APPENDIX 8 CALMNESS IN THE HARBOUR FOR THE BREAKWATER EXTENSION ALTERNATIVES

We calculated the calmness in the harbour area of the Port of Caldera for each of the following alternatives for the breakwater extension and the existing state of the breakwater. Each calculation case is shown in Fig. M−1.

a) Case 1 : Existing state (length of the breakwater from its turn point : 150 m)
b) Case 2 : Breakwater extension length : 200 m, Direction of extension : the same direction as the end part of the existing breakwater
c) Case 3 : Breakwater extension length : 300 m, Direction of extension : the same direction as the end part of the existing breakwater
d) Case 4 : Breakwater extension length : 400 m, Direction of extension : the same direction as the end part of the existing breakwater
e) Case 5 : Breakwater extension length : 200 m, Direction of extension : parallel to the trunk part of the existing breakwater
f) Case 6 : Breakwater extension length : 400 m, Direction of extension : parallel to the trunk part of the existing breakwater

1. Diffraction Calculation

As a diffraction calculation method, we adopted Takayama's Method [1] which considers the wave reflection of irregular waves. For the spectum of irregular waves, $S(f, \theta)$, are used in the following formulae. These are Bretschneider-Mitsuyasu's Formula for the frequency spectrum, $S(f)$, and Mitsuyasu's Formula for the directional spreading function, $G(f, \theta)$.

$$S(f, \theta) = S(f)G(f, \theta)$$

$$S(f) = 0.257\left(\frac{H_{1/3}}{T_{1/3}}\right)^2 f^{-5} \exp[-1.03(T_{1/3}f)^{-4}]$$

$$G(f, \theta) = \frac{1}{\pi} 2^{2S-1} \frac{\Gamma^2(S+1)}{\Gamma(2S+1)} \cos^{2S}\frac{\theta}{2}$$

$$S = \begin{cases} S_{max}\ (f/f_p)^{-2.5} & (f > f_p) \\ S_{max}\ (f/f_p)^{5} & (f \leq f_p) \end{cases}$$

$$f_p = \frac{1}{1.05\,T_{1/3}}$$

Where, f : frequency
θ : angle of deviation from the principal direcion of the wave
$H_{1/3}$: significant wave height

1) Tomotsuka Takayama ; Wave Diffraction and Wave Height Distribution inside a Harbour, Technical Note of The Port and Harbour Research Institute (Ministry of Transport), No. 367, Mar. 1981, 1~140 p.

$T_{1/3}$: significant wave period

f_p : peak frequency of the frequency spectrum

S : parameter showing the degree of directional concentration of the wave

S_{max} : S at the peak frequency, f_p

The wave conditions to be used in the diffraction calculation are as follows.

a) Direction of wave incidence : The following values are used with reference to the refraction charts shown in the APPENDIX 1.

N 229° for the existing state

N 225° for the breakwater extension alternatives

b) Significant wave period : 12 s and 18 s are used for the significant wave periods. The former value is the median of the distribuion of the significant wave period observation values which are shown in Table IV—4 (CHAPTER IV), and the other is nearly the maximum value of this distribution.

c) Degree of directional concentration : The major part of the incident waves to the Port of Galdera region are long period swells which are propagated over long distances, therefore S_{max} =75 was adopted.

d) Wave reflection coefficient : A wave reflelection coefficient of 90% is used for the vertical walls, 40% for the rubble mound slopes, and 10% for the sand beaches. The wave reflelection coefficient used for each waterline in the Port of Galdera area is shown in Fig. M−1.

The diffraction charts which were calculated using the above-mentioned method are shown in Fig. M−2(1) to Fig. M−2(12).

2. Calmness in the Harbour Area

For the following six points which are shown in Fig. M−1. we calculated the calmness, using the results of the above mentioned diffraction calculation and the occurrence probability of significant wave heights and the periods of the incident waves which are shown in Table IV−4 (CHAPTER IV).

① : Front of the roll-on/roll-off pier
② : Center of the −7.5 m berth
③ : Center of the −10 m berth
④ : Center of the −11 m berth
⑤ : Front of the small craft basin
⑥ : Point 100 m inside from the center of the extended breakwater

Points ② to ④ are selected to estimate the workable days for the cargo handling works at each berth, point ⑤ is for the mooring works of the small crafts in the basin, point ① is for the loading works of rubble stones and armour materials, and point ⑥ is for the maintenance dredging.

The cumulative occurrence probabilities of significant wave heights at each point which were calculated for each breakwater extension alternative and the existing state are shown in Table M−1(1) to (6) and Fig. M−3(1) to (6)

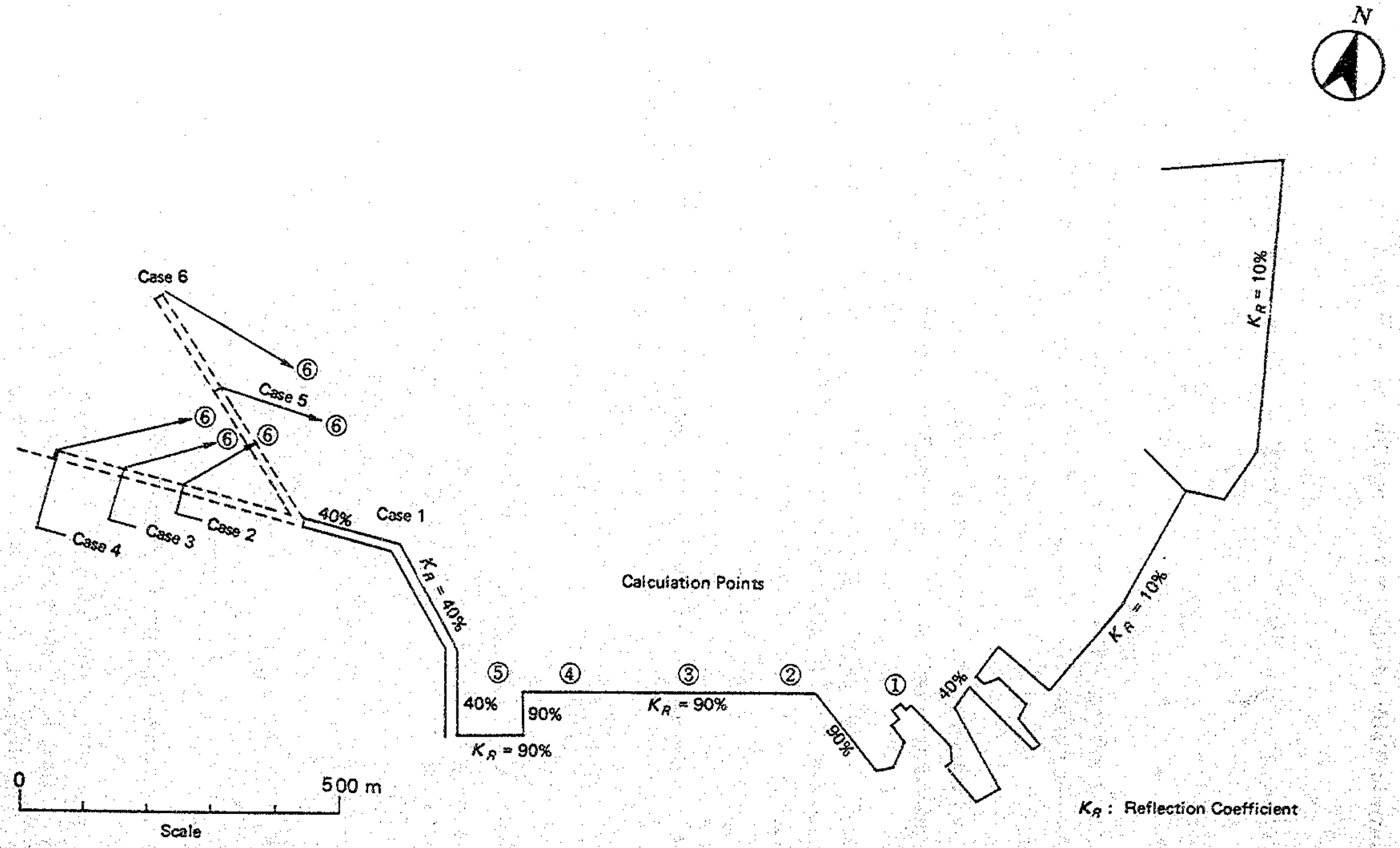

Fig. M-1 Breakwater Extension Alternatives and the Calculation Points for Calmness

