Seven decades of shoreline changes along a muddy mangrove coastline of the Upper Gulf of Thailand

Authors: Kimhuy Sok, Butsawan Bidorn, William C. Burnett, Jun Sasaki, and Phachirarat Sola

Journal : Land Surface Processes and Landforms

Water and Environment Research Unit, Institute of Technology of Cambodia (ITC)

Contents

- Introduction
- Materials and Methods
- Results
- Discussion
- Conclusions

Seven decades of shoreline changes along a muddy mangrove coastline of the Upper Gulf of Thailand

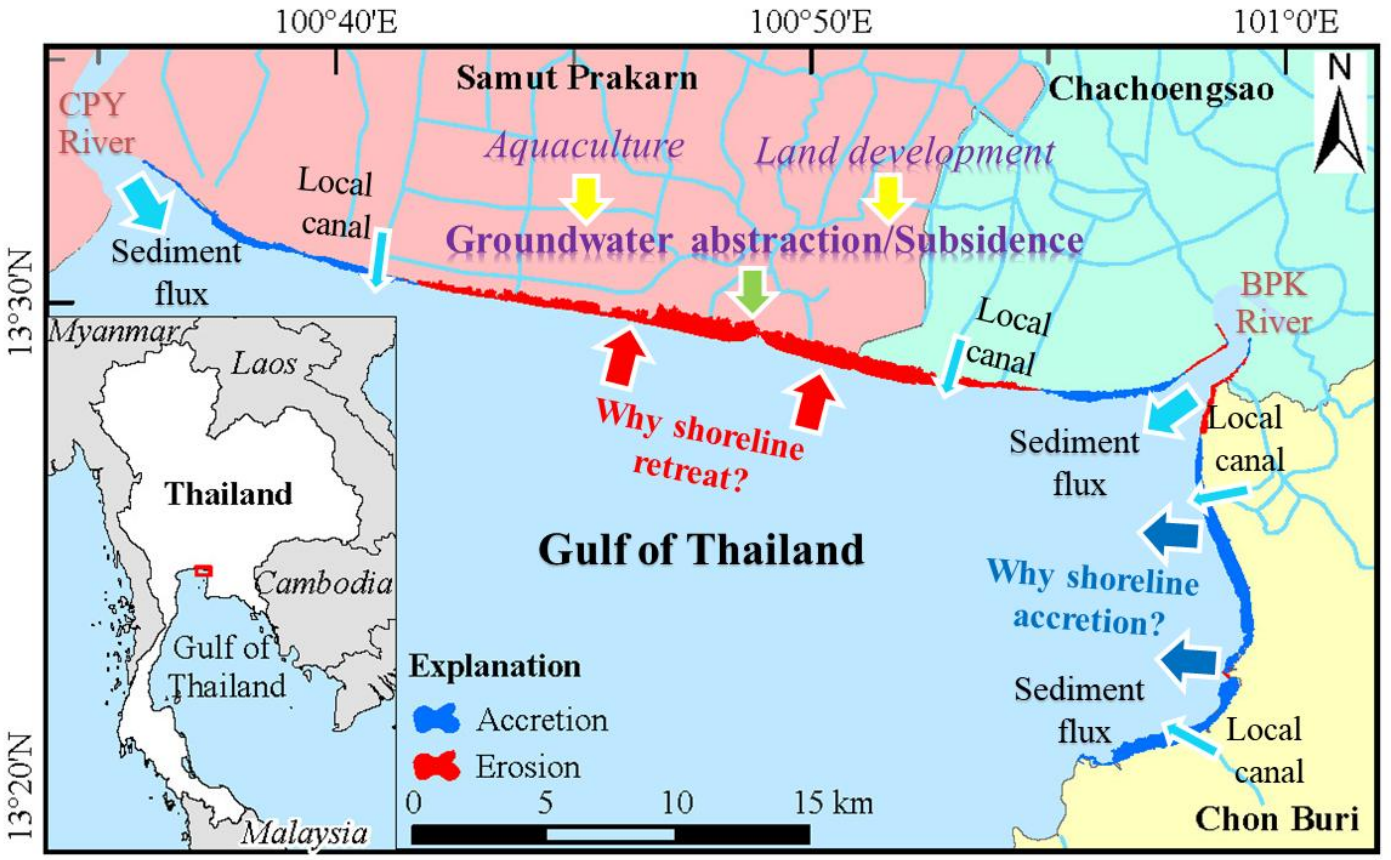
Introduction

- **Coastal deltas** are landforms dynamically shaped by the interaction of riverine and coastal sediment processes.
- Deltaic areas have commonly been selected for **major commercial** locations of society.
- The **BPK Delta** is one of the major economic regions of Thailand.
- The **WBK** coast is recognized as one of the most severe **shoreline retreat** in the world.
- The **EBK** coast is part of the coastal zone of what has been called the "**Eastern Economic Corridor**" (EEC).

Objectives

1) assess the changes in shoreline movement along the BPK coastline during the past seven decades; and

2) evaluate the major factors influencing the shoreline evolution of the muddy coasts formed by the BPK River.

