1981

Beaches of the Illawarra

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Publication Details

This report was originally published as Bryant, RW, Beaches of the Illawarra, Wollongong Studies in Geography No.5, Department of Geography, University of Wollongong, 1980, 4p.

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Abstract
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WOLLONGONG STUDIES IN GEOGRAPHY No. 5
Department of Geography, University of Wollongong.

BEACHES OF THE ILLAWARRA - E. Bryant

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INTRODUCTION

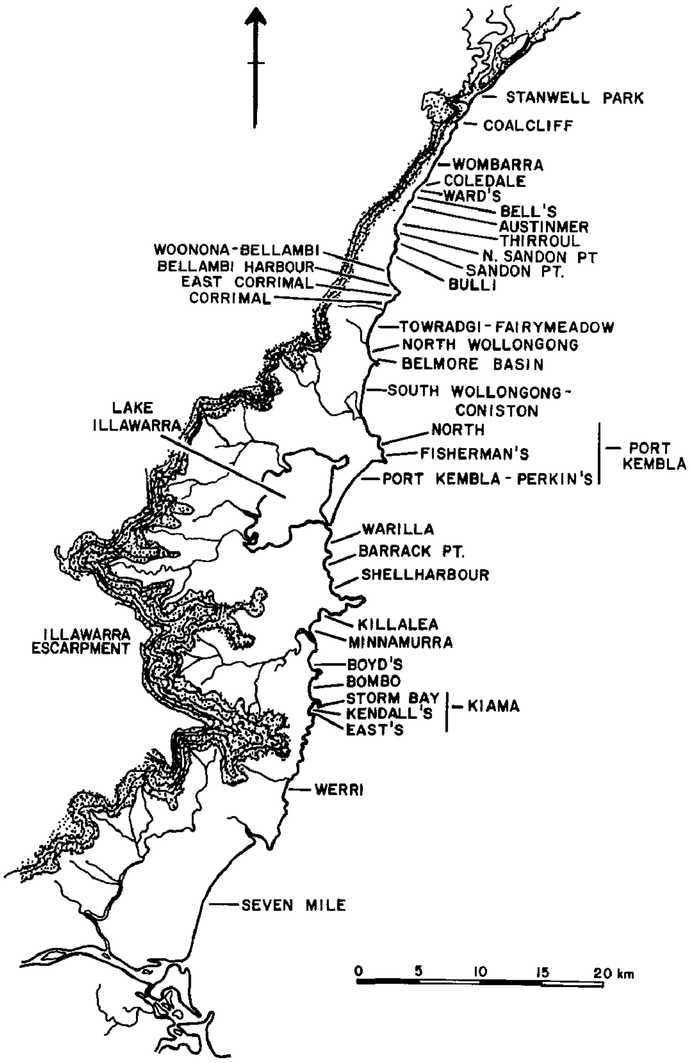
The beaches of the Illawarra between Stanwell Park and Werri fit within a general dynamic classification characterizing most beaches of the world. At the one end of this classification lies the reflective beach which is devoid of inshore topography, mainly sheltered and temporally stable. At the other end lies the dissipative beach which is characterized by a barred surf zone, situated on exposed coastline and susceptible to rapid change. Because of structural control on the geology of the Illawarra coastline some of the beaches are often directed, or even forced, into morphology which may at first appear abnormal for the setting of that beach. Additionally man is interfering in places with the coastal environment to the extent that some beaches may be irreversibly locked into an erosional cycle.

DISSIPATIVE-REFLECTIVE BEACH MODEL

The general dynamic classification of beaches can be described quite simply. There are two extreme types of beaches termed reflective and dissipative between which most of the world's beaches can be classified. Both types are different from each other regarding wave dynamics, morphology, sedimentology, faunal characteristics and stability (Short, 1979; Wright et al., 1979; Brafield, 1978). The two types are genetically related in that accretion from the surf zone towards the shore directs a dissipative beach towards reflectivity while erosion of sediment from the beach face seawards leads to dissipative conditions. Figure 1 diagrammatically illustrates these two types of beaches and the associated morphology which may exist if a beach is in a transitional stage between the two extremes.

