

Surfers as coastal protection stakeholders

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The Fall 2007 issue of *Shore & Beach* was a dedicated issue focused on shore protection and surfing, highlighting the frequent conflict between the surfing community of coastal stakeholders and coastal community interests that wish to stabilize the shoreline. It is estimated that there are over 20 million surfers worldwide (Walther 2007; Lazarow *et al.*, 2007). Many of the members of ASBPA and our colleagues in the coastal research and management community count themselves among those 20 million surfers. Within the framework of the National Environmental Policy Act (NEPA), a “surf spot” is a “natural cultural resource.” In general, coastal engineers and managers don’t intentionally design shore protection or navigation projects to be detrimental to existing surfing resources. Comparably many coastal erosion control and navigation projects have also inadvertently created excellent surf spots, such as Sebastian Inlet, Florida, Manasquan Inlet, New Jersey, Oceanside Harbor, California, among others. Yet, many projects adversely affect surfing. The surfing community is keenly aware of past losses of world class surf spots around the world – attributable to shore protection or navigation projects. Through grassroots organizations such as Surfrider Foundation, Surfers Environmental Alliance and Save the Waves, surfers are now organized to protect existing surf spots and support coastal management that takes into consideration surfing issues. Herein, the potential conflict is investigated in greater detail in an effort to enlighten coastal communities to the concerns of surfers and to potential mitigation measures.

Surfer Demographics

Surfers are a special subset of recreational beach users. Surfers are typically frequent visitors to the beach, often making daily or weekly trips; surfers commonly have a strong cultural passion and sense of ownership of their surf spot as a “natural cultural resource.” They typically visit the beach in the early morning or late evening, extending the hours of tourism in coastal communities (Nelsen *et al.*, 2007). Many avid surfers live or work close to a particular surf spot for the sole purpose of being able to surf daily. In some instances, their career choices are directly related to their desire to be able to surf as frequently as possible. On average, experienced surfers have at least a college degree and are in the upper middle-class income bracket (Nelsen *et al.*, 2007). Depending on the location, ease of access, and length of stay at a surf spot, surfing related expenditures can add significantly to the local coastal economy. As an example, Nelsen and Pendleton estimate that expenditures to local businesses, including fuel and food add \$40.16 per surfer per surf session to the coastal economy at Trestles Beach, California (in Lazarow *et al.*, 2007).

Surf breaks are the product of complex interactions of nearshore bathymetry, wave characteristics (height, period and direction), tide level, local wind conditions, and, if present, interactions with shoreline structures. Surfers are keenly aware of the environmental conditions that produce high-quality surfing. Most surfers spend a significant amount of time monitoring

weather and wave forecasts and viewing real-time wave buoy data in an attempt to anticipate the time and location of quality surfing. The location that a surfer will choose to surf is often dependent on the wave direction, tide level and wind conditions. Small changes in the local bathymetric conditions caused by shifting sands, sediment supply, storm activity, and structure interaction can significantly change the quality of a surf break positively or negatively for short to long periods of time. In particular, changes in the nearshore beach slope can shift the breaking characteristics of the waves from plunging breakers ideal for surfing, to spilling breakers that are not as easy to surf (Figure 1).



Figure 1: Surfers riding (a) plunging breaking waves at Bradley Beach, NJ (photo, T. Herrington) and (b) spilling breaking waves on the North Shore of Hawaii (photo, A. Mahon).

What Makes a Surfable Wave?

Although a quality surfing experience is highly subjective and dependent on the location and experience of the surfer, it is recognized within the surfing community that specific surfing locations offer more consistent, quality surfing conditions. The fact that many of these surf spots are referenced by name (i.e., Pipeline, Rincon, Trestles, Bells Beach, Sebastian Inlet, Manasquan Inlet) is a testament to how infrequently all of the conditions required to generate a quality surf break occur and how important these areas are to surfers when the right conditions converge.

Walker (1974) first noted a relationship between surfboard speed and wave peel rate required to make a wave surfable. The peel rate, V_p , is the speed at which a wave breaks along the crest and the angle enclosed by the wave crest and the breaker line is called the peel angle, α (Figure 2). Smaller peel angles require higher surfer velocities, which are more challenging. Therefore, peel angles must be sufficiently large for a wave to be surfable: 30-45 degrees for advanced surfers, 60-90 degrees for beginners (Benedet *et al.*, 2007). The peel rate is mostly determined by the angle between the wave crest and bottom contours. The more oblique the angle of wave approach to the beach, the greater the amount of wave refraction and the slower the peel rate. On sandy beaches with straight and smooth bottom contours, it has been noted that refraction will cause large, long-period swell to become almost parallel with the bottom contours leading to peel rates significantly higher than attainable board speed (Dally and Osiecki, 2007).

