The Relationship Between Morphodynamics and Surfability at Brava Beach, Southern Brazil

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ABSTRACT

The aim of this work is to determine the relationship between beach morphodynamics and surfability. The studied area was Brava Beach, Itajaí – Santa Catarina, Brazil that is an oceanic sand intermediate beach exposed to all incident swells and offers the most constant conditions for surfing. Data were collected between August – 2001 and March – 2002. The beach was subdivided into seven sectors and regularly visited two to three times per week. The parameters monitored were: wave breaker height (Hb), period (T), type and direction of incoming waves, wind direction, category, position and number of surfers at the line up, peel angle and rate. A subjective index was attributed for surfability in each beach sector. Data collected showed a strong relationship between the morphodynamics and the surfability, where the quality for surfing is increased in morphodynamic stages from intermediate to dissipative; and demonstrated that surf conditions are extremely variable along the beach. The average wave breaker height during the monitoring was 1.1 m, the average period was 8.1 s and the predominant wave breaker type was plunging. The best surfing conditions were observed when the morphodynamic stage was close to dissipative ($\Omega > 4$), with plunging breakers of about 2 m height coming mainly from northeast (NE) and southeast (SE) with peel angles higher than 60°. This condition provided the bar-rip topography that favored peeling waves, improving the quality of surfing. The worst surfing conditions were observed in morphodynamic stage near reflective and wave breaker height less than 0.5 m independent of direction and type of incoming waves. When morphodynamic stage is close to reflective ($\Omega \leq 1$), the peel angles values are lower and the waves tend to close out. Peel angles presented great variations throughout the year; the peel parameter was ideal for surfers with beginner and intermediary skill level. The most common surf categories observed at Brava beach is the shortboard, the second higher occurrence was the body board. Both of these are most suitable for fast peeling waves. The long board and kayak were observed mostly between the months of December and March. Therefore the typical surfer of Brava beach is the shortboarder. This category of surfing (shortboard) was observed in all months and in higher number at all sectors of beach.

ADDITIONAL INDEX WORDS: *Surfing, surfers, sand beach, peel angle, Santa Catarina beaches, Brazil.*

INTRODUCTION

The relationship between people and the ocean comes from remote times, influencing culture, economy and society. Surfing as a sport has an increasing number of practitioners over the world. Studies that addressed this topic are very useful for a large segment of the population,

especially those who think about the shore as an enjoyment spot and surf related enterprises (CUNHA, 2002). Amongst the surf-related studies are those who analyze the surf climate (which is known as surfability, the term used to qualify and quantify a surf site for practice as well as its potential) (RAICHLE, 1998; PATTIARATCHI *et al.,* 1998; BANCROFT, 1999; HUTT and BLACK, 2001; DALLY, 2001).

Surfability studies are fundamental in development and construction of artificial surf reefs. Those reefs are many times used for multi-purpose *viz.* increase surfability as well as shore protection (BANCROFT, 1999; JACKSON, 2001; HUTT and BLACK, 2001). The work reported herein describes the relationship between beach morphodynamics and surfability parameters at Brava beach, Itajaí, Santa Catarina Southern Brazil.

DATA COLLECTION

Morphodynamic and surfability data were collected between August – 2001 and March – 2002 in 81 surveys. The beach was subdivided in seven sectors and regularly visited two to three times per week in order to maximize the monitoring of the different sectors of the beach during different morphodynamic stages and surfability conditions (Figure 1). The field surveys were conducted mostly during the morning when wind conditions (offshore winds) are favorable for surfing. The data were collected using a field worksheet, a Brava Beach map, binoculars and a measuring tape. Monitored parameters were: wave breaker height (*Hb*), period (*T*), type and direction of incoming waves, wind direction, category, position and number of surfers in the line up, peel angle, peel rate and a subjective index for surfability along each beach sector:

