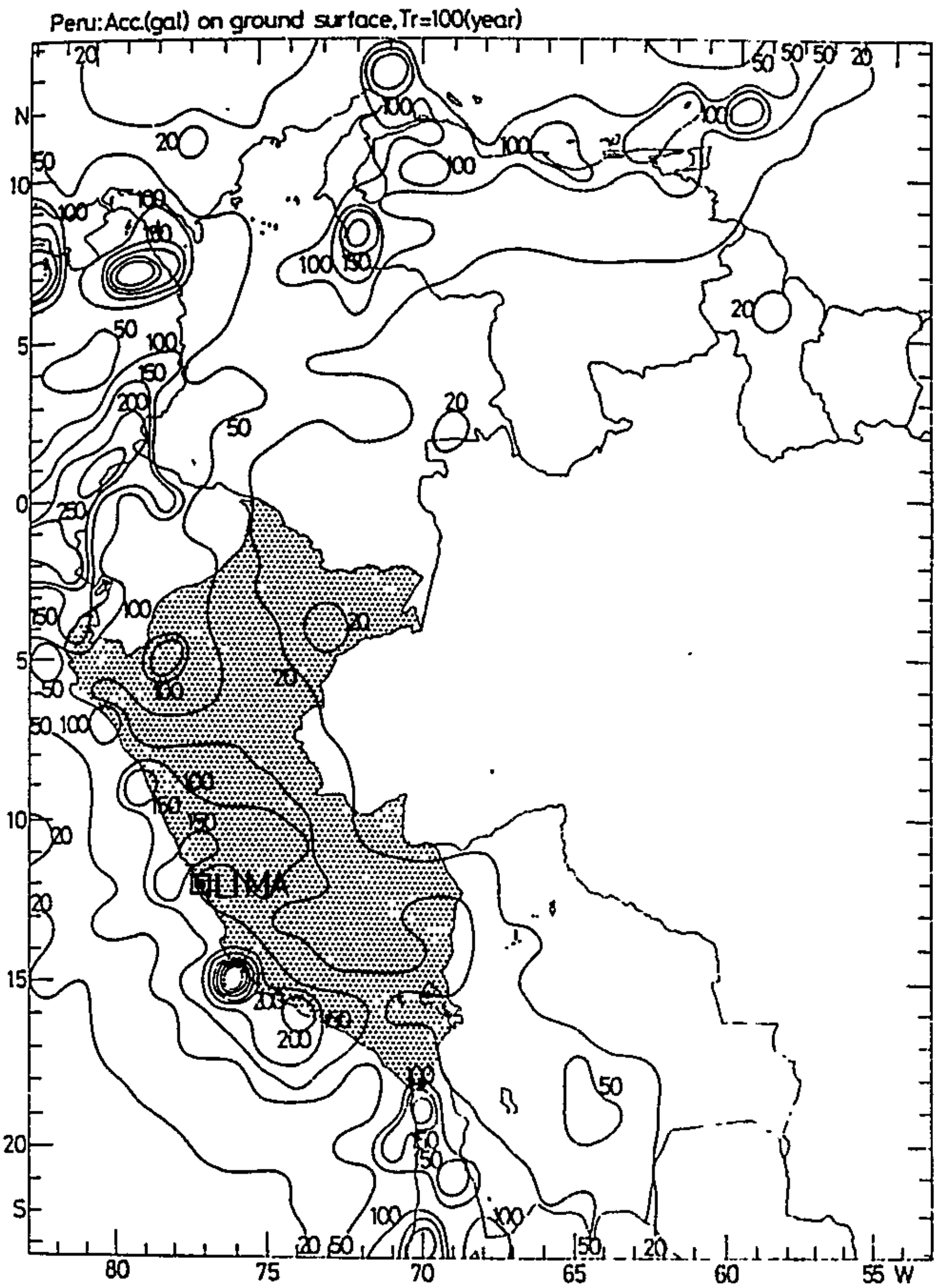


Fig. 3-38 Maximum acceleration amplitude (gal) for return period 100 years

CHAPTER 4
Basic Priorities for Development of Callao Port

CHAPTER 4. BASIC PRIORITIES FOR DEVELOPMENT OF CALLAO PORT

4-1 Socio-economic Activities in the Area Centered Around Metropolitan Lima

Metropolitan Lima is by far the most important area in Peru in terms of population and production from manufacturing industries. About 27% of the nation's population (Fig. 4-1) and about 65% of the total production from manufacturing industries (Fig. 4-2) are concentrated there. This concentration of population and economic activities is still continuing despite government measures for regional development. Urbanization is a worldwide tendency and it is inevitable that industries will seek to expand or construct their plants in areas where they can benefit from proximity to other industries already concentrated there. Therefore, the concentration and expansion of population and industries in metropolitan Lima will steadily continue in the future, although the pace of this progress may slow down.

Further, the nation's land transportation systems (roads and railways, Fig. 4-3) are formed with metropolitan Lima as the center. The socio-economic activities of this area are closely connected with its periphery by these transportation systems so that the activities of the metropolis and the development of its periphery are integrated together.

Additionally, the socio-economic activities of metropolitan Lima require close industrial and economic ties with many foreign countries because of the scale and the character of these activities. Indeed, they are closely related to the world economy through import of industrial materials, equipment and daily necessities, and the export of local products. A gateway to the sea, linking Peru with the countries of the world, is essential to the development of metropolitan Lima.

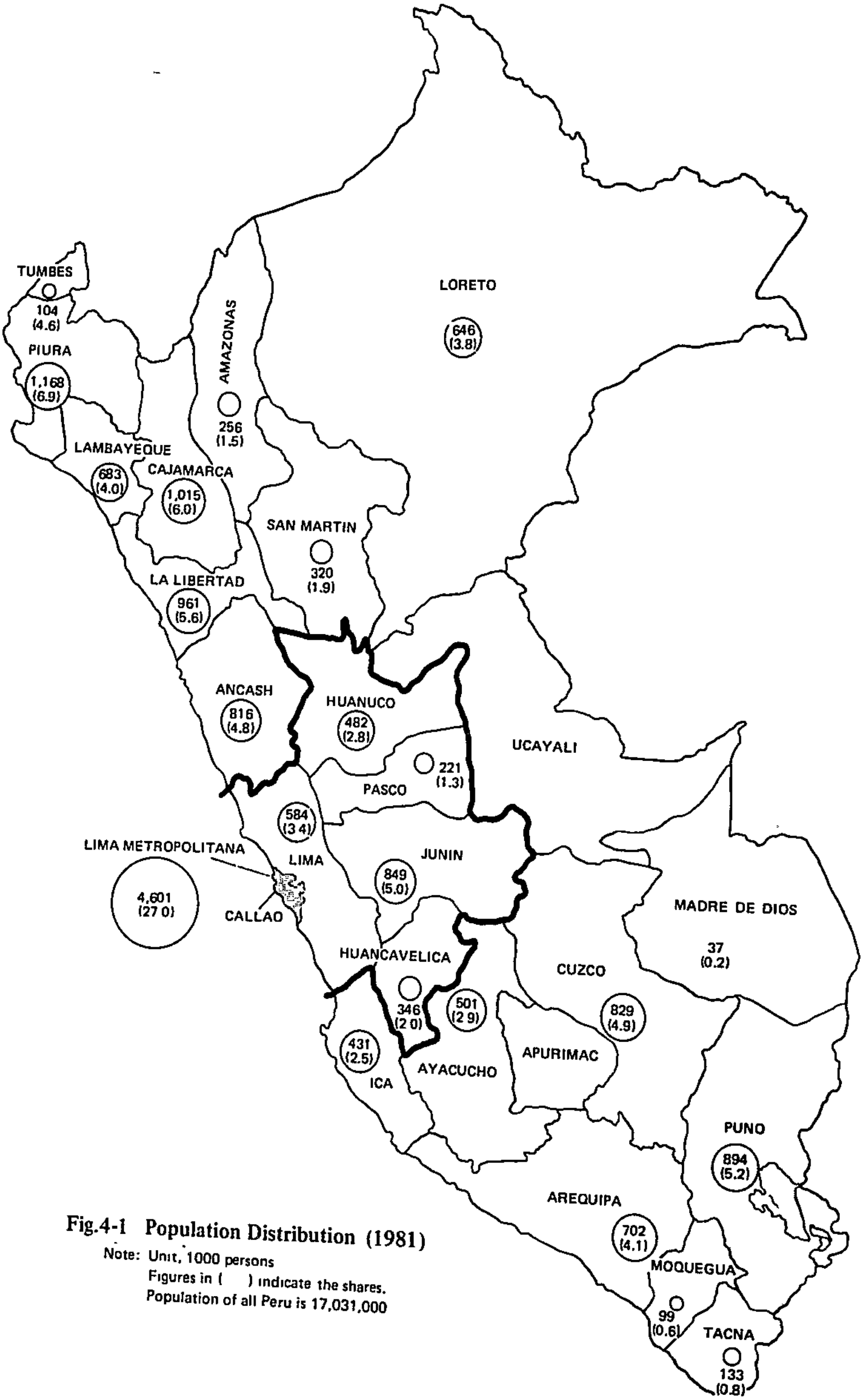


Fig.4-1 Population Distribution (1981)

Note: Unit, 1000 persons
Figures in ( ) indicate the shares.
Population of all Peru is 17,031,000

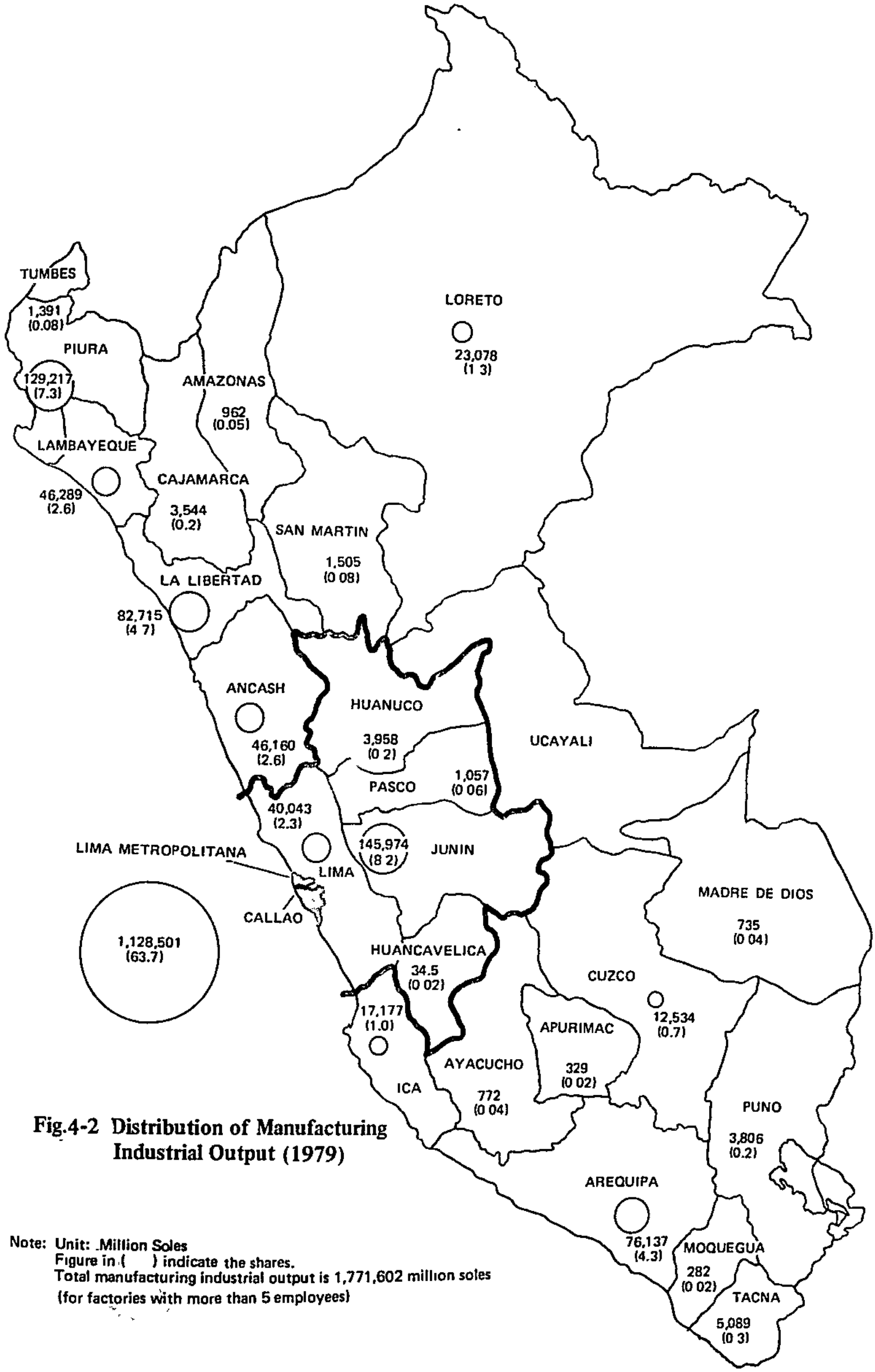


Fig.4-2 Distribution of Manufacturing Industrial Output (1979)

Note: Unit: Million Soles
Figure in ( ) indicate the shares.
Total manufacturing industrial output is 1,771,602 million soles
(for factories with more than 5 employees)

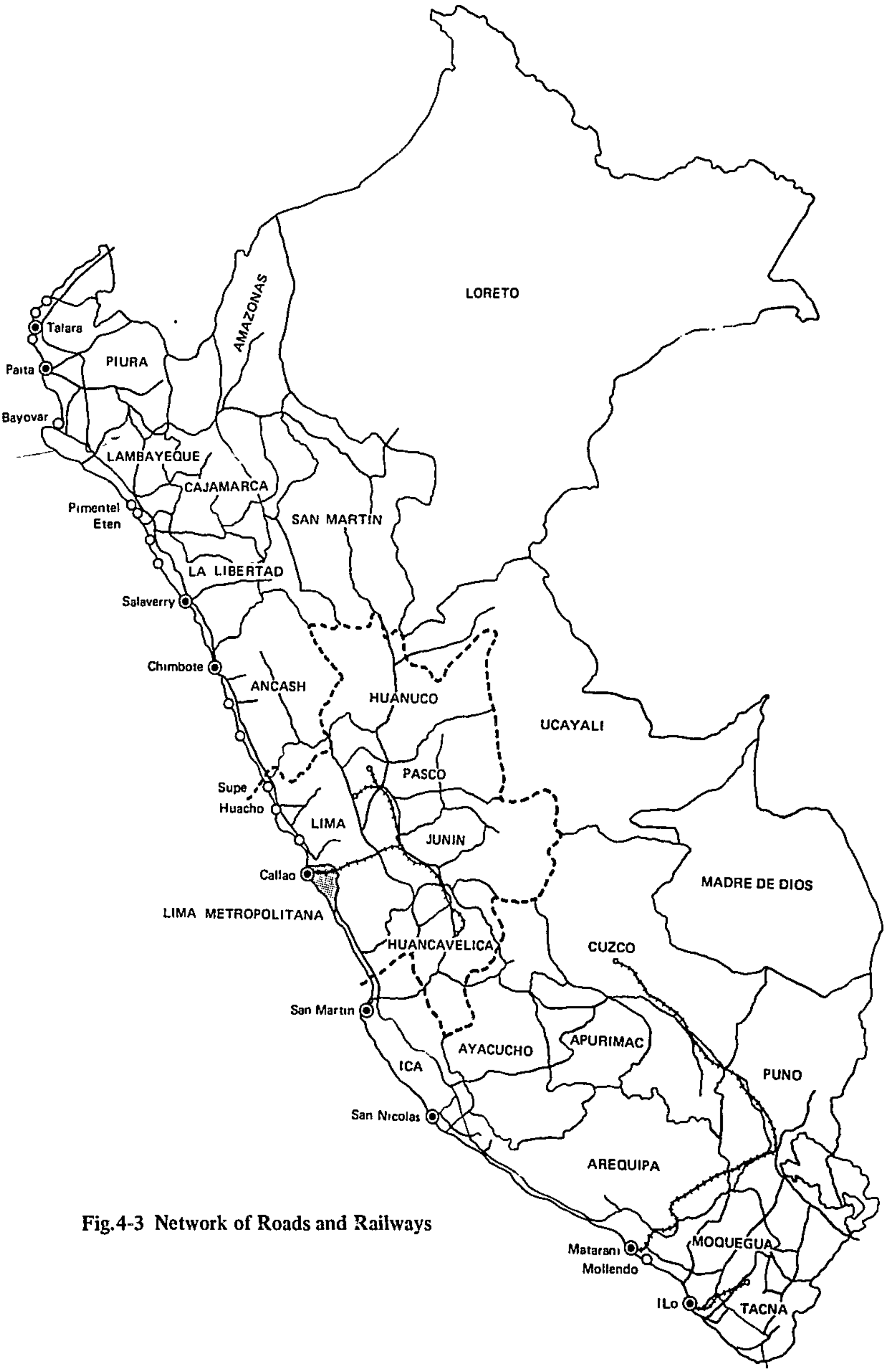


Fig.4-3 Network of Roads and Railways

4-2 Port Functions Required of Metropolitan Lima

The port for metropolitan Lima must perform diverse functions because the socio-economic activities in this area are on a large scale and qualitatively advanced.