A dissipative beach has a flat foreshore of less than 2 degrees and a multi-barred inshore while the reflective beach has a steep foreshore of up to 7 degrees with a planar inshore devoid of any topographic expression. It is the inshore that characterizes the dissipative beach. Spilling waves break over the bars at an angle to shore and induce longshore currents. Wave motion causes water to pile up at shore so that rip currents form in order to return water, and with this sediment, seawards by way of rip channels spaced at regular intervals alongshore. In breaking, waves lose much of their energy and even if they reform and break again, must cross a wide flat surf zone only to reach the shore with much reduced wave height and power. This wave height reduction occurs because of frictional interaction between the incoming wave and sand on the seabed. So great is energy dissipation in the surf zone that little remains to carry sediment up the foreshore for berm construction or beach face accretion. On a reflective beach, waves do not break until they reach the shoreline so there is only a narrow surf zone with no longshore currents, rips or bars. Hence, unlike the dissipative beach, the reflective beach evidences little change in morphology in the longshore direction. Because waves reach the shore so abruptly some of their energy bounces or reflects back seawards from the beach face. This appears at first innocuous, but reflected energy indirectly produces beach cusps on the foreshore, and if sufficient can remove sediment seaward. Becuase wave form is little altered and wave energy conserved until the shoreline, sediment can easily be moved landward and deposited as an accretional berm at the high tide mark.

The way energy is dispersed at the shoreline also controls the rate of grain size variation across and along the foreshore. Because of wave energy dissipation, dissipative foreshores are dominated by multiple bores and swash current velocities. Often water going up the beach as swash cannot return seaward as backwash before



the next incoming wave so that there is much backwash-incident wave interference. Most sediment movement is confined to the surf zone with finer sediment moving easiest alongshore. However longshore sorting of sediment is never strongly developed. Rip cells may form such that longshore currents are directed in opposing directions towards rip channels. If these rips migrate then sediment on the foreshore is continually being shifted in both directions along the beach. As a result strong changes in grain size cannot develop along dissipative foreshores and gradients which do develop are not stable over time. Such is not the case on reflective beaches where movement is confined to the foreshore. Because of the steep foreshore slope, backwash current velocities prevail under the effect of gravity down the beach face. Any water on the beach face clears the beach before the arrival of the next wave. This strong backwash motion removes coarse sediment from the beach face and directs it along the beach under the influence of any longshore wave motion. Although this longshore motion is weak it invariably is unidirectional. Over time the sand on the reflective beach foreshore becomes very well sorted such that grain size increases dramatically from the sheltered end of the beach towards the more exposed end. Such gradients persist indefinitely.

It is this difference in temporal stability in size gradings and morphology between dissipative and reflective beaches which presents the clue to the formation of each type. It has been asserted that reflective beaches are the accretional product under decreasing wave energy levels and that dissipative beaches are the erosional product under higher energy conditions prevalent during storms (Short, 1979; Wright et al., 1979). Measurement of wave energy between the two beach types in Broken Bay, Sydney doesn't support this premise. Reflective beaches owe their origin to the fact that wave refraction into the beach is so efficient that no matter what deep water wave direction is present, the wave crests always approach the shoreline from the same direction, near-parallel to the beach face alignment. Dissipative beaches are not so favoured and must continually try to adjust their configuration to changing wave directions produced by the passage of high or low pressure cells across the coastline. Wave crests on breaking in the surf zone rarely parallel the general trend of the shoreline. Sediment must be continually eroded and supplied elsewhere for shoreline adjustment. This results in the greatest sediment movement occurring in the surf zone under longshore current transport. This difference in the degree of wave refraction controls the location of the two beach types. Dissipative beaches usually are found as ocean beaches exposed to a wide range of wave directions. Cronulla in Sydney and Perkin's beach, Port Kembla are examples of these types. Because of their adjustment to continual morphological change, such beaches are best able to absorb the effects of storm conditions. Reflective beaches in contrast are situated within bays or behind the sheltering effects of headlands. The beaches within Broken Bay and Batemans Bay along the N.S.W. coast generally fit into this category. Because such beaches rarely need to change their shoreline configuration, they are not adjusted to abnormal wave periods and heights and hence suffer most under adverse wave conditions.

