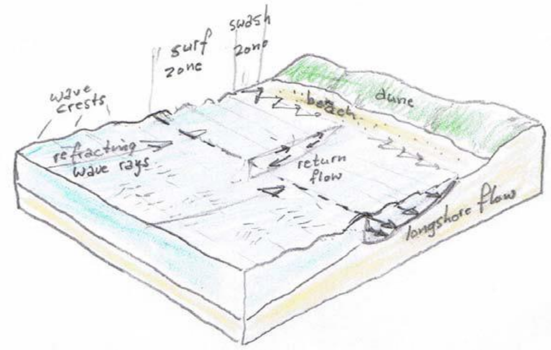
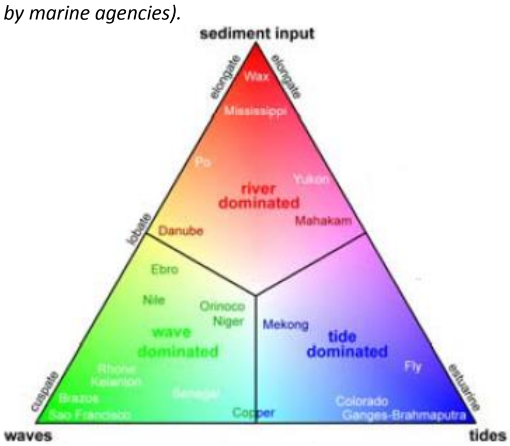
Summary Coastal Dynamics I: complete

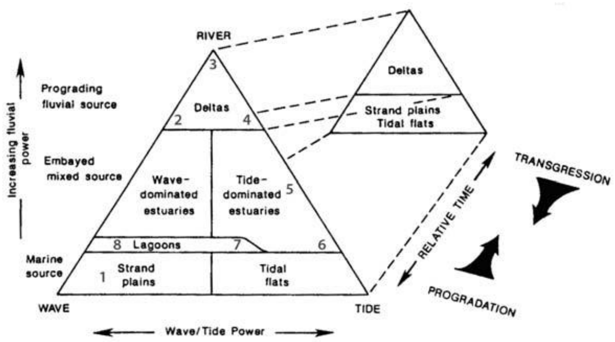
Coastal Dynamics I (Technische Universiteit Delft)



Chapter 2:
Wide continental shelf: facilitates sediment accumulation and rapid coastal progradation, reduce wave energy, amplify tidal amplitude, have higher potential storm surge elev.
Leading edge coast: narrow shelf, steep profile, large waves, short steep streams, coarse sediment supply from river, at edge of crustal plate
Amero-trailing edge coast: wide shelf, large sediment supply, broad coastal p lains, deltas and barriers. Most mature trailing coast
Afro-trailing edge coast: continent in middle of plate, little sediment supply, slow coastal development.
Sandy coasts: humid climates, passive margin coasts, 20-40 latitude, energetic wave/tidal environm.
Holocene: sealevel rise, pleistocene: ice age-> sea level fall
Effects: Eustatic(amount of water, expansion of water, ocean basin volume, shape of oceanic geoid) and regional(seismic, isostatic(loading by ice/water), land subsidence)
Re/transgression: sea/landward shift of the shoreline
Pro/retrogradation: sediment is deposited such that shoreline moves Sea/landward
Emergence/Submergence: land emerges out of the water/land is flooded due to relative sealevel fall/rise
Classification: Material*(hard/soft)*, Inman&Nordstrom*(Tectonic controls)*, Valentin*(sea-level):advanced vs retreated coasts.* Shepard *(dominant processes):*primary*(shaped by non-marine agencies)* vs secondary*(shaped by marine agencies).*

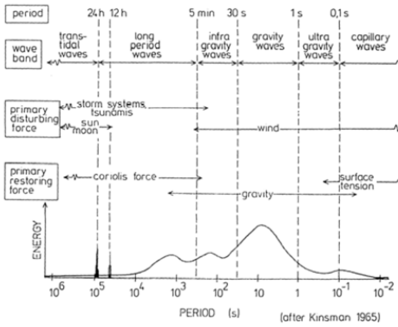


Galloway



Shore classification

Chapter 3:



$E=E_k+E_p=\rho g\sigma^2$

$$H_{rms}=\sqrt{\frac{1}{N}\sum_{i=1}^{N}H_i^2}\quad H_{1/3}=\frac{1}{N/3}\sum_{j=1}^{N/3}H_j\quad \langle\eta^2\rangle=\int_0^\infty E(f)\,df=\sigma^2=m_0$$

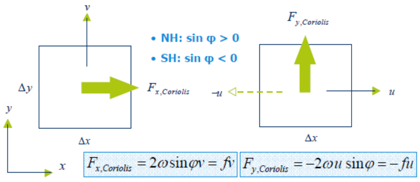
Random phase model: in deep water and not too steep waves the phases are uniformly distributed between $-\pi$ and π. Surface elevation is Gauss-distributed.

