Categorizing the Types of Surfing Breaks around Jetty Structures

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ABSTRACT

Coastal modifications to control erosion, maintain navigation channels, and create harbors are often undertaken near surfing breaks. Surfing conditions can be improved by these activities, but they can also adversely affect existing surfing breaks. Jetties are coastal structures that on occasion improve surfing conditions. Even though there is an increasing volume of literature on the ways ordinary waves transform into surfing waves, the mechanics of surfing breaks around jetties has not been explored in detail.

Four main types of surfing breaks that are created or enhanced by jetties have been identified. The types are dependent on the length of the jetty relative to surfzone width and the degree to which the ebb delta influences wave propagation. Case studies clearly show the behaviors of the different types of jetty breaks. Monochromatic wave refraction modeling of each site has identified the surfing break components that produce the surfing waves.

Understanding the effects of a coastal structure on sediment transport, ecology, water quality, shoreline position, and recreation is important to minimize and mitigate any potential negative effects and to streamline coastal permitting. The effects on surfing conditions are being considered more often as the social and economic value of surfing to coastal communities is realized. This research helps to better predict the impact of jetty construction or alteration on surfing conditions.

ADDITIONAL KEY WORDS: *Surfing break components, surfing reef components, component scale, wave refraction, numerical modeling*, *coastal structures, coastal modification.*

INTRODUCTION

Although there are many papers that discuss the physical processes that turn ordinary waves into surfing waves (SCARFE et al., 2003c), the mechanics of surfing breaks around jetties had not been explored in detail until recently (SCARFE et al., 2003b). This knowledge is needed to minimize and mitigate negative impacts on surfing breaks caused by coastline alterations. The inclusion of surfing amenity into coastal projects is of great social and economic benefit to coastal communities (MEAD and BLACK, 2002), and the practice is becoming more frequent as coastal planners, scientists, and engineers become more aware of the value of surfing.

Surfers know that some coastal structures, such as jetties, can improve surfing conditions. However, when surfing conditions are improved by jetties, these improvements are accidental rather than preconceived, because there has been insufficient understanding about how jetties create surfing breaks (SCARFE et al., 2003b). The information we now have about the design of artificial surfing reefs (BLACK, 2001; MEAD, 2001; SCARFE, 2002) can also be used to create artificial surfing breaks around jetties.

This paper attempts to solve these problems by identifying the main morphological types of surfing breaks that exist around jetties. Each type is described with a case study of a specific surfing break, including its bathymetric classification (MEAD and BLACK, 2001a and 2001b; SCARFE et al., 2003b). The monochromatic wave refraction model WBEND (BLACK and ROSENBERG, 1992; BLACK, 2000) was used in this study to show the effects of the components on wave propagation.

CLASSIFICATION OF JETTY SURFING BREAKS

Four types of surfing breaks around jetties have been identified. The two defining variables in type of jetty break are the delta's effect (preconditioning, wave breaking, or none) and the size of the jetty (longer/shorter than surfzone width).

A *Type One* jetty break occurs where waves break shoreward of the end of the jetty. The jetty length is longer than the surfzone width. Trapped sediment accumulates against the jetty, creating a fillet that acts as a wedge component. Energy from along the wave crest converges against the jetty, creating a peak in wave height and a take-off zone. The wave then peels along the wedge feature.

A *Type Two* jetty break is created by the ebb tidal delta. Waves are preconditioned over the delta before breaking further inshore. The shoaling and refraction over the delta form peaks in wave height and rotate waves suitable for surfing. Surfing waves are then formed by a combination of wave height peak, wave angle oblique to seabed contours, and bar formations created by rip currents.

A *Type Three* jetty break is also created by an ebb tidal delta. The delta provides stable contours for waves to break over rather than acting as a preconditioning component. Some preconditioning will happen over the delta, but the dominant process that creates the surfing waves is wave breaking.

A *Type Four* jetty break is an example of a jetty construction that does not change the existing surfing conditions. The jetty is not sufficiently long to trap enough sediment and change the beach width significantly. The surfing conditions exist because of other natural features such as reef that create surfable waves.

Jetty surfing breaks do not always fit perfectly into the four jetty types described here. Just as wave breaking type involves a continuum from spilling and plunging to collapsing (KOMAR, 1998), so do the types of jetty surfing breaks. For example, the major difference between a Type One and a Type Four jetty break is the length of the jetty relative to surfzone width. A 75 m long jetty may behave as a Type One jetty for small swells. However, as the swell increases, so does the surfzone width, and the surfing break may behave more as a Type Four. Surfing conditions around jetties can be further complicated by other structures, such as attached and detached breakwaters. This paper does not consider jetties that are complicated by other structures.

TYPE ONE JETTY

Peeling waves are created at a Type One jetty by a combination of three primary mechanisms: wave reflection, wave convergence, and wedge contours aligned obliquely to wave crests. Waves approaching at an angle to the jetty travel unbroken along the jetty wall. Energy from along the wave crest clusters together as it reflects off the jetty and back toward the remainder of the wave crest, creating a peak in wave height.

