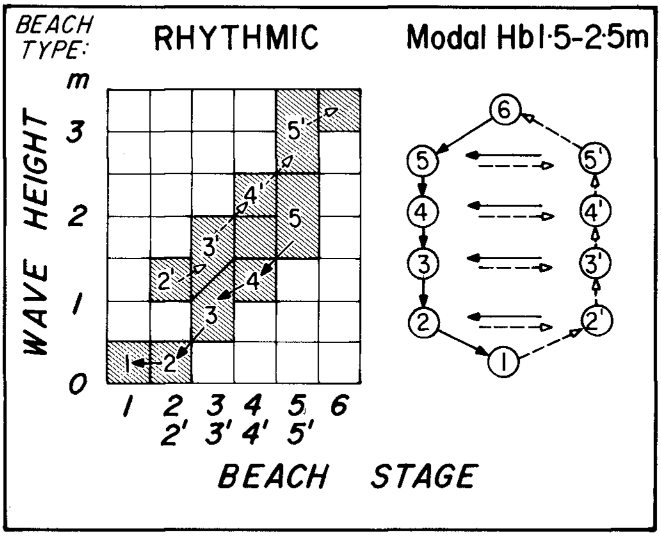

Figure 3: Location of the modal beach-stage (shaded) for levels of breaker wave height under rising and falling wave conditions. On right are the linkages between the ten beach-stages. Solid lines indicate falling wave height and movement to accretionary stages, dashed lines rising wave height and movement to erosional stages. Movement between and amongst the stages can only be in the direction of the arrows.

sand. However, over shorter time periods and in many locations wave height does not vary so considerably and as a consequence the beach oscillates around a modal type. Basically three modes of wave-beach interaction have been described in the literature - reflective, rhythmic and dissipative. Table 1 lists their origin and characteristics. The breaker height required to generate a modal reflective, rhythmic or dissipative beach (on medium to find sand beaches) can readily be determined from Figure 2b.

Reflective beaches are associated with waves less that 1m in height. They are characterised by beach-stages 1 (berm) and 2 (cusps), with a relatively steep beach face, waves breaking on a coarse grained low tide step and barless surfzone (though 'relic' outer bars may exist further offshore).

Table 1 - MODES OF WAVE - BEACH INTERACTION

Wave Energy (Breaker Height)	Surf Zone Dynamics[1]	Beach-Surfzone Morphology	Reference - terminology
High (>2.5m)	Dissipative	Shore parallel bars, channels mega-rips predominantely shore normal circulation	Sasaki - Ingragravity (>2.5m) Short - Beach-stages 6, 5´ Wright, et al - Beach Type 1, 2
Moderate (1-2.5m)	Rhythmic	Rips crescentic bars megacusps, etc. rip circulation	Sasaki - Instability Short - Beach-stages 5,4,4´,3,3´ Wright, et al.- Beach type 3,4,5
Low (<1m)	Reflective	Barless steep beach-face cusps, berm, wave reflection	Sasaki - Edge Wave Short - Beach-stages 2,2´,1 Wright et al. - Beach type 6

1. Guza and Inman´s (1975) terms, dissipative and reflective are used to describe the high and low energy surf dynamics, while Homa-ma and Sonu (1962) term rhythmic is attached to the intermediate moderate energy beaches.

Rhythmic beaches require breakers 1 to 2.5m high to maintain their classic rip circulation. Crescentic/transverse bars, rip feeder and rip channels, and megacusps produce the characteristic ´rhythmic´ longshore variation in beach and surfzone morphologies.

Dissipative beaches occur when waves exceed 2.5m resulting in the formation of shore parallel channel/s and bar/s and predominately shore normal circulation (beach-stage 6). Beach-stage 5´ characterises the dissipative extreme in shorter embayed beaches where the constraints imposed by headlands, etc. encourage megarips to persist even during very high wave conditions.

