Coastal Dynamics 1 (CIE4305)

Judith Bosboom and Marcel J.F. Stive

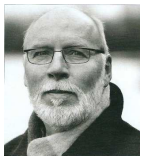
Section of Hydraulic Engineering

Please get a clicker from one of the boxes

(and don't forget to hand it in again after the lecture!)

Instructors






Judith Bosboom Stefan Aarninkhof Marcel Stive Jan van Overeem

See contact information on Brightspace

Teaching assistants

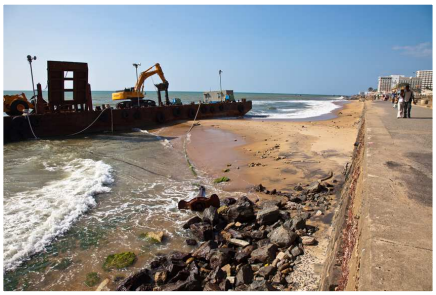
Alejandra Gijón Mancheño

Yorick Broekema

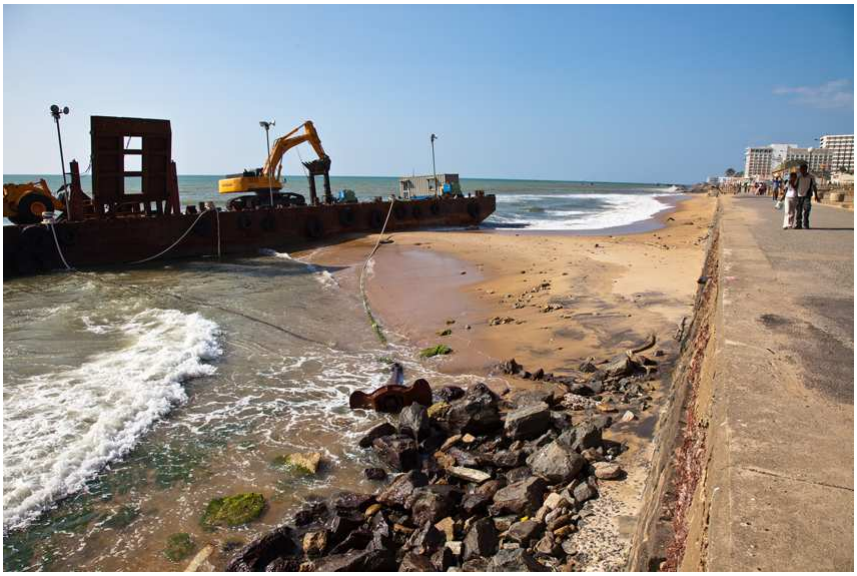
Stuart Pearson

See contact information on Brightspace

Introduction



What has happened?



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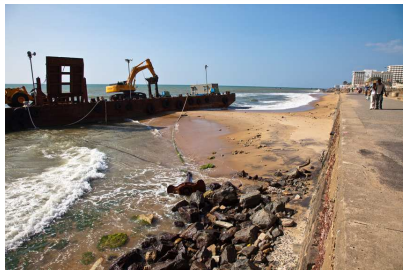
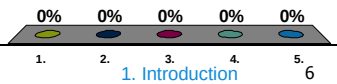


1. The ship hit the shoal visible on the photo and ran aground.
2. A beach fill was made to easier get the cargo from the stranded ship on land.
3. Behind the stranded ship, sand is deposited due to reduced wave heights.
4. This dredging vessel is preparing a recreational beach.
5. All of the above is nonsense



1. Introduction

Contents

A. Course information
B. The beach: a river of sand
C. Getting acquainted
D. Coastal morphodynamics

1-A Course information

CIE4305 (6EC!) focuses on **coastal dynamics**

- Focus on physical phenomena with and without human interference
  - Dominant processes
  - Coastal response
  - Diversity of coastal systems
  - Only functional design of protection measures

See study goals in the lecture notes (Chapter 1)

- Technical design of structures:
  - CIE4310: Bed, bank and shore protection
- Advanced course on coastal dynamics and modelling:
  - CIE4309: Coastal Dynamics 2

Coastal Dynamics 1

Contents

- Lecture notes and lectures follow these 10 topics. Chapter 11 on ICZM is not part of CIE4305
- Lecture notes (version 0.5 2015) are available from VSSD shop (Leeghwaterstraat 42).

1. **Introduction (Chapter 1)**
2. Large-scale coastal variation
3. Oceanic wind waves and tide
4. Global wave and tidal environments
5. Coastal hydrodynamics
6. Sediment transport
7. Cross-shore transport and profile development
8. Longshore transport and coastline changes
9. Coastal inlets and tidal basins
10. Coastal protection

1-A Course information

Lectures and lecture notes

- Approximate **lecture schedule** on blackboard:
  - Seven weeks of lectures on Mon, Tue, Wed & Thu
  - Slides (after each chapter), changes etc. on **Brightspace.**
- Your **lecture notes** are a complete description of the material. But: lectures for outlines, examples, difficult topics, topical subjects
- **Clicker questions** not necessarily representative for exam questions

1-A Course information

Exam and prior knowledge

- **Exam**
  - 18th of April (review April 30th and May 1st)
  - Retake 29th of June (review July 6th)
  - Maple TA computer test
- **2 trial exams** (1 homework & 1 'real' trial on April 4th)
- **Maple TA homework tests**
  - > 70% of the points => full bonus point for the exam
  - 50-70% of the points => half bonus point for the exam
  - Only valid for the exams in 2018

Prior knowledge

CIE4305 builds upon BSc courses on fluid mechanics and hydraulic engineering and on the MSc course Ocean waves.