Another mechanism that creates surfing waves is caused by the permanent rip current alongside the jetty. The jetty provides a stable feature for the development of a rip, which scours out a channel abutting the jetty. Wave energy in the channel refracts away from the jetty and toward take-off, reinforcing the peak created by the wave reflection. The focused wave energy eventually breaks when the water depth becomes shallow enough. A wedge component is created by the fillet against the jetty. The wedge allows the wave to continue peeling until the break point reaches the shore.

Case Study: Mission Bay North Jetty, Mission Beach, San Diego, California

The North Jetty, completed in 1950, stabilizes the mouth of Mission Bay and impounds sediment on the north side (SHAW, 1980). The jetty is 1000 m long with approximately 550 m of its construction exposed to wave action on the north side. The other 450 m are abutted by land and the navigation channel.

Good surfing waves can be found just north of the jetty on lower tides, even when the beach to the north has relatively poor surfing conditions. The waves at this jetty break significantly longer than the beach and with higher intensity. The take-off point is reasonably consistent, whereas the beach breaks are very “shifty.”

The two diagrams in Figure 1 show that the Mission Bay North Jetty surfing break is made up of a meso-scale Ramp/Wedge configuration. The first diagram shows the seabed contours around the jetty. The second is a simplified schematic of the components with refraction patterns.

When waves approach obliquely to a jetty, the wave travels unbroken alongside the jetty, and energy from along the crest combines, forming a peak in wave height. This focusing at the take-off point can be seen in Figure 2. A strong rip current 5-10 m wide is permanently present between the take-off and the jetty. This channel allows surfers to easily reach the take-off zone and pushes the take-off area away from the jetty, making surfing safer.

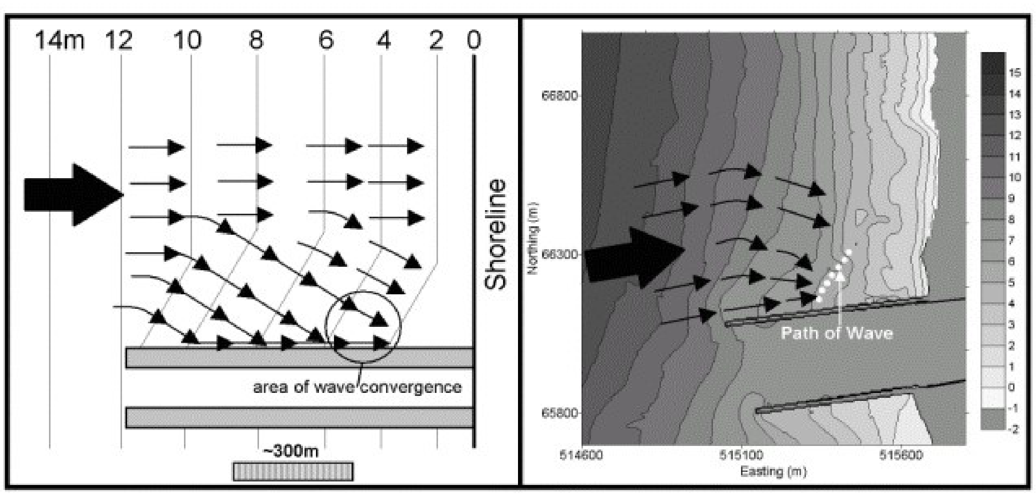

Figure 1. *Two diagrams illustrate how the Mission Bay north jetty produces surfing waves. The first diagram shows the bathymetry, and the second idealized schematics of refraction over the surfing break components (Ramp/Wedge configuration).*

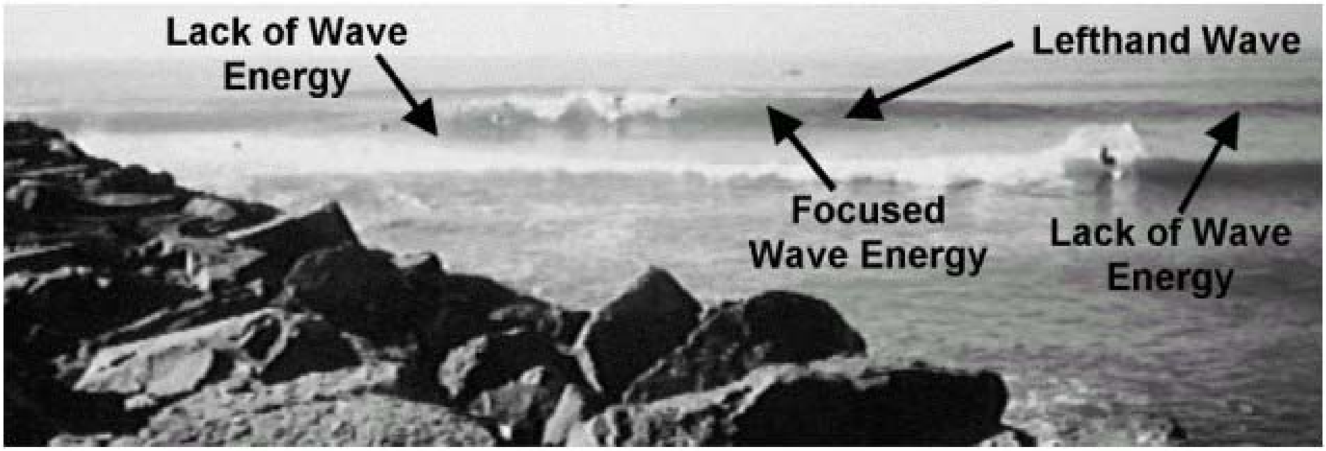

Figure 2. *Surfing waves at Mission Beach Jetty. The best surfing waves are lefthanders. Notice the focusing of wave energy.*

TYPE TWO JETTY

Jetties are likely to have ebb tidal deltas, but some of these deltas are larger than others. The delta of a Type Two jetty break has a large influence on the preconditioning of waves before they break further inshore. Waves are also modified over the delta with other types of jetty breaks, but this is not the dominant process that creates the surfing waves.

