Modelling the sediment transport between Punta Rasa and Mar Azul

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1. Introduction

As more or less all over the world the coastal stretch (se Fig. 1) from Punta Rasa to Mar Azul underlies a coastal retreat. Intensive settlement close to the coastline makes coastal protection measures necessary. The beaches are sandy and mostly used for tourism. Hard structures, f. e. groins or seawalls, are a non practicable solution for this coastal area, because lee- or beach erosion are associated with this measures. Nourishments can be a good solution. No erosion will be induced nor the beach as a tourism facility will be negative influenced. Just the opposite is the case.

For developing a design of a nourishment it is necessary to estimate the sediment transport long shore and cross shore as well as the shape (sea side slope, height, extension etc.) of the nourished body. Numerical models can give a hint for the solution of this challenge.

One of the leading companies in the world for coastal modelling is the Danish Hydraulic Institute. The model "LITPACK" has already been successful applied for similar coastlines. For details of the theoretical background of this model see: http://www.dhi.de.

2. Data base

The topographical information from the offshore region where taken from the sea chart H114. After digitising this map a 10 x 10 meter grid (see fig. 2) was calculated with the program SURFER8. Five cross-shore profiles where extracted from the grid (see fig. 2) from –10 meter to the upper limit of –1 meter. The beach profiles where measured by the university of Mar de Plata in March 2007 This separate profiles where merged to cross-shore profiles from the coastline to –10 meter depth (see fig. 5-9). The gap between –1 meter and low tide measurement where filled up by using the slope from –1 meter downwards. Therefore we have a weakness in the most important sediment transport zone, the upper surf zone.

The wave data where calculated by wind-wave correlation from the oceanographic service in Buenos Aires on several positions. For the calculation of the sediment transport the position 136139 for the north part from Punta Rasa to Punta Medanos (see Fig. 3) and the position 146139 for the south part from Punta Medanos to Mar Azul (see fig. 4) where used. The time series from 1995-2000 was used after an analysis of the representation of the data. The time step is 6 hours.

Sediment data where taken during the seismic survey in december 2006 and from own beach observations.

