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Authors: De Melo Apoluceno, D., Howa, H., Dupuis, H., and Oggian, G.

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Morphodynamics of Ridge and Runnel Systems during Summer

D. De Melo Apoluceno†, H. Howa‡, H. Dupuis† and G. Oggian†

†DGO, CNRS - UMR 5805 "EPOC"
Université Bordeaux I
Avenue des Facultés
33405 Talence Cedex
France

‡Université d'Angers, UFR Sciences
2 Boulevard Lavoisier
49045 Angers Cedex 01
France

ABSTRACT

Morphological analysis of ridge and runnel systems is carried out for a 1.6 km long straight shoreline at the Truc Vert Beach (French Atlantic Coast). Foreshore has been investigated through high-resolution shoreline cartography and topographic surveys recorded during summers, from 1999 to 2001. Hydrodynamic data are from the VAG-ATLAwave model and a TRIAXYS wave buoy.

1999 shoreline maps show three rhythmical ridge and runnel systems with an average wavelength of 480 m. The SSW-NNE trend bars were about one meter high. Runnels were SW-NE oriented. The crosshore profiles of 1999 point out the shoreward sediment's transfer of both berm and bar. During summer 2000, bars and channels are disrupted, whereas 2001 surveys show an irregular and double system of nearshore and foreshore bars.

The shoreline map analysis underlines a conceptual model of ridge and runnel systems described by four phases: from the nearshore bar formation to the bar welding to the foreshore and system organization. These rythmical systems migrate longshore to the south.

ADDITIONALINDEXWORDS: *longshore dynamics, conceptual model, bar formation, Atlantic Coast.*

INTRODUCTION

Bars are the main morphological result of the interaction between sediment transport gradients and wave dynamics. Thus, bars assume varied morphological shapes along many beaches around the world (HOLMAN and BOWEN, 1982; WRIGHT and SHORT, 1984; AAGAARD, 1991; MULRENNAN, 1992; LIPPMAN *et al*., 1993; KOMAR, 1998; MICHEL and HOWA, 1999).

Three major concepts of nearshore bar formation do exist. The first one combines the bar formation with sediment sediment convergence close to the wave breakpoint (DALLY and DEAN, 1984; DOLAN and DEAN, 1985; HOLMAN and SALLENGER, 1993). The second concept links bar formation to (anti) nodes positions of infragravitary standing waves (BOWEN and INMAN, 1971; BOWEN, 1980; AAGAARD, 1991; SHORT, 1991; HOLMAN and SALLENGER, 1993; O'HARE and HUNTLEY, 1994). Finally, the third one connects the bar formation to instabilities, that arise from interactions between the bed forms and either the flow or the incident wave field (FALQUES *et al*., 2000).

The "ridge and runnel" terminology was introduced in the literature by KING and WILLIAMS (1949) to define multiple swash bars cut by drainage channels. These authors defined this morphology to fetch-limited sea environments, with high tides and fine sand; whereas microtidal beaches are known as "barred beaches". For HAYES and BOOTHROYD (1969), ridge and runnel systems are the result of nearshore topography readjustment of excess sediment to wave conditions. According to their model, the bar formation depends on fair-weather conditions. Once formed, the bars migrate to the shore and weld to the foreshore. Therefore, the ridge and runnel morphology can be observed in various wave climate zones. Moreover, SONU (1972) proposed a genetic model for rhythmic topography: nearshore bars formed by edge waves, and the crosshore morphodynamical cycle relates to storm and post-storm periods. Ridge and runnel terminology is used after the HAYES and BOOTHROYD (1969) model.

Since physical process of flow, as well as stochastic and deterministic sediment dynamics are uncertain, knowledge about bar formation and dynamics are still far from definitive (COWELL *et al*., 1999). The crosshore bar dynamics previous works revealed the relative stability of bars in low-energy environments (BOCZAR-KANAKIEWICK and DAVIDSON-ARNOTT, 1987; O'HARE and HUNTLEY, 1994) and the high mobility of bars along oceanic coasts. In this environment, bars migrate offshore during storms and move back to the nearshore and foreshore during fair-weather conditions (AAGAARD, 1991; MULRENNAN, 1992). Nevertheless, longshore bar dynamics knowledge remains limited (VAN ENCKEVORT and RUESSINK, 2001, LAFON *et al.*, Submitted) and there is need for bar morphodynamics understanding.

This study aims to characterize longshore and crosshore morphodynamics of ridge and runnel systems, coupling with summer hydrodynamical conditions, based on a three years survey on a mesotidal to macrotidal oceanic coast, the Gironde Coast, southwest France.

