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Appendix I, Maps

Figure I. 1 Overview map Mar del Plata to Miramar

Figure I. 2 Surroundings of Los Acantilados

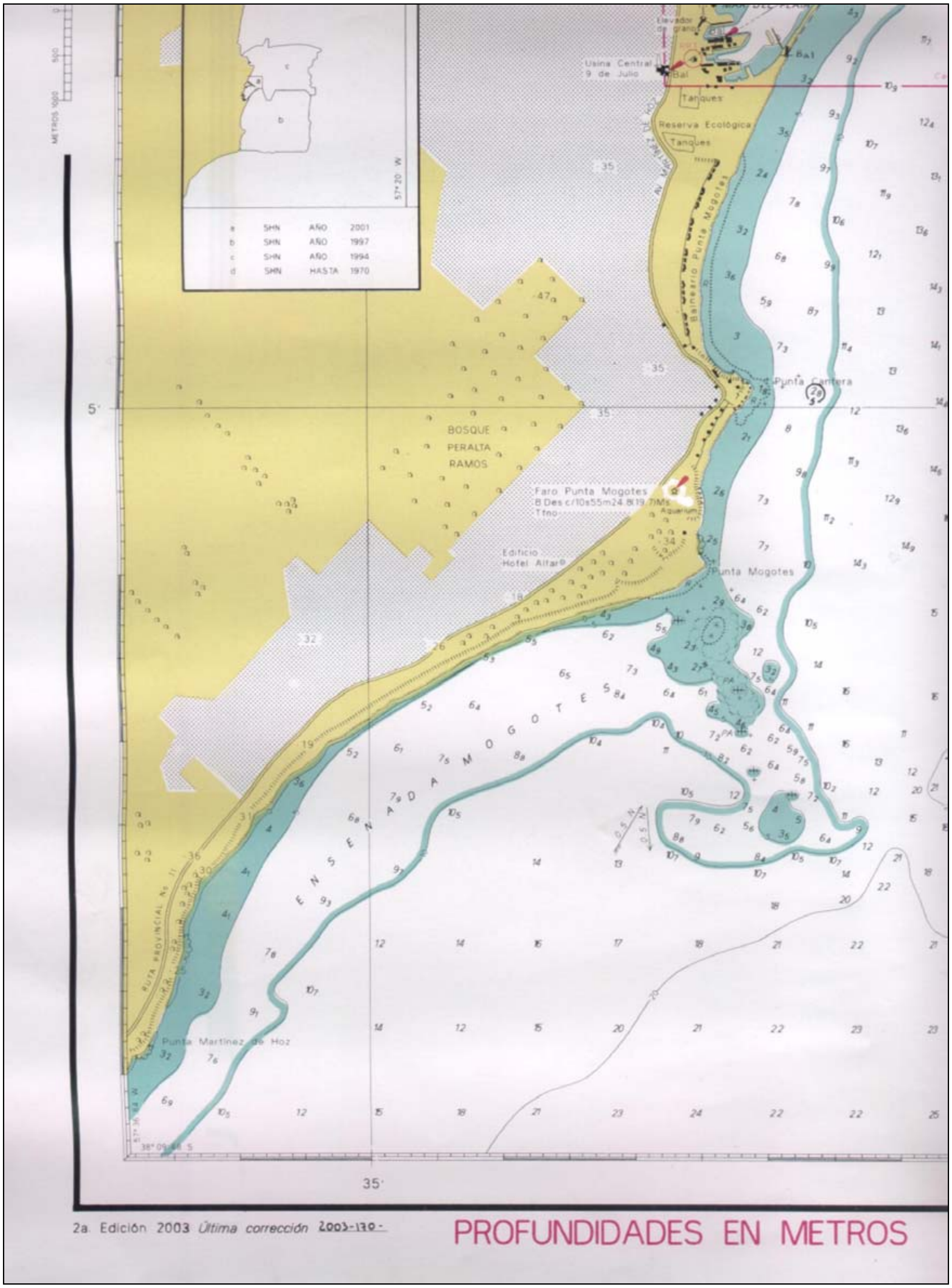

Figure I. 3 **Sea map of the area with depths**

Figure I. 4 Concessions of the beach

Figure I. 5 Depth profiles in m

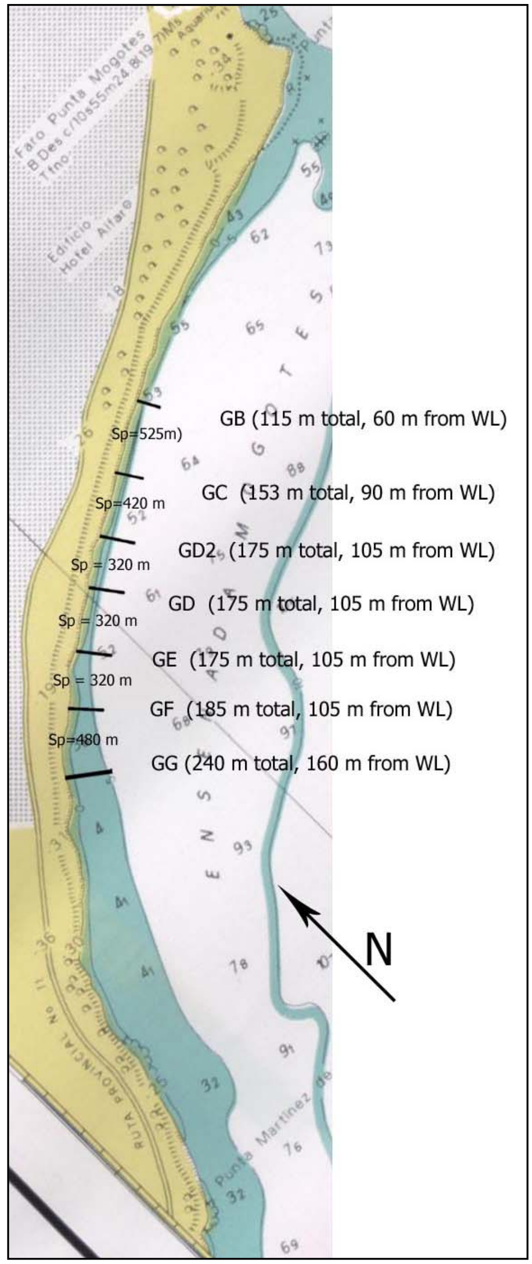

Fig. I. 6 Rays and preliminary groyne design

Fig. I. 7 Final groyne desing

Appendix II, Views of the research area

Fig. II. 1 Punta Cantela, with the groyne in the back

Fig. II. 2 North view from Los Acantilados, with the tombolo in the back

Fig. II. 3 South view from Los Acantilados, erosion

Fig. II. 4 Leaking groundwater trough the cliffs

Fig. II. 5 Heavy erosion north of Punta Cantela

Fig. II. 6 Big parts of the cliff fall off, clearly visible how the rock easily break in two.

Fig. II. 7 Ebb gully's in rock!

Fig. II. 8 South view from Los Lobos

With the following three overviews of the area, one gets a perfect image of the existing situation. Courtesy goes out to Mister Rodriguez, inhabitant of Mar de Plata.

Figure II. 9 Arial photograph from the North, with the salient of Punta mogotos in the front of the picture.

Figure II. 10 Picture taken from the South 50 years ago

Figure II. 11 Picture taken from the same place a few years ago

The following series of give an overview from South of North, starting at the point were the big groyne in front of the presidents house was build and ending with a view to the South at Los Acantilados. Clearly visible is the total lack of sand.

Figure II. 13 The presidential goyne

Figure II. 14

Figure II. 15

.

Figure II. 16

Figure II. 17

Figure II. 18

Figure II. 19 View from the North at Los Acantilados

Appendix III, Stone material cliffs

Figure III. 1 Hard 'Tosca' stone, only approximately 10% of the cliff's material

Figure III. 2 Very erosive 'Loess Pampeano'. This piece of rock was easily broken off the cliffs by hand

Appendix IV, Historical erosion data

Table IV. 1[1] **Erosion problems over the last three decades in the surroundings of Mar del Plata**

Figure IV. 1[2] **Erosion in meters per year as recorded in year 1983.**

[1] Produccion en Investigacion Cientifica, fuera del marco del proyecto. Ferrante, A. Alvarez, R. Jorge 1999 'Quantification of the coastal marine erosion between 1970 and 1998 on General Pueynedon County, Buenos Aires Province' 4th Open Science Meeting Loicz Bahia Blanca, Argentina, 15 al 18 de niviembre de 1999.

[2] El character erosivo de la linea de costa entre Mar Chiquita y Miramar, Buenos Aires Province. E.J. Schwan, J.R. Alvares y J.L. Cionchi 1983

Appendix V, Sea level rise

Figure V. 1 **A time series of mean sea level at Quequen from 1918 to 1982**

Figure V. 2 **A time series of mean sea level at Buenos Aires from 1905 to 1987**

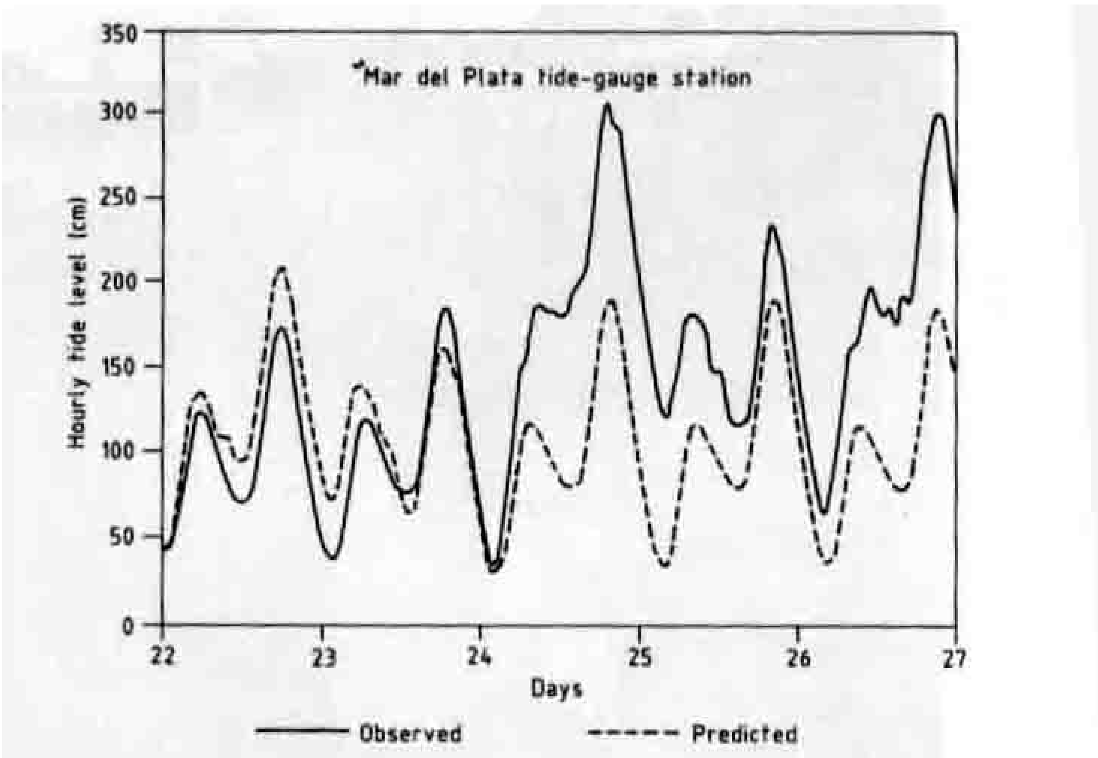

Figure V. 3 **Tide levels in Mar del Plata during the storm of June 22-27, 1994**

Appendix VI, The tide

All the data given below, were obtained at the website www.hidro.gov.ar. Which is the website of Servicio Hidrografia de Naval de Argentina

Table VI. 1 Sea level in Mar del Plata

PUERTO MAR DEL PLATA	
Carta argentina H-251	Lat.: 38° 03' S
Huso Horario + 3	Long.: 57° 31' W
Régimen de marea: Mixta	3^h 50^m
Establecimiento de puerto medio: VI^h 21^m	
Nivel medio 0,91 m	
referidas al plano de reducción que pasa 0,91 m debajo del nivel	

Table VI. 2 Tide in Mar del Plata

Alturas en metros sobre el plano de reducción								
	Pleamar			Bajamar			Amplitud	
Jan –Mar 2004	Máxima	Media		Más baja	Media		Máxima	Media
	2,03	1,31		0,16	0,53		1,78	0,78
Apr – Jun 2004	Máxima	Media		Más baja	Media		Máxima	Media
	2,03	1,31		0,16	0,53		1,78	0,78
Jul – Sep 2004	Máxima	Media		Más baja	Media		Máxima	Media
	2,03	1,31		0,16	0,53		1,78	0,78
Oct – Die 2004	Máxima	Media		Más baja	Media		Máxima	Media
	2,03	1,31		0,16	0,53		1,78	0,78

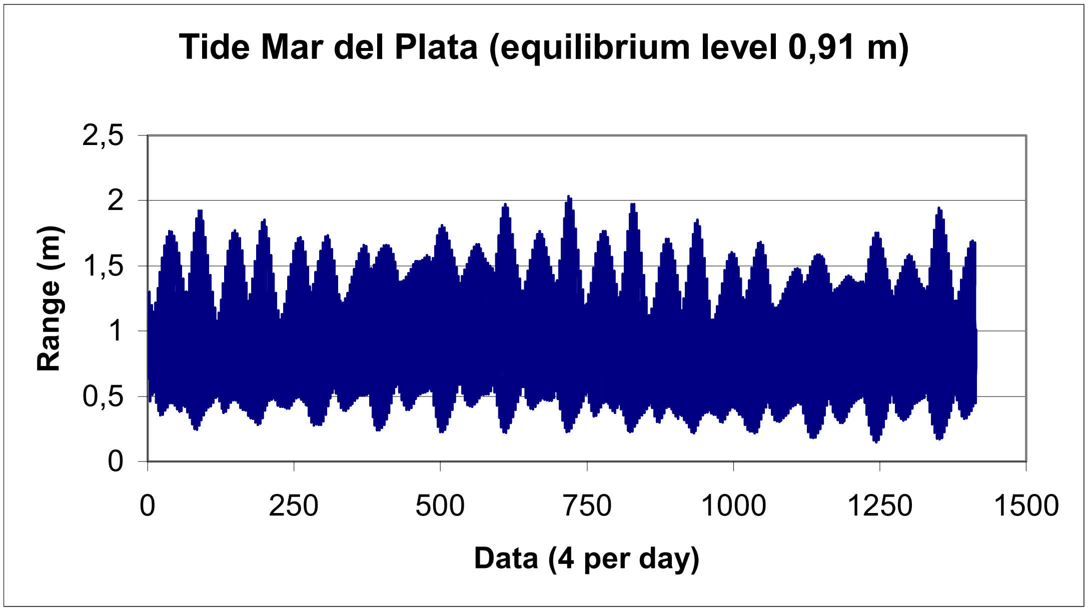

Figure VI. 1 **Plotted tidal data of one year in Mar del Plata**

Appendix VII, Offshore Wave climate

For the wave data two databases have been used, www.hydrobase.net from the Alkyon, Emmeloord, The Netherlands and www.waveclimate.com From Argoss (Advisory Research Group on Geo Observation Systems and Services) Marknesse, The Netherlands. Alkyon data is based on ship observations from global wave statistics(GWS). The data from Argoss is obtained by satellite measurements.

Differences between these to sources can be expected because of the totally different way of measuring. In this appendix the data will be analysed and compared. Furthermore conclusions will be drawn with respect to the use of the following parameters: Significant wave height, Average wave period and wave directions. No distinction is made between wind waves and swell waves. The data is contains the total of sea waves in an offshore climate.

Argoss Data

The data of Argoss is obtained by satellite measurements. The Centre of area is at 38° 07'S, 56° 30'W the size of area is 100x100 km. Most of the results are based on 12310 samples from 1158 passes.
Different types of data are presented in the different scatter tables.