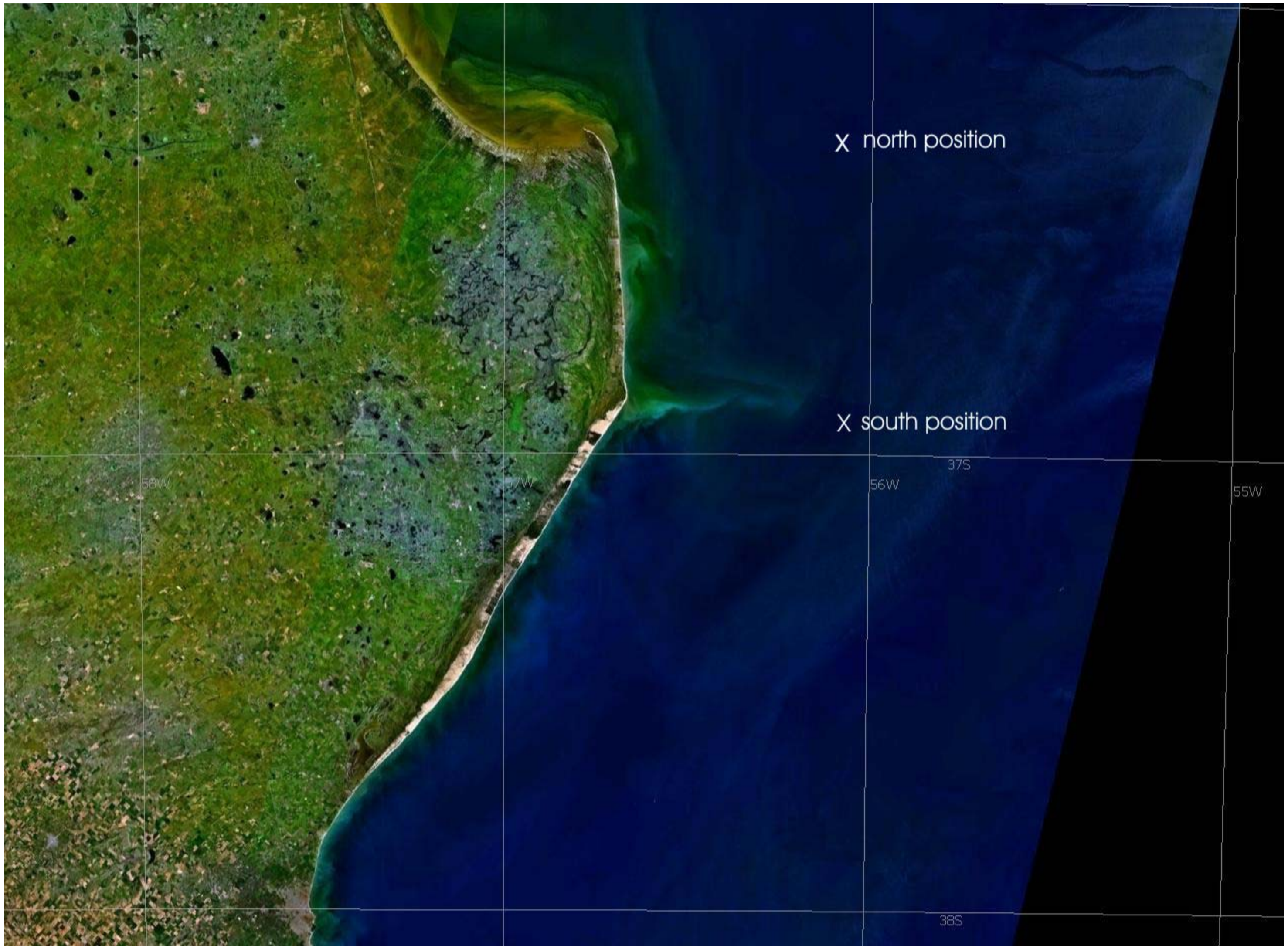

Fig. 1: Overview of the study area and position of wave climate

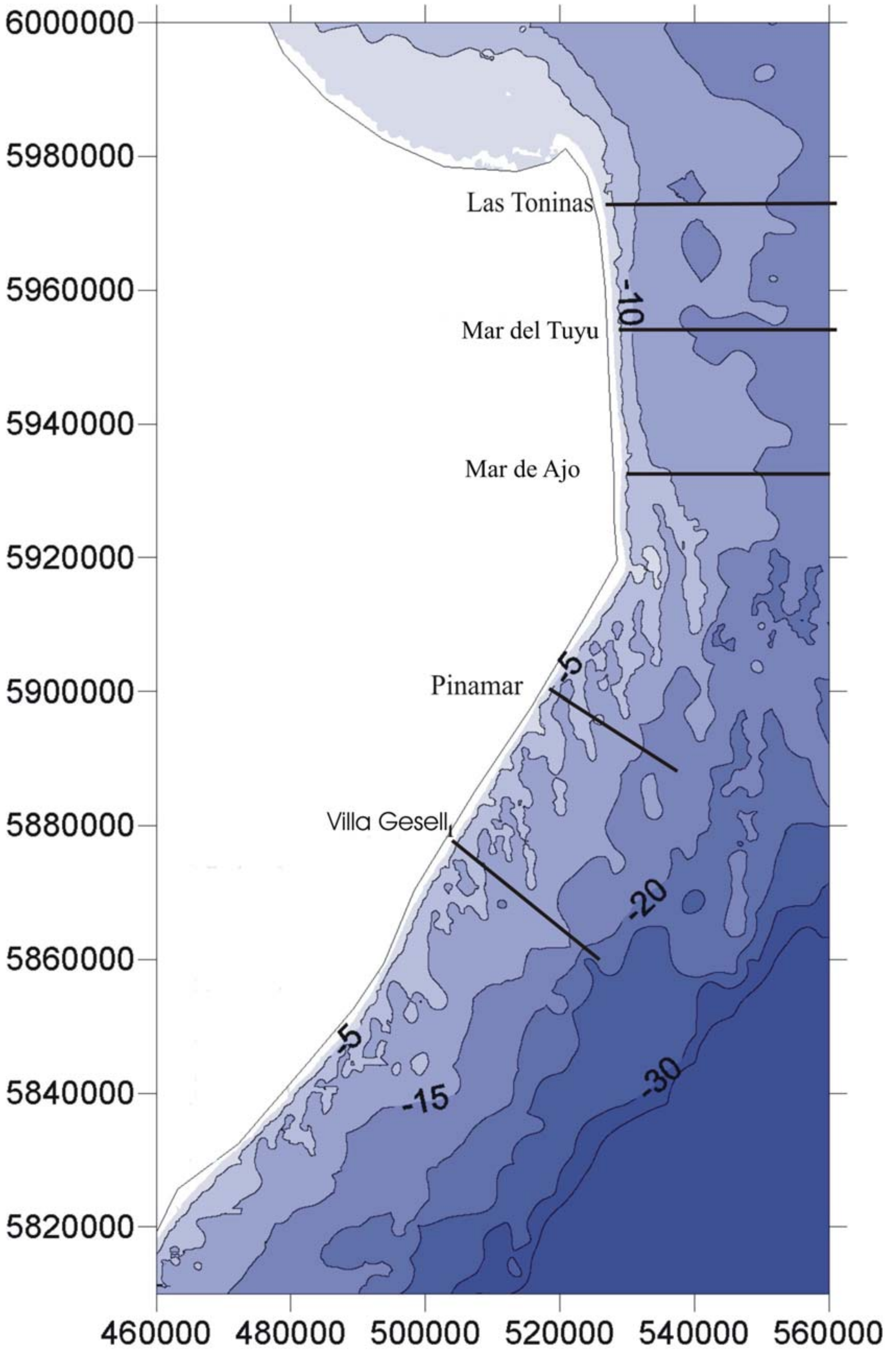

Fig. 2: Bathymetric map of the study area

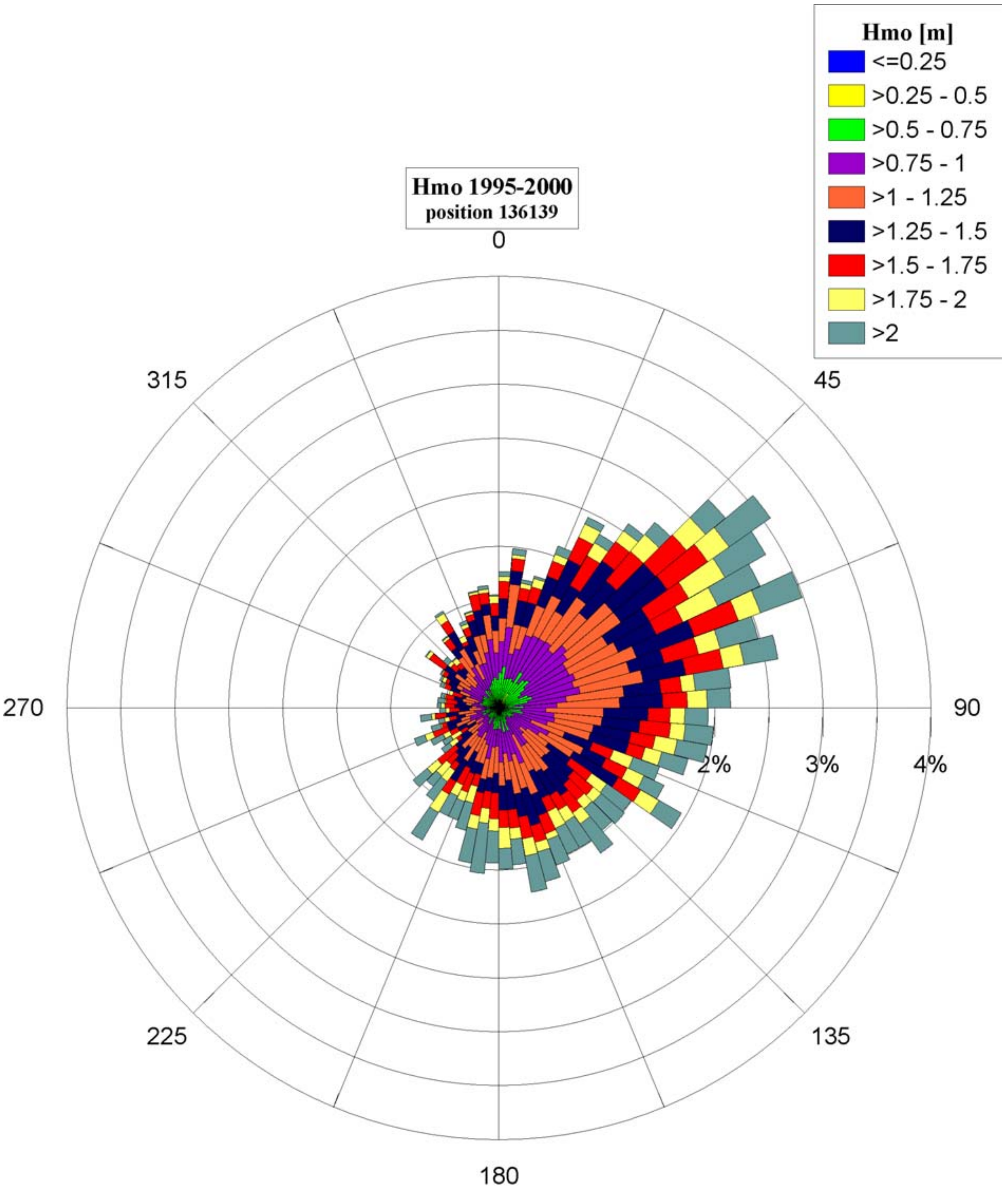

Fig. 3: Wave rose for the northern Position

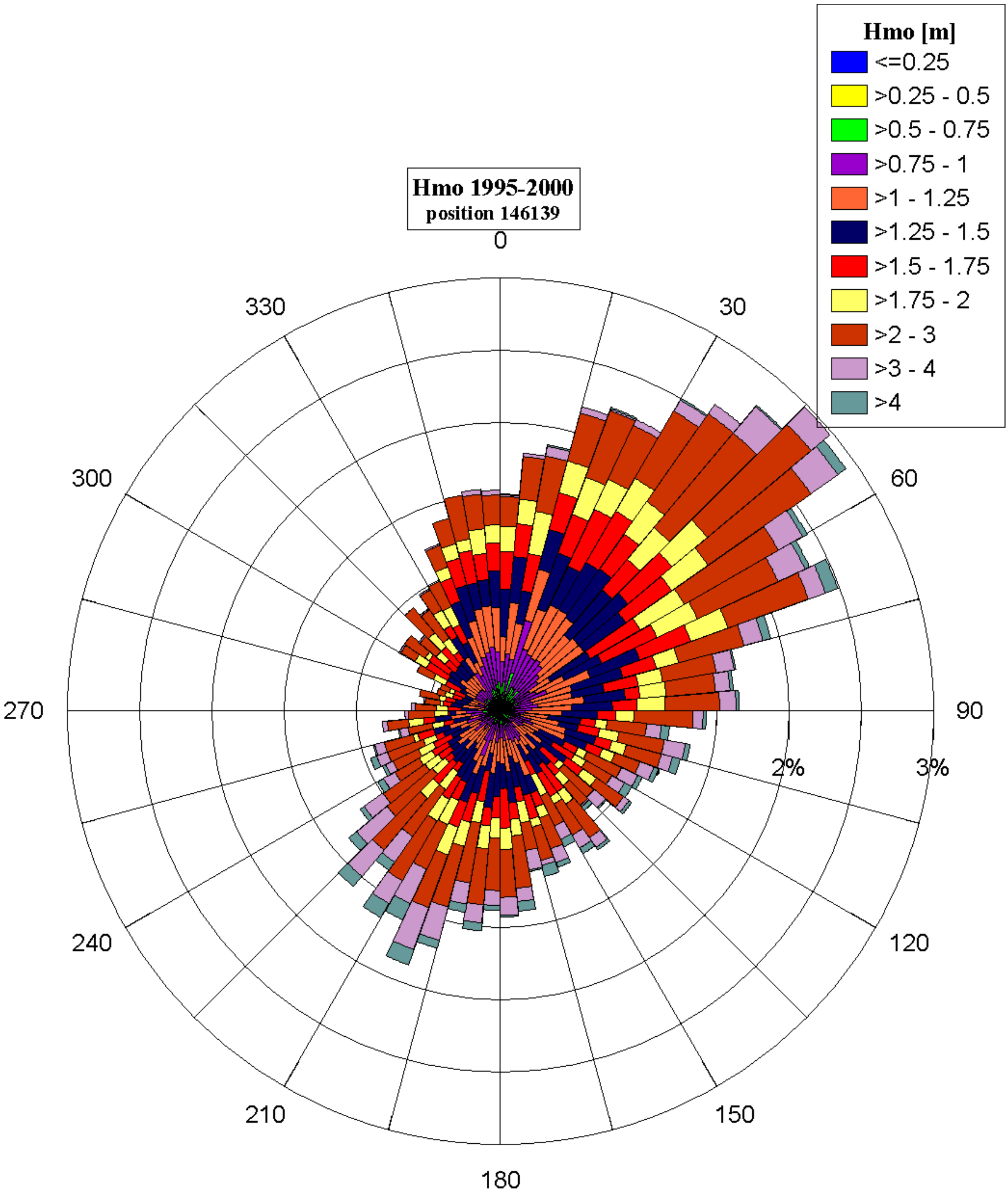

Fig 4: Wave rose for the southern position

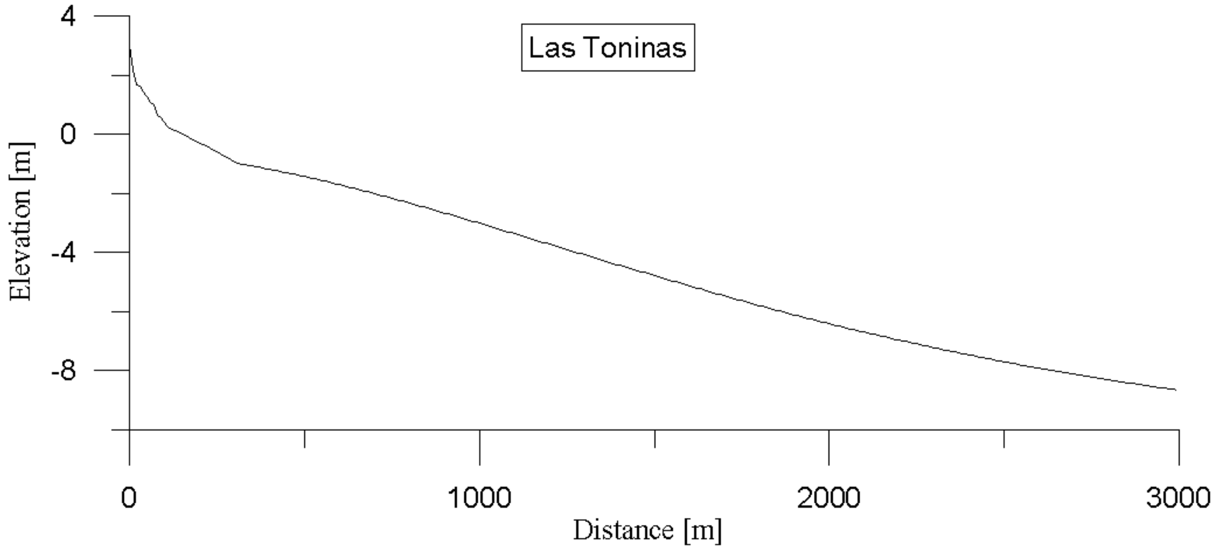

Fig. 5: Profile Las Toninas

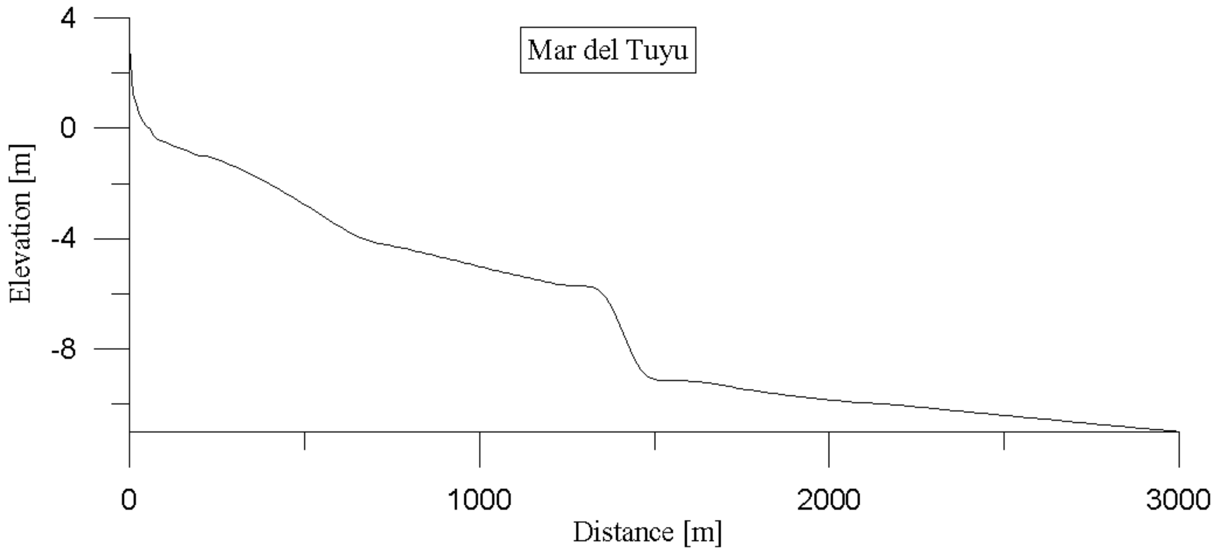

Fig. 6: Profile Mar del Tuyu

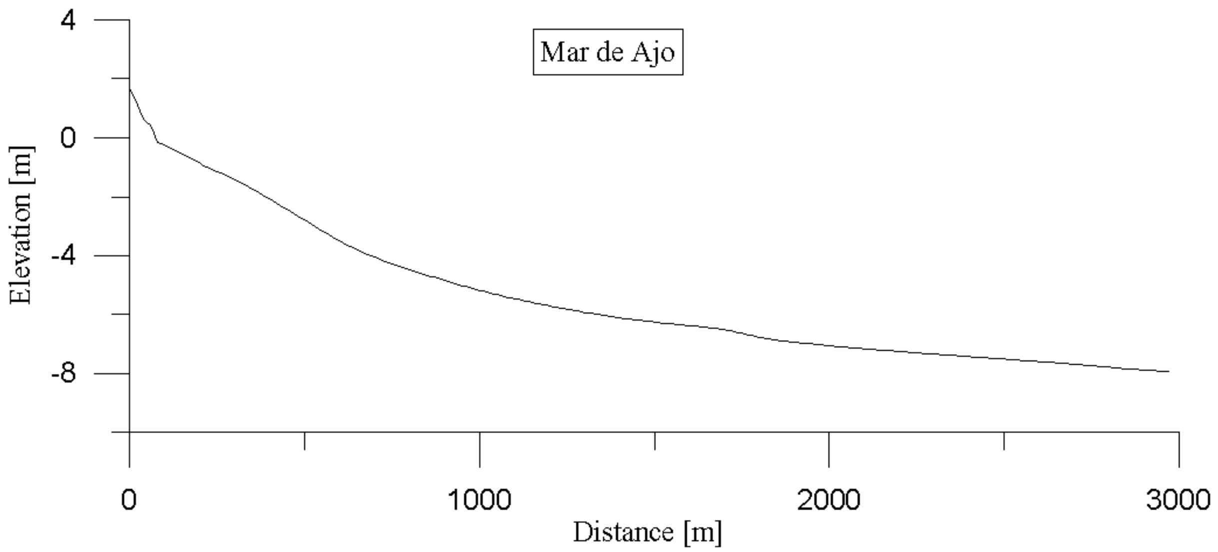

Fig. 7: Profile Mar de Ajo

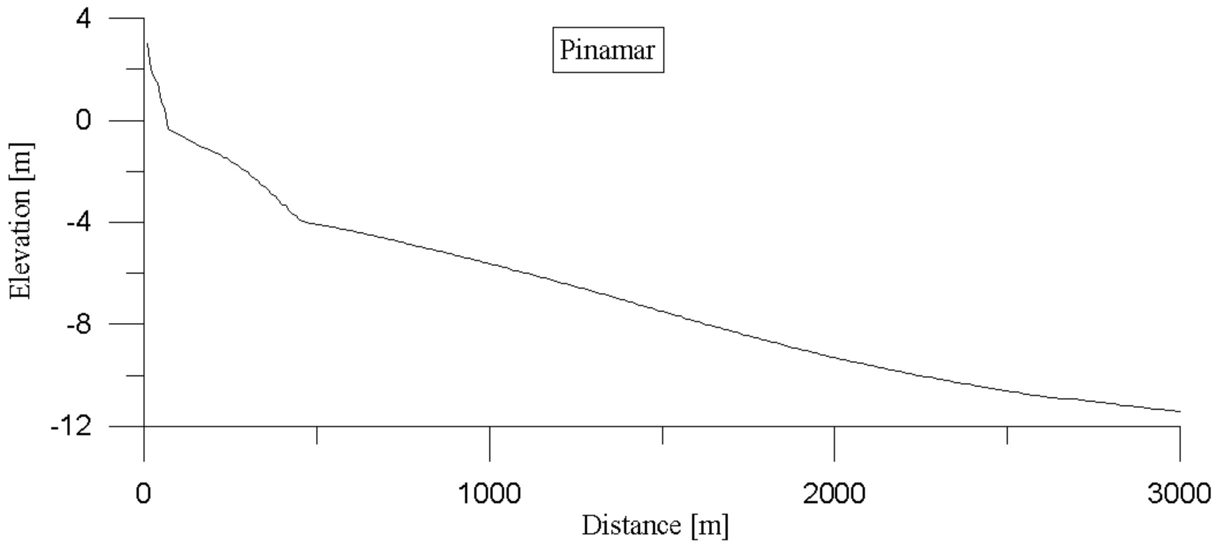

Fig. 8: Profile Pinamar

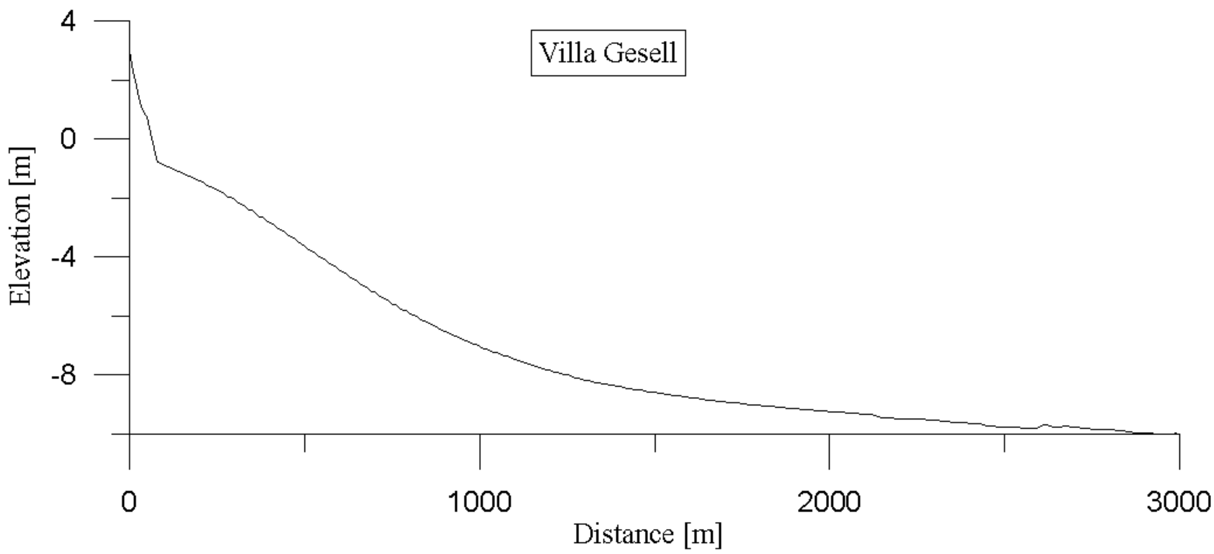

Fig. 9: Profile Villa Gesell

3. Results

In the first step the annual sediment transport rate was calculated (see. Tab.1). For the modelling the data mentioned above where used. No tidal current measurements and time series of tidal range where available. Therefore the calculations where carried out without tidal current and with tidal current. By personal communications from Enrique Schnack the tidal current was estimated as 0.3 m/s. The gross transport (this is the overall sediment transport) between Punt Rasa and Punta Medanos lies between 526000 m^3/y (Las Toninas) and 867300 m^3/y (Mar del Tuyu). The net transport (the difference between the transport to the north and to the south, the resulting transport) is going to the north and lies between ≈ 90000 m^3/y and ≈ 150000 m^3/y. Taken into account the tidal current the transport will

