ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018
The State of the Art and Science of Coastal Engineering

Beach Morphological Changes on Sendai Coast by Typhoon Lionrock

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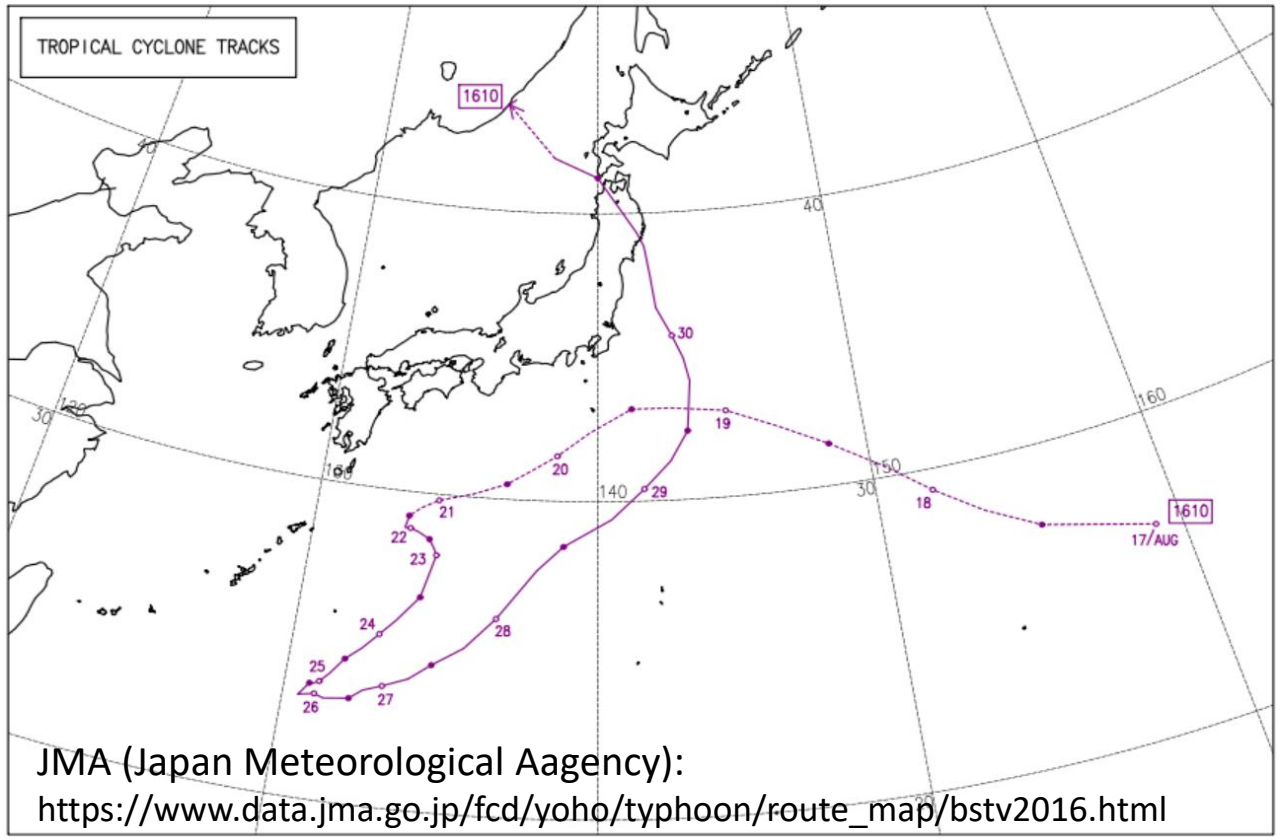
1. Introcduction ~ Typhoon Lionrock, 2016

Route of Typhoon Lionrock (from JMA web-site)



JMA (Japan Meteorological Aagency):
https://www.data.jma.go.jp/fcd/yoho/typhoon/route_map/bstv2016.html

- First typhoon to approach and hit Tohoku Area from Pasific Ocean in the observation history of Japan
- Causing severe damages by heavy rain in Tohoku and Hokkaido Areas
- The time of high tide was approximately same as the arrival time of the typhoon

- Field survey on Sendai Coast during and soon after the typhoon events in order to investigate the magnitude of the high tide and high waves and their effects on sediment transport processes
- Aerialphoto analysis of morphological changes and their long-term effects