STUDYAREA

The study area is located at the Truc Vert Beach (Figure 1), lying at nearly 12 km North of Cap Ferret Beach, on the Gironde Coast (France). Gironde owns a nearly North-South 100 km long shoreline backed by Holocenic aeolian dunes.

Semidiurnal tides show a mean tidal range of 3.2 m, increasing to 4.3 m at spring. West winds are predominant (MICHEL and HOWA, 1994). Wave climate is characterized by the Biscarosse buoy and the VAG-ATLA model (GUILLAUME, 1987). Wave records take from Biscarosse buoy between 1996 to 2000 show an average significant height (Hs) of 1.3 m and significant period (Ts) of 7.6 s. Data outputs from VAG-ATLA model provide a mean annual of wave heights (Hs) of 1.7 m with wave periods (Ts) of about 7.8 s, and a wave directions ranging from 270° to 315°. 77% of waves are from W-NW sector during summer. These N-NW waves induce a longshore drift of about 6.89x10m-3 per year southwards (MICHEL and HOWA, 1994). During storms, wave can reach heights up to 7 m with 20 s of period. The area is a mesotidal to macrotidal coast and a mixed energy tide-dominated environment (DAVIS and HAYES, 1984).

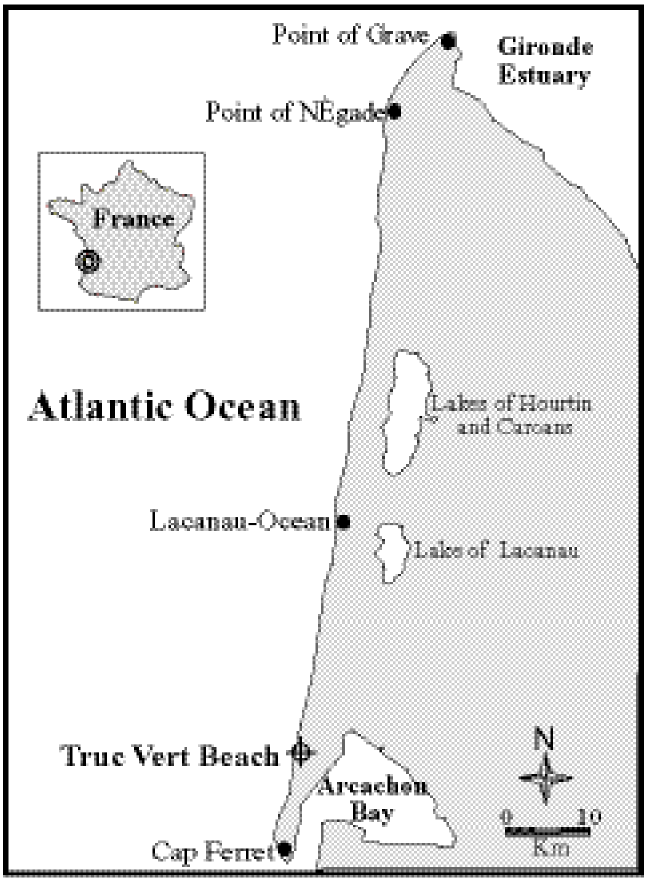

Figure 1. Location of the study area.

The Gironde Coast shows rhythmical systems of subtidal crescent-shaped bars and intertidal bars during summer. Crescent bars are observed in the upper shoreface, between -7 m and -2 m (MICHEL *et al*., 2000), at about 400 m of distance seaward from the beach. Wavelength of crescent bars range from 580 and 820 m on average (LAFON *et al.*, Submitted). Summer beach profiles usually shows ridge and runnel system and berm. Mean grain size ranges from 400 to 500 mm. The mean slope of the intertidal zone is b=0,022 and the ratio between the tidal range and intertidal slope (TR/b) ranges between 90 and 195m. Thus, the intertidal zone shows large crosshore mobility during tidal cycles.

DATA COLLECTION AND METHODS

Field Methods

In order to characterize the morphology of the intertidal zone, sixteen surveys composed of high-resolution shoreline maps and topographic crosshore profiles were held in summer conditions of 1999, 2000 and 2001. These surveys were made in: 05/31, 07/01, 07/16, 07/31, 09/01 and 09/13, in 1999; 08/31, 09/18, 10/14, 10/15 and 10/27, in 2000; and 05/23, 06/22, 07/23, 09/04 and 09/20, in 2001.