increase in all profile especially in Mar de Ajo, where the sediment transport increased by ≈ 200000 m^3/y to 940000 m^3/y. The net sediment transport increased up to ≈ 550000 m^3/y. Between Punta Medanos and Mar Azul the gross sediment transport without tidal current lies by ≈ 120000 m^3/y but the net transport in Pinamar is to the north and the net transport in Villa Gesell is to the south. Taking into account the tidal current the gross transport increased extreme in Pinamar and reaches up to ≈ 560000 m^3/y and to ≈ 150000 m^3/y in Villa Gesell. But more important is the net transport. Most of the sediment in Pinamar is transported to the north and the net transport direction in Villa Gesell invert to the north.
Figures 10 to 24 show the gross transport, the net transport and the overall transport to the north for each profile.
The main sediment transport take place between –1 meter and –6 meter water depths, depending on the steepness of the profile. For example the sediment transport zone in Las Toninas is much wider than in Pinamar. Only the profile in Mar de Tuyu has two peaks of sediment transport zones, depending on the steep slope in a distance of 1500 meter of the coast.
The net transport between Las Toninas and Mar de Ajo is to the north in the whole profile while in Pinamar the transport on the beach is to the south, but the transport in the foreshore is also to the north.
In Mar del Tuyu the high transport rate in ≈ 1300 meter distance to the beach dissipates a lot of wave energy on a short distance so that the overall transport rate increased. The sediment transport rate in the near shore zone in Mar del Tuyu and Mar de Ajo are more or less the same.

	Wave climate 1995-2000 Position 136139				Wave climate 1995-2000 Position 144139			
Profile Name	Net transport to north	Gross transport	Net transport with tidal current to north	Gross transport with tidal current	Net transport to north	Gross transport	Net transport with tidal current to north	Gross transport with tidal current
Las Toninas	86730	526600	512400	710700				
Mar del Tuyu	153000	847300	370000	926600				
Mar de Ajo	101300	741100	548300	940700				
Pinamar					22390	124200	562900	564200
Villa Gesell					-18760	112100	85070	149400

Tab. 1: annual sediment transport in m^3/year

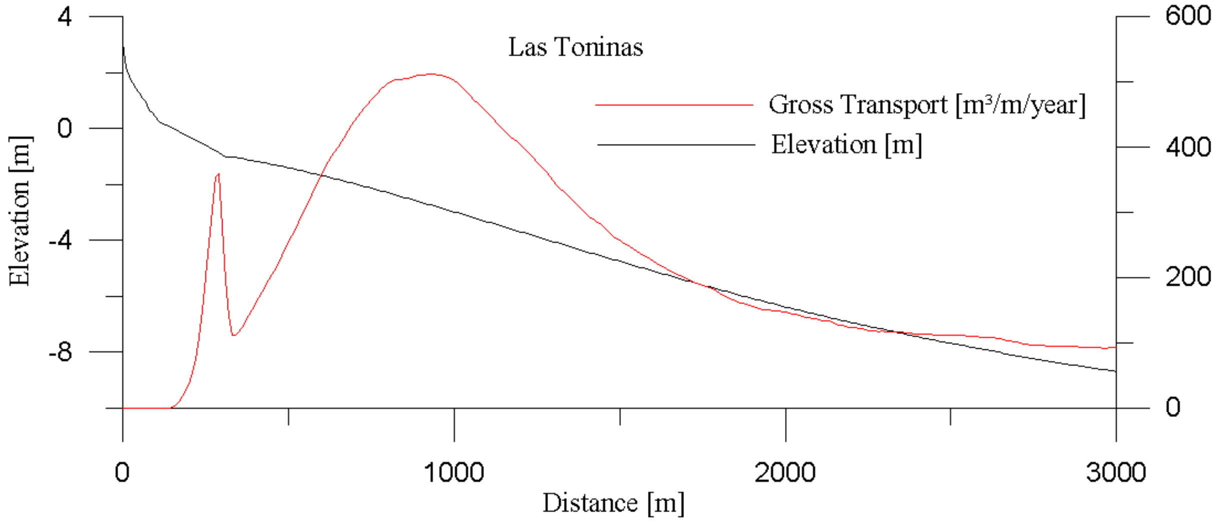

Fig. 10: Gross transport Las Toninas

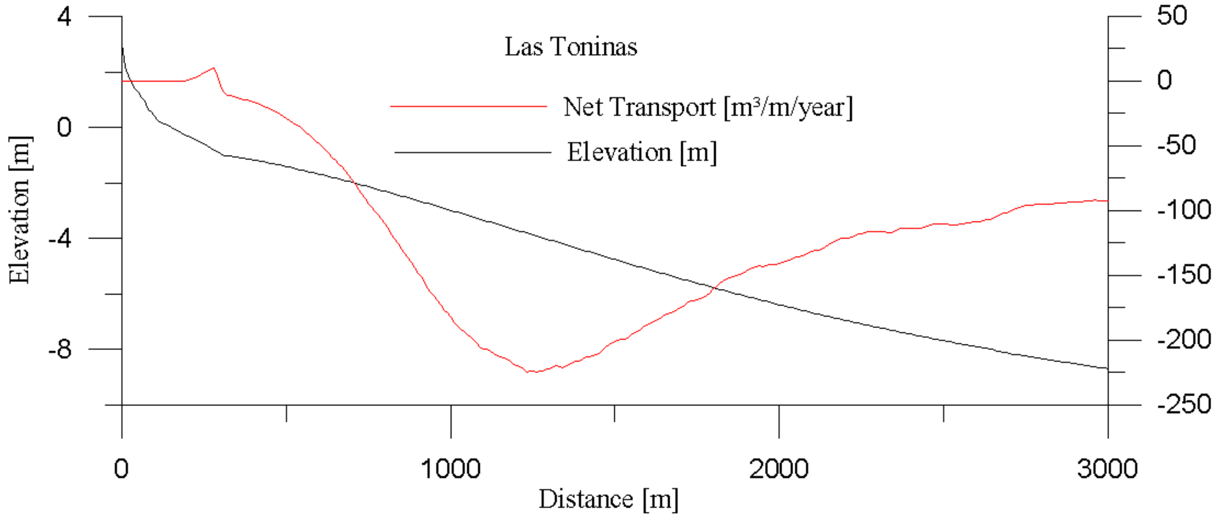

Fig. 11: Net transport Las Toninas (minus is to the north)

