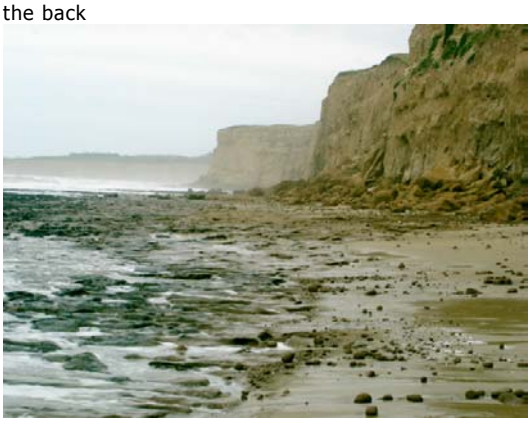
Appendix Views of the research area

Punta Cantela, with the groyne in the back

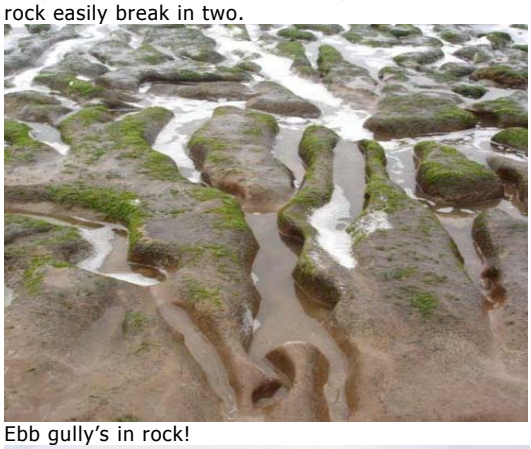
Heavy erosion north of Punta Cantela

North view from Los Acantilados, with the tombolo in the back

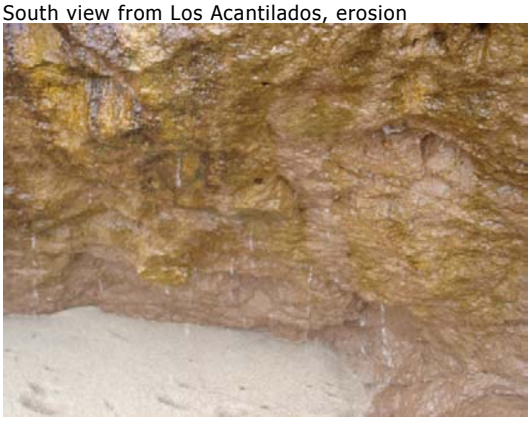
Big parts of the cliff fall off, clearly visible how the rock easily break in two.



South view from Los Acantilados, erosion



Ebb gully's in rock!