The shoreline map means the contour line of the shoreline during low-tide. The field method of shoreline maps collection consists of mapping out with a DGPS almost 1.6 km of shoreline (from 276700Y to 278500Y, Lambert 3 French geographical coordinate system) during spring low-tide. Shoreline altitudes vary with tidal ranges from 0.4 to 1.2 m above the Lower Astronomical Tide (LAT), using the SHOM's database (Service Hydrographique et Océanographique de la Marine, Copyright SHOM FRANCE – 1999, 2000, 2001). Tidal range variation points out that the accuracy of the method is approximately 0.8 m in altitude. Whereas the shoreline maps and topographical surveys comparison reveals a positioning accuracy of this contour line collection method of about 20 m.

The three-dimensional morphology is obtained from topographic crosshore profiles, which are made using a total laser station theodolite. The whole topographic profiles was made from one unique geographical spot lying at the dune summit, in the middle of the study site. This spot is reference level (PK-89 settled by Forest National Centre at 316620X-277621Y). The method accuracy is about 5 cm.

Field Data Analysis Methods

The analysis of shoreline maps (2-D morphology) follows three objectives: first of all, characterize the positioning and the orientation of bars and channels, second of all determinate the wavelength of ridge and runnel systems, and finally, estimate the longshore movements of these systems. Wavelength of one ridge and runnel system (ɣ) means the alongshore length of this system, hence the distance between the ridge and the runnel into consideration. Wavelengths of ridge and runnel systems are estimated by measuring the runnel axis positioning, and calculating of the difference between two consecutive positions of runnel. Longshore ridge and runnel dynamics is estimated by recognizing pre-existing ridge and runnel shapes, and estimating their movements.

Topographical survey analysis performs foreshore 3-D morphology characterization. Profile altitudes are taken out of the NGF reference level (2.04 m higher than the LAT). Volume calculation is made with Surfer Software (Golden Software).

Hydrodynamic Data Analysis Methods

Hydrodynamic data are from both the VAG-ATLA wave model (GUILLAUME, 1987) and a TRIAXIS wave buoy (AXYS Technologies, Inc.). VAG-ATLA model (AVISO database) is based on ARPEGE meteorological model, developed by French Met Office. The TRIAXYS wave directional buoy has been moored in about -54 m deep, at nearly 15 km offshore apart from the Cap Ferret Beach (299920X-268050Y). This buoy has been installed by University of Bordeaux I and CETMEF. VAG-ATLA data are utilized in 1999 and 2000 hydrodynamical analysis. TRIAXYS buoy data are analysed from august to october 2001. Wave analysis parameters are significant wave height (Hs), significant wave period (Ts) and wave direction.

VAG-ATLA model outputs data were validated through comparison with data from Biscarosse buoy (BUTEL *et al.*, this issue). Significant wave height (Hs) comparison yields both an overestimation at about 0.2 m from VAG-ATLA data, and a root mean square error determination at 0.47 m. Significant wave periods (Ts) from VAG-ATLA are overestimated by about 0.45 s, whilst the period determination accuracy is nearly 2.2s.

Figure 1. Location of the study area.

Date 1	Date 2	longshore migration rate
1999/05/31	1999/07/01	0.8 m/day
1999/07/01	1999/07/16	2.4 m/day
1999/07/16	1999/07/31	0.4 m/day
1999/07/31	1999/09/01	0.5 m/day
1999/09/01	1999/09/13	4.3 m/day

LONGSHORE MORPHOLOGYAND DYNAMICS OF RIDGE AND RUNNEL

Analysis of Shoreline Maps from 1999

Shoreline maps of summer 1999 (from 05/31 to 09/13) show a rhythmical morphology with three clean-cut ridge and runnel systems (Figure 2A). Systems range from 340 m to 650 m long (mean wavelength of ridge and runnel systems (ɣ) of 480 m). Runnels are preferentially SW-NE and SSW-NNE oriented. Bars are nearly parallels to the coast.

Ridge and runnel systems migrate southwards at a mean rate of about 1.7m/day (Figure 2A). However, this migration is not steady for all systems. Migration ranges from 0 m to 60m ± 20 m between two consecutives shoreline maps. Mean rates of migration from even number of consecutive maps are showed in Table 1. Finally, migration involves a mean rate of sediment transport that can be assessed by the following relationship (White, 1987):

$$\underline{Q}_1 = \underline{U}_1\ \underline{N}_0\ z_0 \tag{1}$$

Where $\underline{U}_l$ is the mean migration rate, N_0 is the concentration of sand by volume unity on the shore (equal to 0.62; MICHEL, 1997) and z_0 is the bars' amplitude (ranges from 0.5 m to 1 m). Therefore, mean sediment transport rate in the longshore direction ranges from about 0.12 m^3/m/day to 2.7 m^3/m/day.