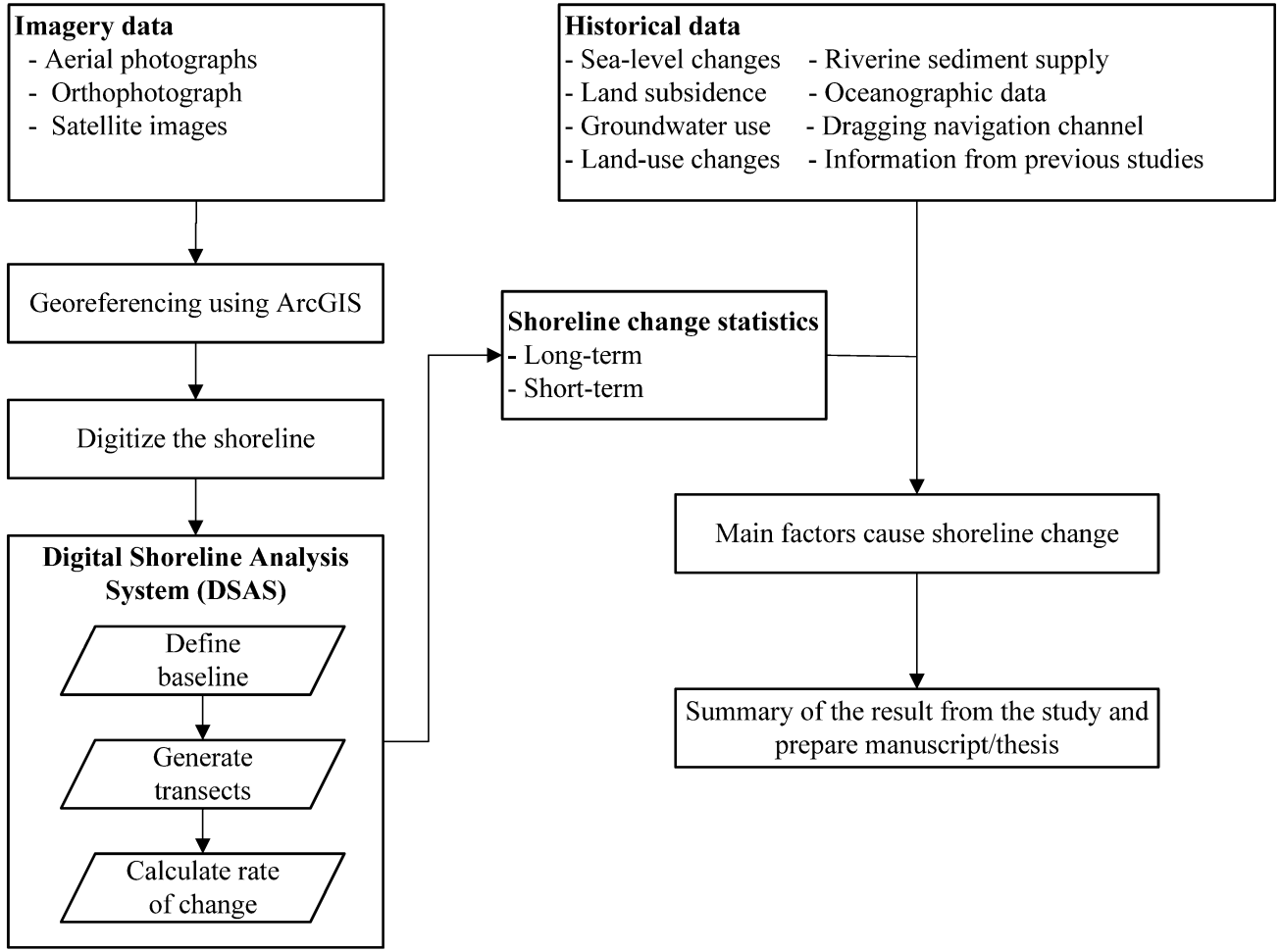


General information of the BPK Delta.

- **Abbreviation** BPK: Bang Pakong; EBK: eastern side of the BPK River; WBK: western side of the BPK River.

Materials and Methods

- **Aerial photographs** (1953 to 1996) and **orthophotographs** (2002) are obtained from the **Royal Thai Survey Department** (RTSD).
- **Satellite images** (2004 to 2024) are acquired from Maxar Technologies, CNES, Airbus satellites using **Google Earth Pro** software.
- **Shoreline change statistics** were estimated using **DSAS**.
- **Long- and short-term shoreline change** statistics were assessed in this study.
- **Short-term shoreline change** is crucial to evaluate changes in shoreline movement patterns that have responded to **recognized climatic** and **human activities** at certain times.

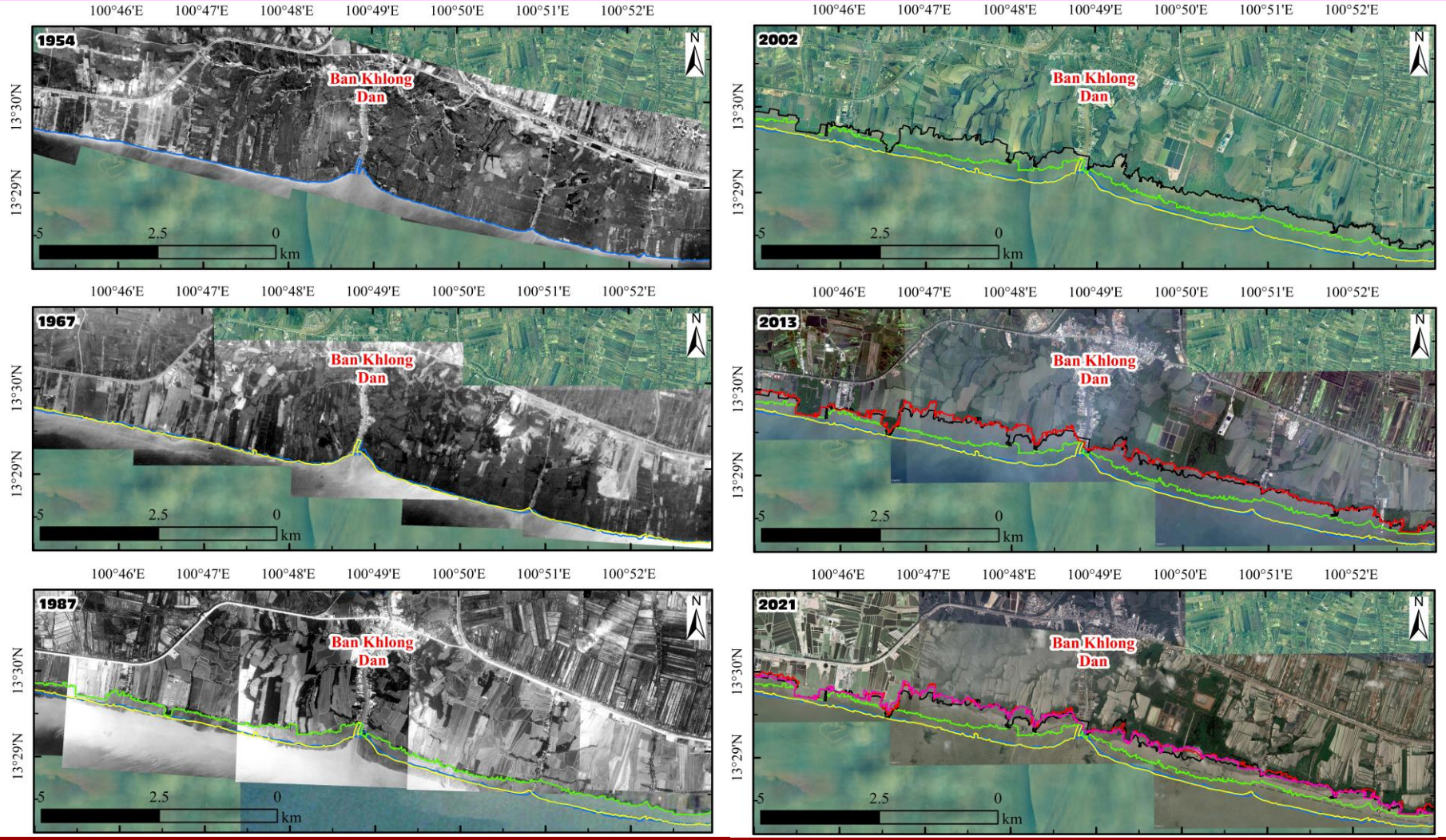


Research framework

Materials and Methods (Cont.)