Callao Port's primary function is distribution. In this respect the port makes possible imports of grain, automobiles, machines and fertilizers and other items related to livelihood, etc. that are related to industry and agriculture, and exports of fishery processed goods, ores, etc. produced by industrial activities. A secondary function somewhat different from the first is the use of the port for recreation by pleasure boats, including yachts and motorboats. A third function is to provide transport for crew members of ships anchored in the offing and for marine sightseers. A fourth function is use of the port by the fishing industry.

Besides these, a port has the fifth function of providing space for residences and for industries, etc. This function consists of reclaiming land and providing space to develop urban activities or attract petro-chemical and other heavy chemical industries. In terms of the future development of the port of metropolitan Lima, the most important of the above functions is the distribution function. As trade with other countries is expected to expand and as the Government is seeking to develop the nation's coastal shipping, this function will become increasingly important. Further, with improving living standards, the need for marine recreation will increase, requiring expansion of the second function as well.

It is unlikely that the third function will increase in importance in the future, while future demands on the fourth function can probably be met by improving Ventanilla fishery Port.

Regarding the fifth function, there is at present ample space both inland and in the coastal zone, so reclamation is not likely to be required in the near future.

Thus, it is the first and second functions that are of greatest importance for the future of the port that will serve metropolitan Lima. In particular expansion of the first function – the function of distribution – is the greatest task to be tackled.

4-3 How to Expand Port Functions in Metropolitan Lima

There are several possible alternatives for expanding the distribution function at the port of metropolitan Lima. One alternative is to expand this function at the existing Callao Port. Another alternative is to share this function with neighboring ports. A suitable choice from among these alternatives can be made after studying the amount of space required, the impact of this development on social and natural environments, possibilities for efficient and rational land transportation systems connecting the origin and destination of cargoes and the port, effects on regional development of port improvement, etc. In metropolitan Lima and its vicinity, there are Huacho Port to the north of Callao Port, and San Martin Port to the south. (Although there are also perhaps potential sites for construction of new ports on other stretches of coast, the discussion here is limited to the abovementioned three ports.)

The two ports, other than Huacho Port, have ample room for development, with no major restrictions on space. It is considered technically feasible to carry out expansion of these two ports without causing any serious environmental impact. However, of the three ports, only Callao Port has an adequate accumulation of necessary commercial distribution functions in such fields as communications and banking. Callao Port is thus by far most appropriate for future development.

Callao Port is also preferable in terms of the relations between the origins and destinations of cargoes and the port. Metropolitan Lima, only about 30 km from Callao Port, is the nation's largest area of production and consumption. Therefore, the metropolis is considered to be the origin or destination of most cargoes handled by the port.

It is not easy to predict the regional development effects of port development because such a prediction first involves calculating an investment versus benefit ratio. From the national economical point of view, it is deemed to be most benefitial to develop Callao Port which is located closest to the center of socio-economical activities.

Another consideration is the possibility of preventing congestion at Callao Port of creating extra capacity for prospective cargo increases by charging other ports with the handling of certain types of cargoes or certain amounts of cargoes. For example, Huacho Port might be charged with the handling of ore concentrates, because these are mainly produced in an area physically close to the port. However, there is little chance of such a plan being enacted, because a substantial investment would be required for construction of a new railway, while the amount of ore concentrates to be exported would be too small to justify such an investment. Along these same lines, San Martin Port could also be charged with the handling of some grain and container cargoes. However, assuming that the origin and destination of these cargoes is Metropolitan Lima, then the extra cost of transporting these cargoes over land for about 250 km from San Martin Port would be necessary. Furthermore, in the case of export cargoes, this would reduce their international competitiveness. In the case of imports, the extra transporting distance might cause domestic price hikes. Perhaps San Martin Port should be made the nucleus of a development involving Pisco and its vicinity, attracting industries heavily dependent on marine transportation for importing raw materials or exporting products. In addition to the above discussion, it appears that in terms of the national layout of hinterlands for ports, it would be most natural and reasonable for Callao Port's hinterland to include the Departments de Lima and the four surrounding states. (Fig. 4-4)

Therefore, as long as the origin and destination of most cargoes is centered in the metropolitan Lima area, and provided there is space for expansion at Callao Port, then developing and expanding the functions of Callao Port would better serve the national economy than delegating port function to other ports.

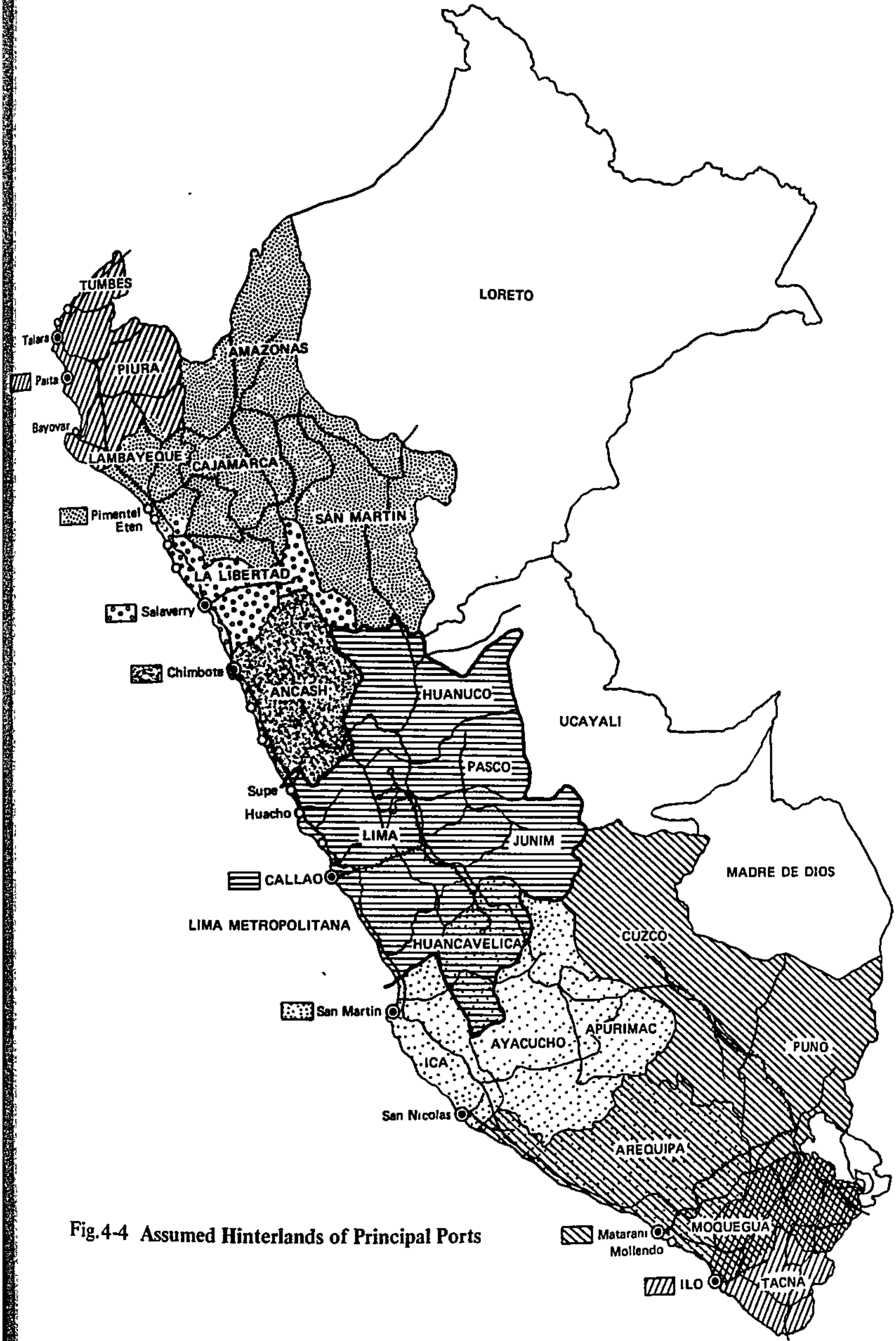


Fig.4-4 Assumed Hinterlands of Principal Ports

4-4 Basic Priorities for Developing Callao Port

Callao is the largest foreign-trade port in Peru. The Callao Port functions must, in the future, be further improved to support the development of metropolitan Lima, and to realize the port's role as the hub of the Nation's Marine transportation system.

The most important function to be expanded at Callao Port is the distribution function, as discussed in Section 2 of this chapter. The basic priorities concerning the improvement and strengthening of Callao Port in the future are as follows:

(1) Modernization of Marine Transportation

Container transportation on the west coast of South America has passed its introductory phase and entered into a period of sustained growth. Full-container ships are in service, containerization of general cargoes is making rapid progress and the ports of these pacific coast countries have a large number of containers stacked and waiting for mobilization. Though the history of container transportation is merely 20 years, old ports that lack facilities to receive container ships have become internationally less competitive with diminished prospects for further development.

As for the existing Callao Port, though it is the largest port in Peru, it is not equipped and prepared to properly receive full-container ships.

Therefore, the first basic priority for development of Callao port is to make possible the entry of full-container ships. This would make possible the entry of the enlarged ships that form the basis of modern marine transportation, and ultimately, make Callao the largest container port on the west coast of South America.

(2) Strengthening of Distribution Functions

Port facilities inappropriate to cargo volume, together with inadequate port management, can greatly affect the international balance of payments. Port congestion not only weakens international competitiveness in the export market (because of demurrage charges, etc.), but also leads to cost increase of import cargoes.

In past times, Callao Port has been seriously congested. However, since then port operations have been smoothly conducted due to the efforts of ENAPU. Nevertheless the volume of cargoes routed through Callao Port is expected to increase steadily with the development of metropolitan Lima. It is imperative that the port not slip back into the congested conditions of former times.

The distribution functions of Callao Port can be strengthened by redeveloping and reinforcing existing facilities, and by improving the management related to cargo handling.

(3) Safety Measures

A port must assure the safety of harbor workers, ships as well as cargoes. Needless to say, an accident involving only a single ship could bring the entire port to a halt for some time.

If facility maintenance fails to pay full attention to safety, accidents, involving heavy casualties, may occur.

Safe passage of ships in and out of the port, and a secure, calm anchorage, are basic prerequisites at any port. Callao Port is fortunate to be sheltered against waves from the south by

San Lorenzo Island and La Punta. It is free of the problems caused by large waves. However, more attention must be paid to securing the port against swells. Furthermore, more attention must be paid to safety measures in regards to earthquake resistance and in regards to the durability of port facilities.

(4) Harmony with Local Community

The presence of a port profoundly affects the local community. Port activities accelerate the development of the local community and the development of the local community, in turn, necessitates the expansion of port functions. But a disorderly expansion of port functions may sometimes spoil the development of the local community and destroy its culture.

Callao Port has long been integrated with the life of the local people. Residents have become familiar with the sea through the medium of the port, and they have been able to come in contact with the other cultures of the world. In the future, too, Callao Port must improve and develop itself, while maintaining its harmony with the local community and the life of its people.

CHAPTER 5
Forecast on Future Volume of Cargoes to be Handled at Callao Port

CHAPTER 5. FORECAST ON FUTURE VOLUME OF CARGOES TO BE HANDLED AT CALLAO PORT

5-1 Present Situation and Trend of Cargoes Handled at Callao Port

5-1-1 Port Statistics Used in This Study

Statistics concerning cargoes handled at Callao Port are based on the study done by ENAPU in 1979 with respect to the plan to modernize and expand the facilities of Callao Port, namely, data compiled in the RESUMEN DEL INFORME DE LA COMISION TECNICA NOMBRADA POR DIRECTIVA N° 004-79 ENAPU/GG DEL 20.08.79 PARA EL "PLAN DE MODERNIZACION Y AMPLIACION DE LA INFRAESTRUCTURA DEL TERMINAL MARITIMO DEL CALLAO". Data from 1960 – 1979 are consolidated in this ENAPU report of 1979 but data of 1980 and 1981 were newly prepared for this study. These data were made available by ENAPU from information based on manifests which ENAPU collected from shippers for the purpose of collecting port fees.

5-1-2 Trend of Volume of Cargoes Handled at Callao Port

Data, obtained continuously for the 22 years from 1960 – 1981 from the two abovementioned sources of material, are the volumes of six types of cargoes indicated in Table 2-5, namely, imported general cargoes, exported general cargoes, exported minerals (metallic ore concentrates), imported grains (bulk cargoes), petroleum (total of export, import and domestic transportation) and domestic cargoes other than petroleum. Since no data on the domestic transportation of petroleum in 1977 and 1978 are available, the figures for these years are the totals of exports and imports only. Fig. 5-1 graphically shows the total volume of cargoes plotted by year.

As can be seen from this figure, values in not only 1977 and 1978 but also 1975 and 1976 are extraordinarily large and it is considered that, as pointed out in the above-mentioned ENAPU report, these data are rather unreliable. Therefore, these extraordinary data must be omitted from the analysis.

5-1-3 Kinds of Cargoes Handled at Callao Port

There are 99 kinds of cargo under the ENAPU tariff. Statistical data on these 99 items by foreign-trade export/import and domestic-trade export/import are available for the three years of 1979 – 1981.

Table 5-1 shows data on 24 categories into which the 99 items are consolidated for the convenience of analysis.

Composition of cargoes for 1981, for example, is as indicated in Fig. 2-2. Foreign-trade cargoes represent 75.8% and domestic-trade cargoes represent 24.2%, the ratio being approximately 3:1. Wheat, maize and other grains occupy about a half of the import cargoes with 47.5% and the rest are such capital goods and consumer goods imported from developed countries as fertilizers, chemicals, metal industry products, machines and parts.

Zinc, lead, copper and other metal ores represent the majority of export cargoes with 61% and the remainder are comprised of petroleum, such metal industry products as ingots, fishery products and processed goods.

As for domestic trade, most of it is import and 94.6% of the imports consist of the transportation of petroleum products from the oil refineries in Northern Peru.