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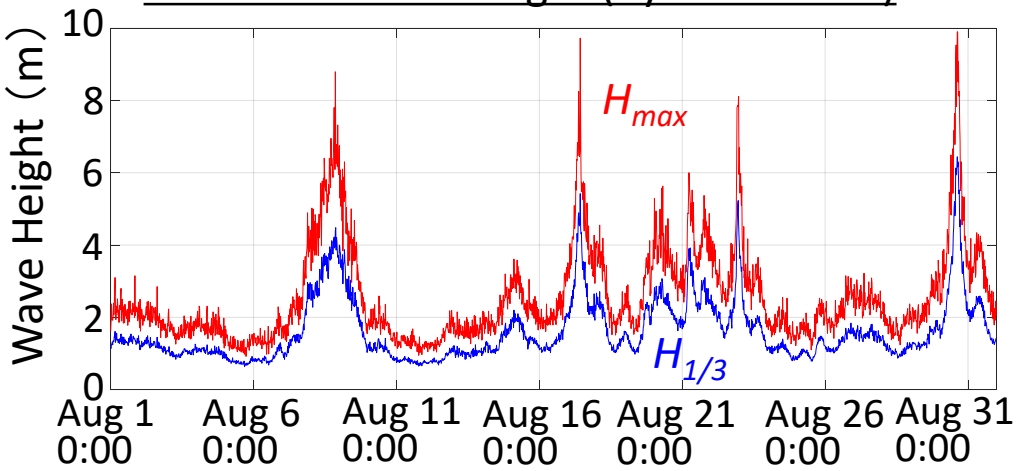
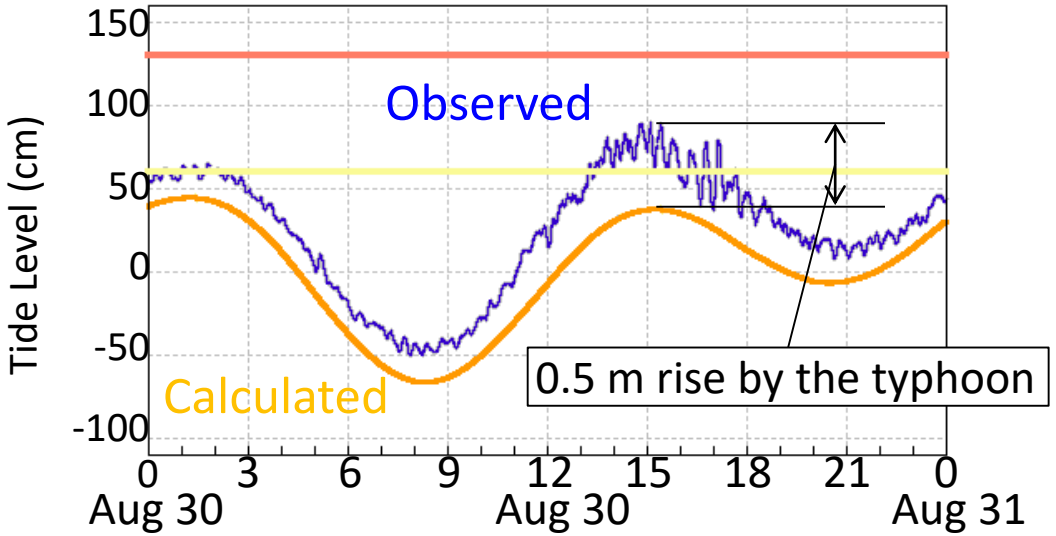
1. Introcduction ~ Sendai Coast (1) wave conditions

Study Area: Sendai Coast (12 km sandy beach)

Observed Wave Height (by NOWPHAS)



Observed Tide Level (from JMA website)



1. Introcduction ~ Sendai Coast (2) Effect of 2011 tsunami

Study Area: Sendai Coast

Effect of the 2011 Great East Japan Earthquake Tsunami

Erosion and breaching of sand dune

Erosion after tsunami

Remaining effect on the beach process

1. Introcduction ~ Sendai Coast (3) Aerial photographs

Study Area: Sendai Coast

Aerial photographs

- Period: 1992 ~ Current
- Frequency: every 1 or 2 months
- Altitude: approximately 900m
- Conditions:
  - digital camera
  - resolution: approximately 9 cm/pixel
  - approximately 60 % overlap

1. Shoreline analysis
   - to quantify morphological changes
   - to evaluate long-term effect of this event
2. Stereo Image Analysis
   - to discuss sediment transport induced by the typhoon more in detail

