SURF ZONE RESONANCE AND COUPLED MORPHOLOGY

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ABSTRACT The edge wave hypothesis for periodic inshore morphology and circulation is tested for five beaches and is supported by resulting wave-current spectral and cross-spectral data. Beach types range from a reflective, narrow surf zone, case through various dissipative medium to high energy beaches including some with inshore bar-trough morphology and one broad surf zone troughless one. In all cases beachface reflectivity is moderately high (ε < 2.5) and inshore resonance occurs, indicated by strong spectral peaks at lower than incident frequency with wave-current co-peaks being 90°out of phase. Several different edgewave frequency and mode combinations are indicated. The reflective beach shows an n = o subharmonic edge-wave (*i.e.* at half incident wave frequency) which Guza and Davis (1974) predict as the most likely case, *viz.* the (o,o) triad. The troughless dissipative case shows a (1,0) edgewave triad; the same occurs in some bar-trough dissipative cases but in other cases is supplanted by the (o,o) sub-harmonic wave and/or by a lower subharmonic wave at ¼ incident frequency. The likelihood of a given edge waveset appears to be regulated by surf friction, and a change of edge wave set appears likely to explain observed changes of inshore circulation.

INTRODUCTION Several models exists for periodic morphology and associated cellular circulation on surf beaches. We present detailed wave and current data which support the edge wave model in the context of rip cells on high energy sandy beaches, and which indicate that inshore morphodynamic patterns change in response to discontinuous change of edge wave mode and frequency. In what follows, we discriminate between two categories of periodic phenomena, rip cells and beach cusp cells on the grounds that rip cells occupy broad dissipative surf zones and can exist in several different morphodynamic states, whereas cusps essentially are inter-tidal phenomena on reflective beaches and vary in scale rather than in form. We note that cusps frequently coexist with rips, especially where a steep beach face lies behind the inshore trough of a broad dissipative surf zone.

When inshore morphology is rectilinear, initiation of periodic patterns requires periodic variation longshore of wave height, so that inshore radiation stress gradients can force cellular circulation. Periodic wave height variation has been suggested to be due:

(1) to intersection of two wave trains originating by refraction offshore (*e.g.* Dalrymple, 1975); or (2) to inshore wave edges interacting with the incident waves (*e.g.* Bowen and Inman, 1969); or (3) to a periodic deformation of water surface due to instability in the radiation stress field (Hino, 1975). The refraction hypothesis may have local application, but the widespread occurrence of beach cusps under shore-parallel swell conditions argues against this as a universal mechanism. On the other hand, the existence of edge waves on natural beaches has been supported by analysis of inshore current spectra by Huntley and Bowen (1975), and Guza and Inman (1975) show that beach cusps are coupled with edge wave development. Theoretical argument for edge wave initiation of rip cells was developed by Bowen and Inman (1969), but has been criticised by Hino (1975) - the proponent of the radiation stress instability theory - on the grounds that excitation of sufficiently large edge waves is improbable in a dissipative broad surf zone.

However, Guza and Davis (1974) show that edge wave excitation through resonance with incident waves is possible under reflective conditions when incident wave amplitude (a_i) is such that

$$a_i^2 > \gamma\, k\, (N_1, N_2)/\omega_i \qquad \text{... (1)}$$

where γ is kinetic viscosity, ω_i is incident frequency, N_1 and N^2 are mode numbers of a possible edge wave pair, and $k\ (N_1, N_2)$ is a constant for given N_1, N_2 (note $K\ (N_1, N_2)$ values tabulated by Guza and Davis were subsequently found by Guza and Inman, 1975, to be too great by a factor of 4. It is debated whether excitation occurs in dissipative situations when the reflectivity parameter

$$\varepsilon = a_i\, w^2/g\, tan^2\, \beta \qquad \text{... (2)}$$

(where β is beach slope) is greater than about 2.0. This is important for the edge wave initiation of rips. Our results indicate resonance and edge wave existence in several morphodynamically different dissipative and reflective contexts, and indicate conditions where edge wave modes and periods change abruptly, depending on inshore bar morphology, incident wave conditions, and tide. In another paper in this volume (Wright *et al.* 1978) we discuss the morphodynamic associations between six commonly occurring morphologic types, different resonant frequencies, and different scales of inshore circulation. In the present paper we examine evidence for inshore resonance from five selected experiments.

EXPERIMENTAL METHODS

Several sandy surf beaches in N.S.W. Australia (Fig. 1) were chosen to represent a range of hydrodynamic and morphodynamic conditions, ranging from highly reflective steep beaches without a bar, through dissipative cases with either a rectilinear bar-trough system or a crescentic system, to dissipative cases where broad bars have accreted to the beach, forming long and broad inshore shoals (*e.g.* Wright *et al.* 1978; in press). The beaches experience medium to high wave energies, and experiments were done with mean breaker heights typically between .08 and 2 m.

Wave and current measurements were taken on a continuous basis, using pressure transducers for waves and fast-response directional flow meters for currents. Our standard instrument mount includes a pressure transducer plus orthogonal horizontal flow meters (shore-normal and shore-parallel), on a stable portable base, connected by cables to chart recorders, data logger, and a mini-computer in a mobile onshore van. Several instrument mounts can be deployed together. The system is described in detail by Bradshaw *et al.* (1978).

Measurements were made when waves essentially were normally incident (*i.e.* crests shore parallel). Spectral and cross-spectral analysis provide the key for edge wave identification. Standard spectral methods were used employing auto and cross covariance analysis, detrending and use of hanning or cubic filters, and Fourier transformation. Sampling intervals (Δ t) of 1 or 2 seconds were used. Spectral and cross spectral analysis (*e.g.* Bendat and Piersol, 1971) are guided by the following points:

(i) Auto or cross-correlogram reduction of primary data is repeated with different maximum leg numbers when preparing each spectrum, to establish stability of spectral peaks.