- Monthly distribution of the significant wave height
- Percentage of occurrence of significant wave height versus wave direction
- Percentage of occurrence of sign. wave height versus mean wave period
- Probability of exceedance versus significant wave height

Figure VII. 1 Area from which dat are used for calculations

Table VII. 1

Monthly distribution of sign. wave height (m)													
lower	**upper**	Jan	Feb	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**1**	**Sep**	**Oct**	**Nov**	**Dec**
00	**01**	13.1	12.3	11.9	8.9	7.4	5.2	7.3	6.6	7.5	11.1	9.5	9.7
01	**02**	59.5	64.4	59.5	46.0	61.9	41.9	52.4	54.8	54.8	59.0	62.2	65.1
02	**03**	20.7	17.3	21.3	28.5	22.1	37.3	29.3	26.4	24.3	18.9	23.4	18.4
03	**04**	4.6	4.9	6.2	11.1	6.8	10.8	8.2	7.4	8.8	9.3	2.7	6.8
04	**05**	1.9	1.1	1.2	4.5	1.7	2.8	1.1	3.8	4.4	1.4	1.3	0
05	**06**	0.3	0	0	0.8	0.2	1.9	1.8	1.0	0.2	0.2	0.9	0
06	**07**	0	0	0	0.1	0	0	0	0	0	0	0	0
07	**08**	0	0	0	0	0	0	0	0	0	0	0	0
total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

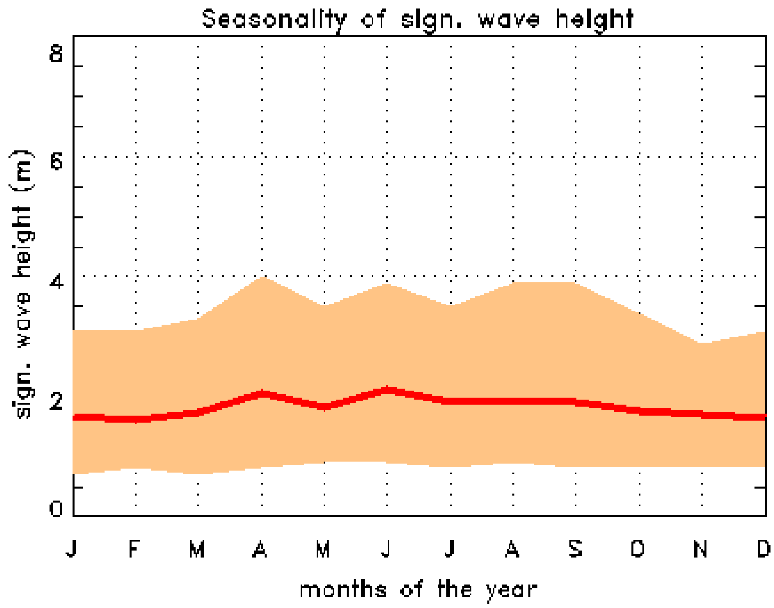

Figure VII. 2 Significant wave height

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The most important conclusion which can be drawn from table and graph above is, that the significant wave height to a large extent is even distributed over the different seasons. During the winter months June, August and September much higher wave heights occur. Because of this conclusion is it justified to use one significant wave height including the typical direction and wave period for each season, for longshore sediment transport calculations.

Table VII. 2

Percentage of occurrence of sign. wave height (m) in rows versus wave direction in columns										
	lower	**337.5**	**22.5**	**67.5**	**112.5**	**157.5**	**202.5**	**247.5**	**292.5**	
lower	**upper**	**22.5**	**67.5**	**112.5**	**157.5**	**202.5**	**247.5**	**292.5**	**337.5**	**total**
00	**01**	0.6	1.2	4.7	2.4	4.1	0.6	0	1.2	14.8
01	**02**	2.4	7.1	9.5	10.7	17.8	3.0	0	1.2	51.5
02	**03**	1.2	3.0	1.8	2.4	6.5	5.9	1.8	1.2	23.7
03	**04**	0	0	1.2	1.2	3.0	3.0	0.6	0	8.9
04	**05**	0	0	0	0	0	0.6	0	0	0.6
05	**06**	0	0.6	0	0	0	0	0	0	0.6
06	**07**	0	0	0	0	0	0	0	0	0.0
total		4.1	11.8	17.2	16.6	31.4	13.0	2.4	3.6	100.0

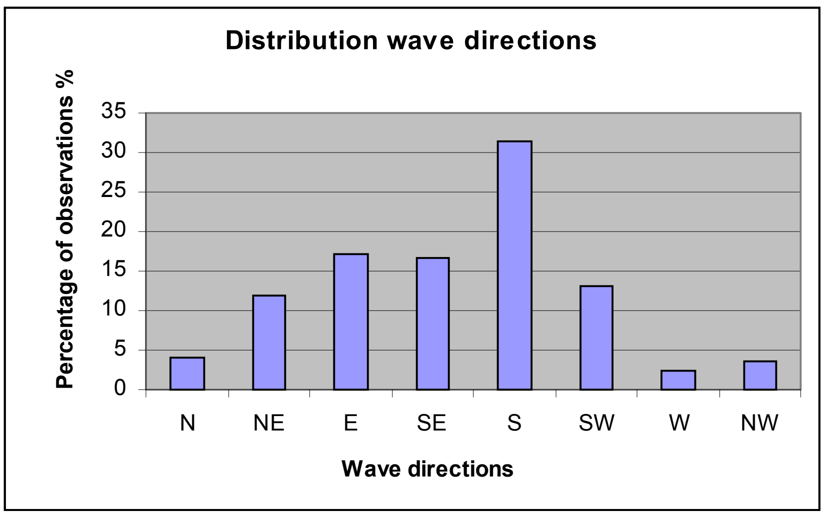

Figure VII. 3 Distribution wave direction

As can been seen in the scatter table and histogram of the wave directions, the most important directions are North-East, East, South-East, South and South-West. The directions are that for an offshore wave climate. This contains therefore all directions. In the analysis later on a selection will be made which will exclude the shadow directions.

Table VII. 3

Percentage of occurrence of sign. wave height (m) in rows versus mean wave period (s) in columns												
	lower	**04**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	
lower	**upper**	**05**	**06**	**07**	**08**	**09**	**10**	**11**	**12**	**13**	**14**	**total**
00	**01**	0	1.2	4.7	5.9	2.4	0.6	0	0	0	0	14.8
01	**02**	0	3.6	10.1	18.3	10.7	6.5	1.8	0.6	0	0	51.5
02	**03**	0	0	4.1	8.9	4.1	3.6	1.8	0.6	0.6	0	23.7
03	**04**	0	0	0	4.1	2.4	1.2	0.6	0.6	0	0	8.9
04	**05**	0	0	0	0	0	0.6	0	0	0	0	0.6
05	**06**	0	0	0	0	0	0.6	0	0	0	0	0.6
06	**07**	0	0	0	0	0	0	0	0	0	0	0.0
total		0.0	4.7	18.9	37.3	19.5	13.0	4.1	1.8	0.6	0.0	100.0

Results are based on 169 samples from 168 passes

The most important wave period according to this data is between 6 and 9 seconds, as can be seen in the scatter table.

Figure VII. 4 **Exceedence curve Argoss**

Figure VII. 5 **Reoccurence interval Argoss**

Alkyon (Global Wave Statistics)

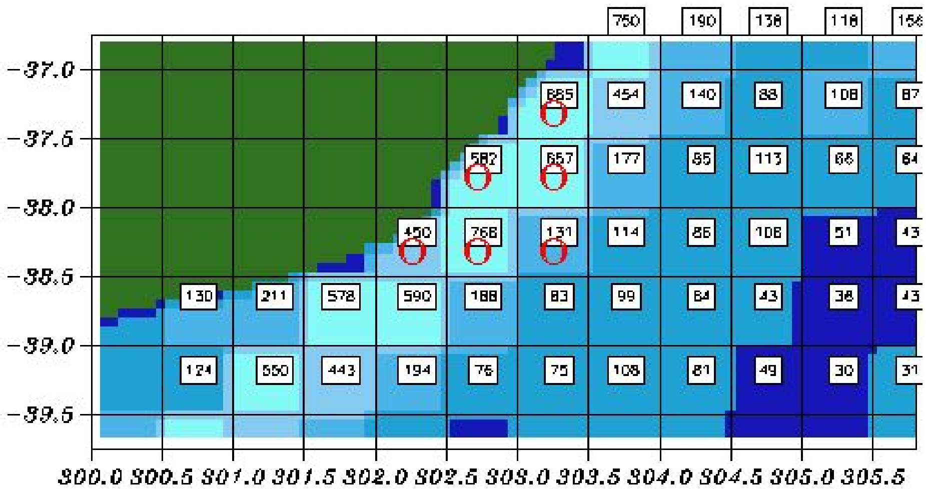

Figure VII. 6 **Wave area Alkyon**

The data used for the following analysis of the wave height is from the areas marked with an O in the above figure. The numbers in the boxes represent the number of observations in that area. This area is needed because of the amount of observations needed to get a reliable analysis.

Table VII. 4 **Wave heights and direction**

Hs		dir (Deg)								
(m) Lower	Upper	-22,5 to 22,5	22,5 to 67,5	67,5 to 112,5	112,5 to 157,5	157,5 to 202,5	202,5 to 247,5	247,5 to 292,5	292,5 to 337,5	Total
,00	,25	2,19	,80	,48	,34	,74	,60	,60	,51	6,25
,25	,75	4,49	4,12	2,27	1,90	3,01	2,16	2,39	2,30	22,63
,75	1,25	4,17	4,71	2,92	2,81	6,08	3,09	1,79	1,82	27,40
1,25	1,75	2,61	2,56	2,04	2,04	5,08	2,30	1,19	1,02	18,85
1,75	2,25	1,28	1,68	1,56	1,11	4,29	1,50	,85	,37	12,63
2,25	2,75	,60	,48	,26	,57	2,10	,94	,45	,31	5,71
2,75	3,25	,26	,40	,31	,54	1,39	,60	,23	,20	3,92
3,25	4,25	,06	,23	,11	,20	,60	,45	,14	,06	1,85
4,25	5,25	,06	,03	,11	,	,26	,06	,11	,03	,65
5,25	6,25	,	,	,	,	,03	,	,06	,	,09
6,25	7,25	,	,	,	,	,	,	,	,	,
7,25	8,25	,	,	,	,	,	,	,	,	,
8,25	9,25	,	,	,	,	,	,	,	,	,
9,25	10,25	,	,	,03	,	,	,	,	,	,03
10,25	11,25	,	,	,	,	,	,	,	,	,
11,25	12,25	,	,	,	,	,	,	,	,	,
12,25	13,25	,	,	,	,	,	,	,	,	,
13,25	14,25	,	,	,	,	,	,	,	,	,
14,25	15,25	,	,	,	,	,	,	,	,	,
15,25	>	,	,	,	,	,	,	,	,	,
Total		15,70	14,99	10,11	9,51	23,57	11,70	7,81	6,62	100,00
Hs average		1,01	1,16	1,30	1,35	1,57	1,44	1,25	1,06	1,30

Season:	All year
Period:	1960 to 1997
Location:	Mar del Plata (x = 302.67, y =-38.17)
Source:	Ship observations
No. of obs.:	3522

From these data it is clear that not only most of the waves come from the south but that these waves are also the highest. The average Hs over the year is 1.3 metres. The directions West; North West are not important for this problem because those directions are on the landside of the coast but are in this data because of the fact that it is measured offshore.

Figure VII. 7 Exceedence curve Alkyon

Figure VII. 8 Reoccurrence interval Alkyon

Table VII. 5 Significant wave heights and duration

Hs (m) Lower	Upper	Tobs (s) 3,5 to 5,5	5,5 to 7,5	7,5 to 9,5	9,5 to 11,5	11,5 to 13,5	13,5 to 15,5	15,5 to 17,5	17,5 to 19,5	19,5 to 21,5	21,5 to >	Total
,00	,25	5,59	,20	,09	,28	,	,03	,	,	,06	,	6,25
,25	,75	18,23	2,13	,82	,82	,31	,17	,	,09	,06	,	22,63
,75	1,25	18,09	4,83	1,85	1,14	,74	,54	,06	,17	,	,	27,40
1,25	1,75	8,26	5,99	2,41	,85	,60	,51	,06	,14	,03	,	18,85
1,75	2,25	4,32	4,49	2,21	,99	,40	,14	,03	,	,06	,	12,63
2,25	2,75	1,62	2,24	1,02	,51	,14	,14	,	,	,03	,	5,71
2,75	3,25	,57	1,96	,80	,28	,17	,14	,	,	,	,	3,92
3,25	4,25	,11	,91	,34	,20	,17	,11	,	,	,	,	1,85
4,25	5,25	,03	,11	,20	,20	,09	,03	,	,	,	,	,65
5,25	6,25	,	,03	,06	,	,	,	,	,	,	,	,09
6,25	7,25	,	,	,	,	,	,	,	,	,	,	,
7,25	8,25	,	,	,	,	,	,	,	,	,	,	,
8,25	9,25	,	,	,	,	,	,	,	,	,	,	,
9,25	10,25	,03	,	,	,	,	,	,	,	,	,	,03
10,25	11,25	,	,	,	,	,	,	,	,	,	,	,
11,25	12,25	,	,	,	,	,	,	,	,	,	,	,
12,25	13,25	,	,	,	,	,	,	,	,	,	,	,
13,25	14,25	,	,	,	,	,	,	,	,	,	,	,
14,25	15,25	,	,	,	,	,	,	,	,	,	,	,
15,25	>	,	,	,	,	,	,	,	,	,	,	,
Total		56,84	22,88	9,80	5,28	2,61	1,82	,14	,40	,23	,	100,00

Season:	All year
Period:	1960 to 1997
Location:	groot all year (x = 302.67, y =-38.17)
Source:	Ship observations
No. of obs.:	3522
Type of data:	Highest of sea & swell
Tidal phase:	undefined level
Record:	Ship Observations HSS data Season: All year
Tobs average	6.16 s.

Table VII. 6 Wave direction over the year

	N	NE	E	SE	S	SW	W	NW	Total
Winter (Jun.-Aug.)									
Percentage (%)	16,23	9,06	8,77	7,60	23,54	13,01	12,57	9,21	100,00
Hs Average (m)	1,03	1,05	1,30	1,40	1,49	1,44	1,54	1,19	1,33
Ts Average (s)	5,94	5,85	6,77	7,27	6,98	6,23	5,87	5,64	6,38
Spring (Sept.-Nov.)									
Percentage (%)	14,27	15,92	12,74	12,03	23,47	11,20	5,19	5,19	100,00
Hs Average (m)	0,93	1,01	1,37	1,27	1,62	1,42	0,98	1,12	1,27
Ts Average (s)	5,46	5,97	6,37	6,54	6,51	6,16	5,18	6,95	6,20
Summer (Dec.-Feb.)									
Percentage (%)	16,73	23,37	11,15	8,54	24,08	9,02	3,44	3,68	100,00
Hs Average (m)	1,09	1,32	1,27	1,38	1,60	1,46	1,04	0,90	1,34
Ts Average (s)	5,73	5,89	6,12	6,89	6,22	6,26	5,60	5,98	6,08
Autumn (Mar.-May)									
Percentage (%)	15,78	12,06	7,44	10,26	24,13	13,08	9,70	7,55	100,00
Hs Average (m)	0,98	1,19	1,25	1,48	1,62	1,40	1,27	1,11	1,32
Ts Average (s)	5,31	6,01	6,50	6,85	6,53	5,84	5,83	5,43	6,06

From the seasonal data it can be seen that there is a constant amount of waves coming from southern and south-eastern direction. The higher wave period compared to the rest of the data shows that this is probably swell coming from the rough southern part of the ocean. In the summer there are also a big amount of waves coming from North-Eastern direction however the shorter wave period and lower Hs indicate that these are more wind waves. In the winter more waves come from the west however these are not important for this problem.

Conclusions

The data obtained form the ships observations do hardly include swell waves with a long period. From a ship it is difficult to see swell waves with a length of 200 metres. It is difficult to predict a once in 100 years storm from data which do not include the larger waves with the long periods. The data from www.waveclimate.com is obtained by satellite measurements and not very accurate especially in the smaller waves with short periods. To determine the design wave for the hard structures the data from the satellites is used. However for the modelling of the wave climate for determining the transport the data obtained from www.hydrobase.net is used.

Table VII. 7 Exceedence wave height for different periods

Hss once in 50 years	5.1 m.
Hss once in 100 years	5.6 m.

For the input in the modelling software Table VII.8 is used where the Ts is always rounded up and the directions on the coast side are deleted. The wave climate is then as below.

Table VII. 8 Input wave climate for computer calculations

	N	NE	E	SE	S	SW	Total
Winter (Jun.-Aug.)							
Days	19	11	10	9	27	15	91
Hs Average (m)	1,0	1,1	1,3	1,4	1,5	1,4	1,3
Ts Average (s)	6,0	5,9	6,8	7,3	7,0	6,3	6,4
Spring (Sept.-Nov.)							
Days	15	16	13	12	24	11	91
Hs Average (m)	0,9	1,0	1,4	1,3	1,6	1,4	1,3
Ts Average (s)	5,5	6,0	6,4	6,6	6,6	6,2	6,2
Summer (Dec.-Feb.)							
Days	17	22	11	8	24	9	91
Hs Average (m)	1,1	1,3	1,3	1,4	1,6	1,5	1,3
Ts Average (s)	5,8	5,9	6,2	6,9	6,3	6,3	6,1
Autumn (Mar.-May)							
Days	18	13	8	11	26	15	91
Hs Average (m)	1,0	1,2	1,3	1,5	1,6	1,4	1,3
Ts Average (s)	5,4	6,1	6,5	6,9	6,6	5,9	6,1

For the input in the quick calculation by hand the wave climate is modeled as below.