If a beach is long enough it often evidences a continuum in beach morphology alongshore. In N.S.W., one end of a beach is often more exposed than the other. The sheltered end tends to be more reflective and beach morphology grades into more dissipative conditions towards the exposed end. The transitional case in Figure 1 illustrates the morphology commonly found on beaches in this situation. Similarly as morphology is controlled by the degree of accretion or erosion on a beach, it is possible for a beach to shift towards the reflective or dissipative end of the morphological spectrum over time. As a reflective beach erodes, the berm and foreshore sediment moves offshore to form bars with subsequent surf zone, longshore current and rip development. On a dissipative beach, fair weather accretion drives the bars shorewards welding them to the beach as shoals or moving sediment onto the foreshore in berm development. The surf zone is increasingly attenuated and rips and longshore currents diminish in area and strength. For example, after the May-June period of erosion in 1974, many beaches along the N.S.W. coast were fully dissipative. Two years later, without any major storms, beaches had returned to reflective conditions with shoals lying tightly inshore of the low tide mark and wide, high accretional berms present at the high tide location. Many of the Illawarra beaches are at present in this latter stage.

THE MODEL AND ILLAWARRA BEACHES

While Illawarra beaches (Figure 2, Table 1) fit within the above classification, individual beach characteristics are controlled by the underlying geological structure of the area and proximity of the escarpment to the shoreline. Except for Lake Illawarra, the area is devoid of any substantial coastal plain. Primary or regional structural trends are orientated NE-SW parallel to the escarpment with secondary structural control running roughly NW-SE. Where cliffs and hills extend to the coast, beach aspect, the direction the beach faces, is controlled by these trends. Stanwell Park, Port Kembla and Kiama beaches are directly orientated along these strucural lineaments. These SE and NE beach orientations coincide with the main directions for wave approach along the N.S.W. south coast. Over 35% of waves originated from the SE as swell while 25% originate from the NE mainly as sea breezes. Where the coastal plain widens and beaches have developed between headlands, beach orientation faces east. Fairy Meadow, South Wollongong and Perkin's beaches fit this pattern.

Associated with the escarpment's proximity to the coast, is the fact that the continental shelf adjacent to the Illawarra is narrower and steeper (gradients greater than 0.5 degrees) then most other shelves in the world. As a result the sand supply of many beaches is semi-compartmentalized permanently or under storm conditions. This means that sediment can leak out of beach compartments and move under the influence of longshore currents to cliff line sections or to other beaches (Davies, 1974). Over half the beaches, especially along the north Wollongong coast, are in this sense ephemeral and susceptible to permanent sand lost when large storms generate surf zones encompassing enclosing headlands. Eight beaches, mainly north of Wollongong, have no active source of sediment from adjacent beaches or inland streams, and can be considered sand starved. These beaches including Coalcliffe, Coledale, Sandon Pt. North and Fisherman's at Port Kembla, are in a fragile equilibrium with the wave climate.

The fact that the Illawarra is part of the southern Sydney basin with landward dipping beds at the coastline puts one further constraint upon many beaches. Bedrock often crops out on beaches in the form of reefs in the inshore zone. Many beaches because of their sheltered, structurally controlled positions should have reflective morphology, but the fact that waves break some distance from shore over reefs forces the inshore to take on dissipative characteristics. Normally beach profiles steepen and become reflective as inshore sediment moves shoreward during beach accretion. The presence of bedrock so close to sea level prohibits this change in profile. Only at high tide when inshore water depths increase up to 2m, are waves not influenced by underlying bedrock and able to break at shore. The beaches are in general terms reflective at high tide but dissipative at low tide. Morphology is mainly reflective as there is little sand available for bar formation. Wave and current dynamics are however dissipative because at low tide a surf zone with attendant rips and longshore currents can develop. Continual shoreline retreat caused by storms only increases the area of reefs on these beaches and shifts what should seemingly be a reflective beach further and permanently towards the dissipative end of the spectrum. One third of Illawarra beaches largely near headlands where bedrock is more likely to outcrop seawards, have these mixed characteristics. Of the remaining beaches 15% can be considered fully reflective and 10% dissipative. The reflective beaches, --Belmore, North, Fisherman's, Storm Bay, and Kendall's exist as pocket beaches on serated headlands while the dissipative beaches, --Towradgi-Fairy Meadow, Port Kembla-Perkin's and Werri stand on sections of coast with abundant sand reserves principally tied up as dunes. The transitional beaches characterize 30% of all beaches. They never reach the reflective stage in fair weather periods and rarely become totally dissipative over their full length except during large storms. If general coastline retreat continues in the future, then many of these transitional beaches underlain by shallow bedrock will join the ranks of the mixed beach type.