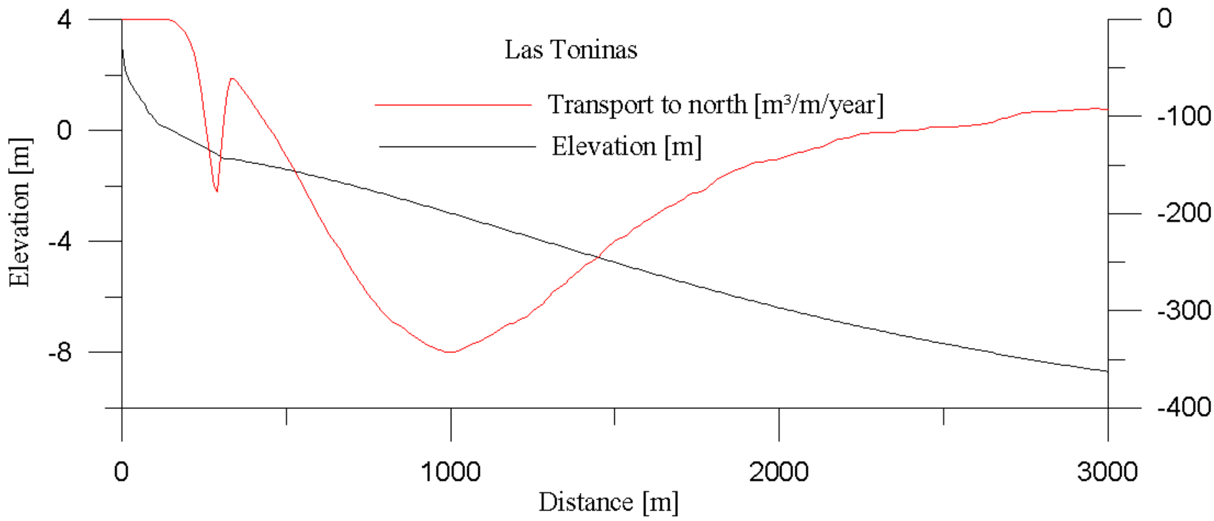

Fig. 12: Transport to north Las Toninas

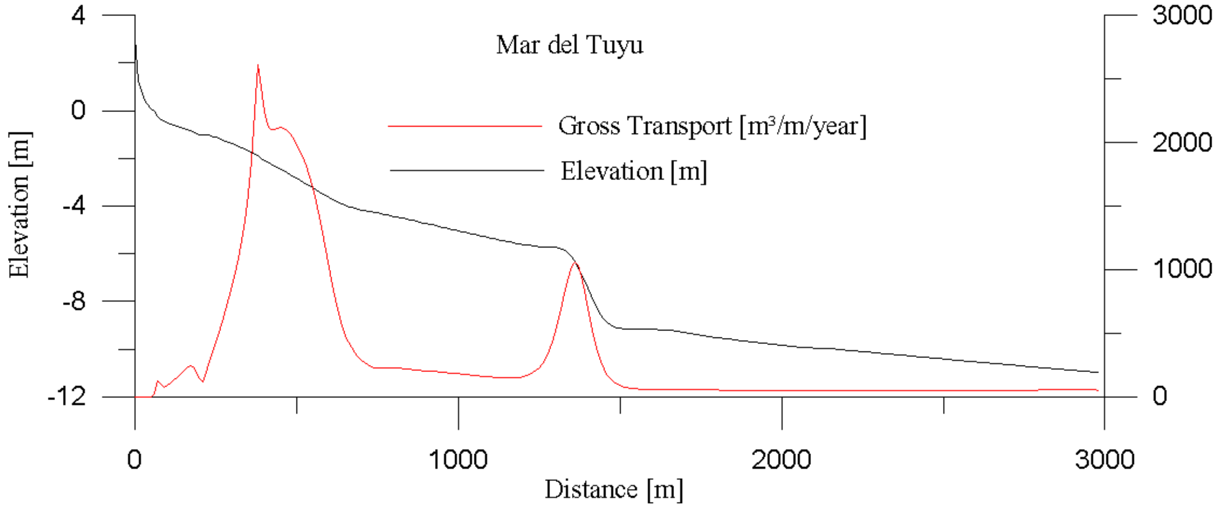

Fig. 13: Gross transport Mar del Tuyu

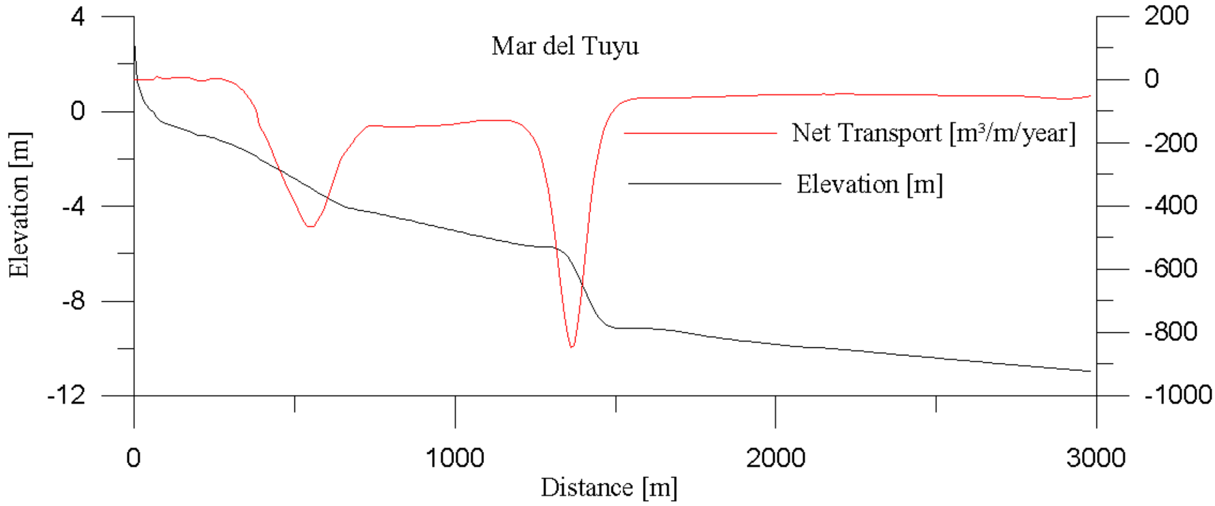

Fig. 14: Net transport Mar del Tuyu (minus is to the north)

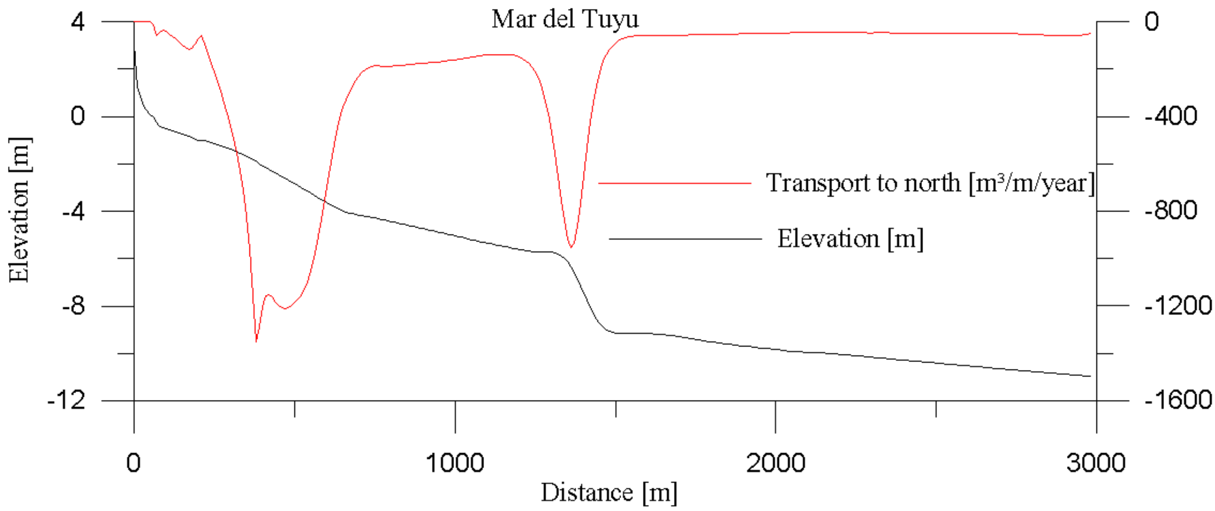

Fig. 15: Transport to north Mar del Tuyu

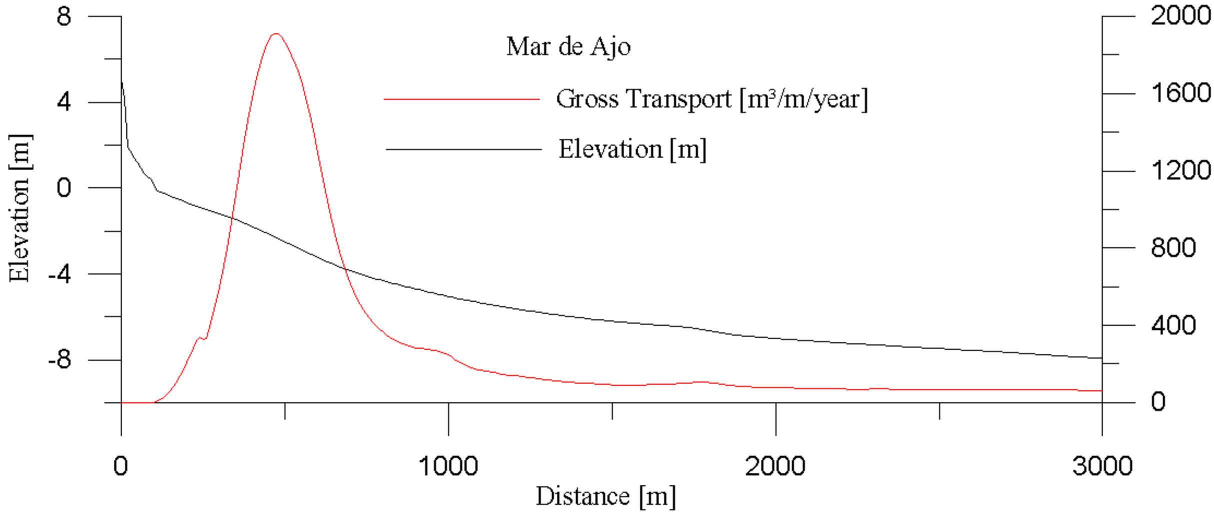

Fig. 16: Gross transport Mar de Ajo

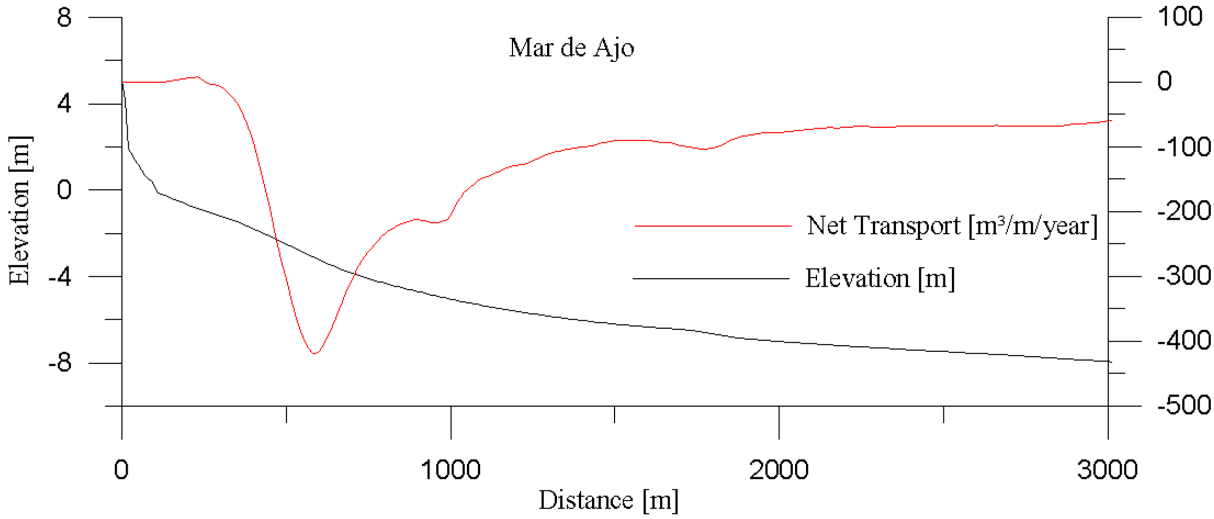

Fig. 17: Net transport Mar de Ajo (minus is to the north)