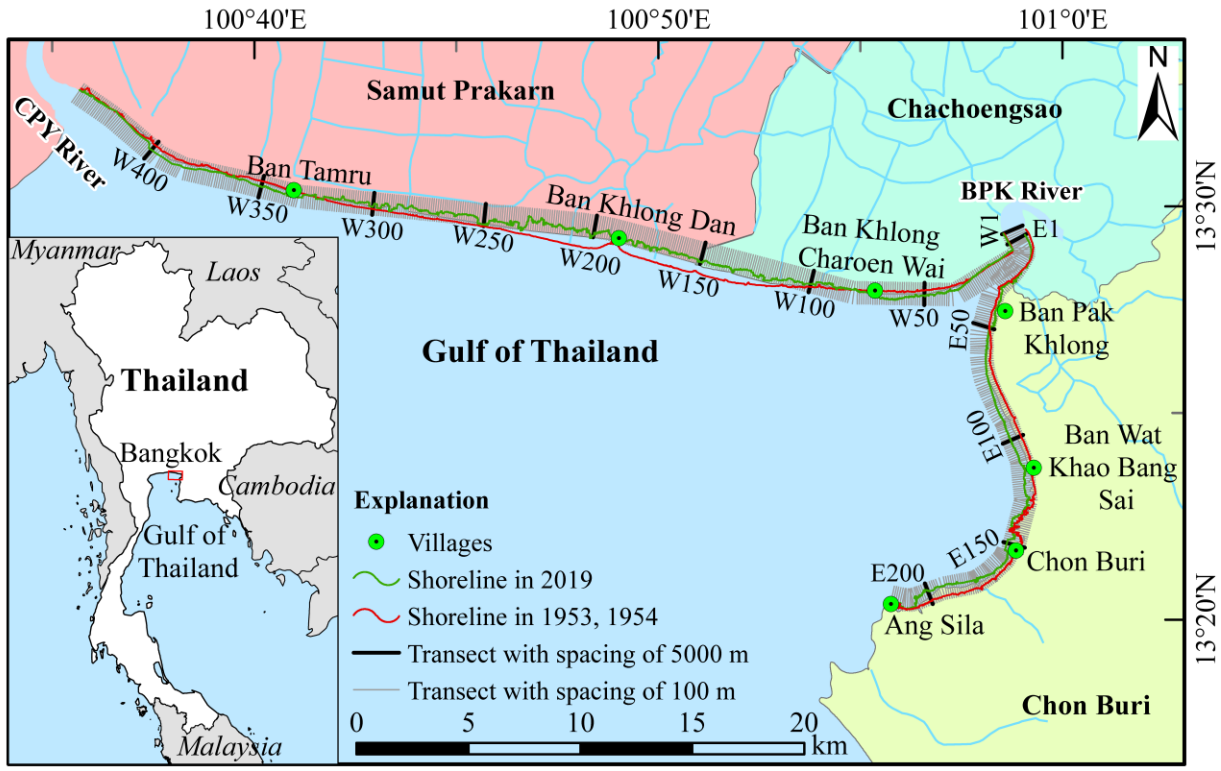
Shoreline digitization

- All images were georeferenced into **UTM projection Zone 47 with the WGS 84** and were rectified with a **2002 base map** to eliminate distortion.
- **Muddy coastline**: outer line of closed mangrove canopy and **artificial coastline**: alignment of identifiable coastal structures such as roads, bridges, dikes, and seawalls.
- **Shoreline positions** was extracted by on screen digitization.



Materials and Methods (Cont.)

- Coastline of the BPK Delta was separated into **2 main littoral cells**: WBK coast (44 Km) and EBK coast (22 km).
- **Transects of 442 and 220** with a spacing of **100 m** are developed perpendicular to the baseline of the **WBK and EBK coasts,** respectively.
- **Digital Shoreline Analysis System** (DSAS) was used calculate the statistical rate of shoreline change.
- **Net Shoreline Movement (NSM)** was used to estimate the length of the shoreline movement.
- **End Point Rate (EPR)** and **Linear Regression Rate (LRR)** were employed to estimate short- and long-term shoreline change rates, respectively.

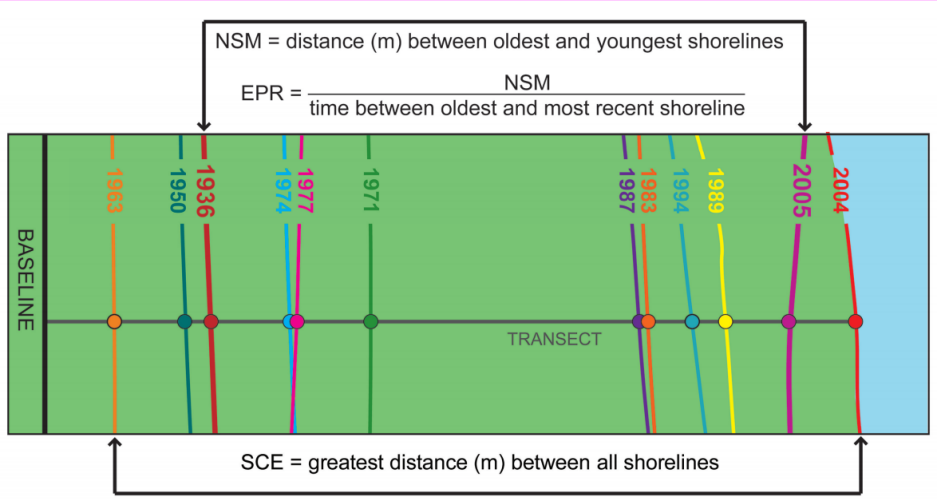


Map of the Bang Pakong Delta.