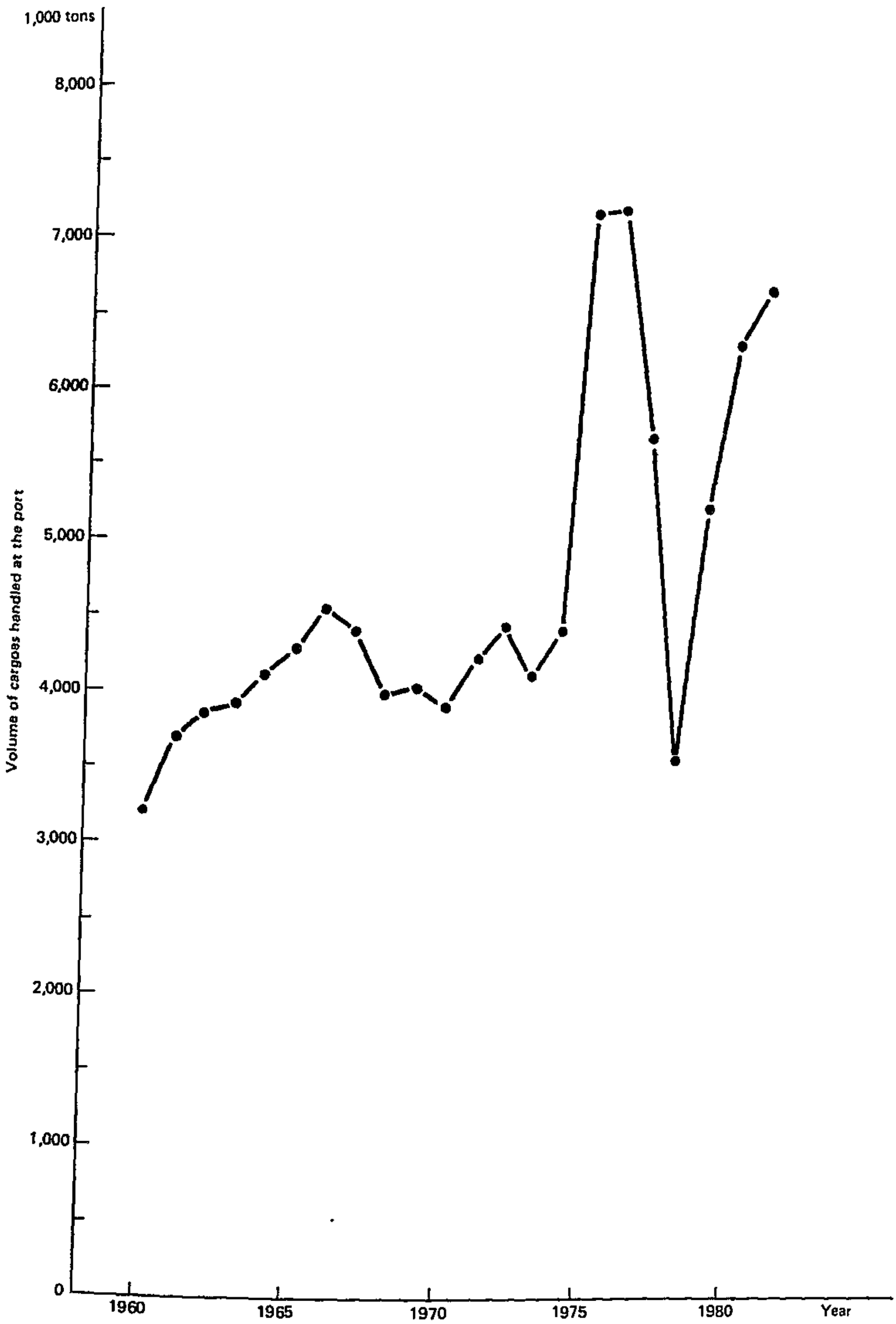


Fig. 5-1 Trend of Volume of Cargoes Handled at Callao Port

Table 5-1 Volume of Cargoes Handled at Callao Port, by Commodity

Commodity	1979					1980					1981				
	Foreign trade Import	Foreign trade Export	Domestic trade Import	Domestic trade Export	Total	Foreign trade Import	Foreign trade Export	Domestic trade Import	Domestic trade Export	Total	Foreign trade Import	Foreign trade Export	Domestic trade Import	Domestic trade Export	Total
Grains	1,005	3	0	0	1,008	1,428	3	0	0	1,431	1,319	2	0	0	1,321
Coffee	0	58	0	0	58	0	39	0	0	39	0	42	0	0	42
Cotton	0	4	0	0	4	0	8	0	0	8	0	15	0	0	15
Sugar	0	0	0	0	0	42	0	0	0	42	110	0	0	0	110
Other agricultural products and processed goods	21	9	0	0	30	51	12	0	0	63	58	13	0	0	71
Livestock products and processed goods	45	17	0	0	62	123	17	0	0	140	137	17	0	0	154
Fishery products and processed goods	0	169	105	0	274	58	140	89	0	287	45	102	46	0	193
Logs	8	9	0	0	17	16	7	0	0	23	14	5	0	0	19
Paper and pulp	20	1	0	0	21	34	0	0	0	34	76	0	0	0	76
Other wood processed goods	0	3	0	0	3	0	1	0	0	1	1	1	0	0	2
Coal	50	0	0	0	50	28	0	0	0	28	25	0	0	0	25
Metal ores	0	1,137	0	0	1,137	0	1,378	0	0	1,378	0	1,411	0	0	1,411
Non-metal ores	24	1	0	0	25	20	4	0	0	24	17	3	0	0	20
Metal industry products	46	395	0	0	441	137	162	0	0	299	256	215	0	0	471
Cement	1	245	0	0	246	0	201	0	0	201	0	78	0	0	78
Other ceramic products	10	0	0	0	10	14	0	0	0	14	14	0	0	0	14
Petroleum products	78	210	907	125	1,320	120	161	1,042	92	1,415	98	238	1,425	113	1,874
Fertilizers and chemicals	238	16	37	0	291	282	14	36	0	332	259	15	36	0	310
Textile industry products	2	41	0	0	43	10	33	0	0	43	8	38	0	0	46
Ships	0	3	0	0	3	0	6	0	0	6	0	12	0	0	12
Automobiles	5	0	0	0	5	18	0	0	0	18	47	0	0	0	47
Can parts	24	4	0	0	28	43	2	0	0	45	51	1	0	0	52
Other machines and parts	58	7	0	0	65	93	11	0	0	104	147	20	0	0	167
Other general cargoes	48	62	0	0	110	90	80	0	0	170	97	84	0	0	181
Total	1,683	2,394	1,049	125	5,251	2,607	2,279	1,167	92	6,145	2,779	2,312	1,507	113	6,711

5-2 Socio-Economic Frame Prerequisite to Cargo Volume Forecasting

5-2-1 Population

Forecast values available in the "Orientacion General del Plan Nacional de Desarrollo 1982 – 2000", the guideline of the National Development Plan, are used as future population estimates. These are values estimated assuming adoption of a policy for decreasing the future population growth rate. As indicated in Table 5-2, the growth rate until 2000 averages about 3%.

Table 5-2 Future Target Values of Population

Population (1,000 persons)			Increase over the base year (times)			Average increase rate (%)		
1981	1990	2000	1990/1981	2000/1990	2000/1981	1990/1981	2000/1990	2000/1981
17,031	23,331	30,018	1.370	1.287	1.763	3.56	2.56	3.03

Source; Orientacion General del Plan Nacional de Desarrollo 1982-2000, INP, Diciembre 1981

5-2-2 Gross Domestic Product

Future target values of gross domestic product (GDP) in Peru are set according to the above-mentioned general guideline of the National Development Plan. These are shown in Table 5-3.

The future target values shown here are just targets under the National Development Plan and will not be so easy to attain.

The GDP trend of the past 22 years indicates, as in Table 5-4, that growth rate of GDP varied between –0.49% and 11.35%, that the average increase rate during 1960 – 1981 is about 4.5% and that this rate dropped to 3.1% during the last 10 years. Further, in today's world economy of many developing countries are being profoundly affected by the economic recession of developed countries and Peru, which is no exception, saw its annual GDP growth rate drop to 2.2% during the first half of 1982. Though the rate is expected to recover in the future, the recovery will not be rapid.

Table 5-3 Future Target Values of Gross Domestic Product

Gross domestic product (1973 price: 100 million soles)			Increase over the base year (times)			Average increase rate (%)		
1981	1990	2000	1990/1981	2000/1990	2000/1981	1990/1981	2000/1990	2000/1981
5,029	8,764	15,695	1.74	1.79	3.12	6.37	6.00	6.17

Source; Orientacion General del Plan Nacional de Desarrollo 1982-2000, INP, Diciembre 1981

Table 5-4 Gross Domestic Product in Peru

Year	Gross domestic product	
	Amount (1973 price; 100 million soles)	Rate of increase over previous year (%)
1960	2,158	11.36
1961	2,308	6.95
1962	2,497	8.19
1963	2,600	4.12
1964	2,791	7.35
1965	2,935	5.16
1966	3,124	6.44
1967	3,229	3.36
1968	3,220	Δ0.28
1969	3,345	3.88
1970	3,526	5.41
1971	3,703	5.02
1972	3,765	1.67
1973	3,926	4.28
1974	4,219	7.46
1975	4,411	4.55
1976	4,500	2.02
1977	4,497	Δ0.07
1978	4,475	Δ0.49
1979	4,659	4.11
1980	4,838	3.84
1981	5,029	3.95

Source: Compendio Estadistico 1980 I.N.E.
Cuentas Nacionales del Perú, Mayo 1982

Under these circumstances, the following three cases are assumed as economic frames for forecasting the volume of port cargoes in this study:

Case I: Case where the GDP growth rate is 6.37% for 1981 – 1990 and 6.00% for 1990 – 2000 which are targets under the National Development Plan.

Case II: Case where the GDP growth rate is set at 2.2% for 1982 in view of the latest economic situation. It is set at 4.0% for 1983 in anticipation of gradual recovery to the level of economic growth rate during the past three years and set at 5.0% after 1984.

Case III: Case where the GDP growth rate is the same for 1982 and 1983 as in Case II and it is set at 4.0% after 1984.

The future values of GDP for each case are as indicated in Table 5-5.

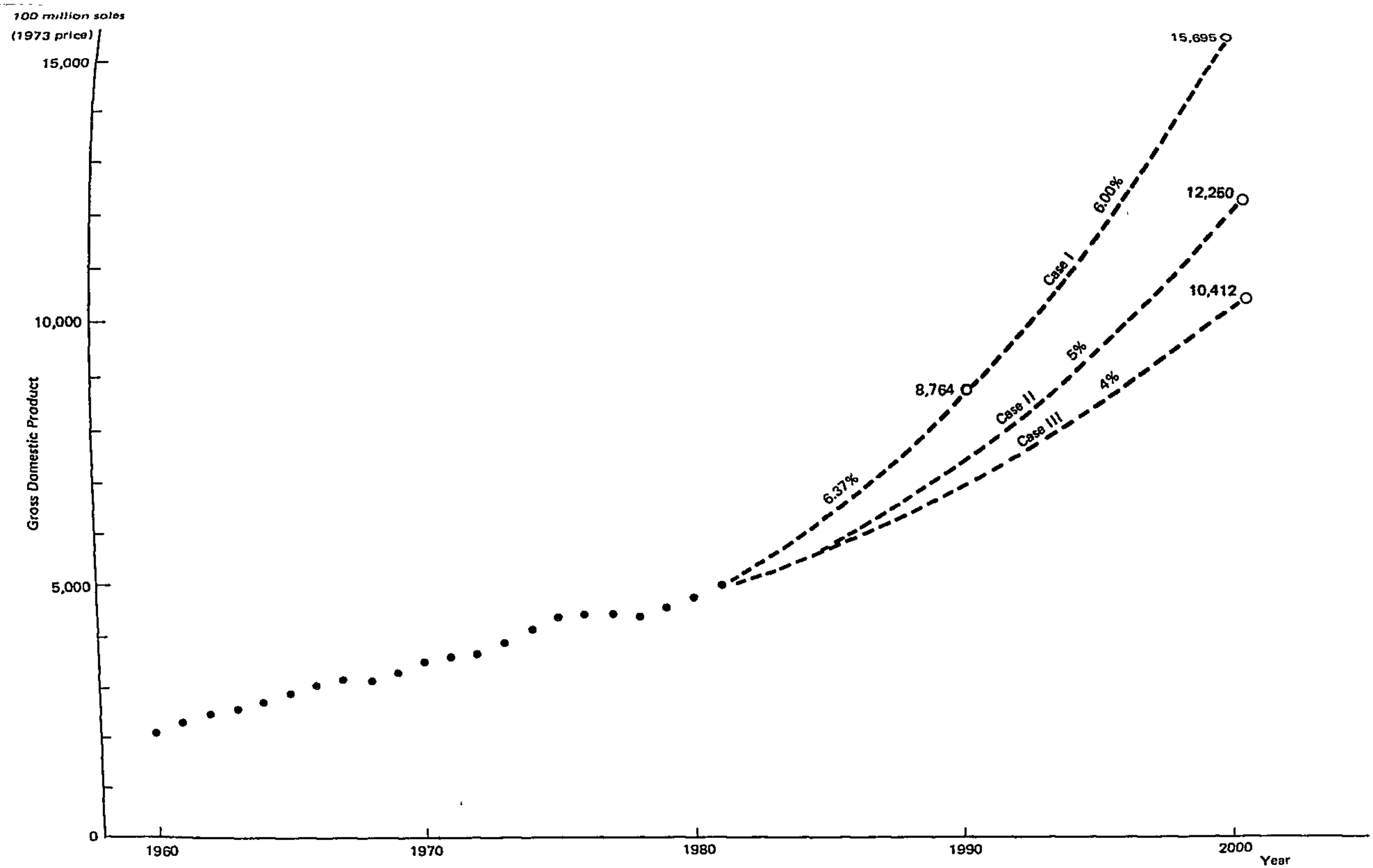


Fig. 5-2 Trend of Gross Domestic Product

Table 5-5 Setting of Future Values of Gross Domestic Product

Unit: 100 million soles

Case	1981	1987	1990	2000
I (6.37 – 6.00%)		7,284	8,764	15,695
II (5%)	5,029	6,497	7,521	12,250
III (4%)		6,253	7,034	10,412

5-3 Future Forecast on Volume of Cargoes at Callao Port

5-3-1 Forecast on Volume of General Cargoes

(1) Procedure of Forecasting

"General cargoes" as defined here means "all cargoes minus petroleum products, minerals (concentrates) and grains (bulk cargoes)". In forecasting the future volume of general cargoes, import general cargoes and export general cargoes are estimated separately because in the structural trade pattern of Peru their kinds and types are different. Peru exports mainly primary products and imports mainly secondary products.

Peru imports a wide variety of goods including mainly dry chemicals, iron and steel, machines and spare parts, sugar and general cargoes and most of these items are directly and closely related to the productive and consumptive activities in the hinterland. However, no secular data by industry, necessary for the analysis, is available. Therefore, for estimation by item, correlative analysis with the gross domestic product (GDP), representing total volume and the scale of economic activities, is used.

The exports, meanwhile, mainly comprise metal mining products, fishery products and processed goods, cement, coffee, textiles and general goods. These are produced by mining, fish processing and cement manufacture, which are industries related to the natural resources of Peru. Because assessing the future trends of these industries is relatively easy, the future of the nation's export goods is forecast for each of these main items separately.

The volume of domestic transportation is not covered by the present analysis because it is small and consists mostly of the unloading of fishery products.

(2) Estimation of Volume of Import General Cargoes

Investigation based on ENAPU statistics concerning the past trend of the volume of import general cargoes handled at Callao Port has been carried out. The accuracy of data on the volume of cargoes for two or three years are questionable but it indicates that otherwise this volume correlates fairly well with the gross domestic product.

Here, the gross domestic product of the entire country is used as a predictor variable, because no secular data on production in the hinterland of Callao Port is available. The hinterland of this port includes 41.5% of the national population and 74.5% of the production output from the manufacturing industries. Therefore, using GDP as an predictor variable is considered to be reasonable.

The volume of imported general cargoes is estimated by correlative analysis with the gross domestic product. (Fig. 5-3)

For obtaining the correlative equation between the volume of import general cargoes and GDP, data of 1960 – 1968 and 1980 – 1981 are used, leaving out the data of 1969 – 1979. This is because 1969 – 1979 was a period when policies such as the restriction of imports were taken under a military government and the economic activities of the country during that period are believed to be structurally different in many respects, from its present economic activities.

Fig. 5-4 and Table 5-6 show the estimated volume of imported general cargoes at Callao Port. The estimation was done by substituting the future GDP values into the correlative equation.