Leaking groundwater trough the cliffs

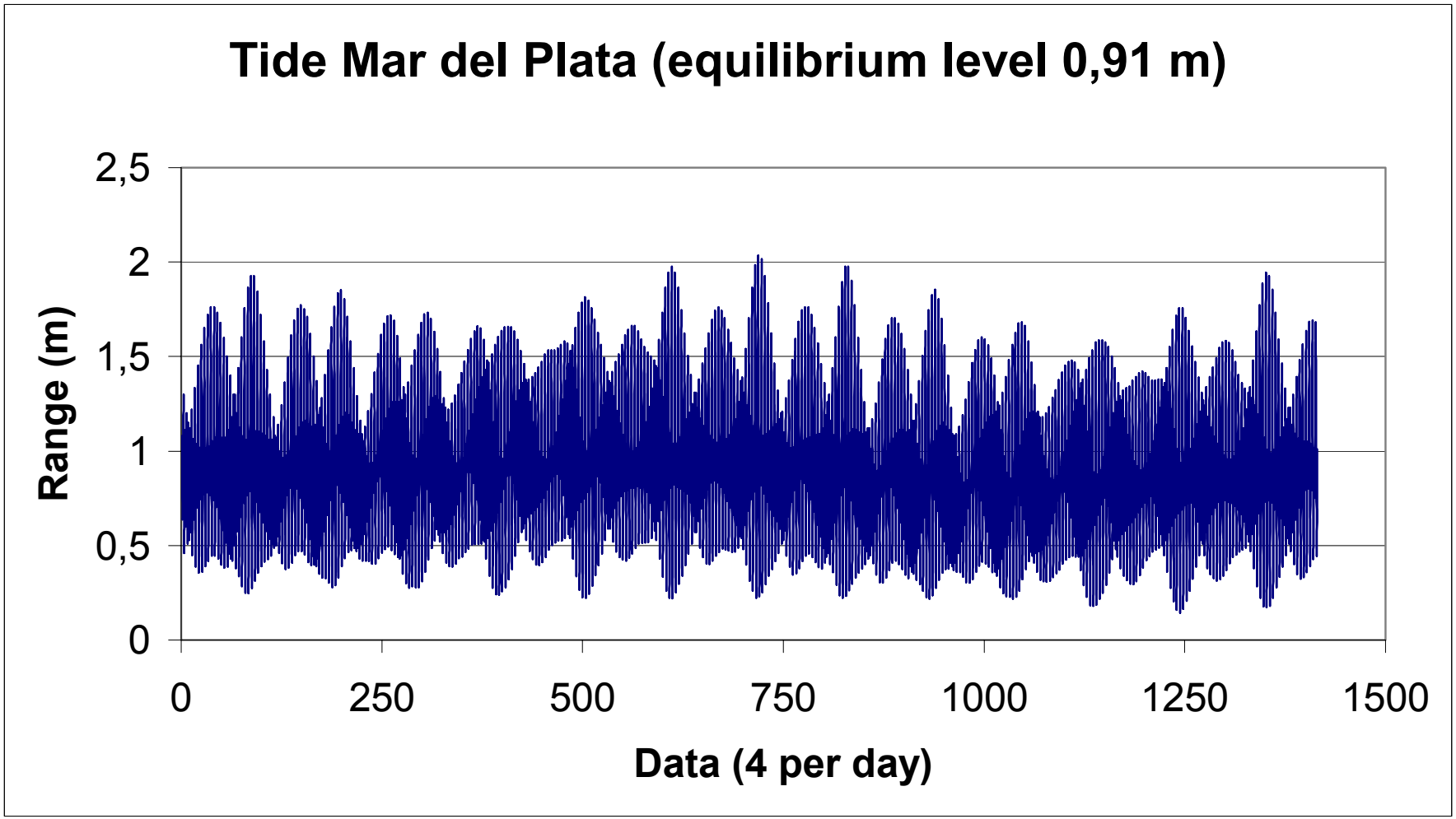
South view from Los Lobos

Appendix 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 deArgentina

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

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


Tide Mar del Plata (equilibrium level 0,91 m)
Range (m)
2,5
2
1,5
1
0,5
0
0
250
500
750
1000
1250
1500
Data (4 per day)

Offshore Wave climate

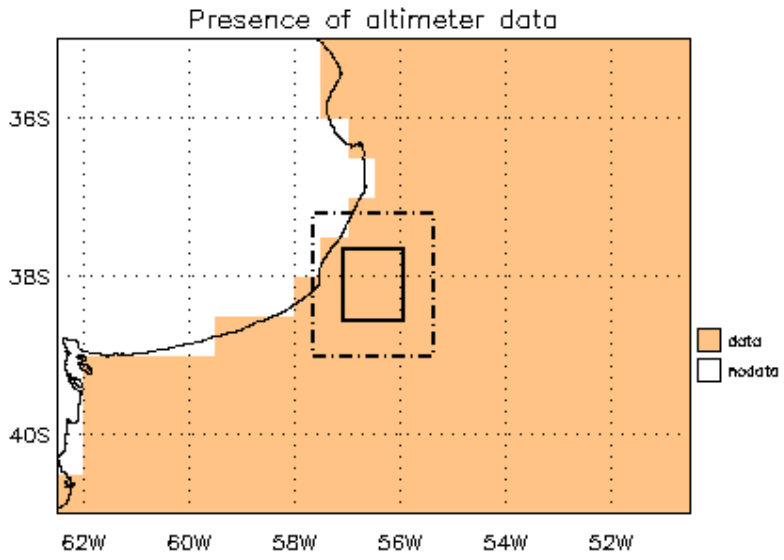
For the wave data two databases have been used, www.hydrobase.net from the Alkyon, Emmeloord, The Netherlands and www.waveclimate.com From Argoss (Advisory Research Group on Geo Observation Systems and Services) Marknesse, The Netherlands. Alkyon data is based on ship observations from global wave statistics(GWS).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