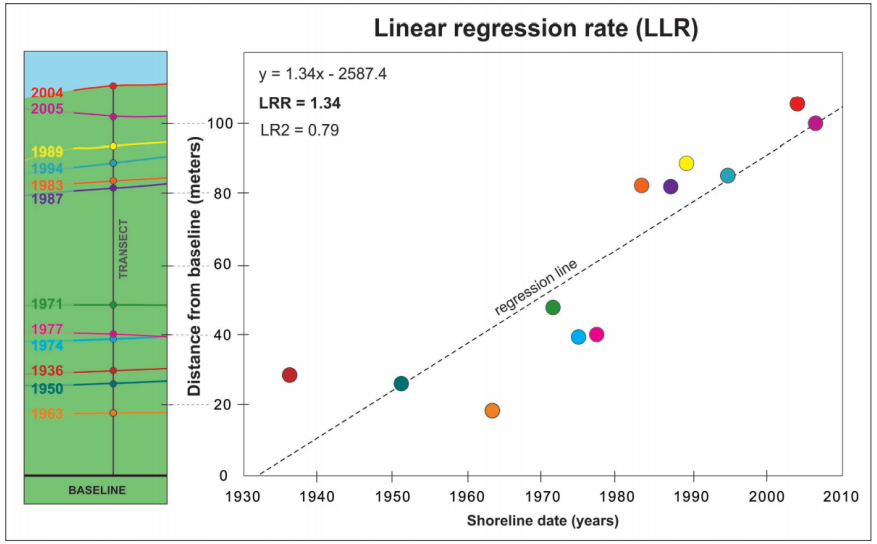
Materials and Methods (Cont.

Shoreline change statistic

- **Net Shoreline Movement (NSM)** is the distance between the oldest and the newest shoreline for each transect.
- **End Point Rate (EPR)** is calculated by dividing the NSM by the time elapsed between the oldest and the most recent shoreline.
- **Linear Regression Rate (LRR)** is a linear regression rate-of-change statistic computed by fitting a least-squares regression line to all shoreline points of each transect, and the slope of the regression line represents rate of shoreline change.



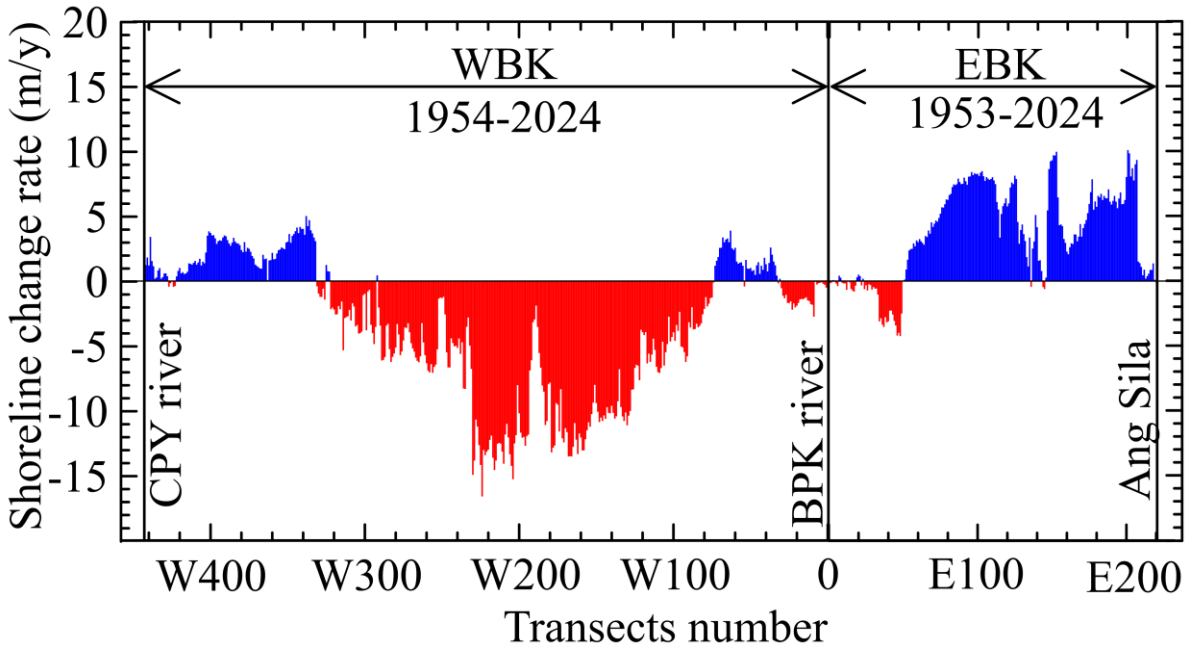
The computation of NSM, SCE, and EPR. Source: Thieler et al. (2017)



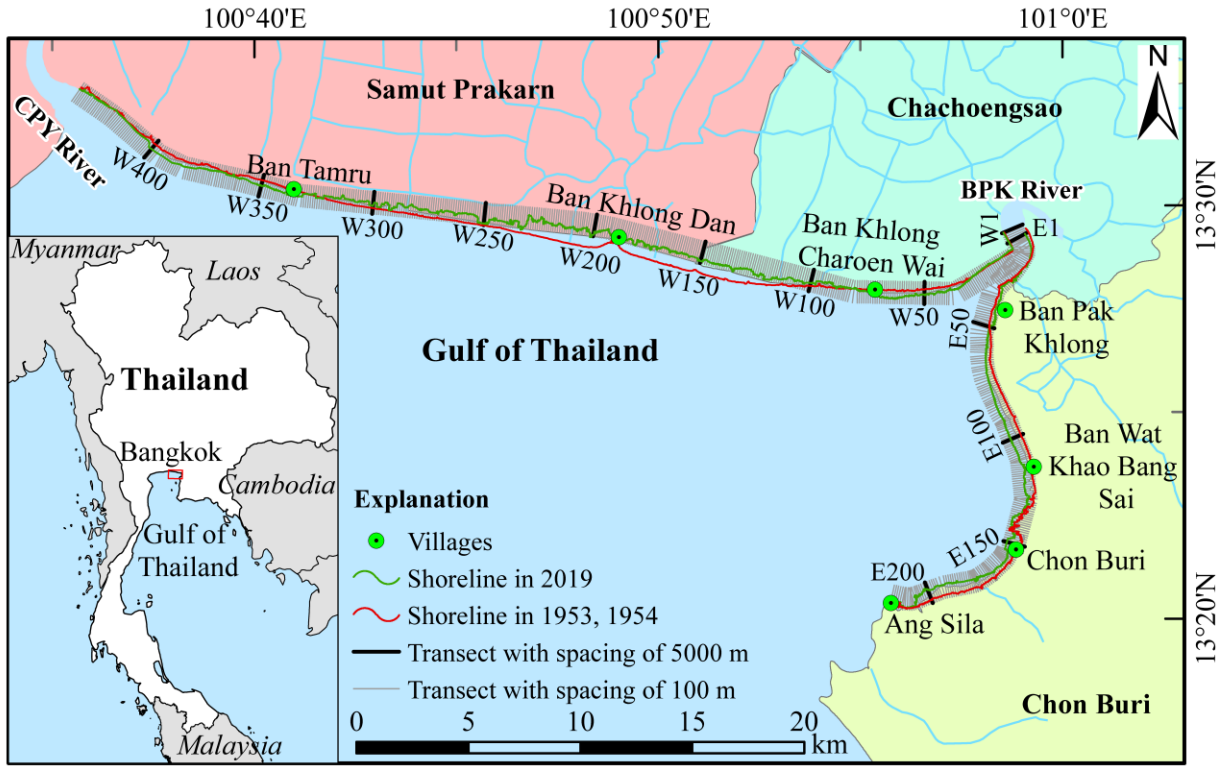
The computation of LRR. Source: Thieler et al. (2017)

Results

Long-term shoreline change



Long-term shoreline change along the EBK and WBK coasts.