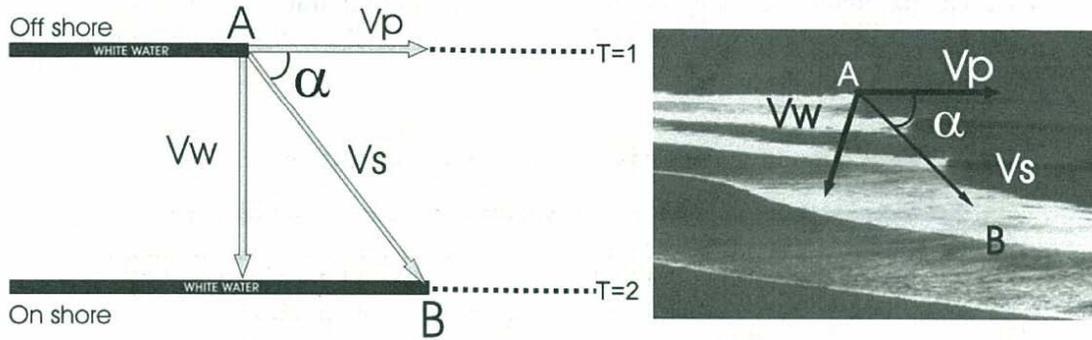


Figure 2: Peel angle terminology (from Dafferner and Klein, 2009)

Surfable waves are typically found on beaches where seabed slope and offshore bathymetry combine with wave height, period and direction to form the necessary platform needed to transform shoaling waves into peeling breakers. Offshore sandbars are a common feature at many popular surfing spots, typically forming naturally in a rhythmic fashion in response to changing wave patterns and longshore currents. Sandbars can also form around littoral barriers to the longshore sediment transport, such as headlands, jetties, groins and piers, especially along coasts with strong unidirectional longshore currents. These barriers often enable elongated sandbars to form in the lee as sediment bypasses the headland or structure. If appropriately oriented relative to the angle of wave approach, the offshore bars will refract waves enabling them to break along the sandbar in a peeling fashion with a continuously distinct breaking point and rolling shoulder (unbroken portion of the breaker). In addition, a sloping bottom along the length of the sandbar is typically needed to ensure an adequate length of ride for the surfer, as opposed to an abrupt change in seabed slope which can cause the wave to close out (collapse on itself). All of these conditions combine to generate breakers adequate for surfing.

The location and geometry of natural sandbar formations often undergo seasonal variations in location and orientation and can change quickly in response to large storm waves or the influx of a large quantity of sand as occurs with a beach nourishment project. These spatial and temporal variations can improve or degrade the surfing conditions along a reach of coastline. Surfers will often change their preferred surfing location based on the seasonal variation in sandbar orientation and incident wave direction. Sandbars formed in the lee of barriers to alongshore sediment transport are “anchored” to the barrier and generally exhibit greater stability in location and orientation when compared to natural sandbar systems. As these sandbar systems are formed in response to the dominant wave direction, reversals in wave direction will often make the bar unsurfable. Surfers along sandy coastlines stabilized with coastal structures will tend to surf adjacent to the structures — based on the incident wave direction and bar orientation.

Effects of Large-scale Beach Nourishment and Structure Modification

At the present time, the most economically justified and environmentally beneficial solution to chronic shoreline erosion is typically to place sand back into the active beach system through beach nourishment as opposed to construction of shoreline armoring or coastal stabilization structures. Beach nourishment directly offsets erosion by placing sand to provide a wide, sacrificial sand platform that provides the benefits of coastal protection, habitat creation and

improved recreational beach area. If maintained through periodic renourishment, beach nourishment can provide long-term benefits to coastal communities.

Beach nourishment projects are designed to translate the eroded profile of the beach seaward a distance far enough to provide the desired level of protection. Theoretically, with sand fill equivalent to the native beach sand, all of the features of the existing beach (foreshore slope, sandbar location and size, and offshore slope) will be exactly replicated on the nourished beach (Figure 3). Many projects translate the cross-shore profile from 10-15 ft above sea level to offshore depths of 20-30 feet below sea level. During the construction of a nourishment project, it is impossible to accurately place sand below the sea surface so designers place the required volume of sand per length of beach in the form of a wider than designed beach berm. Immediately after construction, the placed beach fill has a steeper offshore slope than the normal equilibrium profile (Figure 3); however, with time and normal storm activity, the nourished beach will eventually equilibrate to the shape of the natural pre-nourished beach.