The delta of a Type Two jetty break creates surfing waves through two main processes. First, waves are focused and height is significantly larger than if the delta was not present. Second, the waves are rotated obliquely to the shoreline, increasing the wave peel angle and chance of surfable waves.

The configuration of surfing break components that is formed by the delta can be simple or complex (MEAD and BLACK, 2001a and 2001b). Ramps, wedges, focuses, ridges and platforms can all be created by deltas. The general effect of these components on waves is to cause them to be focused and rotated. Deltas are constantly changing with fluctuations in sediment supply and wave climate, and therefore, so is the reef component configuration.

Case Study: “The Poles”, Atlantic Beach, Florida

“The Poles” in Atlantic Beach, Florida is used here as an example of a Type Two jetty break. It is a surfing break located on the south side of the jetted St. John’s River. The length of the southern jetty is approximately 500 m. This surfing break has anomalously large waves for the region formed by wave preconditioning over the river’s southern delta formation (RAICHLE, 1998). The jetty has created a distinct delta formation and a surfing break. Surfing waves would have been different prior to jetty construction because the delta would have been shaped differently. For example, the jetty focuses the outgoing water, creating a deep channel that makes the delta more pronounced.

The two diagrams in Figure 3 provide simplified schematics of the components and schematics at “The Poles,” as well as its actual bathymetry. The general effect of the Ramp/Focus/Wedge configuration has been described by MEAD and BLACK (2001b). First, the ramp aligns waves to the favored orthogonal direction in preparation for convergence of wave energy on the focus. The peak of the wave energy then breaks further offshore than the rest of the wave, creating an easier takeoff point for the surfer who can ride the wave breaking along the wedge.

Figure 4 shows a 2 m, 15 sec period wave for different wave directions (SCARFE et al., 2003b). Analysis on a meso-scale shows that the waves shoal along the ramp, converge on the focus, and refract on the wedge for all simulations. However, the width, location and intensity of the focused band of wave energy vary between simulations, because the influence of each micro-scale component changes for the different wave directions (SCARFE et al., 2003b).

Each micro-scale component can work independently or in conjunction with other components to create the large, focused wave heights. In Figure 4, the wave peaks at 5.3 m, 300m south of the jetty when waves come from 55°. When the wave direction is more southerly (100°), the wave peaks at only 4.3 and focuses right next to the jetty. This difference is caused by the micro-scale focus features at the tip of the delta creating two bands of wave energy. These bands converge to create the larger wave height for easterly waves, whereas for more southerly swells, one band is directed too far north to converge and breaks north of the southern jetty.

The large river mouth is jetted, and anecdotal local knowledge suggests that the wave amplification is a result of the jetty itself (RAICHLE, 1998). Waves will peel alongside the jetty in a similar way to a Type One jetty, but the delta will have the largest effect on wave preconditioning. As seen from the model simulations, depending on the wave direction, waves will either be focused next to the jetty or further south down the beach. When more easterly waves are present, it is less likely that large waves will be present right next to the jetty. The delta is present at this jetty, but not at Mission Bay, because this jetty trains a river, whereas Mission Bay is a harbor.