(ii) We are concerned to identify oscillatory motions at incident wave frequency, subharmonics of this, or at surf beat frequencies, and consider only spectral peaks very significantly above the white noise spectrum.

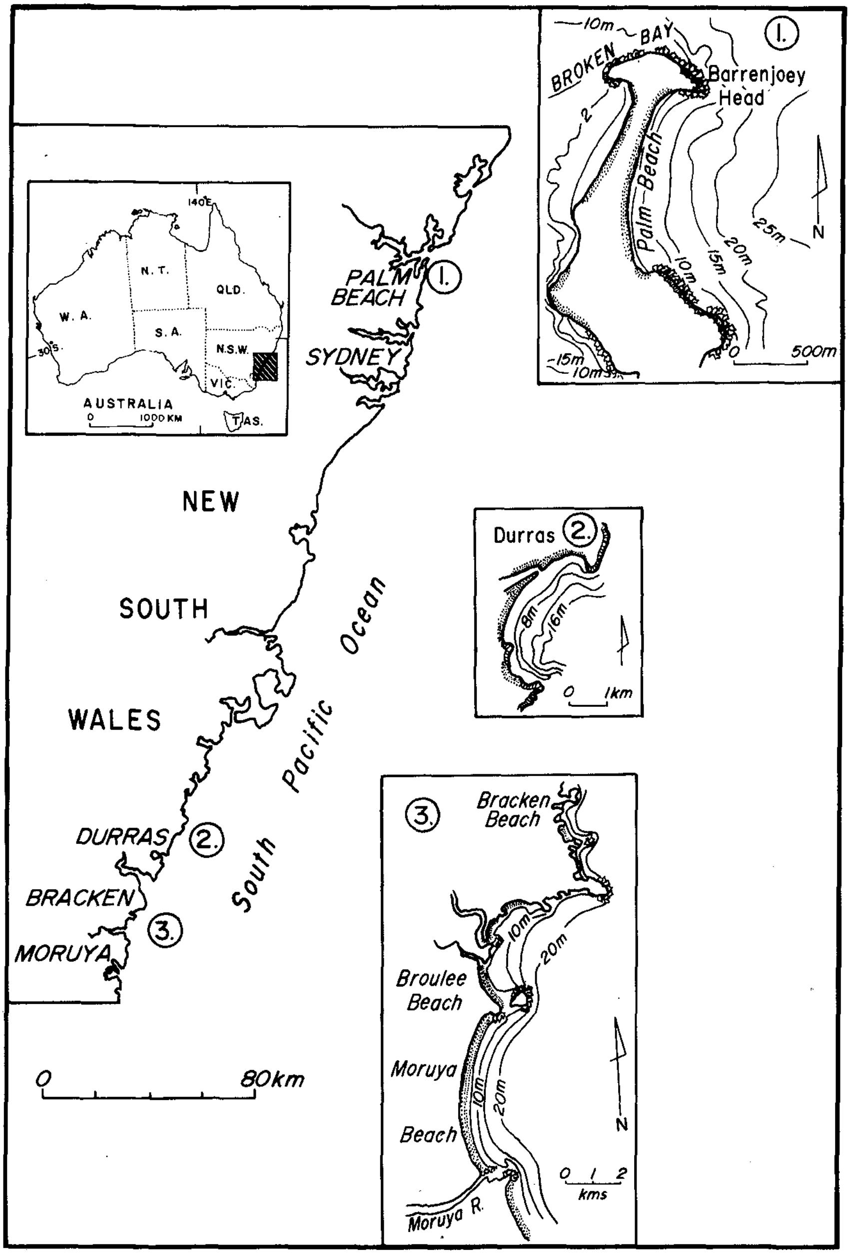
(iii) Cross-spectral coherence is a guide to usefulness of phase estimates of cross-spectral peaks, *i.e.* when coherence is low the phase estimate is judged unreliable.

We consider that an edge wave is indicated:

(i) when phase difference between water surface and horizontal current is close to $\frac{\pi}{2}$, and (ii) when an inferred edge wave spectral peak diminishes in magnitude away from the shore (*i.e.* the same test as used by Huntley and Bowen, 1975).

Magnitude relationships of shorenormal and shore-parallel current components in a rip feeder channel usually differ from those predicted from the edge wave velocity potential (ϕ) field,

Figure 1 Locations of beaches used as experiment sites (Palm, Durras, Bracken, Moruya).



$(u, v) = \Delta\phi$, due to the presence of the current. At some of these sites we separate the bidirectional current time series into component left- and right-flow spectra to show that dominant drift is at edge wave rather than incident frequencies.

In the experiments which follow, not all results are final as some are based on measurements taken when field conditions precluded sampling at several sites, and for others the full analysis of data logs is still in progress.

FIELD EXPERIMENTS

We report from several dissipative beaches plus one reflective beach. The latter is included to furnish a connection between our work and that of Guza and Inman (1975) and others, and to provide a methodologic bridge to the dissipative cases. Locations and maps are shown in Figure 1. The dissipative beaches - Moruya, Durras, Palm Beach - have well sorted medium sand, dominantly qaurtz with variable but significant quantities of shell fragments. The reflective example - Bracken Beach - had bimodal sediment of coarse sand and gravel. The New South Wales coast experiences a variable wind-wave climate, with strong sea-breeze in summer, superimposed on persistent high energy swell from the southeast. Significant wave height exceeds 1.5 m for 50% of the time and 4 m for 1% of the time. Wave periods around 10 seconds are most common. Tides are semi-diurnal and have an average springtide range of 1.6 m.