- **Breaker Height** (*Hb*): Height was visually estimated; by verifying height between crest and through at the wave breakpoint. Previous tests made to verify methodological accuracy demonstrate that data obtained by wave gauge devices are similar to those obtained visually (MELLO, 1993; KLEIN *et al.*, 2002). The wave heights were subdivided in intervals 0.25 m and minimum of 15 waves were measured in each sampling sector.
- **Period** (*T*): Peak Period, e.g. the period in well defined wave series, was determined (MELLO, 1993; KLEIN *et al*., 2002) by locating distinguishable fixed points over the surf zone (like rocks, boats, surfers or any stationary objects). When well-defined wave series entered the sampling area a chronometer was used to measure time lag between two consecutive crests passing through the fixed point. This procedure was repeated four times and the average time was calculated and used as wave period.
- **Wave Type**: In the seven sampling sectors the wave breaker type was observed and classified in four categories according to KOMAR (1976). Since this is a surfing related work as well, wave types were divided in two groups: Suitable for surfing (plunging and spilling) and unsuitable for surfing, these are characterized by high peel ratemaking surfing impossible.
- **Wave Direction**: Incoming wave direction was determined by observing from an elevated vantage point whenever possible (Life-guard stations). To mark the wave direction Cardinal and Collateral points were used.
- **Wind Direction**: In each beach sector the wind direction was determined by visual methods. Cardinal and collateral points was attributed to define the wind direction.
- **Category, Position and Number of Surfers**: During the surveys the number of surfers in the line up was counted, their position along the beach and category practiced was determined. A large number of surfers concentrated in one single spot (a 'crowd') is generally related to good quality for surfing. However, large number of surfers can lead to injuries on surfers and swimmers while disputing a wave.

- **Peel Angle and Rate**: According to BANCROFT (1999) the Peel angle and rate are essential to determine the level of difficulty that waves present to the surfers (Figure 2). Those parameters are obtained at the beach by measuring the following variables:

1. Peel Velocity (*Vp*) was determined as the distance traveled by the breaking wave (foam) during a time interval, given by equation below:
2.

$$Vp = \frac{dp}{tp} \tag{1}$$

Where Peel distance is *dp* and *tp* is the time that a surfer rides the wave.

3. To obtain peel distance (*dp*), a point straight-ahead to the surfer's entry point was marked and lateral displacement was measured with a measuring tape. The time for this displacement was assumed to be a peel time (*tp*).
4. The velocity of wave (*Vw*) was obtained with the equation:

5.

$$Vw = 1.25 \times \sqrt{g \times Hb} \tag{2}$$

Where *Vw* is the velocity of wave in the surf zone, *g* is the acceleration of gravity and *Hb* is wave breaker height.

4. Once wave velocity (*Vw*) was obtained, the value of peel time (*tp*) was assumed to be equal to the time displacement of the wave at surf zone (*tw*). Therefore, wave displacement (*dw*) can be calculated using the following equation:
5.

$$dw = Vw \times tw \tag{3}$$

Where *dw* is wave displacement, *tw* is displacement time.

6. When *dw* e *dp* was obtained, the displacement of surfer (*ds*) in the wave could be calculate by the Pythagoras equation:

7.

$$(ds)^2 = (dw)^2 + (dp)^2 \tag{4}$$

With ds calculated, the peel angle (α) will be obtained by the relation:

$$\cos\alpha = \frac{dp}{ds} \tag{5}$$

So peel angle (α) value is a function of arc cosine. The peel rate (*Vp*) is proportional of peel angle (α). For higher *Vp* the peel angle (α) is lower.