Table VII. 9 Input wave climate for hand calculations

	NE	S	SW
Year			
Days	179	141	45
Hs Average (m)	1,2	1,5	1,4
Ts Average (s)	6	7	6

Appendix VIII, Sediment

Sediment samples were taken from 10 sites along the coast. One upstream off the research area and one downstream of the area and 8 of the beach of "Los Acantilados" itself. From the beach at four different locations both on the foreshore and one the backshore samples were taken. See Figure VIII.1. At the locations where two numbers are printed the smaller number is at the foreshore and the bigger at the backshore.

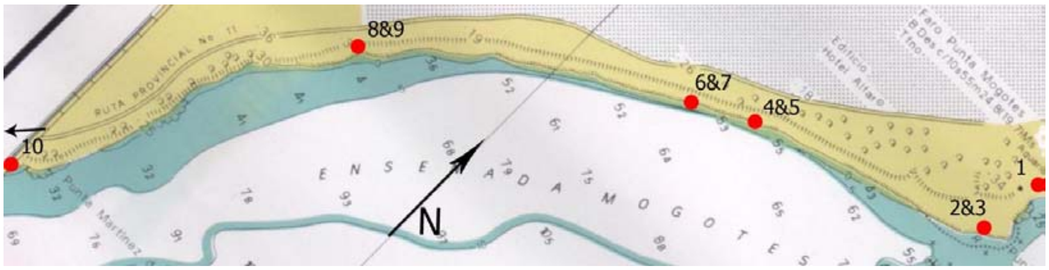

Figure VIII. 1 Locations of sediment samples

The sieve results of the samples are put below. The sieve results show the following D_{50} for the different locations

Table VIII. 1 Sediment size

Nr.	D50 (μm)
1	189
2	379
3	812
4	707
5	1866
6	871
7	268
8	287
9	203
10	5278

These data give different results for the different locations. The small D_{50} from location 1 is probably due to the fact that the breaking on the reef stops all big particles and only the small particles are able to move further north. The sorting of the grain size in this area is therefore very small, so only small particles are present.

The large particles on location 2 and 3 are mainly of organic material. These are shells which grow on the reef are put ashore by the currents. The backshore particles are smaller because of the transport by wind of small particles from foreshore to the backshore. In these samples a broad spectrum of different sizes are present as can be seen from the graphs although the sorting of sample 2 is smaller.

The bigger particles from location 4 and 5 are retrieved from the start of the salient. In this part the bigger parts start to get out of suspension and the smaller particles end up further north although the samples have a large sorting so also some smaller particles are present. Also some organic material was found in these samples.

The results from location 6 and 7 are hard to explain and the particles on the backshore are coarser than the particles on the foreshore which is not usual. It could be that this is an eroding part of the coast which was at the time of taking the samples was accreting with sand from the south part of the beach. Later visual research of this part of the beach show coarser particles although no elaborate measurements were done and are not present in this appendix.

In the southern part of the beach (nrs. 8 en 9) only fine sand particles are found. These sand particles were dunes since placed there by the wind since it was part of the backshore a few decades ago and now eroding. This can also be seen from the small sorting of the grain size in these samples. These seem very representative samples for the sand of the beach because hardly any organic material was found in these samples. These results also are similar to results of previous measurements of sand of the coast of Mar del Plata. For the calculations done in different models a D_{50} of 250 μm and a D_{90} of 330 μm will be used.

The sample taken about 4 kilometres south of Los Acantilados (nr. 10) was taken just on the accreting side of a large groyne. The extra turbulence caused by the refracting and breaking waves near the groyne probably cause the heavier and larger and small particles to get on the beach. This is also shown in the large sorting of the sizes of the particles in sample 10. In this sample hardly any organic material was found.

Table VIII. 2 Sediment analyse sample 1

ANALISIS GRANULOMETRICO							
MUESTRA:	1						
FECHA:	Oct.04						
PESO INICIAL:		80,7690					
TAMIZADO							

PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,0000	0,0000	0,0000	0,0000	0,0000
-1.5	2,83	7	0,0000	0,0000	0,0000	0,0000	0,0000
-1	2	10	0,0000	0,0000	0,0000	0,0000	0,0000
-0.5	1,41	14	0,0000	0,0000	0,0000	0,0000	0,0000
0	1	18	0,0000	0,0000	0,0000	0,0000	0,0000
0.5	0,71	25	0,0000	0,0000	0,0000	0,0000	0,0000
1	0,5	35	0,0210	0,0260	0,0260	0,0260	0,0260
1.5	0,35	45	1,0400	1,2900	1,3160	1,2900	1,3160
2	0,25	60	11,2930	14,0072	15,3232	14,0072	15,3232
2.5	0,177	80	42,4610	52,6661	67,9893	52,6661	67,9893
3	0,125	120	24,9250	30,9155	98,9048	30,9155	98,9048
3.5	0,088	170	0,8680	1,0766	99,9814	1,0766	99,9814
4	0,062	230	0,0120	0,0149	99,9963	0,0149	99,9963
FONDO			0,0030	0,0037	100,0000	0,0037	100,0000
Cantidad recuperada:			80,623				
	Error:		0,146				

%	en Phi	en mm
1	1,5	0,354
5	1,8	0,287
16	2	0,250
25	2,1	0,233
50	2,4	0,189
75	2,5	0,177
84	2,6	0,165
95	2,8	0,144

	Parámetros estadísticos			
MEDIANA	(Median) =	2,400	Phi =	0,189 mm
MEDIA	(Mean) =	2,333	Phi =	0,198 mm
DSTD	(Sorting) =	0,302	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Muy Buena		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	-0,267	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Negativa		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,025	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Mesocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 3 Sediment analyse sample 2

ANALISIS GRANULOMETRICO							
MUESTRA:	2						
FECHA:	Oct.04						
PESO INICIAL:		80,7750					
TAMIZADO							
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,0000	0,0000	0,0000	0,0000	0,0000
-1.5	2,83	7	0,0000	0,0000	0,0000	0,0000	0,0000
-1	2	10	0,0000	0,0000	0,0000	0,0000	0,0000
-0.5	1,41	14	0,3540	0,4386	0,4386	0,4386	0,4386
0	1	18	3,5160	4,3563	4,7949	4,3563	4,7949
0.5	0,71	25	12,6540	15,6784	20,4733	15,6784	20,4733
1	0,5	35	15,1920	18,8229	39,2962	18,8229	39,2962
1.5	0,35	45	14,2530	17,6595	56,9558	17,6595	56,9558
2	0,25	60	10,7480	13,3168	70,2726	13,3168	70,2726
2.5	0,177	80	13,4750	16,6956	86,9682	16,6956	86,9682
3	0,125	120	9,2450	11,4546	98,4227	11,4546	98,4227
3.5	0,088	170	1,2010	1,4880	99,9108	1,4880	99,9108
4	0,062	230	0,0500	0,0620	99,9727	0,0620	99,9727
FONDO			0,0220	0,0273	100,0000	0,0273	100,0000
Cantidad recuperada:			80,71				
	Error:		0,065				

%	en Phi	en mm
1	-0,3	1,231
5	0	1,000
16	0,4	0,758
25	0,7	0,616
50	1,4	0,379
75	2,2	0,218
84	2,5	0,177
95	2,7	0,154

	Parámetros estadísticos			
MEDIANA	(Median) =	1,400	Phi =	0,379 mm
MEDIA	(Mean) =	1,433	Phi =	0,370 mm
DSTD	(Sorting) =	0,934	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Moderada		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	0,005	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Casi simétrica		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	0,738	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Platicúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 4 Sediment analyse sample 3

ANALISIS GRANULOMETRICO								
MUESTRA:	3							
FECHA:	Oct.04							
PESO INICIAL:		81,7900						
TAMIZADO								
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.	
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000	
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000	
-2	4	5	3,8600	4,7240	4,7240	4,7240	4,7240	
-1.5	2,83	7	2,9760	3,6421	8,3661	3,6421	8,3661	
-1	2	10	4,0240	4,9247	13,2907	4,9247	13,2907	
-0.5	1,41	14	5,2300	6,4006	19,6914	6,4006	19,6914	
0	1	18	12,9590	15,8596	35,5509	15,8596	35,5509	
0.5	0,71	25	14,9840	18,3378	53,8887	18,3378	53,8887	
1	0,5	35	9,6090	11,7597	65,6484	11,7597	65,6484	
1.5	0,35	45	7,4940	9,1713	74,8198	9,1713	74,8198	
2	0,25	60	7,0970	8,6855	83,5053	8,6855	83,5053	
2.5	0,177	80	9,5120	11,6410	95,1463	11,6410	95,1463	
3	0,125	120	3,8010	4,6518	99,7981	4,6518	99,7981	
3.5	0,088	170	0,1520	0,1860	99,9841	0,1860	99,9841	
4	0,062	230	0,0070	0,0086	99,9927	0,0086	99,9927	
FONDO			0,0060	0,0073	100,0000	0,0073	100,0000	
Cantidad recuperada:			81,711					
	Error:		0,079					

%	en Phi	en mm
1	-2,3	4,925
5	-2	4,000
16	-0,7	1,625
25	-0,3	1,231
50	0,3	0,812
75	1,1	0,467
84	2	0,250
95	2,5	0,177

	Parámetros estadísticos			
MEDIANA	(Median) =	0,300	Phi =	0,812 mm
MEDIA	(Mean) =	0,533	Phi =	0,691 mm
DSTD	(Sorting) =	1,357	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Pobre		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	0,119	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Positiva		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,317	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Leptocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 5 Sediment analyse sample 4

ANALISIS GRANULOMETRICO								
MUESTRA:	4							
FECHA:	Oct.04							
PESO INICIAL:		82,2470						
TAMIZADO								
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.	
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000	
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000	
-2	4	5	3,0280	3,6919	3,6919	3,6919	3,6919	
-1.5	2,83	7	1,4800	1,8045	5,4964	1,8045	5,4964	
-1	2	10	3,5890	4,3759	9,8722	4,3759	9,8722	
-0.5	1,41	14	3,2770	3,9955	13,8677	3,9955	13,8677	
0	1	18	10,5780	12,8972	26,7649	12,8972	26,7649	
0.5	0,71	25	19,4730	23,7423	50,5072	23,7423	50,5072	
1	0,5	35	13,4970	16,4561	66,9633	16,4561	66,9633	
1.5	0,35	45	7,7200	9,4126	76,3759	9,4126	76,3759	
2	0,25	60	6,3010	7,6825	84,0584	7,6825	84,0584	
2.5	0,177	80	8,8890	10,8379	94,8962	10,8379	94,8962	
3	0,125	120	3,9540	4,8209	99,7171	4,8209	99,7171	
3.5	0,088	170	0,2270	0,2768	99,9939	0,2768	99,9939	
4	0,062	230	0,0050	0,0061	100,0000	0,0061	100,0000	
FONDO			0,0000	0,0000	100,0000	0,0000	100,0000	
Cantidad recuperada:			82,018					
	Error:		0,229					

%	en Phi	en mm
1	-2,3	4,925
5	-1,6	3,031
16	-0,4	1,320
25	-0,1	1,072
50	0,5	0,707
75	1,4	0,379
84	1,9	0,268
95	2,6	0,165

	Parámetros estadísticos				
MEDIANA	(Median) =	0,500	Phi =	0,707 mm	
MEDIA	(Mean) =	0,667	Phi =	0,630 mm	
DSTD	(Sorting) =	1,211	< 0,35	Muy buena selección	
			0,35 - 0,50	Buena selección	
Selección =	Pobre		0,50 - 1	Moderadamente seleccionada	
			1 - 2	Pobremente seleccionada	
			2 - 4	Muy pobremente seleccionada	
			> 4	Extremadamente mal seleccionada	
ASIMETRÍA	(Skeweness) =	0,109	-1 a -0.3	Muy Negativa	
			-0.3 a -0.1	Negativa	
Simetría =	Positiva		-0.1 a 0.1	Casi simétrica	
			0.1 a 0.3	Positiva	
			0.3 a 1	Muy Positiva	
CURTOSIS	(Kurtosis) =	1,148	< 0,65	Muy platicúrtica	
			0,65 - 0,9	Platicúrtica	
Agudeza o =	Leptocúrtica		0,9 - 1,11	Mesocúrtica	
Forma de la distribución			1,11 - 1,5	Leptocúrtica	
			1,5 - 3	Muy leptocúrtica	
			> 3	Extremadamente leptocúrtica	

Table VIII. 6 Sediment analyse sample 5

ANALISIS GRANULOMETRICO								
MUESTRA:	5							
FECHA:	Oct.04							
PESO INICIAL:		98,0730						
TAMIZADO								
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.	
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000	
-3	7,93	5/16	4,3650	4,4564	4,4564	4,4564	4,4564	
-2	4	5	6,6040	6,7422	11,1986	6,7422	11,1986	
-1.5	2,83	7	12,1790	12,4339	23,6325	12,4339	23,6325	
-1	2	10	25,2090	25,7366	49,3691	25,7366	49,3691	
-0.5	1,41	14	21,1810	21,6243	70,9934	21,6243	70,9934	
0	1	18	13,9040	14,1950	85,1884	14,1950	85,1884	
0.5	0,71	25	6,2220	6,3522	91,5406	6,3522	91,5406	
1	0,5	35	2,5950	2,6493	94,1899	2,6493	94,1899	
1.5	0,35	45	2,0680	2,1113	96,3012	2,1113	96,3012	
2	0,25	60	1,3200	1,3476	97,6488	1,3476	97,6488	
2.5	0,177	80	1,5140	1,5457	99,1945	1,5457	99,1945	
3	0,125	120	0,7470	0,7626	99,9571	0,7626	99,9571	
3.5	0,088	170	0,0410	0,0419	99,9990	0,0419	99,9990	
4	0,062	230	0,0010	0,0010	100,0000	0,0010	100,0000	
FONDO			0,0000	0,0000	100,0000	0,0000	100,0000	
Cantidad recuperada:			97,95					
	Error:		0,123					

%	en Phi	en mm
1	-3,3	9,849
5	-2,8	6,964
16	-1,7	3,249
25	-1,5	2,828
50	-0,9	1,866
75	-0,3	1,231
84	0	1,000
95	1,1	0,467

	Parámetros estadísticos			
MEDIANA	(Median) =	-0,900	Phi =	1,866 mm
MEDIA	(Mean) =	-0,867	Phi =	1,823 mm
DSTD	(Sorting) =	1,016	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Pobre		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	0,042	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Casi simétrica		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,332	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Leptocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 7 Sediment analyse sample 6

ANALISIS GRANULOMETRICO							
MUESTRA:	6						
FECHA:	Oct.04						
PESO INICIAL:		89,8930					
TAMIZADO							
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,4770	0,5307	0,5307	0,5307	0,5307
-1.5	2,83	7	1,4810	1,6477	2,1784	1,6477	2,1784
-1	2	10	4,8000	5,3403	7,5187	5,3403	7,5187
-0.5	1,41	14	10,1910	11,3381	18,8567	11,3381	18,8567
0	1	18	20,9070	23,2602	42,1170	23,2602	42,1170
0.5	0,71	25	16,7440	18,6287	60,7456	18,6287	60,7456
1	0,5	35	9,1370	10,1654	70,9111	10,1654	70,9111
1.5	0,35	45	8,2850	9,2175	80,1286	9,2175	80,1286
2	0,25	60	6,8720	7,6455	87,7741	7,6455	87,7741
2.5	0,177	80	7,3660	8,1951	95,9692	8,1951	95,9692
3	0,125	120	3,3770	3,7571	99,7263	3,7571	99,7263
3.5	0,088	170	0,2360	0,2626	99,9889	0,2626	99,9889
4	0,062	230	0,0040	0,0045	99,9933	0,0045	99,9933
FONDO			0,0060	0,0067	100,0000	0,0067	100,0000
Cantidad recuperada:			89,883				
	Error:		0,01				

%	en Phi	en mm
1	-1,8	3,482
5	-1,2	2,297
16	-0,6	1,516
25	-0,4	1,320
50	0,2	0,871
75	1,2	0,435
84	1,8	0,287
95	2,5	0,177

	Parámetros estadísticos			
MEDIANA	(Median) =	0,200	Phi =	0,871 mm
MEDIA	(Mean) =	0,467	Phi =	0,724 mm
DSTD	(Sorting) =	1,161	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Pobre		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	0,288	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Positiva		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	0,948	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Mesocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 8 Sediment analyse sample 7