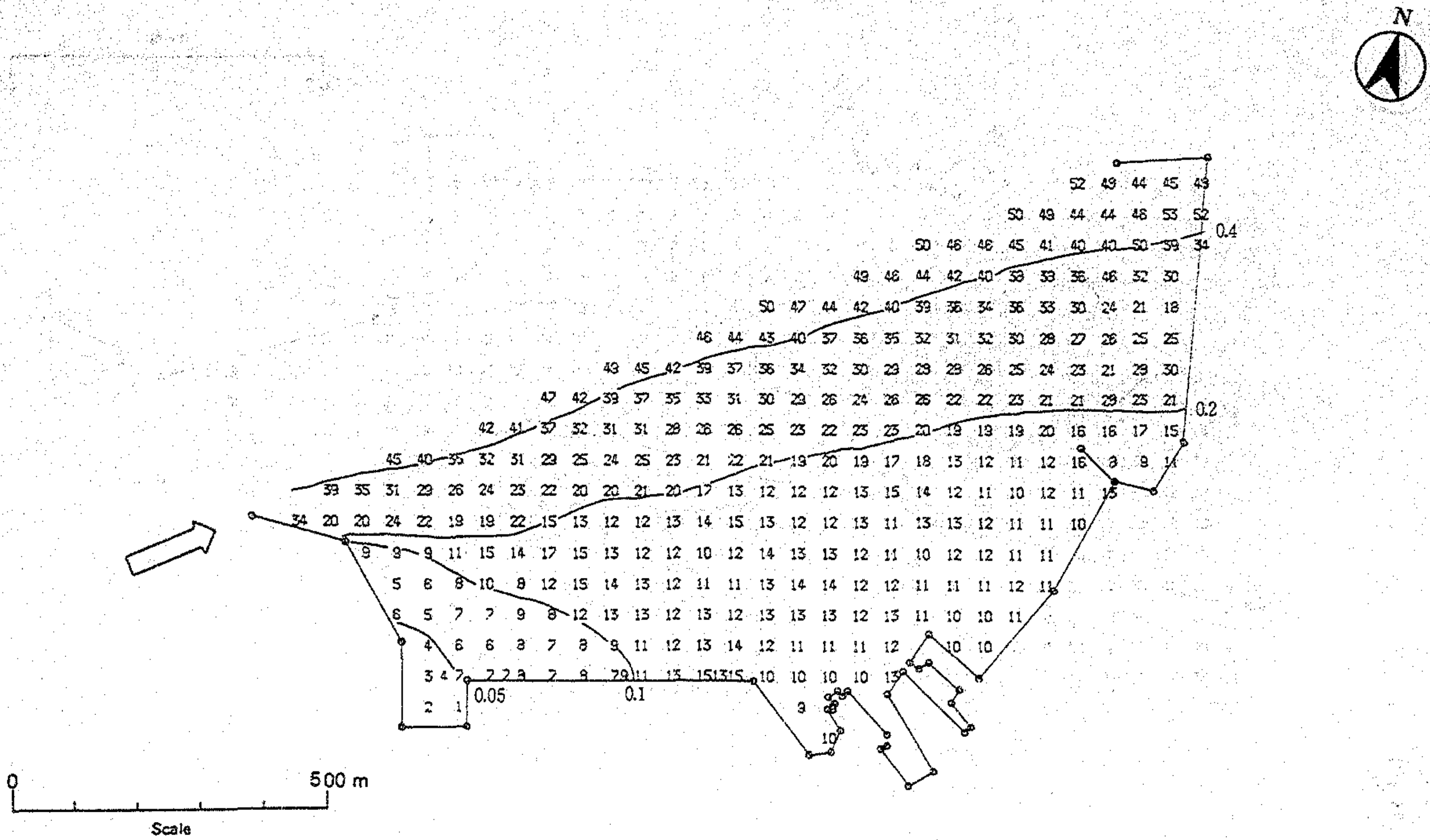

Fig. M-2 (1) Diffraction Chart (Case 1, $T_{1/3}$ = 12s), Unit: %

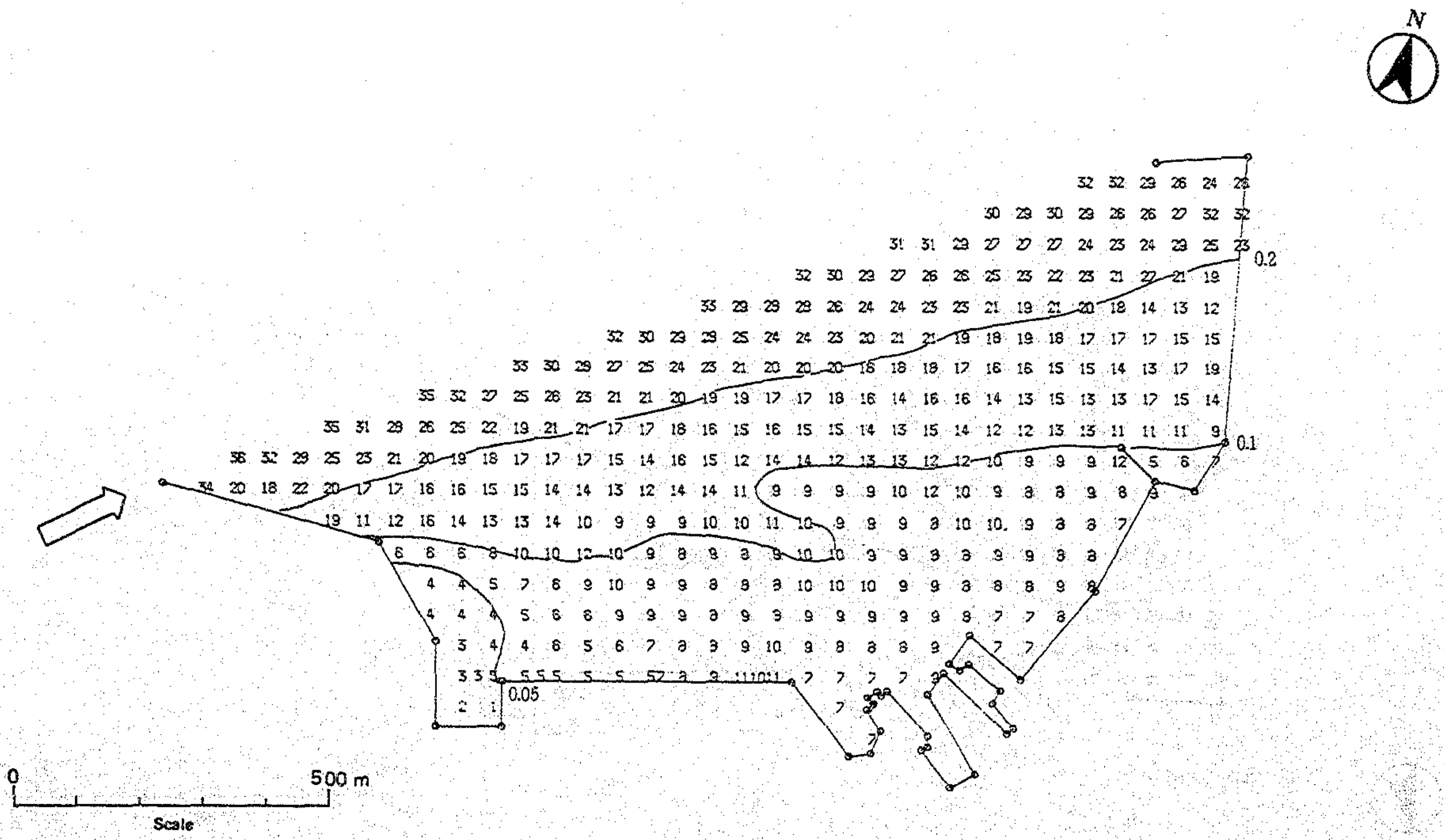

Fig. M-2 (2) Diffraction Chart (Case 2, $T_{1/3} = 12s$), Unit: %

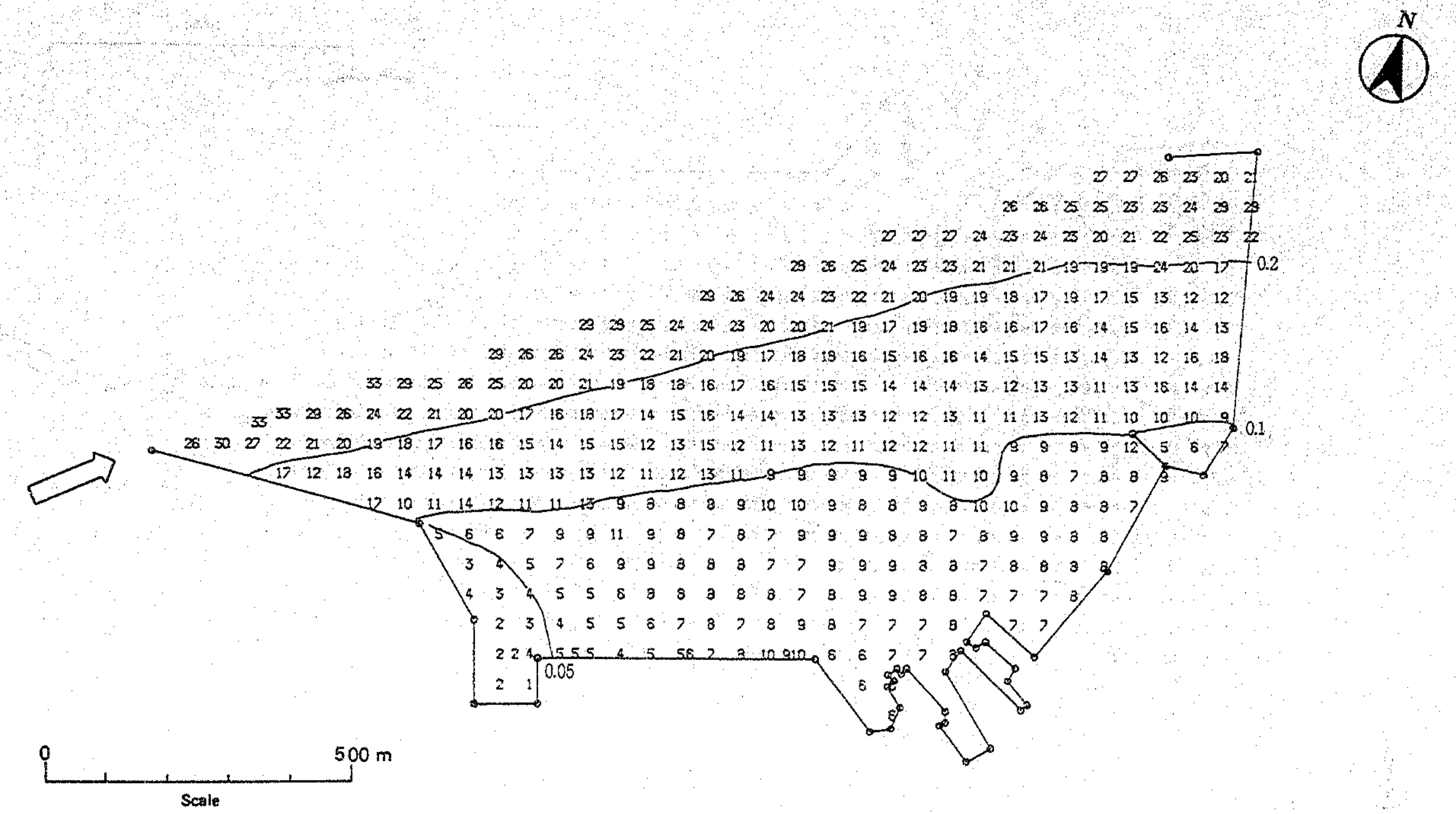

Fig. M-2 (3) Diffraction Chart (Case 3, $T_{1/3} = 12s$), Unit: %

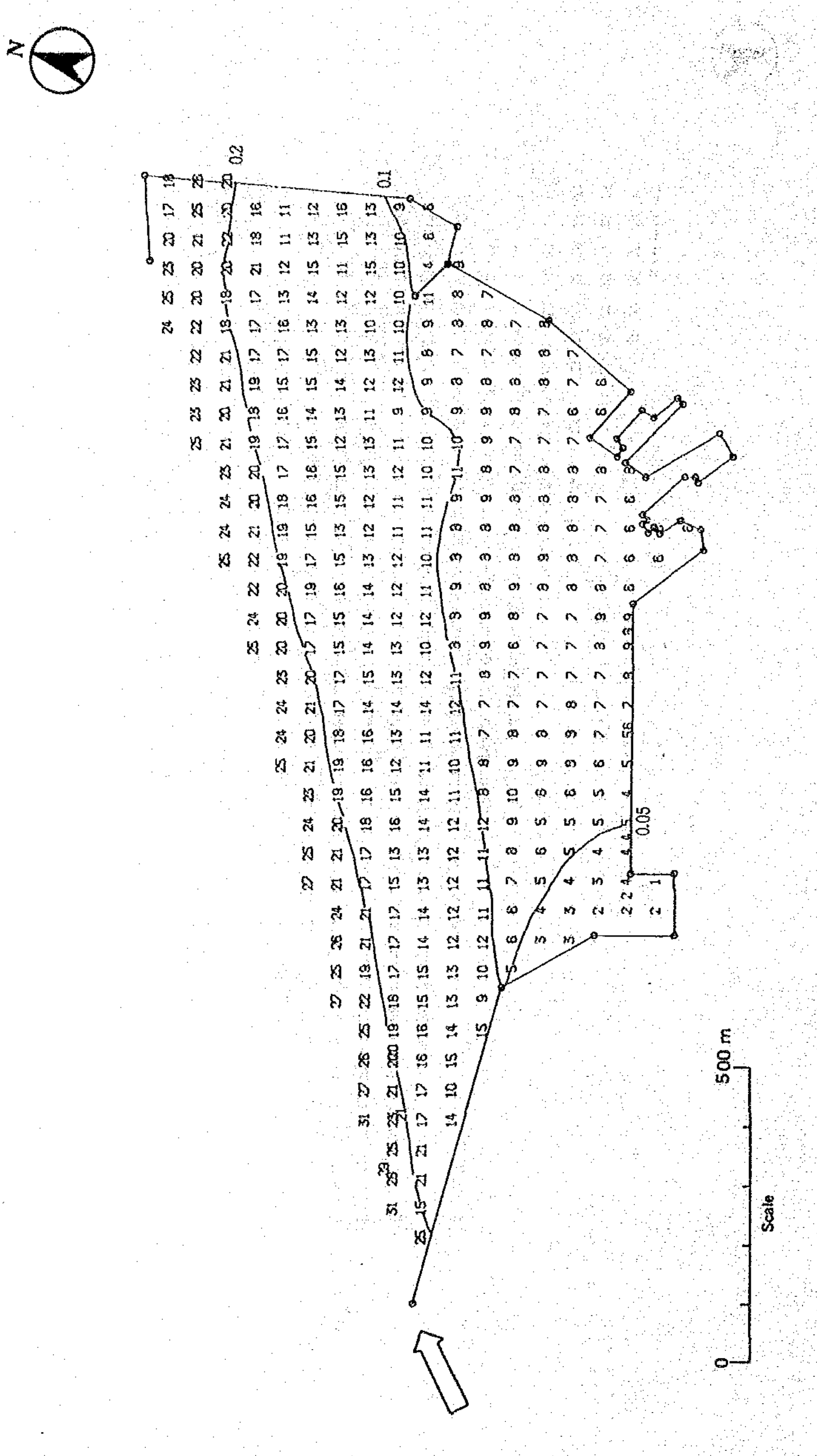

Fig. M-2 (4) Diffraction Chart (Case 4, $T_{1/3}$ = 12s), Unit: %

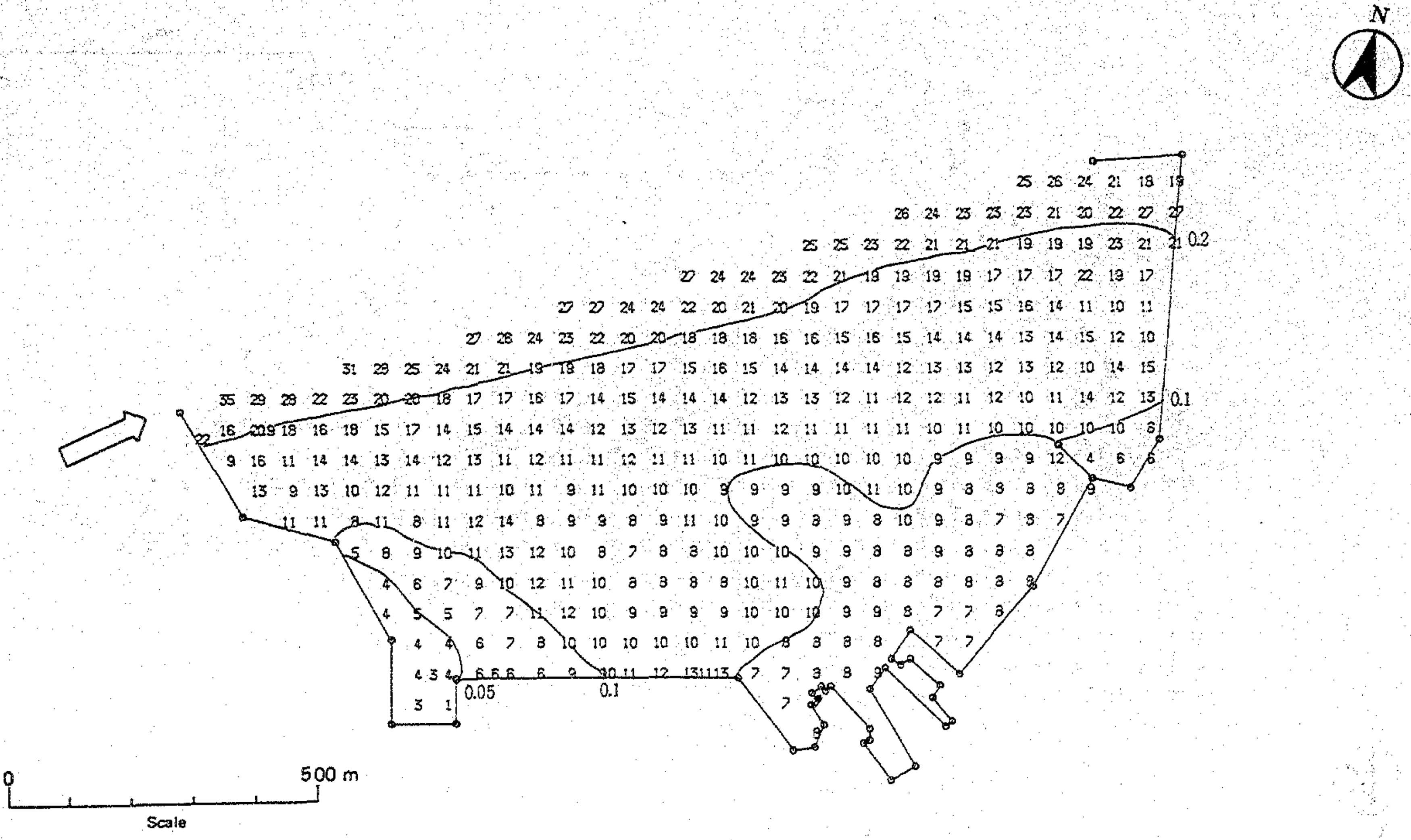