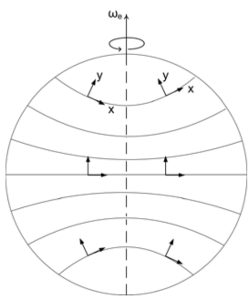
Description	Notation	$H/\sqrt{m_0}$	H/H_s
RMS height	H_{rms}	$2\sqrt{2}$	0.707
Mean height	$\bar{H}$	$\sqrt{2\pi}$	0.63
Significant height	$H_s=H_{1/3}$	4.004	1

Dispersion relationship: $\omega=\sqrt{gk\tanh kh}$ c=L/T=ω/k
Group velocity is smaller than phase velocity except for very long waves
Dissipation processes filter out shorter waves, dispersion is due to different wave speeds.
Sea: Variable height/direction, high, short, steep slow
Swell: Regular, lower, longer flatter, faster
Wavegroups: Dispersive wave groups: waves disappear at the front and reappear at back, individual waves travel faster than group wave front.
Grouping: $k_{group}=k_1-k_2$ (same for ω)-> $c_g=\Delta\omega/\Delta k$

Generation of tide

Rotation of earth: 23hr56min. Lunar month(sidereal month): 27.3 days(to same point 29.5 days due to rotation of earth around sun(catch up)), Lunar day: 24hr50min, Solar year: 365.25 days.
Gravitational attraction of moon and sun provide centripetal acceleration. The **differential pull** generates the tide, also called **tidal force.**
Tidal components: M2: *12hr25min eq ampl: 0.24m* S2: *12 hr eq ampl: 0.11m*
Period between 2 spring tides M2 and S2: $T=\frac{1}{T_{S2}^{-1}-T_{M2}^{-1}}$
Tidal constituents: K1, O1: Moon declination. K1, P1: sun declination. K1,P1,O1: diurnal inequality. K2: Amplitude modulation of M2/S2 for declinational effect of moon and sun.
Tidal propagation is hindered by continents.
Small amplitude long wave: $\frac{\partial\eta}{\partial t}+h\frac{\partial v}{\partial y}=0$
Coriolis
Coriolis effect diverts a moving particle to the right(left) on the Northern(Southern) hemisphere. Newtons equations are only valid for a fixed inertial frame, Coriolis is needed to correct for our accelerating non-inertial frame. NH: x,y-plane turns anti-clockwise





Amphidromic points(have zero tidal range) NH=anti-clockwise
Co-tidal/phase lines: lines of simultaneous HW(radiate from node)
Co-range lines: lines of constant tidal range(concentric)
Degenerate point: centre located over land
Kelvin waves: Coastally trapped due to Coriolis force
u=0, f=constant, no friction gives:

$$-fv=-g\frac{\partial\eta}{\partial x}\qquad \frac{\partial v}{\partial t}=-g\frac{\partial\eta}{\partial y}\qquad \frac{\partial\eta}{\partial t}+h\frac{\partial v}{\partial y}=0$$

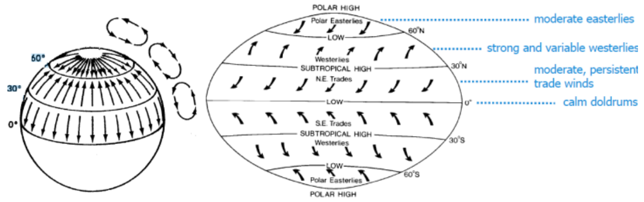
Cross shore momentum balance is geostrophic: pressure gradient balances Coriolis. **Alongshore momentum balance**: inertia balances pressure gradient, alongsh. velocity in phase with water lvl, in NH keeps

Tidal analysis: f_n=nodal factor(to correct 18.6 year cycle) β_n=astronomical argument(phase correction) $\eta_t = a_0 + \sum_{n=1}^{N} f_n a_n \cos(\omega_n t - \alpha_n + \beta_n)$

Chapter 4: Global wave and tidal environment

Zonal wind systems

Uneven heating results in heat advection by ocean currents and winds. Cold air sinks at the poles and warm air rises at the equator



Winds deviate due to Coriolis force

Reversing monsoons are caused by differences in temperature of land and sea(land warms/cools faster). For Asia: in summer ocean->land, in winter land->ocean

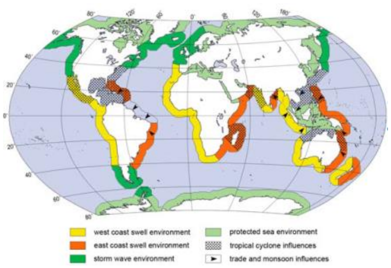
Global wave environment

Low wave energy: H_s<0.6m, Medium wave energy: 0.6m<H_s<1.5m High wave energy: H_s:1.5m.

-Waves are highest at mid-latitudes due to the relatively strong westerlies

-mid latitude wave climate at NH is strongly seasonal due to Asia landmass

-SH shows less seasonality.