ANALISIS GRANULOMETRICO							
MUESTRA:	7						
FECHA:	Oct.04						
PESO INICIAL:		81,7950					
TAMIZADO							
PHI	**MM**	**ASTM**	**PESO MUESTRA**	**%P**	**%ACUM**	**Frecuencia**	**% Acumul.**
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,0000	0,0000	0,0000	0,0000	0,0000
-1.5	2,83	7	0,0000	0,0000	0,0000	0,0000	0,0000
-1	2	10	0,0000	0,0000	0,0000	0,0000	0,0000
-0.5	1,41	14	1,8520	2,2659	2,2659	2,2659	2,2659
0	1	18	2,3520	2,8776	5,1435	2,8776	5,1435
0.5	0,71	25	3,3980	4,1574	9,3009	4,1574	9,3009
1	0,5	35	4,9430	6,0477	15,3486	6,0477	15,3486
1.5	0,35	45	13,6410	16,6895	32,0381	16,6895	32,0381
2	0,25	60	18,3980	22,5096	54,5477	22,5096	54,5477
2.5	0,177	80	26,1860	32,0381	86,5858	32,0381	86,5858
3	0,125	120	9,9040	12,1174	98,7031	12,1174	98,7031
3.5	0,088	170	1,0430	1,2761	99,9792	1,2761	99,9792
4	0,062	230	0,0160	0,0196	99,9988	0,0196	99,9988
FONDO			0,0010	0,0012	100,0000	0,0012	100,0000
Cantidad recuperada:			81,734				
	Error:		0,061				

%	en Phi	en mm
1	-0,4	1,320
5	0	1,000
16	1	0,500
25	1,3	0,406
50	1,9	0,268
75	2,3	0,203
84	2,5	0,177
95	2,7	0,154

	Parámetros estadísticos			
MEDIANA	(Median) =	1,900	Phi =	0,268 mm
MEDIA	(Mean) =	1,800	Phi =	0,287 mm
DSTD	(Sorting) =	0,784	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Moderada		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	-0,304	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Muy Negativa		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,107	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Mesocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

Table VIII. 9 Sediment analyse sample 8

ANALISIS GRANULOMETRICO							
MUESTRA:	8						
FECHA:	Oct.04						
PESO INICIAL:		81,7950					
TAMIZADO							
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,0000	0,0000	0,0000	0,0000	0,0000
-1.5	2,83	7	0,0000	0,0000	0,0000	0,0000	0,0000
-1	2	10	0,0000	0,0000	0,0000	0,0000	0,0000
-0.5	1,41	14	0,0000	0,0000	0,0000	0,0000	0,0000
0	1	18	0,0230	0,0278	0,0278	0,0278	0,0278
0.5	0,71	25	0,1150	0,1392	0,1671	0,1392	0,1671
1	0,5	35	1,3770	1,6672	1,8343	1,6672	1,8343
1.5	0,35	45	21,8220	26,4214	28,2558	26,4214	28,2558
2	0,25	60	30,9600	37,4855	65,7412	37,4855	65,7412
2.5	0,177	80	22,1890	26,8658	92,6070	26,8658	92,6070
3	0,125	120	5,8750	7,1133	99,7203	7,1133	99,7203
3.5	0,088	170	0,2220	0,2688	99,9891	0,2688	99,9891
4	0,062	230	0,0070	0,0085	99,9976	0,0085	99,9976
FONDO			0,0020	0,0024	100,0000	0,0024	100,0000
Cantidad recuperada:			82,592				
	Error:		-0,797				

%	en Phi	en mm
1	0,9	0,536
5	1,2	0,435
16	1,4	0,379
25	1,5	0,354
50	1,8	0,287
75	2,1	0,233
84	2,4	0,189
95	2,6	0,165

Parámetros estadísticos					
MEDIANA	(Median) =	1,800	Phi =	0,287	mm
MEDIA	(Mean) =	1,867	Phi =	0,274	mm
DSTD	(Sorting) =	0,462	< 0,35	Muy buena selección	
			0,35 - 0,50	Buena selección	
Selección =	Buena		0,50 - 1	Moderadamente seleccionada	
			1 - 2	Pobremente seleccionada	
			2 - 4	Muy pobremente seleccionada	
			> 4	Extremadamente mal seleccionada	
ASIMETRÍA	(Skeweness) =	0,171	-1 a -0.3	Muy Negativa	
			-0.3 a -0.1	Negativa	
Simetría =	Positiva		-0.1 a 0.1	Casi simétrica	
			0.1 a 0.3	Positiva	
			0.3 a 1	Muy Positiva	
CURTOSIS	(Kurtosis) =	0,956	< 0,65	Muy platicúrtica	
			0,65 - 0,9	Platicúrtica	
Agudeza o =	Mesocúrtica		0,9 - 1,11	Mesocúrtica	
Forma de la distribución			1,11 - 1,5	Leptocúrtica	
			1,5 - 3	Muy leptocúrtica	
			> 3	Extremadamente leptocúrtica	

Table VIII. 10 Sediment analyse sample 9

ANALISIS GRANULOMETRICO							
MUESTRA:	9						
FECHA:	Oct.04						
PESO INICIAL:		84,5840					
TAMIZADO							
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	0,0000	0,0000	0,0000	0,0000	0,0000
-3	7,93	5/16	0,0000	0,0000	0,0000	0,0000	0,0000
-2	4	5	0,0000	0,0000	0,0000	0,0000	0,0000
-1.5	2,83	7	0,0000	0,0000	0,0000	0,0000	0,0000
-1	2	10	0,0000	0,0000	0,0000	0,0000	0,0000
-0.5	1,41	14	0,0000	0,0000	0,0000	0,0000	0,0000
0	1	18	0,0000	0,0000	0,0000	0,0000	0,0000
0.5	0,71	25	0,0000	0,0000	0,0000	0,0000	0,0000
1	0,5	35	0,7870	0,9310	0,9310	0,9310	0,9310
1.5	0,35	45	5,4460	6,4421	7,3731	6,4421	7,3731
2	0,25	60	13,4840	15,9504	23,3235	15,9504	23,3235
2.5	0,177	80	36,2130	42,8369	66,1604	42,8369	66,1604
3	0,125	120	27,3590	32,3633	98,5237	32,3633	98,5237
3.5	0,088	170	1,2090	1,4301	99,9539	1,4301	99,9539
4	0,062	230	0,0370	0,0438	99,9976	0,0438	99,9976
FONDO			0,0020	0,0024	100,0000	0,0024	100,0000
Cantidad recuperada:			84,537				
	Error:		0,047				

%	en Phi	en mm
1	1,1	0,467
5	1,4	0,379
16	1,8	0,287
25	2,05	0,241
50	2,3	0,203
75	2,5	0,177
84	2,8	0,144
95	3,1	0,117

	Parámetros estadísticos				
MEDIANA	(Median) =	2,300	Phi =	0,203 mm	
MEDIA	(Mean) =	2,300	Phi =	0,203 mm	
DSTD	(Sorting) =	0,508		< 0,35	Muy buena selección
				0,35 - 0,50	Buena selección
Selección =	Moderada			0,50 - 1	Moderadamente seleccionada
				1 - 2	Pobremente seleccionada
				2 - 4	Muy pobremente seleccionada
				> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	-0,029		-1 a -0.3	Muy Negativa
				-0.3 a -0.1	Negativa
Simetría =	Casi simétrica			-0.1 a 0.1	Casi simétrica
				0.1 a 0.3	Positiva
				0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,548		< 0,65	Muy platicúrtica
				0,65 - 0,9	Platicúrtica
Agudeza o =	Muy Leptocúrtica			0,9 - 1,11	Mesocúrtica
Forma de la distribución				1,11 - 1,5	Leptocúrtica
				1,5 - 3	Muy leptocúrtica
				> 3	Extremadamente leptocúrtica

Table VIII. 11 Sediment analyse sample 10

ANALISIS GRANULOMETRICO							
MUESTRA:	10						
FECHA:	Oct.04						
PESO INICIAL:		126,825					
TAMIZADO							
PHI	MM	ASTM	PESO MUESTRA	%P	%ACUM	Frecuencia	% Acumul.
-4	15,9	3/5	7,0580	5,5706	5,5706	5,5706	5,5706
-3	7,93	5/16	40,0870	31,6393	37,2099	31,6393	37,2099
-2	4	5	41,1760	32,4988	69,7088	32,4988	69,7088
-1.5	2,83	7	5,0100	3,9542	73,6630	3,9542	73,6630
-1	2	10	2,9540	2,3315	75,9945	2,3315	75,9945
-0.5	1,41	14	2,4110	1,9029	77,8974	1,9029	77,8974
0	1	18	3,0160	2,3804	80,2778	2,3804	80,2778
0.5	0,71	25	2,3160	1,8279	82,1058	1,8279	82,1058
1	0,5	35	1,8880	1,4901	83,5959	1,4901	83,5959
1.5	0,35	45	3,1980	2,5241	86,1200	2,5241	86,1200
2	0,25	60	4,2720	3,3717	89,4917	3,3717	89,4917
2.5	0,177	80	9,0590	7,1500	96,6417	7,1500	96,6417
3	0,125	120	4,1070	3,2415	99,8832	3,2415	99,8832
3.5	0,088	170	0,1280	0,1010	99,9842	0,1010	99,9842
4	0,062	230	0,0100	0,0079	99,9921	0,0079	99,9921
FONDO			0,0100	0,0079	100,0000	0,0079	100,0000
Cantidad recuperada:			126,7				
	Error:		0,125				

%	en Phi	en mm
1	-4,3	19,698
5	-4	16,000
16	-3	8,000
25	-3,3	9,849
50	-2,4	5,278
75	-1	2,000
84	1	0,500
95	2,4	0,189

	Parámetros estadísticos			
MEDIANA	(Median) =	-2,400	Phi =	5,278 mm
MEDIA	(Mean) =	-1,467	Phi =	2,764 mm
DSTD	(Sorting) =	1,970	< 0,35	Muy buena selección
			0,35 - 0,50	Buena selección
Selección =	Pobre		0,50 - 1	Moderadamente seleccionada
			1 - 2	Pobremente seleccionada
			2 - 4	Muy pobremente seleccionada
			> 4	Extremadamente mal seleccionada
ASIMETRÍA	(Skeweness) =	0,600	-1 a -0.3	Muy Negativa
			-0.3 a -0.1	Negativa
Simetría =	Muy Positiva		-0.1 a 0.1	Casi simétrica
			0.1 a 0.3	Positiva
			0.3 a 1	Muy Positiva
CURTOSIS	(Kurtosis) =	1,140	< 0,65	Muy platicúrtica
			0,65 - 0,9	Platicúrtica
Agudeza o =	Leptocúrtica		0,9 - 1,11	Mesocúrtica
Forma de la distribución			1,11 - 1,5	Leptocúrtica
			1,5 - 3	Muy leptocúrtica
			> 3	Extremadamente leptocúrtica

%psefitas:	0,00	MUESTRA 1 ARENA DEL TIPO:				
%psamitas	100,00	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	0,00	0,03	15,30	83,58	1,09
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
2,4	2,33	0,30	-0,27	1,02		
=		Muy Buena	Negativa	Mesocúrtica		

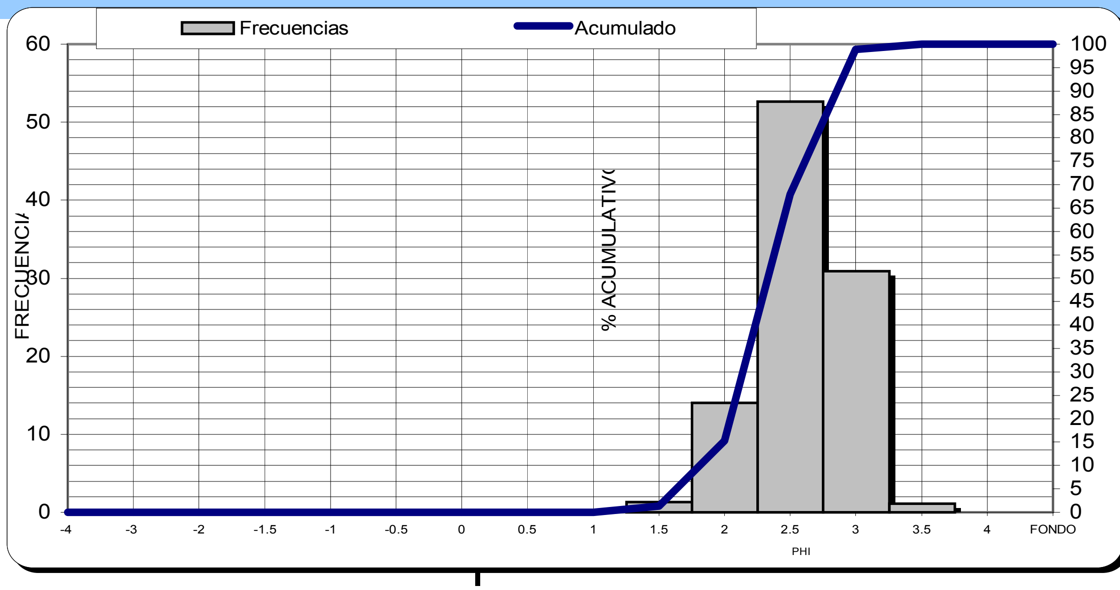

Figure VIII. 2 Sediment size sample 1

%psefitas:	0,00	MUESTRA 2 ARENA DEL TIPO:				
%psamitas	99,97	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,03	4,79	34,50	30,98	28,15	1,55
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
1,4	1,43	0,93	0,01	0,74		
=		Moderada	Casi simétric	Platicúrtica		

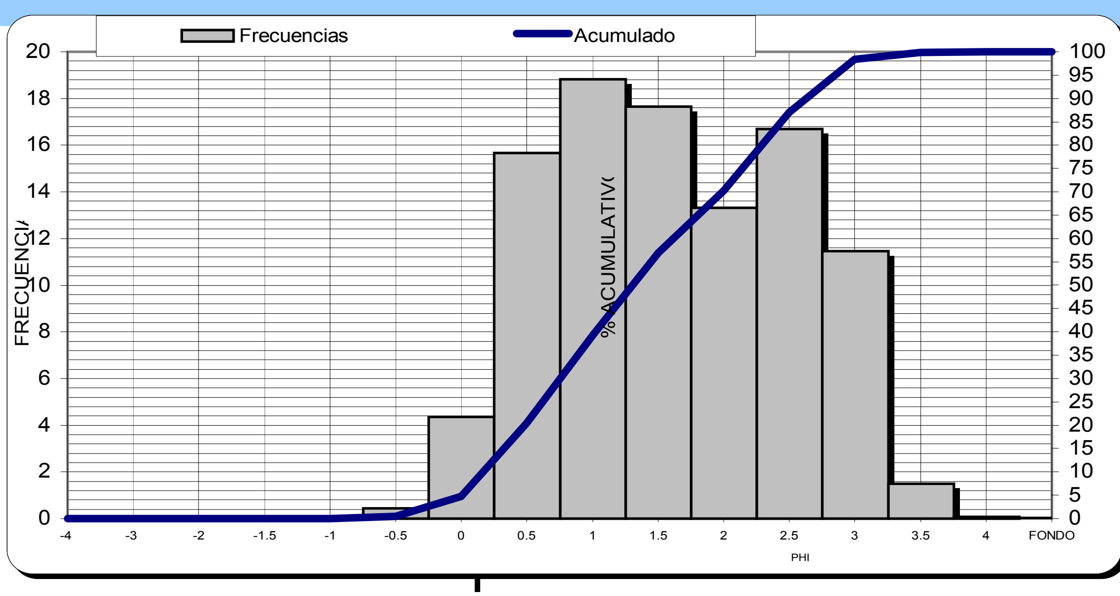

Figure VIII. 3 Sediment size sample 2

%psefitas:	8,37	MUESTRA 3 ARENA DEL TIPO:				
%psamitas	91,63	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,01	27,18	30,10	17,86	16,29	0,19
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
0,3	0,53	1,36	0,12	1,32		
=		Pobre	Positiva	Leptocúrtica		

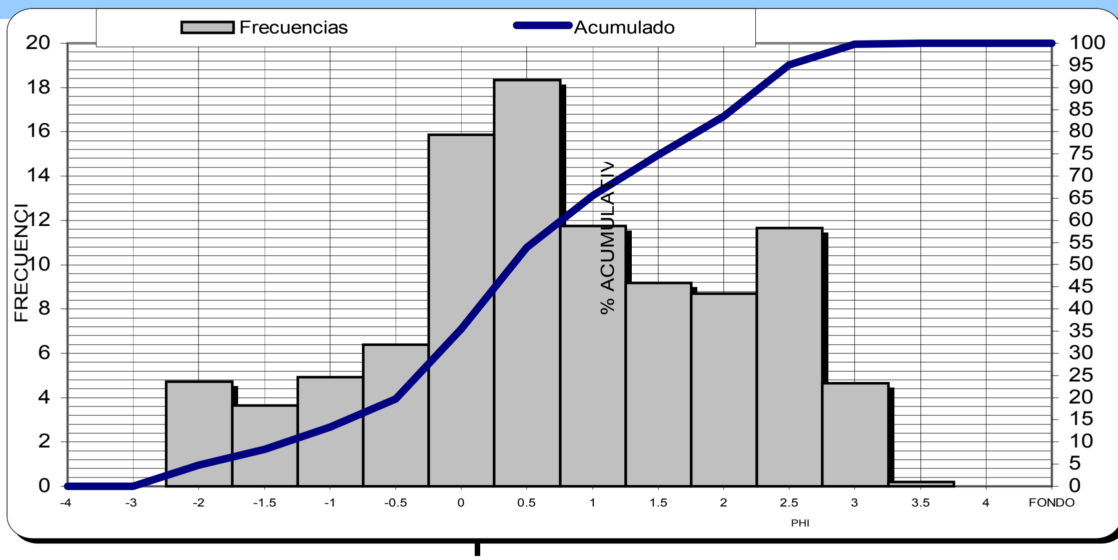

Figure VIII. 4 Sediment size sample 3

%psefitas:	5,50	MUESTRA 4 ARENA DEL TIPO:				
%psamitas	94,50	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	21,27	40,20	17,10	15,66	0,28
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
0,5	0,67	1,21	0,11	1,15		
=		Pobre	Positiva	Leptocúrtica		