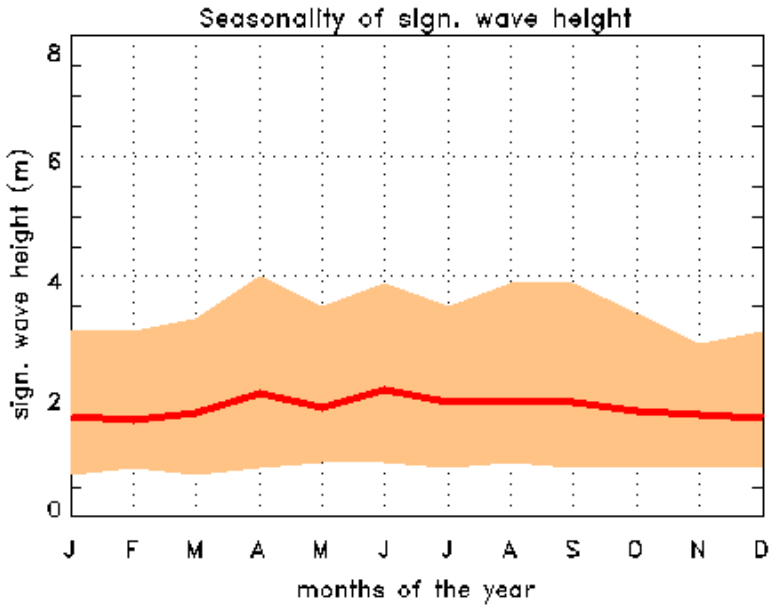
Argoss Data

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



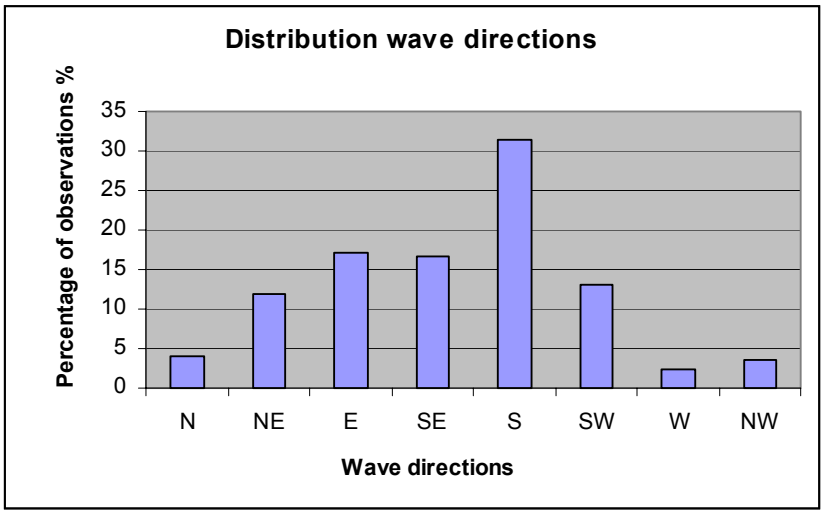
Monthly distribution of sign. wave height (m)													
lower	**upper**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
00	**01**	13.1	12.3	11.9	8.9	7.4	5.2	7.3	6.6	7.5	11.1	9.5	9.7
01	**02**	59.5	64.4	59.5	46.0	61.9	41.9	52.4	54.8	54.8	59.0	62.2	65.1
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



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.