Map of the Bang Pakong Delta.

- **WBK coast (1954-2024)**

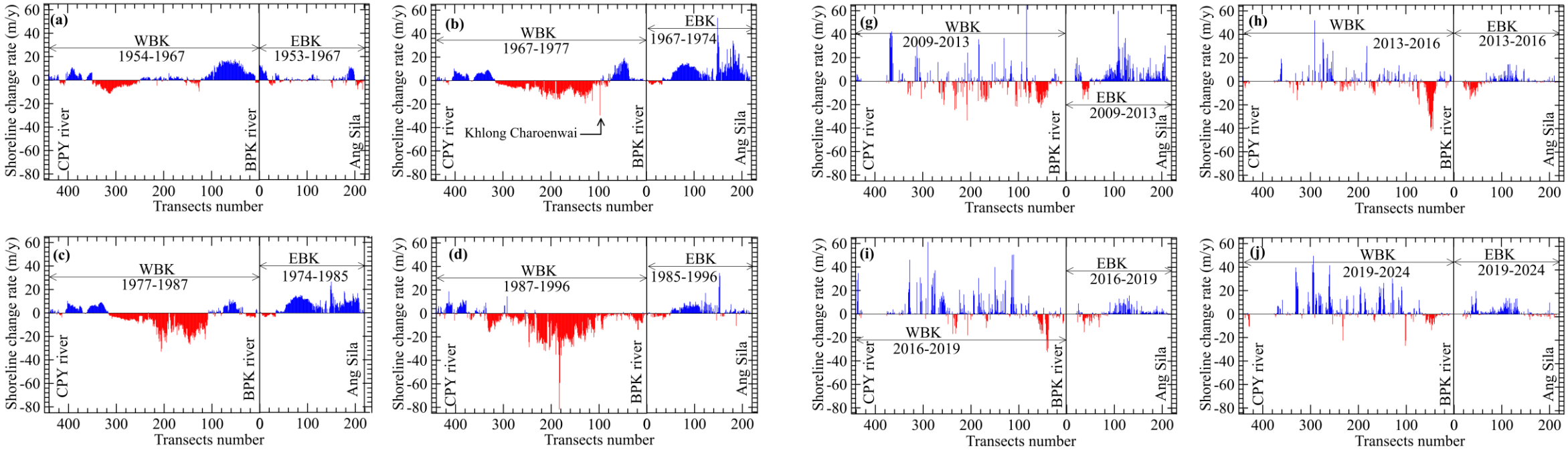
Retreat : 62%; -6.5 m/y; 940 ha
Accretion : 32%; 2.2 m/y; 290 ha

- **EBK coast (1953-2024)**

Retreat : 12%; -2.2 m/y; 31 ha
Accretion : 73%; 5.4 m/y; 565 ha

Results (Cont.)

Short-term shoreline change



WBK coast can be divided into three major periods:

(1) 1954–1967 : the early period of the country's development (a)

(2) 1967– 2002 : a period of rapid coastal degradation (b–e)

(3) 2002–2024 : a period of coastal reclamation (f-j)

EBK coast can be divided into three major periods:

(1) 1953–1967 : the early development period (a)

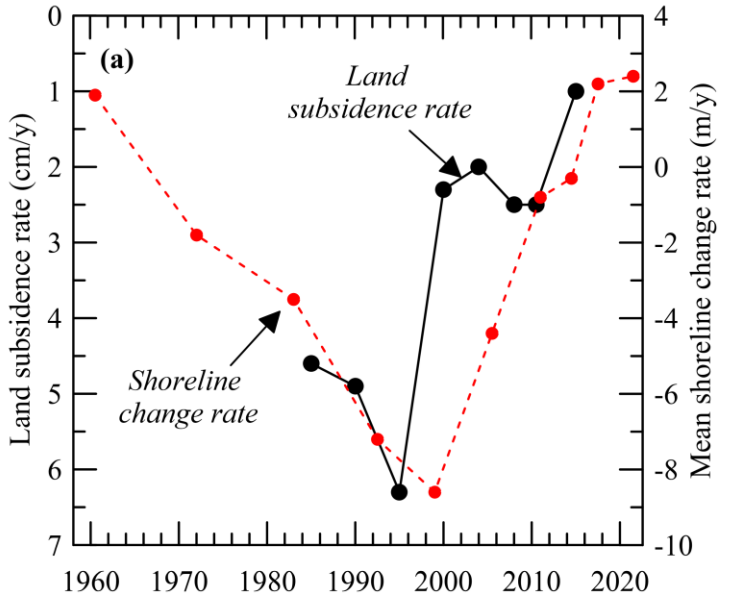
(2) 1967–2013 : extended period of intensive mangrove colonization (b-g)

(3) 2013–2024 : a period of declining mangrove colonization (h-j).

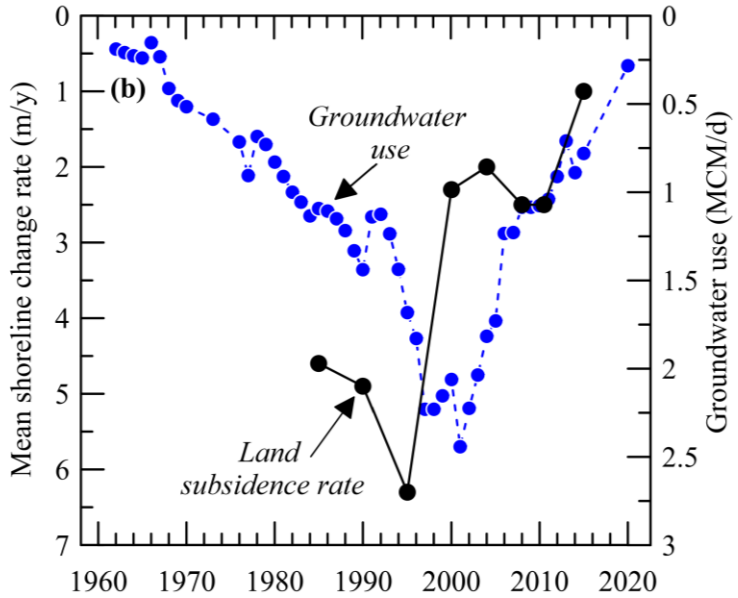
Discussion

Shoreline change along the WBK coast

- **Several factors** have been suggested as possible causes of **receding coastlines** along the **WBK coast**.
- **Land subsidence** is one of the main factors caused **rapid shoreline retreat** along the WBK coast.
- **High rate of subsidence** in this region was caused by **groundwater extraction**.
- **Eustatic sea-level rise** was no significant increasing trend between 1940-2019.
- There is **no significant change** in the **weather climate** in Thailand during the past five decades, which will directly **affect sea conditions**, has been reported.