1-A Course information

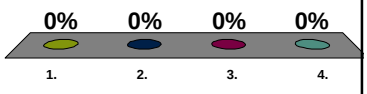
Did you study Open Channel Flow (CTB3350)?

1. No, and I know very little about shallow water waves and tidal propagation
2. No, but I took a course on shallow water waves somewhere else
3. Yes, but I did not pass the exam yet
4. Yes, and I passed the exam

Prior knowledge

CIE4305 builds upon BSc courses on fluid mechanics and hydraulic engineering and on the MSc course Ocean waves.

But: in Chapters 3 and 5 a lot of the relevant material is repeated (and can be examined)



1-A Course information

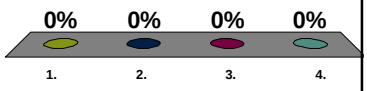
Did you study CIE4325 (ocean waves)?

1. No, and I know very little about linear wave propagation and wind waves.
2. No, but I took a course on these subjects somewhere else
3. Yes, but I did not pass the exam yet
4. Yes, and I passed the exam

Prior knowledge

CIE4305 builds upon BSc courses on fluid mechanics and hydraulic engineering and on the MSc course Ocean waves.

But: in Chapters 3 and 5 a lot of the relevant material is repeated (and can be examined)



1-A Course information

Understanding rather than memorizing

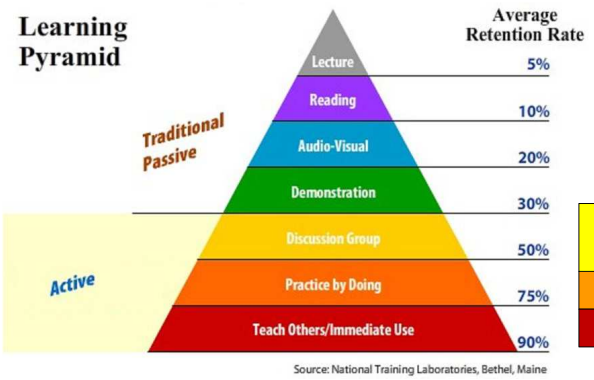
- Focus on understanding (more than on memorizing or calculating)
  - Be critical. **Why?**
  - Explain to others
- Open book exam
- Week 3.6: seminar with **student presentations** (tentative this year…)

"Try participating in the student lectures as it is a great way to learn and to practice presenting"

(see also other tips from students on Brightspace: How to pass this course?)

1-A Course information

From passive to active learning



Reading assignment;
Maple TA Discussion board

Maple TA assessments

Student presentations

1-A Course information

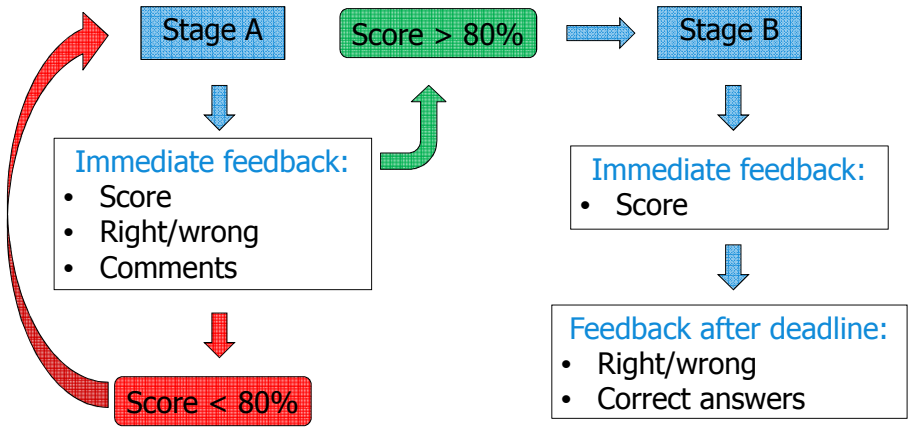
Maple TA homework tests for each chapter

Make good use of stage A!

- Formative stage A tests
  - Assessment **for** learning
  - Unlimited availability (until retake)
- Summative stage B tests
  - Assessment **of** learning
  - Can only be taken once
  - Time limit & deadline
  - Count towards (half) bonus point

1-A Course information

For each chapter: stage A and stage B



1-A Course information

See Brightspace instructions

Need help with the course material or Maple TA ?

- Discussion board (moderated by teaching assistants)
- Friday lunch break: question hour by teaching assistants
- Questions about stage B only after deadline

Chapter no	Maximum points stage A	Pass level stage A (approx. 80%)	Maximum points stage B	Deadline stage B	Time-limit stage B (minutes)
1+2	17	13	14	Sun 2018-02-18	25
3	32	25	31	Sun 2018-02-25	45
4	14	11	9	Sun 2018-02-25	15
5 - part I	26	20	20	Sun 2018-03-04	35

1-A Course information

Pre-class reading assignment Chapter 3 – Waves part

- (Inter)active reading through annotations and discussion
- 1 reading assignment only (Chapter 3 – Waves)
- Annotations before class (deadline Feb 18)
- 1 class about Chapter 3 - Waves (Feb 19)
- Tip: see videos of 2014-2015 for two Chapter 3 – Waves lectures

See Brightspace instructions

1-A Course information

Brightspace

- All course information on Brightspace
  - Lecture and seminar schedule
  - Maple TA schedule with points, time limits & deadlines!
  - Rules for (half) bonus point and exam
  - Access to Maple TA assignments
- Discussion board for stage A
- Online lecture notes
- Reading assignment
- Slides and Collegerama subject index
- How to pass this course?

1-A Course information

How to contact us?