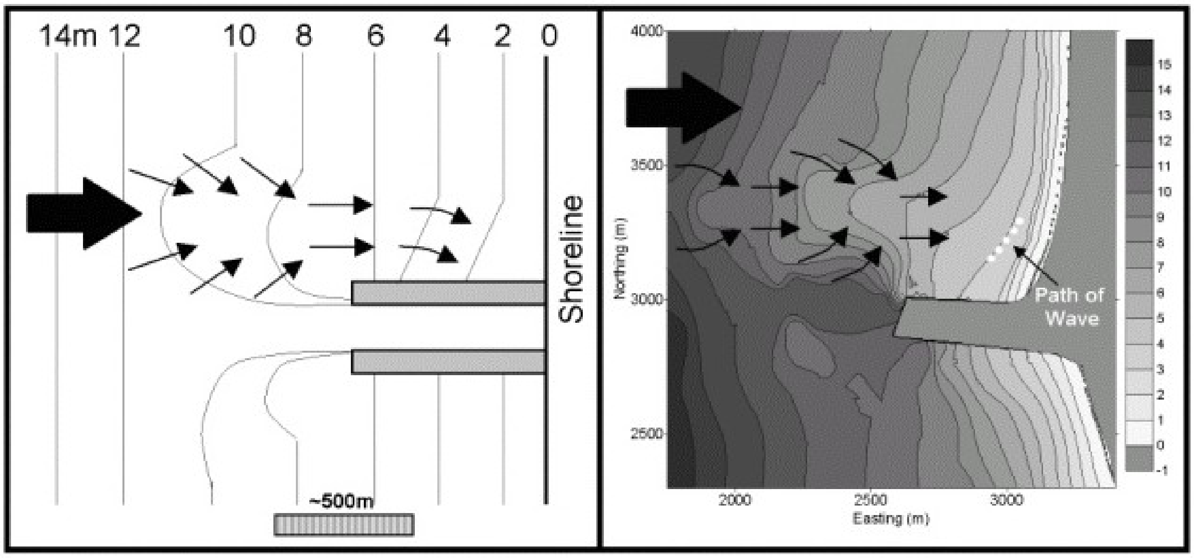

Figure 3. *Two diagrams illustrate how the delta and jetty at "The Poles" produces surfing waves. The first diagram shows the bathymetry, and the second idealized schematics of refraction over the surfing break components (Ramp/Focus/Wedge configuration).*

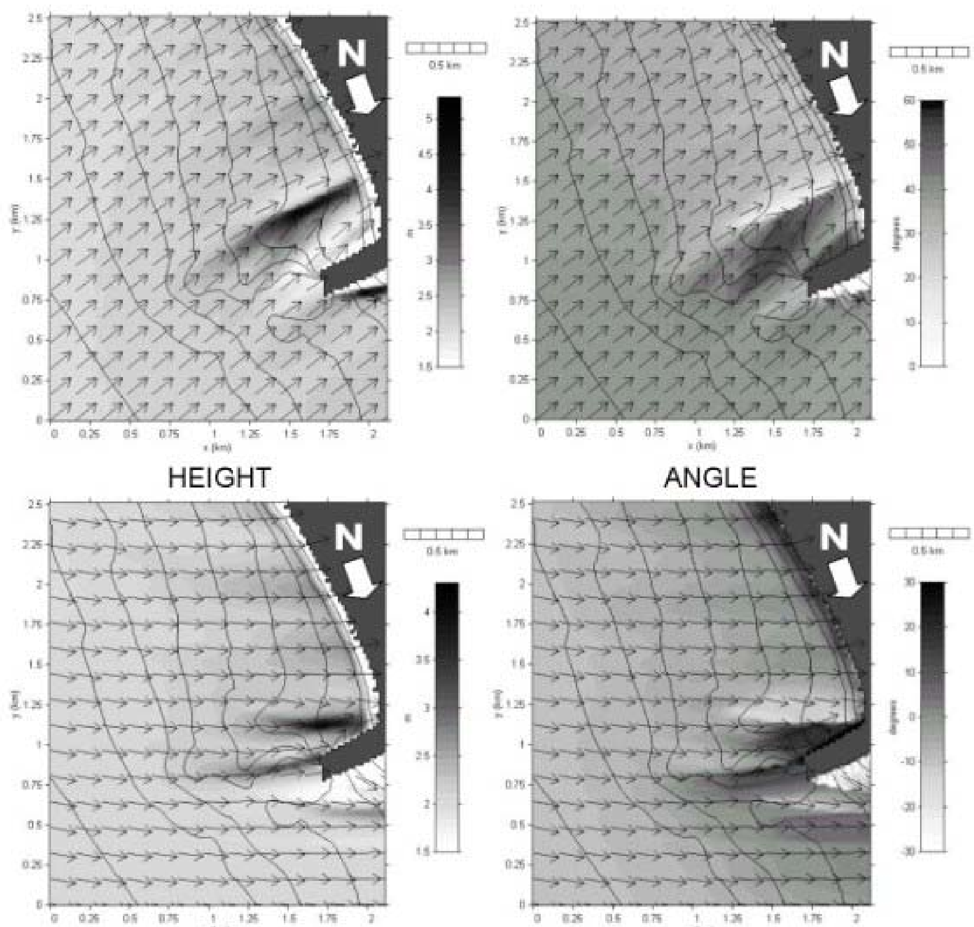

Figure 4. *Refraction predictions at "The Poles" for a 2 m, 15 s wave from 55° degrees (top images; model grid direction 35°) and 100° degrees (bottom images; model grid direction -10°).*

TYPE THREE JETTY

Type Three jetty surfing breaks occur when the ebb delta of the jetted inlet is shallow enough to initiate wave breaking. Preconditioning also occurs over the delta, but not to the same extent as with Type Two breaks. The main effect of the delta is to align the contours, causing breaking and producing surfable peel angles. If the water is not shallow enough to break waves, good surfing waves will not be created solely by wave preconditioning.

This type of break can be affected by tides, as the water can become too deep to cause wave breaking on the delta. Depending on delta and nearshore bar configuration, the delta may act as a preconditioning component, turning the break into a Type Two when the tide is high. This will not always occur, and waves can also break further nearshore in a manner not conducive to surfing.

The water going in and out of the jetty also impacts on wave breaking since these types of breaks occur close to jetty structures. Strong currents can be observed, especially when the tidal prism is large and combined with river outflow. Outgoing water delays wave breaking and/or causes waves to break in shallower water, increasing breaker intensity.