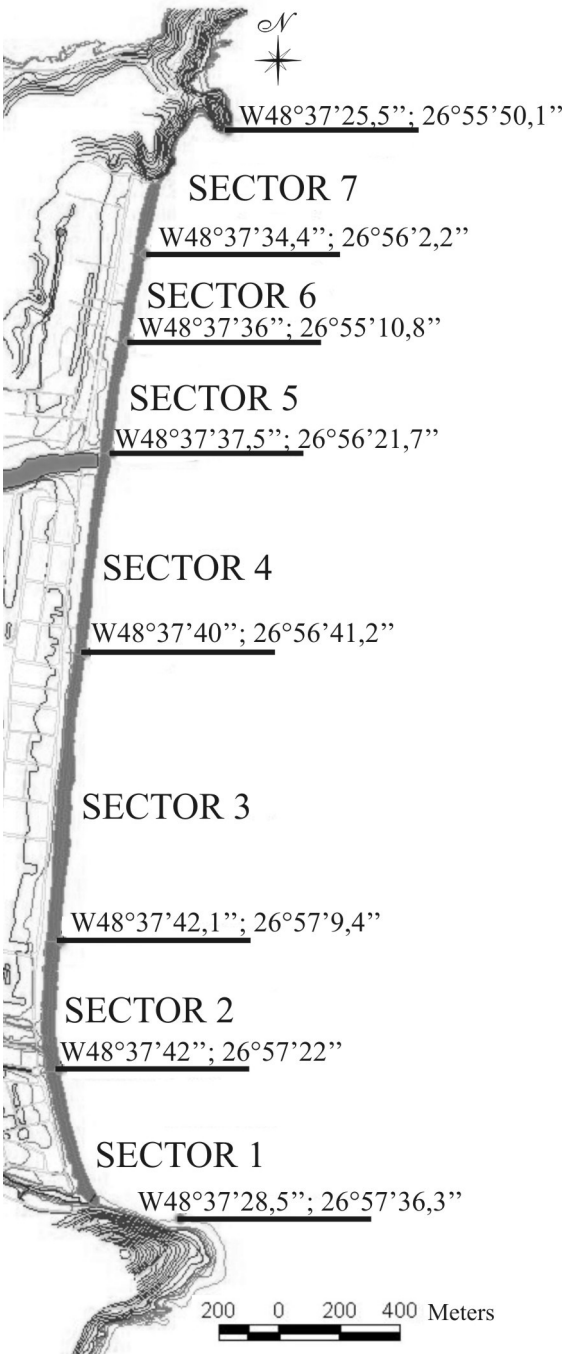

Figure 1. The Brava beach map used at surveys and the sampling sectors location along the beach.

- **Surfability Subjective Index**: an empirical index was developed to quantify the surfability in each beach sector (Table 1). This index is composed by a scale from A (that indicated better surf conditions) to E (that indicates worst surf conditions or unsurfable conditions).
- **Morphodynamic Stage (Omega - Ω):** To determine the morphodynamic stage of Brava beach, data surveyed in field was applied at equation:

$$\Omega = \frac{Hb}{T \times Ws} \tag{6}$$

Where *Hb* is wave breaker height, *T* is period and *Ws* is the grain sedimentation velocity. The value used for *Ws* is 4.36 cm/s (average grain size 0.31 mm) determined by KLEIN and MENEZES (2001) for Brava beach. Short (1999) suggested that reflective beaches occur when $\Omega < 1.5$, while dissipative beaches occur $\Omega > 5.5$. For $\Omega=2.40\pm0.19$ occur low tidal terrace/ridge runnel beach types; for $\Omega=3.15\pm0.64$ occur transverse bar and rip system; for $\Omega=3.50\pm0.76$ occur rhythmic bar and beach system; for $\Omega=4.70\pm0.93$ occur longshore bar and through system.

Table 1. Description of the settings used to quantify the surfability.

INDEX	DESCRIPTION
A	Perfect conditions for surfing, no wind interference, high peel angle, no crowd, high breaker height (Hb≥1.5m); surfers call this 'classic' conditions.
B	Ideal conditions for surfing but with one of the following limitations: small waves (Hb≤ 1.0m), or strong onshore winds, or crowd, or long time between wave series (sets).
C	Good conditions for surfing but with some limitations, for example: small waves and strong winds (onshore, offshore) but high peel angles and plunging waves.
D	Poor conditions for surfing, strong onshore winds, low peel angle values ($\alpha \leq 45°$), waves closing out, waves with breaker height less of 0.3 meters.
E	Worst conditions for surfing or unsurfable conditions, waves totally closing out (storms), no waves (flat)