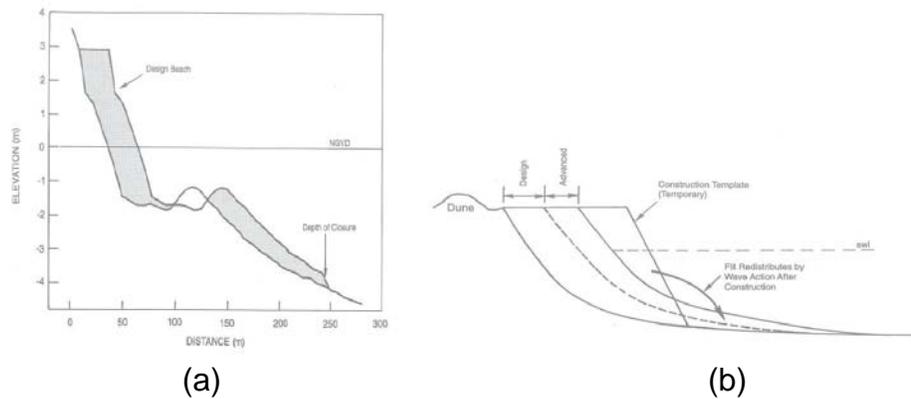


Figure 3: (a) Idealized beach nourishment design template and (b) beach nourishment construction template (reprinted from NRC 1995).

The assumption is that the wave climate that shaped the original eroded beach will redistribute the nourishment material into the same cross-shore profile. How similar the adjusted profile becomes depends on many factors, including similarity of the placed sediment grain size distribution to the native beach, wave climate, storm activity, and the longshore/cross-shore sediment transport in the system.

By design, beach nourishment projects will — at least initially — impact the nearshore breaking wave characteristics, affecting the surfability of breaking waves. If the beach fill has different grain-size characteristics than the native beach, these impacts can be permanent or occur as long as the placed fill remains on the beach. Beach nourishments are often frowned upon by the surfing community, as the new material alters the offshore bathymetry, often generating short-term, unfavorable alterations to previous surfing conditions as the nourishment material adjusts toward the natural profile. However; once adjusted, surfing conditions often return to their previous quality and in some cases are improved due to the increased sediment in the coastal system. As part of the typical design, beach nourishment projects often bury existing coastal structures (such as groins that are desirable surf spots) and fill in pocket beaches in the lee of

headlands. In these cases, surfing is typically negatively impacted until the structures become exposed again or the pocket beach recedes. In many instances, it can take up to a year or more for a surf spot to reappear following a beach nourishment project.

There have been several documented cases where coarser sediments have been placed during a nourishment project and caused severe beach steepening along with the disappearance of offshore sandbars, as was the case in Copacana Beach, Brazil (Benedet *et al.*, 2007). In 1996, a series of groins were buried by beach nourishment in Sea Bright, New Jersey; the surf breaks that once formed off the tips of the groins were no longer present, and the waves were no longer surfable. Alternatively, the introduction of finer sediments in Delray Beach, Florida, promoted offshore bar formation, surf break development, and filled in a deep trough in the offshore bathymetry (Pierro and Benedet, 2008).

Along heavily armored coasts (e.g. Monmouth County, New Jersey), beach nourishment projects have included the total or partial removal of groins in an effort to reduce the impoundment capacity of the existing groin field. Notching groins at the desired location of the swash zone has been observed to enhance bar formation and surfing (Rankin *et al.*, 2004). In other instances, the removal of a pier (e.g. Oil Piers, CA) or groin has negatively impacted bar formation and surfing quality.

Surfing Resource Preservation and Mitigation Strategies

Recognition by coastal communities, local project sponsors, coastal regulatory agencies and federal interests that quality surf spots are a finite “natural cultural resource” as defined by the National Environmental Policy Act (NEPA), may initiate the development of a framework for sustainable surfing resource preservation or mitigation. Presently, at a minimum, surfing resources should be included in the assessment of environmental resources impacted by a shore protection project so that appropriate planning can be developed to mitigate any potential adverse impacts to surfing. An integral part of this process is the inclusion of surfing interests early in the project evaluation and planning. By engaging surfers, inputs or concerns can be addressed early in the design process.

Surfing stakeholders must be knowledgeable of the plan formulation process and be engaged early on, when existing conditions, problems, opportunities and potential management measures are identified. If potential impacts to surfing resources can be identified early on and management measures formulated to minimize such impact, a great deal of controversy causing additional time and expense may be avoided. (An example of surfing interests getting involved late in the process, causing significant time delay and additional cost is the realignment of the Ponce Inlet south jetty in Volusia County, FL.)