Case Study: "Southside" at Tamarack, Carlsbad, California

"Southside" is located offshore of the northern, jetted inlet channel of the Agua Hedionda Lagoon in Carlsbad, California. Both jetties are 150 m long and were completed in 1954 (SHAW, 1980). Although a large percentage of the water that enters through the inlet channel is output through another jetted channel to the south, enough is discharged through the northern jetty to create a small delta that produces quality surfing waves. The sand buildup is also affected by reefs in the area (SCARFE et al., 2003b). "Southside" has a delta-formed, Ramp/Focus configuration of features (Figure 5). Righthand waves break directly offshore of the southern jetty and in toward the beach (Figure 6). Lefthand waves do break, but the rides are generally not as long as those of righthanders.

Depending on the buildup of sediment in the lee of the focus, righthand waves can be ridden almost all the way to shore. The buildup of sediment at the time of the survey does not appear to allow for these long rides. The angle between the shallow water contours and the predicted wave directions (Figure 6) would produce very low peel angles. If the beach to the south of the jetty is more scoured, longer rides will be possible (SCARFE *et al.*, 2003c). This eroded profile would have obvious negative impacts on beach usage, but improve surfing conditions.

A swell direction of 260° is expected to provide the longest rides for two reasons. First, the focus feature extends out to approximately 8 m depth because the delta joins the natural reef just north of the jetties. This creates a shadow zone south of the delta when waves come from a northward direction. As a result there is a gradient in height along the wave crest, promoting peeling waves. This gradient can be seen the photo of surfing waves at "Southside" in Figure 6. The second reason for the longer rides is that the wave direction is at a larger angle to the contours, suggesting higher peel angles. Larger wave heights were predicted from other wave directions because of stronger focusing, but this does not guarantee better surfing waves, because peel angles would be lower.

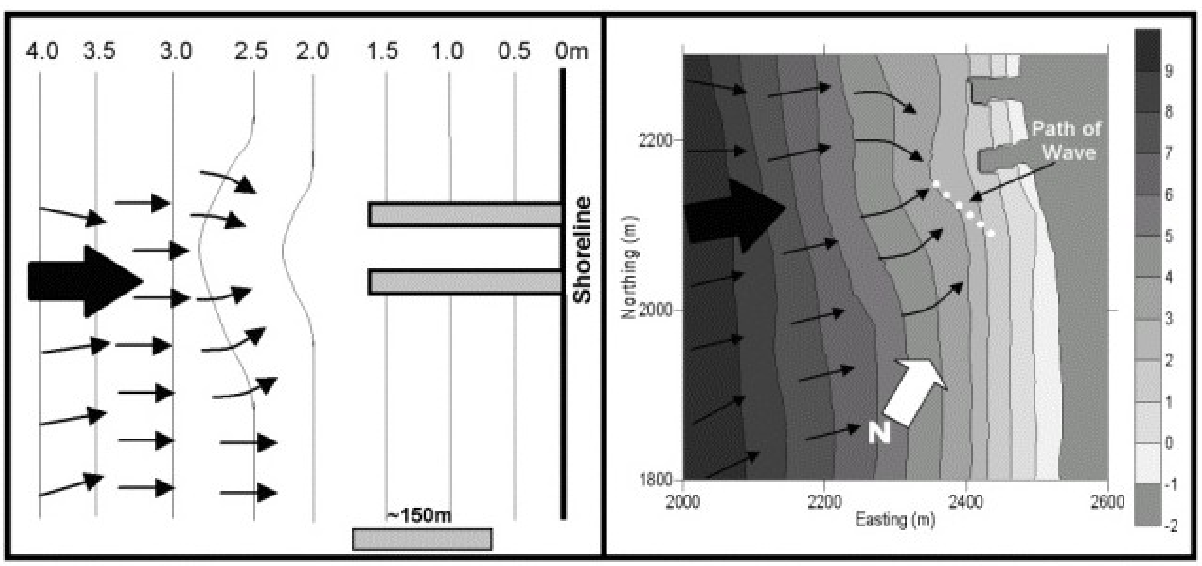

Figure 5. *Two diagrams illustrate how the delta and jetty at "Southside" produces surfing waves. The first diagram shows the bathymetry, and the second idealized schematics of refraction over the surfing break components (Ramp/Focus configuration).*