EFFECT OF MAN

The various morphological states outlined above are not static in that the presence of storms or long periods of accretion play a natural role in altering morphology. Man is increasingly becoming an instrument for this alteration. Many beaches have promenades, surf club facilities or tourist and residental structures encroaching on the beach backshore. While the effects of these small developments seem minor, such structures compete with storm waves for the storage of sand backing the beach. As two-thirds of the beaches have obvious evidence of erosion, this sand supply will inevitable be needed some day to replenish foreshore sediment eroded seawards during storms. Such competition between man and nature on the backshore is detrimental to the beach as a whole.

Man is increasingly reducing the chance the beaches have for storm recovery by also exacerbating erosive conditions. Building of storm drain exits on beaches, increased runoff with suburban development, and, in one rare case at Thirroul, the pumping of swimming pool water onto the beach also accelerates erosion. Water tables are raised in the beach as a result of this type of action and this added water eventually must drain into the ocean through the beach face. Such seepage is always conducive to foreshore erosion as evidenced by the increased rates of foreshore retreat between 'dry' storms and those accompanied by heavy rainfall (Chappell et al., 1979). Any additional recharge of the water table by man is subtly preventing foreshore accretion during fair weather periods and thus increasing the possibility of foreshore obliteration in future storms. Council attempts have been initiated to remove this threat.

On a larger scale Stanwell Park, Austinmer, Sandon Pt. North, Woonona-Bellambi, East Corrimal, Corrimal, Towradgi-Fairy Meadow, Port Kembla-Perkin's, Warilla beaches are known to have had construction sand extracted this century from either the foreshore or dunes. This procedure is now prohibited on all but Perkin's beach. The full amount of sand extracted will never be realized but some of the present erosion on these beaches must be attributed to this cause.