(a) Shoreline change vs land subsidence rates

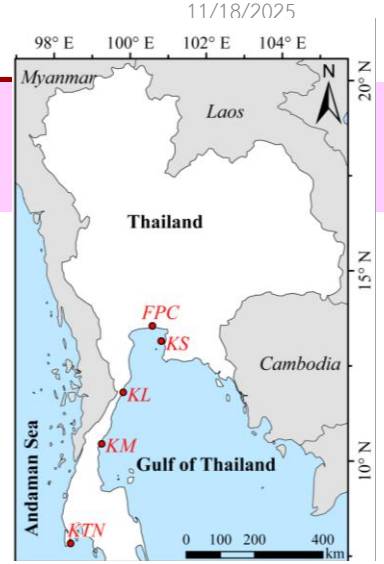


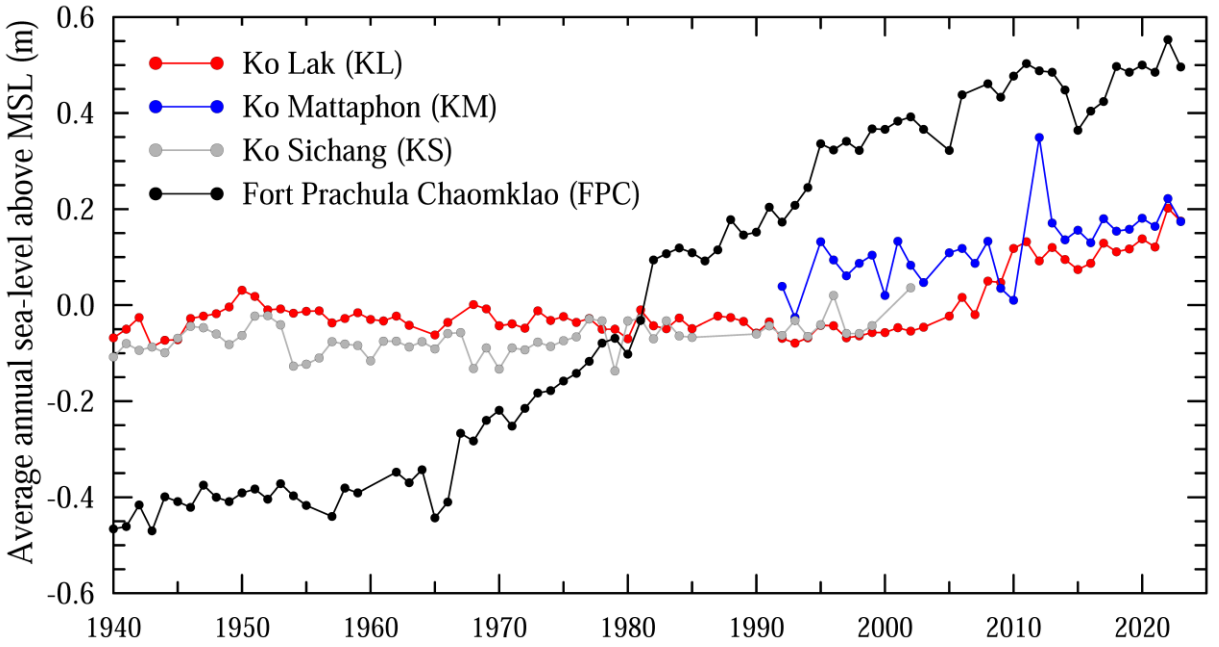
(b) Groundwater extraction vs land subsidence rate

Discussion

Shoreline change along the WBK coast

- **Several factors** have been suggested as possible causes of **receding coastlines** along the **WBK coast**.
- **Land subsidence** is one of the main factors caused **rapid shoreline retreat** along the WBK coast.
- **High rate of subsidence** in this region was caused by **groundwater extraction**.
- **Eustatic sea-level rise** was no significant increasing trend between 1940-2019.
- There is **no significant change** in the **weather climate** in Thailand during the past five decades, which will directly **affect sea conditions**, has been reported.