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



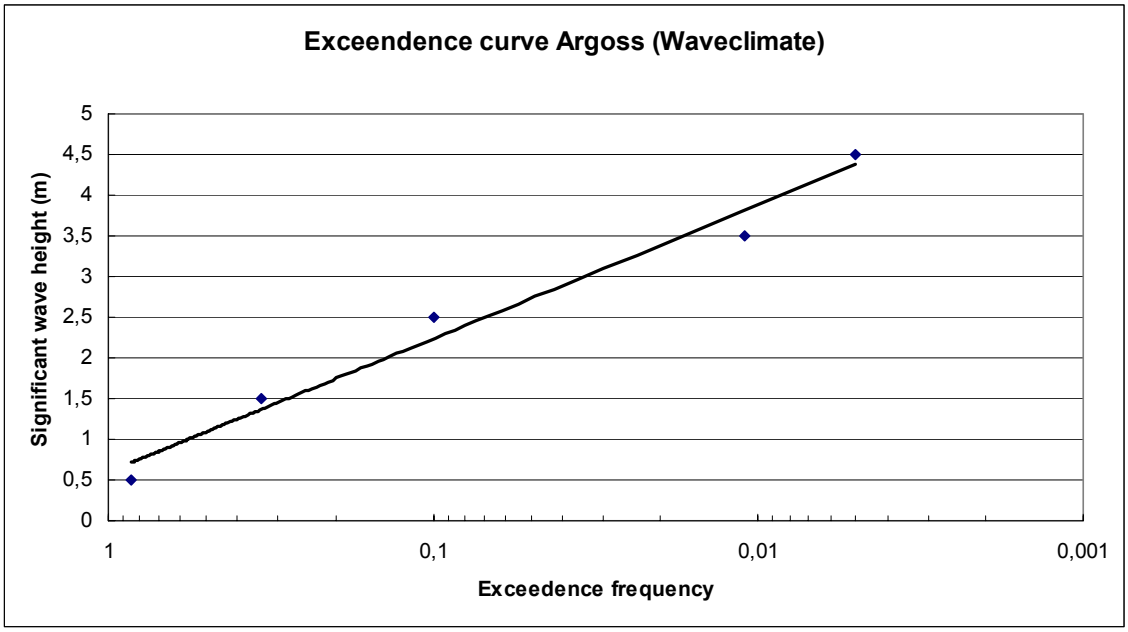
As can been seen in the scatter table and histogram of the wave directions, the most important directions are North-East, East, South-East, South and South-West. The directions are that for an offshore wave climate. This contains therefore all directions. In the analysis later on a selection will be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

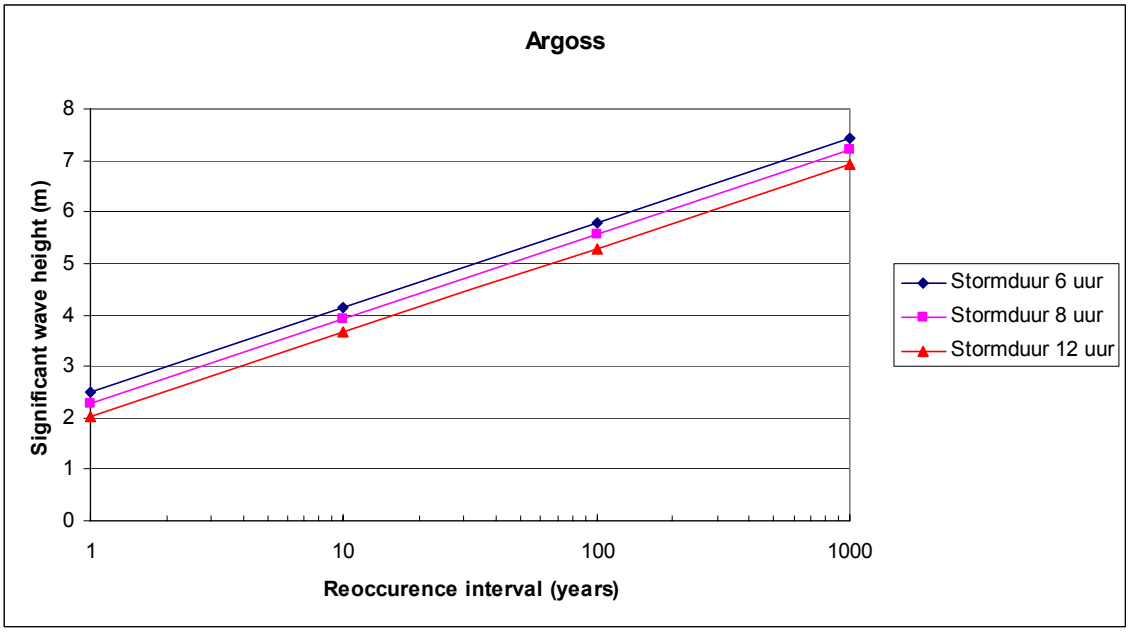
Percentage of occurrence of sign. wave height (m) in rows versus mean wave period (s) in columns