Fig. M-2 (5) Diffraction Chart (Case 5, $T_{1/3}$ = 12s), Unit: %

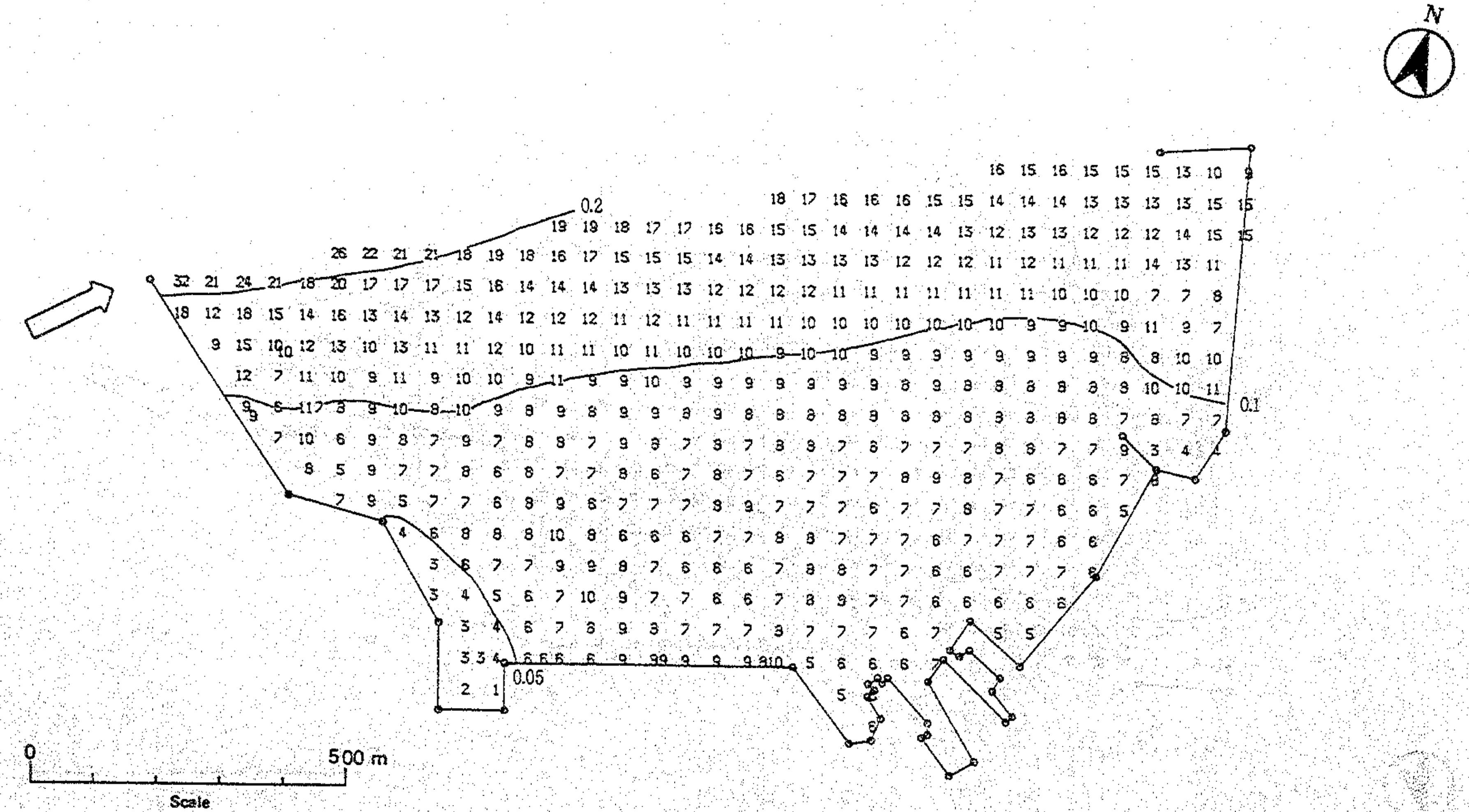

Fig. M-2 (6) Diffraction Chart (Case 6, $T_{1/3}$ = 12s), Unit: %

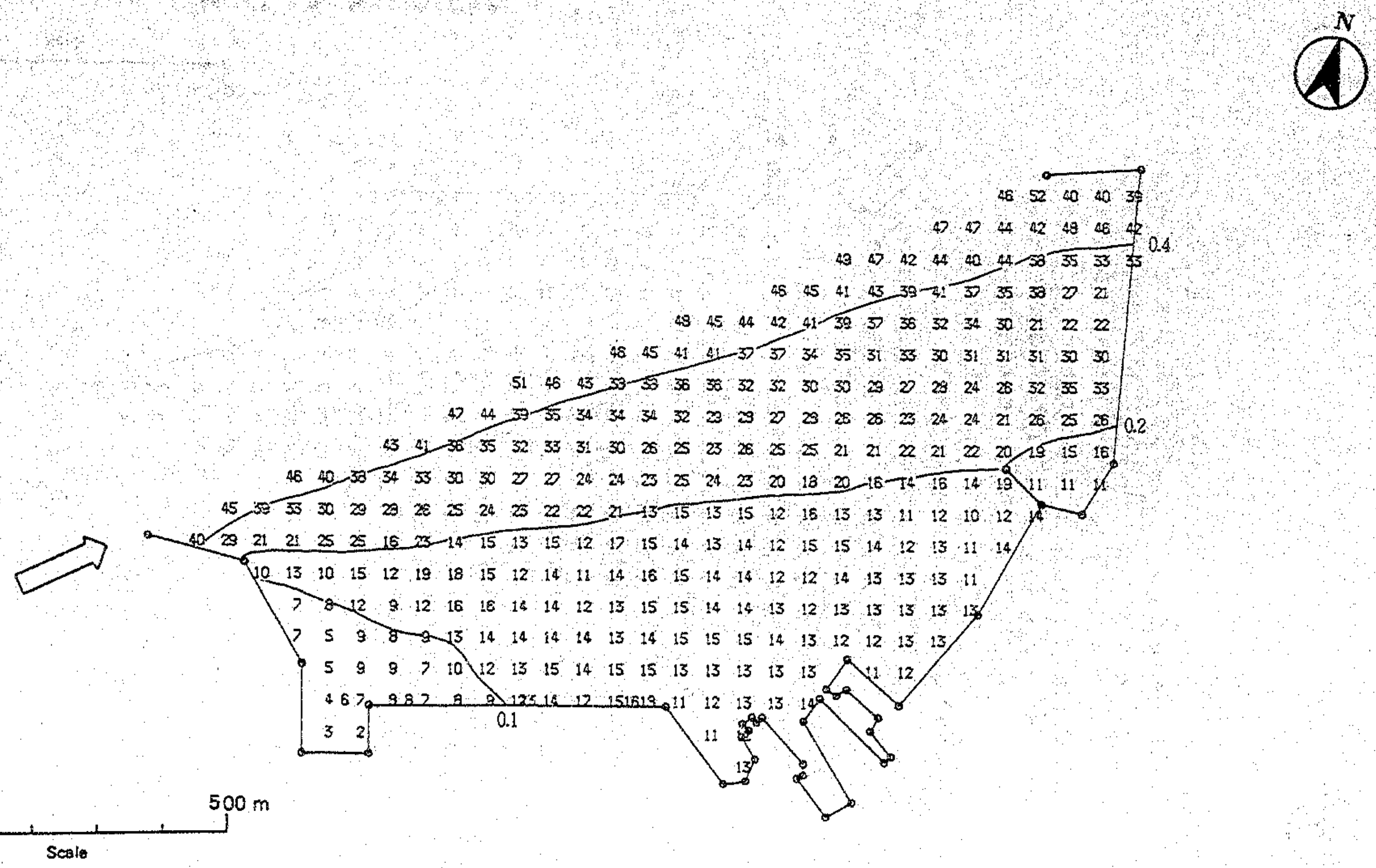

Fig. M-2 (7) Diffraction Chart (Case 1, $T_{1/3}$ = 18s), Unit: %

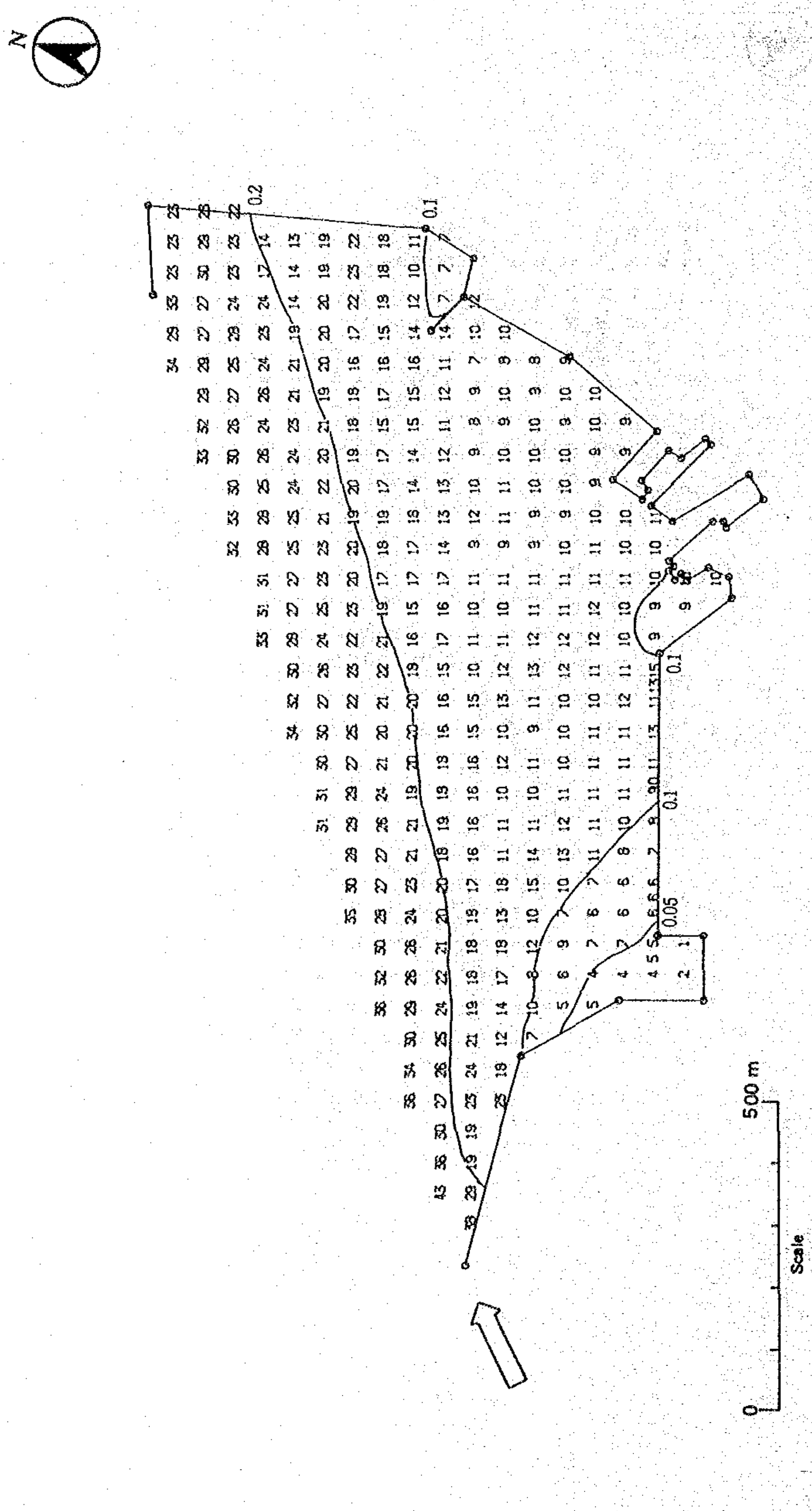

Fig. M-2 (8) Diffraction Chart (Case 2, $T_{1/3}$ = 18s), Unit: %

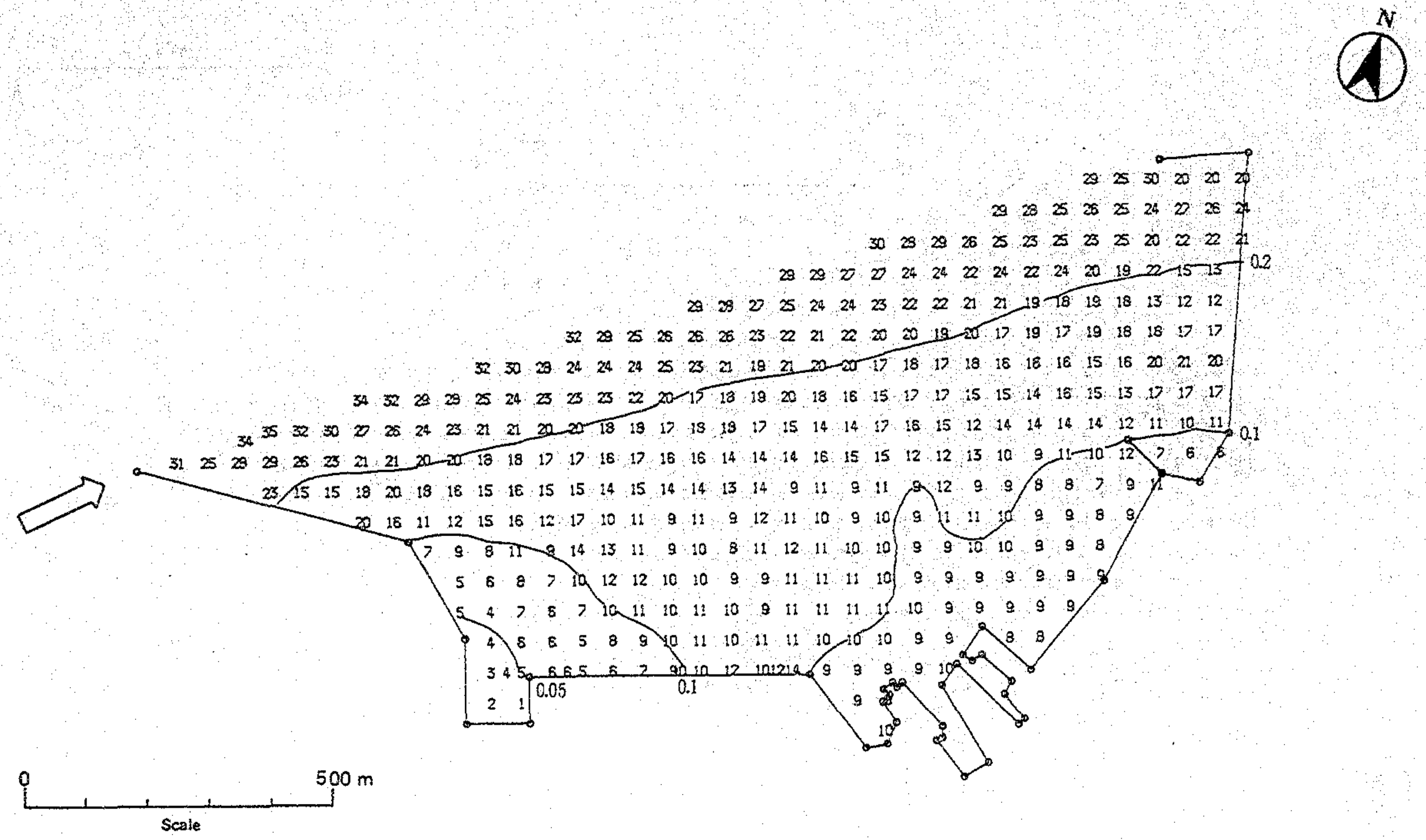