Sites were chosen to sample a range of inshore morphologies. Measurements were made generally under swell conditions. Figure 2 shows site details for representative experiments discussed herein. The sites are briefly described in terms of the morphodynamic classification scheme of Wright *et al.* (1978). Primary morphodynamic data are listed in Table 1.

(i) A typical reflective experiment on Bracken Beach is shown in Figure 2a. Typical of reflective beaches (*e.g.* Wright *et al.* in press), Bracken Beach has a linear, low gradient nearshore profile (fine sand) which passes through a pronounced gravel step into the steep beach face of coarse sand. Beach cusps are well developed, the active cusps often being nested within much larger cusps high on the beach face, which are relict from storm waves. Waves break at the gravel step and surge up the beach face with high runup. Features such as transverse or crescentic bars, swash bars and inshore gutters invariably are absent.

(ii) Moruya experiment 1 (Figure 2b) took place in the presence of a long-shore bar-trough system with incipient periodic morphology and a moderately steep beach face. Topography was transitional between the parallel bar-trough system referred to by Wright *et al.* (1978) as Type 2 dissipative beach state, and the crescentic bar-

- TABLE 1 -

MORPHODYNAMIC PROPERTIES OF 5 EXPERIMENTAL SITES

Expt Number	Site	Topo Type*	H_b (m)	T_p (sec)	β (°)	ε_b^{**}	X_s (m)
(i)	Bracken	R	0.6	7.5	6.9	2.3	15
(ii)	Moruya 1	2-3	0.7	9	3.5	2.5	70
(iii)	Moruya 2	3	0.8	11	3.5	1.6	90
(iv)	Palm	5	1.2	10	3.5	2.3	50
(v)	Durras	2	1.4	10	4.5	1.6	75

* R - reflective; other types a/c classification of Wright, *et al.* (in press).

** calculated for observed inshore wave height near the beach face (*i.e.* after prior dissipation).

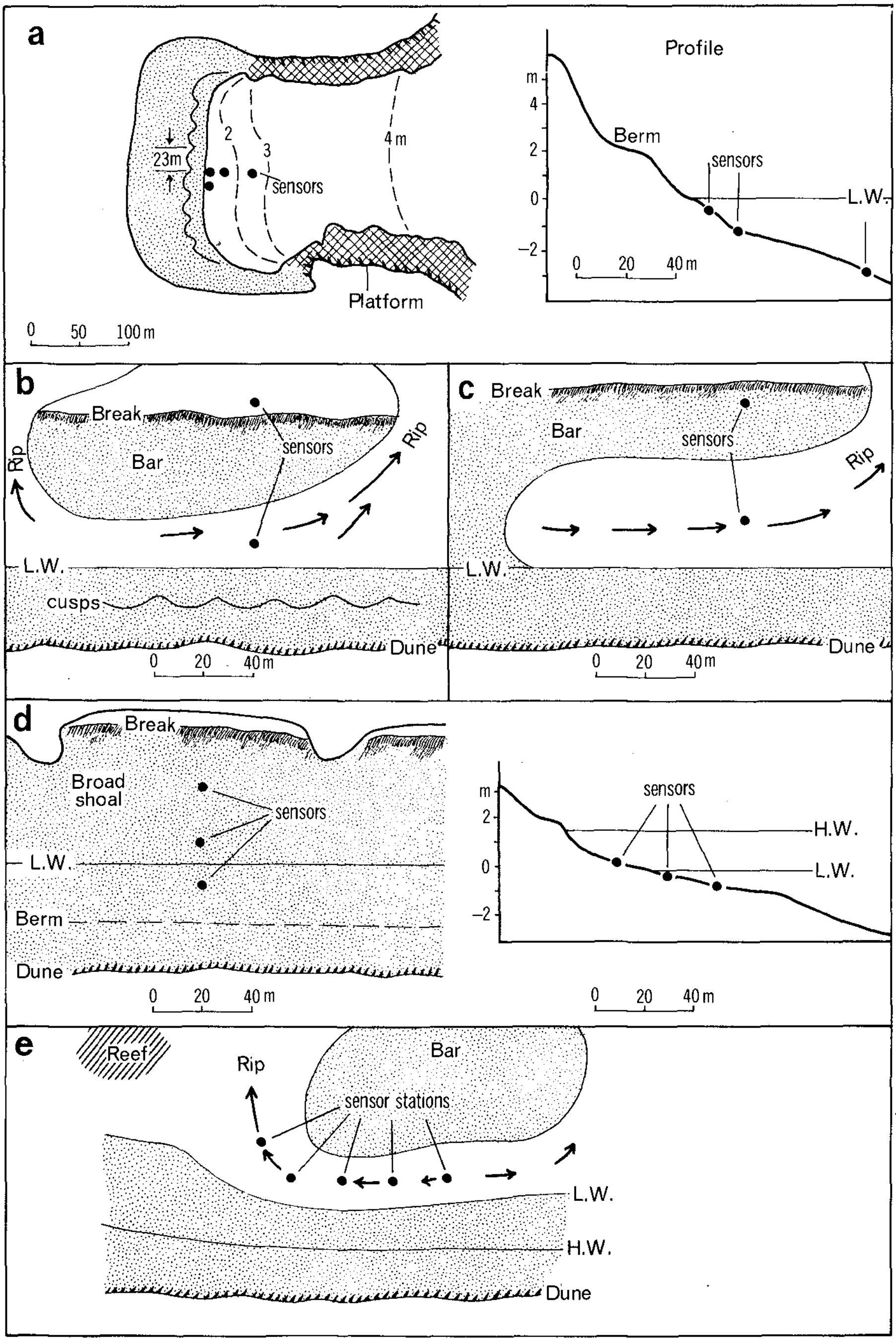
- TABLE 2 -

SURF ZONE PARAMETERS AND POSSIBLE EDGE WAVE DATA, DISSIPATIVE BEACHES

Expt.	$1/Te(H_3)$	χ_s	n	L_e	β_s (°)	D
Bracken	0.067	2	0	46	-	-
Moruya 1	0.05	11	0	40	1	0.75
		11	1	120	"	0.25
	0.023	2.4	0	190	"	0.16
Moruya 2	0.023	3.5	0	190	0.6	0.27
Palm	0.063	13	1	75	1.4	0.9
	0.03	2.9	0	110	"	0.6
Durras	0.063	14	1	100	1.4	0.9
	0.03	3.2	0	150	"	0.6