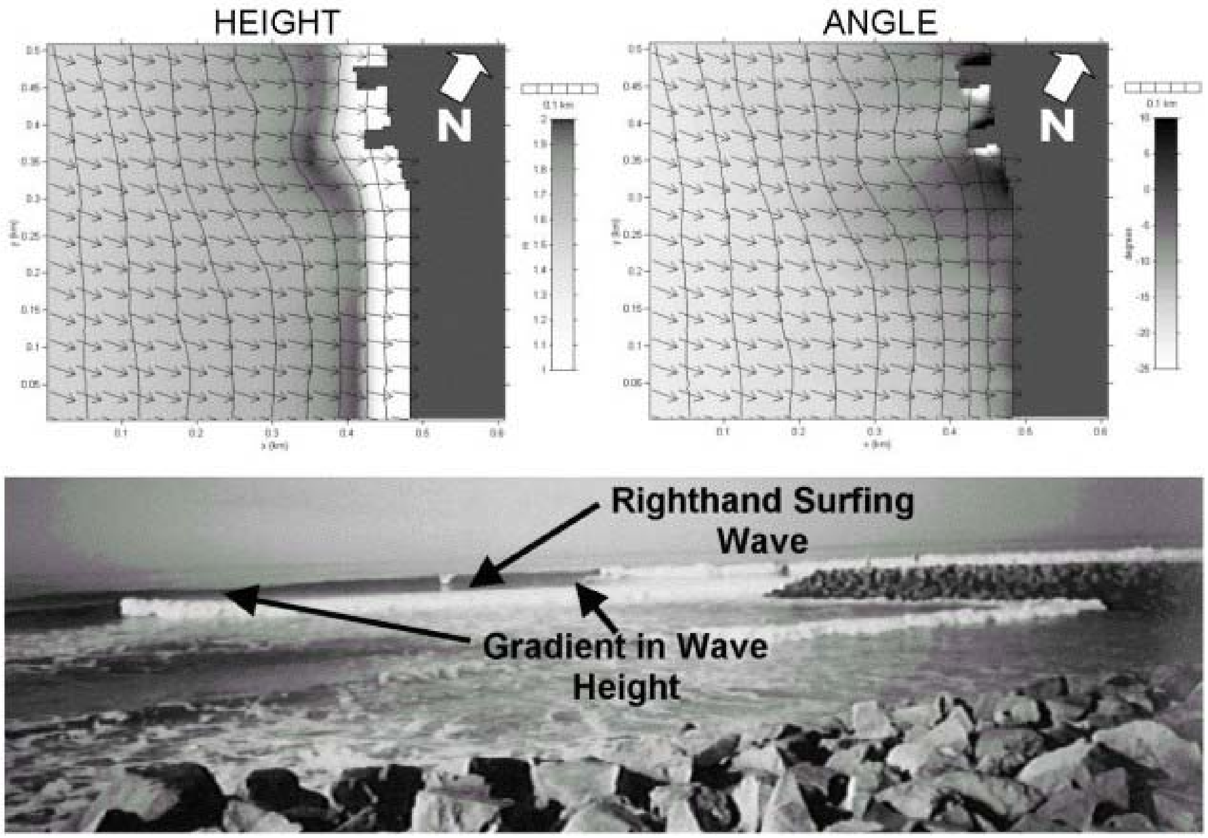

Figure 6. *Refraction predictions and image of peeling surfing waves at "Southside". The modeled wave is 1.5 m, 14 s from 260° (model grid direction -20°). Note the gradient in wave height along the wave crest that promotes righthand peeling.*

TYPE FOUR JETTY

A *Type Four* jetty break is an example of a jetty construction that does not change the existing surfing conditions. The jetty is not sufficiently long to trap enough sediment and change beach width significantly. The surfing conditions exist because of other natural features such as reef that create surfable waves.

Case Study: Tamarack, Carlsbad, California

A combination of side-scan surveying and sub-bottom profiling by ELWANY et al. (1998) showed the location of the natural reefs that help to create the surfing breaks at Tamarack. The reefs extend from the shore to about 12 m deep, and from the inlet to the jetty to 1 km north. A combination of sand and reef creates the three breaks called Spotland, Main Peak and Middles. The reefs do not protrude significantly above the natural beach shape, but still provide enough relief to improve surfing conditions.

The jetty has acted to increase beach width slightly, but not enough to affect surfing conditions. It is likely that the reef features provide stable bars and consistent trapping of sediment. If the reefs were not present, then the sand would be too mobile to create the stable bars needed to produce good surfing waves. Surfing conditions are expected to be similar without the jetties. It should be noted that the surfing break "Southside" is expected to be improved if not created by the jetties.

Spotland, Main Peak and Middles are created by sand and reef focusing features in the surfzone. The breaks are a Ramp/Focus configuration, which creates shifty peaks of high wave energy (Figure 15). The focusing features have only a subtle impact on the convergence of wave energy forming surfing waves because of a small variation in wave height and some localized rotation of wave directions (Figure 16). Examples of good surfing conditions at Mainpeak can be seen in Figure 17. The surfing rides experienced at these breaks are only brief because of the shape of the focus features. Longer surfing rides would be experienced if the focus contours were at a more oblique angle to the ramp contours.