	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

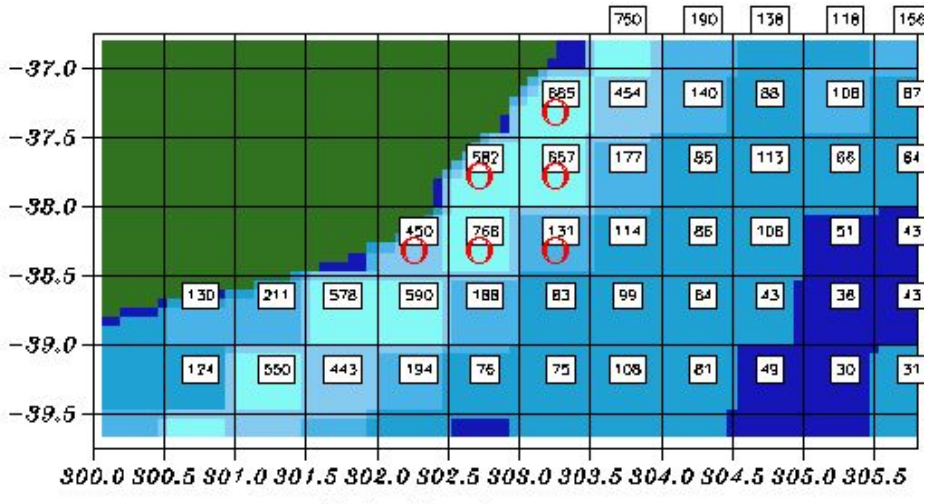
Results are based on 169 samples from 168 passes

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


Exceendence curve Argoss (Waveclimate)
Significant wave height (m)
5
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
1
0,1
0,01
0,001
Exceedence frequency


Argoss
Significant wave height (m)
8
7
6
5
4
3
2
1
0
1
10
100
1000
Reoccurence interval (years)
Stormduur 6 uur
Stormduur 8 uur
Stormduur 12 uur

Alkyon (Global Wave Statistics)