(NOTE: χ_s must exceed 7.0 for n = 1 to occur)

Figure 2 Inshore morphodynamic states for 5 experiments. (a) Bracken Beach, reflective. (b) Moruya Beach 25 May '77 shore-parallel bar-trough system. (c) Moruya Beach 27 May '77 shore-parallel plus transverse bar system. (d) Palm Beach 9 April '78 broad dissipative shore-tied goal. (e) Durras Beach shore-parallel bar-trough system.



rhythmic shoreline situation of Type 3. The primary break typically was plunging with waves tending to reform as they traversed the trough.

(iii) Moruya experiment 2 (Figure 2c) was representative of a typical Type 3 state, where crescentic bars intermittently tie to the beach through transverse bars. Beach face and inshore wave conditions resembled Moruya experiment 1 (*cf* Table 1).

(iv) Palm Beach experiment (Figure 2d) represents an advanced stage in an accretionary phase where a broad shoal extending the full width of the surf zone had developed through shoreward bar migration (Type 5 of Wright *et al.*). The upper beach face was moderately steep; the lower portion flatter. Reflectivity varied accordingly with tidal stage. The entire surf zone was crossed by spilling bores.

(v) Durras experiment (Figure 2e) was conducted within a parallel bar-trough system. Topography approached Type 2 but was influenced by a nearshore reef at the northern end of the site. The trough is relatively shallow, and larger sets of waves developed spilling bores across the surf zone while small sets reformed inshore of the break. This experiment differed from the others in that measurements were taken at 5 sites alongshore, within the trough.

SURF ZONE RESONANCE

The results of each of the selected experiments described above reveal several distinctive resonant frequencies and modes which appear strongly dependent on the morphology prevailing at the time of the experiments. The resonant phenomena associated with each set of conditions are elucidated by spectral and cross-spectral analyses of the measured time series of water surface and inshore current oscillations.

(1) Reflective case - Bracken experiment (10 December, 1977)

The steep beach face showed pronounced cusps at 23 m spacing. Waves and currents were measured seawards of the shore break at three locations off a cusp horn, and near the step off a cusp bay (Figure 2a). Spectra (from the middle station off the cusp horn) reveal several important features some of which are shown in Figure 3).

(a) Wave spectra show sharp peaks at incident wave frequency (0.13 Hz) at all stations off the cusp horn although this peak weakens at the inner station and off the cusp. Water surface motion at this frequency is dominated by the incident waves, indicated by zero phase difference between horn and bay 0.13 Hz peaks. In this experiment, water surface elevation and currents were in phase at incident wave frequency at all stations.

(b) The shore-normal current spectra show strong peaks at the frequency of the first subharmonic (.067 Hz) at both the middle and inner stations. This peak is also expressed in water surface elevation spectra; it is present as a secondary peak in the middle station but becomes the dominant peak at the inner station. Flow is $\frac{\pi}{2}$ rds out of phase with water surface elevation at this subharmonic frequency.

(c) Segregation of current spectra into offshore and onshore components by separating the primary record into half series indicates that seaward flows had highest spectral energy at subharmonic frequency, while at incident frequency onshore and offshore energies are equal.

A subharmonic edge wave is inferred from the strong peaks at subharmonic frequency and from the $\frac{\pi}{2}$ current-wave phase relationship. Guza and Davis (1974) have shown that subharmonic edge waves are preferentially excited. Guza and Inman (1975) argue that cusp spacing should be one-half edge wave length, Le:

$$Le = (g/2\pi)\ T_e^2\ (1 + 2_n)\ \tan\beta \qquad \ldots \quad (3)$$

where n = mode number = 0,1,2,3 ... (Bowen and Inman, 1969). Bowen and Inman (1969) also suggest that dominant mode decreases with decreasing dimensionless surf zone width

$$\chi_s = \omega_e^2\ X_s/g\ \tan\beta \qquad \ldots \quad (4)$$

where $\omega = 2\ /T_e$ and X_s is horizontal distance from the beach face to the break point. For edge waves to be trapped, χ_s must exceed a minimum value, χ min, which Huntley (1976) estimates as

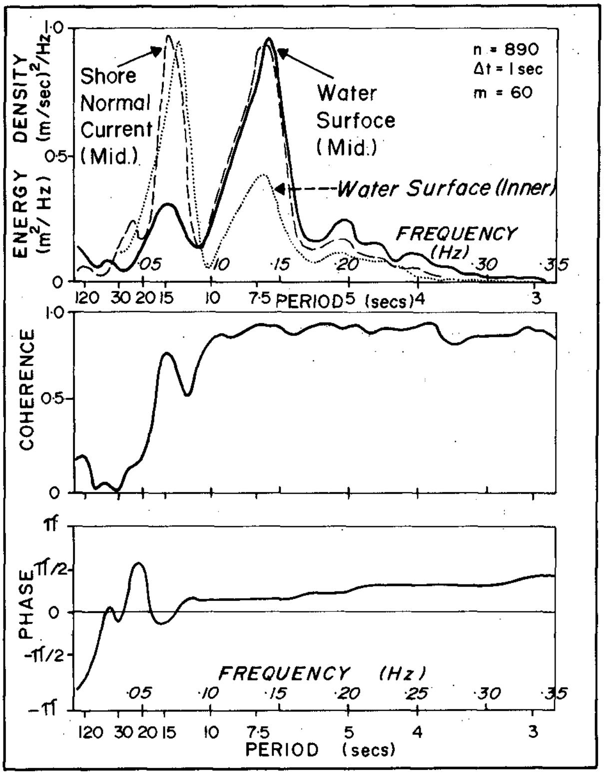
$$\chi_{min} = 3.5\ n\ (n + 1) \qquad \ldots \quad (5)$$

