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Integrating Surfing in the Socio-economic and Morphology and Coastal Dynamic Impacts of the Environmental Evaluation of Coastal Projects

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ABSTRACT

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During the study for the viability of the implementation of an Artificial Surf Reef in São Pedro´s beach, Estoril, Portugal, contracted by the Municipality of Cascais, we developed at Instituto Superior Técnico a novel orientation to the Environmental Evaluation of Coastal Projects. We present our novel approach, improving the Socio-Economic Factor and the Morphology and Coastal Dynamic Factor of Environmental Evaluation Studies of Coastal Projects. In the Socio-Economic Factor we address the impact of surfing in the, local and national, sports, tourism and industry. We show that surfing, a natural sport, has been growing at a nearly constant rate for the last three decades in Portugal, also as an economic activity, and it maintains the potential to continue its development in the next decades. We also show that the entire Portuguese West coast provides excellent conditions, in the European Continent, for the development of surfing. In the Morphology and Coastal Dynamic Factor, we address the parameters that quantify the quality of waves for surfing, and the parameters that quantify the rip currents. While rip currents affect surfing, they also affect sediment transport and the safety of bathers. We describe the parameters that coastal projects and environmental studies should evaluate, to maintain the quality of surfing, and also to assess the impact of coastal works on beach morphology and on bathers. The present orientation may be proposed to the "Agência Portuguesa do Ambiente" (Portuguese Environment Agency) in order to protect and develop Surfing in the Portuguese Coast.

Surf, Environment, Economy

INTRODUCTION

While surf, both as a sport and as an economic activity has been growing at a steady rate in Portugal over the last decades, Coastal Engineering projects and works have been destroying waves. This has been clearly causing social problems that could be avoided, if the Environment Impact Assessment would include surfing in the Human, Water and Landscape factors. Here we show how to include the impact on surfing in the Socio-Economic Factor and in the Morphology and Coastal Dynamic Factor of the Environmental Evaluation Study of Coastal and Offshore Projects.

In this Section, we also review the recent Portuguese coastal constructions with a negative impact on surfing, and the present impact of surfing in the national sports and economics. In the next Section we propose a novel method to include surfing in the

Figure 1. (left) A large wave surfed at Jardim do Mar prior to the 2003 seawall construction, (center) a tube ride at Cabedelo do Douro before the 2006 construction of the new Douro jetty, (right) the Carcavelos Beach at it has been during the last decades (SurfTotal 2008).

Table 1: List of high quality waves harmed by coastal works in the Portuguese coast in the present decade (SOS 2008). The initial loss corresponds to the part of the wave lost due to the projected construction. In all cases the surfing community proposed the mitigation of the negative impact on surfing, thus we also present a final loss. In only three cases there were corrections to the project, or to the construction, in order to preserve, at least partly, the surf: Lugar de Baixo, Santo Amaro, and Carcavelos.

surf spot	region	main qualities	construction type	year	initial loss	final loss
Rabo de Peixe	Azores	big and long	fishing harbor jetty	2000	50%	50%
Lugar de Baixo	Madeira	tubular and long	sea wall for Marina	2001	100%	40%
Santo Amaro de Oeiras	Lisbon	tubular and long	jetty for beach nourishment	2003	50%	30%
Jardim do Mar	Madeira	big and long	sea wall for coastal protection	2005	50%	50%
Carcavelos	Lisbon	tubular and sandy	groins for beach nourishment	2005	30%	0%
Ponta Delgada	Madeira	long and big	swimming pool with jetty	2005	100%	100%
Cabedelo do Douro	Oporto	tubular and sandy	jetty for coastal protection	2006	100%	100%

Environmental Studies. Then in the subsequent section we apply our method to the Cascais Municipality Project for a Surf Reef in São Pedro do Estoril. Finally we conclude in the last Section

List of recent Portuguese coastal constructions with a negative impact on surfing

During the present decade, the list of the best Portuguese waves for surfing has been reduced by coastal engineering (SOS 2008). A high quality surf wave must be either very long, or very big, or very tubular. Notice that in the surf terminology a wave is not the function defined over the whole oscillating surface of the sea, but a single wave front breaking in the surf. We will follow the surf terminology from now on.