Storm wave climate:
Most energetic; located between 40-60 N and S; year round in SH, in winter in NH; combination of sea/swell; waves are typical sea waves, impacts west and south facing coasts; deep water H=2-3m 90% of time, 5-6m 10% of time; wave periods are 5s, longer during storms; locally generated by westerlies;

West coast swell climate:
Year-round in SH; in winter in Northern hemisphere; located between 0-40° (N and S); reaches west coasts of Americas, Africa, Australia and New Zealand; originate from NH and SH storm wave belts; in tropics swell can also stem from trade winds; persistent and long waves (typical period 10 s); uniform in direction, shape and size; typical wave heights 1-2 m; not much variation in wave heights around the mean(only as result of tropical storms); arriving from northwest in the NH and from southwest in the SH; higher in the higher latitudes and slowly decreasing toward the equator;

East coast swell climate: Directed at east facing coasts, lower and less frequent than west coast swell

Global tidal environments

Categories: micro/meso/macro: <2m, 2-4m, >4m

Form factor: $(K_1+O_1)/(M_2+S_2)$ F=0-0.25: semi-diurnal, F=0.25-1.5:mixed mainly semi-diurnal, F=1.5-3:mixed, mainly diurnal, F>3: diurnal.

Diurnal tides have smaller tidal ranges

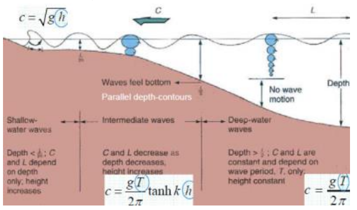
Coastal impact

Wave dominated: dynamic sandy coastal profile with bars and dunes, beach slope dependent of wave characteristics

Tide dominated: tides smear beach morphology; wide, low gradient and muddy tidal flats, salt marshes and mangroves, tidal ridges

Coastal hydrodynamics

Wave height transformation



$c = \sqrt{gh}$ $\quad c = \frac{gT}{2\pi}\tanh kh$ $\quad c = \frac{gT}{2\pi}$

Steady energy balance:

$\frac{\partial}{\partial x}(Ec_g cos\theta) + \frac{\partial}{\partial y}(Ec_g sin\theta) + D = 0$

Shoaling:

Energy flux U=constant=Enc

This gives: $\frac{H_1}{H_2} = \sqrt{\frac{c_1}{c_2}\frac{n_1}{n_2}} = K_{sh}$

$c_g = nc = \left[\frac{1}{2} + \frac{kh}{\sinh 2kh}\right]\frac{\omega}{k}$

Refraction is given by Snell's law: sinθ/c=constant $K_r = \sqrt{\frac{\cos\theta_A}{\cos\theta_B}}$ At a uniform coast

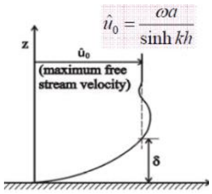
K_r reduces the wave height increase due to shoaling

Diffraction if a breakwaters length is twice its distance to shore H_{atA}=0(tombolo). If smaller it is not(salient).

Orbital velocities $\hat{u}(z) = \omega a \frac{\cosh k(h+z)}{\sinh kh}$ become more assymetric in shallower waters.

Dynamic pressure doesn't have effect at bottom in deep water

Bed friction Wave boundary lager is transition from "normal" orbital motion to bed. At bed: flow sticks to the wall(no-slip condition) due to viscosity and turbulence. Vorticity is generated at the boundary. Large velocity gradients give large shear stresses. Thickness is limited to 1-10 cm



$\hat{u}_0 = \frac{\omega a}{\sinh kh}$

Orbital motion incurs bed shear stress, can set sediment into motion. Friction in the boundary layer causes dissipation of energy. Wave force pushes the flow forward, Longuet-Higgins streaming: this streaming causes net onshore directed sediment transport and should be taken into account. ($U_\delta = \frac{3}{4}\frac{\hat{u}_0^2}{c}$) Instead of a detailled boundary layer a quadratic friction law can be used $\tau_b = \rho c_f |U| U$

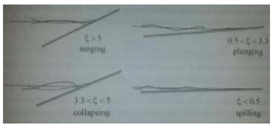
Wave friction as function of particle excursion amplitude: $\frac{\xi_0}{r} = \frac{\hat{u}_0}{\omega r}$

Wave skewness and asymmetry

Stokes higher order terms correct for non-linear surface elevation. Shoaling waves have long flat troughs and narrow peaked crests. Skewness is given by $\langle\eta^3\rangle$ which is zero for a linear wave(alsof or combination of linear waves). Orbital velocities also become skewed, crest propagates faster than through. This cannot be seen in Stokes waves since they are phase-locked. Sediment transport due to wave skewness: $\langle S\rangle = B\langle u_0^3\rangle$ S>0 for positively skewed signal.