Table 5-6 Estimated Volume of Import General Cargoes at Callao Port

Unit: 1000 tons

Case	1981	1987	1990	2000
I (6.37 – 6.00%)		2,258	2,728	4,923
II (5%)	1,584	2,009	2,334	3,832
III (4%)		1,932	2,180	3,250

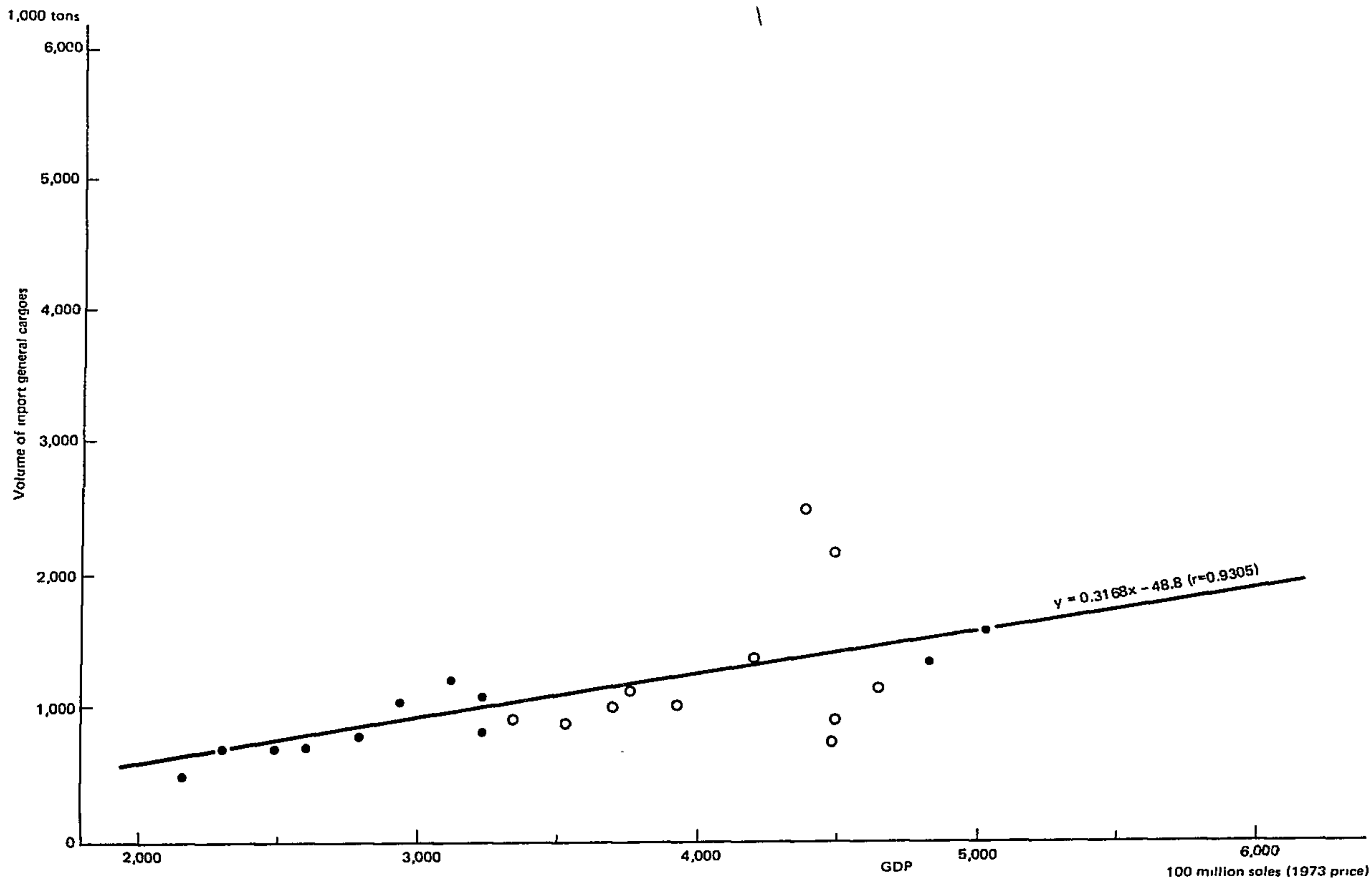


Fig. 5-3 Relation between General Cargoes (Import) and GDP

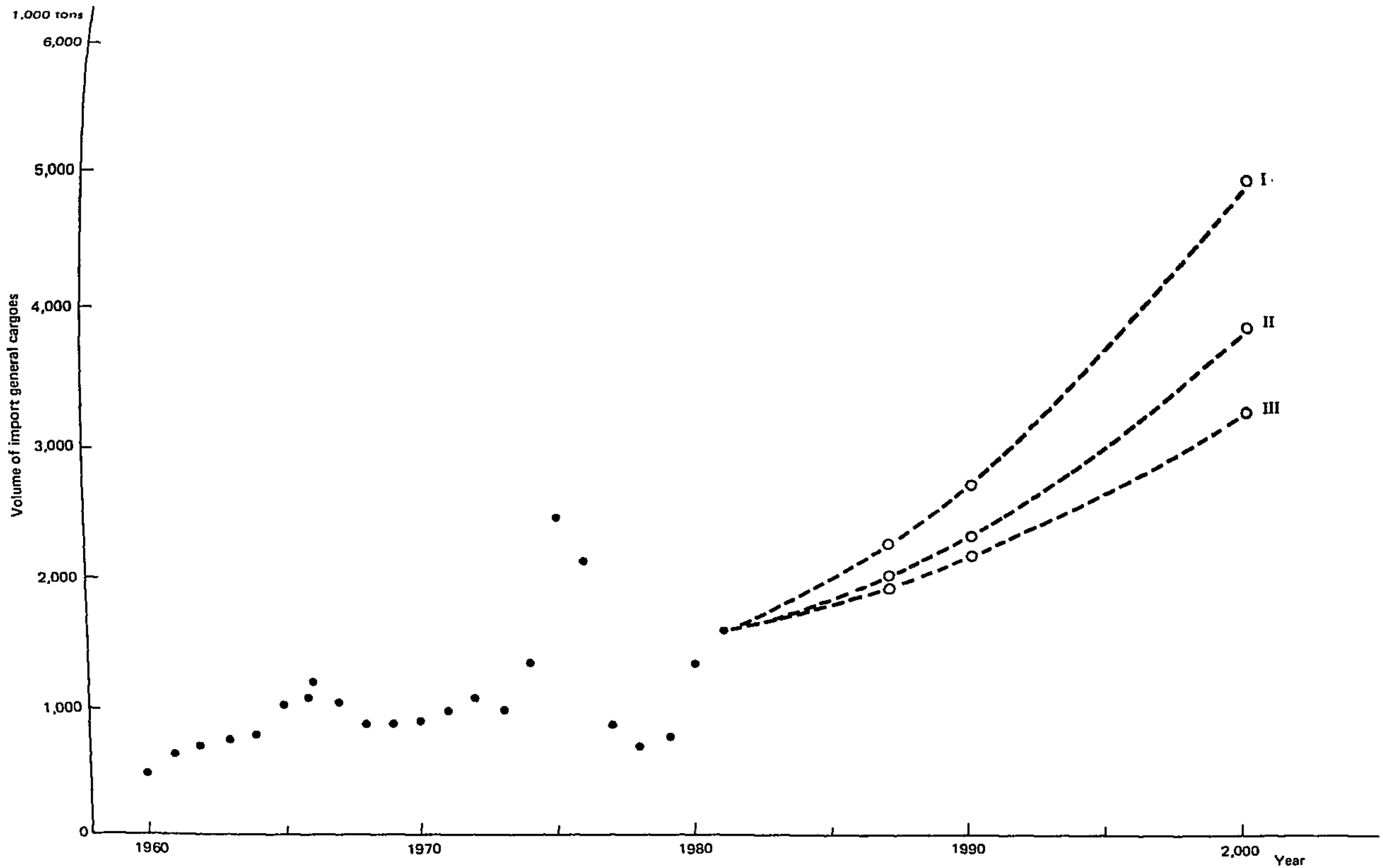


Fig. 5-4 Forecasting of Volume of Import General Cargoes at Callao Port

(3) Estimation of Volume of Export General Cargoes

As can be seen from the item composition of export general cargoes in Table 5-1, the main commodities are such agricultural products as grains, coffee, cotton and sugar, fishery products and processed goods, metal mining products, cement and such manufactured goods as spinning and weaving products. These are estimated by commodity according to the following procedure. The results are shown in Table 5-10 and Fig. 5-7.

1) Agricultural products

The principal exported agricultural products of Peru are coffee, cotton and sugar. Their export records are shown in Table 5-7 and the share of export of Peruvian ports is shown in Table 5-8.

Of these, sugar is excluded because it is produced mainly in Norther Peru and none is exported through Callao Port.

The export volumes of coffee and cotton vary considerably due, probably, to weather and the situation of the world market.

Yet, the average export volumes of coffee and cotton are, respectively, 40,000 – 50,000 tons and 30,000 – 40,000 tons.

As a future forecast, their export will be assured hereafter since they are important export crops and will be exported in the larger quantities than ever.

The export of grains is assumed to continue at the present level.

Table 5-7 Export Records of Principal Agricultural Products

Unit: 1,000 tons

Year	Coffee	Cotton	Sugar
1974	27.0	45.6	462.2
1975	43.2	36.6	421.8
1976	42.2	35.7	284.0
1977	43.9	21.2	411.8
1978	53.5	18.1	265.9
1979	69.5	20.0	180.8
1980	44.2	32.2	52.8
1981	45.5	31.5	–

Source: Ministerio de Agricultura

Table 5-8 Share of Ports of Shipment of Principal Agricultural Products

Unit: %

Port	Coffee	Cotton	Sugar
Pico y Paita	–	80	–
Callao	90	20	–
Matarani	10	–	–
Salaverry	–	–	100

Source: Ministerio de Agricultura

2) Fishery products and processed goods

The export of fishery-related goods by commodity is shown in Table 5-9.

The production of fish meal and fish oil has sharply decreased since 1972 due to poor catches of anchovy but, due to the change of fishery policy, efforts have recently begun to develop the processing of fishery products, such as the production of canned goods and the freezing of fish.

During the past five years, efforts to develop fish processing continued and the export increased at the average increase rate of 10%.

It is forecast that the export of processed goods, such as canned and frozen fish, will increase hereafter. It is assumed that, during the next nine years until 1990, the export will increase at the average increase rate of 10%, and that, after 1990, they will increase at the nation's target economic growth rate (6%).

Table 5-9 Past Export of Fishery-Related Goods by Commodity

Unit: 1,000 tons

Commodity	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Fish meal	214.5	188.?	250.0	52.4	36.9	64.2	66.3	41.0	41.1	43.6	20.5
Fish oil	45.2	95.4	102.0	0.1	10.3	12.9				22.9	4.2
Canned goods	2.6	5.0	5.8	7.7	4.3	3.9	5.6	13.0	27.6	23.0	57.0
Frozen fish	0.9	0.4	1.1	12.5	22.1	14.5	18.0	22.9	19.2	16.0	49.6
Salted fish							0.2	0.2	0.3		0.5
Fish in olive oil			1.0	1.9	0.7	0.5	1.7	0.8	2.7	7.0	3.4
Sea weeds	0.3	0.1			0.1		0.1	0.1	0.1		0.1
Others	0.3	0.1			3.4					1.0	0.1
Total	263.6	289.3	359.9	74.6	77.8	96.0	92.0	77.9	90.8	113.5	135.4

Source, Ministerio de Pesquría

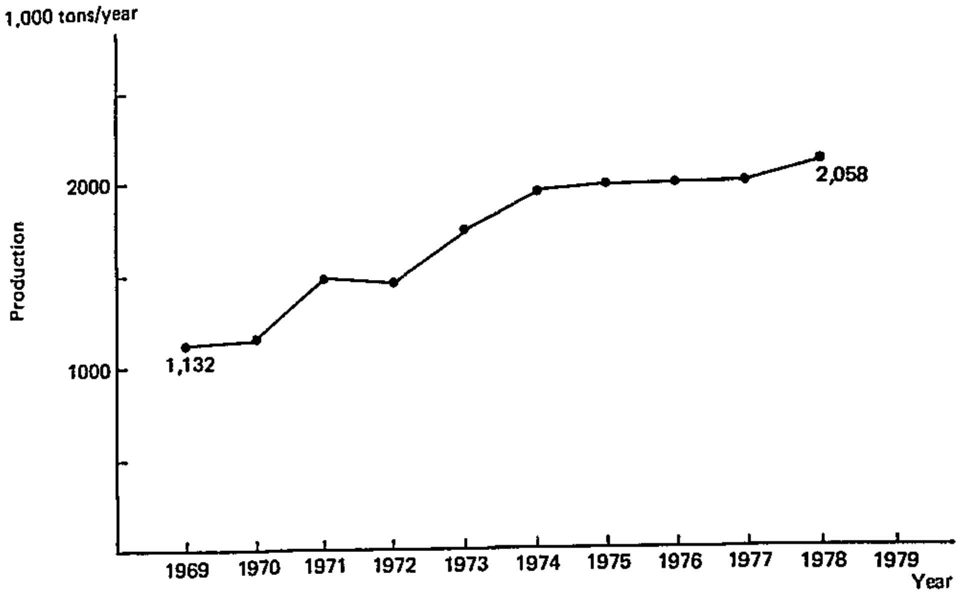
3) Metal mining products

Peru will continue to develop its mining industry as the most important of its export industries and increase the export of "mining products with more added value".

Table 5-32 shows trends of the past export of metal mining products which are mainly exported through Callao Port. As a future forecast, it is assumed that their export will continue to increase annually at 4.2% which was the average growth rate during the past 10 years.

4) Cement

The Peruvian demand for cement has rapidly grown due to the recent increase of social capital investment and the booming construction of hotel, office and other buildings. Accordingly, the domestic production of cement increased by an annual average rate of about 7% during the 1970s, as indicated in Fig. 5-5.



Source; United Nations "Year Book of Industrial Statistics"

Fig. 5-5 Trend of Cement Production

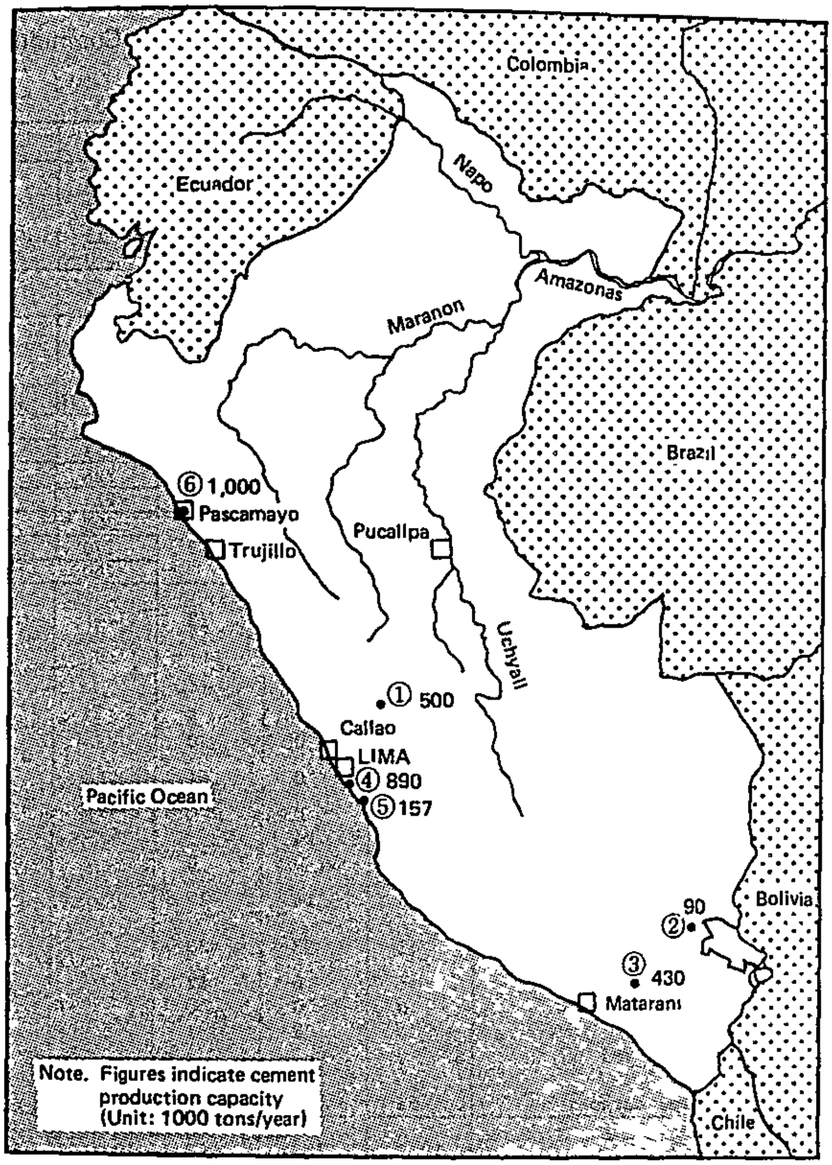
In Peru, cement is now produced at the six mills indicated in Fig. 5-6 and their production capacity is 3,067,000 ton/year (as of 1980). Surpluses from the domestic production are exported to such neighboring countries as Argentina, Chile and Equador.

The domestic demand for cement will increase in the future due to the step-up of the nation's economic activities. In response, each cement mill already has a short-term plan to expand its production equipment and, in the long run, too, production capacity is likely to be increased in step with the demand.

Regarding the prospect of cement export, in the short run there is ample room for export increase since production capacity cannot presently meet demand increase in other South American countries and these countries will probably require Peruvian cement, but in the long run, the export of Peruvian cement is unlikely to increase much because the demand in Peru itself will increase at a considerable rate and because cement production capacity will be expanded in the rest of South America.

Yet, in view of the fact that Peru is expected to positively increase its export of cement as an nontraditional export commodity, it is our forecast that the export of cement will increase until 1990 in proportion to the nation's economic growth and that from 1990, it will remain at the same level.

The share of Callao Port in the export of cement is assumed to remain constant since the regional distribution of the nation's cement production capacity is unlikely to greatly change in the future.



Source; World Cement Direclory 1980. Bolume), CEMBUREAU

Fig. 5-6 Regional Distribution of Cement Production Capacity

5) Others

Commodities included in this category are mostly such nontraditional export commodities as spinning and weaving products, fertilizers and chemicals, "other machines and parts" and "other general cargoes". The Government has a long range policy to reinforce the nation's manufacturing industries and make them internationally competitive to promote the export of nontraditional export commodities.

The forecast for these commodities, assumes that their export will increase at the growth rate of the gross domestic product, since their production is closely related to the nation's macroscopic economic activities.