- See Brightspace for our contact information
- **Discussion board**
  - All questions/comments that may be of interest to others too
  - About course material or Maple TA tests per Chapter
  - About practicalities
- **Question hour on Friday**
- If the discussion board is not appropriate: J.Bosboom@tudelft.nl, room 3.66

1. Introduction

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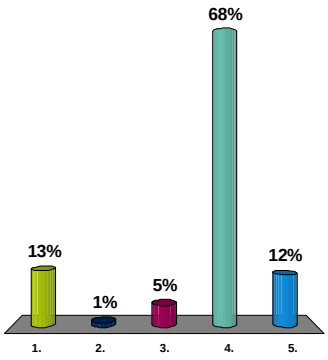
A. Course information
B. The beach: a river of sand
C. Getting acquainted
D. Coastal morphodynamics

1-B The beach a river of sand

Which of the following conclusions is wrong?

1. Continental rock is a major supplier of material to the coast
2. The longshore current depends on the incident wave angle
3. The coastline and the outer edge of the surfzone are the two banks of the "river of sand"
4. The offshore transport by storm waves is irreversible
5. Sedimentation takes place where the longshore transport reduces



1-B The beach a river of sand

Diversity in beach material and size

- Diversity in origin of material:
  - (reworked) continental sands
    - granite rock: feldspar, quartz, light in color, (heavy minerals)
    - (basalt rock: rich in heavy minerals, dark)
  - skeletons (shell fish, coral): carbonate
- Diversity in size:
  - (mud), sand, gravel, pebbles, cobble, (shingle)
  - carbonate sands (tropical beaches), shell fragments, limestone

1-B The beach a river of sand

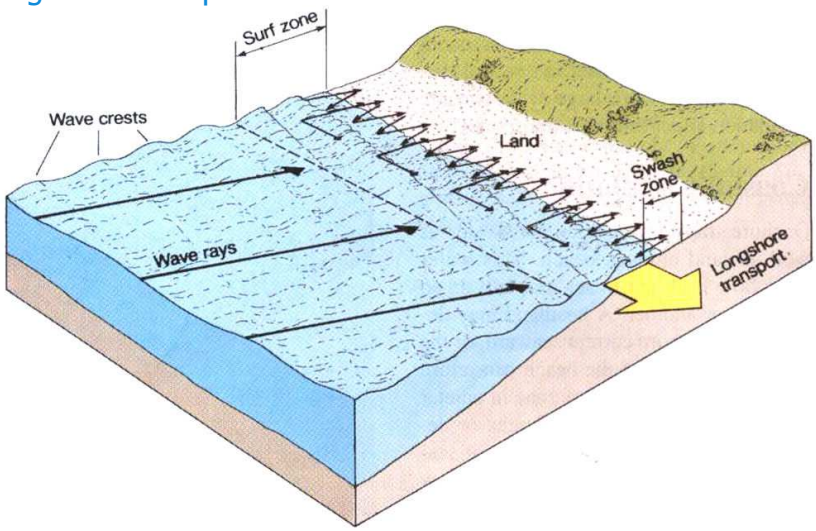
Why beaches are not composed of mud or boulder ...

Table S1 Sediment size and settling rates (from Short, 1999, © John Wiley & Sons Limited, reprinted with permission)

Size	Grain diameter	Time to settle 1 m	Distance traveled per hour in 1 m/s current
Clay	0.001–0.008 mm	Hours to days	3.6 km
Silt	0.008–0.063 mm	5 min–2 h	3.6 km
Sand	0.063–2.000 mm	5 s–5 min	10's m
Cobble	2 mm–6.4 cm	1–5 s	<<1 m
Boulder	>6.4 cm	<1 s	0

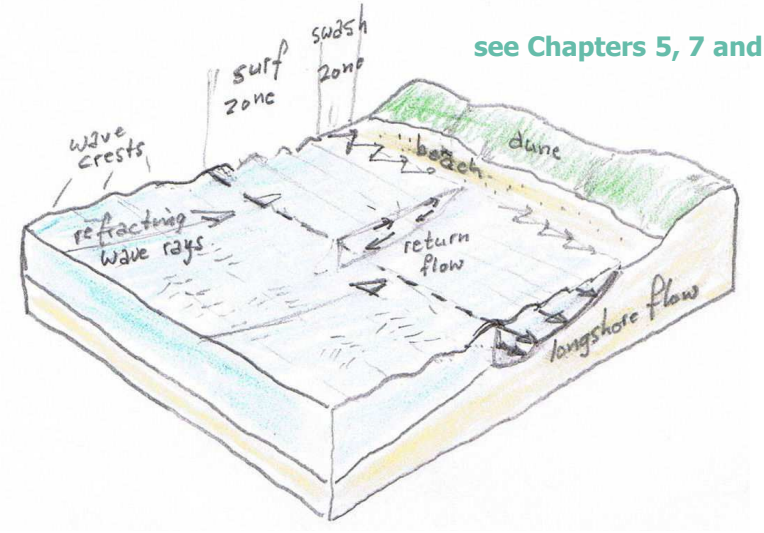
1-B The beach a river of sand

Longshore transport



1-B The beach a river of sand

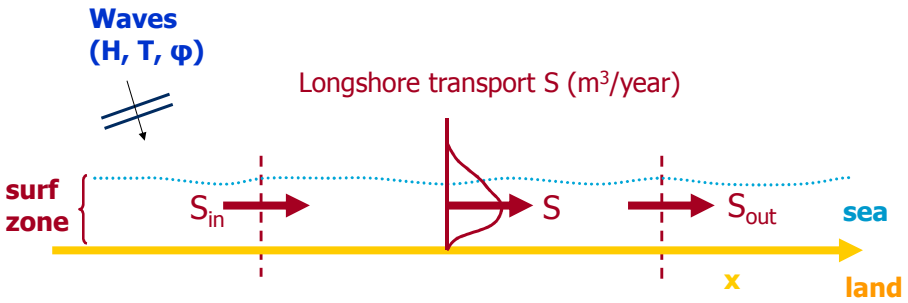
The beach – a 3D river of sand



see Chapters 5, 7 and 8

1-B The beach a river of sand

Coastal changes occur in case of transport gradients



Stable coast:	$S_{in} = S_{out}$
Accretion:	$S_{in} > S_{out}$
Erosion:	$S_{in} < S_{out}$