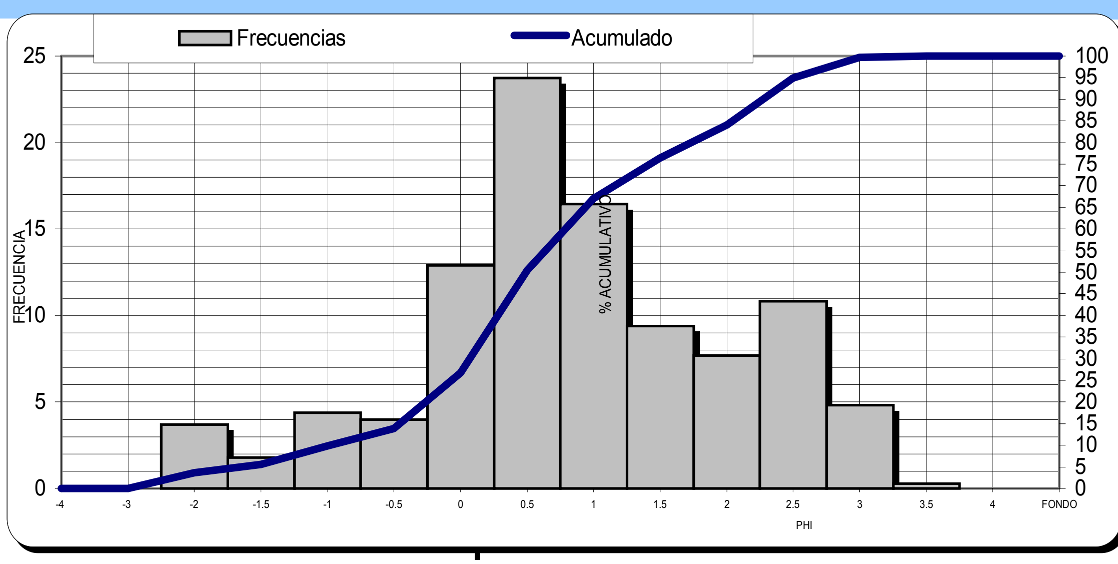

Figure VIII. 5 Sediment size sample 4

%psefitas:	23,63	MUESTRA 5 ARENA DEL TIPO:				
%psamitas	76,37	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	61,56	9,00	3,46	2,31	0,04
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
-0,9	-0,87	1,02	0,04	1,33		
=		Pobre	Casi simétrica	Leptocúrtica		

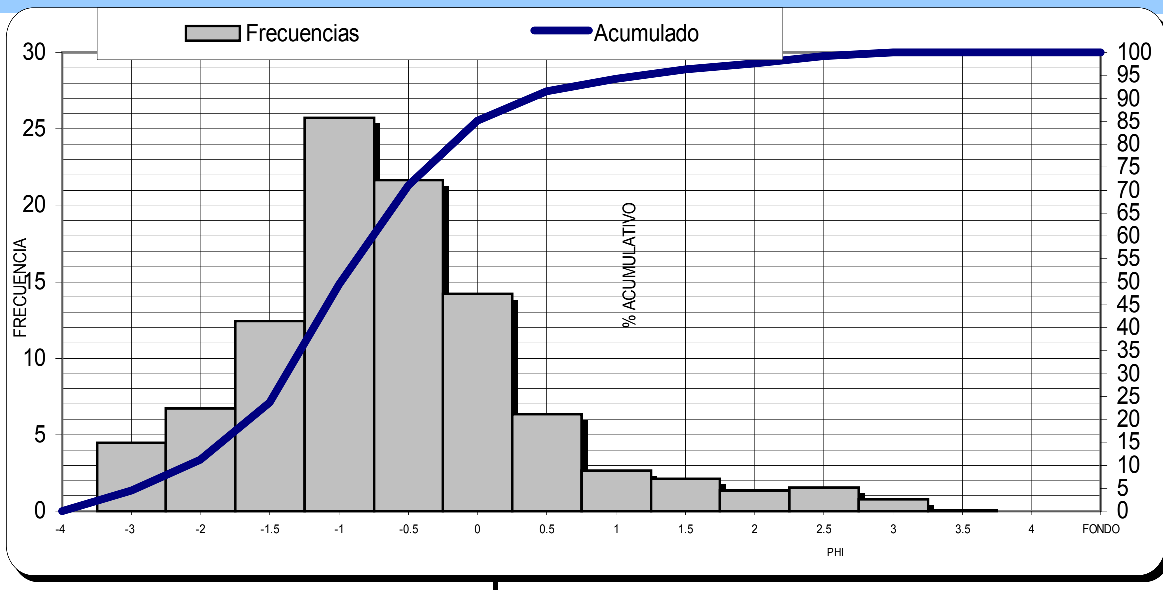

Figure VIII. 6 Sediment size sample 5

%psefitas:	2,18	MUESTRA 6 ARENA DEL TIPO:				
%psamitas	97,81	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,01	39,94	28,79	16,86	11,95	0,27
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
0,2	0,47	1,16	0,29	0,95		
=		Pobre	Positiva	Mesocúrtica		

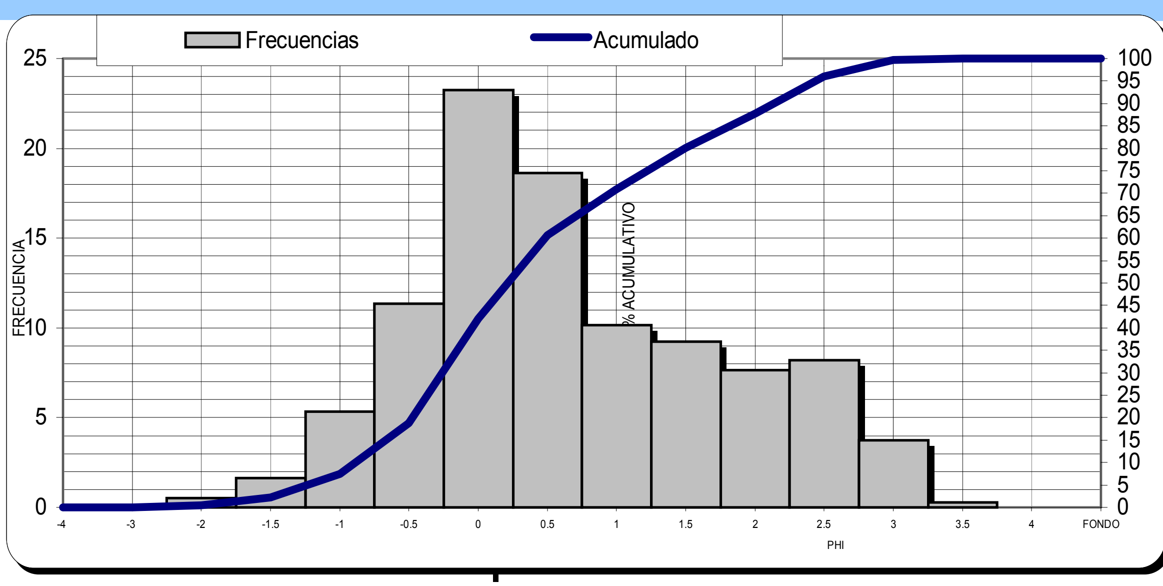

Figure VIII. 7 Sediment size sample 6

cc	0,00	**MUESTRA 7 ARENA DEL TIPO:**				
%psamitas	100,00	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	5,14	10,21	39,20	44,16	1,30
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
1,9	1,80	0,78	-0,30	1,11		
=		Moderada	Muy Negativa	Mesocúrtica		

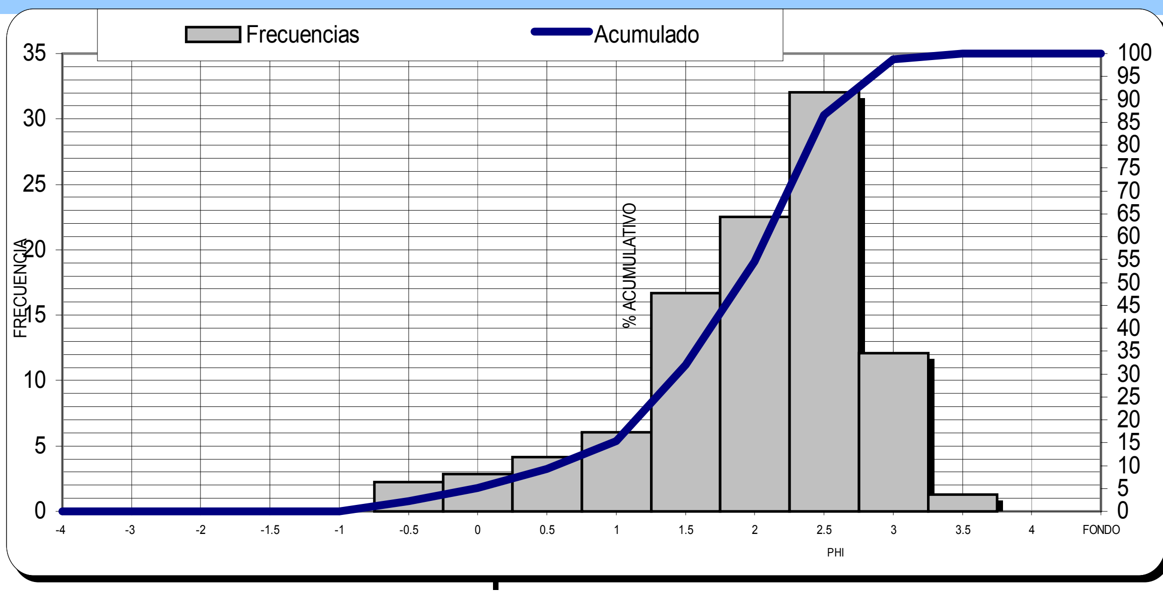

Figure VIII. 8 Sediment size sample 7

%psefitas:	0,00	**MUESTRA 8 ARENA DEL TIPO:**				
%psamitas	100,00	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	0,03	1,81	63,91	33,98	0,28
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
1,8	1,87	0,46	0,17	0,96		
=		Buena	Positiva	Mesocúrtica		

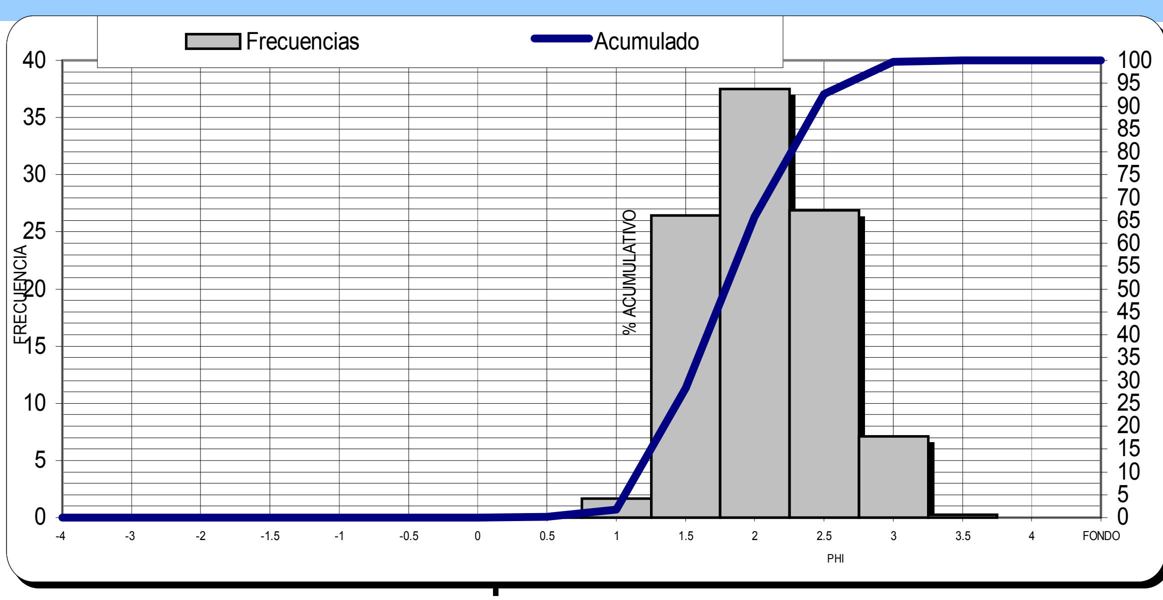

Figure VIII. 9 Sediment size sample 8

c	0,00	MUESTRA 9 ARENA DEL TIPO:				
%psamitas	100,00	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,00	0,00	0,93	22,39	75,20	1,47
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
2,3	2,30	0,51	-0,03	1,55		
=		Moderada	Casi simétrica	Muy Leptocúrtica		

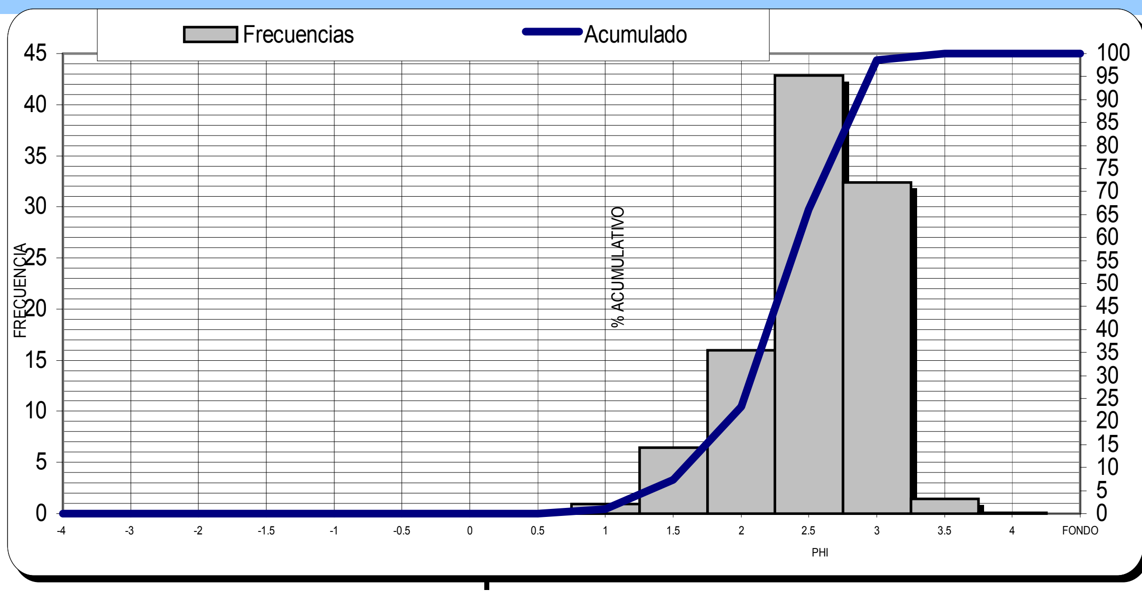

Figure VIII. 10 Sediment size sample 9

%psefitas:	73,66	MUESTRA 10 ARENA DEL TIPO:				
%psamitas	26,33	m.gruesa	gruesa	mediana	fina	m.fina
% pelitas	0,01	6,61	3,32	5,90	10,39	0,11
MEDIANA	MEDIA	DSTD	ASIMETRIA	KURTOSIS		
-2,4	-1,47	1,97	0,60	1,14		
=		Pobre	Muy Positiva	Leptocúrtica		

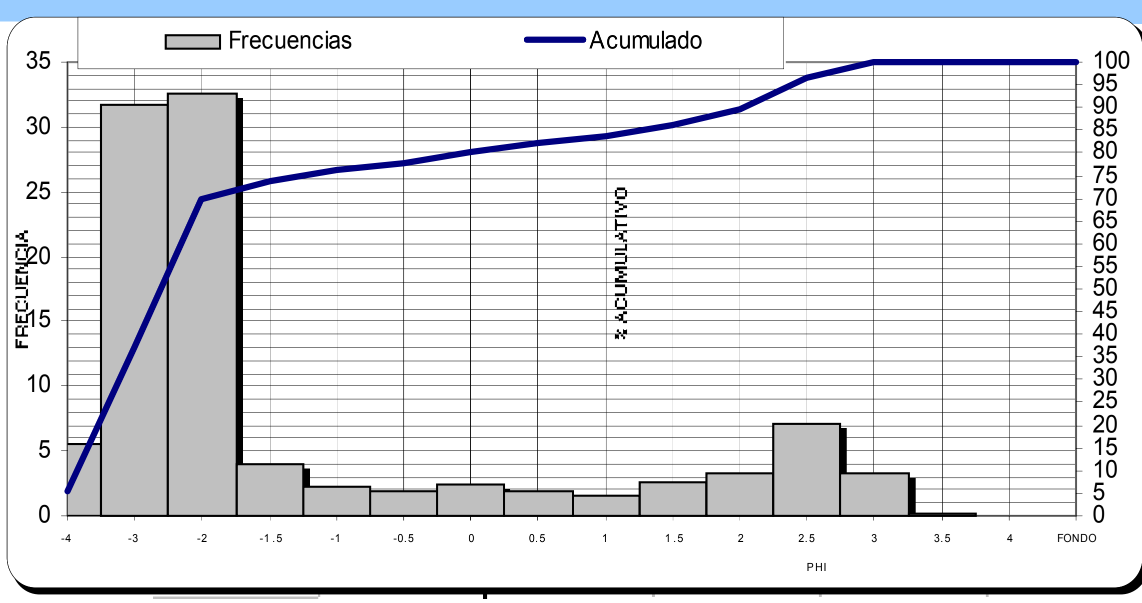

Figure VIII. 11 Sediment size sample 10

Appendix IX, Bathymetry

The different profiles are derived from the following sources: chart H-250 from the Argentina Navy[3], a local report on the beach profiles[4] and a site reconnaissance. Clearly visible from Figure IX.1 is the orientation of the research area, namely Southwest to Northeast and that it has a length of approximately 8100 m. Fifteen profiles are taken perpendicular to the coast and can be seen below.