MORPHODYNAMIC STAGE and SURFABILITY

Different wave breaker heights and types were observed throughout the year and on the same day along the extent of the study area. In this work the average wave height obtained was 1.1 m, this value is larger than the determined values in previous studies concluded on Brava beach by KLEIN and MENEZES (2001) and KLEIN *et al.* (2002) where the average breaker height was between 0.5 and 0.8 m. The highest average breaker height in all sectors of beach was occurred in October, with a general average height of 1.9 m. The lowest breaker heights were registered during November, January and March where:

- November: seven surveys were made with an average breaker height of 0.7 m and a variation coefficient of 33%.
- January: average breaker height of 0.7 m with 55% of variation coefficient in twenty-five surveys.
- March: average wave breaker height 0.8 m with 86% of variation coefficient obtained in seven surveys.

The average period registered during this work was 8 s; it was equal that the one obtained by KLEIN and MENEZES (2001) at Brava beach.

In November, Brava beach presented the lower omega values ($0.5<\Omega<2.5$). The highest omega values were observed in October ($1.5<\Omega<6$). Dissipative beaches present predominantly spilling breakers, while intermediate beaches present plunging breakers, with reflective, surging and collapsing breakers (WRIGHT and SHORT, 1984; SHORT, 1999); However spilling and plunging waves were observed in October with omega values near 6, and for the lower values of omega (0.75), spilling breakers types were also observed with very low breaker height (Hb<0.5 m). Ideal and unsuitable waves (low Hb or peel angle) for

surfing were equally observed. Plunging waves had higher occurrence (39%), spilling waves presented 31% of occurrences and unsuitable for surfing conditions represented 30% of occurrences. According to BANCROFT (1999), plunging and spilling waves are ideal for surfing but plunging breakers are preferred by surfers (especially experienced surfers).

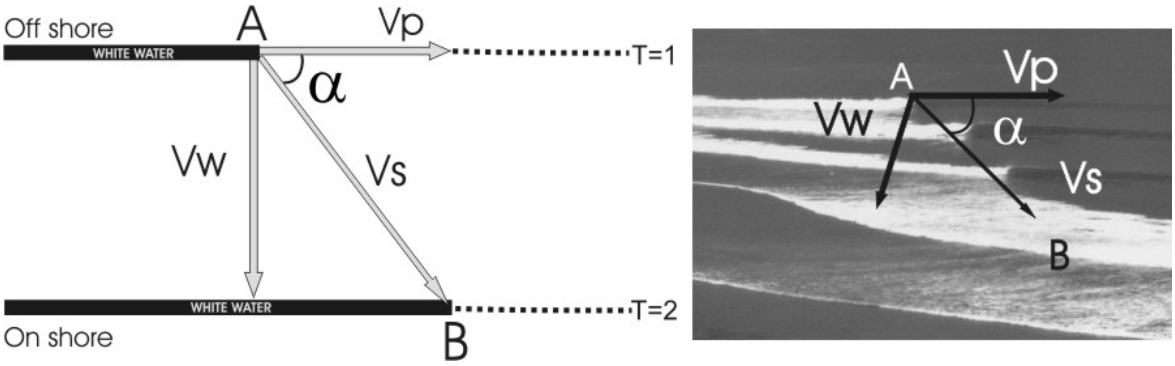

Figure 2. Peel parameter at surf zone, Vw is wave velocity, Vs is surfer velocity, Vp is peel rate, α is peel angle.

October exhibited a higher percentage of occurrences of plunging waves, with swell waves predominantly from southeast direction. The predominant wind direction was northeast; total absence of wind during surveys was observed as well providing the best surfing conditions. Spilling waves had higher occurrence during December, the predominant direction of incoming waves in this month was east-southeast, and the predominant wind direction was east, southeast and west (offshore winds). Unsuitable for surfing conditions occurred mostly in January, related to low wave heights (*Hb*) observed in the second half of the month where the average breaker height was less then 0.5 m.