Wave breaking when crest angle is about 120°. Miche says: $H_{max} \approx 0.14L$ (deep water) $H_{max} = 0.88h$ (shallow water)

Breaking parameter for shallow water: $\gamma = \left[\frac{H}{h}\right]_{max} = \frac{H_b}{h_b} \approx 0.88$, for solitary wave theory this is 0.78. γ=constant

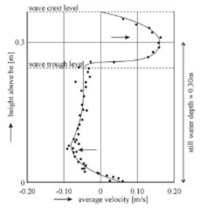


Iribarren number: $\xi = \frac{\tan\alpha}{\sqrt{\frac{H_0}{L_0}}}$

Surface roller: dissipates energy

$q = \overline{\int_{-h_0}^{\eta} \rho u dz}$

Momentum and wave forces

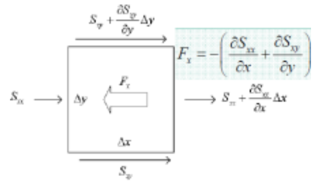


Waves carry mass and momentum. Only momentum transport above wave trough, time-averaged transport below trough is 0. Stokes drift(orbital motion not perfect->mass flow to coastline). Breaking waves have high return currents, LonguetH streaming may be overridden by this.

Radiation stress is the depth-integrated and wave-averaged flow of momentum due to waves.

dS_{xx}/dx gives set-up and set down.

dS_{yx}/dx gives longshore current



$F_x = -\left(\frac{\partial S_{xx}}{\partial x} + \frac{\partial S_{xy}}{\partial y}\right)$

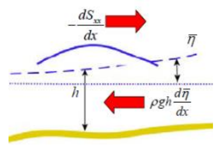
$S_{xx} = \overline{\int_{z=-h_0}^{\eta} \left[(\rho u)u + p_{wave}\right] dz}$

Is the expression for the radiation stress. The expression consists of 2 parts: 1 caused by momentum transfer by particle velocity, the other by wave-induced pressure.

	General	$\theta = 0$	$\theta = 0$ shallow water (n=1)
S_{xx}	$(n - \frac{1}{2} + n\cos^2\theta)E$	$(2n - \frac{1}{2})E$	$\frac{3}{2}E$
S_{yy}	$(n - \frac{1}{2} + n\sin^2\theta)E$	$(n - \frac{1}{2})E$	$\frac{1}{2}E$
$S_{xy} = S_{yx}$	$n\cos\theta\sin\theta E$	0	0

Wave set-up set down and undertow

Increse in rad. Stress in shoaling zone(set-down, offshore force) and decrease in surf zone(set-up, onshore force).



Change in radiation stress is compensated by undertow. When wave breaking is considered in a non-depthaveraged equation extra circulation is observed.

Longshore current

$F_y = -\frac{dS_{yx}}{dx} = -\frac{d}{dx}\left[Enc\cos\theta \frac{\sin\theta}{c}\right]$

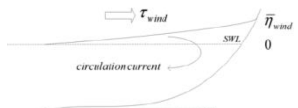
Alongshore wave force is non-zero only in surf zone. This wave force is balanced by a bed shear stress. Note: for irregular waves the border of the surf zone varies

For the bed shear stress in alongshore direction a quadratic friction law is used for time averaged bed shear stress.

3D effects

Due to turbulent forces the velocity profile changes. Typical 3D current patterns caused by alongshore variations are: eddy formation in the lee side of structures, 3D current patterns around shoals, creation of rip currents. Behind a breakwater variations in wave height also cause 3D current patterns.

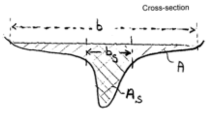
Wind-induced set-up and currents



$\rho g h \frac{d\bar{\eta}}{dx} = \tau_{wind,x}$ $\quad \tau_{wind} = C_d \rho_a W^2$

Wind causes shear stress which is balanced by set-up. The velocity profile is totally different from wave setup: velocities are large at surface.

Coastal hydrodynamics: Tide in coastal waters
Flood currents: in direction of wave propagation. Ebb currents: opposite to wave propagation. Horizontal tide: velocity. Vertical tide: water level. Ebb to flood: low water slack. Slack is usualy just after HW/LW. Flood current runs northward along Dutch coast, ebb southward. Velocity leads elevation with quarter period for M2tide.
Tidal propagation with linear friction is given by: $g\frac{\partial\eta}{\partial y} = -\frac{r}{h}v$
Tidal velocity is proportional to $\sqrt{h}$. Tides vary per coastal location. Tida is also skewed, high water is further above the mean than low water below. Falling and rising period are not equal: **Tidal assymetry.** Tide can overshadow(or not) wave induced longshore current.
Tidal propagation into basins



Simpliofication: no intertidal areas, prismatic channel gives 1D long wave equation for small tide

Diffusion equation: friction dominated flow

Now propagation in two directions!
No damping
Reflection at landward end of basin
Standing wave pattern:
- Water level and velocity 90° out of phase
- Nodes and anti-nodes

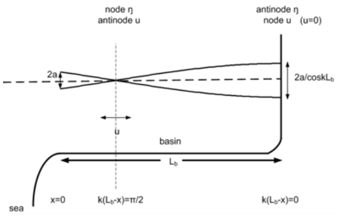
Phase velocity:
$c = \sqrt{gh}$

$$\frac{\partial^2\eta}{\partial t^2} - gh\frac{\partial^2\eta}{\partial x^2} + \frac{r}{h}\frac{\partial\eta}{\partial t} = 0$$

- Amplitudes are progressively damped with distance from the inlet
- No reflection at end of basin
- The velocity leads the surface elevation with 45°
- Phase speed is influenced by friction:

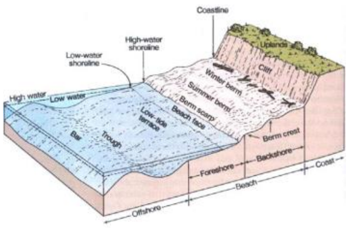
$c = \sqrt{2\omega g h^2 r^{-1}}$

Classical wave equation: inertia dominated flow

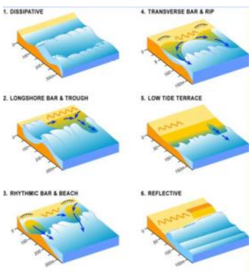


Resonance occurs if reflected and incident wave cancel each other out at mouth. In the left case for: L_b=1/4L, 3/4L etc. Usually both friction and inertia occur. The character is then between the two seperate cases. Other facors with influence are friction, energy convergence by width constrictions and shoaling. Short basin: $u_s(x,t) = \frac{\partial\eta_0}{\partial t}\frac{A_b}{A_s}$
Tidal assymetry
High tide propagates faster than low tide. Friction slows low tide down, low tide feels bottom more. Rising period<falling period**. For sediment transport:** 1. $h_{HW} > h_{LW} \Rightarrow c_{HW} > c_{LW}$ 2. $c_{HW} > c_{LW}$ => smaller rising period than falling period 3. shorter rising period => shorter flood duration than ebb duration 4. shorter flood duration means larger maximum flood velocity than maximum ebb velocity 5. larger maximum flood velocity means net landward transport of sand. If ratio a/h is large enough flood is dominant. This can be counteracted by larger intertidal storage, these slow high tide propagation down and can cause ebb dominance. This is usually the case for small a/h ratios.
Flood-dominant systems: Shallow channels, little intertidal storage, Shorter flood duration, higher velocity floods, Sediment import to channels **Ebb-dominant systems**: Deep channels, extensive intertidal storage areas, Shorter, higher velocity ebbs, Channels get flushed. Negative sediment transport
Overtide: higher harmonics of basic tidal constituents(M4, M6). Sawtooth asymetry is dominant asymmetry in short basins.
Fines settle around flow reversal and is thus controlled by duration of slack

Sediment transport
Transport including/excluding pores. $I_m = (\rho_s - \rho)(1-p)S_{ip}$. Sediment transport has current and wave related part. Transport is given by concentration*velocity
Complexity in predictions
Reasons: Velocity field in the nearshore is oscillatory, Sediment resuspension and transport respond non-linearly to the forcing, (and what is the forcing?), Vortex shedding due to the existence of bed forms, Suspension ejection events at flow reversal, Lagged response to forcing and phase differences in vertical, Different transport contributions in opposite directions
Practical transport modelling
Different types of transport: bed load(supported by intergranular forces), suspended load(supported by turbulence), sheet flow(bed load at high shear stresses). Bed load: determined by bed shear stress due to currents and waves, can be both time averaged or instantaneous (responds to intra-wave variations->quasi-steady(*non time dependent)*). Suspended load transport: only current related transport is taken into account.
(Critical) bed shear stress
Drag, gravity and lift forces on grains. Lifting is determined by critical Shields parameter: $\theta_{cr} = \frac{\tau_{b,cr}}{(\rho_s - \rho)gD} = \text{const}$ with $\tau_{b,cr} = \rho u_{*,cr}^2$. Parameter is dependant on Reynolds number: Re*=u**D/v. This is valid for a flat bed under uniform flow. Ripples, grain gradation(and bed armouring), oscillatory flow and slope effect can complicate it.
Bed load transport
Instantaneous response above a critical value. Time-averaged bed load related to a instantaneous bed shear stress is given by: $\langle\Phi_b(t)\rangle = \langle f(\theta'(t), \theta_{cr})\rangle$: e.g.: formula of Ribberink. Time-averaged bed load related directy to time-averaged bed shear stress gives: $\langle\Phi_b(t)\rangle = f(\langle\theta'(t)\rangle, \theta_{cr})$ e.g.: Bijker-formula. If a oscillatory signal is skewed and its <u>=0 the <S> can be unequal to zero, since S is not proportional to u but to $\langle|u|^2u\rangle$. Transport reacts quasi-steady to the flow field.
Suspended load transport
Current and wave related part. Current part is wave induced(undertow, longshore current, LH streaming), wave part(transport by oscillatory water motion: short wave asymmetry, bound long waves). Wave part is usually neglected.(difficult to model, quite unknown).
Time plays a role so **quasi-steady approach is not valid** any more!
For a plane bed turbulent diffusion is a good explanation for the transport of sediment from lower to higher levels(and from high concentration to the lower concentration in the top layer of the water). The Rouse number defines the sediment concentration profile and also the mode of transport. If the Rouse number($\frac{w_s}{\kappa * u_*}$) is larger than 2.5->bed transport. Rouse<0.8->only wash load. Memory effect plays a role, especially in tidal inlets
Energetics approach
Energy is needed to keep bed load moving and suspended load at height above bed. $\tan\alpha \to \tan\varphi_r$ *gives avalanching*, $\tan\alpha \to w_s/u$ gives autosuspension.
$\langle S_b\rangle$ is proportional to $\langle u|u|^2\rangle$ and $\langle |u^3|\rangle$
$\langle S_s\rangle$ is proportional to $\langle u|u^3|\rangle$ and $\langle |u^5|\rangle$
Cross-shore transport and profile development
Equilibrium shoreface profile