Analysis of Shoreline Maps from 2000

The firsts four shoreline maps of summer 2000 (from 08/31 to 10/15) reveal disordered systems of bars cut by numerous channels, especially in 2000/09/18 (Figure 3A). Channels are preferentially SW-NE oriented, but also NW-SE channels are noted. These maps do not show a characteristic ridge and runnel morphology. Wavelengths of ridge and runnel systems (ɣ) are particularly difficult to establish, except to 2000/10/27 shoreline map. This one shows three ridge and runnel systems, similarly to the morphology of summer 1999. Rhythmical systems have wavelengths (ɣ) ranging from 360 m to 470 m, and runnels WSW-ENE and SW-NE oriented (Figure 3B). It is not possible to evidence a migration pattern for this set of shoreline maps.

Analysis of Shoreline Maps from 2001

The overall view of shoreline maps of summer 2001 (until 2001/07/23) evidences disordered shorelines characterized by a regular occurrence of bars submerged. In fact, all shoreline maps of summer 2001 (from 2001/05/23 to 2001/09/20) show a particular morphological evolution, pointed up by analysis of even number of consecutives maps.

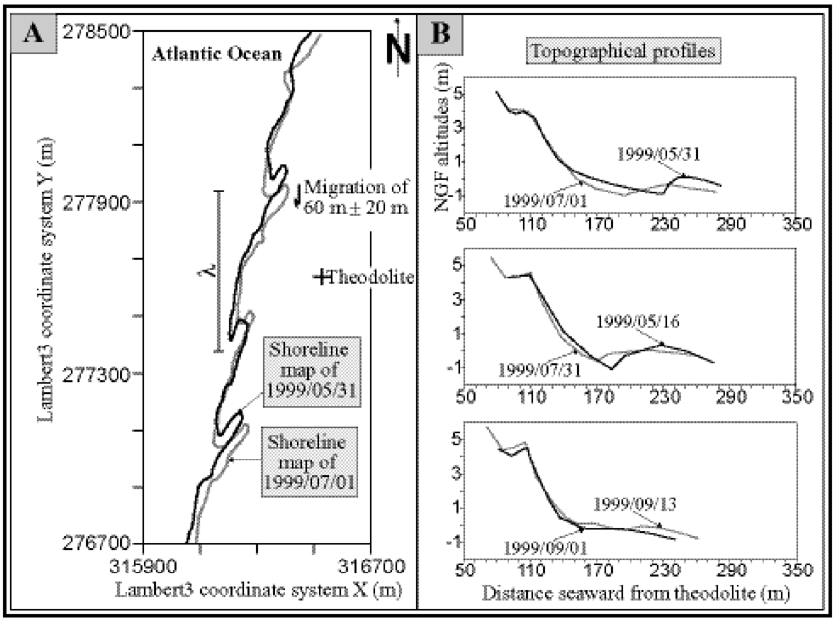

Figure 2. (A) Shoreline maps mean the contour line of the shoreline during spring low-tide of 1999/05/31 and 1999/07/01. Shoreline maps show three ridge and runnel systems with wavelengths (γ), which mean the alongshore lengths of ridge and runnel systems, ranging from 340 m to 550 m. Longshore migration southwards ranges from 0 m to 60 m ± 20 m (mean rate of 0.8 m/day). (B) Topographical profiles (from 1999/05/31 to 1999/09/13) show: accretion and migration of berm to the upper intertidal zone, cycles of erosion or accretion of beachface and bar, migration of bar to the middle intertidal zone and a double ridge and runnel formation (1999/09/13).