1-B The beach a river of sand

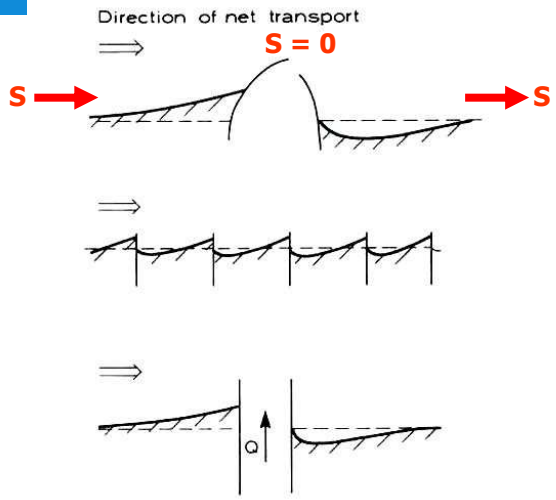
Engineering problems are often related to longshore transport gradients

- Structural coastal problems arise:
  - When the alongshore transport is interrupted
  - When the alongshore transport is (gradually) changing alongshore

see Chapters 8 and 10

1-B The beach a river of sand

Structures (partially) blocking the transport



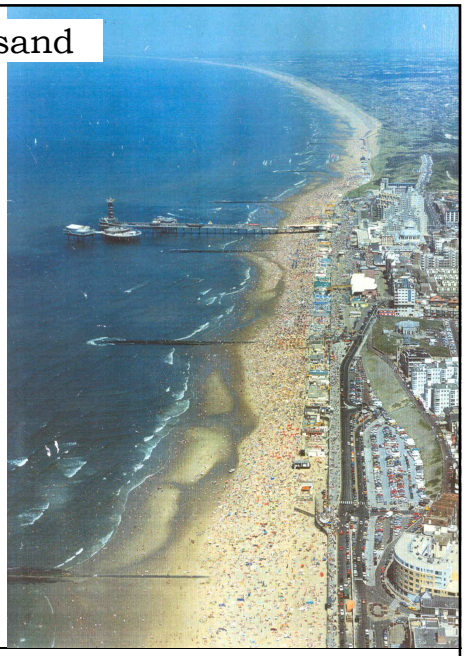
Harbour

Groyne field

Jetties at a river mouth

1-B The beach a river of sand

Groynes along the coast of Scheveningen



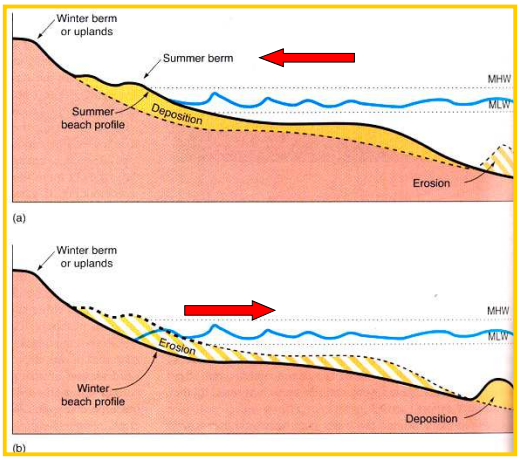
1-B The beach a river of sand

Scheveningen harbour

1-B The beach a river of sand

See Chapter 4

Seasonal influence (mainly 40-60° N)



Summer: small waves transport sand landward => beach rich in sediment

Winter and/or after storm: beach poor in sediment (high waves transport sediment offshore)

1-B The beach a river of sand

Dune erosion due to modest storm surge

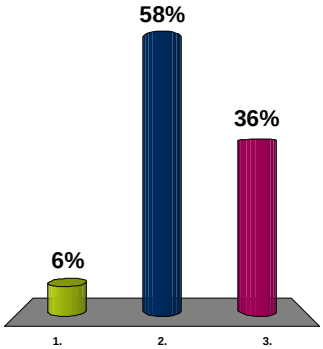
1-B The beach a river of sand

North of Holland coast

1-B The beach a river of sand

What dune erosion rate do you expect for a (Dutch) design storm?

1. 2-3 m^3/m
2. 20-30 m^3/m
3. ✓ 200-300 m^3/m



1-B The beach a river of sand

Horizontal circulation currents

South-Holland Coast with Delfland groynes.
These groynes perpendicular to the coast act like brakes with regard to longshore transport of sand. That is their positive function. They also have a negative function since they initiate rip currents perpendicular to the coast causing considerable off-shore sand transport. The resulting offshore sand plumes can be observed from the air.
Photo 1985 - © & courtesy Ir. Bureau Svašek b.v.