In 2001 the Lugar do Baixo surf spot, where a very tubular wave used to break, in the Southwest coast of Madeira, was partly submerged by a seawall. The seawall was part of the structure of a new marina. The surfing community persuaded the Government of Madeira to relocate the marina West of the surf spot, but nevertheless the seawall remained, destroying 40% of the wave.

In 2003, the Santo Amaro surf-spot, where again a very tubular winter wave used to exist, was partly cut by a jetty, projected to preserve the artificial nourishment of the Santo Amaro Beach. Moreover the pier localized a rip-current that ruined the surf in part of the remaining wave. The surf community met with the Mayor of Oeiras, asking for the shortening of the Jetty. The Mayor agreed on a 30% cut of the jetty's length. Although this did not restore the initial length of the wave, the rip-current decrease recovered the quality in most of the wave, which lost 30% of it's length.

In 2005, two groins were projected to preserve the artificial nourishment of the Beach of Carcavelos, in the Coast of Cascais, that would destroy 30% of the waves in Carcavelos, and change all the other ones. In that case the Mayor of Cascais organized a Public Audition, and after the audition he decided to cancel the project, since surfing is a crucial activity in Carcavelos.

These are the only cases where the negative impact on surfing was mitigated. The success of the mitigation was total in Carcavelos thanks to the Mayor of Cascais, Mr. António Capucho, and partial in Santo Amaro de Oeiras thanks to the Mayor of Oeiras, Mr. Isaltino Morais, and Lugar de Baixo thanks to the Vice-Presidente of Madeira Autonomous Government, Mr. João Cunha e Silva.

Several other high quality surf spots were destroyed (SOS 2008), or half destroyed during the present decade see Table 1. In most of them the construction was carried on, although the surfing community proposed mitigation tried in all of them to maintain the waves. Some of the waves are illustrated in Figure 1.

These waves were lost because the impact on surfing of the coastal engineering works was not correctly quantified from the onset. So far, in the only three cases where the negative impact on surfing was mitigated, the decision to mitigate the negative impact on surfing was directly taken at a high level, by the local authority in charge of the construction. We propose that the coastal studies and projects include surfing as a relevant factor from the onset.

The socio-economic impact of surfing in local communities and in Portugal

The loss of waves raises a serious social problem. To quantify the problem we now review recent data on the socio-economic impact of surfing, globally, nationally and locally.

Worldwide, there are 23 million surfers (EuroSIMA 2006) with 500,000 to 600,000 surfers in the UK and 200,000 surfers in France. In 2005, 20,000 surfboards were sold in France. The global surf market (EuroSIMA 2006) in 2005-2006 represented €11 billion, up from €10 billion the year before. 65% of the market was represented by the four of the biggest surf companies. Of this number, the European market accounts for approximately €1.48 billion with €1.1 billion of that coming from companies based in the Aquitane region of France. Four of the major suppliers – Quiksilver, Billabong, Rip Curl, and Oxbow – account for €839 million.

In Portugal we have more detailed results on the number of surfers (SurfTotal 2008, Alfarroba 2008, FPS 2008). The number of surfers has been growing at at nearly constant rate since surf appeared in Portugal, 40 years ago. In Figure 2 we show the evolution of the number of surfers, surfing regularly at least once in a week, over the last decades. Presently there are 50,000 to 70,000 surfers surfing regularly in Portugal, at least once in a week. The growth factor is of 25% to 30% per year. The present number of surfers is detailed according to the respective level of surfing in Table 2. Notice that, while a sizeable part, up to 25% of the Portuguese population between 15 and 35 years old may already have surfed at least once, only 3% of the young population surfs on a regular weekly basis. Moreover the number of members of the Portuguese Federation of surf only accounts for nearly 1% of the total number of 443,000 federated athletes.