Figure IX. 1 Rays

Two schematisations will be needed to solve two problems. One is an assumption for the overall slope for the Bijker formula, called m. The other is the shape of the beach and fore shore to make first calculations on the quantity of sand needed for beach nourishments possible, which will be called s.

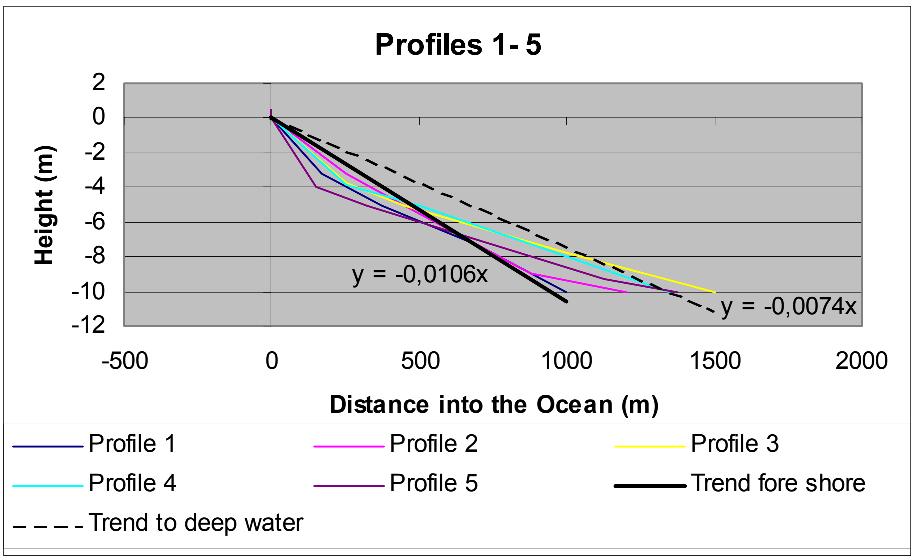

Figure IX. 2 Profiles 1-5 with m_1 = 0,007 and s_1 = 0,01

Figure IX. 3 Profiles 6-12 with m_2 = 0,006 , $s_{2\ \text{fore shore}\ 1}$ = 0,04 and $s_{2\ \text{fore shore}\ 2}$ = 0,003

(transition at 125 off shore)

[3] H-250, Rada Mar del Plata, Publicado por el Servicio de Hidrografia Naval - Armada Argentina – Buenos Aires 2003 Ultima correccion.
[4] Recuperacion de playas de intense extraccion de arena: ensenada de mogotes, Mar del Plata, Argentina, 1987-1990. 1992, M.O. Farenga, R. Adamini, F.I. Isla.

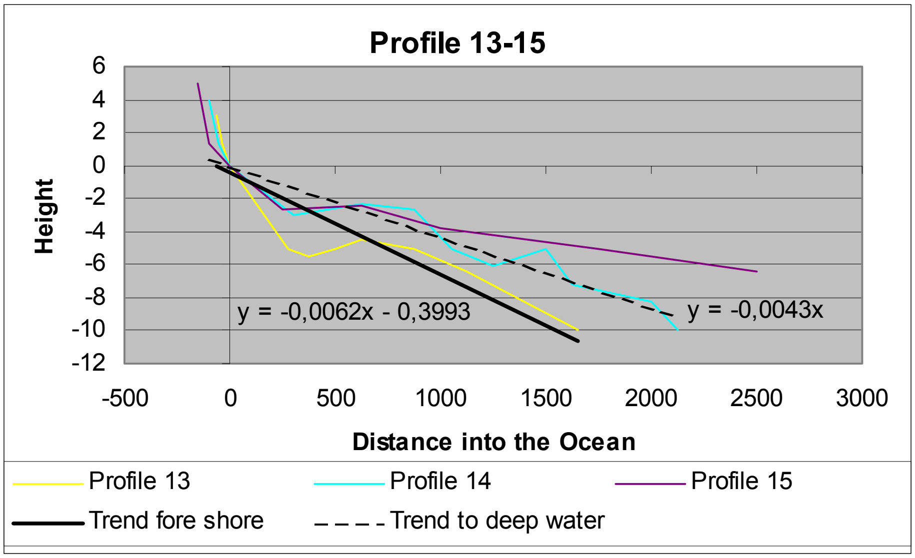

Figure IX. 4 **Profiles 13-15 with m_3 = 0,004 and s_3 = 0,006**

Appendix X, wind set-up

Since no values for storm surges and wind set-up near Mar del Plata could be found in literature the storm surge is calculated with the following formula:

$$dh_1 = 0.5\kappa \frac{u^2}{gh} F \cos\varphi$$

- u = wind velocity
- h = water depth
- F= Fetch length
- ϕ = approach angle to the coast (0= perpendicular)
- $k = 2 * 10^{-6}$

With this formula the wind set-up on deepwater and in the shallow zone is calculated all year and during a design storm.

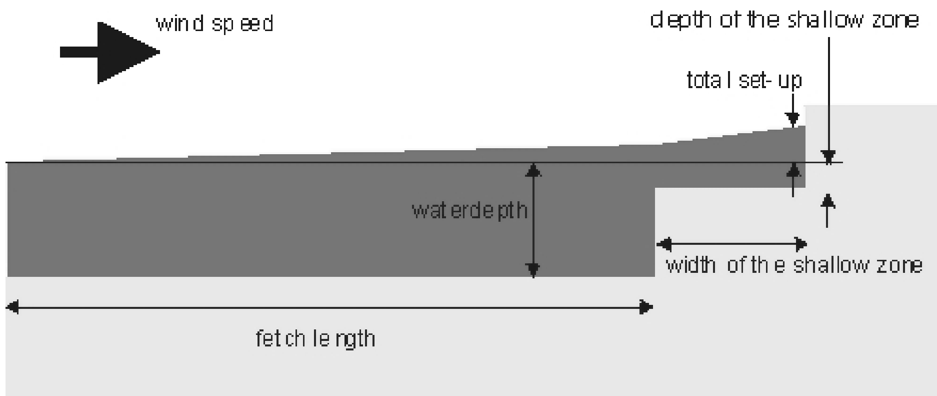

Figure X. 1 **Modelling of the coast**[5]

The sea in front of Mar del Plata is modelled as a straight coast with a deep part of 100 km, with a depth of 80 metres. The shallow part has a length of 40 km. and a depth of 40 metres. With the following wind climate:

Table X. 1 **Annual wind climate Mar del Plata**[6]

U (m/s) Lower		Upper	Ud (Deg) -22,5 to 22,5	22,5 to 67,5	67,5 to 112,5	112,5 to 157,5	157,5 to 202,5	202,5 to 247,5	247,5 to 292,5	292,5 to 337,5	Total
,0	0,25	,5	1,76	,	,03	,	,	,03	,	,	1,83
,5	1,13	1,8	1,40	1,49	,88	,58	,94	,33	,79	,37	6,78
1,8	2,55	3,3	3,01	2,56	1,52	1,19	2,74	1,67	1,67	1,40	15,76
3,3	4,30	5,3	5,14	4,32	2,92	2,49	3,71	3,07	2,74	2,16	26,56
5,3	6,85	8,4	4,59	4,26	1,98	1,98	3,65	3,10	2,43	2,53	24,52
8,4	9,80	11,1	2,49	1,89	,79	,70	2,92	2,13	1,31	1,19	13,42
11,1	12,65	14,1	,94	,85	,27	,24	1,86	1,43	,79	,40	6,78
14,1	15,57	17,0	,40	,21	,12	,21	,85	,61	,21	,09	2,71
17,0	19,00	21,0	,06	,03	,	,09	,33	,33	,15	,09	1,10
21,0	22,75	24,5	,	,	,	,	,12	,03	,09	,	,24
24,5	26,50	28,5	,03	,	,	,03	,03	,	,	,	,09
28,5	30,75	33,0	,06	,	,	,	,	,	,	,	,06
33,0	16,50	>	,06	,	,03	,	,	,	,03	,03	,15
Total			19,96	15,61	8,55	7,51	17,16	12,75	10,22	8,24	100,00
		u avg	5,54	5,71	5,22	5,82	7,24	7,42	6,38	6,17	6,23

[5] From kennisbank waterbouw: http://www.kennisbank-waterbouw.nl/CressHelp/A1.1/Z1.htm
[6] From Alkyon hydrobase www.hydrobase.net

The wind set-up calculated with the average wind speed per direction is never more than 1 centimetre and so the wind set-up during the calculation of the sediment transport will be modelled as zero.

For the design storm it is hard to rely on ship observations because ships avoid navigating through severe storms and so the design storm is modelled with a direction perpendicular to the coast and a wind speed of 40 metres per second. With these values a set-up on the deep part of 23 centimetres and on the shallow part the set-up is 20 centimetres. So the total wind set-up during a storm surge is 43 centimetres.

Appendix XI, Wave set-up

The wave set-up can be calculated with help of the short wave theory. With some algebra and assumptions the total wave set-up can be described by[7]:

$$\eta_{tot} = \frac{3}{8}\gamma^2 h_{br}$$

In which:

η_{tot}	=	Total wave set-up	(m)
γ	=	Breaker index	(-)
h_{br}	=	Depth at the breaker line	(m)

For the calculations different parameters where used as can be seen below, followed by the results:

Table XI. 2 **Wave set-up for different parameters**

	Most important wave climate H_s = 1,5 m.	Strom conditions H_{ss} = 5,1 m.
h_{br}	1,5 m	5,1 m
γ	0,8	0,8
η_{tot}	0,5 m	1,4 m

[7] Korte Golven, Prof. dr. Ir. J.A. Battjes, septmber 2001, Tudelft, page 8.6-8.15

Appendix XII, UNIBEST

For the calculations on the sediment transport of Los Acantilados UNIBEST CL+ vs 5.11 is used. UNIBEST consist of two modules, UNIBEST LT (Long shore Transport) and UNIBEST CL (Coastline development). The UNIBEST LT module calculate long shore transport a result of wave and currents. With the CL module coastline development scenarios can be run with the output of UNIBEST LT.

The main targets of the calculations with UNIBEST are to:
- Compare and validate hand calculations done for Ray 8
- Estimate the capacity of the long shore sediment transport
- Produce a global sediment transport capacity curve of the area
- Produce a sediment transport capacity curve of the area for the different wave directions

Los Acantilados Model

The construction of the model of Los Acantilados is done for the upstream and downstream boundary conditions as outlined the section XX. For the coastline real world coordinates points are used every few hundred meters. These point form the coastline. The model boundary at sea is included in the bottom profiles. With these four boundaries the model is geometrically determined.

Section and Rays

The stretch of Los Acantilados is divided in 15 sections. These sections are defined as 'rays'. For these rays a data on the bottom profile, coastal angle have been determined. These data combined with a wave climate, a storm surge, tide, wave and transport parameters, UNIBEST LT calculates for each ray a long shore transport capacity.

Figure XX Overview

Figure XII. 1 Rays

Assumptions and setting of the input parameters

Rays
The 15 rays are chosen from South West to North East with mutual distances depending on the curvature of the coast. The South East is numbered 1 and the last North East ray is numbered 15.

Ray angles
The angles are defined perpendicular to the coast in the world's protractor.

Bottom profiles
The bottom profiles are obtained from Map H-250 see appendix XX h 250 and measurements presented by F.I. Isla, 1991[8].
For the current situation calculation for each ray a different bottom profile is used. As for the nourished situation the bottom profiles are grouped. And for ray 1 to 5 and for ray 6 to 11 two profiles are used. For ray 12 to 15 the original bottom profiles were used.

Wave climate
Two types of wave climates have been used, as outlined in the section XX and explained in appendix XX. One elaborated monthly climate and a simplified climate to compare the UNIBEST calculation with the calculation done by hand.

Tide
For the tide the data is used a described in the section XX. The mean tidal amplitude is 0.78 cm with an average current velocity of XX

Storm Surge
Wind setup calculations have been made in appendix XX. These calculations are done with CRESS and by hand. The results were that an average wind setup is 0.01 m. This value is negligible for the calculation in UNIBEST.

Wave parameters
UNIBEST is set with default wave parameters. These were used with the exception of the bottom roughness (k_b) was set on 0.12m and the breaker index was set on 0.78.

[8] Balance Sedimentario y Estacionalidad en 8 Playas de Mar del Plata, Argentina, 1991

Sediment parameters
Two settings have been used Bijker (1971) and Cerc (1984).
For Bijker (1971) the values are set as in shown in Table XII.1 below:

Table XII. 1 Coefficients used in the Bijker formula

Formula of BIJKER	Value of parameter	Dimension
D_{50}	250	μm
D_{90}	330	μm
Bottom Roughness k_c	0.06	m
Sediment fall velocity	0.0306	m/s
Criterion Hs/h (deep water)	0.07	-
Coefficient b (deep water)	1	-
Criterion Hs/h (shallow water)	0.8	-
Coefficient b (shallow water)	5.00	-

Cerc (1984)

Table XII. 2 Coefficients used in the Cerc formula

Formula of Cerc	Value of parameter	Dimension
A coeffcient	0.014	-
Breaker index	0.8	-

Dynamic border
The dynamic border is the limit between the static and the dynamic zone of transport. This values used differ for each bottom profile, because it is dependent of the critical depth. This critical depth is determined in the section XX and is 9.0meter.

Truncation transport border
The truncation transport border is the border from where the sediment will be moved. The UNIBEST manual gives that generally this boundary is the same as the dynamic border as will be assumed here.

Results

The determination on the long shore transport has been done with the formulas of Bijker (1971) and Cerc (1984). The background and the use of the formulas of Bijker (1971) and Cerc (1984) are outlined in the appendix XX.

The current bottom profiles 1-5 do not contain sediment. To obtain a more reliable long shore transport estimation the calculation are done with the nourished profiles, which can be seen in appendix XX.

Comparison with hand calculation
First a calculation to check the hand calculation was executed. This was done for ray 8 as the hand calculation was done for the same ray. The hand calculation wave climate was used in combination with the current bottom profile.

The long shore transport quantities for ray 8 were the following:

Table XII. 3 Comparison UNIBEST and hand calculations

Formula	Hand Calculation k(m3) / (m y)	UNIBEST k(m3) / (m y)
Bijker (1971)	1060	250
Cerc (1984)	1100	1230

Comparing the values for Cerc of the hand calculation and UNIBEST, it must be noticed they match very well.
As can been seen the most important difference in the calculated transport values are found in Bijker. This is the result differences in the input and calculation principle of the hand calculation.

- Linear velocity distribution in the breaker zone in the hand calculation
- Linear bottom profile in the hand calculation
- Varying friction coefficient in space in the hand calculation

Distribution and characteristics of Q_s for ray 8:

In the Figure below more detailed information for the output a ray 8 with Bijker (1971) can be found.
For the other calculations this information will not be given, but transport quantities will be quoted in tables.

The equilibrium angle of the coastline is given. It depends on the wave characteristics as well as on the bathymetry. Also the distribution of the sediment transport along the profile can be seen.

The green arrow gives the border for 50% of the transport and also the value for the dynamic border is given.