Temporal Variation in Beach Morphology

The foregoing is concerned with beach response to the absolute level of breaker height. To illustrate how natural beaches respond to variations in breaker height through time, ten years of daily wave data and four years of daily beach response for the Sydney region are summarised in Figure 4. The annual wave climate varies systemmatically through the year from periods of high to moderate to low waves with the beaches responding accordingly moving between dissipative, rhythmic and reflective beach types.

In a typical year beginning in December northeast seabreeze waves of moderate height (1-1.5m) cause minor beach scarping and erosion and a series of rips. During February and March, seabreezes persist but their effect is often overshadowed by the arrival of moderate to high 2-3m northeast and east swell generated by tropical cyclones. These waves cause moderate beach erosion, and the development of fewer but larger and more intense rip systems. If high waves persist, longshore channels and offshore bars eventually form. April and early May is a low energy transition period of beach accretion. May and particularly June and July are dominated by cycles of moderate to high (2-3m) southeast swell and storm waves resulting in moderate erosion. The beaches in this period are dissipative with major rip systems (spacing 500m) and in exposed portions longshore bars and channels. This period of erosion is followed by gradually decreasing southeast swell. The low waves (0.5-1.5m) produce onshore sediment transport and beach accretion at times moving the bar onto the beach as a series of cusps or a berm. By November the beaches are often in their most accreted and reflective form.

A further method of illustrating the range of Sydney

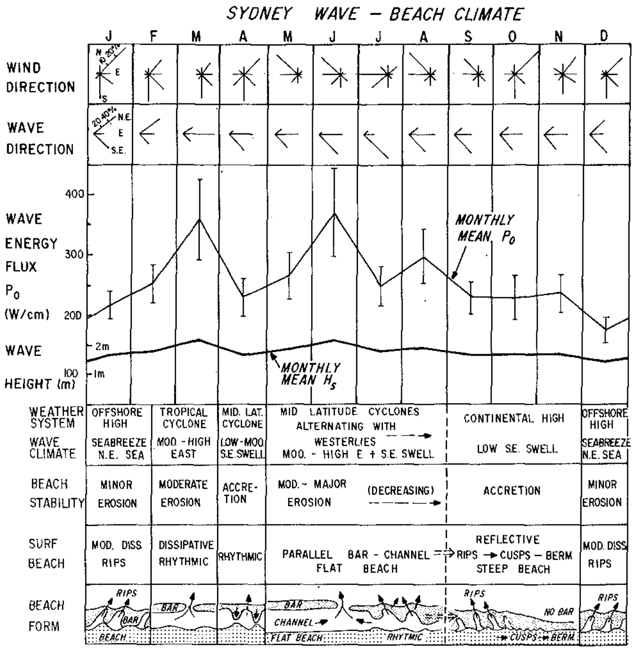

Figure 4: The annual Sydney wave climate and beach form. The wave height and energy is based on a nine years (1971-79) monthly mean of daily wave conditions (M.S.B. data). The stradling line and bars equal ± one standard deviation. The beach response through the year is reflected in the beach stability, surfzone type and beach form. The plan view of beach form illustrates the beach response typical open beach responding fully to the above conditions (from Short and Wright, in press).

beach types is the beach-stage curve (Short, 1979a) shown in Fig. 5. This plots the percent frequency of occurrence of the accretion and erosion beach-stages, along with the annual (combined) beach-stage curve. The curve identifies the modal rhythmic beach type for the Sydney coast. This is to be expected given Sydney's modal wave characteristics (H = 1.5-2m, T = 10 sec). Short 1979a presents hypothetical beach-stage curves for other higher and lower energy wave-beach systems.