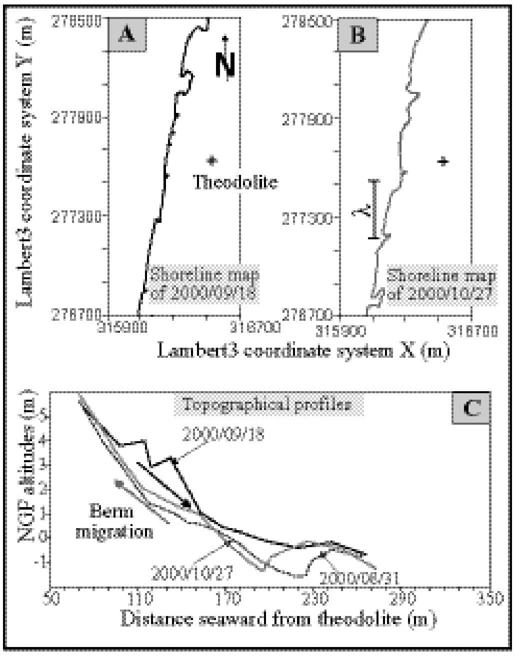

Figure 3. (A) Shoreline map of 2000/09/18. (B) Shoreline map of 2000/10/27. (C) Topographical profiles (2000/08/31, 2000/09/18 and 2000/10/27). 2000/09/18 data show unordered systems of bars in the low intertidal zone, and a wide double berm in the upper intertidal zone. 2000/10/27 data point out ridge and runnel systems from 360 m to 470 m long (γ) and a small and low berm. Topographical comparative analysis reveals a migration of the berm backwards and forwards on the foreshore (2000/09/18 and 2000/10/27).