The dotted line gives the cumulative course of the sediment capacity, which can be used to determine the amount of sediment that will be stopped by for example a breakwater.

Figure XII. 2 Distributions for ray 8

Next the determination of the transport for ray 1 to 15 with the nourished profiles and the monthly-distributed wave climate is presented in the table below.

Table XII. 4 Values long shore transport Bijker and Cerc per Ray

Ray	Bijker (1971) k(m3) / (m y)	Cerc (1984) k(m3) / (m y)
1	189	698
2	124	460
3	106	401
4	191	710
5	199	740
6	188	740
7	185	720
8	165	641
9	165	641
10	156	612
11	140	540
12	67	428
13	60	268
14	60	263
15	38	207
Average transport per ray	140	519

In the table above a large difference can be noticed between the values for Cerc and for Bijker. The Cerc values are roughly a factor 4 larger than the Bijker values.
As can be seen in the appendix XX were the Cerc formula is described in more detail, a number of parameters are not used in Cerc, which are used in Bijker. These most important parameters are:

- Bottom roughness
- Grain size
- Bed slope
- Velocity distribution
- Difference between bed load transport and suspension transport

Because of the absence of these parameters Cerc, always seems overestimates the long shore transport.

The values of the table above are plotted in the figure below to obtain sediment transport curves. Despite the large differences in the values of Bijker and Cerc, both the results show a decrease in the sediment transport in the South West of the area, further a relatively constant transport and at the North West of the coast a decrease as well. A negative sediment transport flux causes accretion, as positive sediment transport flux cause erosion. At the first 2 rays of the area there was never beach because this is a rocky point. There fore is validated that the increase in transport between ray 3 and 5 cause heavy erosion on Los Acantilados beach. The decrease in transport from ray 11 to15 is because the rif causes a shadow area in the wave climate in that area.

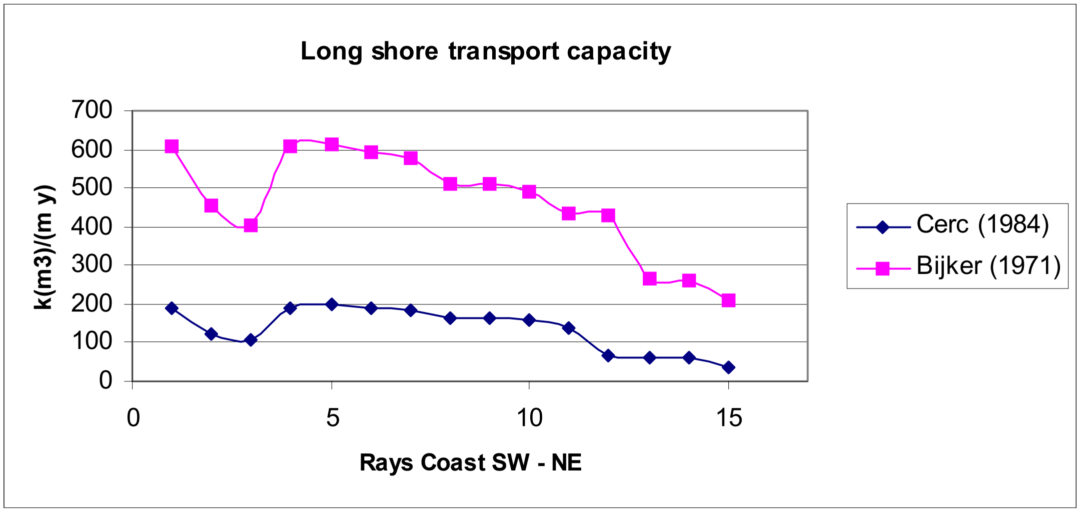

Figure XII. 3 Long shore transport capacity from UNIBEST

In the figure shown below the long shore transport capacity is presented for separated wave directions. This graph is used for determining the wave direction of which the contribution of the transport is the largest.

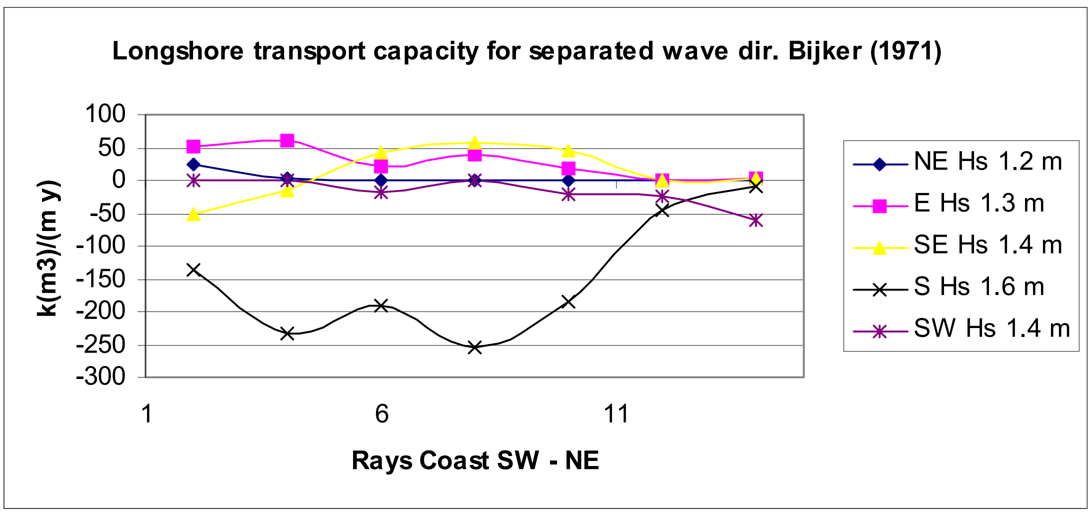

Figure XII. 4 Long shore transport capacity for separated wave directions Bijker (1971)

Conclusions

What can be concluded is that the coast of Los Acantilados has a strong potential in long shore transport. This corresponds of course to the past decade of severe erosion problems. With the long shore transport curve it can de nicely be seen that at Punta Martinez de Hoz sediment will constantly be moved in North East direction. At Punta Mogotos the tombolo will continue accreting Because of the decrease in the gradient.
As for the different values for the long shore sediment capacity calculated with UNIBEST, there can be concluded that there are to many flaws in the Cerc principle to rely on. Therefore Bijker values are more reliable to use.
The average long shore transport is according to the Bijker calculations is 140 k(m^3) / (m y). Former calculations done by Ministry of Transport, Public Works and Water Management (Rijkswaterstaat, the Netherlands)[9] at the coast of Mar de Plata show a long shore transport of 150 – 200 k(m^3) / (m y). The Ministro Publicas Obras Provincia Buenos Aires[10] estimates the long shore transport in front of the coast of Los Acantilados on 160 k(m^3). For this the calculations with UNIBEST are valid.

[9] Port and Coastal Study Mar del Plata , April 1997
[10] Conversation with Roberto S. Sciarrone and Ruben E. Melendez from the Ministros Obras Publicas (Public Works) of the province of Buenos Aires

Appendix XIII, Bijker calculation by hand

The Bijker formula

The Bijker formula consists of two components, the bed load transport component and the suspended load transport component.

$$\boxed{S \approx S_b + S_s}$$

In which:

S_b	=	Bottom sediment transport (m^3/ms)
S_s	=	Suspended sediment transport (m^3/ms)

The formula for 'S_b' is:

$$\boxed{S_b = \frac{b \cdot D_{50} \cdot V \cdot \sqrt{g}}{C} \cdot \exp\left[\frac{-0,27 \cdot \Delta \cdot D_{50} \cdot \rho \cdot g}{\mu \cdot \overline{\tau_{cw}}}\right]}$$

In which (previous explained parameters will not be mentioned):

b	=	Coefficient, in surf zone 5	(-)
D_{50}	=	Median grain diameter (50%)	(m)
V	=	Current velocity (m/s)	
r	=	Bottom roughness	(m)
g	=	Gravitational acceleration (m/s^2)	
Δ	=	Relative density $\left[= \left(\rho_s - \rho_w\right) / \rho_w\right]$	(-)
ρ_s	=	Mass density sand (kg/m^3)	
ρ_w	=	Mass density water (kg/m^3)	
μ	=	Ripple factor $\left[= \left(C / C_{90}\right)^{\frac{3}{2}}\right]$	(-)
C	=	Chezy coefficient $\left[= 18 \log\left(\frac{12h}{r}\right)\right]$ ($m^{0,5}/s$)	
C_{90}	=	Chezy coefficient $\left[= 18 \log\left(\frac{12h}{D_{90}}\right)\right]$ ($m^{0,5}/s$)	
D_{90}	=	Grain diameter (90%)	(m)
h	=	Depth	(m)
$\overline{\tau_{cw}}$	=	Time averaged bottom shear stress due to waves and currents (N/m^2)	

The timed averaged bottom shear stress due to the waves and currents '$\overline{\tau_{cw}}$' is calculated by:

$$\boxed{\overline{\tau_{cw}} = \frac{\rho \cdot g \cdot V^2}{C^2} \cdot \left[1 + \frac{1}{2} \cdot \left(\xi \cdot \frac{u_b}{v}\right)^2\right]}$$

In which (previous explained parameters will not be mentioned):

ξ	=	Bijker's parameter $\left[= C\sqrt{\frac{f_w}{2g}}\right]$	(-)
f_w	=	Jonsson's friction parameter $\left[= \exp\left(-5{,}977 + 5{,}213\left(\frac{a_0}{r}\right)^{-0{,}194}\right)\right]$	(-)
a_0	=	Maximum horizontal displacement 'at the bottom' $\left[= \frac{H}{2\sin(kh)}\right]$	(m)
H	=	Wave height	(m)
k	=	Wave number $\left[= \frac{2\pi}{\lambda}\right]$	(1/m)
λ	=	Wave length	(m)
u_b	=	Orbital velocity near the bottom $\left[= a_0\left(\frac{2\pi}{T}\right)\right]$	(m/s)
T	=	Wave period	(s)
v	=	Kinematics viscosity, in water of 12°C 1,25E-6	(m^2/s)

Bijker coupled the adapted bed load transport formula to the suspended load transport formula of Einstein. The suspended sediment can be shown to be directly proportional to the bed load transport. This results in:

$$S_s = 1.83 \cdot Q \cdot S_b$$

Or the total sediment transport:

$$S = S_b(1 + 1{,}83 \cdot Q \cdot S_b)$$

In which (previous explained parameters will not be mentioned):

Q	=	Einstein's integral term	(-)

To determine this ratio between bottom and suspended transport one can read Einstein's integral term from the table below. For this table it is necessary to calculate z_*, and the ratio r/h.

Table XIII. 1 Calculations of z*

	z*									
r/h	0	0,2	0,4	0,6	0,8	1	1,5	2	3	4
0,00001	303000	32800	3880	527	88	20	2,33	0,973	0,432	0,276
0,00002	144000	17900	2430	377	71,6	17,9	2,31	0,973	0,432	0,276
0,00005	53600	7980	1300	239	53,6	14,4	2,28	0,967	0,432	0,276
0,0001	25300	4320	803	169	42,7	13,6	2,25	0,967	0,432	0,276
0,0002	11900	2330	496	119	33,9	11,9	2,21	0,967	0,431	0,275
0,0005	4360	1020	260	74,3	24,6	9,8	2,13	0,962	0,431	0,275
0,001	2030	545	158	51,2	19,1	8,4	2,05	0,951	0,43	0,275
0,002	940	289	95,6	35,1	14,6	7	1,96	0,94	0,428	0,274
0,005	336	123	48,5	20,8	10	5,4	1,78	0,907	0,424	0,273
0,01	153	63,9	28,6	13,8	7,3	4,3	1,62	0,869	0,417	0,27
0,02	68,9	32,8	16,5	8,9	5,2	3,3	1,42	0,809	0,404	0,264
0,05	23,2	13,1	7,7	4,8	3,1	2,2	1,1	0,694	0,374	0,249
0,1	9,8	6,3	4,1	2,8	2	1,5	0,84	0,568	0,339	0,236
0,2	3,9	2,8	2	1,5	1,2	0,9	0,55	0,414	0,317	0
0,5	0,8	0,7	0,6	0,5	0,4	0,3	0,17	0	0	0
1	0	0	0	0	0	0	0	0	0	0

With the following formula z_* can be calculated:

$$\boxed{z_* = \frac{w}{\kappa \cdot V_*}}$$

In which (previous explained parameters will not be mentioned):

z_* = Rouse number (-)

w = Grain fall velocity $\left[\log(1/w) = 0.4758(\log D_{50})^2 + 2.1795(\log D_{50}) + 3.1915\right]$ (m/s)

κ = Von Karman coefficient, always 0,4 (-)

V_* = Shear stress velocity (m/s)

V_{*cw} = Shear stress velocity under waves and currents $\left[= \sqrt{\frac{\tau_{cw}}{\rho}}\right]$ (m/s)

Assumptions and parameter values

Bijker assumes the velocity distribution through the breaker zone almost linear, while the distribution acutely has more of a round profile, see Figure XIII.1. There are different ways to recalculate the sediment transport from the Bijker distribution to a more realistic one. After the calculation with Bijker this will be considered

Figure XIII. 1 Velocity distribution breaker zone

Further more a few parameters have to be declared. This is done in the table below.

Table XIII. 2 Wave parameters

Parameter		Value	unit
γ	Breaking index	0.8	(-)
ρ_{sand}	Density sand	2650	(kg/m3)
ρ_{water}	Density water	1025	(kg/m3)
D_{50}	Median grain Diameter	0.00025	(m)
D_{90}	90% grain Diameter	0.00033	(m)
r	Bottom roughness coefficient	0.06	(m)
w_s	Fall velocity grain	0.03060	(m/s)

The origin of the above mentioned parameters is the following[11]. The values of the breaker index, density of water and sand are common over the world and don't need further explanation. The two grain diameters were measured, as can be seen in appendix xx . The bottom roughness coefficient is very difficult to determine. In case of a flat sand bed this bottom roughness is related to the grain diameter. But if ripples are present, the roughness is related to the size of the ripples. Problem here is that no measures can be made, since the nourishment is yet only theoretical, whether there are ripples and, if they are present, what their size is. However one has to make an assumption and ripples are very common on these types of beaches, 0,06 was chosen. This way is more likely that the amount of erosion is overestimated then underestimated. As last parameter, the fall velocity was calculated. There are many different formulas for the fall velocity, in this case the empirical formula for sediment diameters in the range from 50 μm to 300 μm in water with 10 °C was used as given earlier.

As mentioned before the following wave climate was used for the calculation by hand:

Table XIII. 3 Modelled wave climate

	NE	S	SW
Year			
Days	179	141	45
Hs Average (m)	1,2	1,5	1,4
Ts Average (s)	6	7	6

Furthermore the parameters for the bathymetry are given. These have an important influence on the results and choosing/determining these must be done carefully. Bijker makes the assumption of a straight beach with straight depth contours as well. First the used parameters are given and then discussed.

Table XIII. 4 Beach parameters

Parameter		Value	Unit
m	Beach Slope	0.01	(m)
-	Orientation of the coast	154	(º)[12]

The m value is hard to determine. In prior calculations for the new, to be nourished, beach either a slope of m = 0,01 or m = 0,02 was used. Bijker assumes a straight coast, with a constant beach slope and this only accounts, more or less, for the profiles 8,9 and 10, so here the m = 0,02. But the profiles here to deep water have an average slope of m = 0,006 which has a very different influence on the wave height, by means of refraction and shoaling. Besides this, one can not know how the nourished beach will adapt to the

[11] This subsection was written with information from Coastal Engineering CT5308, volume II. Ir. E.T.J.M. van der Velden, september 2000, TU Delft
[12] This value is related to the well-known world system, in which 0º is North and 180º is South.

wave climate. The value of m = 0,01 is chosen. This takes both influences, beach nourishment and slope to deep water, into account. As mentioned before the profile 8 through 10 show the most straight, their orientation is used. It is noted that the facts that the coast isn't straight, the profiles don't have a constant slope and that nearby shallows, like the 'Banca Pescadores', are not taken into account, will have significant influence on the accuracy of the calculation.

Calculation and results

Before the formula can be used, one has to have a clear picture of the wave development. This can be done by means of the short wave theory[13]. The theory, assumptions and calculations will not be given here, only a short overview of results to get an inside in the local wave climate.

The most important of the three main wave directions are waves from the south. Due to the orientation of the coast the biggest waves, namely 1,5 m., make a big angle of approach of 26º from deep water. In picture xx one can see the development of these waves till the point were the waves start breaking.