Table 5-10 Estimation of Volume of Export General Cargoes by Commodity

		1979	1980	1981	1987	1990	2000
Agricultural products	Grains	3	3	2	3	3	3
	Coffee	58	39	42	62	62	62
	Cotton	4	8	15	15	15	15
	Sugar	0	0	0	0	0	0
Fishery products and processed goods		169	140	102	181	241	432
	Canned fish	40	52	62			
	Frozen fish	50	59	24			
	Fish meal	44	19	12			
	Fish oil	41	9	3			
Metal industry products		395	162	215	275	311	470
Cement	Case I	245	201	78	253	305	305
	Case II				226	262	262
	Case III				218	245	245
Others	Case I	173	186	209	303	364	652
	Case II				270	313	509
	Case III				260	292	433
	Other agricultural products and processed goods	9	12	13			
	Livestock products and processed goods	17	17	17			
	Logs	9	7	5			
	Paper and pulp	1	0	0			
	Other wood processed goods	3	0	1			
	Coal	0	0	0			
	Non-metallic ores	1	4	3			
	Other ceramic products	0	0	0			
	Fertilizers and chemicals	16	14	15			
	Spinning and weaving products	41	33	38			
	Ships	3	6	12			
	Automobiles	0	0	0			
	Car parts	4	2	1			
	Other machines and parts	7	11	20			
	Other general cargoes	62	80	84			
Total	Case I	1047	739	663	1092	1301	1939
	Case II				1032	1207	1753
	Case III				1014	1169	1660

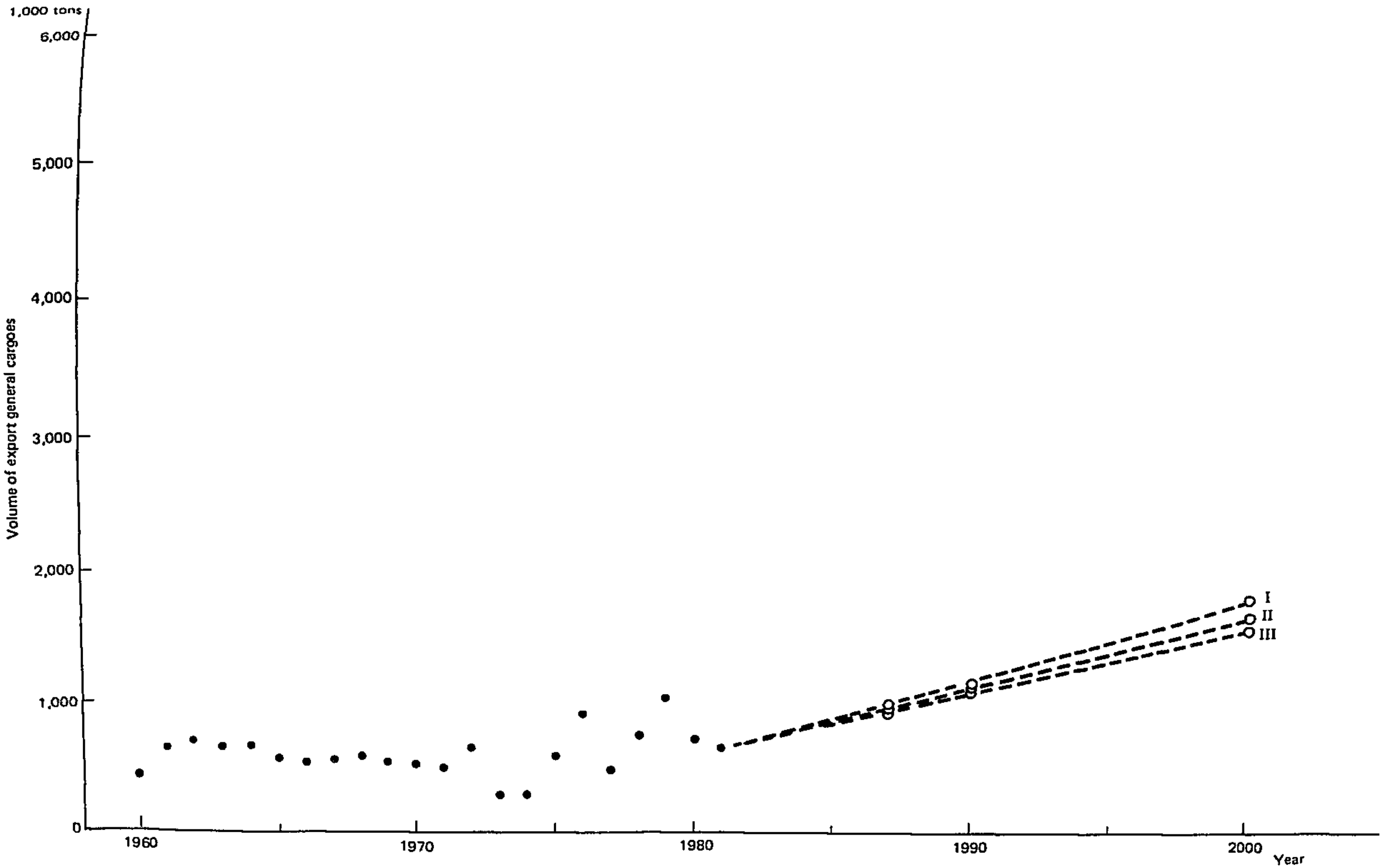


Fig. 5-7 Forecasting of Volume of Export General Cargoes at Callao Port

(4) Volume of General Cargoes in Target Years

The estimated volumes of export general cargoes and import general cargoes handled at Callao Port in the target years are shown in Table 5-11. Here, the volume of general cargoes includes container cargoes.

Table 5-11 Estimation of Volume of General Cargoes Handled at Callao Port (Including Container Cargoes)

Unit: 1,000 tons

Case	1981			1987			1990			2000		
	Import	Export	Total	Import	Export	Total	Import	Export	Total	Import	Export	Total
I (GDP 6.37-6.00%)	1,584	663	2,247	2,258	1,092	3,350	2,728	1,301	4,029	4,923	1,939	6,862
II (" 5%)				2,009	1,032	3,041	2,334	1,207	3,541	3,832	1,753	5,585
III (" 4%)				1,932	1,014	2,946	2,180	1,169	3,349	3,250	1,660	4,910

5-3-2 Forecasting of Volume of Container Cargoes

(1) Procedure of Forecasting

The volume of container cargoes is forecast by multiplying the percentage of containerization, estimated using a logistic curve, by the volume of general cargoes. The "percentage of containerization" is the ratio of the volume of container cargoes to the volume of general cargoes.

The percentage of containerization must be estimated on the basis of the past trends of containerization by export/import, by commodities and by routes, taking into account such factors as the preparedness of container handling facilities at ports of call and the trends of ship assignment by shipping companies.

But in the case of Callao Port, the volume of container cargoes has been forecast by the following procedure because of such restrictions as the limited career of the port as regards container transportation and the scarcity of local statistics on container transportation.

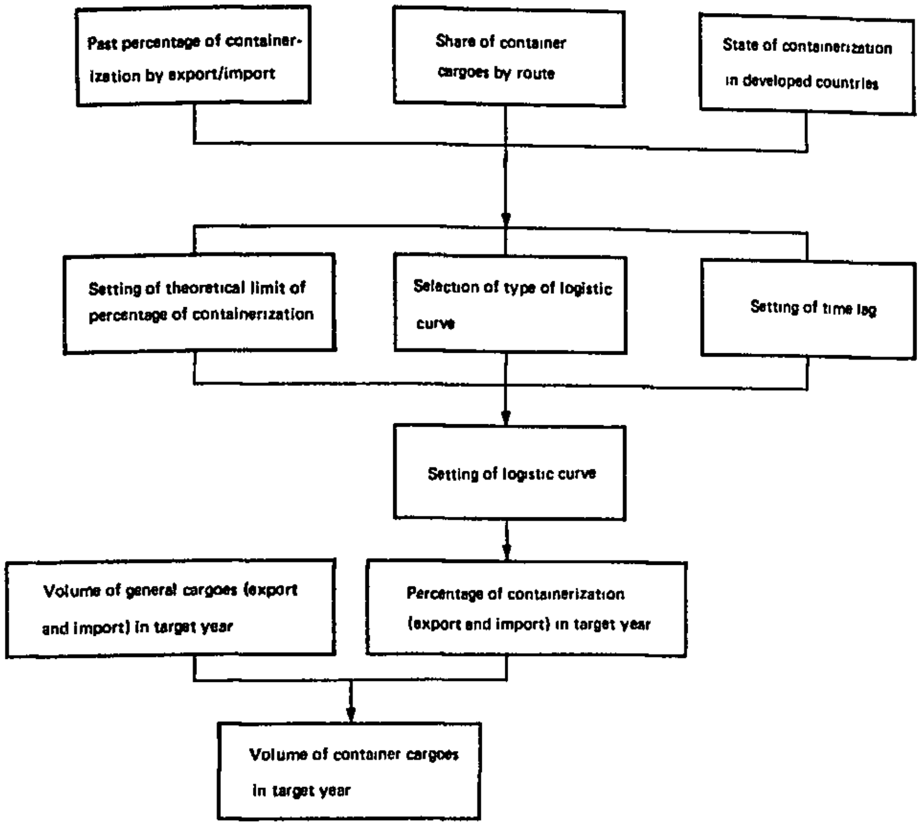


Fig. 5-8 Procedure of Forecasting of Volume of Container Cargoes

(2) Present Condition and future of Container Transportation on the West Coast of South America

As of 1982, there were many container ship lines connecting the west coast of South America to the U.S., Europe and other areas of the world.

On these lines, a total of 23 shipping companies are engaged in container transportation either singly or in groups.

15 of these shipping companies make container ship calls at Callao Port. (See Table 5-12)

Table 5-13 shows the situation regarding container ships in service for container transportation on the west coast of South America. Of the container ships in service, the majority are multi-purpose ships (53%) and semicontainer ships (32%), and only 3 full-container ships (3%) are in operation.

The loading capacity of these full-container ships is about 600 TEUs, which is comparatively small.

The largest full-container ships presently in service are in the 18,500 DWT class. Of other ships, the largest are 22,500 DWT class multipurpose ships.

In April 1981, the Andes Consortium (CCNI, NYK, K-Line) put into service 3 full-container ships on the Far-East line and began monthly service.

In June 1981, CSAV (Chili) put into service 3 RO/RO ships on the East Coast Gulf line, and in August 1981, Empremar (Chili) deployed 4 multipurpose ships on the European line. FMG (Columbia) deployed semi-container ships and multi-purpose ships to the North American and Far East lines.

Meanwhile from August 1981, ENS (Empresa Naviera Santa SA) of Peru began every-other-month service on the North America-Gulf line, and from October 1981, CPV (Compania Peruana de Vapores) began monthly service on the Far East line.

The situation points to the fact that, on the west coast of South America, although container transportation is increasing the ports themselves are not fully equipped with container handling facilities.

Table 5-12 Container Routes on the West Coast of South America

Route	Shipping Company	Shipping Company Delivering Container Ships at Callao Port
Far East	4	2
U.S.A.	11	6
Europe, Mediterranean Sea	7	6
Australia, New Zealand	1	1
Total	23	15

Table 5-13 Container Ships Serving the West Coast of South America

Classification	Abbreviation	Ships	Handling Capacity		
			Average	Maximum	Minimum
Fully Cellular	FC	3	582	692	502
Semi Container Ship	SC	30	346	852	100
Converted to Semi Containership	CS	8	217	316	100
Multipurpose or General Carrier	GC	50	260	676	92
RO-RO/Cellular	RC	3	440	440	440
RO-RO	RR	1	400	–	–
Total		95	301	852	92

The most concrete deployment plan at present is that of the European line by Consortium Eurosal, to be implemented in early 1984.

According to the plan, 7 container ships of 1,600 ~ 1,800 TEUs are scheduled for weekly service. Ports of call in South America will be Buenaventura (Columbia), Guayaquil (Equador),

Fig. 5-9 The number of ports serviced by container shipping routes on the South American west coast

Callao (Peru), San Antonio and Valparaiso (Chili).

Of these ports, only Guayaquil and San Antonio are equipped with facilities (1 gantry crane and 1 mobile crane, respectively) to handle containers.

For this reason, Eurosal is said to be planning to deploy container ships equipped with cranes.

In addition, on the North American line, full-container ships are expected to be deployed sometime soon.

Whether these container ships will call at every port or just at special ports with connecting feeder service to other ports, is yet to be determined. Judging from the present facilities at each port and the cargo-collecting capacities, container ships serving the west coast of South America will call only at the special ports.

(3) Trend of Containerization at Callao Port

Percentage of containerization by export/import, obtained from ENAPU's statistical data, is shown in Table 5-14. Percentage of containerization in 1981 ranges between 6.1 and 11.1%. According to the experience in other countries, Callao Port's containerization is presently at the stage immediately before a remarkable increase in the percentage of containerization.

Past percentages of containerization by commodities (99-item classification) are shown in Table 5-15.

In analyzing trends of containerization, it is desirable beforehand to check, route by route, the following characteristics of routes.

① The situation of containerization

② The types and lots of principal cargoes

③ The future sailing schedules of shipping companies.

Then, the percentage of containerization by ship route in the target years can be determined. But due to the shortage of available statistical data and information, the following procedure has been taken.

Table 5-16 shows "shares and volumes of general and container cargoes by trading partner in 1977", as obtained from ENAPU. The shares were calculated from the volume of cargoes (tons) in the case of general cargoes and from the number of handled containers in the case of container cargoes. This table shows that container transportation is used on nearly all routes. However, these containers are carried almost entirely by conventional ships. Though some semi-container ships and multipurpose ships are put into service, no full-container ships are used on these routes. Since containerization is still in the early stages of progress at Callao Port, it is difficult to separate ship routes into regular container service routes and routes at the undeveloped stage, and then to analyze the future prospect of containerization by ship routes.

Table 5-14 Percentage of Containerization of Callao Port

Unit: 1,000 tons, %

Item	Import			Export			Total		
	1979	1980	1981	1979	1980	1981	1979	1980	1981
Volume of general cargoes	789.4	1,344.2	1,584.7	1,048.5	740.3	663.5	1,837.9	2,074.4	2,248.2
Volume of container cargoes	14.2	56.9	96.6	12.4	15.2	73.4	26.6	72.1	170.0
Percentage of Containerization	1.8	4.3	6.1	1.2	2.1	11.1	1.4	3.5	7.6

Table 5-15 Percentage of Containerization by Commodity (99 Items Classification)

	Commodity	Import			Export		
		1979	1980	1981	1979	1980	1981
01	General cargoes	10.4	20.1	25.5	1.9	3.0	7.8
03	Baggages	29.3	33.8	46.1	18.6	35.4	43.2
04	Baggages of ship Crew members and passengers	0	6.6	13.1	0	7.6	4.8
13	Processed wood	-	-	-	2.7	0.7	42.7
15	Paper	1.5	1.8	2.9	-	-	-
16	Quebracho	0	0	5.1	-	-	-
18	Cardboards and printed matter	7.8	12.7	17.2	-	-	-
20	Dried vegetables	0	7.5	13.1	0	2.5	32.5
22	Oats	13.8	74.6	30.8	-	-	-
24	Coffee	-	-	-	0	0	18.5
26	Barley	0	0	7.2	-	-	-
29	Other grains	-	-	-	0	0	14.9
33	Beverages	18.6	27.8	48.8	11.3	18.1	32.5
34	Canned goods	28.5	52.1	49.8	2.4	1.0	60.0
35	Fresh and dried fruit	-	-	-	0	0	7.9
36	Furs, tanned skins and hairs	0	57.4	75.6	0	5.9	13.7
37	Meat	0	0	9.0	-	-	-
38	Dairy products	0.6	0.4	2.6	-	-	-
39	Other livestock products	-	-	-	0.8	0.2	16.2
43	Canned fish	-	-	-	0	6.0	56.2
44	Gunny sacks	-	-	-	0	0	0.6
47	Tobacco	0	46.0	11.7	-	-	-
63	Dye stuffs	0	10.0	17.2	-	-	-
64	Liquid chemicals	-	-	-	0	0	1.3
66	Perfumes	0	0	3.8	-	-	-
67	Pharmaceuticals	0	0	11.2	-	-	-
68	Dry chemicals	1.4	5.5	8.7	0	0.1	21.0
70	Clay and kaolin	0	0	0.2	-	-	-
76	Hardware	0.5	1.7	4.4	-	-	-
77	Tin plates	0	16.6	0.9	-	-	-
78	Bricks	0	3.2	0	-	-	-
79	Pipes	0.2	0	0.6	-	-	-
82	Iron and steel	0	0.1	0	-	-	-
89	Others ores	0	0.6	0	-	-	-
91	Tires	0	25.3	9.5	8.3	62.3	50.0
92	Machines and spare parts	6.4	8.5	9.7	5.3	8.5	10.9
93	Electrical equipment	22.7	31.1	57.6	0	0.2	0
94	Electronic equipment	21.3	21.2	44.8	-	-	-
95	Vehicles	0.4	0.3	0.4	0	0	4.5
96	Spinning and weaving products	13.0	37.5	46.0	25.6	24.9	33.5
97	Assembly parts (vehicle)	0	0.4	27.0	-	-	-
99	Vehicle spare parts	16.1	16.2	19.7	0	4.1	8.9

Table 5-16 Shares and Volumes of General and Container Cargoes by Trading Partner in 1977

Trading Partner	General cargoes		Container cargoes	
	Volume of cargoes (1,000 tons)	%	Number of full-loaded containers	%
Northern Europe	332.1	25	1,682	38
Mediterranean Countries	101.1	8	140	3
U.S. east coast and Gulf	411.8	31	1,567	37
U.S. east coast and Canada	96.7	7	304	7
Caribbean Countries	3819	3	142	3
West coast of South America	41.8	3	192	4
East coast of South America	99.6	8	90	2
Japan and Far East	169.4	13	279	6
Australia	16.2	1	0	0
Africa	6.0	0.5	0	0
Others	6.5	0.5	0	0
Total	1,320.1	100	4,397	100

Source. ENAPU

Containerization is more advanced on the routes to Northern Europe, the U.S. east coast and the Gulf of Mexico, than on the other routes because containerization is more advanced in these countries and because large volumes of cargoes are transported by these routes. But taking these differences into consideration, in sufficient data is available determine the percentage of containerization. So, future percentages of containerization could not be estimated by route. In this report, percentage of containerization has been calculated by export/import for all routes.

