CHAPTER 196

STORM EROSION ON A SANDY BEACH

Jesús Martínez *
Ricardo Alvarez *
Ignacio Alonso *

Abstract

Present paper describes the different behaviour of the foreshore of a sandy beach faced with stormy events. Two storms have been selected, since they present a fairly distinct wave approaching direction between them, according with wave forecast maps.

For the first stormy situation waves came for west, and the effect was an accretion on the north end of the beach while an important erosion happened on the south side. With regard to the second storm in which waves came from northwest, an erosive trend was observed all along the beach.

Sandy movements are quantified as net volume changes as well as by means of the erosion and accretion percentages, defined from the sedimentary variability indice.

Description of the beach under study

The beach under study has a total length of 3000 m., is located in the north coast of the Island of Gran Canaria (Spain), and is sheltered from the prevailing northeastern wind and swell. (Fig. 1)

According with Larson's (1988) definition of the backshore and the foreshore, in certain areas the width of the foreshore can reach 100 m. and that of the backshore 50 m. The submerged beach is partially broken up by a fragmented rocky bar that emerges at low tide and affects the larger part of the beach.

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* Department of Física, University of Las Palmas de G. C.
Apartado 550, Las Palmas, Spain.

This beach is divided into two principal sub-environments, according with the beach stages proposed by Short (1978): Las Canteras North between ranges 10 to 16, and Las Canteras South between ranges 1 to 8. The former behaves as a reflective beach while the last one as a dissipative beach. There is an small central sector called "Short Beach" between ranges 8 to 10 which is studied separately due to its peculiarity, since it is considered an small pocket beach 90 metres long that is in the middle of a much larger pocket beach. (Fig. 2).

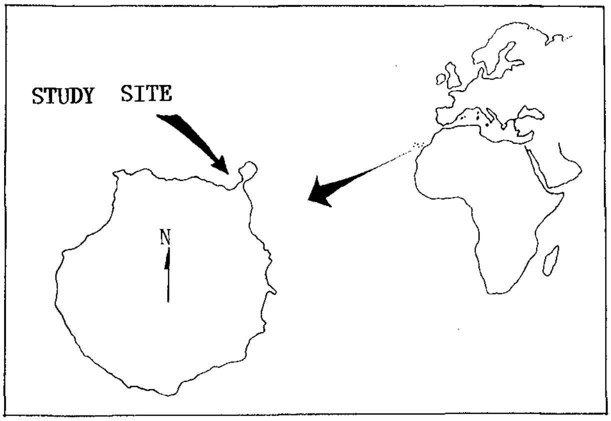

Figure 1. Location map of the beach under study.

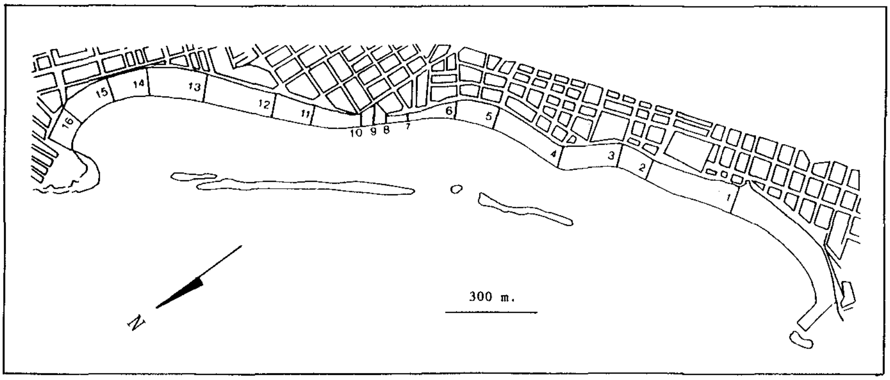

Figure 2. Scketch of Las Canteras beach showing position of the different rangelines and the rocky bar.

If the whole beach is considered, the major accretions take place during the summer period, when the prevailing swell is coming from northeast. The major erosions show up during the fall-winter period, coinciding with the seasonal northwestern storms.

Methodology

Profile data

Sixteen rangelines across the beach have been surveyed between June 26, 1987 and July 24, 1990, approximately at monthly intervals. Surveys were always carried out at low tide using a leveling method, down to about 1 to 1.5 metres below MSL (Martínez et al, 1990).

With regard to the first stormy event, the survey of December 7, 1987 was carried out almost at the end of the storm, but the previous survey was carried out just a month before. In the second situation, an extra survey was carried out just at the end of the storm, only four days after the previous survey which was almost at the beginning of the higher waves.