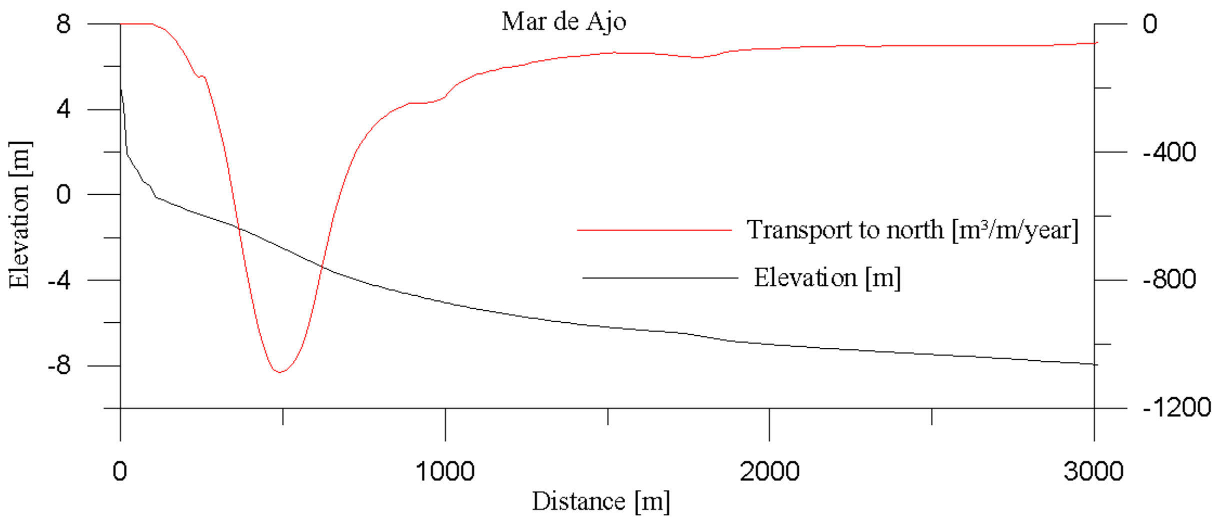

Fig. 18: Transport to the north Mar de Ajo

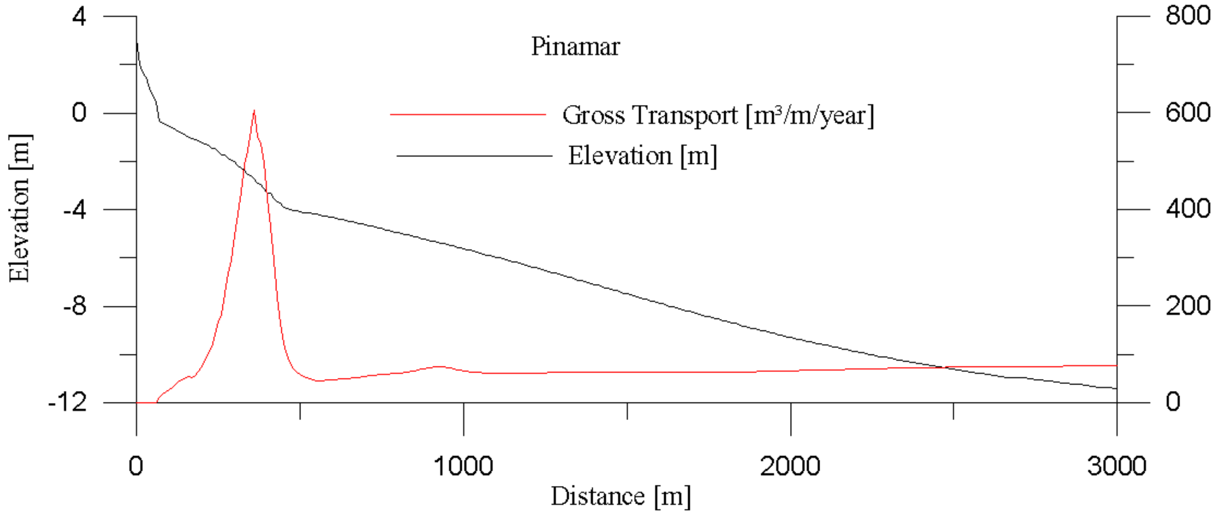

Fig. 19: Gross transport Pinamar

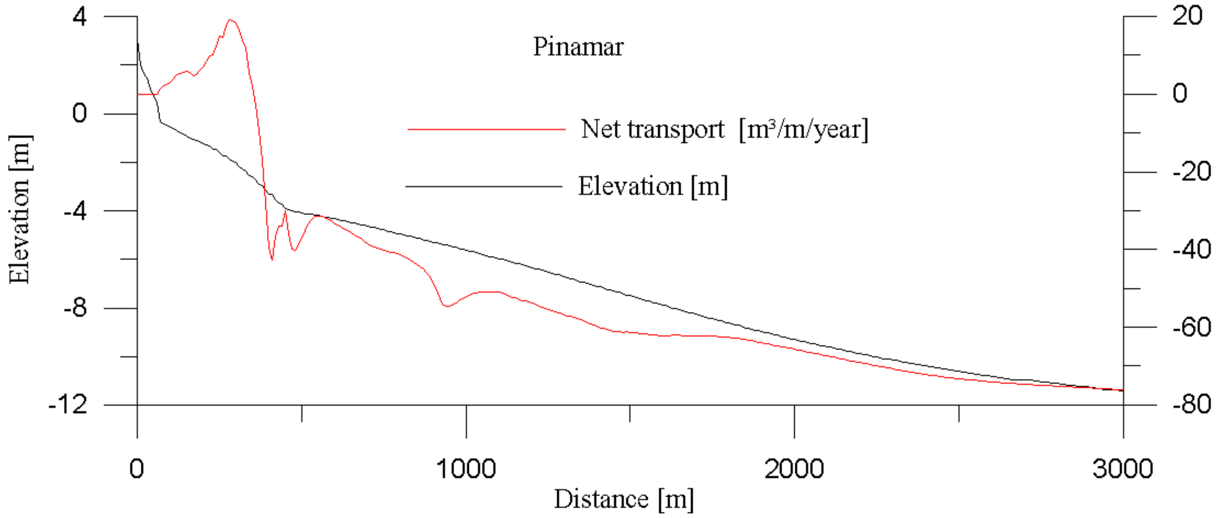

Fig. 20: Net transport Pinamar (minus is to the north)