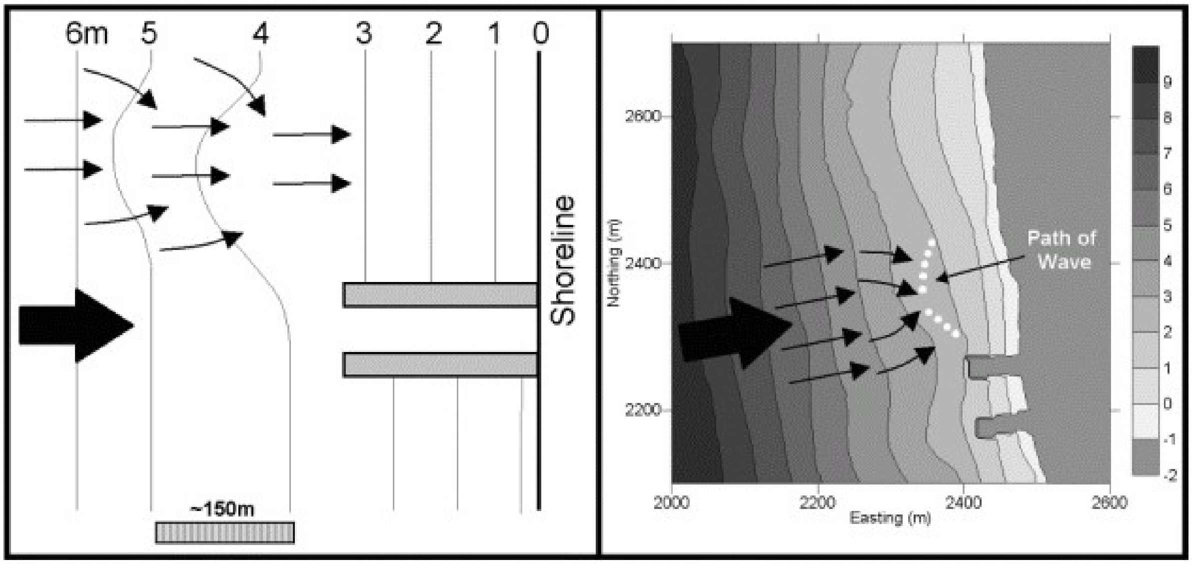

Figure 7. *Two diagrams illustrate how natural reef and the jetty at Tamarack produce surfing waves. The first diagram shows the bathymetry, and the second idealized schematics of refraction over the surfing break components (Ramp/Focus configuration).*

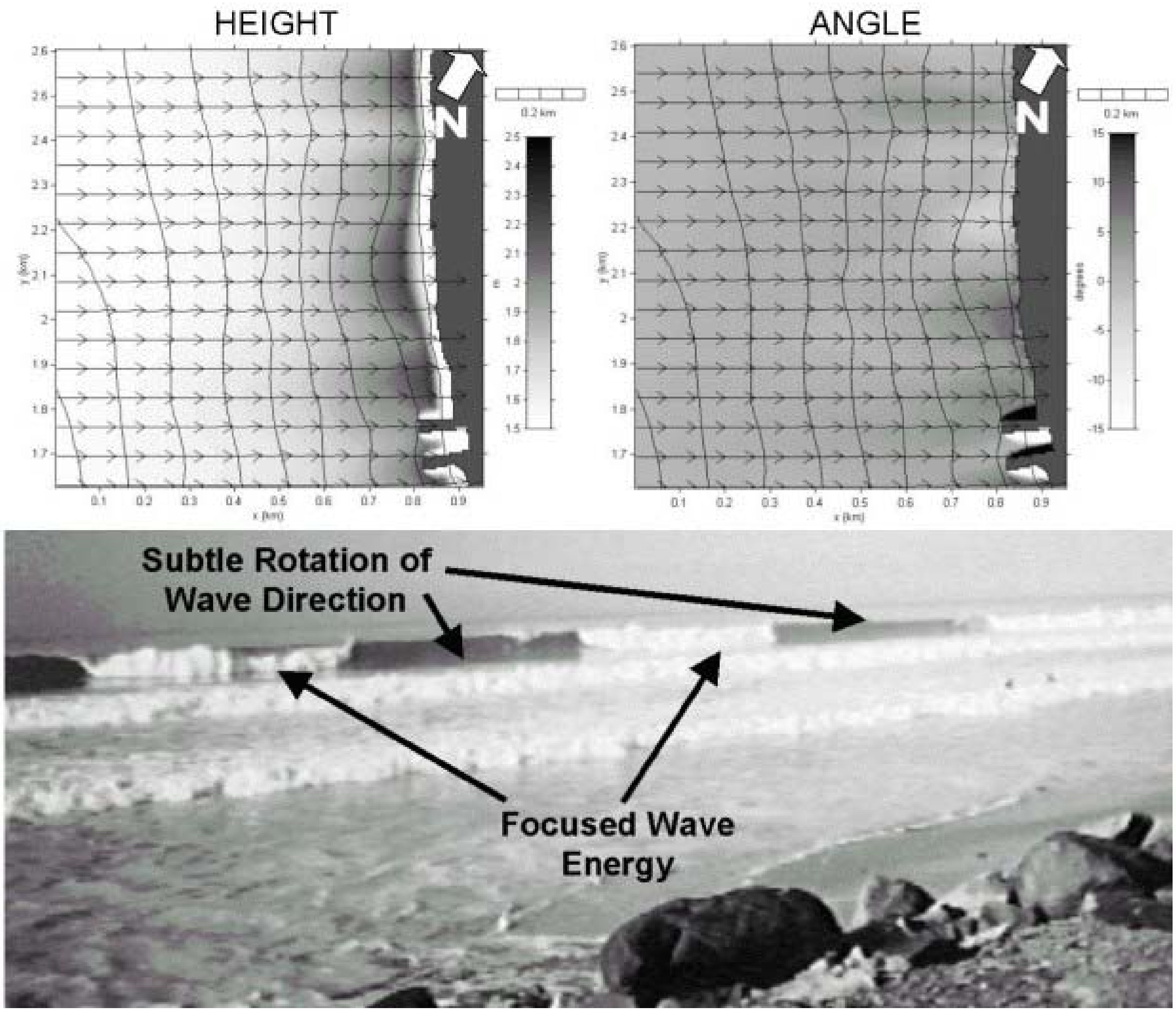

Figure 8. *Refraction predictions and image of peeling surfing waves at Tamarack. The modeled wave is 1.5 m, 14 s from 240° (model grid direction -0°). Short peeling waves form because of subtle focusing and rotation of waves.*

DISCUSSION

Engineering of the coast to control erosion, maintain navigation channels, and create harbors is often undertaken near surfing breaks. Surfing conditions can be improved by engineering, but more often the activity is undertaken at the expense of the surfing break. Jetties are coastal structures that on occasion improve surfing conditions, but this outcome is not guaranteed. Utilizing information presented in this paper when designing or altering jetties will help minimize negative impacts and possibly improve surfing conditions.