Sedimentary accretions and ersions on the foreshore were calculated according with Kriebel et al (1986).

Storm characteristics

Two stormy situations have been selected:

- First one between December 2 and 9, 1987.
- Second one between December 26, 1989, and January the second, 1990, although the strongest point took place on December 29 and 30.

First stormy situation corresponded to an strong Atlantic squall centered westhward Portugal, that produced barometric lows of 1006 mb. over the Canary Islands, and winds up to 75 km/h where registered. To estimate the approaching wave direction, wave forecast maps were employed. It can be seen the sea coming from west. (Fig. 3).

Significant wave heigths higher than 4 metres, and maximun heigths around 7.5 metres were recorded by means of a wave gauge placed 1800 metres offshore the beach. (Fig. 4).

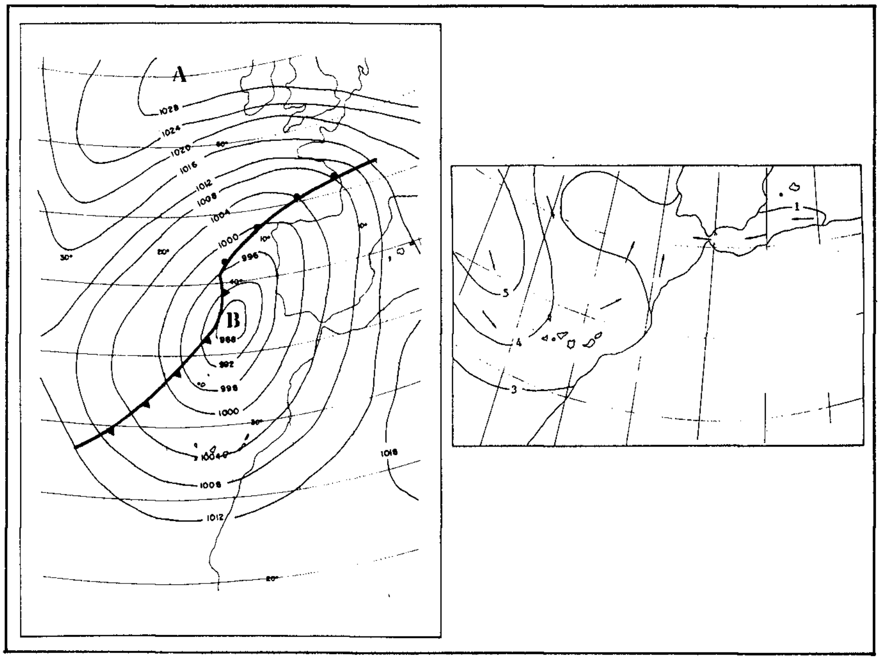

Figure 3. Weather chart and wave forecast map corresponding to December 3, 1987.

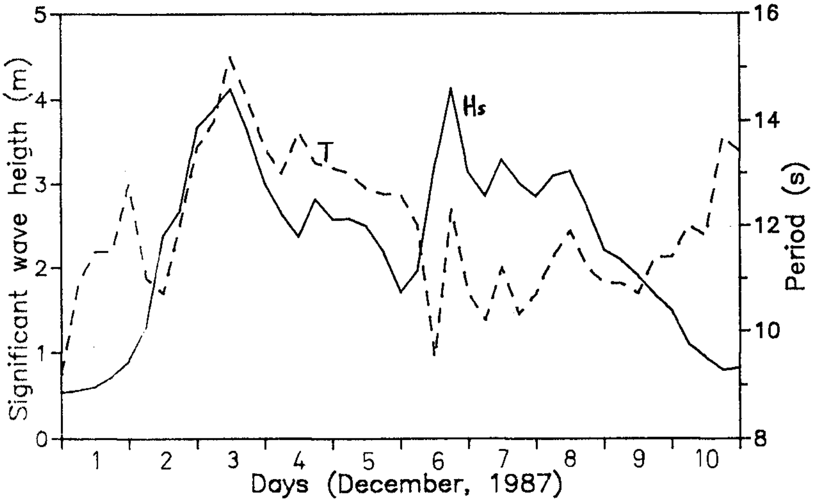

Figure 4. Evolution of significant wave heigth (Hs) and period (T) during the first storm.

The second storm was due to another squall centered northeast Canary Islands, that produced barometric pressures of 1000 mb and winds up to 100 km/h in the Canary Islands area.