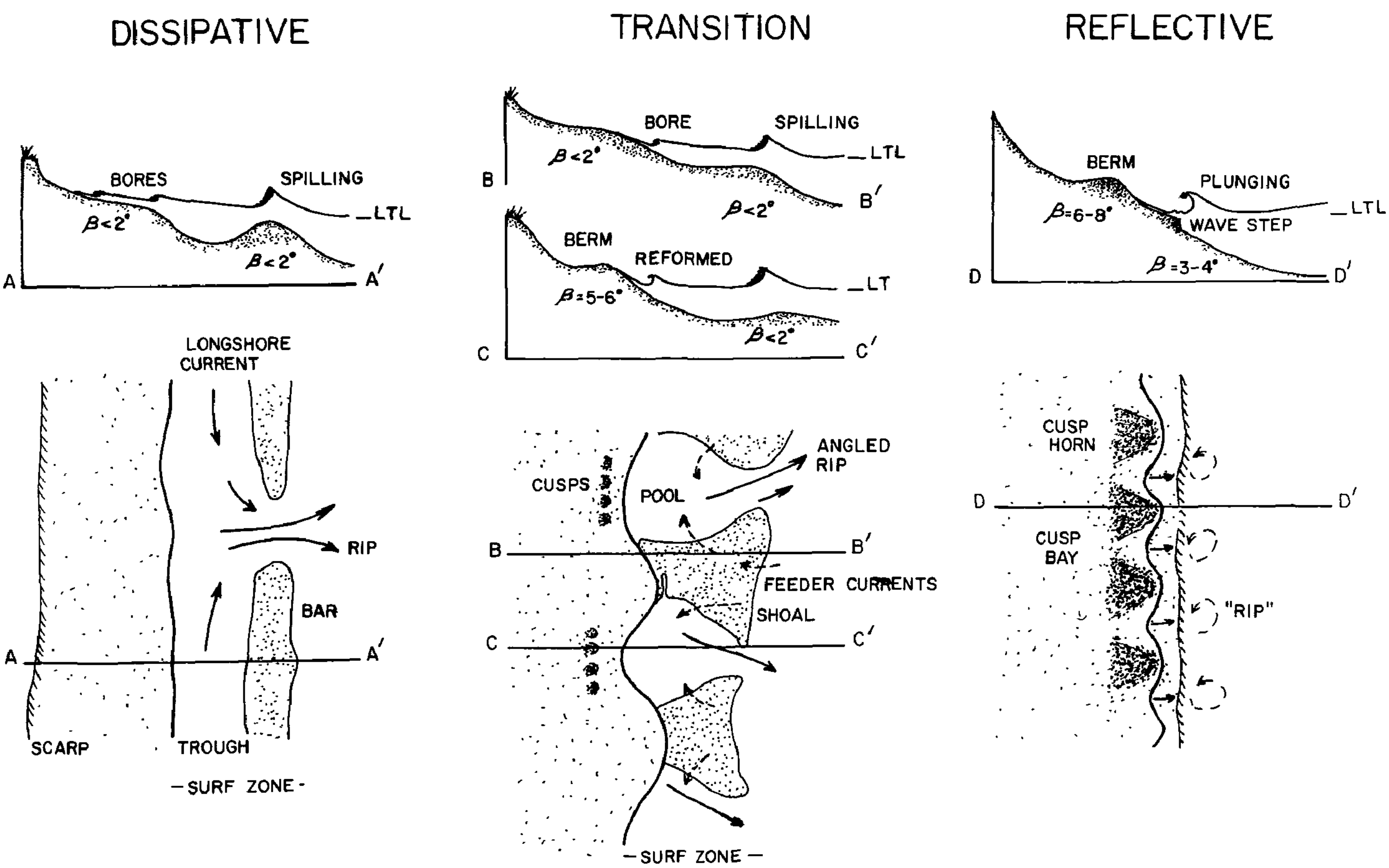


TABLE 1

Beach Name	Type	Aspect	Compartmentalization	Sediment Supply	Man's Effect	Reefs	Stability
Stanwell Park	transition	SE	opens south	fixed	mining	-----	stable
Coalcliff	mixed	ENE	open	starved	-----	80% inshore	eroding
Wombarra	mixed	ESE	open	fixed	-----	40% inshore	S eroding
Coledale	mixed	E	open	starved	yes	80% inshore	N eroding
Ward's	platform	ESE	open	starved	-----	100%	eroding
Bell's	platform	E	open	starved	-----	100%	eroding
Austinmer	mixed	ESE	partially open	fixed	yes	80% inshore	stable
Thirroul	transition	ESE	open	fixed	yes	50% inshore	eroding
Sandon Pt. North	mixed	ENE	opens north	fixed	yes	at ends	S eroding
Sandon Pt.	mixed	E	normally closed	starved	yes	40% inshore	eroding
Bulli	mixed	ESE	partially open	fixed	-----	60% inshore	eroding
Woonona-Bellambi	transition	ENE	open	fixed	yes	30% inshore	eroding
Bellambi Harbour	platform	NNE	open	starved	yes	100%	stable
East Corrimal	mixed	ESE	open	to dunes	mining	100%	stable
Corrimal	transition	SE	open	to dunes	mining	80% inshore	eroding
Towradgi-Fairy Meadow	dissipative	SE	open	to dunes	mining	at ends	stable
North Wollongong	mixed	ENE	open	fixed	yes	20% inshore	stable
Belmore	reflective	-----	closed	fixed	yes	40% inshore	stable
South Wollongong-Coniston	transition	E	opens N?	fixed	yes	-----	eroding
North	reflective	NE	opens N	starved	yes	60% inshore	eroding
Fisherman's	reflective	NE	closed	starved	-----	25% inshore	eroding
Port Kembla-Perkin's	dissipative	ESE	to dunes	from S	mining	-----	eroding
Warilla	transition	E	leaks N	starved	yes	-----	eroding
Barrack Pt.	mixed	E	closed	fixed	-----	headlands	stable
Shellharbour	mixed	ENE	normally closed	fixed	-----	headlands	eroding
Killalea	mixed	SE	closed	fixed	-----	20% inshore	eroding
Minnamurra	transition	E	leaks S	fixed	-----	30% inshore	stable
Boyd's	transition	E	normally closed	fixed	-----	at ends	S eroding
Bombo	transition	ESE	closed	fixed	yes	20% inshore	S eroding
Storm Bay	reflective	E	closed	fixed	yes	at ends	eroding
Kendall's	reflective	NE	closed	fixed	-----	at ends	eroding
East's	mixed	E	closed	fixed	yes	40% inshore	eroding
Werri	dissipative	ESE	normally closed	fixed	yes	headlands	S eroding