In what concerns surf as a sport activity, details are also found in Table 2. Notice that two surfers raised and training in Portugal are seeded in the top 46 of the Association of Surfing Professionals world tour competition(ASP 2008): Tiago Pires from the Lisboan region and Marlon Lipke from the Algarve Region, two of the Portuguese regions with a longer surf tradition.

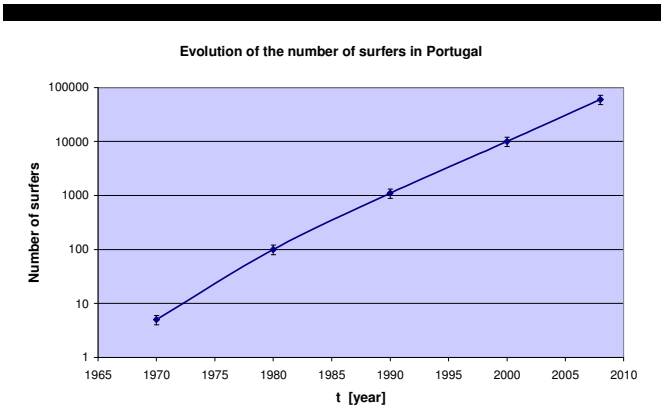

Figure 2. Evolution of the number of surfers surfing regularly in Portugal, at least once in a week, over the last decades.

In what concerns the economic impact of the surfing industry (SurfTotal 2008, Alfarroba 2008, FPS 2008), there are two different methods to arrive at the economic perspectives, the total cash flow of the different surf companies, and the cost of surfing supported by each of the 50 to 70 thousand regular surfer. We highlight that there are more than 100 surf schools, 200 surf-shops with a cash flow of €200 thousand to €500 thousand per year and per shop, 10 surf Magazines, 20 surfboard factories. Each WQS 6*, with €100 thousand prize money, brings to the competition site 500 people for 2 weeks, increasing the local cash flow by €1 million. On the other hand, each regular surfer spends approximately €2 to €3 thousand per year directly in the surf gear and in travelling. Adding it all we arrive to a number consistent with the €150 to €200 million of the total cash flow for the surf industry only in Portugal.

To this number we must add the economic impact of surf on tourism. Notice that presently the impact of surfing in Tourism comes mostly from local surfers. Surfers contribute importantly to the beach bars and restaurants in popular surf spots which are open during all year thanks to the presence of surfers and of customers attracted by the surf activity. In the remaining beaches, more distant from the urban centres where most surfers reside, the hotels, bars and restaurants only benefit from surf during the weekend. Presently there are, say, 20 surf-camps that already rely on foreign tourists. The surf-camps are small hotels dedicated to surfers, also offering surf tours and surf classes, mostly in the touristic regions and in the popular surf spots.

In what concerns the number of jobs in the surf industry, we account for 1000 to 2000 jobs directly related to surfing in 2008.

Locally, there are different partial studies. Interestingly, in the Municipality of Cascais, where the Portuguese surf was born, surf is already the second sport with more federated athletes, right after football. In some small fisherman villages, the number of surfers is already close to saturation, since most of the young people already surf. Studies in the Alentejo (Secret Wave 2008) and Madeira (Lopes 2008) regions suggest that the exponential growth of the number of surfers and of the surf business follows similar growth rates in the different regions of the country.

METHOD TO INCLUDE THE SURF IN THE ENVIRONMENTAL EVALUATION OF COASTAL PROJECTS

Until very recently, surfing has not been accounted for in the environmental evaluation of coastal projects. The only exceptions are quite recent, and we highlight the Artificial Surf Reef in São Pedro´s beach reported here, and the facilities to support surf clubs in São Pedro do Estoril and in Costa da Caparica.

