

1) Department of Physical Geography, Faculty of Geosciences, Utrecht University, Heidelberglaan 2, 3584 CS Utrecht
2) Deltares Research Institute, Dept. Applied Geology and Geophysics, Princetonlaan 6-8, 3584 CB, Utrecht
3) TNO Geological Survey of the Netherlands, Dept. Geomodelling, Princetonlaan 6-8, 3584 CB, Utrecht

protected a wide back-barrier area that saw extensive peat formation. In the last 2.5 ka however, large areas of the coastal plain area became ingressed and marine inundated, mainly as a consequence of human reclamation. Especially the peat lands in coastal segments with narrow beach barriers were more sensitive to flooding and ingressions. These saw series of new tidal inlet systems develop that partly silted up again.

Coastal segments that had received abundant fluvial and marine sediment supply in times before, were much less affected by Late Holocene ingressions. The wide barrier complex and tidal-river levee systems in the back-barrier area helped preventing ingression. In the Northern Netherlands, accretion of salt marsh ridges took place half way in the back-barrier area, while regional ingression and loss of peat land occurred in further inland areas.

Figure 1 displays five maps of the Dutch coastal plain at different time steps: 2.5 ka, 2 ka, 1.5 ka, 1 ka, and 0.5 ka. The maps illustrate the evolution of the landscape, showing the progression of the coastline and the formation of Lake Flevo. Key features labeled include the Rhine, Meuse, Scheldt, Oer-IJ, Haringvliet, Marsdiep, Dollard, and Lake Flevo. The legend defines the symbols used in the maps:

- Active:**
 - Channel (subtidal): Blue
 - Tidal flat (inratidal): Light blue
 - Tidal flat (supratidal): Green
 - Supratidal ridge or levee: Dark green
 - Beach barrier: Orange
- Inactive:**
 - Channel (subtidal): Grey
 - Tidal flat (inratidal): Light grey
 - Tidal flat (supratidal): Green
 - Supratidal ridge or levee: Dark green
 - Beach barrier: Orange
- Hatching:**
 - ... covers channel
 - ... has been reworked after this timestep
 - ... covers channel and has been reworked after this timestep

Southwest

- Major transgression (~2 - 0.5 ka)
- Large new tidal inlet systems (~2 - 0.5 ka)
- Decrease in habitation

West (Holland)

- Stable due to beach barriers
- Silting up estuaries (~2 ka)
- Habitation on silting up tidal areas

Northwest

- Coastal retrogradation
- Connection Wadden sea to Flevo Lagoon (~2 ka)

North

- Initial regression (inlets silting up, supratidal areas expanding ~3 - 2 ka)
- Major peat hinterland transgression (~2 - 1.5 ka), coinciding with formation new tidal inlet systems
- People colonize newly formed land

Age
0 ka
1 ka
2 ka
3 ka

A Longshore km 50 100 150 200 250 300 350 A'

Modern
Late Holocene
Iron Age
Bronze Age

Westerschelde
Oosterschelde
Grevelingen
Haringvliet
Maasmond
Oerij inlet
Zipe Masdlep
Vlie
Boorne / Ameland inlet
Middelzee
Palsens
Frisian inlet
Lauwers inlet
Hunze
Eems

large scale peat formation

large scale peat formation

Major reworking

Legend

Tidal inlets

- Initially inherited tidal inlet
- Tidal river outlet
- Sea ingresson

Gradual silting up

Period of activity

Gradual beginning/dating uncertain

Back-barrier drainage inlet A taken over by inlet B

Beach barriers

- Stabilized and preserved
- Dune formation

Back-barrier (projected)

- Subtidal and intratidal deposits
- Accretion (regression) of supratidal ridges
- Late Holocene back-barrier clays (transgression on peat rim)

N

Kilometers

Legend

- Late Holocene tidal deposits
- Beach barriers
- Late Holocene channels and subtidal lagoons
- Middle Holocene and Late Holocene tidal deposits
- Middle Holocene tidal deposits

- Late Holocene transgressions were mainly forced by subsidence as a consequence of cultivation and reclamation of the coastal peat rim area.
- Late Holocene storm-surge erosion paths at new locations become ingressions because peat rim subsidence enlarged the tidal volume.
- Tidal-river outlets were inherited from the Middle Holocene, their position could change due to capture by landward extending sea ingressions or avulsion.
- Coastal segments react differently on reclamation activities mainly because of their inherited Holocene geological situation.

Project website

Poster pdf

- *Deltares*: Peter Vos, Ad van der Spek
- *Dark Age project team*: Marjolein Gouw-Bouman, Bert Groenewoudt, Wim Hoek, Esther Jansma, Rowin van Lanen, Hans Middelkoop
- *TNO - GSN*: Freek Busschers, Kay Koster
- *Cultural Heritage Agency*: Menne Kosian, Henk Weerts