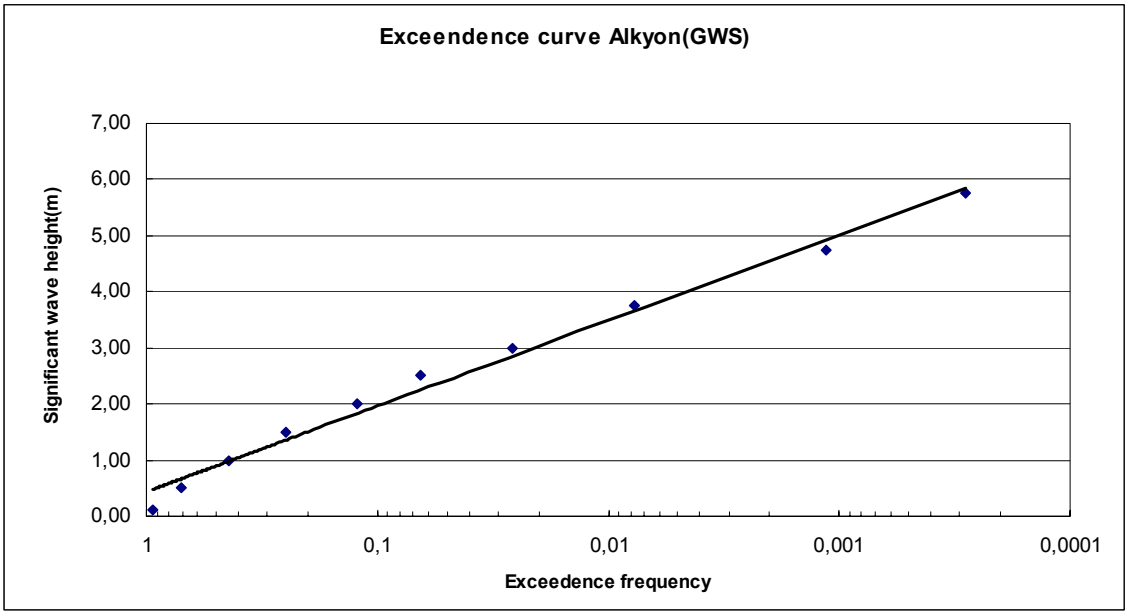


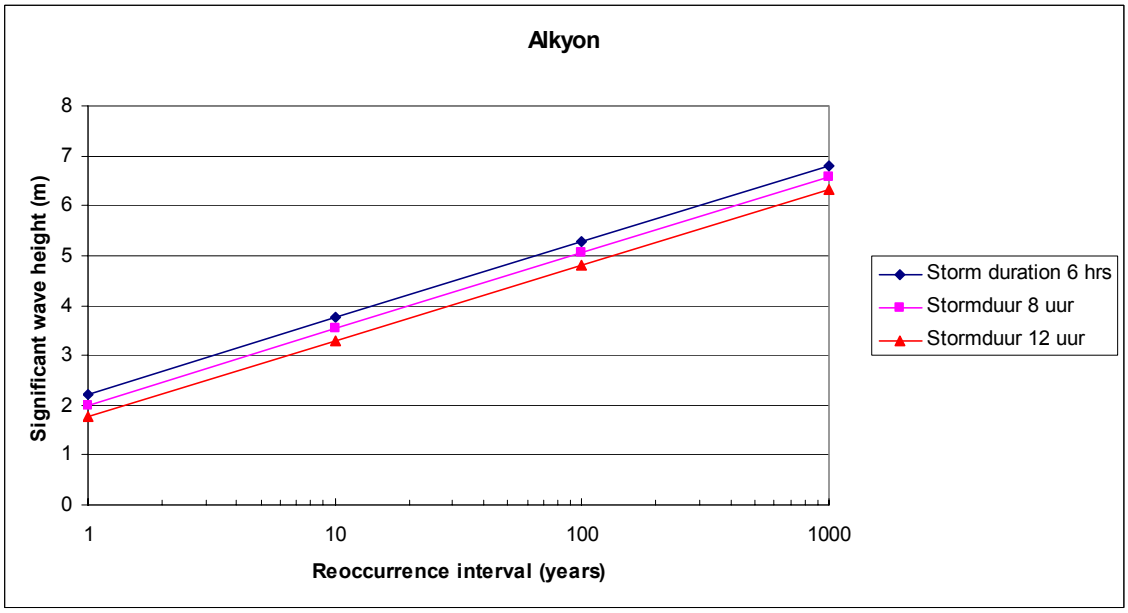
The data used for the following analysis of the wave height is from the areas marked with an O in the above figure. The numbers in the boxes represent the number of observations in that area. This area is needed because of the amount of observations needed to get a reliable analysis.

Hs (m)		dir (Deg)								
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.


Exceendence curve Alkyon(GWS)
Significant wave height(m)
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
1
0,1
0,01
0,001
0,0001
Exceedence frequency


Alkyon
Significant wave height (m)
8
7
6
5
4
3
2
1
0
1
10
100
1000
Reoccurrence interval (years)
Storm duration 6 hrs
Stormduur 8 uur
Stormduur 12 uur

Hs (m) Lower	Hs (m) 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.

	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.

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

For the input in the modelling software table XX 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.

	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 modelled as below.

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

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

For the input in the modelling software table XX 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.

	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 modelled as below.