Table 2: Number of Portuguese surfers with different levels of surfing in 2008, where bodyboarding and longboarding is included. The numbers are rounded-off. Notice that up to 25% of the Portuguese population between 15 and 35 years old may already have surfed at least once. However the Surf Federation members constitute only 1% of the total federated athletes, in all sports.

surf level	Number of surfers
competing world wide	10
professional competitor	50
competing in Portugal	1,000
Surf Federation members	5,000
surfing every week	50,000
surfed at least once	100,000 to 500,000

Thus we propose a method to address surfing in the environmental evaluation of coastal projects. Here we discuss only the two factors with a main surf impact, the Socio-Economic factor and the Morphology and Coastal Dynamic Factor. In general the environmental impact studies normally follow a guideline, including several different factors, that we do not need to mention here. Even when other factors may benefit from maximizing the surf quality, such as the coastal protection, or the flora and fauna factor, we will not mention them here.

Improving the impact on the Socio-Economic Factor

In general, it is essential to first assess the total socio-economy of the region of the coastal project, and then to measure the impact of surfing in the socio-economy, in order to weight the surf impact.

A survey must be carried out in order to evaluate the number and level of the surfers, the place of residence of local surfers, and the transport they prefer to arrive and leave the zone, the number of days that foreign surfers stay there, the type of accommodation they prefer, the reasons why they prefer the site of the project to practice surf, how much they spend for a day, how many times they surf in a year, the opinions about the implantation of a new coastal project. With the number on surfers, the data we provide in the Section Introduction can be interpolated to assess the sport and the economic impact of surfing. This study can be completed with the evaluation of the cash flow of the surf industry and services, including surf-shops, surf-schools, surf-camps, surf-factories and surfing competition.

The contact with surf clubs can help in the perception about the number of partners and the number of surf practitioners, their age, residence, transport mean and costs, level of surfing as in Table 1, season of the year in which they prefer to surf, type of wave they are more comfortable with, and the existence of a stabilised surf community, the popularity of the surf in the area, both from an international, a national and a local perspective.

This study can then be competed with the indirect impact of surf in the local economy. Surfing positively impacts in the economic activities related with tourism and leisure, namely restaurants, bars, travel agencies, sports and sea activities, increases the attractiveness of the area for commerce and services, and the evolution of Tourism in the country. Surfing also requires good accesses to the surf zone and to the neighbouring coast.

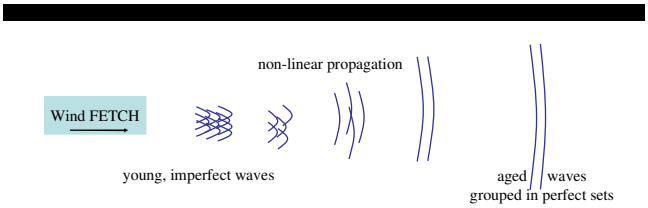

Figure 3. Sketch illustrating the ageing of surf waves. Close to the fetch area where the waves are generated, the wave profile is imperfect, but while the waves propagate over very large distances, they age and group in wave sets with perfect profiles.

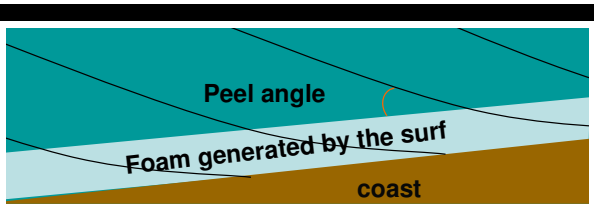

Figure 4. Horizontal projection of the surf breaking. Different quantitative parameters can be viewed with a horizontal projection, including the peel angle, the surf lane or possible length of the surfers path, the distance of the surf to the shore and other possible safety hazards.

Only after the Environmental Impact Study is completed, the public consultation is carried out to evaluate its acceptance by the public. (Custódio *et al*. 2008). Thus, it is absolutely necessary to have prior meetings with people concerned about the project and to clarify its objectives, to get a better perception of their feelings about the project, and to hear suggestions.

This stage of impacts evaluation must consider the analysis carried out previously in the pre-public consultation, in order to guarantee the interests of the different entities. In the construction phase, the impacts must be evaluated considering: the duration of the construction, the period of the year chosen to construct the structure and the construction time in the sea and in the earth

In the case of a project designed to improve surfing, or other nautical sports, it is also important to assess the public perception on the visibility and image of the project, related with the improvement of an active life style associated with youth and health, normally connected with this type of sports.