Sand extraction as a major cause of beach erosion has been replaced by breakwall construction as the main factor now threatening Illawarra beaches. While breakwalls protect directly man-made property or provide shelter from wave action, they also increase reflectivity in both the onshore and longshore directions. Increased reflectivity in the onshore direction is generally concommittant with beach accretion, but beyond a certain point it can accelerate backwash velocities so that any accreting sand cannot remain on the beach face. Instead sand piles up inshore and on non-compartmentalized beaches is more susceptible to longshore removal. Such a process accounts for the depleted state of Warilla beach whereas adjacent untouched beaches presently evidence maximum sand build-up on the foreshore. The Warilla breakwall which was built to protect residences landward has kept shoreward moving sand in the surf zone where longshore currents have moved it northward to be lost permanently into the entrance of Lake Illawarra or onto Perkin's beach. At North Wollongong the breakwall surrounding Belmore Basin has depleted North Wollongong beach by a similar process. Reflection in the longshore direction has prohibited sand deposition at the southern end on the beach. This sand is now being lost permanently northwards to Fairy Meadow beach. Man's potential for modification even extends to larger beaches such as South Wollongong-Coniston. The breakwall at Port Kembla harbour appears to be having a similar effect on the inshore sand reservoir on Coniston beach. More significantly the expansion of the breakwall adjacent to the new coal loader may be shortening the length of the whole beach in a dramatic way. The backshore erosion in past storms opposite the southern tip of the golf course and adjacent to the Showground on South Wollongong beach has been induced by two mega-rips developed by long period, high energy waves. The spacing and number of these mega-rips is controlled by the length of the beach which effectively ends southwards at the Port Kembla harbour breakwall and northwards at Flagstaff Point. Up to 5 mega-rips can be accommodated over this distance. If the southern boundary of the beach becomes the breakwall adjacent to the new coal loader, then the beach length decreases to 3300m or less. The mega-rip spacing must adjust to a shorter beach length. The rips are either squeezed closer together or else reduced in number. Points of erosion in the future along South Wollongong beach will appear opposite these new rip locations, however these locations may not correspond with any past points of erosion.

CONCLUSIONS

The structural setting of the Illawarra controls the morphology of its beach development. The proximity of irregular topography near the coast, the narrow shelf width and landward dipping bedrock has led to the formation of small, semi-compartmentalized ephemeral beaches which are steep and reflective at high tide but dissipative with attendant longshore currents and rips at low tide. Where the coastal plain is wider or sand more abundant, long fully dissipative beaches have developed. The increased frequency of storms in the last 15 years has eroded many beaches leading to increased bedrock exposure inshore. This is causing seemingly reflective beaches to become increasingly more dissipative. The beaches may be locked into a cycle of inevitable erosion because the variation in current dynamics inherent on dissipative type beaches is foreign to the stability required of these reflectively situated beaches.

Man's competition with the beach zone has enhanced the depletion of sand by locking up backshore supplies through the construction of buildings and promenades, by removing sand for construction purposes and by increasing beach water tables during storms through increased urban runoff and stream channelization. More deleterious then these effects is the construction of breakwalls which has removed permanently sand from North Wollongong and Warilla beaches, and which may change the position of erosional storm mega-rips on South Wollongong beach. Because of their physiographic setting, Illawarra beaches have a tenuous existence; man's interference can only illustrate their fragile nature.

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