If, during the planning process, adverse surfing impacts are expected, several mitigation strategies have been demonstrated to enhance surfability and lessen the negative impacts of shore protection or navigation projects on surfing resources. These strategies include artificial surfing reefs, alternative fill placement, structure modification, and preservation via avoidance of impacts. However; it should be noted that: (a) any morphological change — via a project or

natural causes — will result in a changed surfing conditions; (b) it is virtually impossible to exactly replicate an existing surf spot.

Surf Spot Preservation

Ideally, project designers should first seek to avoid impacts and thus preserve existing surf spots during the feasibility and design phases of a project. Although this approach can avoid any negative impact of the project on surfing resources, it may require significant changes in the protection levels afforded landward of surf spots. Additionally, the long-term morphological changes associated with increased (in the case of beach nourishment projects) or decreased (in the case of structures) sediment transport into the surfing area must be evaluated. In 2002, national and local surfing interests working with the National Park Service collaboratively revised a long standing beach renourishment plan that placed over 4 million yd³ of sand along a critically eroding section of Sandy Hook, NJ that is also the location of a high-quality surf spot. The revised plan attempts to preserve the surfing resource by placing the fill downdrift of the surf spot while still providing the desired level of shore protection in the critical erosion zone. Some in the surfing community have begun to take proactive steps to preserve world class surf spots by identifying and designating them as surfing reserves (e.g. http://www.savethewaves.org/world_surfing_reserves).

Multipurpose Artificial Surfing Reefs

Recognizing that natural fringing reefs and coastal outcrops create salients and tombolos that stabilize the shoreline in their lee has led to the application of artificial submerged structures — intended to provide coastal stability along unsheltered coasts. The geometry, size and orientation of natural reefs in relation to the incident wave climate can work to refract, shoal and break waves across the crest of the reef, reducing the energy available to generate wave driven alongshore sediment transport, thus potentially stabilizing the coast. Pioneering work has been done by Black and Mead (2001) and Black *et al.*, (1997) on the use of multi-purpose artificial reefs (a submerged structure) to dissipate wave energy for the dual purpose of shoreline stabilization and surfing enhancement, which has led to the proposed use of large submerged structures as a means of coastal protection. Several multipurpose artificial surfing reefs (MASR) have been constructed around the world with the intent of improving shore protection, marine ecology, and surf. MASRs are typically constructed using geotextile sand filled tubes or rock and should be closely tuned to the local wave climate to enhance wave refraction, shoaling and breaking.

One of the first constructed artificial surfing reefs was the experimental Pratte's Reef, located in El Segundo, California. Constructed over a two-year period between 2000 and 2001, it was the first structure in the United States designed specifically to mitigate the loss of a local surfing break due to removal of a pier. The structure was constructed with 200 14-ton geotextile sand filled bags placed on the bottom in a V-shape. Due to the light weight of the breakwater units, the reef was quickly broken up by the large swell prevalent in the region. Monitoring studies determined that the underperformance of the experimental Pratte's Reef was attributed to design deficiencies rather than the local wave climate. The reef was removed in 2010.

Only two MASRs have been extensively studied in an effort to quantify the structure's impact on surfing and/or shoreline stability. Eight years of monitoring at Cables artificial surfing reef in Western Australia determined that engineered artificial reefs are capable of generating consistent, surfable waves 80% of the time that breaking waves are present on the reef (Pattiaratchi 2007). Substantial monitoring of the Narrowneck Artificial Reef along the Gold Coast of Australia over the past decade resulted in similar findings. Constructed with sand filled geotextile bags and designed in conjunction with a beach fill to primarily provide shore protection with a secondary benefit of surf enhancement, the Narrowneck reef appears to have reduced erosion in the lee and updrift of the reef and also provided locally improved surfing conditions, although not of the quality of the surrounding regional surfing breaks (Jackson *et al.*, 2007). To generate the desired wave transformations, MASRs typically cover between 270,000 ft² to over 5.4 million ft² of the seabed and can extend over 1,000 ft offshore. This tends to make the reefs less attractive to surfers (Jackson *et al.*, 2007). Anecdotal evidence suggests that most of the MASRs have produced mixed results due to difficulties in constructing the reefs to the design specifications, uneven settlement of the filled geotextile units, and unrealistically high surfer expectations that MASRs will create surfable waves reliably regardless of conditions.