Fig. M-2 (9) Diffraction Chart (Case 3, $T_{1/3}$ = 18s), Unit: %

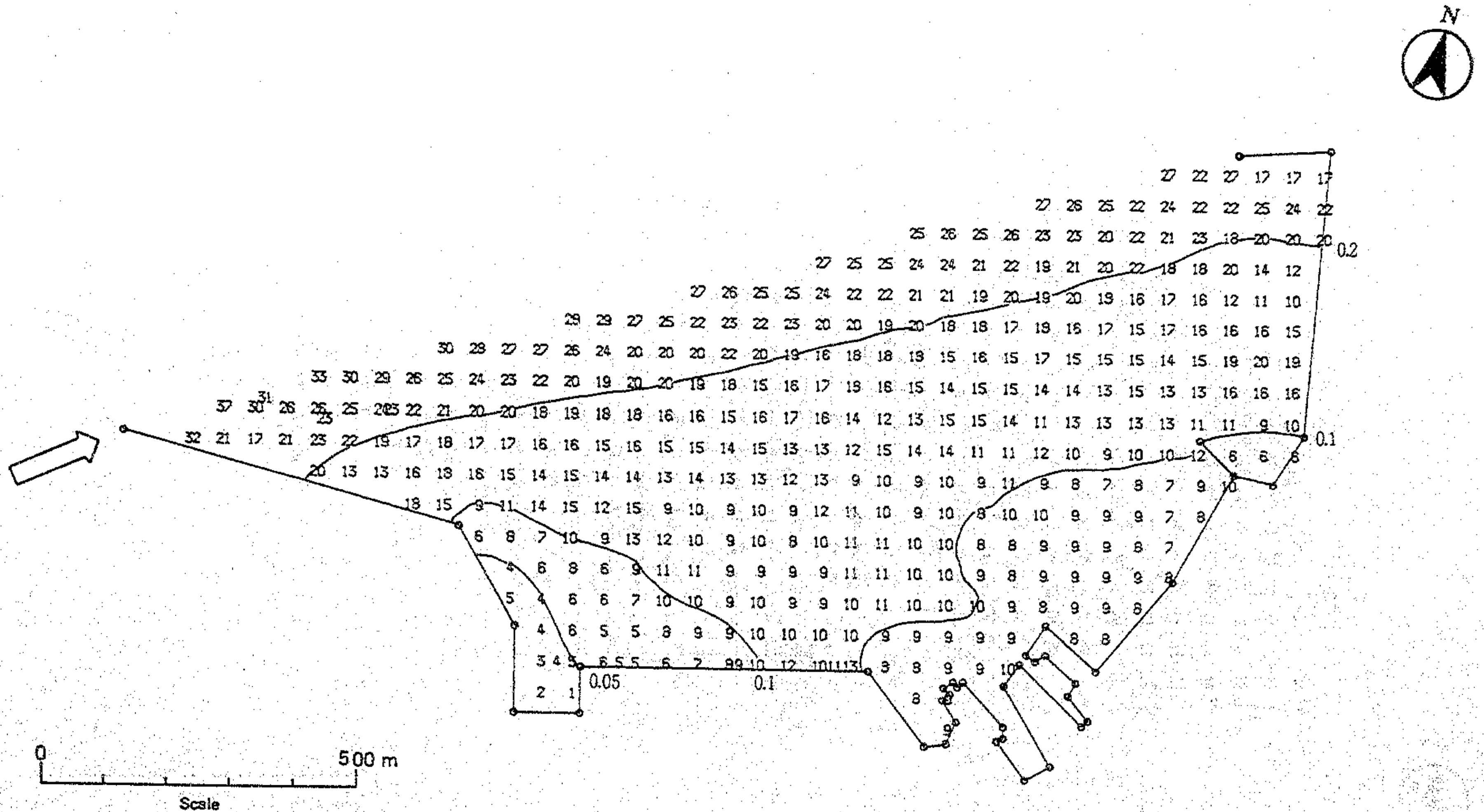

Fig. M-2 (10) Diffraction Chart (Case 4, $T_{1/3}$ = 18s), Unit: %

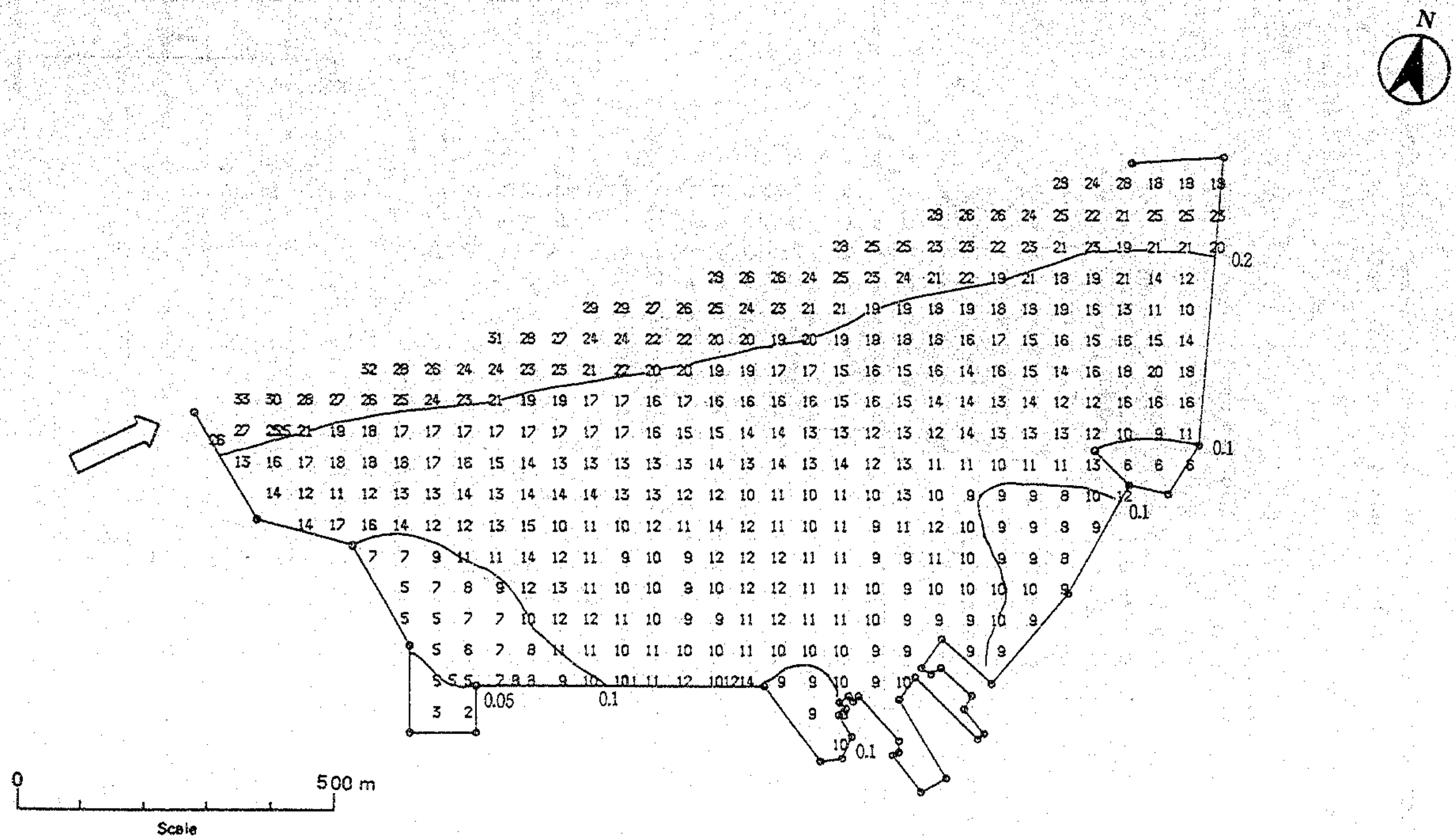

Fig. M-2 (11) Diffraction Chart (Case 5, $T_{1/3}$ = 18s), Unit: %

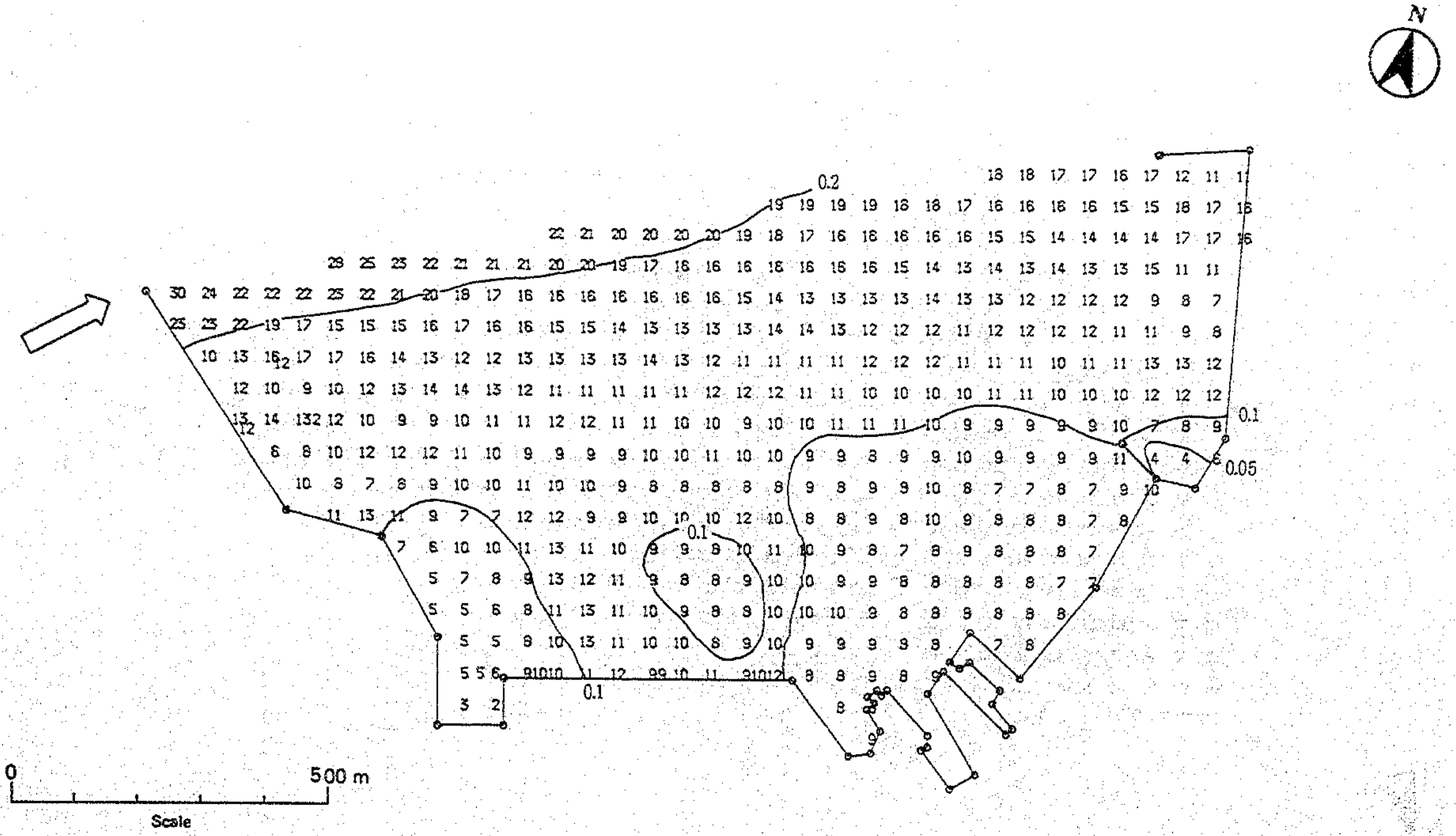

Fig. M-2 (12) Diffraction Chart (Case 6, $T_{1/3}$ = 18s), Unit: %

Table M-1(1) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 1)