(4) Setting a Theoretical Limit for the Percentage of Containerization

The "Theoretical limit for the percentage of containerization" is the percentage of containerization ultimately attained when containerization has fully progressed. Here, these theoretical limits are estimated, taking the cargo characteristics of Callao Port and the actual percentage of containerization at more advanced ports into consideration. The theoretical limit for the percentage of containerization of export and import cargoes handled at Callao Port has been calculated by calculating the mean of the "theoretical limits for the percentage of containerization by commodity" weighted by import/export cargo volume.

For this calculation 99 commodities were reorganized into 24 items. The volume of export/import cargoes by item in 1981 was used. Table 5-17 shows the theoretical limit for the percentage of containerization by export/import cargo and Table 5-18 shows the theoretical limit for the percentage of containerization by item (24 items).

Table 5-17 Theoretical limit for the Percentage of Containerization by Export/Import

Import	Export
75%	68%

Table 5-18 Theoretical Limit for the Percentage of Containerization by Commodity (24 Items)

Commodity	Import	Export
1 Grains*	50	100
2 Coffee	100	100
3 Cotton	100	100
4 Sugar	100	0
5 Other agricultural products and processed goods	100	100
6 Livestock products and processed goods	100	100
7 Fishery products and processed goods	100	100
8 Logs	0	0
9 Paper and pulp	100	100
10 Other wood processed goods	100	100
11 Coal	0	0
12 Metallic ores	–	–
13 Non-metallic ores	0	0
14 Metal industry products	50	50
15 Cement	0	0
16 Other ceramic products	0	0
17 Petroleum products	–	–
18 Fertilizers and chemicals	100	100
19 Spinning and weaving industry products	100	100
20 Ships	0	0
21 Automobiles	0	0
22 Auto parts	100	100
23 Other machines and parts	75	75
24 Other general cargoes	100	100

Note: * Grains here are bagged cargoes and do not include bulk cargoes.

(5) Setting of Logistic Curves Representing Trend of Progress of Containerization

It is known from surveys at many ports with advanced containerization that the percentage of containerization approximately changes according to logistic curve.

The equation for logistic curves representing the progress of containerization is:

$$P = \frac{Pm}{1 + C\,(t\text{-}to)}$$

where, P: Percentage of containerization in t year

Pm: Theoretical limit of percentage of containerization

C: Constant to determine shape of curve

t: Year

to: Time lag shown by unit of year (Constant)

Determining constants using the least square method is not appropriate because only three years of past results at Callao Port are available and these data are for the early stage of containerization only. So, values of constants have been determined based on the average values at many ports with advanced containerization. Value of "C" ranges between 0.6 and 0.7 for export and 0.7 and 0.8 for import.

Now, a curve through the points showing past results in 1979 – 81 can be drawn, using the theoretical limit for the percentage of containerization shown in Table 5-17. This is shown in Figs. 5-10 and 5-11.

For further analysis, the average values of C, i.e. 0.65 for export and 0.75 for import, have been chosen.

(6) Estimation of Volume of Container Cargoes in Target Year

The volume of container cargoes in a target year can be obtained by first obtaining the percentage of containerization in the target year using the logistic curve shown in Figs. 5-10 and 5-11 and then multiplying the volume of general cargoes shown in Table 5-11 by this percentage of containerization.

Table 5-20 shows estimated volume of container cargoes at Callao Port obtained by the above procedure.

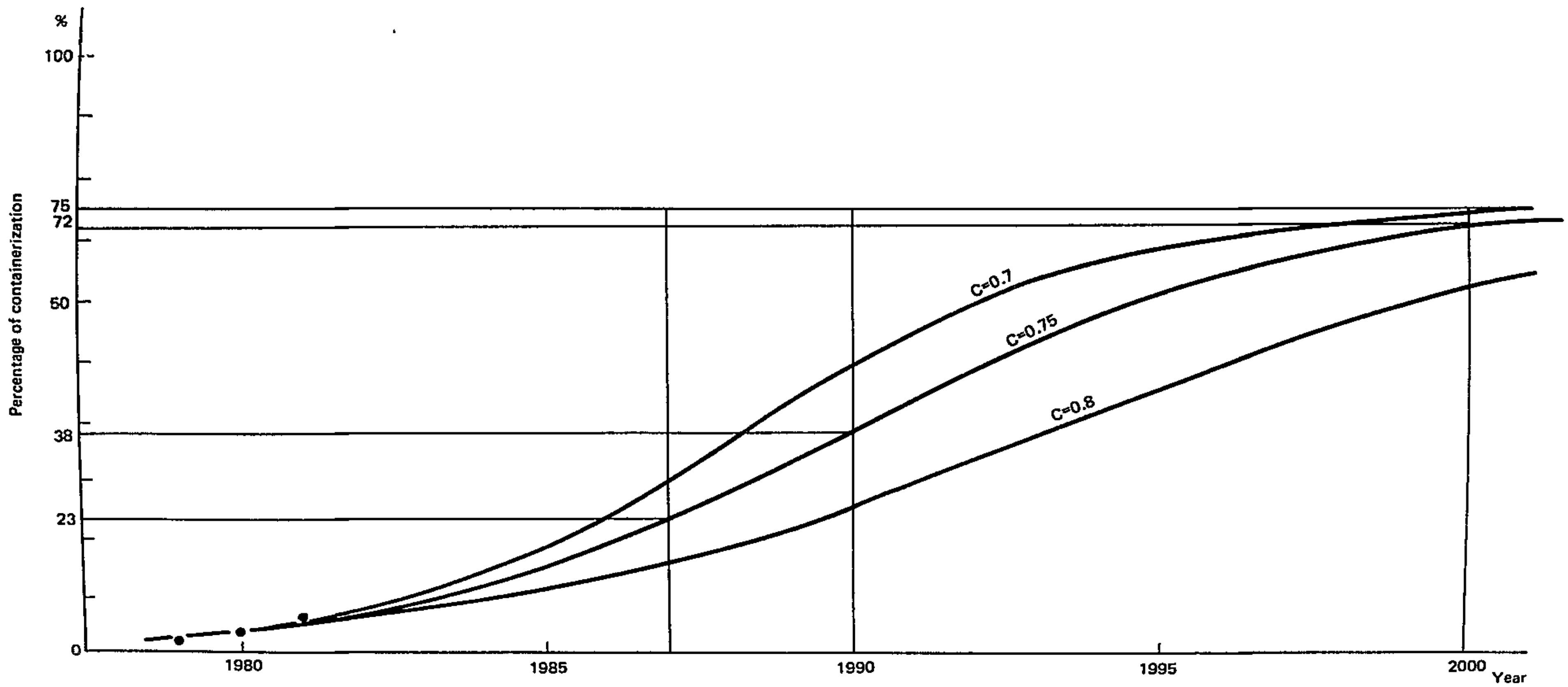


Fig. 5-10 Estimation of Future Percentage of Containerization Using Logistic Curve (Import)

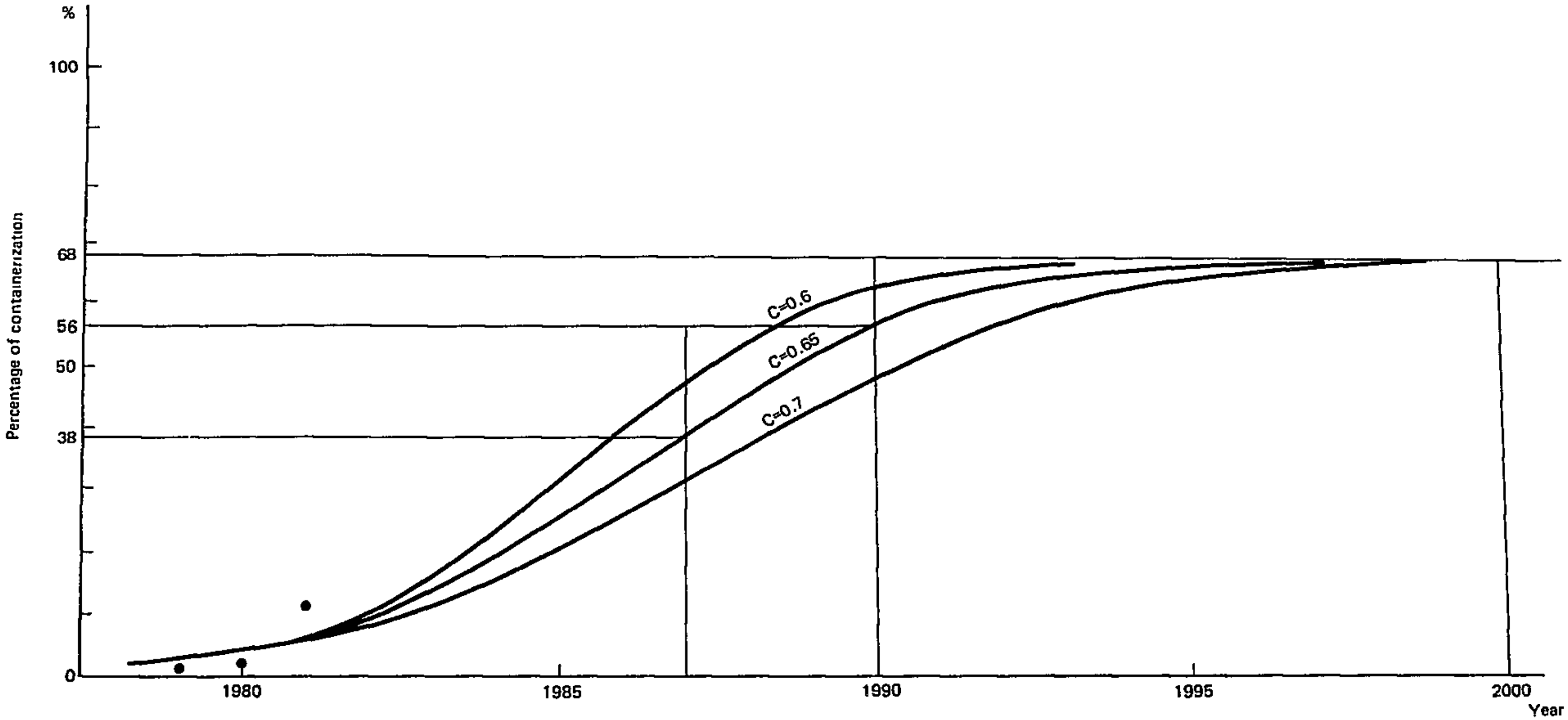


Fig. 5-11 Estimation of Future Percentage of Containerization Using Logistic Curve (Export)

Table 5-19 Estimation of Percentage of Containerization

Year \ Item	Percentage of Containerization (%)	
	Import	Export
1981	6	11
1987	23	38
1990	38	56
2000	72	68

Table 5-20 Estimation of Volume of Container Cargoes at Callao Port

Unit: 1,000 tons

Case	1981			1987			1990			2000		
	Import	Export	Total	Import	Export	Total	Import	Export	Total	Import	Export	Total
I	96.6	73.4	170.0	519	415	934	1,037	729	1,776	3,545	1,319	4,864
II				462	392	854	887	676	1,563	2,759	1,192	3,951
III				444	385	829	828	655	1,483	2,340	1,129	3,469

5-3-3 Forecasting of Volume of Imported Grains

(1) Procedure of Forecasting

Wheat, maize and rice are the three important grains imported through Callao Port and represent about 90% of all imported grains (see Table 5-21).

So, in forecasting the volume of imported grains, only wheat, maize and rice are studied. Estimation of volumes of the other grains (oats, barley, oil seed and "other grains") has been done based on the assumption that their present share will not change in the future.

Table 5-21 Volume of Imported Grains at Callao Port

Item	1979		1980		1981	
	Quantity 1000 tons	Percentage	Quantity 1000 tons	Percentage	Quantity 1000 tons	Percentage
Rice	157	15.6	206	14.5	127	9.6
Oats	20	2.0	12	0.8	12	0.9
Maize	101	10.1	507	35.5	336	25.5
Barley	-	-	-		49	3.7
Oil seed	-	-	-		0	0
Wheat	640	63.8	614	43.0	734	55.7
Other grains	85	8.5	88	6.2	61	4.6
Total	1,003	(89.5) 100.0	1,427	(92.9) 100.0	1,319	(90.7) 100.0

Source: ENAPU

The agricultural policy of Peru first aims at raising technical levels and expanding the area under cultivation through the rational use of water resources. Then, improvement of productivity and increase of production will be induced. As the result of this policy, imports of food will be cut and the self-sufficiency rate of foods will go up.

For this purpose, Peru is seeking to preferentially increase the production of crops suitable for its topographical and natural conditions. At present, realization of self efficiency of rice and maize are considered as immediate targets of Peruvian agricultural policy.

According to the grain import plan of the Ministry of Agriculture, self-sufficiency of rice is scheduled to be accomplished in 1983, then imports of rice will be stopped (see Table 5-22).

Table 5-22 Import Plan of Principal Grains (Ministry at Agriculture)

Unit: 1000 tons

Year / Type	1981	1982	1983	1984	1985	1986	1987
Wheat	921.4	983.0	1,000.0	1,060.0	1,073.4	1,105.4	1,137.4
Maize	450.0	450.0	473.0	500.0	528.5	558.5	590.5
Rice	102.0	55.0	–	–	–	–	–

Source: Documento de Trabajo preparado por la Oficina de Programacion de la DGAIC-1982, para ayuda alimentaria entre U.S.A. y PERU.

Due to the above mentioned reasons, demand forecasting is concerned, mainly, with two items: wheat and maize.

The method of forecasting the volume of grain imports at Callao Port consists of first determining the nation's domestic demand and domestic production. Then, the difference between the demand and production will be assumed as the nation's import needs. The future values of domestic demand are determined using the data about the growth rate of population and the per-capita caloric intake. The future values of domestic production are determined using the future area under cultivation and the future yield per unit area. Finally, volume of wheat and maize imports at Callao Port are determined, using the port's present import share.

(2) Forecasting of Grain Imports at Callao Port

The growth rate of population is determined using the estimated values found in the "Orientación General del Plan Nacional de Desarrollo 1982 – 2000" (see Table 5-2).

As for the growth rate of per-capita caloric intake, the national average (1,927 cal in 1979) is first determined using "present per-capita caloric intakes by region and income stratum" which are shown in the World Bank report "PERU Major Development Policy Issues and Recommendations". It is assumed that the national average caloric intake in the year 2000 will reach the present level of the maximum caloric intake rate of the nation's middle class people (see Table 5-23 and 5-24).