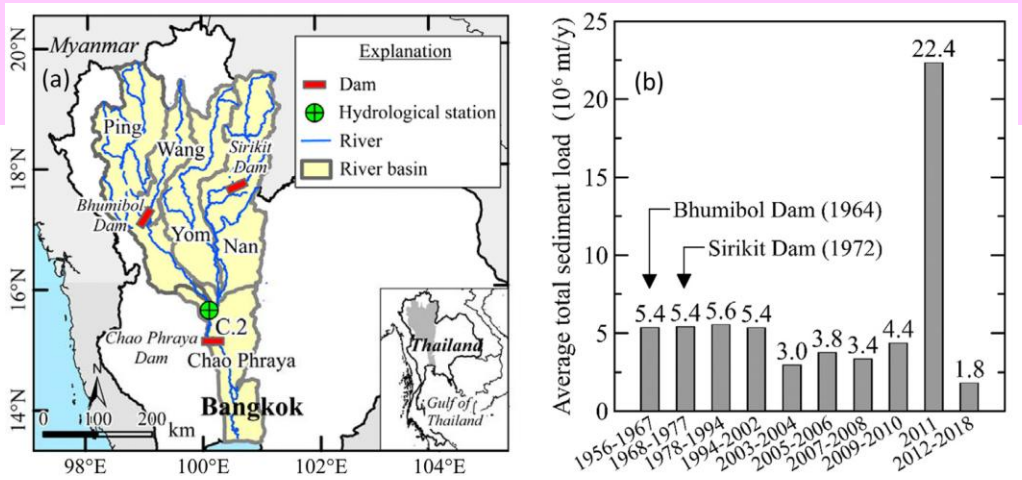


Annual sea-level change in the Gulf of Thailand and Andaman Sea

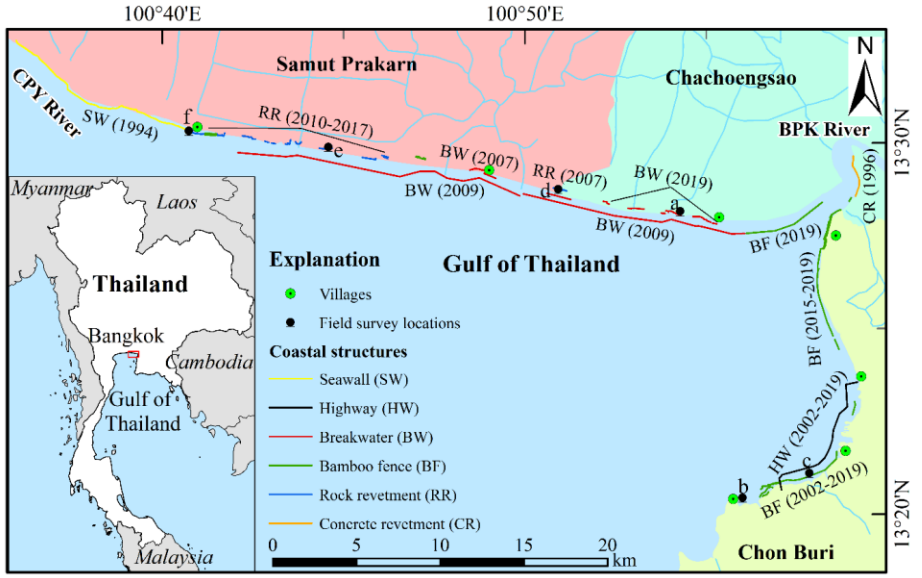
Discussion (Cont.)

Shoreline change along the WBK coast Cont.

- The **riverine sediment** did not decrease after the construction the 2 **largest storage dams** in the CPY River's system.
- **Shoreline accretion** did occur after 2009 when **coastal protection structures** were constructed.
- **A rapid shoreline advance** seaward due to natural mangrove colonization was observed **behind nearshore breakwater** after 2016.



The estimated average annual total sediment loading for the Chao Phraya River (Bidorn et al., 2021)

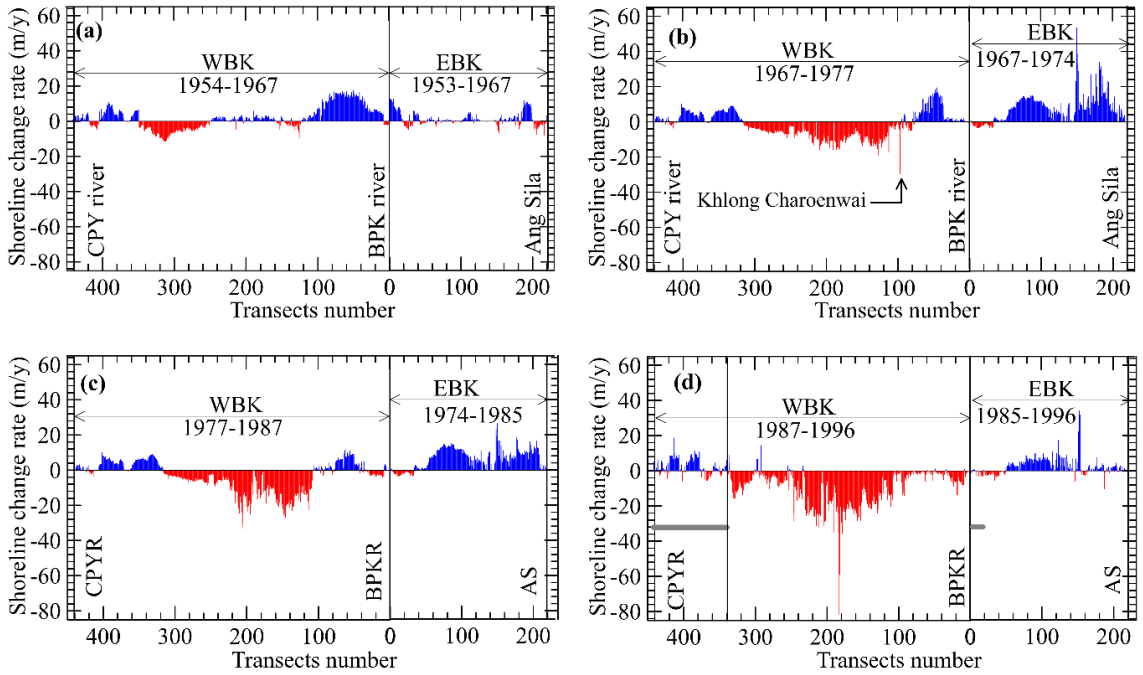


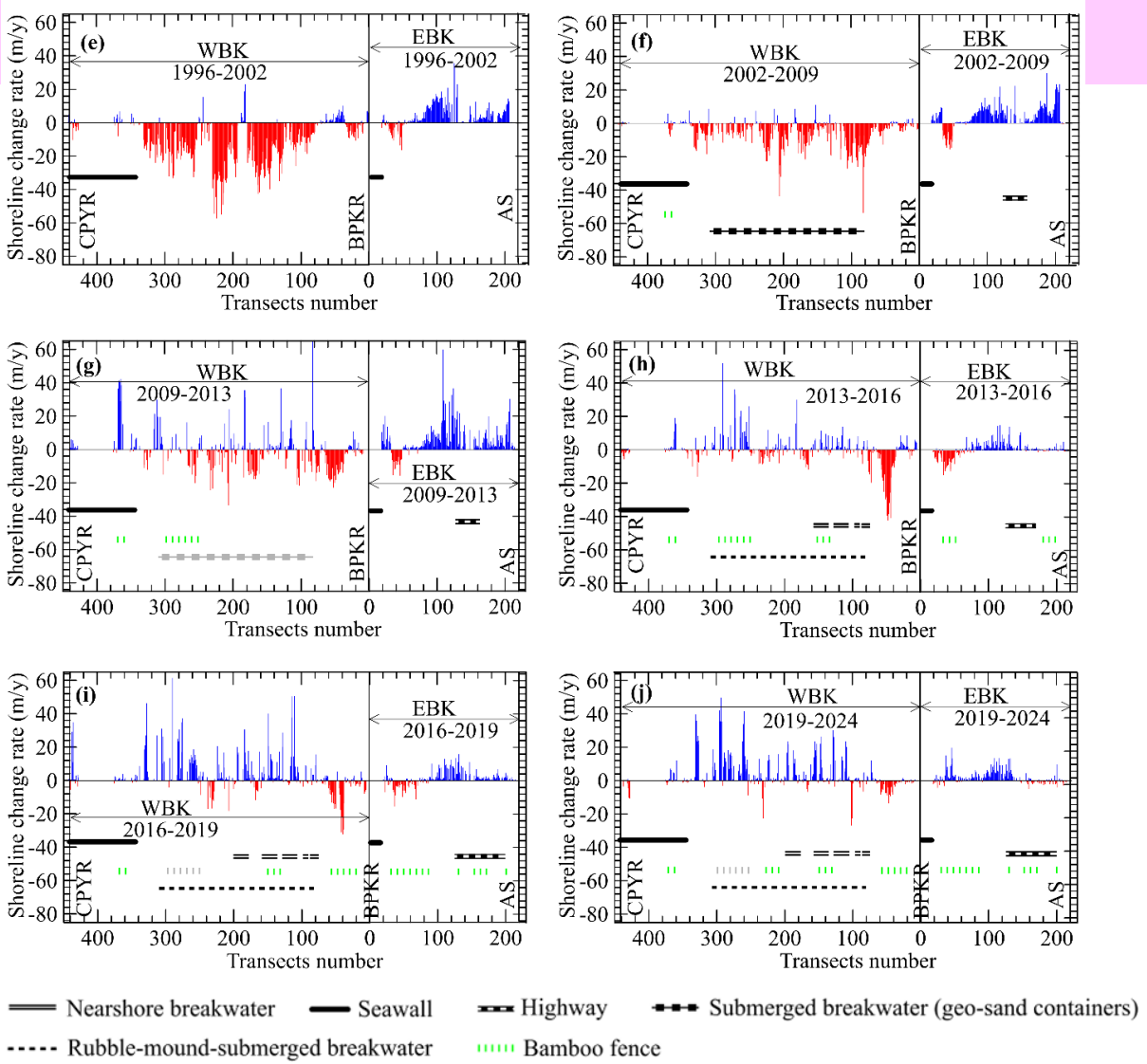
Coastal structures along the WBK and EBK coasts.