Predicting the future growth rate of surfing

Importantly, to compute the impact of surfing in the socio-economy, it is crucial to estimate the future growth of the surf socio-economy. This is important since surfing has been growing exponentially in the past decades, and therefore it cannot be assumed to be constant. We now estimate the growth potential of surfing.

The potential to maintain the nearly constant growth rate of surfing in Portugal, with the exponential growth depicted in Figure 2, can be predicted to continue.

If we compare the 1% due to surf of the total number of federated athletes, to the most popular sports, with 36% of the male federated playing football and 16% of the female federated playing volleyball, we may forecast that the surf will continue it's exponential growth during the next decade. The same prediction can be extracted from the 3%, only, of surfers in the generation between 15 and 35 years old.

Moreover a larger growth of the impact of surf in tourism can be forecasted. Notice a European poll found that 90% of the young western Europeans choose surf as the sport they would most like to practice. Moreover surfing already represents 65% of the activity of the sliding sports such as skiing, snowboarding, skateboarding, and windsurfing. Thus surf tourism can be expected to increase exponentially in the future, and reach cash flows similar to the cash flows of the ski parks. For instance, if the number of weekly visitor surfers would equal the number of national surfers, this would account for 3 Million new tourists per year, and an extra cash flow of €1.5 billion to €3 billion per year for the national tourism.

A major advance of the future surf-tourism may come form surf-camps. A surf-camp is naturally created by a surf-school when the local surf-school invests in foreign surfers that need a local accommodation to be able to attend the surf classes. Very recently there was an explosive growth of surf-schools in Portugal, where many former competition surfers created surf schools, thus maintaining their lifestyle and their professional activity based on surfing. More precisely, in 2008 there were already 130 surf-schools and 70 surf-clubs registered in the Portuguese Surf Federation (FPS 2008), and they are getting close to saturate the national market of surf lessons. To access a wider market, a few of the surf schools already evolved to surf camps, either creating a small hotel, or in association with exiting local hotels.

Thus in the environmental evaluation of coastal projects, the present socio-economic weight of surfing should be assessed, and then extrapolated into the future, considering the potential for the future growth of surfing.

Improving the impact on the Morphology and Coastal Dynamic Factor

To include the impact on surfing in the Morphology and Coastal Dynamic Factor, one only simply needs to quantify the quality of the surfing waves that may be affected by the coastal project.

This constitutes the crux of the present article, since the proposed methodology is the only possible one to assess the quality of surf waves.

The first set of surf quality parameters are extracted from the wave climatology. This includes the wave heights, the period, the direction, the wavelength in the surf area, but importantly it also includes the wave age. The wave age, as illustrated in Figure 3, measures the concentration of the wave energy in sets, which gain a perfect profile with the distance travelled, or with the time elapsed, since the fetch area. The age parameter of a wave can be changed by a coastal work, when the spectrum of the wave is changed by reflection, breaking or refraction.

The climatology also includes relevant parameters for the surf sport, such as the wind direction and strength, the water temperature and the number of daylight hours.

The second set of surf quality parameters is extracted from the horizontal projection of the surf zone, as illustrated in Figure 4. This includes the peel angle, the surf lane or possible length of the surfers path, the distance of the surf to the shore and other possible safety hazards. Importantly the peel angle must be larger than 36 to 30º in the case it is surfed by excellent surfers (Scarfe 2003, Cardoso 2007), and preferably at least 45º, if the wave is to be surfer by regular surfers. Coastal works normally rotate the wave fronts, thus affecting the peel angle and this should be assessed very precisely by the environmental study.