Unfortunately, the wave gauge was out of service, so wave characteristics were estimated from the wave forecast maps provided by the National Meteorological Service. As a result, mean wave heigths up to 4 to 5 metres coming from northwest were predicted. (Figure 5).

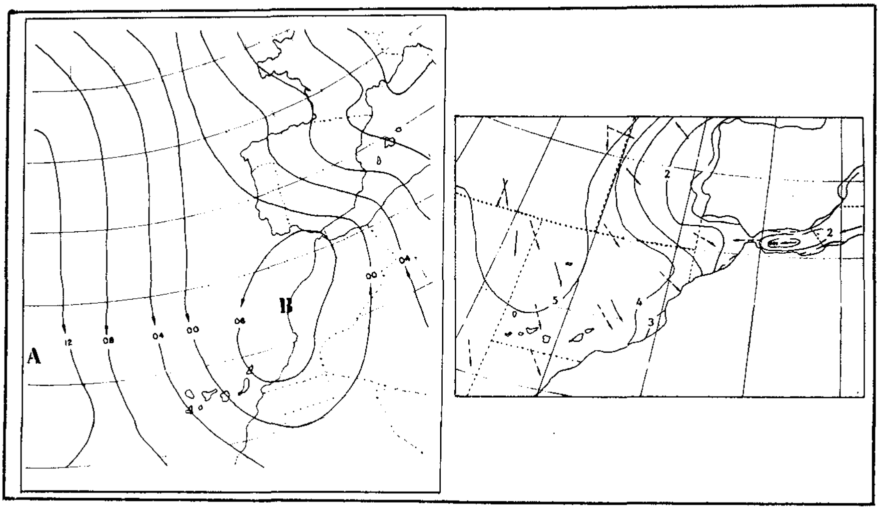

Figure 5. Weather chart and wave forecast map corresponding to December 30, 1989.

New parameters

To analyze the morphological evolution of the beach with regard to these situations, the sedimentary variability indice was emloyed, defined as the change of mean height between highest accretion to lowest erosion and vice versa, which happen on the beach surface within a sedimentary cycle.

This indice is obtained dividing the net losses or accumulations of sand, in cubic metres, by the delimited surface. Starting from this indice, the erosion and accretion percentages are obtained.

The erosion percentage is defined as the percentage of decrease of the sedimentary variability indice between two surveys, within an erosive period.

On the other hand, the accretion percentage is the percentage of increase of the indice between two surveys, but in this case, within an accretionary subcycle.

Both percentages are good to evaluate the relative magnitude of the erosive / accumulative processes in a given period, within the relative erosive / accretive subcycles. It is necessary to take into account that an accumulative process may happen within a general erosive trend, and vice versa.

Discusion and Conclusions

In relation to the first stormy situation, we estimate sedimentary losses of about 2000 cubic metres on a 21 metre wide foreshore strip, all along the beach. (Table 1).

Date	Whole Beach	Las Canteras North (Profs.10-16)	Short Beach (Profs.8-10)	Las Canteras South (Profs. 1-8)
Nov.7-Dec.7 1987	-1944 (-4.2)	2088 (10.5)	-406 (-21.1)	-3677 (-14.4)
Dec.29,1989 -Jan.2,1990	-5988 (-12.6)	-3806 (-19.1)	-96 (-5)	-2077 (-8.1)

Table 1. Sedimentary losses and accumulations in m3 for both storms, only in a 21 metres wide foreshore strip. Data in brackets are the average heigth changes in cm. on the same area.

These losses assume an erosion percentage of 15.5 % of a sedimentary variability indice of 0.27 m., corresponding to the erosive subcycle.

The above-mentioned erosion percentage has a low value in relation to the others of the same sub-cycle. These others reach up to 41.4 % at monthly intervals, out of significant stormy situations. (Table 2).