Table 5-23 Estimated Per Capita Calorie Consumption by Region and Income Stratum of PERU, 1979

Region		Income Strata		
		Low	Middle	High
	Percent of Population	50	40	10
Lima	23.0	1,714	2,003	2,140
Coastal Cities	14.4	2,121	2,338	2,075
Sierra Cities	11.1	2,235	1,246	2,075
Selva Cities	2.7	1,880	1,246	2,075
Rural Coast	8.0	1,902	2,050	2,007
Rural Sierra	34.0	1,971	1,634	2,167
Rural Selva	6.8	2,481	1,646	2,167

Source: PERU Major Development Policy Issues and Recommendations, The World Bank

Table 5-24 Increase Rate of Per-capita Calorie Consumption

Per-capita calorie consumption (cal)		Increase over the base year (times)	Annual Average increase rate (%)
1981	2000	2000/1981	2000/1981
1,963	2,338	1.213	0.92

The future area under cultivation is estimated by Instituto Nacional de Planificatiôn. According to this, the total area under cultivation will increase by approximately 55 percent during the period of 1972 – 1990. Cultivated area for maize and rice will be drastically increased because they are crops suitable for the natural ecological conditions of Peru (see Table 5-25).

Future yields per unit area are determined by trend estimation using national average yield per unit area shown in the above-mentioned World Bank report (see Table 5-26).

Table 5-25 Cultivated Areas of Principal Grains

Item	Cultivated area 1,000 has		Increase over the base year (times)	Annual Average increase rate
	1972	1990	1990/1972	1972/1990
Wheat	134.9	87.2	0.646	Δ2.40
Maize	383.0	440.1	1,149	0.78
Rice	118.1	149.4	1,265	1.31
Total cultivated area	2,361.8	3,675.3	1,552	2.47

Source: Modelo Prospectivo Informe al Horizonte 1990, INP, Diciembre 1980

Table 5-26 Yields of Principal Grains per Unit Area (National Averages)

kg/ha

Year	Wheat	Maize
1970	920	1,610
1971	880	1,650
1972	890	1,641
1973	901	1,635
1974	924	1,663
1975	945	1,751
1976	952	1,883
↓	↓	↓
1987	1,046	2,212
1990	1,074	2,324
2000	1,167	2,696

Source: PERU, Major Development Policy Issues and Recommendations, The World Bank

The nation's domestic demand, domestic production and import of wheat and maize are as shown in Table 5-27, 5-28 and Fig. 5-12, 5-13.

The volume of grains handled at Callao Port was obtained as the sum of two quantities. The one is the volume of wheat and maize handled at Callao Port, which was calculated using their total import volume through Peruvian ports and the handling share by port shown in Table 5-29. The other is the quantity of other grains handled at Callao Port. Table 5-30 shows their sum the total volume of grains handled at Callao Port.

Table 5-27 Estimation of Imported Wheat

Unit: 1,000 tons

Year	Domestic demand	Domestic production	Import
1970		125.4	
1971		122.2	
1972		120.1	
1973		122.6	
1974		127.4	
1975	896.3	126.3	770.0
1976	880.5	127.5	753.0
1977	895.4	115.4	780.0
1978	824.4	104.4	720.0
1979	917.1	102.1	815.0
1980	907.1	77.1	830.0
1981	1,040.0	118.6	921.4
↓	↓	↓	↓
1987	1,355	109	1,246
1990	1,547	104	1,443
2000	2,183	88	2,095

Source: 1) PERU, Major Development Policy Issues and Recommendations, The World Bank, June 1981 – Import in 1975 – 1979
2) Plan Nacional de Desarrollo para 1982 – 1983 Plan Global, INP Febrero 1982 – Demand and production in 1980 – 1981
3) Compendio Estadistico 1980, INE, Julio 1981 Production in 1970 – 1979

Table 5-28 Estimation of Imported Maize

Unit: 1,000 tons

Year	Domestic demand	Domestic production	Import
1970		614.6	
1971		616.4	
1972		628.3	
1973		599.5	
1974		605.6	
1975	1,024.7	634.7	390.0
1976	1,008.0	725.7	282.3
1977	905.0	733.9	171.1
1978	739.6	590.0	149.6
1979	750.3	621.5	128.8
1980		442.8	
1981	1,036.7	586.7	450.0
↓	↓	↓	↓
1987	1,350	685	665
1990	1,542	736	806
2000	2,176	924	1,252

Source: Same as in Table II-26

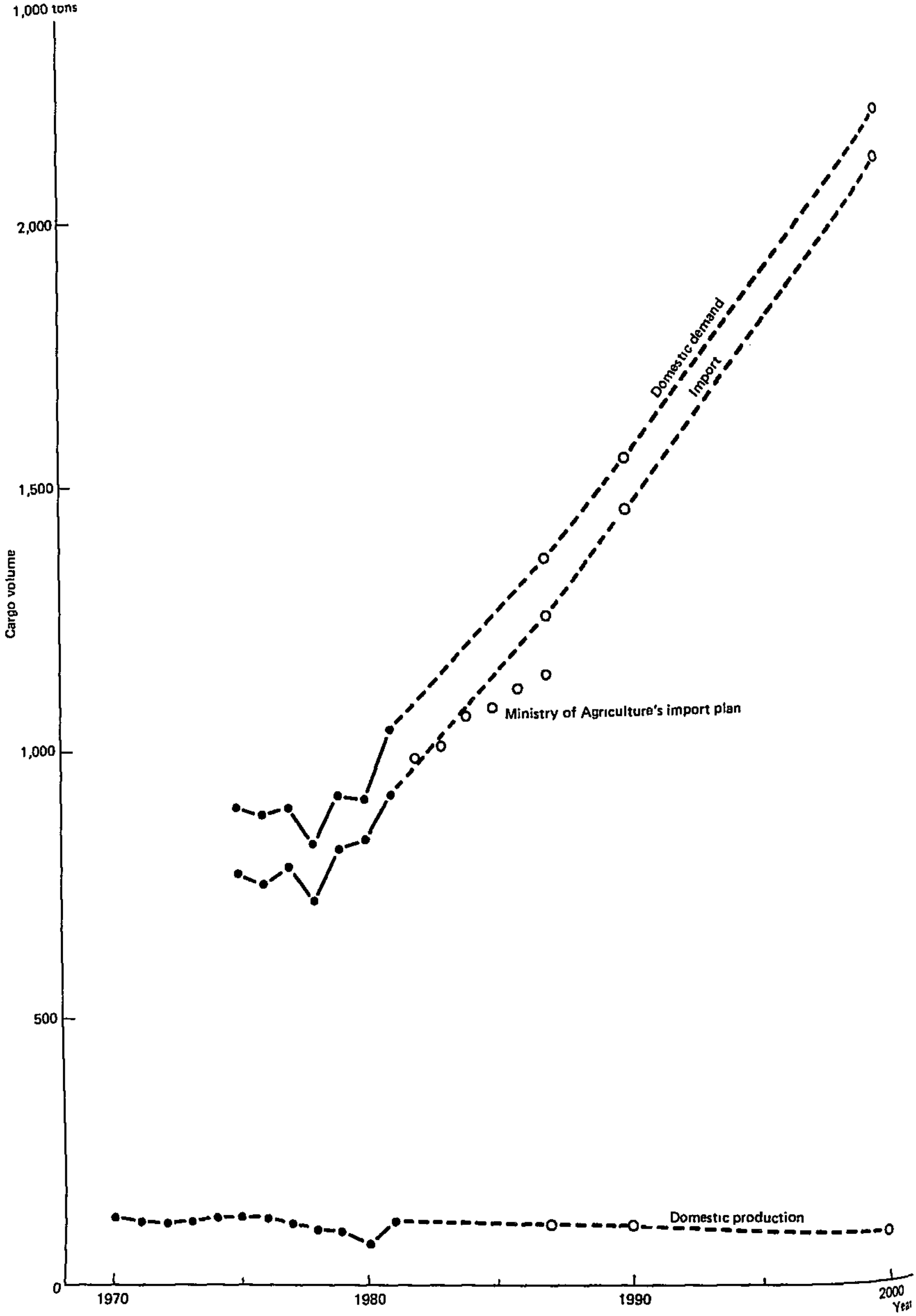


Fig. 5-12 Estimation of Imported Wheat

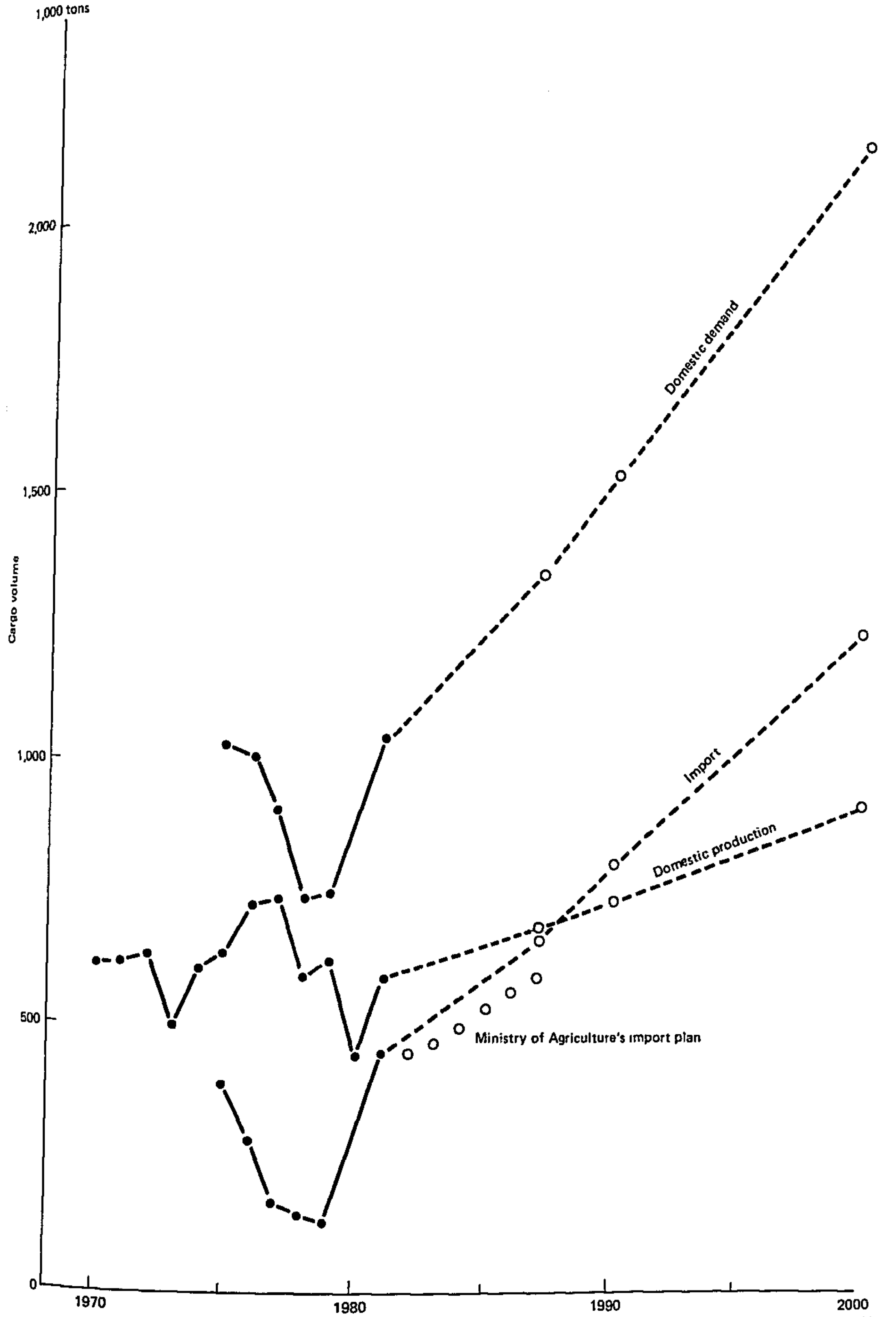


Fig. 5-13 Estimation of Imported Maize

Table 5-29 Share in Import Volume of Principal Grains by Port (1980)

%

Name of port	Wheat	Maize	Rice
PAITA	14	–	–
CALLAO	66	98	60
MATARANI	18	–	–
IQUITOS	2	–	–
SALAVERRY	–	2	–
PACASMAYO	–	–	–

Source: Dirección de Agricolas – DGAIC-Ministerio de Agricultura

Table 5-30 Estimation of Volume of Imported Grains Handled at Callao Port

Unit: 1,000 tons

Year	Wheat	Maize	Rice	Other grains	Total
1981	734	336	127	122	1,319
1987	845	399	0	124	1,368
1990	985	522	0	151	1,659
2000	1,415	914	0	233	2,562

5-3-4 Forecasting of Exported Minerals (Concentrates)

(1) Procedure of Forecasting

The quantity of concentrates exported through Callao Port is forecast by the procedure indicated in Fig. 5-14.

First, the past quantity of concentrates exported through Callao Port are established using ENAPU's statistics. Then the characteristics of cargoes – concentrates – is made clear by studying the secular changes of handled volumes and the share of each mineral. Further, taking the trend of the nation's export of minerals, future mine development plans, ore reserves, concentrate exporting plans and situations of the world economy into consideration, the future circumstances for export are examined. Finally export volume is estimated.

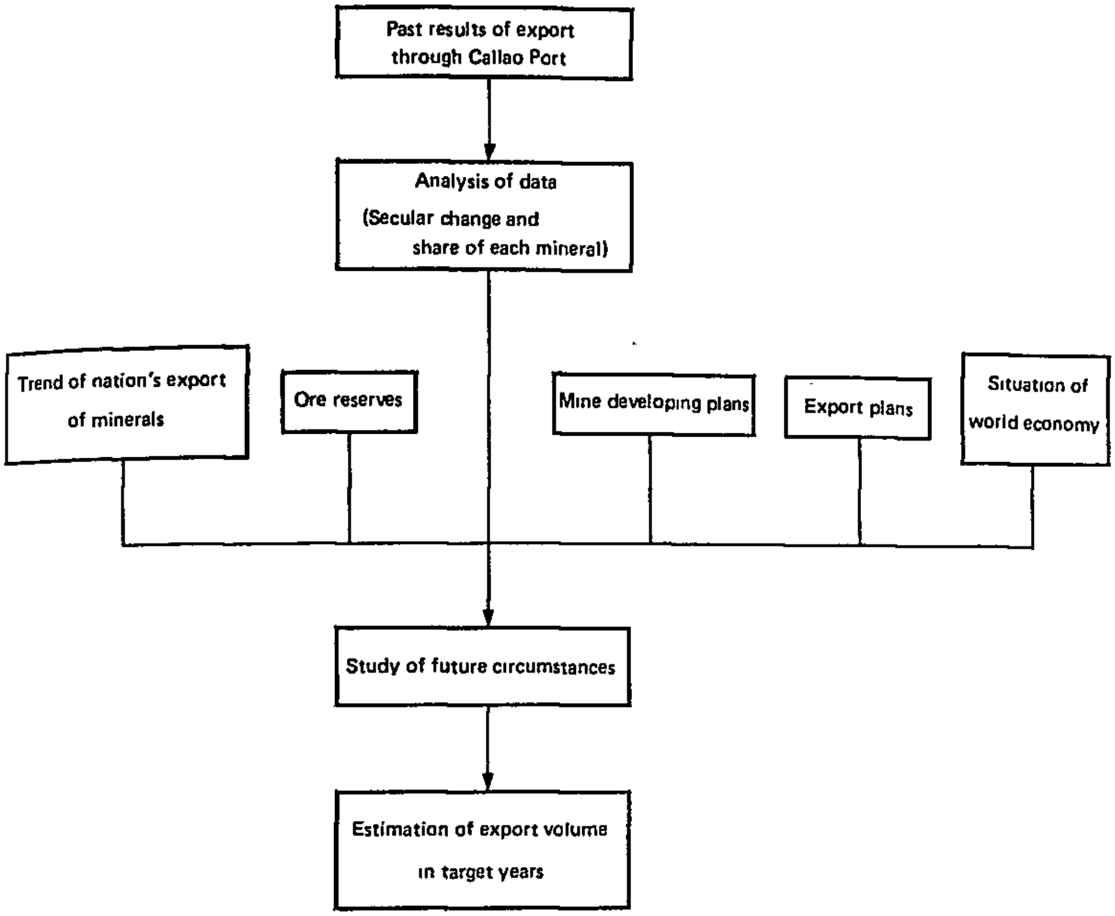


Fig. 5-14 Procedure of Forecasting Export Volume of Minerals (Concentrates)

(2) Past Results of Export of Concentrates through Callao Port

The export volume of concentrates through Callao Port increased at an annual average increase rate of about 6% during 1960 – 1981, as indicated in Fig. 5-17.

The share of each concentrate is not given in the statistics received from ENAPU, so it has been estimated as follows:

According to ENAPU's statistics, the quantities of concentrates exported in 1979 – 1981 are:

(Unit: 1,000 tons)

1979	1980	1981
1,137	1,378	1,411

The kinds of concentrates are barite, copper, silver, lead, zinc and other minerals but the quantity for each mineral is not shown separately. However, the total mining products, comprising concentrates plus ingots and other metal products can be calculated, metal by metal, from ENAPU's statistics. They are shown in Table 5-31.