Unit : %

Calulation points		①	②	③	④	⑤	⑥
Significant wave height	0.10m	62.6	23.3	55.4	90.1	96.2	
	0.20m	95.9	86.8	94.1	99.7	100.0	
	0.30m	99.4	97.5	99.0	100.0		
	0.40m	100.0	99.4	100.0			
	0.50m		100.0				
	0.60m						
	0.75m						
	1.00m						
	1.25m						
	1.50m						

Table M-1 (2) Cumulative Occurrence Probabilities of Significant Wave Heights is the Harbor Area (Case 2)

Unit : %

Calulation points		①	②	③	④	⑤	⑥
Significant wave height	0.10m	81.6	54.5	76.5	98.2	98.2	
	0.20m	98.9	92.7	98.2	100.0	100.0	13.4
	0.30m	100.0	98.6	99.8			52.3
	0.40m		99.7	100.0			76.5
	0.50m		100.0				88.1
	0.60m						94.7
	0.75m						97.7
	1.00m						99.5
	1.25m						100.0
	1.50m						

Table M-1 (3) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 3)

Unit : %

Calulation points	①	②	③	④	⑤	⑥
Significant wave height 0.10m	86.2	57.8	75.3	98.2	98.2	
0.20m	99.4	94.1	98.9	100.0	100.0	20.3
0.30m	100.0	99.0	100.0			68.4
0.40m		100.0				87.1
0.50m						95.3
0.60m						97.7
0.75m						99.3
1.00m						100.0
1.25m						
1.50m						

Table M-1 (4) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 4)

Unit : %

Calulation points	①	②	③	④	⑤	⑥
Significant wave height 0.10m	86.4	64.8	75.3	98.2	98.2	
0.20m	99.4	95.9	98.9	100.0	100.0	33.0
0.30m	100.0	99.4	100.0			77.6
0.40m		100.0				92.4
0.50m						96.7
0.60m						98.6
0.75m						99.6
1.00m						100.0
1.25m						
1.50m						

Table M-1 (5) Cumulative Occurrence Probabinities of Significant Wave Heights in the Harbor Area (Case 5)

Unit : %

Calulation points	①	②	③	④	⑤	⑥
Significant wave height 0.10m	81.0	40.1	77.0	90.9	98.2	8.2
0.20m	98.9	92.5	98.2	99.7	100.0	65.5
0.30m	100.0	99.0	99.8	100.0		88.1
0.40m		100.0	100.0			96.4
0.50m						98.7
0.60m						99.5
0.75m						100.0
1.00m						
1.25m						
1.50m						

Table M-1 (6) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 6)

Unit : %

Calulation points	①	②	③	④	⑤	⑥
Significant wave height 0.10m	86.4	66.8	80.2	81.8	98.2	66.8
0.20m	99.4	96.8	98.9	98.9	100.0	96.8
0.30m	100.0	99.6	100.0	100.0		99.6
0.40m		100.0				100.0
0.50m						
0.60m						
0.75m						
0.75m						
1.00m						
1.25m						
1.50m						

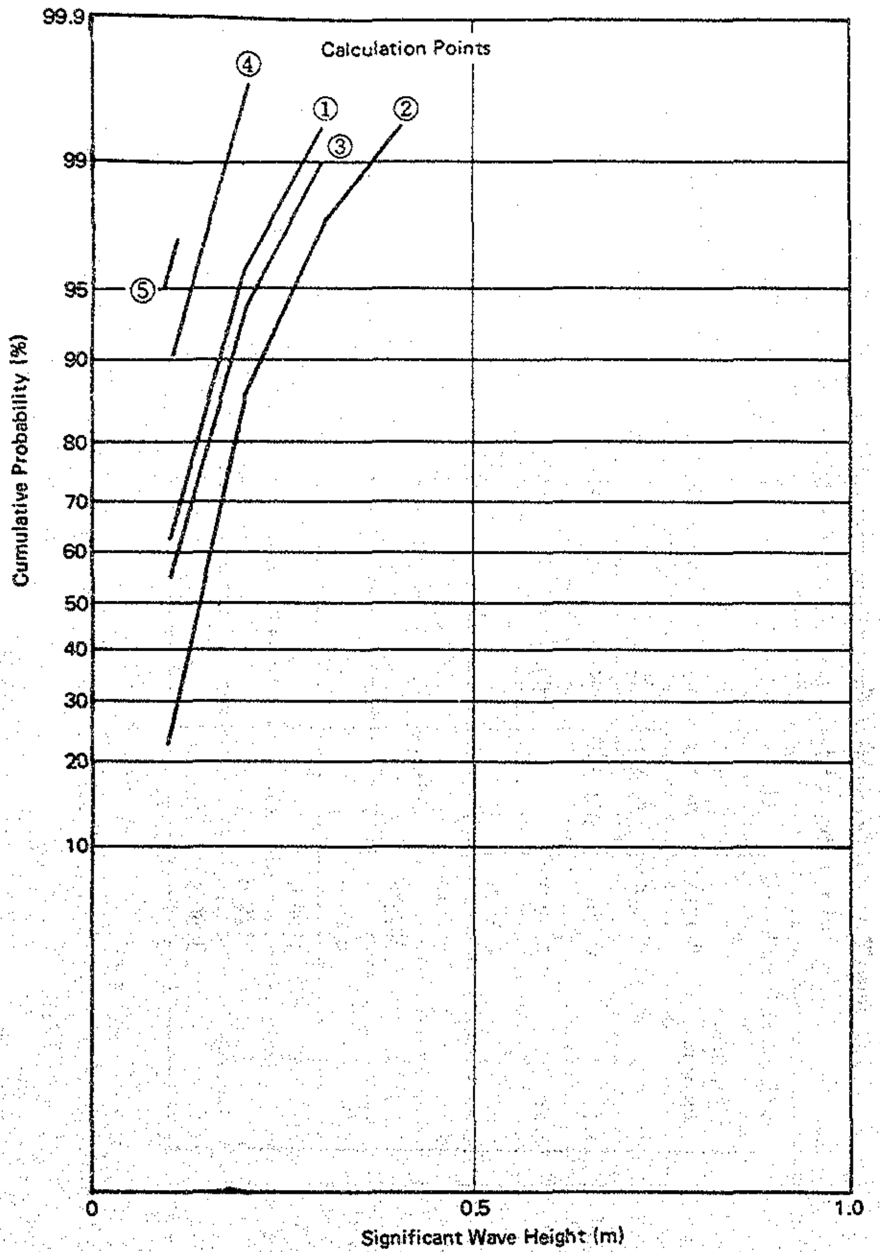

Fig. M-3 (1) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 1)

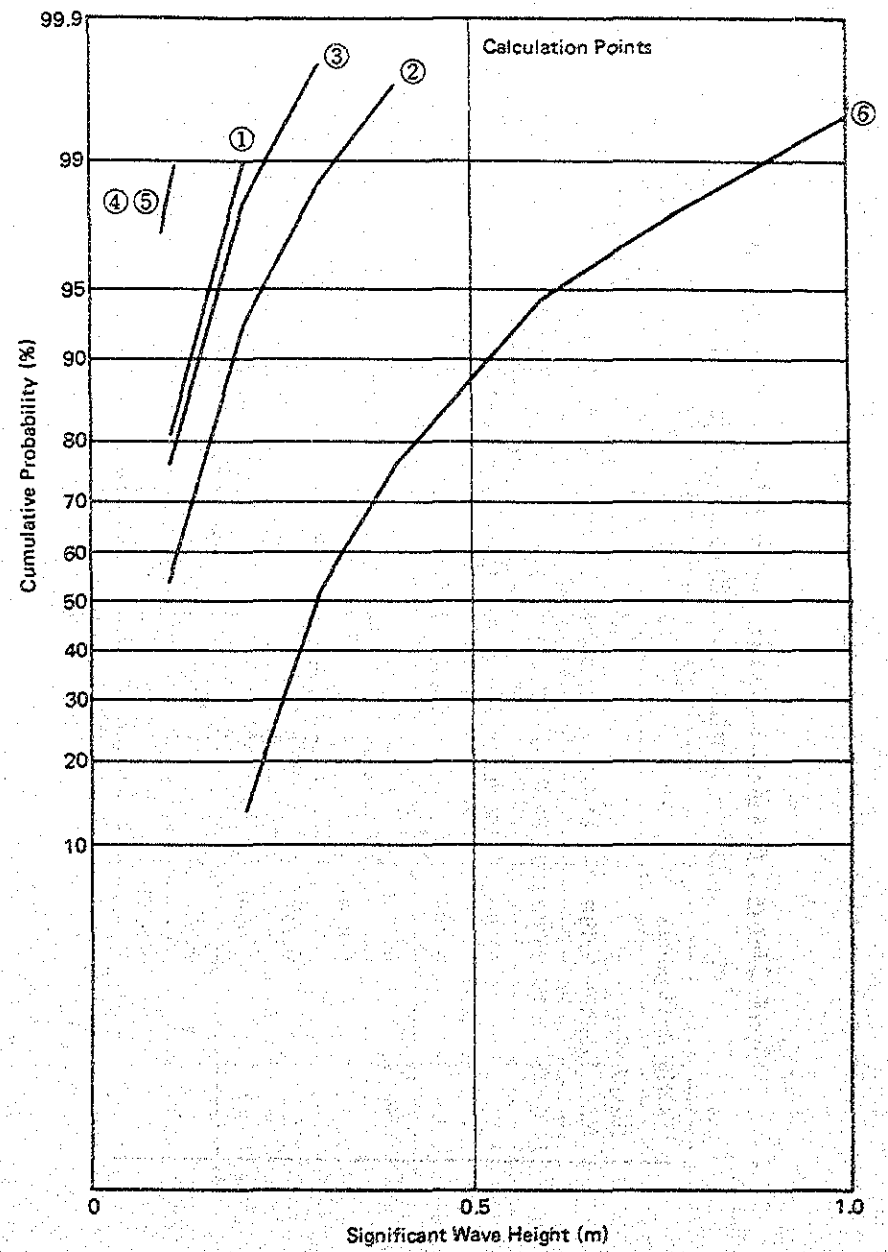

Fig. M-3 (2) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 2)

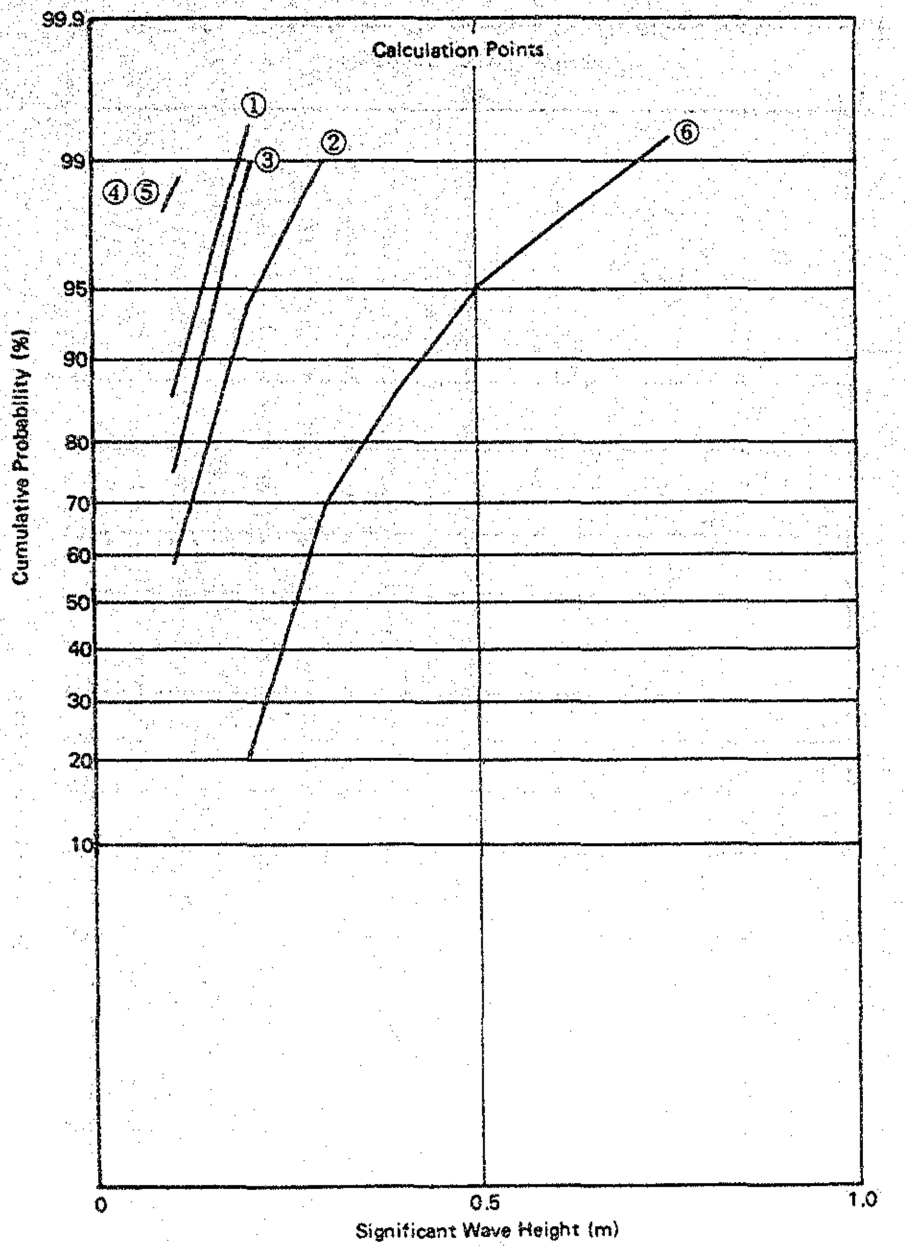

Fig. M-3 (3) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 3)