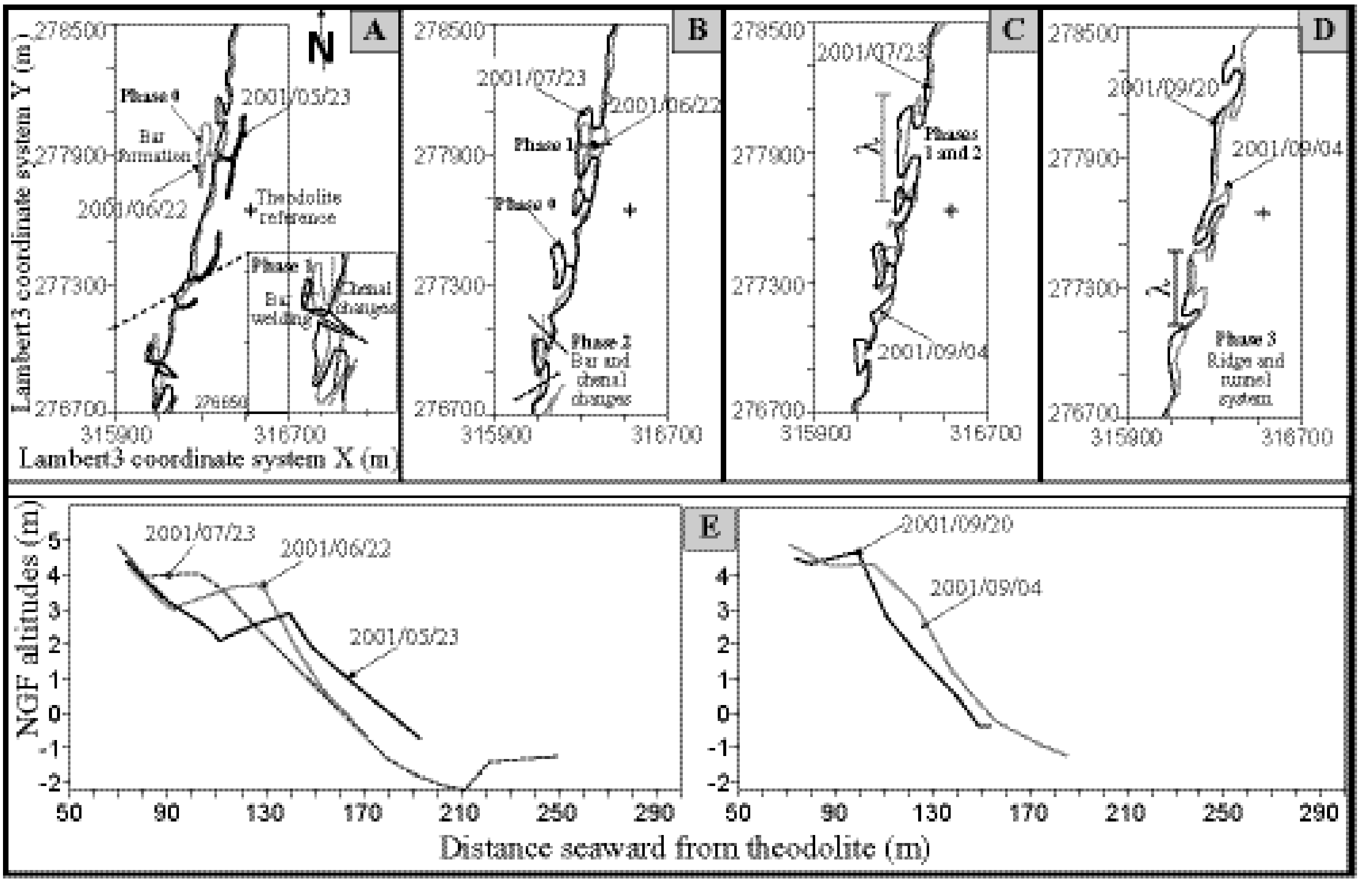

Figure 4. Phases of conceptual model for ridge and runnel system formation. (A) Shoreline maps of 2001/05/23 and 2001/06/22: nearshore bars close to the shoreline (phase 0), and bar welding to the foreshore from nearshore bar migration shorewards (phase 1). (B) Shoreline maps of 2001/06/22 and 2001/07/23: morphological changes in bars and channels (phase 2). (C) Shoreline maps of 2001/07/23 and 2001/09/04: Phase 1 and phase 2. Shoreline map of 2001/09/04 shows bars (wavelength of 300 m and 600 m) cut by channels SW-NE and NNW-SSE oriented. (D) Shoreline maps of 2001/09/04 and 2001/09/20: the last map underlines the phase 3 characterized by ridge and runnel systems (wavelength of 350 m, 500 m and 700 m) cut by runnels SW-NE and SSW-NNE oriented. (E) Topographic profiles (from 2001/05/23 to 2001/09/20): berm accretion and migration to the upper intertidal zone; bar and channel only in 2001/07/23.

Comparison of shoreline maps (2001/05/23 and 2001/06/22) reveals bar welding and sediment accretion at the foreshore accompanied by channels changes (Figure 4A). Channels migrate at south limits of this bar-channel system at about 50 m southwards, and at north limits at about 200 m northwards. Channel migration is also accompanied by channel rotation (Figure 4A); both are influenced by bar welding. These morphological changes characterize the start of ridge and runnel system formation (phase 1). Shoreline maps (2001/05/23 and 2001/06/22) show also nearshore bar formation or bar migration shorewards (phase 0; Figure 4A). Finally, it is observed the closing of two channels by probably sediment accretion on the foreshore.

Nearshore bars close to the shoreline (phase 0), and bar welding to the foreshore (phase 1) are also observed in the shoreline maps of 2001/06/22 and 2001/07/23 (Figure 4B). These maps reveal another phase towards ridge and runnel formation (phase 2; Figure 4B). Phase 2 is characterized by morphological changes in bars and channels. In these initial phases of model evolution it is not possible to determinate ridge and runnel systems wavelengths (γ).

Shoreline maps of 2001/07/23 and 2001/09/04 (Figure 4C) show phase 1 and phase 2. Map of 2001/09/04 points out bars from 300 m to 600 m long cut by channels SW-NE and NNW-SSE oriented (Figure 4C). However, it is not still the ridge and runnel morphology, as observed in the summer 1999. This morphology is only observed in

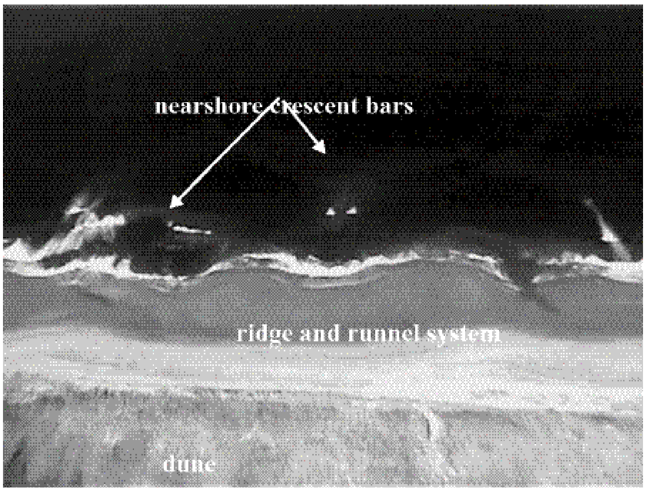

Figure 5. Aerial photograph of the Truc Vert Beach on 2001/09/20. Nearshore crescentic bars are evident as white bands produced by wave breaking. In the foreshore, a ridge and runnel system is indicated. A vegetated dune backs the coast.

2001/04/20. Shoreline map of 2001/09/20 shows 350 m, 500 m and 700 m long ridges cut by runnels SW-NE and SSW-NNE oriented (phase 3; Figure 4D). Aerial photograph taken in 2001/04/20 shows ridge and runnel system at foreshore, and also a double crescent bar system at nearshore (Figure 5). Ridge and runnel morphological evolution is accompanied by a general tendency to the migration southward. Migration is observed when channels are SW-NE or SSW-NNE oriented.