From χ_s values in Table 1, the cut-off mode at 0.067 Hz is n = 0 (from Eq. 5), corresponding to L_e = 46 for β values in Table 1 (Eq. 3). This is twice the measured cusp spacing.

(2) Dissipative bar-trough systems - Moruya experiments (ii) and (iii)

Spectra from two dissipative beach experiments on Moruya Beach are shown in Figure 3 from instruments located as shown in Figures 2b, 2c. Salient elements are as follows:

Figure 3 Representative spectra for reflective beach experiment (ref. Fig 2a for instrument locations).



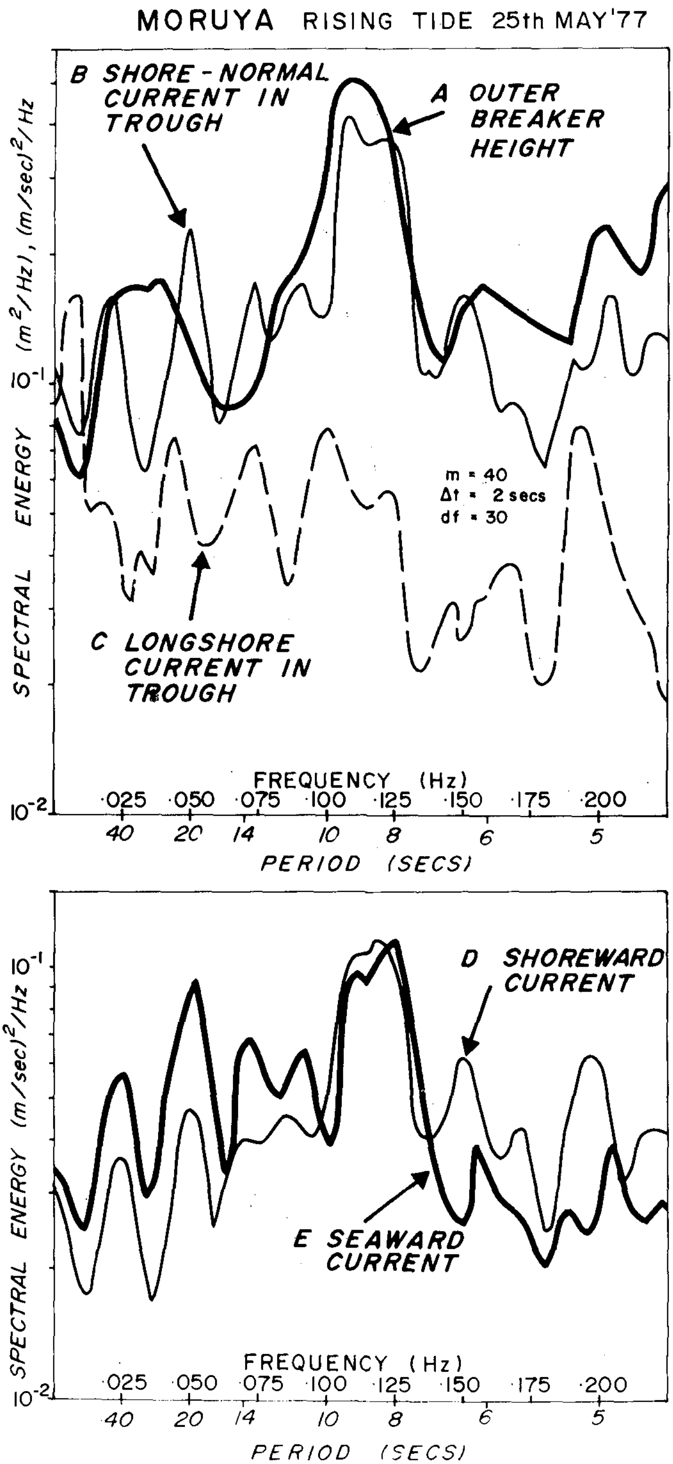
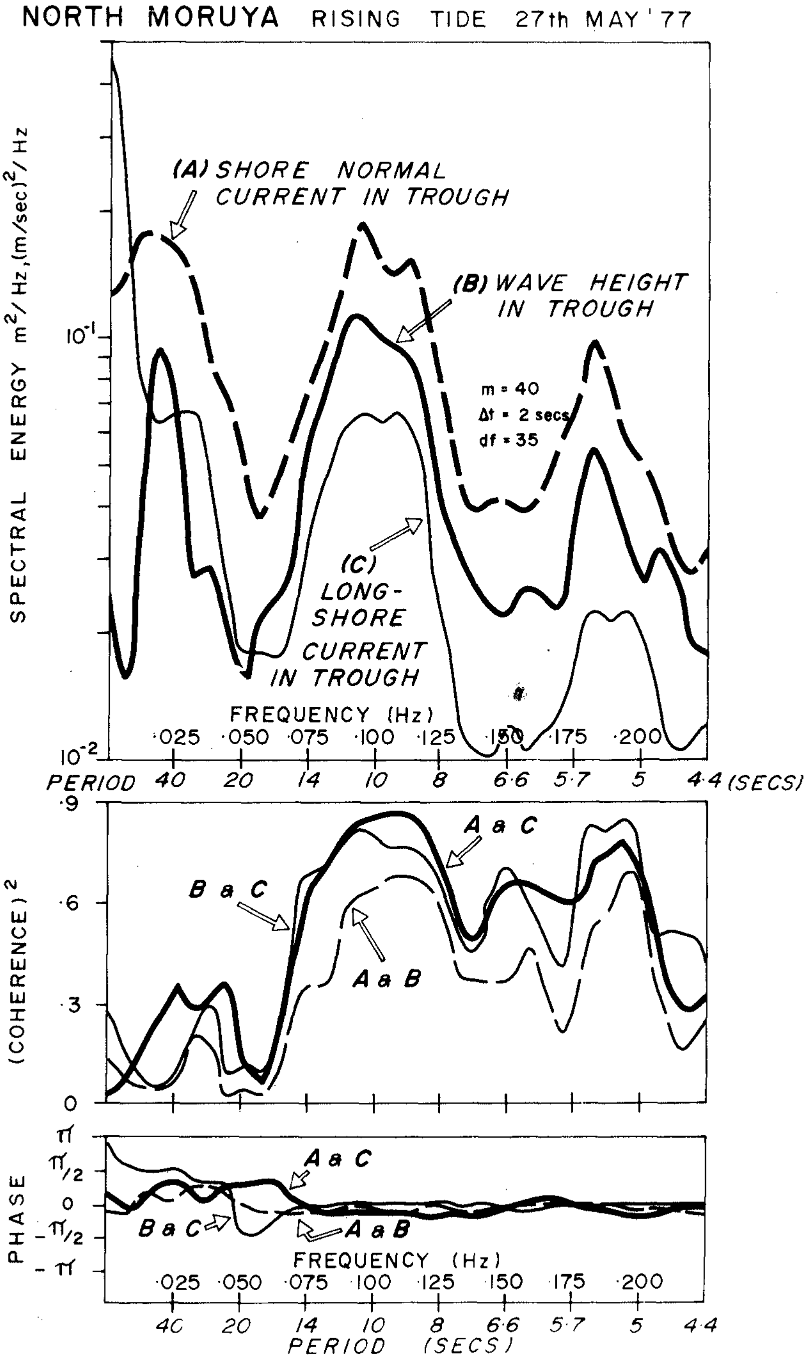