Slope increases for coarser sediments. Slope decreases for higher waves.
Several empirical formulas: Bruun:$h = A(x')^m$ Dean supports this and suggests that there is a uniform energy dissipation per unit volume of water across the surf zon. In his formula he states that A is dependant of the particle diameter/fall velocity. This formula is useful for the prediction of nourishment effects.
Bruun-rule: sea level rise has 'duinafslag' effect on profile.
Beach states
High short waves give wide, flat sandy coasts with mutible bars, dunes and wide coast. Dimensionless fall velocity: $\Omega = \frac{H_b}{w_s T}$.
Beach states have 2 types at end of spectrum: **Dissipative beaches**: Ω>6, wide and flat sandy zone with bars, dunes, wide beach. High energy waves break far offshore. **Reflective beaches**: steep and narrow, Ω<1, low and long waves, less dynamic. Dissipative and reflective beaches are 2D, 4 intermediate states are more 3D with ripcurrents.
Spatial scales can have 2 reasons: self-organization/internal dynamics and external forcing.



Cyclic profile and bar behaviour
In summer beach is rich in sediment, in winter poor. Seasonality is strongest in NH
Episodic events: dune erosion
Surges give redistribution of sediment, no loss of volume. Beach returns to its equilibrium. Dune erosion is estimated from adapted Bruun rule. Dune retreat depends on stormsurgelvl.
Cross-shore transport mechanisms
Energetics approach, decomposition of transport rate:

$$u = \underbrace{\bar{u}}_{\text{time-mean component (streaming outside surf zone, undertow in surf zone)}} + \underbrace{u_{lo}}_{\text{low-frequency motion at wave-group scale}} + \underbrace{u_{hi}}_{\text{oscillatory motion at short wave scale}}$$

$$\langle u|u|^2\rangle = \underbrace{3\langle\bar{u}|u_{hi}|^2\rangle}_{1} + \underbrace{\langle u_{hi}|u_{hi}|^2\rangle}_{2} + \underbrace{3\langle u_{lo}|u_{hi}|^2\rangle}_{3} + \ldots$$

1: mean flow as transporting velocity; 2: short wave skewness; 3: correlation bound long waves and short wave envelope

Gross cross-shore transports are much higher than net transports which makes accurate predictions difficult. Transport mechanisms Onshore directed: LH streaming (outside surf zone), Wave

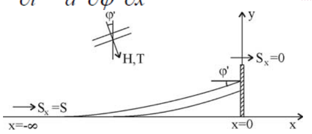
asymmetry, Free long waves (in surf zone)
Offshore directed: Undertow (in surf zone), (Bound) long waves (outside surf zone) Down-hill (on average offshore): Gravity
Analytical solutions: Bowen. Focuses on middle and lower shoreface.

Longshore transport and coastline changes
Longshore transport
Stirring by short waves, transport by longshore current. Transport by waves neglected. Wave stirring: orbital motion causes bed shear stress to vary and sediment is mobilized, breaking waves increase turbulence.

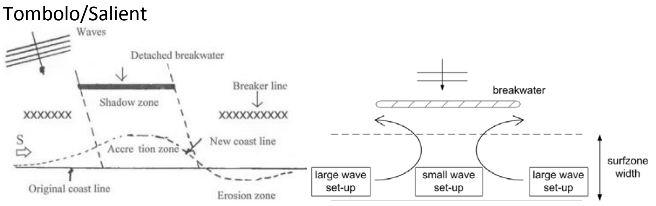
$$\langle S_y \rangle = \underbrace{m_2 \langle u^2 + V^2 \rangle}_{\text{sediment load stirred by wave-current motion}} \underbrace{V}_{\text{longshore current responsible for transport}}$$

Current-only gives: S=mV^n
CERC formula has many different representations which must be applied carefully. Limitations are:only waveinduced longsh curr taken into account, sand transp independent of grainsize, only total sediment transp is given. Transport is proportional to beach slop and inverse prop to grain size.
S,ϕ diagram: gives S for wave angle of incidence.
Calculation of coastline change
Closure depth: lower limit of coastal profile, depth changes seaward have no direct infl on shoreline dynamics. Upper limit: for eroding coast->dunes, accretion: wave run-up. The transport is governed by a continuity equation but this changes into a diffusion equation:

$$\frac{\partial Y}{\partial t} - \frac{1}{d}\frac{\partial S_x}{\partial \varphi}\frac{\partial^2 Y}{\partial x^2} = 0 \quad => \quad \frac{\partial Y}{\partial t} - \frac{s}{d}\frac{\partial^2 Y}{\partial x^2} = 0$$