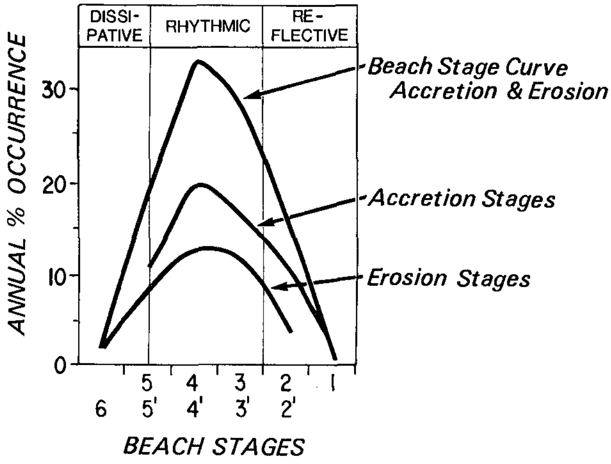

Figure 5: Beach-stage curves for Narrabeen beach plotting the percent frequency of occurrence of accretionary, erosional and combined beach-stages. Based on 950 daily observations.

MODAL BEACH TYPES AND MORPHOLOGIES

Whereas the typical Sydney beach presented in Figures 4 and 5 can experience the entire spectrum of beach types, many beaches tend to remain at the dissipative or reflective extreme or oscillate within the rhythmic range. To examine how such beach morphologies vary over time in reference to modally high, low, or moderate waves three sets of field observations are presented for persistently dissipative, rhythmic and reflective beaches (see Figure 6).

To enable comparisons the data is presented both graphically as two-dimensional beach profiles or cross sections, and numerically using mean beach width (x_b), its standard deviation (σ_x) and coefficient of variation (σ_x/x_b). The standard deviation is a useful indicator of beach mobility and is in fact called the beach mobility index by Dolan et al., (1978). Further, the coefficient of variation is an indicator of backshore mobility and is here termed the backshore mobility index.

The nature of a beach's cross-sectional or profile variation is basically a function of the amount and form of sediment transfer within and between the subaerial beach, surfzone and nearshore. Where wave height is persistently

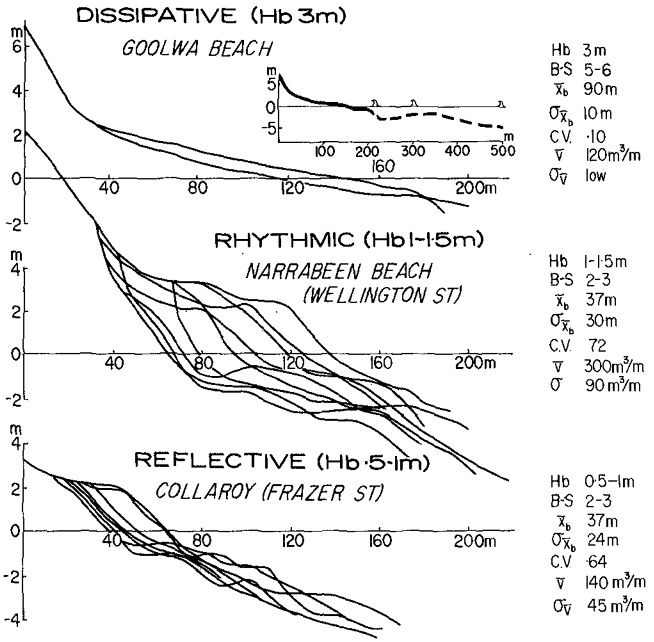

Figure 6: Variation in beach profile and morphometric parameters for a dissipative, rhythmic and reflective beach. Note the relative stability of the dissipative and reflective beach compared to the rhythmic beach. Narrabeen and Collaroy profiles selected from 3 years of monthly beach profiles. Goolwa profiles one year apart.

high (>2.5m) most sediment is carried seaward and stored in the surfzone and nearshore. Because of the time lag in moving sediment onshore from the outer bars bar/s and nearshore the beach face rarely accretes or experiences substantial changes in profile (Fig. 6). The beach is wide with a low gradient. Beach and backshore mobility is low because of the low sediment exchange. While a dissipative beach face represent an 'eroded' beach profile with minimum sand stored on the subaerial beach they are relatively stable features experiencing minor changes in beach profile. Erosion associated with dissipative beaches does not normally result from beach face retreat, rather low frequency wave set up tends to overrun the beach and attack the backshore directly, (as described by Wright, this vol.).