Of these mining products, barite and "other ores" are considered to be entirely in concentrate form while silver seems to be entirely in the form of metal products because no silver concentrate is exported at present. Copper, lead and zinc are exported as both concentrates and metal products. So, the quantities of copper, lead and zinc concentrates exported through Callao Port were calculated by multiplying "volume of all concentrates shown in ENAPU's statistics minus volumes of barite and other ores" by the percentage of each mineral as shown in MINPECO's data of Table 5-32.

The results are as shown in Table 5-33.

Table 5-31 Past Export of Mining Products through Callao Port

Unit: 1,000 tons

Mineral	1979	1980	1981
Barite	432.4	401.0	408.8
Copper	35.4	32.4	75.4
Silver	0	1.0	0.1
Lead	239.2	228.4	241.3
Zinc	776.6	856.0	892.0
Other ores	28.5	4.4	2.1
Total	1,512.1	1,523.2	1,619.7

Source: ENAPU

Table 5-32 Quantities of Mining Products (Concentrates) Exported through Callao Port

Unit: 1,000 tons

Item		1975	1976	1977	1978	1979	1980	1981
Copper								
	Quantities	105.8	50.5	61.3	192.5	109.0	68.7	82.6
	Exported Through Callao Port	28.0	5.3	2.6	1.4	4.2	6.0	22.3
	%	(26.5)	(10.5)	(4.2)	(0.7)	(3.9)	(8.7)	(27.0)
Lead								
	Quantities	119.4	206.8	178.0	189.6	188.0	183.3	161.1
	Exported Through Callao Port	99.0	183.0	139.8	157.8	149.8	146.3	133.8
	%	(82.9)	(88.5)	(78.5)	(83.2)	(79.7)	(79.8)	(83.1)
Zinc								
	Quantities	518.9	696.6	685.3	768.9	748.8	754.3	620.6
	Exported Through Callao Port	486.8	665.6	656.6	731.7	695.9	696.5	581.2
	%	(93.8)	(95.5)	(95.8)	(95.2)	(92.9)	(92.3)	(93.7)
Total								
	Quantities	744.1	953.9	924.6	1,151.0	1,045.8	1,006.3	864.3
	Exported Through Callao Port	613.8	853.9	799.0	890.9	849.9	848.8	737.3
	%	(82.5)	(89.5)	(86.4)	(77.4)	(81.3)	(84.3)	(85.3)

Source; MINPECO

Table 5-33 Quantities of Concentrates Exported through Callao Port by Mineral

Unit: 1,000 tons

Mineral	1979	1980	1981
Barite	432	401	409
Copper	3	7	30
Lead	119	168	182
Zinc	554	798	788
Other ores	29	44	2
Total	1,137	1,378	1,411

(3) Situation of the Peruvian Mining Industry

Table 5-35 shows the trend (after 1970) of the export volumes of mining products by type of product. The export volumes of concentrates, as a whole, are decreasing. This is because the nation's policy is to export products with more added value, if possible.

95% of production was exported in 1981.

About 85% of the national total export was exported through Callao Port, as indicated in Table 5-32.

The ore reserves of copper, lead and zinc which are exported in the form of concentrates through Callao Port are:

Copper	102,777,000 tons
Lead	11,918,000 tons
Zinc	25,808,000 tons

If the present level of production is assumed, possible mining duration of copper is more than 300 years and more than 50 years in the cases of lead and zinc.

Table 5-34 Export of Nation's Mining Products

Unit: 1,000 tons

Item	Copper	Lead	Zinc	Total
Production A	332	186	483	1,001
Export B	319	155	478	952
B/A (%)	96.1	83.0	99.0	95.1

Source: Informe Estadistica, Perú Economica

Table 5-35 Export of Principal Mining Products

Unit; 1,000 tons

Item	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Cobre	208.9	194.0	204.1	190.4	185.2	151.4	181.1	318.6	357.8	386.0	357.2
Refinado	32.6	28.5	27.4	28.0	27.4	29.4	118.2	162.1	174.2	212.1	209.3
Blister	135.3	124.7	134.0	134.2	133.7	92.8	44.7	144.2	134.6	139.6	127.0
Conc. y Min.	41.0	40.8	42.7	28.2	24.1	29.2	18.2	12.3	49.0	34.3	20.9
	(19.6)	(21.0)	(20.9)	(14.8)	(13.0)	(19.3)	(10.0)	(3.9)	(13.7)	(8.9)	(5.9)
Plomo	156.6	138.3	184.1	254.4	164.1	127.9	170.3	168.2	172.5	159.7	154.2
Refinado	63.6	62.7	74.8	60.7	80.5	62.5	68.0	67.8	91.5	85.5	74.2
Barras mixtos	0.7	1.4	0.2	5.1	-	-	0.03	-	-	-	-
Conc. y Min.	92.3	74.2	109.1	188.6	83.6	65.4	102.3	100.4	81.0	74.2	80.0
	(58.9)	(53.7)	(59.3)	(74.1)	(50.9)	(51.1)	(60.1)	(59.7)	(47.0)	(46.5)	(51.9)
Zinc	318.4	331.1	396.7	379.0	426.4	405.9	425.3	458.6	444.5	424.9	469.7
Electrolitica	65.2	52.3	55.4	54.2	46.8	58.9	52.6	58.6	64.9	57.3	37.8
Conc. y Min.	253.2	278.8	341.3	324.8	379.6	347.0	372.7	400.0	379.6	367.6	431.9
	(79.5)	(84.2)	(86.0)	(85.7)	(89.0)	(85.5)	(87.6)	(87.2)	(85.4)	(86.5)	(91.9)
Total	683.9	663.4	784.9	823.8	775.7	685.2	776.7	945.4	974.8	970.6	981.1
Conc. y Min.	386.5	393.8	493.1	541.6	487.3	441.6	493.2	512.7	509.6	476.1	532.8
	(56.5)	(59.4)	(62.8)	(65.7)	(62.8)	(64.4)	(63.5)	(54.2)	(52.3)	(49.1)	(54.3)
Others Metal mining products	297.4	269.6	291.8	282.2	288.4	243.6	283.5	432.7	465.2	494.5	448.3

Source; Ministerio Minera y Energio

(4) Future Export Plans

The Ministry of Mining and Energy has production and export targets for copper, lead and zinc up to 1985 (see Tables 5-36 and 5-37).

According to the concentrate production plan, the production of copper will rapidly increase hereafter but the production of lead and zinc will either increase only gradually or level off.

This is because copper mines will be successively developed at such places as Cobrize (Huancaverica State), Tintaya (Cuzco State), Cerro Verde II (Arequipa State) and Toquepala (Moquegua State).

Table 5-36 Concentrate Production Plan

Unit: 1,000 tons

Mineral	1981	1982	1983	1984	1985
Copper	23.2	38.3	81.7	98.9	188.2
Lead	106.7	124.8	139.7	136.5	136.4
Zinc	320.8	309.3	425.6	439.5	441.3
Total	450.7	472.4	647.0	674.9	765.9

Table 5-37 Concentrate Production Targets

Unit: 1,000 tons

Mineral	1981	1982	1983	1984	1985
Copper	21.7	80.6	121.8	121.8	121.8
Lead	78.2	100.9	127.6	131.0	130.9
Zinc	372.1	664.0	535.1	552.8	555.2
Total	472.0	845.5	784.5	805.6	807.9

(5) Forecast of Export Volume of Concentrates in Target Years

The future trend of the export of concentrates through Callao Port can be considered as follows.

75% of copper production in Peru is produced at the mines of Cuajone and Toquepala in Southern Peru and, in the hinterland of Callao Port, there are no large expansion plans except at Cobriza. Therefore the growth rate of the nation's copper production can not be used as the growth rate of the export volume of copper concentrates through Callao Port.

CENTROMIN-PERU has mines of lead and zinc in the hinterland of Callao and which account for about 50% of nation's total production. However, it does not have any large expansion or investment plan. So, increases of exports through Callao Port due to the exploitation of small mines and the possible production increases at the existing mines, will be gradual.

The production of barite will continue at the present level because new plans for increasing production have not been considered.

It must be remembered that the export of mineral products is greatly affected by economic situations in the countries to which they are exported (mainly Europe and Asia) and the trend of international market prices.

The volume of concentrates handled at Callao Port is steadily increasing and, as indicated in Fig. 5-17, fits a linear equation very well. So, the future growth rate is estimated to be about 3%. This method of forecasting and the growth rate are both considered to be reasonable. Firstly, 3% is considered as a likely future growth rate of the world economy, which is one of the most influential factors determining the export volume. Secondly, the export of mineral products represents more than 40% of the national total exports, so exports are expected to be promoted keenly in future.

Table 5-38 shows volumes of export of concentrates through Callao Port in the target years estimated according to the above-mentioned method.

Source; "Copper Situation in Peru", JETRO

Fig. 5-15 Map of Distribution of Peruvian Copper Resources

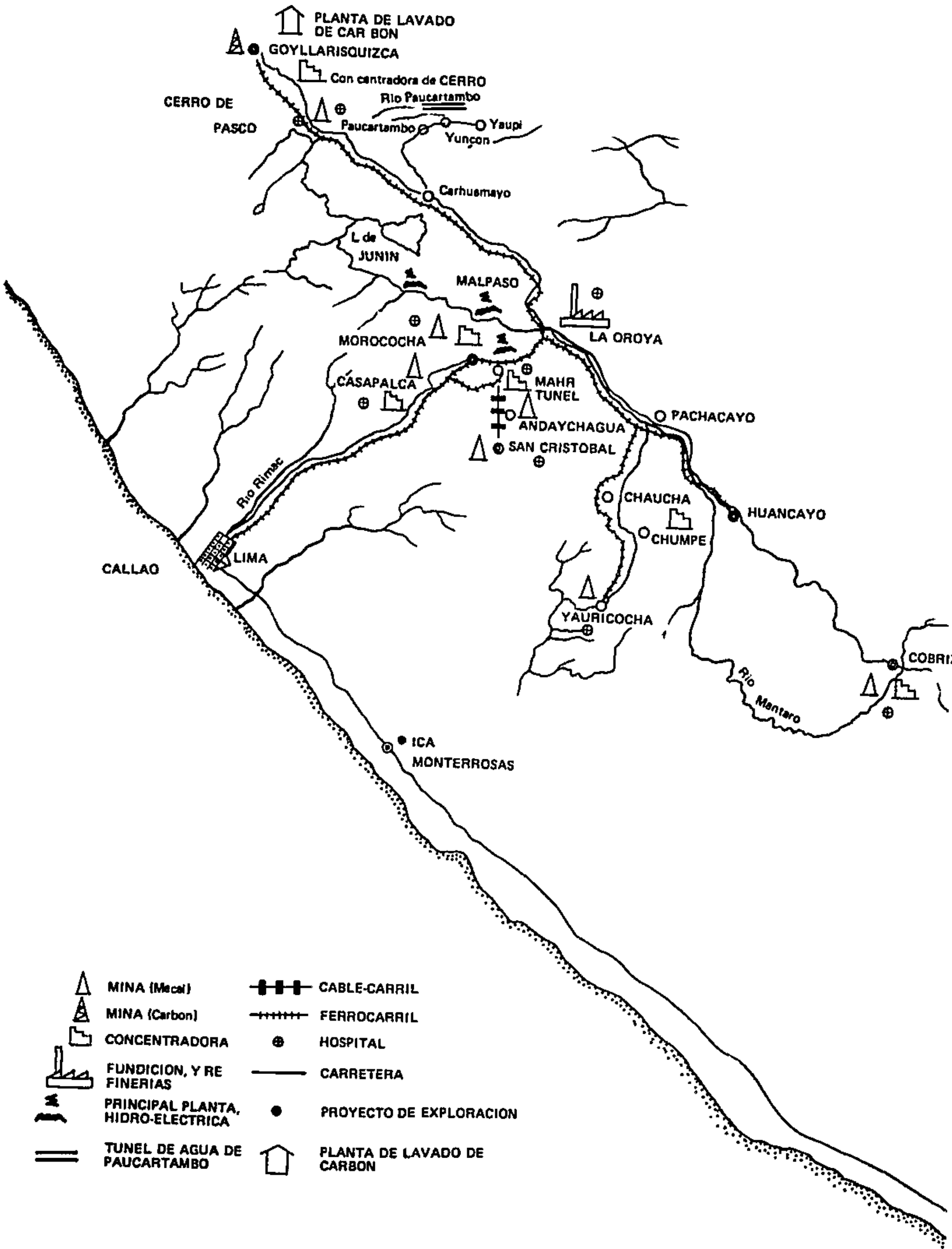


Fig. 5-16 Mines in the hinterland of Callao Port

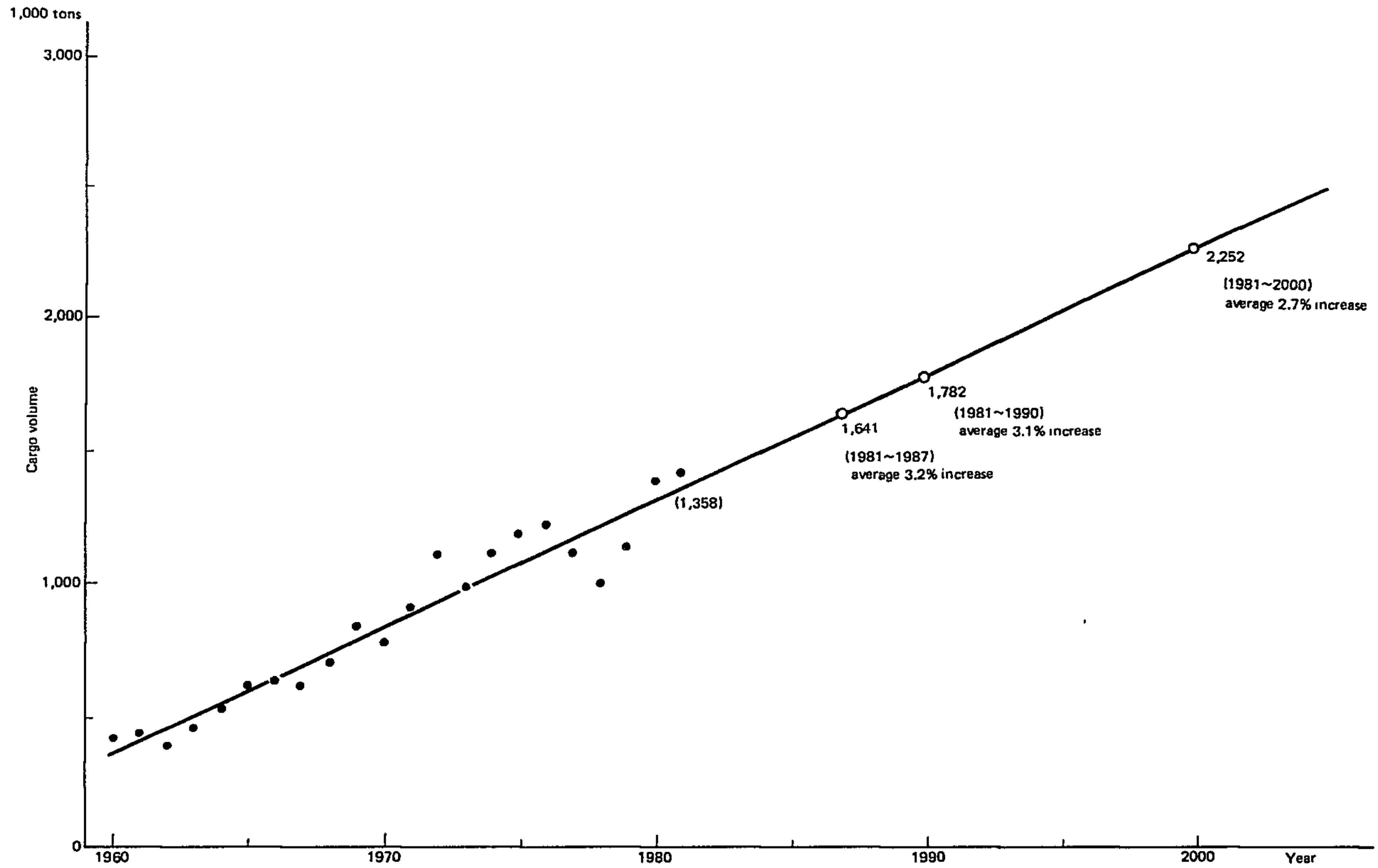


Fig. 5-17 Forecast of Export Volume of Concentrates through Callao Port