1-B The beach a river of sand

Salient versus tombolo

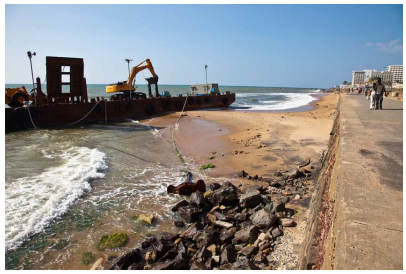
Offshore (or detached) emerged breakwaters

1-B The beach a river of sand

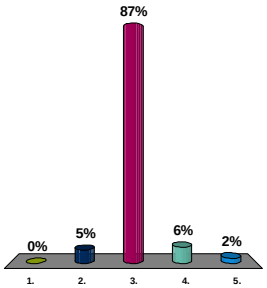
Beach restoration using detached breakwaters

Tombolo behind island

What has happened?



1. The ship hit the shoal visible on the photo and ran aground.
2. A beach fill was made to easier get the cargo from the stranded ship on land.
3. ✓ Behind the stranded ship, sand is deposited due to reduced wave action.
4. This dredging vessel is preparing a recreational beach.
5. Something else



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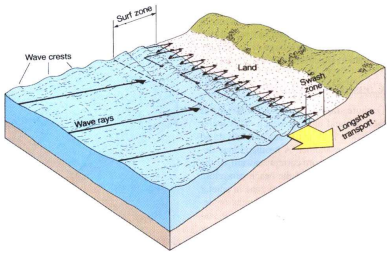
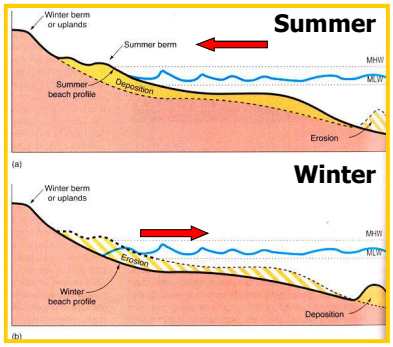
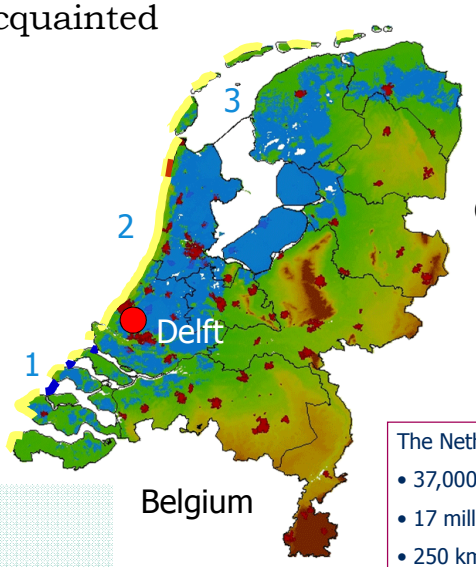




1-C Getting acquainted

Dutch coast

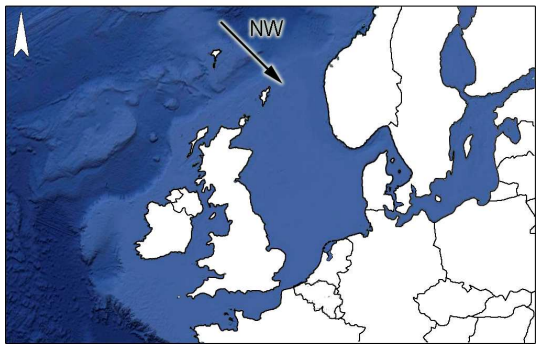


1. "Delta" coast
2. Holland coast
3. Wadden Sea and barrier islands

The Netherlands:
- 37,000 km^2
- 17 million inhabitants
- 250 km dunes
- large part below MSL

1-C Getting acquainted

Storm surge

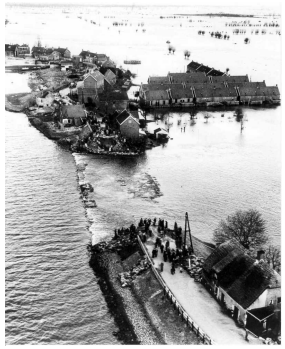


Severe storm NW
- North Sea like a funnel
- water is piled up (cannot escape through Channel)

For the Netherlands:
- high water levels
- high waves

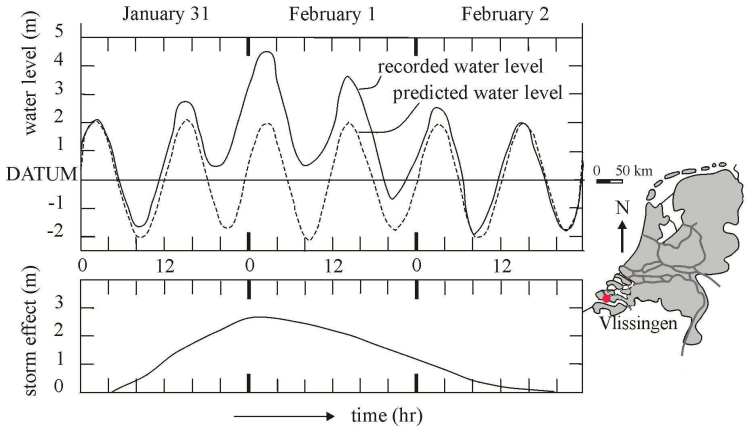
1-C Getting acquainted

Flood disaster 1953 ('Watersnoodramp')