Rhythmic beaches exposed to waves of moderate height (1-2.5m) have the greatest potential for changes in beach form as a consequence of the variable wave climate and storage of sediment in the highly energetic surfzone. As wave height rises and falls, sediment is transported between the three storage zones. Beach volume is large as is the standard deviation reflecting the active sediment exchange between the beach, surfzone and nearshore (Fig. 6). Over time rhythmic beach form can shift from a flat eroded beach face, deep channel and offshore bar, through all the onshore bar migratory forms to a reflective beach. Beach and backshore mobility are both high, indicating a high potential for beach and backbeach erosion through sand removal particularly in rip embayments (see Short, 1979b and Wright, this vol.).

Low wave (< 1m) reflective beaches have low mobility and are relatively stable. Sediment exchange on reflective beaches (Fig.6) is between the steep cusped or bermed subaerial beach through a pivot point (~1m depth) to the attached low tide terrace. Because of their proximity the exchange is rapid. Reflective beaches are most susceptible to erosion (see Short 1979b and Wright, this vol.), however erosion is usually followed by rapid beach accretion. As Collaroy beach (Fig. 6) lies at the more energetic end of the reflective beach type (H = .5-1m) lower energy beaches will show even less mobility.

Figure 7 illustrates the range of temporal changes in beach profile for dissipative, rhythmic and reflective beaches in southeast Australia. The variation in profile elevation within the beach surfzone and nearshore has further implications for identifying areas of sediment storage and exchange. Table 2 indicates the relative importance of the beach, surfzone and nearshore as zones of active sediment storage.

Dissipative beaches represent an 'eroded' beach profile, and as such the 'eroded' material is stored in and particularly seaward of the surfzone. On the southeast Australian coast the active nearshore zone extends out to depths of at least 20m. Because of the depth and location of the potentially active sediment long periods (several weeks to months) of lower waves are required to move the sediment shoreward. On modally dissipative beaches such as Goolwa this rarely, if ever, occurs however in seasonally dissipative-reflective beaches as in Southern California this exchange is well documented (Aubrey, 1979). On N.S.W. dissipative beaches the inner bar occasionally attaches to the shore in late winter. The outer bar while moving

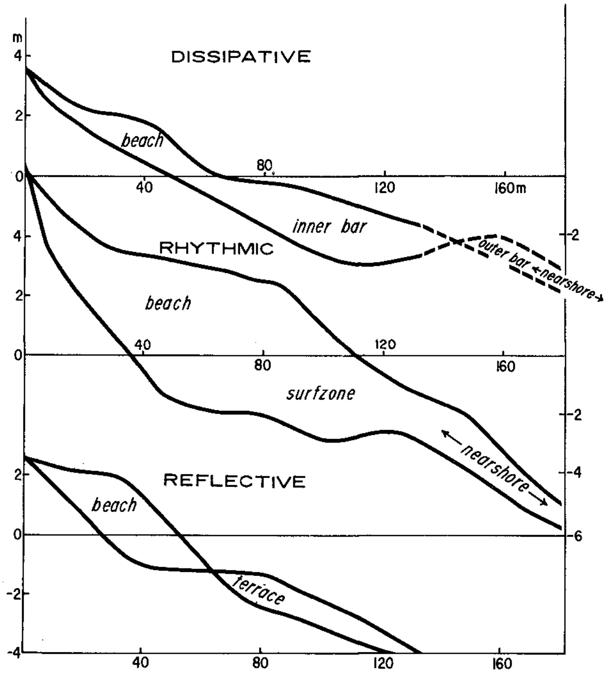

Figure 7: The active sweep zone for a dissipative, rhythmic and reflective beach based on 3 years of monthly beach profiles. Upper from Fens embayment, N.S.W. (data from P. Hesp), lower Narrabeen and Collaroy beaches.