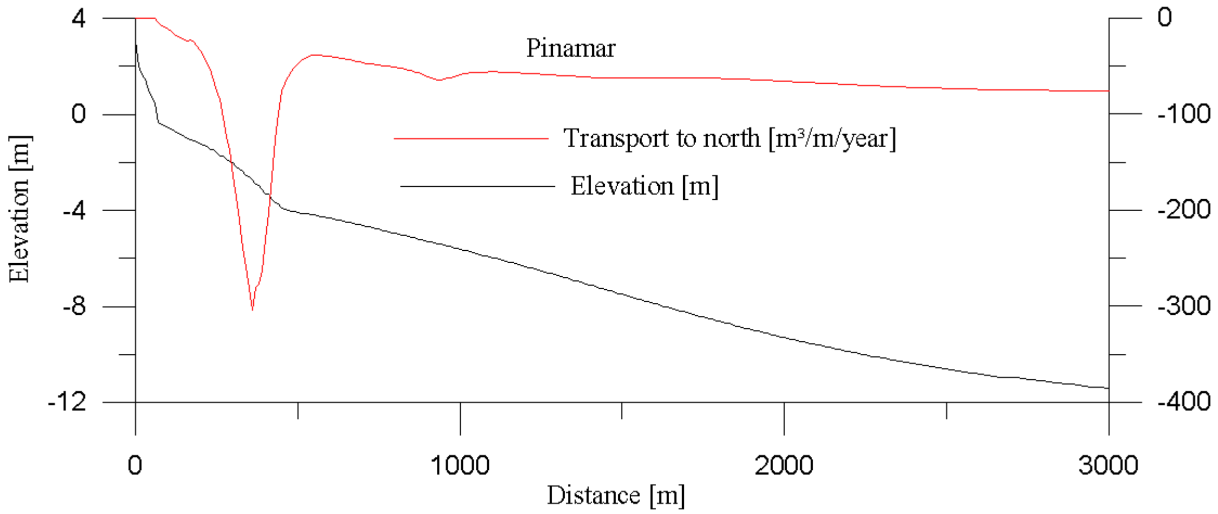

Fig. 21: Transport to the north Pinamar

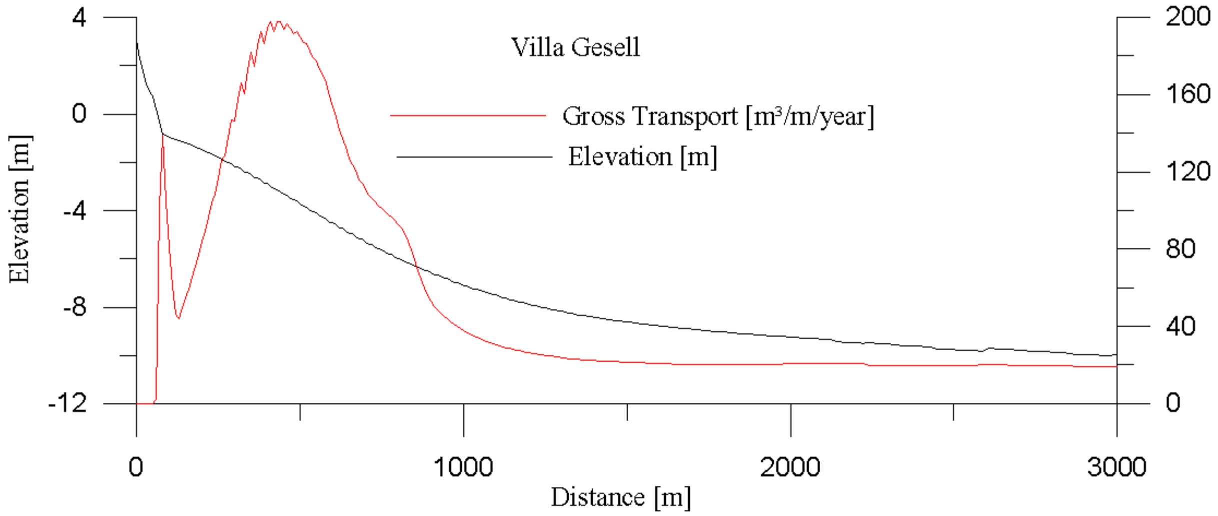

Fig. 22: Gross transport Villa Gesell

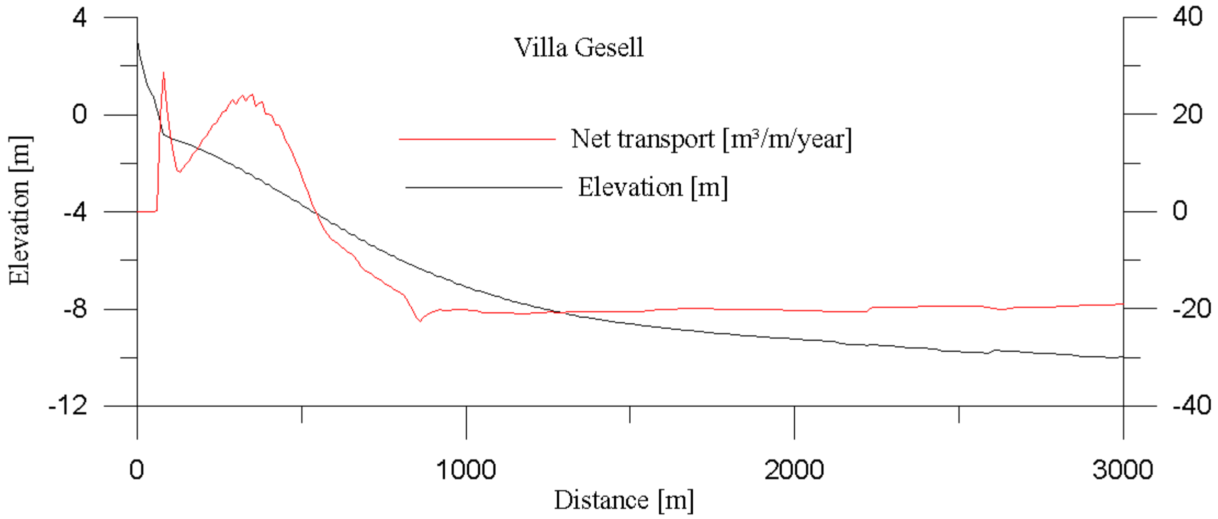

Fig. 23: Net transport Villa Gesell (minus is to the north)

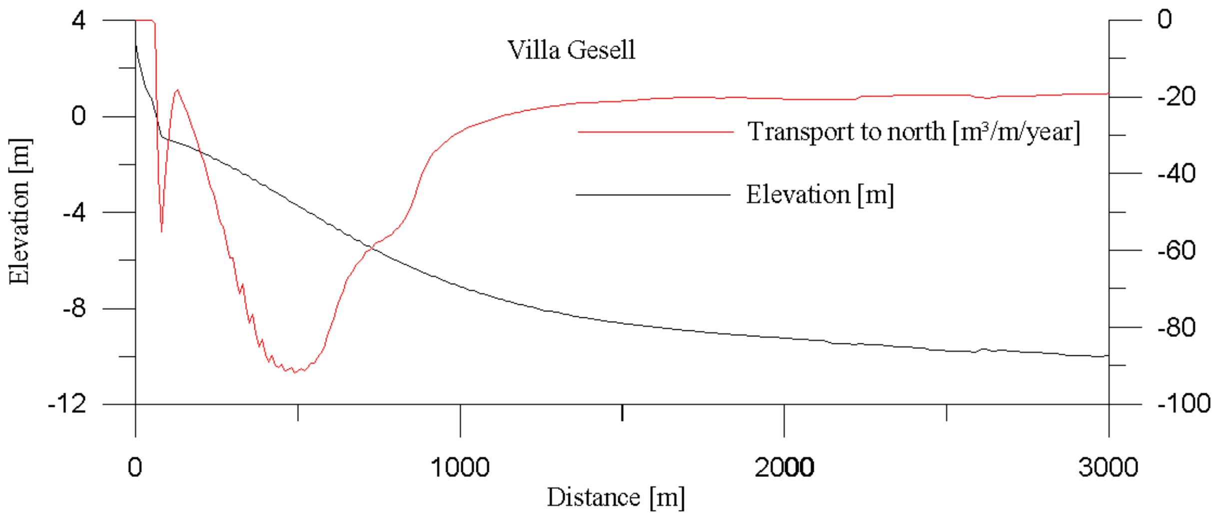

Fig. 24: Transport to the north Villa Gesell

The shape and the grain size of a nourishment are the two most important influenceable conditions. Therefore 4 different nourishment option where taken into account:

Option 1a: 3m high [NN], 50m wide, see side slope 1:10, grain size 0.2mm
Option 1b: 3m high [NN], 50m wide, see side slope 1:10, grain size 0.35mm
Option 2a: 3m high [NN], 30m wide, slope 1:10, 2m high [NN], 20m wide, slope 1:10, grain size 0.2mm
Option 2b: 3m high [NN], 30m wide, slope 1:10, 2m high [NN], 20m wide, slope 1:10, grain size 0.35mm

For the calculation of the profile development the time series from January to mid of February 1995 where taken. This time series was chosen because there was a storm with up to 5 meter wave height. Start date is the 01.01.1995 and end date is 11.02.1995. Additional a grain size of 0.35 mm with a density of 2.65 was taken into account. The profile from Mar de Ajo was taken as an example for the calculation. For an exact calculation of a optimal nourishment we need better profile and wave data for each beach position.

Fig. 25 – 29 show the profile development and the int. long shore transport which is the integrated long shore transport over the time series (6 weeks). A +1 meter mean water level was taken into account during the storm. The higher beach is not influenced during this storm. The annual sediment transport as calculated over the time series from 1995 to 2000 as annual sediment transport is not influenced, because the amount of the sediment transport of the beach is to less regarding the sediment transport over the complete profile.
Fig. 25 shows the sediment transport and the profile evolution up to 3000 m distance from the beach. From ≈ 800 m distance from the beach to the off shore region there is no significant long shore sediment transport and no profile change. The direct influenceable region on the beach ends at ≈ -2 m. Therefore the first 500 m are shown in the fig. 26-29.
No long shore sediment transport on the beach but erosion means, that there is only cross shore transport which is also calculated, but not shown here.
It is obvious that a greater grain size will reduce intensively the sediment transport rate (compare option a with option b) and that option 1 is a little bit but not significant better than option 2.

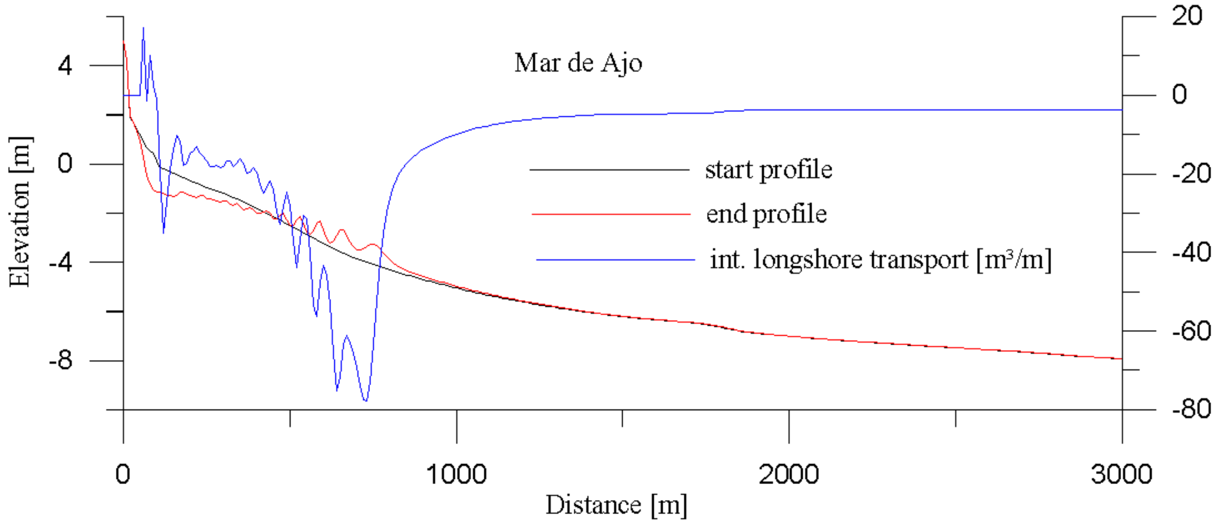

Fig. 25: Profile evolution and int. long shore transport up to 3000 m distance from the beach