Figure 4 Representative spectra for two dissipative bar-trough systems - Moruya experiments (ii) (25 May) and (iii) (27 May) (ref. figs 2b, 2c for instrument locations).



NORTH MORUYA RISING TIDE 27th MAY '77
SPECTRAL ENERGY m²/Hz,(m/sec)²/Hz
(A) SHORE NORMAL CURRENT IN TROUGH
(B) WAVE HEIGHT IN TROUGH
(C) LONG-SHORE CURRENT IN TROUGH
m = 40
Δt = 2 secs
df = 35
FREQUENCY (Hz)
·025 ·050 ·075 ·100 ·125 ·150 ·175 ·200
PERIOD 40 20 14 10 8 6·6 5·7 5 4·4 (SECS)
(COHERENCE)²
A a C
B a C
A a B
PHASE
FREQUENCY (Hz)
PERIOD (SECS)

FIGURE 4 (iii)

(a) Strong subharmonic components appear in current spectra on both occasions in addition to incident-frequency peaks, but at different multiples of incident wave period. For experiment (ii) the incident frequency is close to 0.1 Hz, and secondary current peaks appear at 0.05 Hz and 0.023 Hz, the 0.05 Hz being the stronger. Experiment (iii), with incident frequency again close to 0.1 Hz but a somewhat broader trough, shows only the lower frequency subharmonic current peak at 0.023 Hz, which is very near to ¼ the incident wave frequency. Phase determinations for experiment (iii) show that flow oscillations at .023 Hz are 90° out of phase with water surface oscillations at this frequency, whereas the strong incident-frequency flow is in phase. Progressive motion thus is indicated at incident frequency; standing motion at the $\omega/4$ frequency. The wave record for experiment (iii) at the same point in the trough, shows the same 0.023 Hz ($\omega/4$) peak; this peak is absent in the outer breaker record.

(b) Segregation of the current record from experiment (ii) into onshore and offshore components shows a similar effect to the reflective beach case, *i.e.* offshore current substantially exceeds the onshore component at $\omega/2$ and $\omega/4$ frequencies.

(c) For the second experiment χ_s for the 0.023 Hz peak is 3.6, indicating that only the zero-mode edge wave is likely at this frequency. The corresponding L_e value is 190 m, which is very close to twice the observed spacing of transverse bars (90 m; data in Table 1). However, this does not constitute "proof" of edge wave determination of coupled circulation and topography: firstly, because several modes below cutoff are possible for resonance at $\omega/2$, and secondly, because estimates of L_e are very sensitive to values of β, which often varies down the beach face and over the surf zone. This allows too much freedom when finding a "fit" between L_e and rip or transverse bar spacing, especially when $\omega/1$ and $\omega/4$ peaks both are present as in the first Moruya experiment.

An interesting result is that the low frequency peak at ¼ of incident frequency, which is subordinate to the first subharmonic in Moruya 1, rises to dominance in the second experiment when energy conditions are 20% higher, the trough wider, and the surf zone broader (Table 1). This implies firstly that increasing dissipativeness inhibits excitation of higher frequency edge waves, which is consistent with Guza and Davis (1974) measure (D) of boundary layer dissipation per unit of longshore length, restated as

$$D = E\pi\,(2\gamma\omega_i)^{\frac{1}{2}}/L_e \tan\beta \qquad \ldots (6)$$

where E is total wave energy per unit longshore length. When dominant resonance shifts to $\omega/4$, L_e increases fourfold (relative to $\omega/2$) for a given mode (Eq. 3), and sensible dissipation for the edge wave decreases.