CROSSHORE MORPHOLOGYAND DYNAMICS

The whole topographical profiles of 1999 (from 1999/05/31 to 1999/09/13) shows a characteristic summer morphology with a berm, in the upper intertidal zone (between about 4 m to 5 m altitudes NGF), and a ridge and runnel system in the lower intertidal zone (between 0 m and -1 m altitudes NGF; Figure 2B). A double ridge and runnel system is also observed in 1999/09/13 (Figure 2B). Even number of consecutive profiles reveals cycles of erosion/accretion. These cycles are characterized by a progressive berm accretion, and beachface and ridge and runnel system identical behaviour (erosion or accretion; Figure 2B). Berm and ridge and runnel system migrate to the upper and middle side of intertidal zone at mean rates of 0.1 m/day and 0.8 m/day, respectively.

Profiles from 2000/08/31 to 2000/10/27 do not show a regular morphological evolution. The first profile (2000/08/31) shows a system of bar and channel between 0.5 m and -1.8 m. A small and low double berm is also observed between 0.5 m and 1.1 m altitudes, in the middle intertidal zone. Between 2000/08/31 and 2000/09/18 (Figure 3C), a general accretion of beach profile (about 120m^3/m) and a migration shoreward of the double berm (at mean rate of 1.4 m/day) are observed. Bars and channels do not migrate. 2000/10/14 and 2000/10/15 profiles are located in front of the runnel; consequently the bar is not mapped out. Both profiles show a small berm at about 1 m altitude. Finally, profile of 2000/10/27 shows a ridge and runnel system, characterized by a 1 m height bar, and a small berm. Comparison between 2000/09/18 and 2000/10/27 profiles reveals a erosion of upper intertidal zone with a return of berm at about 1 m altitude (Figure 3C). Profiles of summer 2000 reveal a high dynamics of berm, which moves backwards and forwards in foreshore. Whereas in the low intertidal zone, bar and channel migrate to the middle foreshore at mean rate of about 0.5 m/day.

Profile evolution of summer 2001 (from 2001/05/23 to 2001/09/20) shows a berm, which is progressively flattened and accreted (Figure 4E). Berm migrates to the upper side of intertidal zone at a mean rate of about 0.3 m/day. Contrary, beachface is progressively eroded, which can reveal a sediment transfer from beachface to berm or from beachface to the low intertidal zone. In the low intertidal zone, only the profile from 2001/07/23 shows a bar and a channel (Figure 4E). 2001/09/04 and 2001/09/20 profiles do not show a bar, because of their location in the front of runnel. Therefore, it is not possible to determinate a migration rate of bar systems.

HYDRODYNAMIC CONDITIONS

Between 1999/05/31 and 1999/09/13, VAG-ATLA model output data show mean hydrodynamic conditions characterized by significant wave height (Hs) of 1.2 m, significant period (Ts) of 6.5 s and wave direction of around 300°. Same parameters are analysed between two days of consecutives surveys (Table 2). From 1999/09/05 to 1999/09/13 do not have data from VAG-ATLA model. Occurrences of Hs higher than 2 m are observed only between 1999/05/31 and 1999/07/01 (total of twelve occurrences between 2 m and 3.2 m height), and between 1999/07/31 and 1999/09/01(four occurrences between 2 m and 3 m wave height).

Hydrodynamic conditions between 2000/08/31 and 2000/10/27 are also obtained from VAG-ATLA model. Mean results are Hs of 1.82 m with Ts of 7.91 s, wave direction of around 290°. Output data between two days of consecutives surveys are in Table 2. Graphical analysis reveals a calm wave climate until 09/19, when waves higher than 2 m do not occur. Later, between 29th september and 13th october, seven occurrences of waves between 2 m and 4 m, and two occurrences of waves higher than 4 m (at

2000/10/09 and 2000/10/10) with periods longer than 10 s, are observed.

From summer 2001, hydrodynamic conditions are from TRIAXIS wave buoy. Data are from 2001/08/28. Parameters averages between 2001/08/28 and 2001/09/20 are: Hs of 1.07 m, Ts of 6.49 s and direction at around 318°. Between 2001/08/28 and 2001/09/04, wave conditions were very calm with Hs of 0.9 m, Ts of 6.27 s and direction at around 320°. Similarly, from 2001/09/04 and 2001/09/20 waves showed Hs of 1.1 m, Ts of 6.54 s and direction at around 317°.