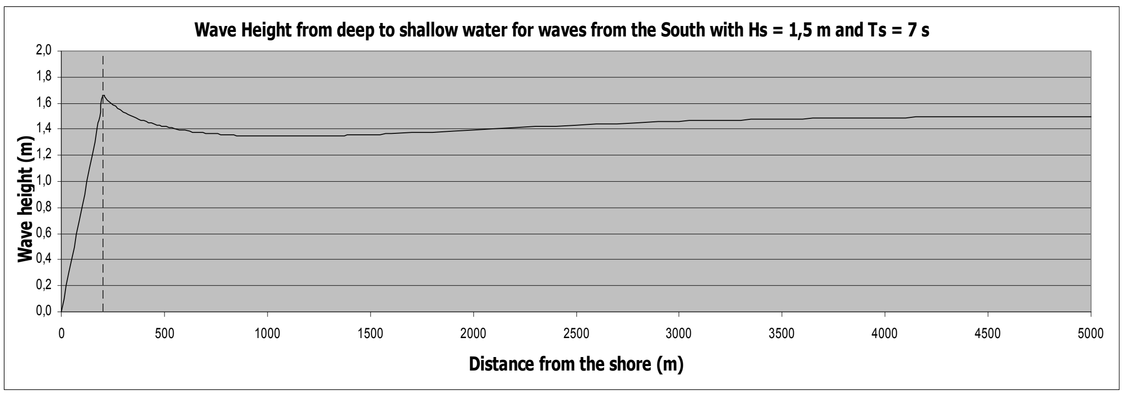

Figure XIII. 2 Wave height due to profile

Same calculations were made with the other two wave directions. Results are given in Table XIII.5 and then discussed.

Table XIII. 5 Wave climate

Wave climate	H_s (m)	T_s (s)	H_b (m)	h_b (m)	y_b (m)
141 days S	1,5	7	1,7	2,0	200
179 days NE	1,2	6	0,3	0,3	25
45 days SW	1,4	6	1,0	1,1	125

The first thing that is important, that under normal conditions the breaker zone has a length of 200 m. One can comment two things on this. Due to the previous mentioned velocity distribution the breaker zone will extend a bit further then 200 m and besides that, the used breaker index of 0,8 is sometimes measured smaller and thus a longer breaker zone occurs. For the Bijker calculations however 200 m will be used.

[13] Coastal Engineering, Volume II. Ir. E.T.J.M. van der Velden, september 2000, TU Delft and Korte Golven, Prof.dr.ir. J.A. Battjes, september 2001 TU Delft.

Secondly it seems rather strange that the waves from the NE and SW break at a lower height then they are on deep water. This is due to the refraction factor: the orientation of the coast gives an angle of approach for waves from the SW of 71º and for waves from the NE 109º. This last angle is a problem for the calculations by hand, because it gave strange and unrealistic results. To tackle the problem and make a reliable assumption the angle of attack was set on 90º. The fact that the profile lies in the shelter of the natural reef enforces the theory that waves from the NE will not enforces a significant sediment transport.

Now calculations with the Bijker formula can be made. With help from MS Excel the following results were obtained.

Table XIII. 6 Results from Bijker formula

Wave climate	**Sediment transport (m^3/s)**	**S in representatives days (m^3)**
141 days S	0,080	970.000
179 days NE	-0,001	-10.000
45 days SW	0.026	100.000
	Average transport in m^3/s	**Total transport in one year in m^3**
	0,033	**1.060.000**

It would be to much to show all available tables, graphs and other results, so here only a few characteristics are given.

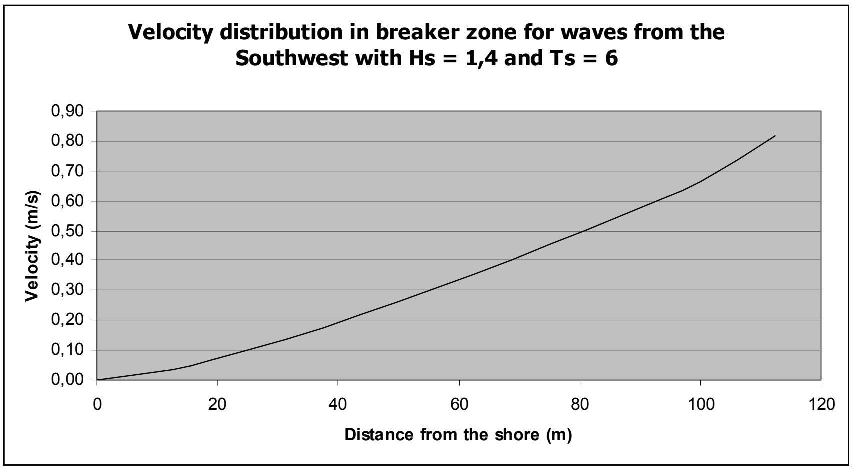

Figure XIII. 3

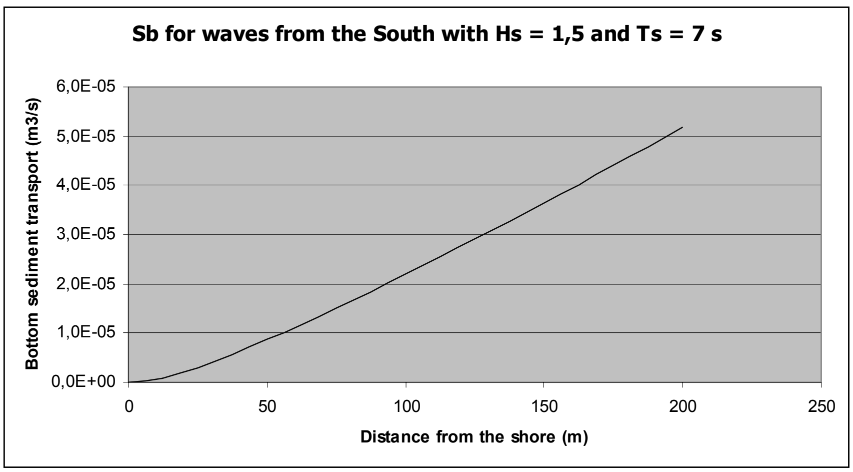

Figure XIII. 4

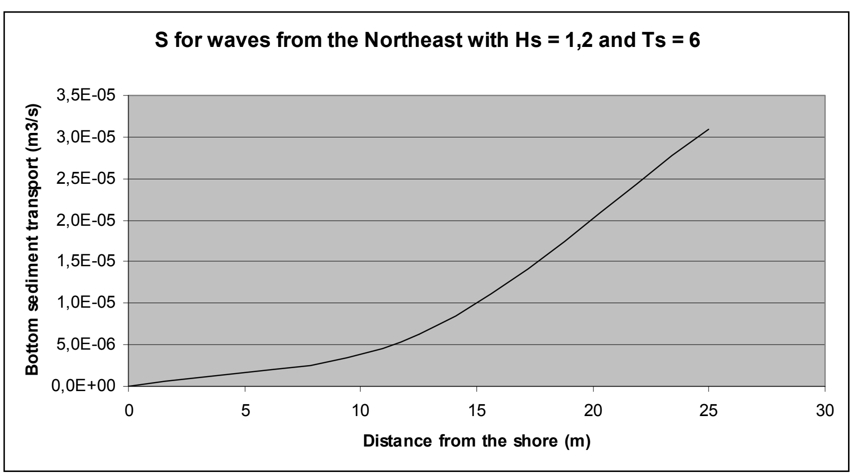

Figure XIII. 5

A few comments can be made related to the results and graph. The velocity distribution throughout that breaker zone is as mentioned before not correct. With that, it is clearly visible that the sediment transport distribution is not entirely correct too. However for the alternative of periodical nourishment a further transformation to a more logic distribution is not considered to be necessary. In the third graph the non-linear sediment transport rates throughout the breaker zone can be questioned. The irregularity attributed to the bad estimations of Einstein's integral term Q. The influence of this error however is not considered to be too great after comparisons with data from Coastal Engineering, Volume II. Ir. E.T.J.M. van der Velden, september 2000, TU Delft. Assumptions and flaws of the Bijker formula and the specific situation are considered to be of a far greater influence.

For instance one can take a look at the breaker index. Is this calculation it was taken at 0,8. When the same calculation were made with 0,6, which is experienced often in practice, the total sediment transportation becomes 960.000 m^3/year. Or when the slope of the bed is at 0,02, the sediment transportation 1.300.000 m^3/year. The different changes have different influences on the different wave climates, creating a big uncertainty in the results of the Bijker formula.

Conclusion

Due to the great number of assumptions and uncertainty's one can undoubtedly have questions about the calculated amount of 1.060.000 m^3/year. As a first calculation however it's a good indication that a significant sediment transport in potential takes place at Los Acantilados and must be have been taking place in the past. If local conditions are such that there is hardly any sand supply from up streams of the long shore current and no protection measures have been made, erosion is the natural result.

Appendix XIV, CERC calculation by hand

The CERC sediment transport formula

The formula formulated by the Coastal Engineering Research Center of the US army Corps of Engineers for sediment transport along the coast was based on a energy bulk model.
Expressed as a formula, the sand transport rate becomes:

$$\boxed{S_x = A'U'}$$

In which:

S_x	=	Longshore sand transport
A'	=	Dimensional coefficient
U'	=	The component of the energy flux entering the breaker zone

Via maths and definitions related to energy flux due to wave height and the angle of attack of the waves at the breaker zone or at deep water, the formula can be rewritten. Many, slightly different, formulas were obtained this way. Choices in the past about the value of A' and whether the Hs (significant wave height) or Hrms (root mean square wave height) should be used, have different backgrounds and it's considered not interesting to go into these subjects here.
Since all previous calculation in this report were done with Hs, therefore Hs will be used in these calculations. Coastal Engineering, Volume II, September 2000 by Ir. E.T.J.M. van der Velden gives the following formulas with the use of Hs.

$$S_x = 0{,}020 H_{s,o}^2 c_0 Kr_b \cos(\varphi_b)\sin(\varphi_b)$$
$$S_x = 0{,}010 H_{s,o}^2 c_0 Kr_b^2 \sin(2\varphi_b)$$
$$S_x = 0{,}020 H_{s,o}^2 c_0 \cos(\varphi_0)\sin(\varphi_b)$$
$$S_x = 0{,}040 H_b^2 c_0 n_0 \cos(\varphi_0)\sin(\varphi_b)$$
$$S_x = 0{,}020 H_b^2 c_b \sin(2\varphi_b)$$
$$S_x = 0{,}040 H_b^2 c_b \cos(\varphi_b)\sin(\varphi_b)$$
$$S_x = 0{,}040 H_b^2 c_b n_b \cos(\varphi_b)\sin(\varphi_b)$$

In which (previous explained parameters will not be mentioned):

$H_{s,o}$	=	Significant wave height at deep water	(m)
H_b	=	Wave height at the breaker line	(m)
c_o	=	Wave celerity at deep water	(m/s)
c_b	=	Wave celerity at the breaker line	(m/s)
n_o	=	Ratio between wave and wave group celerity at deep water	(-)
n_b	=	Ratio between wave and wave group celerity at the breaker line	(-)
Kr_b	=	Refraction coefficient at the breaker line	(-)
φ_0	=	Angle of attack by the waves at deep water	(°)
φ_b	=	Angle of attack by the waves at the breaker line	(°)

Assumptions and parameter values

Directly visible from the above formulas is the fact that the CERC formula doesn't take a few vital parameters into account such as grain size, bed slope and distribution over the surf zone. Although this seems rather bad, the CERC formula normally gives rather helpful results which often are a bit overestimated. The parameters that were used a all derived with help of the short wave theory as mentioned in appendix xx. Values are given below. As in the appendix xx the waves from the Northeast form a problem for the calculation, again angle of approach was set on 90°. With this their contribution to the sediment transport becomes close to zero. On top of that, as mentioned in the appendix xx, profile 8 lies in the shelter from reef which enforces the theory of zero sediment transport.

Table XIV. 1 Wave climate

Parameter	Climate S	Climate NE	Climate SW	Unit
$H_{s,o}$	1,50	1,20	1,40	(m)
H_b	1,66	0,88	0,99	(m)
c_o	10,92	9,36	9,36	(m/s)
c_b	4,30	3,07	3,42	(m/s)
n_o	0,50	0,50	0,50	(-)
n_b	0,95	0,96	0,95	(-)
Kr_b	0,96	0,59	0,59	(-)
φ_0	26	90	71	(°)
φ_b	10	19	19	(°)

Calculations and conclusion

With the parameters and earlier mentioned formulas, the following results given in Table XIV.2 were obtained. Since the formula contains a great number of uncertainties and only an indicative amount of sediment transport is needed, the result of the calculation by hand with the CERC formula will be set on 1.100.000 m^3/year.

Table XIV. 2 Results sediment transport calculations

Total S (m^3/year)
1.070.000
1.070.000
1.070.000
1.070.000
1.100.000
1.100.000
1.070.000

Appendix XV, First calculation amount of nourishment

From appendix xx the two overall beach slopes for the first and second type of cross shore profiles are taken, namely profiles 1–5 -> s1 = 0,01 and profiles 6 – 11 -> s2 fore shore 1 = 0,04 and s2 fore shore 2 = 0,003. Future schematised profiles will look like picture xx. In this picture x depends mainly on the chosen beach slope. In this 'chosen' is not completely correct; de future slope depends off course on the wave climate, grain diameter and other things. But one can assume, for now, similar conditions as the beaches north of the research area. Since the current slope for the profiles 1-5 is 1:100, this slope will be used for calculations of future beach nourishment. The profiles 6-11 have a much steeper fore shore, namely 1:4 and therefore a slope of 2:100 will be used for the calculations.

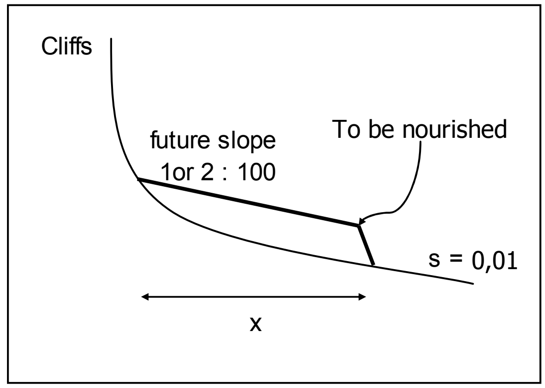

Figure XV. 1 Cross section nourishment

To obtain 50 m of beach with a slope of 1:100, the beach has to rise from the highest high sea level 50 cm. The h.h.s.l. according to appendix xx is 2,03 m. However the mean tide level is 0,91 m and chart data a related to this level. And thus the h.h.s.l. 1,12 m. The new beach therefore has to start at approximately 1,62 m. According to CODE list of demands bathing guests have to be able to bath comfortably and the limit is set to have sand at 2 meters deep below lowest low sea level, which after correction is –0,75 m. So the new profile will go from + 1,62 m to –2,75 m, and thus the total height that has to be overcome is 4,37 m. With a slope of 1:100, this is a 437 m wide beach[14]. From this, the cubic meter of sand to be nourished per meter can be derived. The current slope can be described by $C_1(x) = -0{,}01x$ and the future slope by $F_1(x) = -0{,}01x + 1$. This last equation indicates that an average of 1 meter of beach will be nourished on top of the current profile.

With $\int_0^{437} \left(F_1(x) - C_1(x)\right)dx = \int_0^{437} \left((-0{,}01x + 1) - (-0{,}01x)\right)dx = \int_0^{437} (1)dx = \left[x\right]_0^{437} = 437$,

the quantity becomes 437 m^3/m. The profiles 1-5 expend over an area of 2500 m. And thus a total of 1.100.000 m^3

Analogue the quantity of sand that has to be nourished on the other profiles can be found. A beach of 50 m needs h.h.s.l. + 0,25 m. So from +1,37 m to -2,75 m in total 4,12 has to be overcome. This is a length of 206 m. Different now is the first of the two equations, they become two: $C_{2.1}(x) = -0{,}04x$ (x < 125 m) $C_{2.2}(x) = -0{,}003x - 4{,}7$ (x > 125) and $F_2(x) = -0{,}02x + 1$. One takes the two following integrals:

$$\int_0^{125} \left(F_2(x) - C_{2.1}(x)\right)dx = \int_0^{125} \left((-0{,}02x + 1) - (-0{,}04x)\right)dx = \int_0^{125} (0{,}02x + 1)dx = \left[0{,}01x^2 + x\right]_0^{125} = 281$$

and

[14] Clearly this is a figure which can not be established exactly by big dredging material, but it's for first calculations only.

$$\int_{125}^{206}\left(F_2(x)-C_{2.2}(x)\right)dx=\int_{125}^{206}\left((-0{,}02x+1)-(-0{,}003x-4{,}7)\right)dx=\int_{125}^{206}(-0{,}017x+5{,}7)dx$$
$$=\left[-0{,}0085x^2+5{,}7x\right]_{125}^{206}=234$$

and an amount per meter profile becomes 525 m^3/m. The profiles 6 through 11 expend over 3500 m and thus a total of 1.800.000 m^3 has to be nourished. Together with profiles 1-5 a total of 2.900.000 m^3 has to be nourished.

Figure XIX. 1 **Cross section of the head of the groyne based on sand**

Figure XIX. 2 **Cross section of the trunk of the groyne based on sand**