Discussion (Cont.)

Shoreline change along the WBK coast Cont.

- **A rapid shoreline advance** seaward due to natural mangrove colonization was observed **behind nearshore breakwater** after 2016.

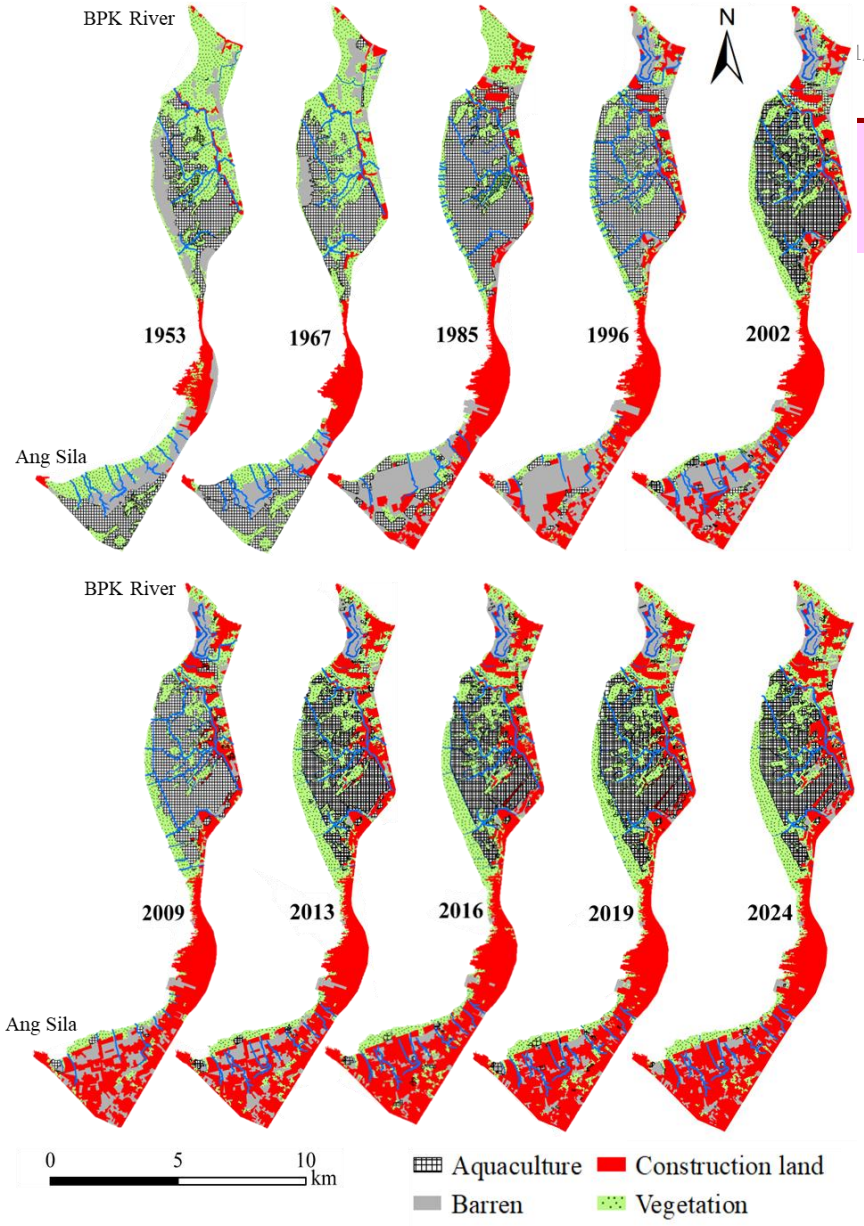




Discussion (Cont.)

Shoreline change along the EBK coast

- The **shoreline advances** along the **EBK coast** were primarily driven by **natural mangrove colonization**.
- After the installation of **bamboo fences** along the EBK, the accretion shoreline turned to **stable shoreline**.
- The **conversion of vegetation areas and mangrove forests** to aquacultural or development areas did not cause **shoreline retreat**.



Land use change along the eastern portion of the Bang Pakong coast (EBK) since 1953

Conclusions

- Based on shoreline positions identified between **1953 and 2019**, the **western coast of the BPK River** (WBK) and **eastern coast of the BPK River** (EBK) display **near opposite** shoreline change patterns.
- The WBK coast experienced **severe shoreline retreat** which was primarily caused by **land subsidence**.
- Our results also indicate that **mangrove deforestation** was not a major factor causing **shoreline retreat**, and **mangrove reforestation** was not a successful **coastal protection approach** in this coast.
- The **WBK coastline stabilized** in 2009 and became an **accretionary coast** after 2016 due to the introduction of **engineered coastal protection measures**.
- Unlike the WBK coast, the **EBK coastline** has been naturally **expanding seaward** over the past seven decades, even though most of the coastal zone has now been converted to aquaculture and urban areas.

Thank you!
Q&A

Seven decades of shoreline changes along a muddy mangrove coastline of the Upper Gulf of Thailand