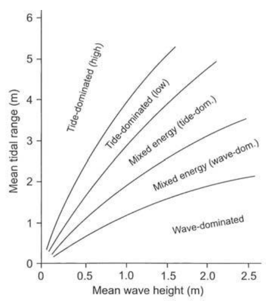


Breakwaters: accretion is zero if coastline is normal to wave incidence. At lee side wave heights are lower due to defraction. Defracted waves cause a secondary current directed towards the breakwater because of set-up differences. Wave heights are also lower. Since the transport must increase from 0 to S some kind of hyperbola occurs for the coast line. It is also possible to take sediment bypassing into account. Multiple line theory can be used for this, it uses 2 transport zones. Erosion volume=Accretion volume.(due to boundaries at infinity)
Coastline features
Tombolo/Salient

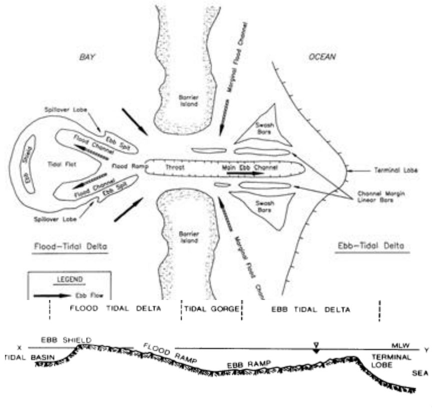


Submerged breakwater causes extra possible erosion due to return flow. Additional effects(secondary current, wave diffraction) can cause salient/tombolo for normally incident waves. Tombolo is likely if breakwater is in or just outside surfzone and length is relatively large.(2x dist from coast). Spits develop where longsh transp cap is diminished due to interruptions(estuary, river, end of island). Spits can also move rivermouths. Rivers can also deposit sediment, for normally incident waves it grows equally on both sides. For oblique waves it is asymmetric and a spit can also be formed through strong longsh transp.
Growth of features
Difference between low and high angle waves. Low angle give accretion along flanks, high angle give accretion along crest.

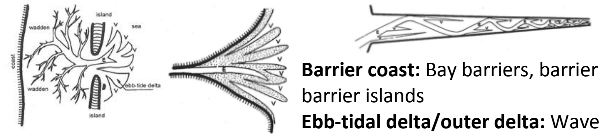
Coastal inlets and tidal basins
Wave vs tidal dominance: dynamic with bars and dunes and wave dependent beach slope vs smeared beach, low gradient, flats, marshes and tidal ridges. Tide dominance can exist in macrotidal and microtidal with low wave areas. Small differences can give different character.



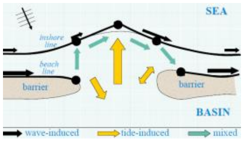
Types:
Tidal lagoons: Waddenzee, enclosed by wave-shaped barriers, limited wave penetration, flows in/out through gorges, little freshwater runoff, infilling wetlands.
Tidal bays: Baye de St. Michel: High lvls of wave energy dissip., little freshw runoff. No barrier islands. Waves break due to depth-limited breaking. Tide is dominant
Estuaries: Strong freshw runoff, tide dominated, most sediment from coastal regions, coarse sediment in seaside, finer in landward regions. Sometimes development of spits, shoals or barriers due to wave effects. Mixed tidal/river influence. Mixing of salt/fresh: characterized by stratified, partially mixed, mixed or homogeneous. Tidal river: river dominance.
For lagoons is assumed: in=out. Strong tidal difference can give tidal bore.
Main morphological elements



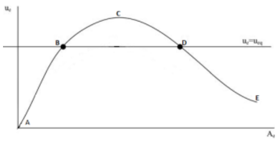
Tidal deltas: Marginal flood channels: Positioned to side of inlet, NOT indicating they are of marginal importance. **Main ebb channel:** Separate from flood channels because water in ebb channel flows seaward at beginning of flood cycle. The margin then gives least resistance. **Channel margin linear bars:** built up as result of interaction of flood and ebb tidal currents and wave-generated currents. **Terminal lobe**: steep seaward-sloping body of sand. **Swash platforms and bars**: broad sheets of sand, built up by swash action of waves(water washes up on platforms after wave breaking).
Basin characteristics: intertidal/supratidal flats. Ebb-dominant channels meander, flood dominant chann shoal landwards



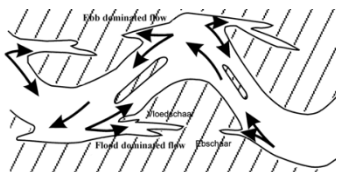
Barrier coast: Bay barriers, barrier spits, barrier islands
Ebb-tidal delta/outer delta: Wave exposure depends on angle of incidence.



Waves have only influence right behind gorge unless channelling occurs(trapped in channel) **Residual currents:** Stokes drift(hor and vert tide in phase), curvature induced secondary flow(to shoals). **Wave-induced currents:** Influence sediment bypassing. Wind causes 2ndary flow pattern. **Wave-current interaction:** currents can refract waves. Show zigzag pattern **Bypassing** can occur through waves and combo of wave&tide. Often happens by shoal migration: flood chann carry sediment, sometimes ends up in ebbchannel and to outer delta, there pickup by wavedriven/tidal longsh currents and transported to other edge. Another part ends up in shoal system and transp by migration of shoals.