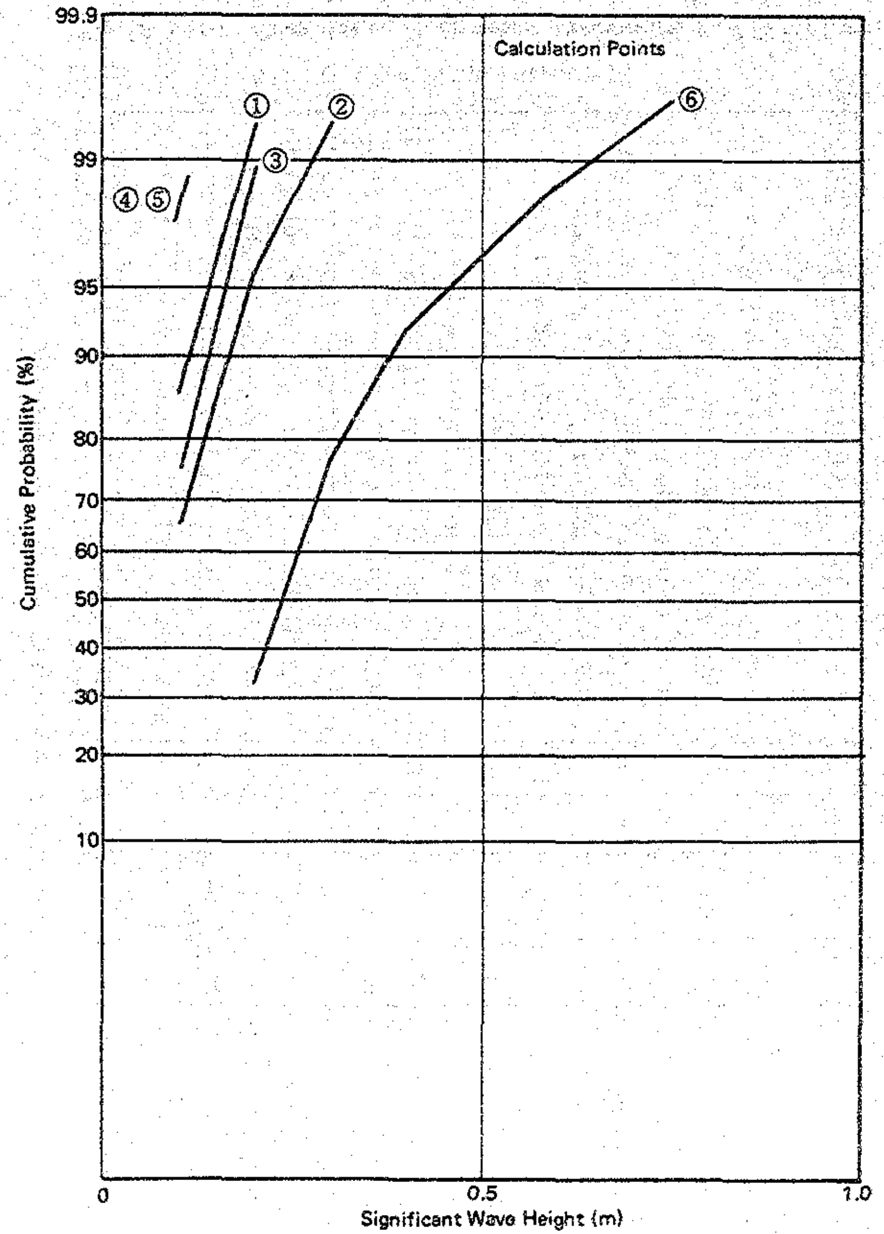

Fig. M-3 (4) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 4)

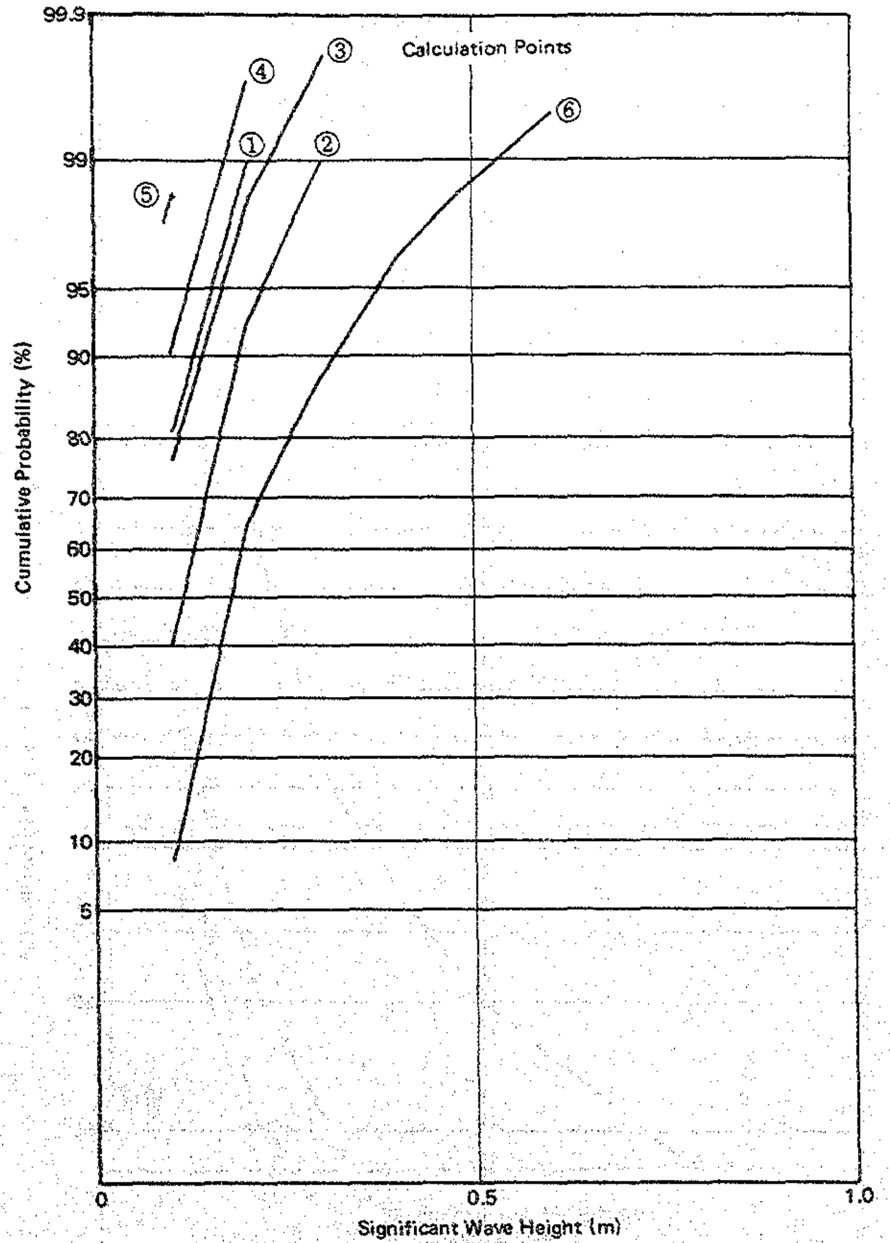

Fig. M-3 (5) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 5)

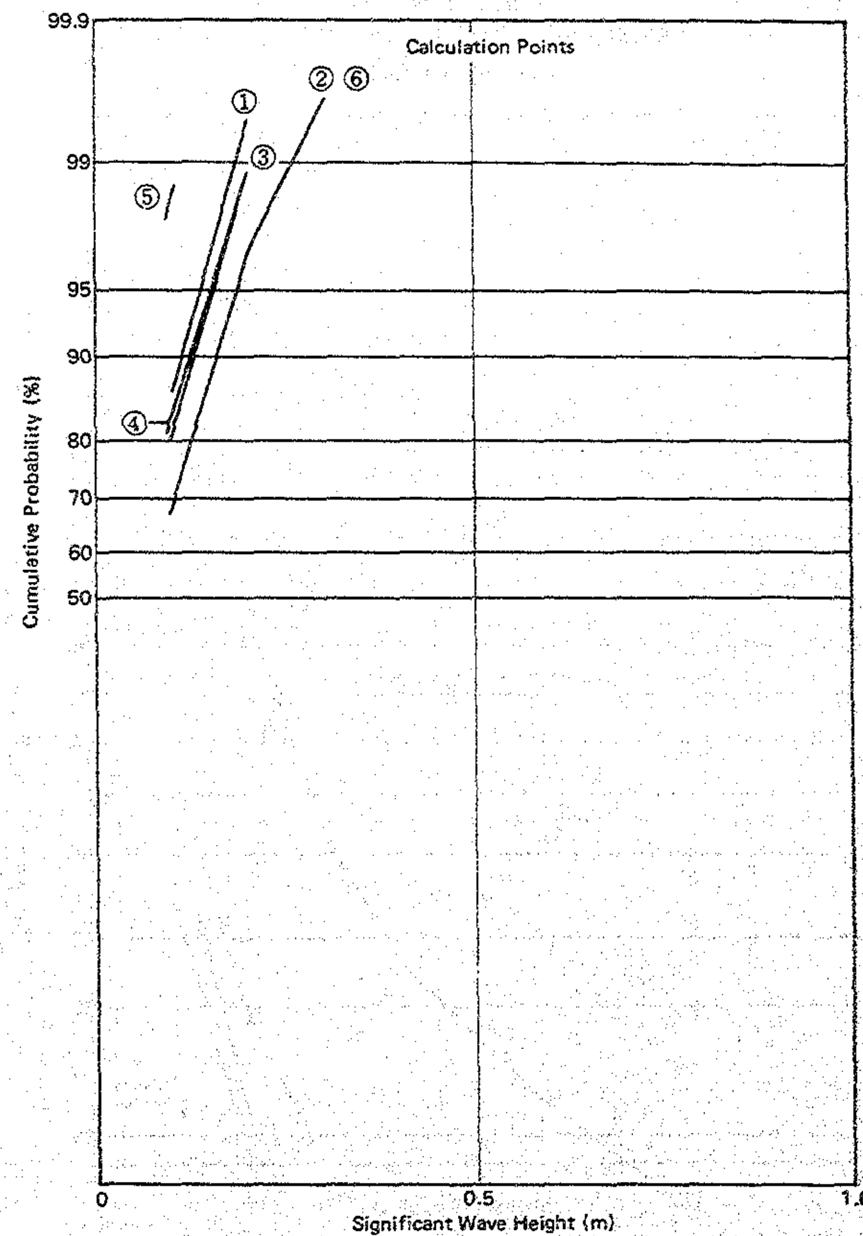

Fig. M-3 (6) Cumulative Occurrence Probabilities of Significant Wave Heights in the Harbor Area (Case 6)

APPENDIX 9 CARGO HANDLING CAPACITY AFTER THE TARGET YEAR

The present terminal facilities and number of workers will be sufficient, if the proposed project is implemented, to handle the estimated cargo volume of 763,300 tons in the target year (1992). However, the total cargo throughput will continue to increase after that time. A rough estimation of the cargo volume increase from 1992 through 1995 has been executed, and two suggestions concerning the appropriate means to expand the handling capacity in order to accommodate the additional cargo volume are presented below.

(1) Increasing the working efficiency per gang per hour

If the systematic program for training workers described in the main body of this study is implemented, we expect that the cargo handling efficiency will increase by approximately 20% in 1992 due to improved working methods as outlined in Table M—1.

However, the increases in cargo handling efficiency in 1995 predicted in the table are based upon the assumption that an effective training program will be implemented, that is, that the workers will be trained in such a way that the handling efficiency will increase. Naturally, JST cannot guarantee that the forecast handling rates will actually be achieved after 1992. Nonetheless, there is every reason to believe that if a systematic training program is implemented, the cargo handling rate should improve by at least 20% by 1995 as a result of the training program and improved working methods.