Date	1		2		3		4	
	E.P.	A.P.	E.P.	A.P.	E.P.	A.P.	E.P.	A.P.
7-28, 1987							3.2	
9- 9, 1987	38.5		92.2				2.6	
10-10, 1987	41.4			8.3			53.9	
11- 7, 1987	4.6		16.1				5.2	
12- 7, 1987 *	15.5			61.8	55.7		35.1	
1-20, 1988		19.1	47.6		18.0			40.2
2-20, 1988		2.2	1.3		14.3			4.1
3-19, 1988		13.0		15.8		1.2		9.1
5- 2, 1988		0.8		12.7	13.2		2.6	
6- 1, 1988		2.7	38.3			20.0		14.8
7- 1, 1988		51.9		96.9		43.2		20.2
7-31, 1988	20.3		7.6			7.8	19.1	
8-29, 1988	13.1		19.9			8.2	3.1	
9-29, 1988		43.7		17.8		20.8		36.4
10-24, 1988	32.3			5.6	1.9		49.2	
11- 8, 1988	62.8		95.9		19.6		36.8	
11-24, 1988		16.2		12.7	6.2			5.8
12-24, 1988		57.7		12.6	22.9			67.4
1-23, 1989	10.3			3.1		12.4	20.5	
2-21, 1989	32.7		4.5		12.3		39.3	
3-23, 1989	35.8		16.4		8.1		27.4	
4-22, 1989		1.2		1.8	41.4			2.9
5-22, 1989		51.7		23.7		33.2		59.3
6-19, 1989		40.5		28.8		27.8		37.8
7-21, 1989	13.6		20.4			8.5	4.6	
9-15, 1989		20.2		58.6		30.5	19.8	
10-17, 1989	66.6		73.1		35.5		43.9	
10-27, 1989	4.7			18.5		1.4	24.8	
11-28, 1989	28.7		45.4		8.3		6.9	
12-29, 1989		52.6		61.4	51.3			47.4
1- 2, 1990 *	24.1		25.0		6.3		22.0	
1-27, 1990		35.4		27.3		17.8		46.5
2-27, 1990	46.0		49.2			49.8	48.4	
3-28, 1990		39.7		38.6	10.3			43.5
4-25, 1990		0.3	5.9			1.4		10.3
6-22, 1990		24.4		24.1		19.1		22.7
7-24, 1990		17.7		28.7		22.2		

Table 2. Values of erosion percentages (E.P.) and accretion percentages (A.P.) on Las Canteras Beach. Column 1 is the whole beach and columns 2, 3 and 4 are the different sectors (Las Canteras North, Short Beach and Las Canteras South respectively). Dates of studied storms are highlighted with *. Erosive and accretive subcycles are separated with horizontal lines.

There was a distinctly different behaviour in the two main sectors of the beach: while a significant erosion took place in Las Canteras South, an important accretion happened in Las Canteras North.

In Las Canteras South, the storm caused an erosion percentage of 35.1 %, of a sedimentary variability indice of 0.41 m. corresponding to the erosive subcycle. That is to say, the foreshore had a mean drop of 0.14 m.

On the other hand, las Canteras North had an accretion percentage of 61.8 % of a sedimentary variability indice of 0.17 metres calculated for the accretionary subcycle. This represents a mean accummulation of 10 cm. for the foreshore along this sector.

This tilt was due to the strong westerly waves, and explains the low erosion percentage for the whole beach, since sedimentary losses and accumulations become balanced between the two main sectors of the beach.

However, it is necessary to take into account that the above-mentioned sandy movements, might be not only due to the storm, but also to other less important sedimentary processes that happened during the 25 previous days to the storm, and that could be responsible for the softening of the final erosion.

If the whole sedimentary cycle is considered, the most important erosion percentages are not precisely related to this significant storm, which was the most energetic one. In the specific case of Las Canteras South, mean sedimentary losses larger than those measured during the storm, were calculated for the pre-stormy period.

An explanation for this fact can be bassed on by considering that a beach, inmediately after having reached its maximum accretion, is very susceptible to suffer great sand losses due to slight increases in waves energy. In this case, these situations happen with the first sporadic manifestations of northwestern swell and with the fall of the dominant northeastern winds.

In relation with the second stormy situation, we estimate sedimentary losses of nearly 6000 cubic meters in only 4 days for the same foreshore strip defined for the previous case, all along the beach. This ammount of eroded sediments involves a decrease of 12.6 cm. all along the beach (see Table 1). The calculated sedimentary variavility indice was 0.52 m., and the relative erosion percentage was 24.1 % within an accumulative subcicle (see Table 2).

Although the whole beach was eroded, the average decrease was around 8.1 cm. in Las Canteras South and 19.1 cm. in Las Canteras North. The respective erosion percentages were 22 % and 25 %, and the sedimentary variability indice was 0.37 m. for the northern sector and 0.76 m. for the southern sector, but in both cases within accumulative subcycles.

In this case there were no tilt, but the greatest erosion took place where the accumulation was previously produced.

The difference in the behaviour of the beach, in view of the two stormy situations analyzed, can be explained due to the different characteristics of the storms, specially as for the waves approaching direction. In the first situation waves were coming from west while in the second one were approaching from northwest.

References

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