Guza and Davis argue that excitation of an edge wave of lower frequency and higher mode than the (0,0) subharmonic is possible only when $a_i^2 \omega_i \gamma > 4 K(0,0)$. The corrected value of K (0,0) is $\simeq 50$ (Guza and Inman, 1975), and from Eq. 1 the minimum incident amplitude at the beach face necessary for growth of higher mode, lower frequency edge waves for our case is $a_i \simeq 6$ cm, which is about 1/7 of observed inshore wave amplitude.

Strong resonance at $\omega/4$ is not predicted by conventional edge wave theory and is generally inconsistent with the concept of resonant triad as set out by Guza and Davis (1974). For this reason and because thus far we have only found resonance at $\omega/4$ in situations of pronounced bar-trough topography, we infer that resonance at this frequency is a consequence of topography. In the cases studied the trough has been deep, the bar has been shallow with a steep (and potentially reflective) landward face and the beach face has been locally reflective. Estimated natural trough frequencies are close to the frequency of the first subharmonic ($\omega/2$) at times when $\omega/4$ peaks occur.

(3) Dissipative surf zone without trough - Palm Beach

An important question is whether edge waves occupying the inshore zone of dissipative systems will always be excited when beach reflectivity is high and the condition of Equation 1 is surpassed substantially. This is relevant to rip current initiation under Type 5 conditions when an inshore trough is absent; our observations indicate an absence of regular rip organization in these conditions (*c.* Figure 2d; see also Wright *et al.* 1978 and in press; Chappell and Eliot, in press). The broad troughless intertidal shoal fronting a moderately reflective high-tide beach ($\Sigma = 2.3$) was monitored for shore-normal currents at 3 sites - mid swag, and at points about 8 m and 20 m seaward of the shore break (Figure 2d). Wave record was obtained only from the inner surf zone site owing to failure of the outer transducer. Neglecting the swash zone record, spectra shown in Figure 5 indicate several interesting points.

The inner surf zone wave spectrum shows a strong incident peak and a minor subharmonic peak ($\omega/2$). This does not appear in the current record, however, which is dominated by a peak at 0.063 Hz with a second peak at 0.03 Hz. Both are close to 90° phase from the water surface oscillations although phase-significance is low. Both peaks exceed the incident-frequency peak at 0.1 Hz which is in phase with the incident wave peak. The mid-surf zone flow-meter shows the 0.063 Hz peak, at lesser amplitude than the incident frequency peak. We interpret these results as indicating the edge wave pair (1,0) of resonant triad, which, according to Guza and Davis (1974) will have edge wave frequencies of (0.63, 0.3) ω_i *i.e.* very close to our observed frequencies. The (1.0) pair is consistent with χ_s values which indicate that mode 1 is possible at 0.63 Hz and only zero mode can exist at 0.03 Hz for the Palm Beach surf zone. Non-appearance of wave peak at 0.063 Hz suggests that the inner surf zone instruments were close to the mode 1 node. Profiles of edge wave surface, $\eta(x)$, and flow $\mu(x)$, calculated from $\mu = d\phi/dx$ and $\eta = (1/g)\delta\phi/\omega$ where $\phi = (ga/\omega)L_n\,(2Kx)\exp(-Kx)$, L_n is the Laguerre polynomial of mode n), in Figure 5, show that this interpretation is consistent, although the 0.03 Hz wave peak would have been expected.

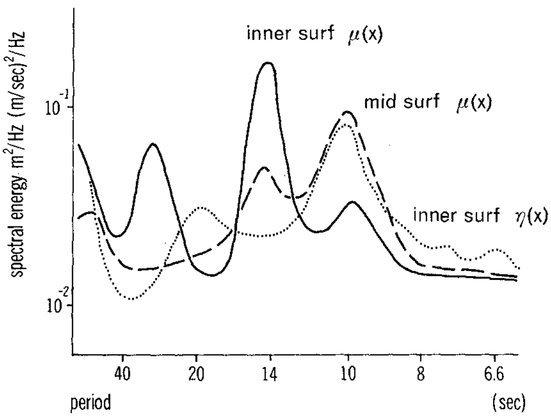
This result, when compared with the Moruya cases, raises the question of why a particular set occurs. We suggest that answer lies with the dissipation parameter D (Eq. 6), and that the highest frequency, lowest mode set will occur which is consistent with the excitation condition (Eq. 1), and for which D is less than a threshold level D_c. Table 2 lists ω_e permitted modes and L_e values, and estimates of D for the Moruya and Palm Beach experiments. These D values are calculated using the surf zone gradient β_s rather than the beach-face β value. Empirically, it appears the D_c is about 1.0 for dissipative beaches. We note, however, that excitation of the first subharmonic (ω/2), (0.0) set is significantly easier than the (1,0) set and suggest that a similar (0,0) set can be excited at ω/4 in preference to the (1,0) : (ω/1.6, ω/3.0) set when a trough of sufficient width is present.

During the Palm Beach experiment, rips were virtually absent, allowing no test of possible edge wave - circulation relationships. To explore this last problem we turn to the final experiment.