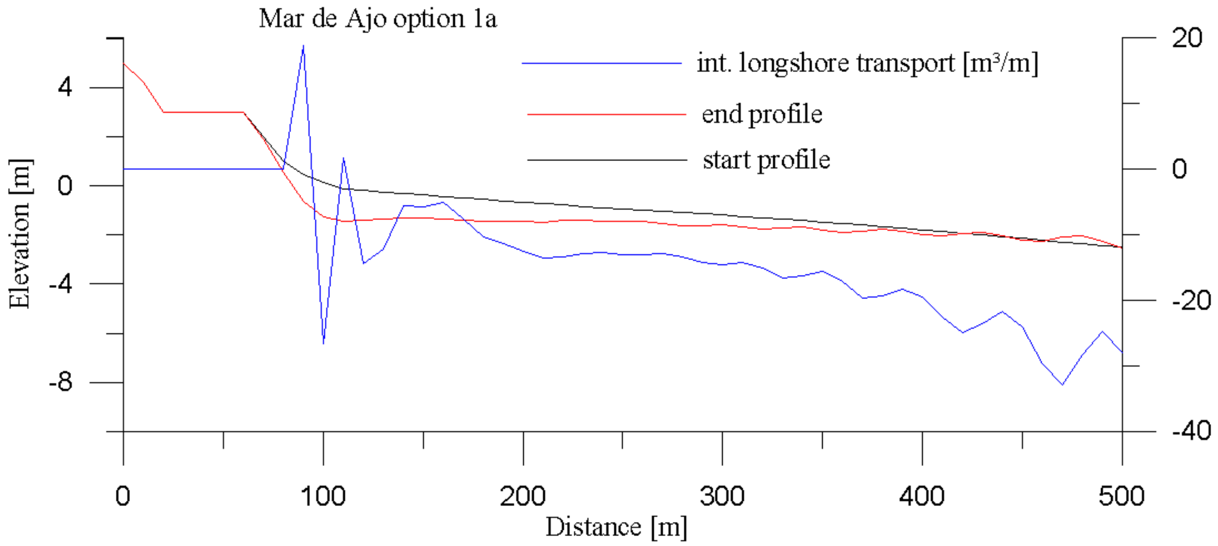

Fig. 26: Profile evolution and int. long shore transport up to 500 m distance from the beach, option 1a (grain size 0.2mm)

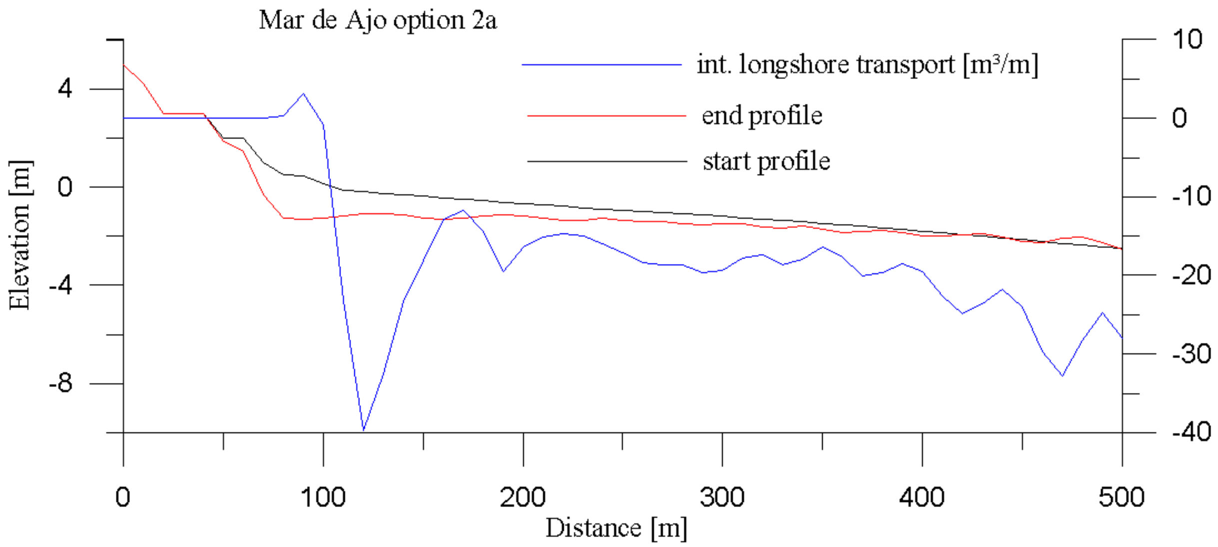

Fig. 27: Profile evolution and int. long shore transport up to 500 m distance from the beach, option 2a (grain size 0.2mm)

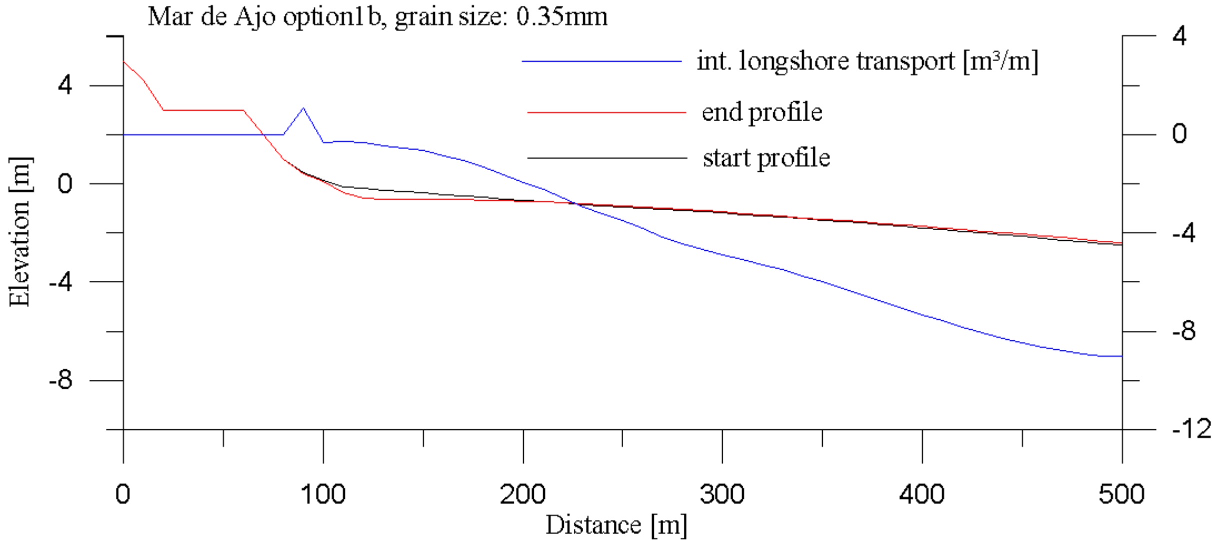

Fig. 28: Profile evolution and int. long shore transport up to 500 m distance from the beach, option 1b (grain size 0.2mm)

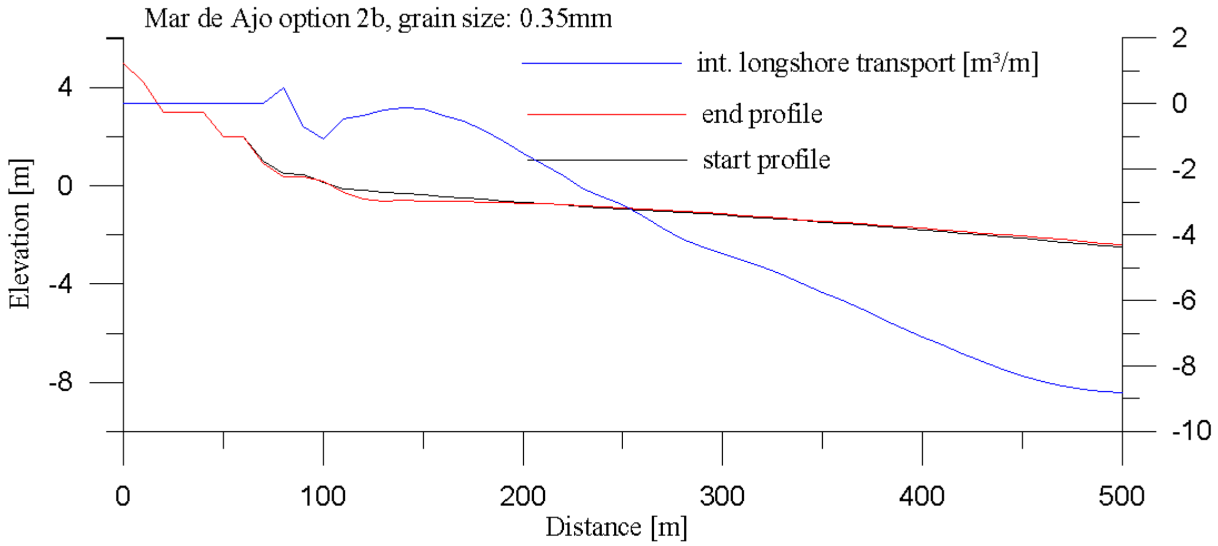

Fig. 29: Profile evolution and int. long shore transport up to 500 m distance from the beach, option 2b (grain size 0.35mm)

Conclusion

The sediment loss is ≈ 550000 m^3/y and the gross transport ≈ 1000000 m^3/y.
A nourishment is a good option for stabilisation of the beach. There will be no negative influences to adjacent regions. In the beginning of the nourishments the eroded beaches and the areas with high coastal retreat should be nourished. After this basis nourishments a annual input of ≈ 500000 m^3 north of Punta Medanos and also east of Mar Azul should stabilize the beaches sustainable. Nourishment of long shore bars are also a option and should be taken into account. A numerical modelling can give hint for the effect of such nourishment but better data are necessary.