Table 2

ZONES OF SEDIMENT STORAGE (%)

	SUBAERIAL	SURFZONE	NEARSHORE
REFLECTIVE	70	30	—
RHYTHMIC	40	40	20
DISSIPATIVE	10	20	70

inshore has not been observed attaching to the shore.

Rhythmic beaches can potentially store sand throughout the system, particularly in the beach and surfzone, and following high wave events in the nearshore. Sand stored in the energetic surfzone and perched on the subaerial beach can rapidly be moved between the two as wave conditions vary.

Reflective beaches store sand almost exclusively on the steep beach or following erosion in the low tide terrace. Exchange is rapid being accomplished in a matter of hours during erosion and a few days to weeks during accretion.

SPATIAL (ALONGSHORE) VARIATIONS IN BEACH TYPE MORPHOLOGIES

In addition to characteristic changes in beach profile through time, each beach type has a characteristic variation in beach profiles alongshore, at any point in time. Three examples from the same beaches are illustrated in figure 8.

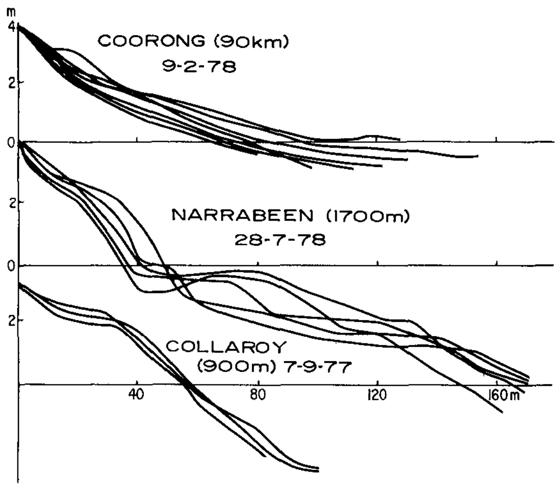

Figure 8: Alongshore changes in beach profiles on a dissipative, rhythmic and reflective beach.

Dissipative beaches are characteristically uniform alongshore having a wide low gradient beach face, fronted by a wide deep channel/s and shore parallel offshore bar/s. Figure 8a a shows seven beach face profiles surveyed on the one day at 15 km intervals along 90km of the highly dissipative Coorong beach. All profiles have a concave subaerial beachface morphology. Each is low gradient with slight variations in gradient resulting from minor changes in grain size. Figure 9a illustrates that the shore parallel channels and bars of the surfzone possess the same conformity longshore. Therefore dissipative beaches exhibit extreme stability and uniformity alongshore.

Rhythmic beaches with their alternating bars and rip channels, megacusps, etc are as unstable spatially as they are temporally. Figures 8b and 9b illustrate this fact. The Narrabeen profiles show the alongshore variation from rip channels, to well developed bars and channels to a welded bar.

Reflective beaches are uniform alongshore except on a microscale when cusps are present. In plan form the continuous cusps or berm and barless surfzone results in lhe regular beach profiles illustrated in Figure 8c, and plan form as show in Figure 9c.

DISCUSSION

Given the seemingly endless variety of beaches around the globe and their ever-changing response to wave conditions it is essential that a logical genetic classification of natural beaches be developed, one that not only permits identification of beach type, but also contains a characteristic set of morphological response and dynamic interactions associated with each beach type.

The results presented here are an attempt to classify beaches into three basic types based on response to the level of breaker wave height for microtidal, medium to fine sand beaches. The characteristics associated with each beach type are tabulated for breaker wave height (Figure 3), two dimensional beach profile response over time (Figures 6 and 7), zones of sediment storage (Table 2), two dimensional alongshore variation in beach profile (Figure 8) and other morphometric parameters (Figure 6). More detailed discussion of beach-surfzone morphodynamics and modes of beach erosion are contained in Short 1979a and b, Short and Hesp (in press), Wright et al. 1979 and Wright (this vol.).