(4) Multiple sites along a bar-trough system - Durras experiment

This experiment is potentially most interesting in that 5 sites at 20 m intervals in a parallel bar-trough system were measured, but unfortunately this was done prior to establishment of the full experimental system. A single instrument set of 2 flow meters and one transducer, logged by chart recorder, was moved to successive sites. This was a preliminary experiment and field work was done largely by a student, Mr E. Wallensky. Figure 6 shows spectral results and net (u, v) velocity components at each site. A longshore current feeding a rip is indicated clearly. There is no transverse or rhythmic topography to influence location of the rip catchment divide. In summary, results indicate a (1,0) edgewave set (0.06 Hz, 0.03 Hz) dominating, with a common node at the rip current and the 0.06 Hz component antinode about 30 m up-trough from the rip, while the 0.03 Hz component has its antinode about 40 m up-trough. These

Figure 5 Spectra for dissipative troughless surf zone, reflective beach face - Palm Beach (ref. fig. 2d). Theoretical edge wave surface and current profiles shown (normalised).



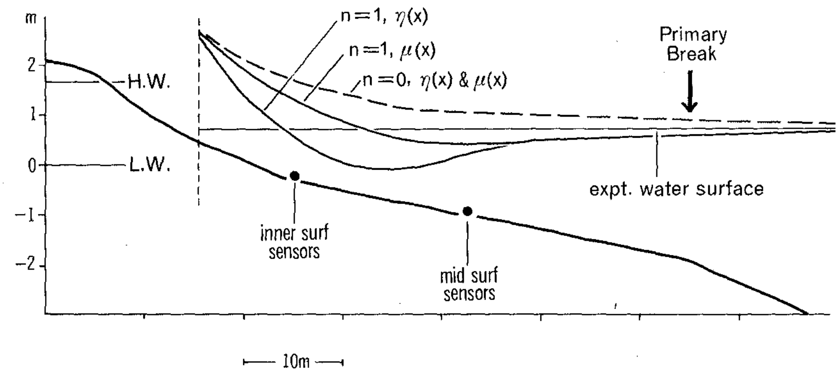
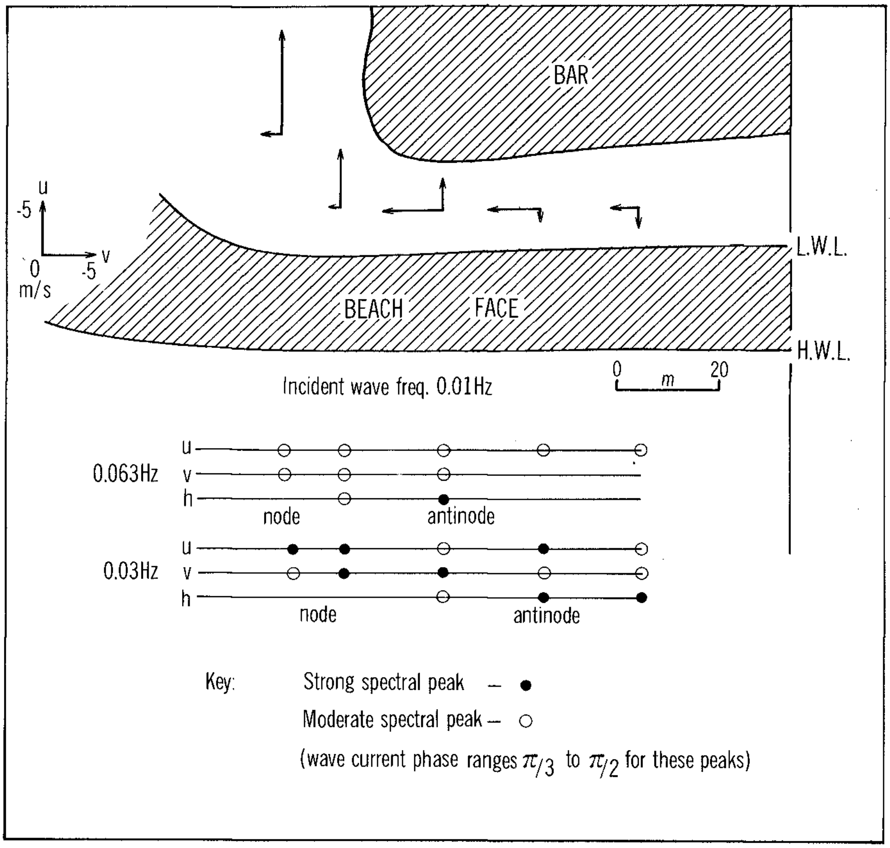


Figure 6 Multiple sites in parallel bar-trough system, showing longshore variation of inferred (1,0) triad spectral peaks and net currents (Durras Beach, ref. fig. 2e).



correspond quite well with predicted quarter-wavelengths (node to antinode) of the (1,0) components, *i.e.* 25 and 38 m.

CONCLUSIONS

The existence of edge waves appears confirmed for dissipative surf beaches, as well as for the simpler reflective case as previously has been argued. Our reflective example supports the hypothesis that beach cusps form from the influence of a stationary zero-mode edge wave at half the incident wave frequency, *i.e.* the first subharmonic. With varying degrees of dissipation it appears that a series of edgewave frequencies can exist with frequencies ω_i/j, where j = 1,1.6, 2,3,4 ... We include j = 1 here to include possible edge waves at incident frequency (although these are less likely, especially as stationary waves: Guza and Inman).

Dissipative surf zones with steep beach faces show a greater range of inshore edge waves, in particular as resonant (0,0) or (1,0) pairs at frequencies of $\omega/2$, or ($\omega/1.6$, $\omega/3$) respectively. Further, the single zero-mode form appears to occur at $\omega/4$. Although the zero mode wave at $\omega/2$ is more easily excited, by a factor of 4, the particular edge wave which occurs is limited by inshore dissipation, and that which exists is the lowest mode, shortest period wave for which inshore friction D (Eq. 6) is less than 1.0.

As far as our measurements go, edge waves appear to influence location of inshore circulation systems, with rips tending to locate at nodes. The fact that edge wave length increases discontinuously as inshore dissipation increases offers an explanation of the phenomenon - often observed - that new or secondary rips appear when wave energy conditions change.

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