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

Appendix Erosion problems throughout the years

Coastal areas	Schnack et al. (1983)		Alvarez y Ferrante (1999)							
	Period 1970-1980		Period 1970-1988		Period 1988-1992		Period 1992-1998		Period 1970-1998	
	Erosion		Erosion		Erosion		Erosion		Erosion	
	Total (m)	Meter/year	Total (m)	Meter/year	Total (m)	Meter/year	Total (M)	Meter/year	Total (m)	Meter/year
GADA 601 F.U. Camet			17.83	0.99	4.00	1.00	3.00	0.50	24.83	0.89
Parque Peña	10.80	0.90	13.20	0.73	3.50	0.87	4.33	0.72	21.03	0.75
Parque Camet Norte			17.15	0.95	6.57	164	4.43	0.74	28.15	1.00
Parque Camet Sur			11.66	0.65	5.00	1.25	8.33	1.39	24.99	0.89
Margen Sur Aª La Tapera					5.00	1.25				
Faro Pta. Mogotes- P. San Jacinto	60.00	5.00			10.00	2.50				
Playa San Jacinto					5.00	1.25	3.50	0.59		
Mirador Playa Serena					6.00	1.50	8.00	1.33		
Playa San Patricio					1.00	0.25	4.50	0.75		
Playa San Carlos	60.00	5.00	64.00	3.55						
Playa Los Acantilados			1.66	0.09	2.50	0.62	2.75	0.46	6.91	0.25
Paya Mar y Sol			7.17	0.40	2.57	0.64	3.84	0.64	13.58	0.48
Playa Barranca de los Lobos	12.90	1.07			2.00	0.50	5.00	0.83		
Playas Las Palomas			3.50	0.19	1.87	0.47	2.80	0.47	8.17	0.29
P. Las Palomas-Est.Chapadmalal			1.50	0.08	2.50	0.62	2.00	0.33	6.00	0.21
Estafeta Chapadmalal	2.40	0.20	6.50	0.36	3.25	0.81	3.42	0.57	13.17	0.47
Colonia Chapadmalal	2.40	0.20	2.33	0.13	1.30	0.32	1.40	0.23	5.03	0.18
Zona Hoteles-Aª Brusquitas			11.00	0.61	4.00	1.00	3.65	0.61	18.65	0.66

Table[1] with erosion problems over the last three decades in the surroundings of Mar del Plata

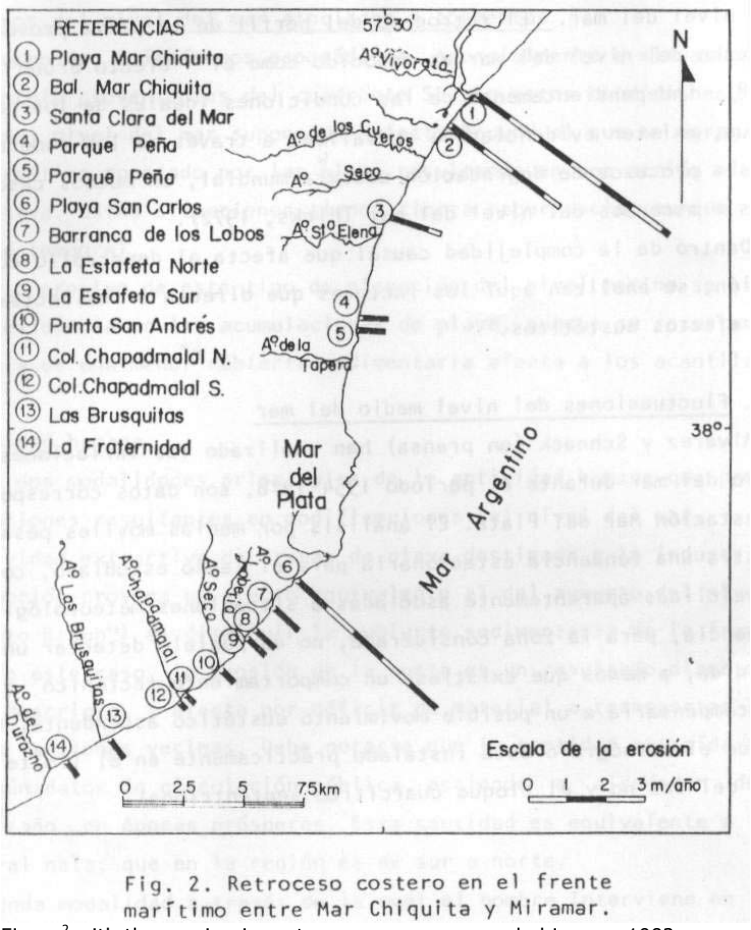


Fig. 2. Retroceso costero en el frente marítimo entre Mar Chiquita y Miramar.

Figure[2] with the 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 stone material cliffs

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

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