Understanding the effects of a coastal activity on sediment transport, ecology, water quality, shoreline position, and recreation is important to minimize and mitigate negative effects and to streamline coastal permitting. The effects on surfing conditions are also being considered more frequently now, as the social and economic value of surfing to coastal communities is being realized.

The research presented here is based on numerical studies of existing bathymetric data. The information was used to differentiate between the types of surfing breaks that are created by jetties. It does not aim to present a detailed study of each location but rather a general overview of the site. Future research on predicting surfing break types around jetties could quantify the results presented here by utilizing information about tidal prism, delta size, and jetty length.

LITERATURE CITED

BLACK, K.P., 2000. *The 3DD computational marine and freshwater laboratory: Model WBEND*. ASR Technical Series, ASR Ltd, PO Box 13048, Hamilton, New Zealand, 10 pp.

BLACK, K.P., 2001. Foreword: Natural and artificial reefs for surfing and coastal protection. In: BLACK, K. P. (ed.), Natural and Artificial Reefs for Surfing and Coastal Protection. *Journal of Coastal Research*, Special Issue No. 29, p. 1.

BLACK, K.P. and ROSENBERG, M.A., 1992. Natural stability of beaches around a large bay. *Journal of Coastal Research*, 8(2), 385-397.

ELWANY, M.H.S., LINDQUIST, A.L., FLICK, R.E., O'REILLY, W.C., REITZEL, J., and BOYD, W.A., 1998. *Study of sediment transport conditions in the vicinity of Agua Hedionda Lagoon – Volume II: Data report.* Center for Coastal Studies, Scripps Institution of Oceanography, La Jolla, CA, SIO Ref. No. 00-08, December 30, 1998.

KOMAR, P.D., 1998. *Beach processes and sedimentation*. 2nd Edition. Upper Saddle River, New Jersey: Prentice Hall, 544 pp.

MEAD, S.T., 2001. *Incorporating high-quality surfing breaks into multi-purpose reefs*. Hamilton, New Zealand: Earth Science Department, University of Waikato, Ph.D. thesis.

MEAD, S.T. and BLACK, K.P., 2001a. Field studies leading to the bathymetric classification of world-class surfing breaks. In: BLACK, K. P. (ed.), Natural and Artificial Reefs for Surfing and Coastal Protection. *Journal of Coastal Research*, Special Issue No. 29, pp. 5-20.

MEAD, S.T. and BLACK, K.P., 2001b. Functional component combinations controlling surfing quality at world-class surfing breaks. In: BLACK, K. P. (ed.), Natural and Artificial Reefs for Surfing and Coastal Protection. *Journal of Coastal Research*, Special Issue No. 29, pp. 21-32.

MEAD, S.T. and BLACK, K.P., 2002. Multi-purpose reefs provide multiple benefits: Amalgamating coastal protection, high quality surfing breaks and ecological enhancement to maximize user benefits and development opportunities. *Proceedings for the Second Surfing Arts, Science and Issues Conference* (SASIC 2, Ventura, California, USA). 9 November. The Groundswell Society, pp. 47-63.

RAICHLE, A.W., 1998. Numerical predictions of surfing conditions at Mavericks, California. *Shore and Beach,* April, 66(2), 26-30.

RANASIGNHE, R., HACKING, N., and EVANS, P., 2001. *Multi-functional artificial surf breaks: A review.* Report published by NSW Department of Land and Water Conservation, Center for Natural Resources. Parramatta, Australia. 53p.

SCARFE, B.E., 2002. *Categorising surfing manoeuvres using wave and reef characteristics*. Hamilton, New Zealand: Department of Earth Science, The University of Waikato. Master's thesis.

SCARFE, B.E., BLACK, K.P., CHONG, A.K., DE LANGE, W.L., PHILLIPS, D., and MEAD, S.T., 2003a. The application of surveying techniques to artificial surfing reef studies. *Trans Tasman Surveyor,* April 2003 (in press).

SCARFE, B.E., ELWANY, M.H.S., BLACK, K.P., and MEAD, S.T., 2003b. *Surfing conditions around jetties.* Center for Coastal Studies, Scripps Institute of Oceanography, La Jolla, CA. SIO Ref. No. 03-XX.

SCARFE, B.E., ELWANY, M.H.S., MEAD, S.T., and BLACK, K.P., 2003c. The science of surfing waves and surfing breaks: A review. *Journal of Coastal Research,* This Issue.

SHAW, M.J. 1980. *Artificial sediment transport and structures in coastal Southern California.* Center for Coastal Studies, Scripps Institute of Oceanography, La Jolla, CA. SIO Ref. No. 80-41. December 1980. 109p.