DISCUSSION

Shoreline map analysis of 2001 reveals a conceptual model for ridge and runnel system formation. The Conceptual model seems to confirm HAYES and BOOTHROYD (1969) and SONU (1972) models. SONU (1972) links nearshore bar formation and bar migration shoreward to after-storm periods. Nevertheless, the conceptual model proposed here describes four phases of nearshore bar formation, migration and welding to the foreshore. These phases are linked to summer hydrodynamical conditions. This model does not study the wave conditions that occur before the nearshore bar formation (phase 0). The conceptual model, in association with the morphodynamical observations of summer 1999, allows the understanding of ridge and runnel longshore and crosshore morphodynamics. During fair-weather conditions, ridge and runnel systems migrate crosshore to the middle intertidal zone and longshore to the south.

After elaborating this model, the remaining question is why the ridge and runnel system analysed in summer 2001 took four months to evolve? Obviously that ridge and runnel morphology was formed faster in 1999. Thus, it seems that the time of ridge and runnel morphological evolution depends on many variables, which are probably related to the equilibrium profile and to the variability of infragravitary waves.

Analysis of the summer 2000 maps points out a morphological evolution from disordered bar systems to a rhythmical ridge and runnel morphology. Nevertheless, the evolution phases of ridge and runnel system formation are not clear to identify. Besides, profile readjustments to hydrodynamic conditions from 2000 are obviously different to morphological evolution from 1999 and 2001. May be, hydrodynamic conditions until 2000/09/18 were not enough for a ridge and runnel system to complete formation. According to this hypothesis, the storm waves (between 200/09/29 and 2000/10/13) were eroding the beach profile (including the berm as point up from topographical profiles). Later, the return of calm wave conditions (between 2000/10/13 and 2000/10/27) promoted the ridge and runnel morphology observed in 2000/10/27. However, these hydrodynamic conditions were obviously not enough to promote a wide berm development. Morphological evolution of summer 2000 suggests that the ridge and runnel formation time is variable.

Nearshore bar formation can be attributed to many theories: wave breakpoint, infragravitary edge waves or interaction bedforms/flow or bedforms/wave field; it can also be explained from two or three hypothesis association as supposed by O'HARE and HUNTLEY (1994). This is considered probably because of the dynamic of study area. Furthermore, morphodynamic of ridge and runnel systems after the welding to the foreshore is obviously influenced by longshore currents and perhaps it is associated to the edge waves, which probably can perform ridge and runnel systems wavelength readjustments.

Table 2. Mean of significant wave height (Hs) and significant wave period (Ts), and median of wave direction (Dir) from VAG-ATLA model.

Date 1	Date 2	mean H_s (In meters)	mean T_s (In seconds)	median Dir (In degrees)
1999/05/31	1999/07/01	1.36	6.42	310
1999/07/01	1999/07/16	1.24	6.69	299
1999/07/16	1999/07/31	1.03	6.75	300
1999/07/31	1999/09/01	1.12	6.43	299
1999/09/01	1999/09/05	1.00	7.10	28
2000/08/31	2000/09/18	1.22	6.66	303
2000/09/18	2000/10/15	2.22	8.10	284
2000/10/15	2000/10/27	2.00	9.30	290

CONCLUSIONS

Ridge and runnel system formation is linked to evolution phases numbered from phase 0 to phase 3. In the initial phase 0, bars are formed in nearshore. It is assumed that one or more mechanisms of bar formation can coexist. Phase 1 includes bar migration shorewards and welding to the foreshore. Channel orientation changes accompaning migration and welding of bars characterize the phase 2. Ridge and runnel morphology is only observed in the phase 3. Ridge and runnel systems have a mean wavelength of about 480 m and whole of runnels SW-NE or SSW-NNE oriented. Data of summer 1999 characterize the morphodynamic behavior of ridge and runnel systems after the phase 3. Ridge and runnel systems migrate southwards, in the littoral drift direction, at an average rate of 1.7 m/day. During this time, crosshore morphodynamics are characterized by migration of berm (mean rate of 0.1 m/day) and of ridge and runnel systems (mean rate of 0.8 m/day) to the upper and middle sides of intertidal zone, respectively. Mean wave conditions of summers 1999 and 2001 had Hs of 1 m to 2 m with Ts of around 6.5 s. Median wave direction were W-NW.

Morphological evolution of summer 2000 corroborate with the model of system formation. However, time variability into morphological responses is obviously linked to wave climate differences. This conceptual model attempts to provide correlations between formation and dynamic of rhythmical morphology and hydrodynamic conditions. While these correlations seem to be reasonably satisfactory, they are certainly not perfect. Time variability for ridge and runnel system formation is not clear yet and need further investigation. Besides, the relationship between system wavelength and edge waves will be a topic of future research.

ACKNOWLEDGEMENTS

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