1-C Getting acquainted

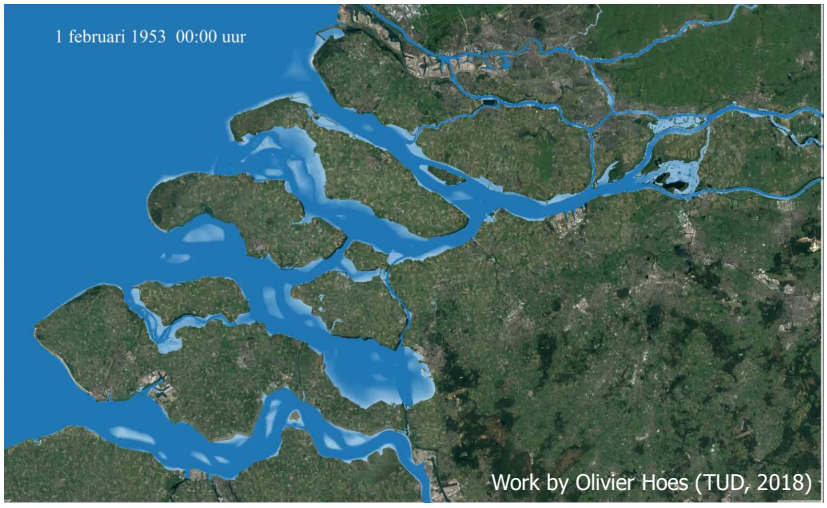
Jan./Feb. 1953: Severe storm NW



Wind set-up + astronomical tide = actual water level

1-C Getting acquainted

Animation of 1953 flood disaster



1-C Getting acquainted

Delta Commission 1953

- Installed by Minister of Public Works
- 12 Civil Engineers, 1 agricultural engineer, 1 economist
- Outcome: Delta Plan
  - Embedded in Delta Law
  - Implemented by Deltadienst Rijkswaterstaat

1-C Getting acquainted

Delta works (1958-1997)

1-C Getting acquainted

see Chapter 9

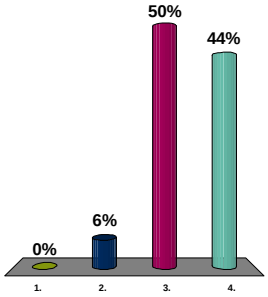
Impact of Delta works (1958-1997) on estuaries

1-C Getting acquainted

Port of Rotterdam – Maasvlakte-2 Land Reclamation

How much sand do you think was needed to build Maasvlakte-2?

1. 240.000 m3
2. 2.400.000 m3
3. 24.000.000 m3
4. 240.000.000 m3 ✓



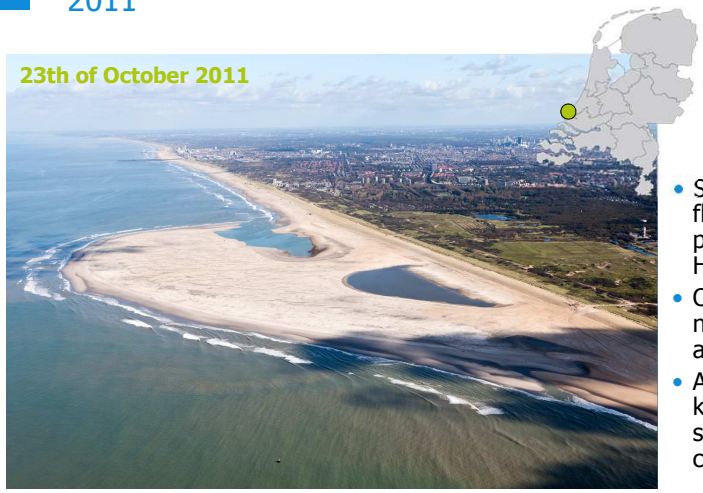
1-C Getting acquainted

see Chapter 10

(Beach) nourishments along Dutch coast

1-C Getting acquainted

Sand engine constructed between March and November 2011



- Safety against flooding for the province of South Holland (20 years)
- Opportunities for nature development and recreation
- Acquiring new knowledge about strengthening the coast (innovation)

1-C Getting acquainted

Sand engine at low tide

21.5 million cubic metres of sand

1-C Getting acquainted

Sand engine after 4 years

1-C Getting acquainted

Delfland Coast (Sand Engine – Scheveningen)

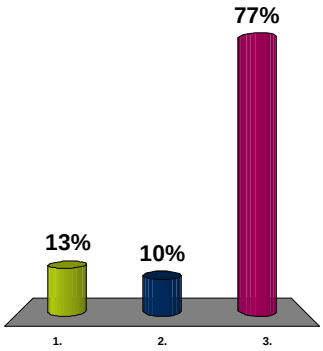
1-C Getting acquainted

Former Delfland Groins

1-C Getting acquainted

What dune erosion rate do you expect for a (Dutch) design storm?

1. 2-3 m^3/m
2. 20-30 m^3/m
3. ✓ 200-300 m^3/m

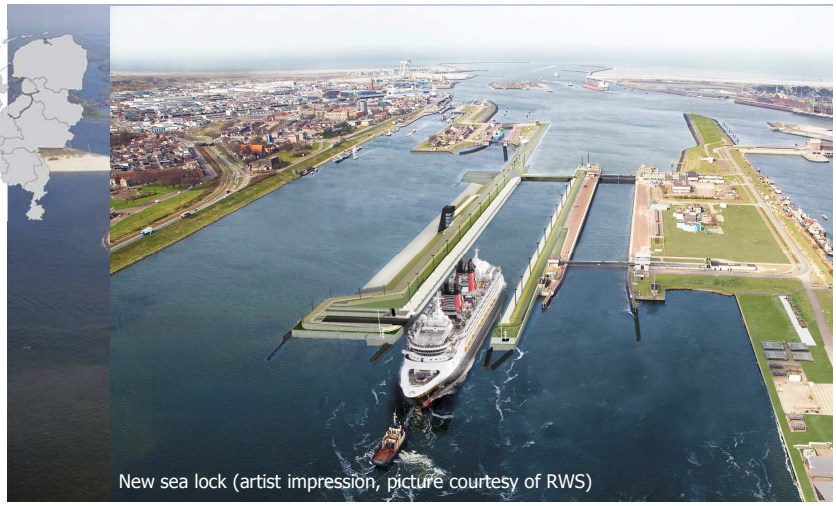


1-C Getting acquainted

Rijnland Coast (Parking in dune - Katwijk)