Alternative Beach Nourishment Placement

The alternative placement of beach nourishment material to create a series of artificial shoals in the surf zone to act as a “feeder beach” or “surfing shoal” has been proposed by Benedet *et al.* (2007) and Dally and Osiecki (2007), respectively. Designed specifically to generate perturbations in the offshore bottom, surfing shoals can refract and shoal the incident wave field to produce surfable peel angles along the shoals. The longevity of the features is dependent on the size of the shoals, sediment grain size and the local wave climate. Material transported out of the shoals can ultimately act as a sediment source for the beach, providing some shore protection benefits while creating surf breaks. If constructed with sufficient volume and proximity to the beach, the shoals could provide a source of sediment significant enough to provide shoreline stabilization over the duration of the typical renourishment cycle.

This concept was incorporated into a scheduled renourishment project within the authorized Sandy Hook to Manasquan, New Jersey, federal shore protection project. Constructed in Long Branch, New Jersey, the \$9 million project placed 700,000 yd³ of sand along a half-mile stretch of beach and included an alternative fill placement (feeder beach) that added approximately \$1 million to the total project cost. The feeder beach design was agreed to by the USACE, the state of New Jersey and local surfing groups as a way of minimizing the impact to existing surfing locations, and potentially creating new surfing opportunities through the creation of offshore sandbars downdrift of the feature. The alternative fill placement (feeder beach) was in the form of a trapezoidal surfing feature near the center of the project. The feeder feature was designed to extend 1,000 ft in alongshore distance and extend 225 ft seaward of the design mean water line. Due to strong unidirectional alongshore gradients in sediment transport encountered at the site, and significant placement slopes of 1:10, it was not possible to place material in water depths between 25-30 feet at the design toe. This resulted in a 150 ft reduction in the width of the surfing feature. The reduced width and significant offshore slope made the feature ineffective in generating highly refracted, surfable waves. Downdrift surf spots, however, remained surfable during construction and benefited over the long-term from sand supplied by the feature. An 18-

month monitoring study determined that over 85% of the placed material remained in the active beach profile, indicating that alternative nourishment placements can provide the desired shore protection benefit without negatively impacting surfing along the entire project length. However, it appears that the construction of artificial shoals may not be practical along coasts with strong unidirectional sediment transport and steep offshore slopes.

Structural Stabilization and Surf Design

In instances where structural stabilization exists or is required to insure the successful design of a project (e.g. inlet jetties), consideration should be given to the potential positive benefits that the structures can provide to the local surfing conditions. It is well established that many existing well known surf spots are a result of, and adjacent to, coastal structures. Sebastian Inlet, Florida, Manasquan Inlet, New Jersey the Cove at Sandy Hook, the Wedge at Newport Beach, California, are examples of structurally created surf spots. During the design or redesign process, assessment of wave transformations adjacent to coastal structures can be used to shape the structure to enhance wave breaking for optimal surfing conditions, leading to the creation of additional surfing resources.

Integrated Beach Nourishment and Surf Mitigation

In many cases, the physical conditions that generate surfable waves also focus wave energy along the coast, resulting in large gradients in sediment transport and shoreline erosion. Under these conditions it is most likely impractical to provide the required shore protection levels while preserving the existing surf spot. Typically, beach nourishment projects — at least temporarily — negatively impact surfability at popular surfing locations, particularly where existing coastal structures (that promote offshore sand bar formation) are buried by fill material, or more permanently where the offshore slopes steepen due to coarse fill material, which alter wave breaking characteristics.

Research is currently being initiated through a cooperative research study between the state of New Jersey and the U.S. Army Corps of Engineers (USACE) Engineering Research and Development Center (ERDC) in Vicksburg, Mississippi, to investigate the integration of surf enhancement elements within beach nourishment projects. Through coupled physical and numerical modeling, research on the use of submerged geotextile groin extensions and submerged geotextile detached offshore breakwaters to sculpt offshore bar formations for surf enhancement is being investigated. The goal is for the combination of the extended groin and offshore breakwaters to promote offshore sandbar formation to generate wave breaking characteristics appropriate for surfing, as well as provide the required shore protection level required. Possible alternatives to be investigated include, sacrificial elements placed after the completion of the construction template, embedded structures placed before nourishment that would become functional as the profile transitions to the design profile, intermediary elements that would be placed during construction, and/or a combination of each, with the goal of maintaining the existing surfing resource over the life of the nourishment project.

Summary

Recognizing that surfing is an important recreational and cultural use of the coastal zone and that surfers are a viable coastal stakeholder group, proactive steps can be taken by coastal communities, local project sponsors, regulatory agencies and federal interests to integrate the identification, preservation, and/or mitigation of surfing resources into planning and project development. Traditional and emerging coastal construction and stabilization techniques can be employed to minimize the impact to, and in some cases enhance, surfing within navigation and shore protection projects.

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