Table M-1 Estimated Future Cargo Handling Efficiency

Kind of Cargo	Present Handling Efficiency	Efficiency in the Target Year 1992	Efficiency in 1995
General	20 MT/h	24 MT/h	29 MT/h
Steel Goods	40 MT/h	48 MT/h	58 MT/h
Container	7 TEU/h	12 TEU/h	15 TEU/h
Break Bulk	20 MT/h	200 MT/h	200 MT/h

note, MT : Metric ton

(2) Increasing the number of gangs per vessel

As noted in the study, the average number of gangs per vessel up to the target year is 2. By expanding the number of gangs per vessel to 3, the cargo handling capacity of the port may increase by as much as 50% without investing in any additional physical infrastructures. However, it would, of course, become necessary to purchase some additional forklifts. Besides, the ability to use three gangs simultaneously depends on various conditions such as the cargo loading conditions and the number of hatches on each vessel.

Based on the recommendations presented in (1) and (2), INCOP may be able to handle the forecast cargo in the year 1995 without constructing any additional mooring facilities.

APPENDIX 10 COMMENTS ON THE IMMINENT DREDGING PLAN AT THE PORT OF CALDERA

COMMENTS ON THE IMMINENT DREDGING PLAN
AT
THE PORT OF CALDERA

Nov. 4, 1985

THE JICA STUDY TEAM
FOR
THE MAINTENANCE PROJECT OF THE PORT OF CALDERA

The sand sedimentation has caused some difficulties for the berthing of large vessels at the −11 m berth at the Port of Caldera. MOPT, therefore, decided to execute urgent maintenance dredging, and requested the JICA study team to submit comments on the said dredging from the viewpoint of engineering. MOPT and the JICA study team held a meeting concerning this matter on Oct. 30, 1985.

This paper is a summary of the comments presented by the JICA study team at this meeting.

1. *Location of the dumping site for the dredged sand.*

The offshore area of Roca Carballo in the direction N 50°W from the No. 2 Buoy near the anchorage is recommendable as the dumping site for the dredged sand to prevent the dumped sand from returning to the dredged area. This water area is vast and deep to accept the dredged materials.

2. Dredging depth and areas.

(1) The berth area just in front of the quaywall, with a design depth of −11 m should not be dredged over the design depth plus the maximun allowance so as not to cause the collapse of the quaywall.

(2) The water area at the corner between the breakwater and the marginal quaywall should be given priority to be positively dredged because of its importance in firmly securing the berth area.

(3) The dredging depth allowance in the turning basin with a depth of −11 m, should be deepened as much as possible.

3. Dredging at the harbour part around the breakwater head.

The dredging of the deposited sand at the harbour part around the breakwater head, the length of which is about 100 m, is recommendable because it would be ineffecfive without further extension of the existing breakwater.

The detailed dredging plan for this water area will be studied as a part of the basic countermeasures against littoral drift sand by the JICA study team. Thus, this water area should be dredged after the completion of the said study.

4. Dredging methods.

(1) Such areas as the corner between the breakwater and the marginal wharf cannot be dredged using a hopper dredger and a blade dragger. Thus, the suction dredger owned by MOPT should be used to reliably dredge these water areas.

(2) There is a sand layer of a certain depth on top of the stones scattered by past high waves in certain harbour areas. Thus, a hopper dredger should dredge the sand layer up to the depth of the surface of the scattered stones. The scattered stones

themselves should not necessarily be dredged in the present dredging work considering the difficulty of such dredging.

5. Inspection of the dredged sand volume.

The volume of dredged sand should be confirmed based on the difference between soundings before and after the dredging. The soundings should be implemented by MOPT itself.

6. Safe maneuvering of general vessels.

The dredging work should not hinder the safe maneuvering of general vessels and the execution of regular port operations. Therefore, detailed adjustment must be worked out in advance between the dredging work and the maneuvering of general vessels.

APPENDIX 11 ESTIMATE OF WORKABLE DAYS FOR BREAKWATER CONSTRUCTION

The workable days of the breakwater construction are estimated using the following method.

1. Workable Days for Construction Works Executed from on Top of the Existing Breakwater

The critical wave height for the works executed from on top of the existing breakwater and their cumulative occurrence probability are estimated as follows, using the limit of uprush.

1. 1 Study Conditions

- ○ Tide level : M.H.W. +2.5 m
- ○ Crown height of the breakwater above the M.H.W. : 4.6−2.5=2.1 m
- ○ Water depth under the M.H.W. : $h=7.0+2.5=9.5$ m
- ○ Water period : $T_{1/3}=12$ s
  (Using the median of the occurrence probabilities : refer to CHAPTER VII, Fig.VII−11)
- ○ Deep water move length : $L_0=1.56\ T^2=225$ m

1. 2 Uprush Heights and their Occurrence Probability

According to the experimental results achieved by Toyoshima and et al.[1] (Fig.M−1), the uprush heights R and their occurence probabilities $P\ [H \leq x]$ are calculated as shown in Table M−1.

Table M-1 Relations between Uprush Heights and their Cumulative Occurrence Probabilities

$H_{1/3}$ (m)	H_0/L_0	h/L_0	R/H_0	R (m)	$P\ [H \geq x]$ (%)
1.5	0.0067	0.042	1.7	2.55	—
1.3	0.0058	0.042	1.6	2.08	90
1.2	0.0053	0.042	1.6	1.92	85

1) Osamu Toyoshima, Nobuo Shuto and Hiroshi Hashimoto ; Uprush Height against Seawall −Bottom Slope 1 : 30−, No. 11 Coastal Engineering Lectures, 1964, pp. 260~265

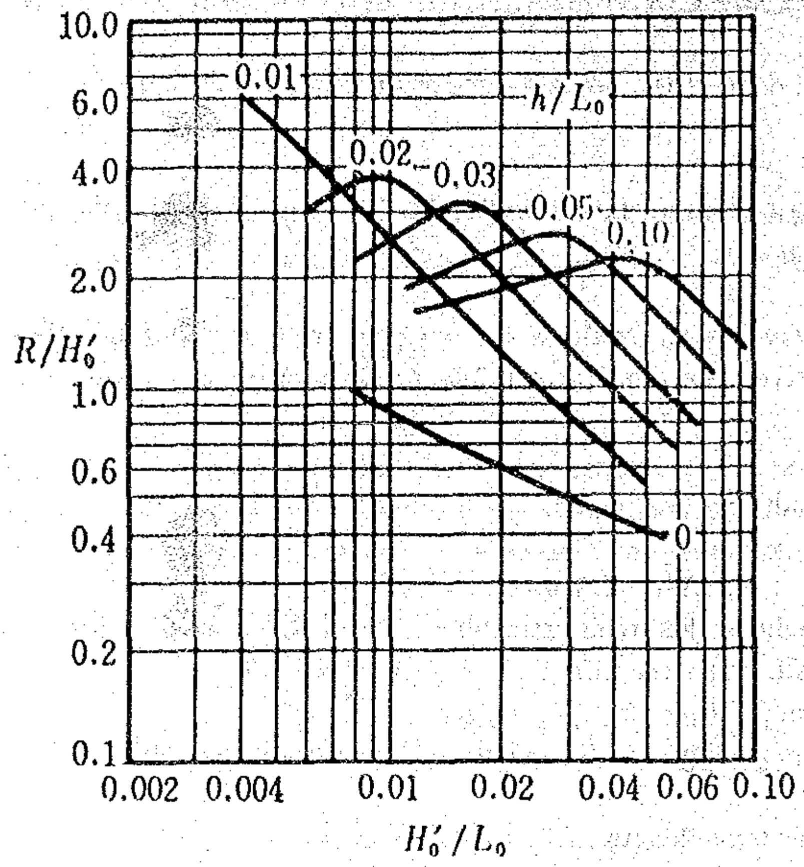

Fig. M-1 Uprush Height
(Slope of Seawall 1:2, Bottom Slope 1:30)

1. 3 Unworkable Days for Construction Works Executed from on Top of the Breakwater

As the above calculations were made based on the significant wave height, waves larger than these will occur at a probability of above 13%. However, considering that the tide levels are usually lower than M.H.W. and the uprush height against the slope of the rubble should be smaller than the values calculated above because Toyoshima's experiment was conducted using a smooth face, it should be possible to work on the breakwater when $H_{1/3}$ is less than or equal to 1.2 m. Thus, the construction will probably have to be stopped due to high waves at a probability of about 15%.

2. Workable Days of Marine Works

2. 1 Installation of Rubble Mound Under Water

The occurrence probability of unworkable days due to poor marine conditions for the installation of the rubble mound under water using barges is estimated to be 30%, assuming that the critisal workable significant wave height for the installation is 1.0 m (refer to CHAPTER IV, Fig.IV—10).

2. 2 Installation of Armour Units

If the critical significant wave height for installation of the armour unit of the breakwater is 0.5 m, the occurrence probability of workable days for this work is estimated to be only 6% (refer to CHAPTER IV, Fig.IV—10). Thus, it will not be efficient to install the Dolos using a floating crane from the outside harbour. Accordingly, the Dolos will be installed using mobile crane or a crawler crane on the breakwater.

The armour stones will be installed using a floating crane, where the diffraction rates on the inside of the harbour are less than 0.5. In this case, the occurrence probability of unworkable days is 30% because $H_{1/3}$ will be 1.0 m.

3. Estmated Workable Rate for Breakwater Construction

The estimated workable rate for each of the above construction works is summarized in Table M—2.

Table M-2 Estimated Workable Rate for Breakwater Construction

Item		Workable Rate
Marine Works	Installation of Underwater Mound	70%
	Installation of Armour Stones	70%
Works Executed from on Top of the Breakwater		85%

APPENDIX 12 SHIP COSTS

Ship costs consist of the price of the ship itself, the crew's wages, equipment cost, machine oil cost, insurance cost, repair cost, depreciation cost, miscellaneous costs, and other costs. Accordingly, the total ship cost depends on the price of the ship itself and the price of the other expenditures.

The price of ships is shown in Table M—1. *)

Table M-1 The Price of Ships

Ship Size ('000 DWT)	10	20	30	40	65	125	250
Price (Million Yen/ship)	1,300	2,250	3,100	3,800	4,750	6,450	9,850

The other costs are projected based on past costs and the projected rate of increase. Consequently, the ship costs are estimated as shown in Table M—2. *)

Table M-2 Estimation of Total Ship Cost

Ship Size ('000 DWT)	10	20	30	40	65	125	250
Ship Cost (Yen/DWT/Month)	4,635	3,002	2,402	2,200	1,750	1,105	754

*) Source : The Report for the Study on the International Commodity Distribution Center Development Project in the Bay of Shibushi, March 1984, The Transport Economy Research Institute of Japan.

APPENDIX 13 EIRR CALCULATION FOR SENSITIVITY ANALYSIS

Sensitivity analysis is made for three cases where

(1) Case EA : The construction costs other than that of dredging, and the purchase costs of the dredging fleet, construction machinery and cargo handling equipment, increase by 10%. In other words, the construction costs of such structures as the extended and shifted breakwater, the gangway and the small craft basin including the pavement cost of open yards increase by 10%.

(2) Case EB : The forecast port cargo volume decreases by 10%.

(3) Case EC : The ship costs decrease by 29%. The ship costs decrease by 50% of that calculated in APPENDIX 12. A ship cost decrease of 30% is adopted as the base case in the main body of the report.

The EIRR is calculated for each of the three simulation cases. The calculation results of each case are shown in Table M—1~Table M—3.

Table M-1 Calculation of the EIRR

Case EA The construction costs other than that of dredging, and the purchase costs of the dredging fleet, construction machinery and cargo handling equipment increase by 10%.

EIRR = 20.8%

(Unit: '000 Colones)

Year	Benefits	Costs			Benefits −Costs	Present Value in 1988		
		With Case	Without Case	Net Cost		Benefits	Net Costs	Benefits −Net Costs
1988		91,479		91,479	-91,479	–	91,479	-91,479
89		285,698	276,723	8,975	-8,975	–	7,430	-7,430
90		315,446	4,402	311,044	-311,044	–	213,196	-213,196
91	61,846	107,199	4,978	102,221	-40,375	35,095	58,006	-22,911
92	123,693	12,147	16,830	-4,683	128,376	58,111	-2,200	60,311
93	123,693	12,147	6,587	5,560	118,133	48,110	2,163	45,948
94	123,693	12,147	7,535	4,612	119,081	39,831	1,485	38,346
95	123,693	12,147	8,297	3,850	119,843	32,976	1,026	31,949
96	123,693	22,225	8,855	13,370	110,323	27,301	2,951	24,350
97	123,693	12,147	17,389	-5,242	128,935	22,602	-958	23,560
98	123,693	12,147	9,804	2,343	121,350	18,713	354	18,358
99	123,693	12,147	10,091	2,056	121,637	15,492	258	15,235
2000	123,693	12,147	10,379	1,768	121,925	12,826	183	12,643
1	123,693	91,527	10,667	80,860	42,833	10,619	6,942	3,677
2	123,693	12,147	18,913	-6,766	130,459	8,791	-481	9,272
3	123,693	12,147	11,141	1,006	122,687	7,278	59	7,219
4	123,693	12,147	275,013	-262,866	386,559	6,026	-12,805	18,831
5	123,693	12,147	11,412	735	122,958	4,989	30	4,959
6	123,693	24,109	11,615	12,494	111,199	4,130	417	3,713
7	123,693	12,147	19,861	-7,714	131,407	3,419	-213	3,633
8	123,693	12,147	11,988	159	123,534	2,831	4	2,827
9	123,693	12,147	12,174	-27	123,720	2,344	-1	2,344
2010	123,693	12,147	12,360	-213	123,906	1,940	-3	1,944
11	123,693	91,527	12,648	78,879	44,814	1,606	1,024	582
12	123,693	12,147	20,708	-8,561	132,254	1,330	-92	1,422
13	123,693	12,147	12,648	-501	124,194	1,101	-4	1,106
14	123,693	12,147	12,648	-501	124,194	912	-4	915
15	123,693	12,147	12,648	-501	124,194	755	-3	758
16	123,693	28,782	12,648	16,134	107,559	625	81	543
17	123,693	-10,115	3,129	-13,244	136,937	517	-55	573
Total	3,277,864	1,290,817	864,091	426,726	2,851,138	370,269	370,269	0

Table M-2 Calculation of the EIRR

Case FB The forecast port cargo volume decreases by 10%.