1-C Getting acquainted

Port of IJmuiden (entrance to Amsterdam)



New sea lock (artist impression, picture courtesy of RWS)

1-C Getting acquainted

Hondsbossche and Pettemer Sea Defence

1-C Getting acquainted

North-Holland Coast (Den Helder)

1-C Getting acquainted

see Chapter 9

Dutch Wadden Sea

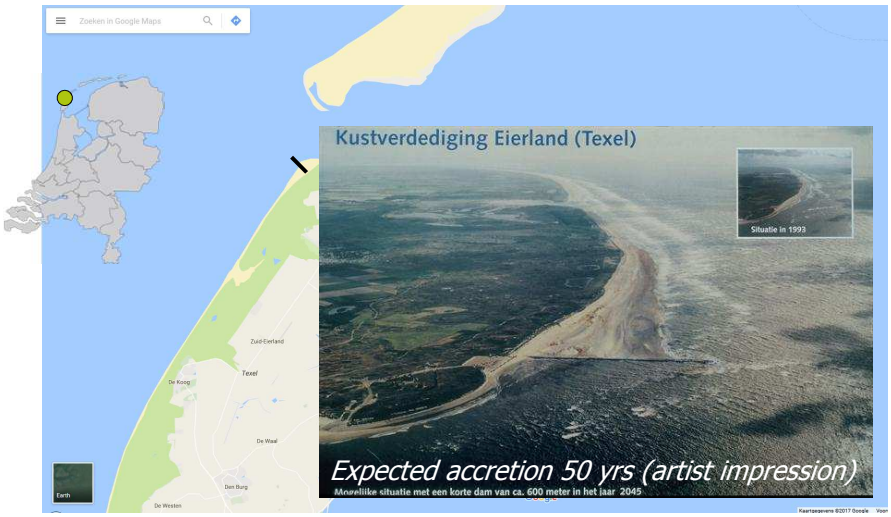
1-C Getting acquainted

see Chapter 9

Dutch Wadden Sea

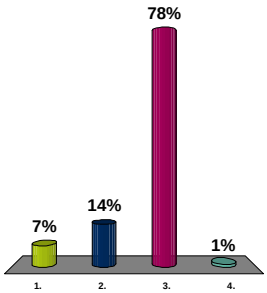
1-C Getting acquainted

Situation Eierlandse dam (800m) Texel



What did happen after construction?

1. The shoreline showed gradual sedimentation on the south side as expected
2. No sedimentation occurred as the dam changed the flow and sediment flushed offshore
3. ✓ Unexpected sedimentation occurred at the north side of the dam due to flow circulations
4. The dam turned out an obstacle for shipping and was removed 3 years after construction



1-C Getting acquainted

During construction 1995

1-C Getting acquainted

see Chapter 9

Accretion on both sides

1-C Getting acquainted

The organizational landscape

- Topsector Water ('Golden Triangle')
  - Government: Ministry I&M, RWS, Water Boards, provinces, …
  - Private companies: Boskalis, Van Oord, Arcadis, RHDHV, W+B, …
  - Research institutes: Deltares, TUD, UU, WUR, UT, NIOZ, …
  - NGO's: WWF, Wetlands International, …
- Multi-disciplinary (research) collaboration NL
  - Netherlands Center for Coastal Research (NCK)
  - EcoShape | Building with Nature
  - Expertise Network Water Defences (ENW)
- International collaboration: Many

1. Introduction

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A. Course information
B. The beach: a river of sand
C. Getting acquainted
D. Coastal morphodynamics

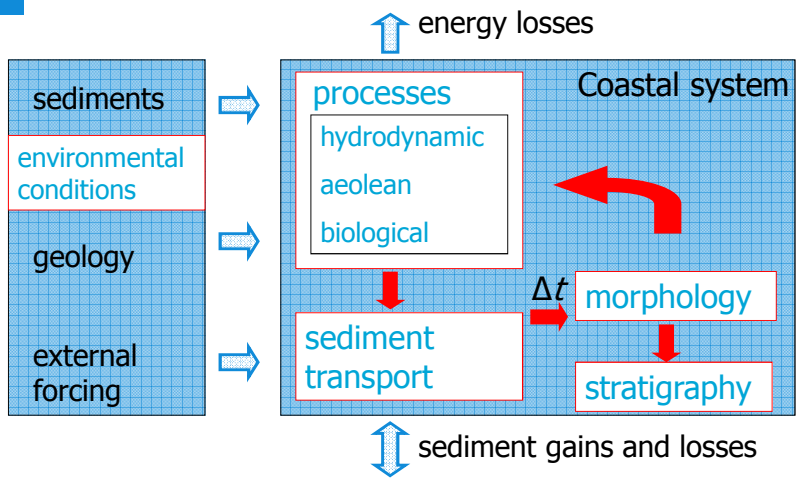
1-D Coastal morphodynamics

Some definitions (1)

- Morphology is the underwater topography
- Morphodynamics is defined as the mutual adjustment of morphology and hydrodynamic processes involving sediment transport

1-D Coastal morphodynamics

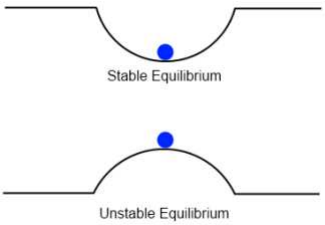
Morphodynamics: the study of coastal evolution