Surfers were observed in all sections of Brava beach practicing the following surf categories:

- Shortboard – short to medium boards with average length of 6.5 feet (2.15 meters) and 3 fins;
- Body board – Small boards without fins, where the surfer lays over the board to ride a wave;
- Long Boarders – Large board with 1 or 3 fins and length over 8 feet (2.7 meters);
- Kayaks – Small fiberglass boat where the surfer uses a paddle to propel himself into a wave.

Long boarders and Kayaks were only observed between the months of December and March in conditions where the waves did not exceed 0.5 m (*Hb*) and were mainly spilling breaker types. These surf categories presented the lowest occurrence in this work. The most common surf category was shortboards, occurring along the whole extension of Brava beach and in every surfing condition, even in unsuitable conditions.

Peel angles obtained during this work, along with wave height observed in the field showed that Brava beach's waves are ideal for beginner and intermediate surf skill levels, where November, December, January, and March, presented ideal waves for beginner surfers, and in the other months, required intermediate skill levels. The subjective index used to qualify the surfability, presents grade from A to E along the year. October received the best conditions for surfability, these were attributed to conditions where omega values are higher than 4.5 and breaker height over 2 m, coming from southeast (SE) and northeast (NE) directions (Figure

3). The grade A always presented plunging waves and in morphodynamic stages intermediate to dissipative.

The index E (worst index) was not registered in October, and the average peel angle calculated for this month was 67 degrees. January present the worst surfing conditions, with especially bad conditions in the second half of the month. These qualifications were attributed to omega values below 1.25 (reflective morphodynamic stages), and wave height not exceeding 0.75 m coming from northeast (NE), east (E) and southeast (SE).

Figure 3. An example of the most representative plunging break and best surfing condition at Brava beach during this work (Photo author - Ricardo Alves).

The best surf conditions observed during January were C and were observed for plunging waves with 1.5 m breaker height coming from east (E) and northeast (NE) directions and for plunging waves with 1.75 m breaker height coming from east – southeast (E-SE) direction, and 3.5 for omega values, only during the first half of this month. Table 2 presents the relationship between morphodynamic stages; peel angle and surfability empirical index values, the peel angle and qualification were attributed only for shortboards.

Table 2. Relationship between morphodynamic stages, peel angle and condition for surfing. (* - Indicate absence of qualification)

	QUALIFICATION INDEX					
PEEL ANGLE	**(A = Best condition; E = Worst condition)**					
≥ 65°	*	E, C	C, B	B, A	A	A
60° - 64°	E, D	E, C	C, B	B, A	B	*
55° - 59°	E, D	E, C	C	C	*	*
≤ 54°	E, D	D, C	D, C	C, B	C, B	*
Morphodynamic Stage (Ω)	**≤ 1**	**≤ 2**	**≤ 3**	**≤ 4**	**≤ 5**	**≤ 6**

CONCLUSIONS

Data collected showed a strong relationship between the beach morphodynamic stage and surfability, where the quality for surfing increases as the morphodynamic stage changes from intermediate to dissipative. This demonstrated that surf conditions are extremely variable along the beach extent. The average wave breaker height during the monitoring was 1.1 m, the average period was 8.1 s and the predominant wave breaker type was plunging. The best surfing conditions were observed when the morphodynamic stage was close to dissipative ($\Omega > 4$), with plunging of about 2 m breaker height coming mainly from northeast (NE) and southeast (SE) with peel angles higher than 60°. This condition provided the bar-rip topography that favored peeling waves, improving the quality of surfing. Worst surfing conditions were observed in the morphodynamic stage near of reflective and wave breaker height less than 0.5 m independent of direction and type of incoming waves. When morphodynamic stage is close to reflective ($\Omega \leq 1$), the peel angles values are lower and the waves tend to close out.

Peel angles presented great variations along the year, where according to BANCROFT (1999), the peel parameter was ideal for surfers with beginner and intermediary skill level. The most common surf categories observed at Brava beach is the shortboard. This category of surfing was observed in all months and in higher numbers at all sectors of beach. The second highest occurrence was the body board. Both of these are most suitable for fast peeling waves. The long board and kayak were observed mostly between the months of December and March.

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