Inlet stability $A_{eq} = CP^q$
Escoffiers model: A-B: channel too small->closes itself. D-E channel smaller but equilibrium at D. B-D erosion until D is reached which is stable. D is stable B is unstable. Escoffier: C=7.8*10^{-5} q=1. Stability from sediment transport: Out=in(TR=M): capacity of entrance is sufficient to flush out imported sediment or annual ebbtidal flux=fraction of littoral drift that enters inlet.



Inner basin geometry
Ebb/floodchutes: due to inertia current overshoots. Floodchutes are better developed than ebb. Deep chann ebbdominated, inter-tidal areas flood dominated. Secondary flow in bends like rivers. Transport towards shoals. Channel volume: $V_c = A_c L_c \propto P\sqrt{A_b} \propto P^{3/2}$
Net import or export
Net im/export of sediment is governed by formulas: $S \approx c * |u^{n-1}|u$ and $u(t) = u_0 + \hat{u}_{M2}\cos(\omega_{M2}t) + \sum_i \hat{u}_i \cos(\omega_i t - \varphi_i)$. Mainly determined by u_0 amplitude of M2 current, amplitudes and phases of M4 and M6 currents. Substituting yiels a formula with 3 terms: 1. assymetry of M2 due to u_o, 2. Assymetry of M2+M4 combined, 3. Assymetry of M2,M4 and M6 governed by phase lags. Non-linear response causes transport even if mean velocity is 0. Transp is determined by u_{max} at flood/ebb.

NET FLOOD-TRANSPORT	NET EBB TRANSPORT	TIDAL ASYMMETRY
Small storage flat area	Large storage flat area	u_{max} flood/ebb
Long shallow channels	Long deep channels	u_{max} flood/ebb
Fast tidal rise at sea	Fast tidal fall at sea	u_{max} flood/ebb

Conditions for silt transp:
Short basin shallow channels little storage: HWslack is longer than LW slack->import of fines

NET FLOOD-TRANSPORT	NET EBB TRANSPORT	TIDAL ASYMMETRY
Small storage flat area	Large storage flat area	u_{max} flood/ebb slack duration HW/LW
Large storage flat area	Small storage flat area	sedimentation HW/LW (this effect often dominates over the above effect)
Shallow channels	Deep channels	u_{max} flood/ebb slack duration HW/LW
Long HW-period at sea	Short HW-period at sea	slack duration HW/LW
Protected location, few waves	Open, many waves	sedimentation HW/LW

Coastal protection

Strategies: retreat(useful with strong coastline fluctuations), accommodate, protect. Soft methods: beach or foreshore nourishment or bypass systems. Hard methods: groynes, breakwaters, revetments, seawalls. Structural vs episodic erosion. Episodic erosion(CH 7) usually returns to equilibrium. Episodic prevention: dune nourishment, seawall or revetment(only at stable coastline). Nourishments: landside(interfer wit infrastructure), seaside(volume is distributed, small amount lost), top of dune(limited space?).

Longshore transp modification: gradient to 0. Jetties can influence littoral drift, seawalls dont!

Groynes

Groyne types: impermeable: crest above MSL, keep sand in compartment between groynes, shoreline parallel to dom wave crest in each compartment(sawtooth) only if bypass=0, else not parallel and still some transport. Permeable groynes: Piles with crest between MLW and MHW, reduce littoral drift, regular shoreline, always sand bypass. Groyne interrupts part of longsh transp. L-head improves efficiency, spacing 1.5-3x length, sufficient sed bypass prevents leeside erosion, downdrift erosion can be reduced by reducing lengths@downdrift side, start constr downdrift to avoid initial erosion of protected area, combine with initial beach nourishments to avoid downdrift erosion.

Offshore breakwaters

Cause accretion in lee, high costs, dangerous for swimmers, ugly, finetuning difficult, bad design->scour/erosion, mitigation of downdrift erosion attention point. Tombolo: $D<0.8L$ Salient: $0.8L<D<2L$ Erosion coastline opposite gap: $L_{gap}>L$ to 1.5L. Submerged breakwaters are difficult to construct.

Preventing storm erosion

Seawall: cutting off supply of material from dune or mainland, reflect incoming waves, trough along toe may endanger foundation, maintaining beach in front may help.

Revetment: similar but with slope. Seadike: high waverunup->high dike needed, scour hole at toe?

Soft measurements

Compensate struct erosion, protect beach and dunes, create beaches, land reclamation. Origin of sand: land, marine, maintenance dredging, pit offshore(can disturbe environment, deep pit vs large pit). Similar to native, sometimes coarser. Chiche between nourishing land/seaduneslope, beach or shoreface. Beach is difficult for equipment, more effective than shoreface but cost higher and ugly. Renourishing: coarser sand gives less loss. Underwater dam/transition slope can reduce needed volume