EIRR = 19.1%

(Unit: '000 Colones)

Year	Benefits	Costs			Benefits – Costs	Present Value in 1988		
		With Case	Without Case	Net Cost		Benefits	Net Costs	Benefits – Net Costs
1988	–	83,163	–	83,163	–83,163	–	83,163	–83,163
89	–	259,725	276,723	–16,998	16,998	–	–14,274	14,274
90	–	288,167	4,402	283,765	–283,765	–	200,092	–200,092
91	48,429	106,426	4,978	101,448	–53,019	28,675	60,069	–31,393
92	96,857	11,374	16,830	–5,456	102,313	48,158	–2,713	50,871
93	96,857	11,374	6,587	4,787	92,070	40,440	1,999	38,441
94	96,857	11,374	7,535	3,839	93,018	33,958	1,346	32,612
95	96,857	11,374	8,297	3,077	93,780	28,515	906	27,609
96	96,857	21,452	8,855	12,597	84,260	23,945	3,114	20,831
97	96,857	11,374	17,389	–6,015	102,872	20,107	–1,249	21,356
98	96,857	11,374	9,804	1,570	95,287	16,884	274	16,611
99	96,857	11,374	10,091	1,283	95,574	14,178	188	13,990
2000	96,857	11,374	10,379	995	95,862	11,906	122	11,783
1	96,857	90,754	10,667	80,087	16,770	9,997	8,266	1,731
2	96,857	11,374	18,913	–7,539	104,396	8,395	–653	9,048
3	96,857	11,374	11,141	233	96,624	7,049	17	7,033
4	96,857	11,374	275,013	–263,639	360,496	5,920	–16,113	22,032
5	96,857	11,374	11,412	–38	96,895	4,971	–2	4,973
6	96,857	23,336	11,615	11,721	85,136	4,174	505	3,669
7	96,857	11,374	19,861	–8,487	105,344	3,505	–307	3,812
8	96,857	11,374	11,988	–614	97,471	2,943	–19	2,962
9	96,857	11,374	12,174	–800	97,657	2,472	–20	2,492
2010	96,857	11,374	12,360	–986	97,843	2,075	–21	2,097
11	96,857	90,754	12,648	78,106	18,751	1,743	1,405	337
12	96,857	11,374	20,708	–9,334	106,191	1,463	–141	1,604
13	96,857	11,374	12,648	–1,274	98,131	1,229	–16	1,245
14	96,857	11,374	12,648	–1,274	98,131	1,032	–14	1,045
15	96,857	11,374	12,648	–1,274	98,131	867	–11	878
16	96,857	28,009	12,648	15,361	81,496	728	115	612
17	96,857	–10,888	3,129	–14,017	110,874	611	–88	699
Total	2,566,711	1,208,378	864,091	344,287	2,222,424	325,940	325,940	0

Table M-3 Calculation of the EIRR

Case EC The ship costs decrease by 29%

EIRR = 17.6%

(Unit: '000 Colones)

Year	Benefits	Costs			Benefits –Costs	Present Value in 1988		
		With Case	Without Case	Net Cost		Benefits	Net Costs	Benefits –Net Costs
1988	–	83,163	–	83,163	–83,163	–	83,163	–83,163
89	–	259,725	276,723	–16,998	16,998	–	–14,457	14,457
90	–	288,167	4,402	283,765	–283,765	–	205,274	–205,274
91	44,176	106,426	4,978	101,448	–57,272	27,180	62,418	–35,238
92	88,352	11,374	16,830	–5,456	93,808	46,235	–2,855	49,090
93	88,352	11,374	6,587	4,787	83,565	39,324	2,131	37,193
94	88,352	11,374	7,535	3,839	84,513	33,446	1,453	31,993
95	88,352	11,374	8,297	3,077	85,275	28,447	991	27,456
96	88,352	21,452	8,855	12,597	75,755	24,195	3,450	20,745
97	88,352	11,374	17,389	–6,015	94,367	20,578	–1,401	21,979
98	88,352	11,374	9,804	1,570	86,782	17,502	311	17,191
99	88,352	11,374	10,091	1,283	87,069	14,886	216	14,670
2000	88,352	11,374	10,379	995	87,357	12,661	143	12,519
1	88,352	90,754	10,667	80,087	8,265	10,769	9,761	1,007
2	88,352	11,374	18,913	–7,539	95,891	9,159	–782	9,941
3	88,352	11,374	11,141	233	88,119	7,790	21	7,769
4	88,352	11,374	275,013	–263,639	351,991	6,626	–19,770	26,396
5	88,352	11,374	11,412	–38	88,390	5,635	–2	5,638
6	88,352	23,336	11,615	11,721	76,631	4,793	636	4,157
7	88,352	11,374	19,861	–8,487	96,839	4,076	–392	4,468
8	88,352	11,374	11,988	–614	88,966	3,467	–24	3,491
9	88,352	11,374	12,174	–800	89,152	2,949	–27	2,976
2010	88,352	11,374	12,360	–986	89,338	2,508	–28	2,536
11	88,352	90,754	12,648	78,106	10,246	2,133	1,886	247
12	88,352	11,374	20,708	–9,334	97,686	1,814	–192	2,006
13	88,352	11,374	12,648	–1,274	89,626	1,543	–22	1,565
14	88,352	11,374	12,648	–1,274	89,626	1,313	–19	1,331
15	88,352	11,374	12,648	–1,274	89,626	1,116	–16	1,132
16	88,352	28,009	12,648	15,361	72,991	949	165	784
17	88,352	–10,888	3,129	–14,017	102,369	808	–128	936
Total	2,341,328	1,208,378	864,091	344,287	1,997,041	331,902	331,902	0

APPENDIX 14 FIRR CALCULATION FOR SENSITIVITY ANALYSIS

Sensitivity analysis is made for three cases as follows :

(1) the port tariff revenues decrease by 10% (Case FA),

(2) the construction costs increase by 10% (Case FB),

(3) the revenues decrease by 10% and the costs increase by 10% simultaneously (Case FC).

The FIRR is calculated for each of the 3 simulation cases. The results are shown in Table M–1~Table M–3.

Table M-1 Calculation of the FIRR

Case FA The case in which the port tariff revenues decrease by 10%

FIRR=6.35%

Unit: '000 Colones

Year	Cost[1]	Benefit	Benefit −Cost	Present Value in 1988		
				Cost	Benefit	Benefit−Cost
1988						
89						
90	233,952		−233,952	206,864		−206,864
91	300,720	33,701	−267,019	250,034	28,021	−222,013
92	20,078	67,402	47,324	15,698	52,697	37,000
93	20,078	67,402	47,324	14,761	49,553	34,792
94	20,078	67,402	47,324	13,880	46,596	32,716
95	20,078	67,402	47,324	13,052	43,815	30,763
96	20,078	67,402	47,324	12,273	41,201	28,928
97	20,078	67,402	47,324	11,541	38,742	27,201
98	20,078	67,402	47,324	10,852	36,430	25,578
99	20,078	67,402	47,324	10,204	34,256	24,052
2000	20,078	67,402	47,324	9,595	32,212	22,617
01	89,380	67,402	−21,978	40,167	30,290	−9,877
02	20,078	67,402	47,324	8,484	28,482	19,998
03	20,078	67,402	47,324	7,978	26,783	18,805
04	20,078	67,402	47,324	7,502	25,185	17,682
05	20,078	67,402	47,324	7,054	23,682	16,627
06	21,962	67,402	45,402	7,256	22,269	15,013
07	20,078	67,402	47,324	6,238	20,940	14,702
08	20,078	67,402	47,324	5,865	19,690	13,825
09	20,078	67,402	47,324	5,515	18,515	13,000
10	20,078	67,402	47,324	5,186	17,410	12,224
11	258,073	67,402	−190,671	62,684	16,371	−46,312
12	20,078	67,402	47,324	4,586	15,384	10,809
13	20,078	67,402	47,324	4,312	14,476	10,164
14	20,078	67,402	47,324	4,055	13,612	9,557
15	20,078	67,402	47,324	3,813	12,800	8,987
16	20,078	67,402	47,324	3,585	12,036	8,451
17	−120,657	67,402	188,059	−20,260	11,318	31,578
Total	1,225,146	1,786,153	561,007	732,775	732,775	0

Note: 1) The costs include minus costs (benefits).

Table M-2 Calculation of the FIRR

Case FB The case in which the construction costs increase by 10%

FIRR=6.53%

Unit : '000 Colones

Year	Cost[1]	Benefit	Benefit −Cost	Present Value in 1988		
				Cost	Benefit	Benefit−Cost
1988						
89						
90	257,347		−257,347	226,786		−226,786
91	330,792	37,445	−293,347	273,653	30,977	−242,676
92	22,086	74,891	52,805	17,152	58,160	41,008
93	22,086	74,891	52,805	16,101	54,597	38,496
94	22,086	74,891	52,805	15,115	51,253	36,138
95	22,086	74,891	52,805	14,189	48,114	33,924
96	22,086	74,891	52,805	13,320	45,166	31,846
97	22,086	74,891	52,805	12,504	42,400	29,896
98	22,086	74,891	52,805	11,738	39,803	28,064
99	22,086	74,891	52,805	11,019	37,365	26,345
2000	22,086	74,891	52,805	10,344	35,076	24,732
01	98,318	74,891	−23,427	43,227	32,927	−10,300
02	22,086	74,891	52,805	9,116	30,910	21,795
03	22,086	74,891	52,805	8,557	29,017	20,460
04	22,086	74,891	52,805	8,033	27,240	19,206
05	22,086	74,891	52,805	7,541	25,571	18,030
06	24,158	74,891	50,733	7,743	24,005	16,261
07	22,086	74,891	52,805	6,646	22,534	15,889
08	22,086	74,891	52,805	6,238	21,154	14,916
09	22,086	74,891	52,805	5,856	19,858	14,002
10	22,086	74,891	52,805	5,498	18,642	13,144
11	283,880	74,891	−208,989	66,335	17,500	−48,835
12	22,086	74,891	52,805	4,845	16,428	11,583
13	22,086	74,891	52,805	4,548	15,422	10,874
14	22,086	74,891	52,805	4,269	14,477	10,208
15	22,086	74,891	52,805	4,008	13,590	9,582
16	22,086	74,891	52,805	3,762	12,758	8,995
17	−132,723	74,891	207,614	−21,225	11,976	33,201
Total	1,347,664	1,984,611	636,947	796,920	796,920	0

Note: 1) The costs include minus costs (benefits).

Table M-3 Calculation of the FIRR

Case FC The case in which the revenues decrease by 10% and the costs increase by 10% simultaneously

FIRR=4.68%

Unit : '000 Colones

Year	Cost[1]	Benefit	Benefit −Cost	Present Value in 1988		
				Cost	Benefit	Benefit−Cost
1988						
89						
90	257,347		−257,347	234,854		−234,854
91	330,792	33,701	−297,091	288,385	29,381	−259,005
92	22,086	67,402	45,316	18,394	56,135	37,741
93	22,086	67,402	45,316	17,572	53,625	36,054
94	22,086	67,402	45,316	16,786	51,228	34,442
95	22,086	67,402	45,316	16,036	48,938	32,902
96	22,086	67,402	45,316	15,319	46,751	31,432
97	22,086	67,402	45,316	14,634	44,661	30,027
98	22,086	67,402	45,316	13,980	42,664	28,684
99	22,086	67,402	45,316	13,355	40,757	27,402
2000	22,086	67,402	45,316	12,758	38,935	26,177
01	98,318	67,402	−30,916	54,255	37,195	−17,061
02	22,086	67,402	45,316	11,643	35,532	23,889
03	22,086	67,402	45,316	11,123	33,944	22,821
04	22,086	67,402	45,316	10,625	32,427	21,801
05	22,086	67,402	45,316	10,150	30,977	20,827
06	24,158	67,402	43,244	10,606	29,592	18,986
07	22,086	67,402	45,316	9,263	28,270	19,006
08	22,086	67,402	45,316	8,849	27,006	18,157
09	22,086	67,402	45,316	8,454	25,799	17,345
10	22,086	67,402	45,316	8,076	24,645	16,570
11	283,880	67,402	−216,478	99,160	23,544	−75,617
12	22,086	67,402	45,316	7,370	22,491	15,121
13	22,086	67,402	45,316	7,040	21,486	14,446
14	22,086	67,402	45,316	6,726	20,526	13,800
15	22,086	67,402	45,316	6,425	19,608	13,183
16	22,086	67,402	45,316	6,138	18,731	12,594
17	−132,723	67,402	200,125	−35,236	17,894	53,130
Total	1,347,664	1,786,153	438,489	902,742	902,742	0

Note: 1) The costs include minus costs (benefits).

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