1-D Coastal morphodynamics

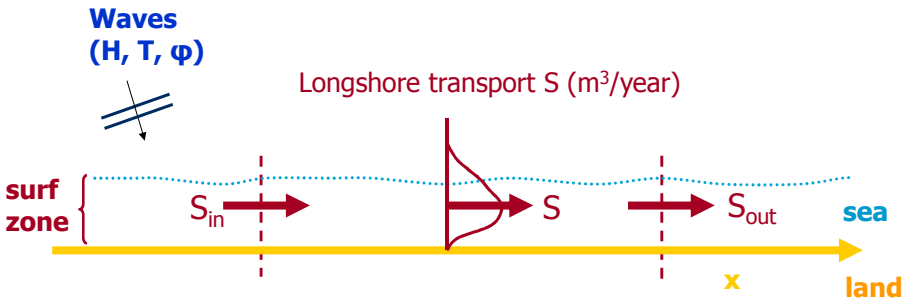
Some definitions (2)

- Equilibrium concept
- **Negative** feedback: stabilization process causing the system to return to the (stable) equilibrium in case of perturbations
- **Positive** feedback: destabilization process causing the system to move away from (unstable) equilibrium in case of perturbations



1-B The beach a river of sand

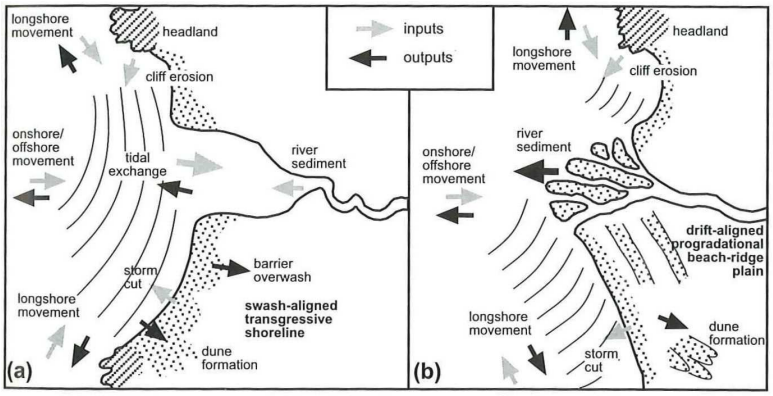
Coastal changes occur in case of transport gradients



Stable coast:	$S_{in} = S_{out}$
Accretion:	$S_{in} > S_{out}$
Erosion:	$S_{in} < S_{out}$

1-D Coastal morphodynamics

Sediment budgets to determine coastal change



Sediment mass balance

$$\frac{\partial z_b}{\partial t} + \frac{\partial S_x}{\partial x} + \frac{\partial S_y}{\partial y} = \text{Source/sink}$$

Note: deposited volume transports

1-D Coastal morphodynamics

Spatial boundaries of the coastal zone

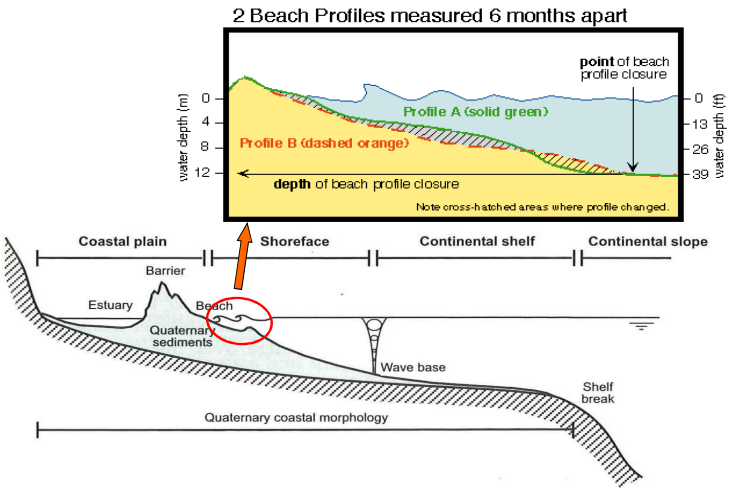
- The edge of the land where it meets the sea or ocean, or
- The zone where land and sea interact, made up of:
  - the land that is affected by being near to the sea (coastlands)
  - the sea that is affected by being near to the land (coastal waters)

Different definitions of the coast (legal, morphological, …)

Definitions related to scale under consideration

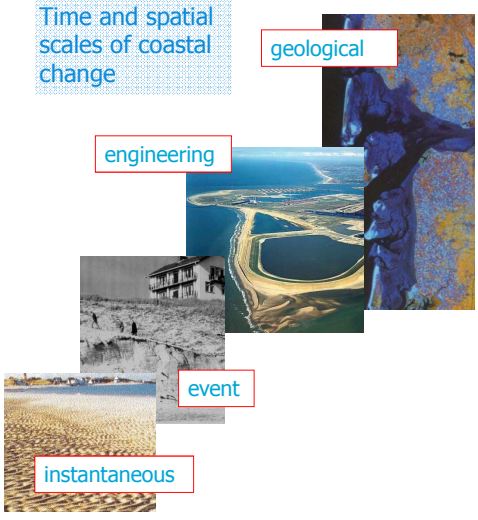
1-D Coastal morphodynamics

Seaward limit of the coast?



1-D Coastal morphodynamics

Time and spatial scales of coastal change



A small eccentricity in channel alignment is inclined to grow leading to a meandering channel system. This process is referred to as:

1. Positive feedback
2. Negative feedback
3. Abstain