The second set of surf quality parameters is extracted from the cross section of the breaking wave, as illustrated in Figure 5. Different quantitative parameters can be viewed in this projection,

including, the Irribarren Number, the smoothness of the wave surface, and the surface available at any time for a surfer to create surfing maneuvers. Notice that the Irribarren number of a tubular wave is in the interval [0.4, 2]. Larger Irribarren numbers result in the collapse into a surging wave, while smaller Irribarren numbers result in a progressive wave, suited for less experienced surfers.

Moreover, the impact on the rip currents must be predicted by the environmental impact study. Rip currents, when crossing the surf lane, inasmuch as an onshore wind, create ripples and other turbulences in the wave surface, thus decreasing the quality of the wave. On the other hand the rip currents are positive for surfing, when they contribute to transport the surfers from the shore to the lineup, i.e. the point where the wave rides start.

RESULTS AND ANALYSIS ON THE ECONOMIC IMPACT OF SURFING: THE SÃO PEDRO ARTIFICAL SURF REEF CASE STUDY

In the São Pedro Artifical Surf Reef Study, the methodology proposed here was for the first time applied. Numerical and physical modelling of the waves and surfing were performed at IST and at LNEC (Bicudo 2008, Fortes 2008).

The potential of the Portuguese Coast for surfing

Since the goal of the project is, not only to preserve all neighbouring surf spots, but also to create a new wave for surfing, we first applied our methodology to the choice of the surf site. We concluded that the Portuguese Coast has a unique potential for surfing, due to the local mild and sunny weather, and also to the perfect age and energy of the wave climatology. We expect in Particular the North and Centre regions of the Portuguese West coast, less explored than the South region, to boost the surf development in the next decade.

In what concerns the Coast of Cascais, our simulations showed that the age and height parameters of the waves are optimized in the neighbourhood of São Pedro.

The São Pedro Surf Reef

In particular the São Pedro surf Reef (Bicudo *et al.* 2008) is designed to be surfed by 40 excellent surfers per hour, equivalent to a population of 2000 regular but with a high surf level. This will boot to the local economy with at least €6 million per year. In the exploitation phase, it will contribute positively to

- the development of the sport, surf-schools, the economy, the employment, and the local activities provided by the increase of the population in the zone (investments in the restoring, hotelling and leisure facilities),
- creation of conditions for the practice of other nautical activities, such as diving and fishing,
- be a flagship to attract foreign surf tourists and international surf competitions to the municipality of Cascais.

The main parameters of the wave are a peel angle of 40º, Irribarren number of 1.0, wave size larger than 0.5m in surfer units (1.0m in oceanographic units) and surf lane of 200m. The wave will be surfed at low to mid tide, during winter, spring and fall.

DISCUSSION AND CONCLUSION: NEW SURF DEVELOPMENTS AND THE COST OF THE MITIGATION OF NEGATIVE SURF IMPACTS

The São Pedro Surf Reef, and other projects to create new waves, produce a new methodology to include surfing in the socio-economic and the morphology and coastal dynamics factors of the Environmental Evaluation of Coastal and Offshore Projects.

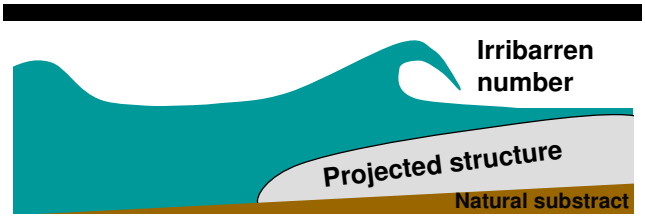

Figure 5. Cross section of the breaking wave. Different quantitative parameters can be viewed with a section, including the Irribarren Number and the smoothness of the wave face.

Moreover the estimated preliminary cost of the surf reef, €2 million, is comparable to the cost of artificial surfing waves in pools, either with propagating waves ones or standing waves which have a similar cost. The wave pools also spend a sizeable power, ranging from 200 KW for waves for beginners, to 500 KW or 1 MW for waves for expert surfers. This can be used to evaluate the cost to mitigate the destruction of a good surfing wave by a coastal project that neglects surfing in its impact study. The loss of ruining a perfect wave is certainly more costly than that.

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