2. Field Survey ~ A: Sendai Port to Nanakita River mouth

Sendai Port ~ Nanakita River Mouth

Photo: Mar. 4, 2016

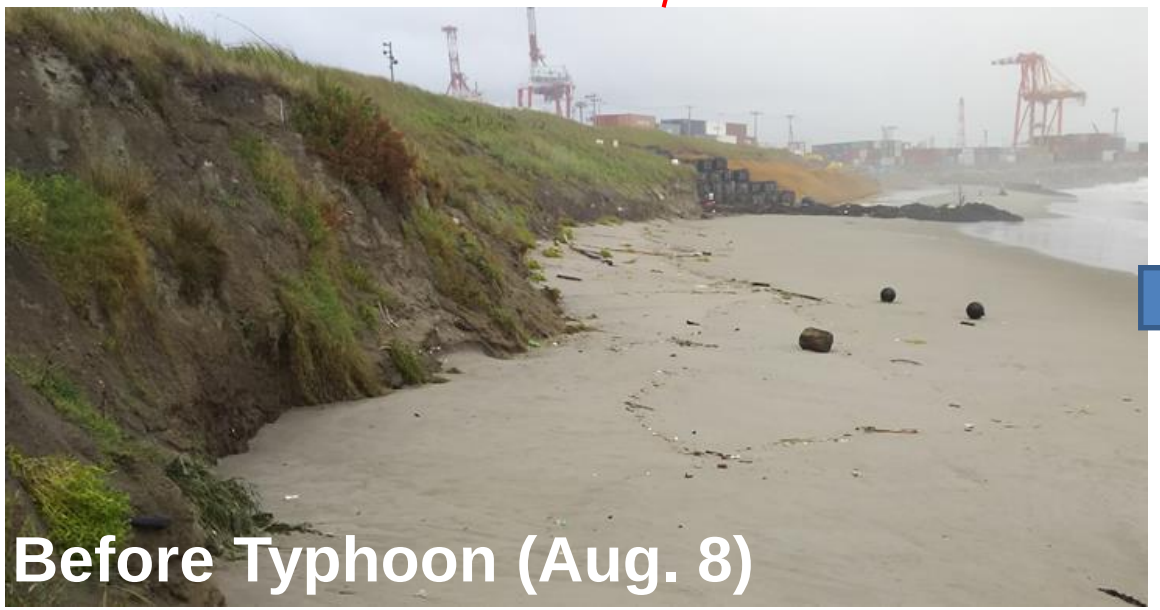
High waves during the typhoon event

Erosion of embankment toe by the waves

2. Field Survey ~ A: Sendai Port to Nanakita River mouth

Sendai Port ~ Nanakita River Mouth

Photo: Mar. 4, 2016



2. Field Survey ~ A: Sendai Port to Nanakita River mouth

Sendai Port ~ Nanakita River Mouth

Photo: Mar. 4, 2016

Grasses bended by the wave overtopping

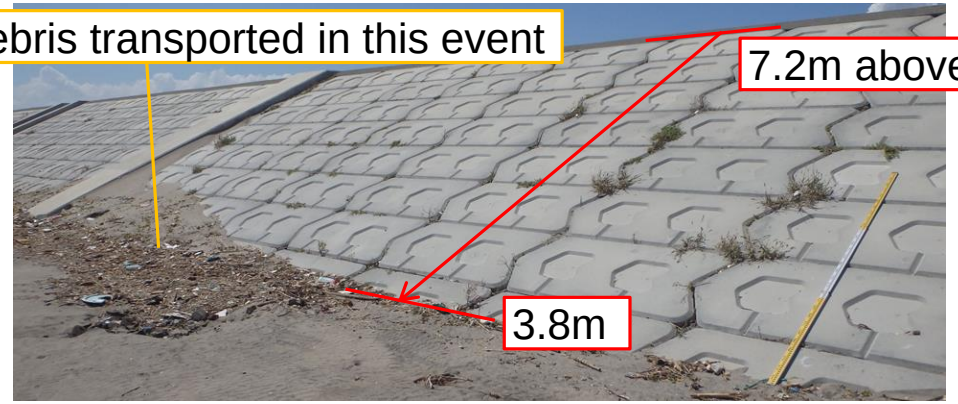
Wave Overtopping of Sand Dune

Sediment transport over the sand dune

2. Field Survey ~ B: Arahama Coast

Arahama Coast

Photo: Mar. 4, 2016



High waves during the typhoon event

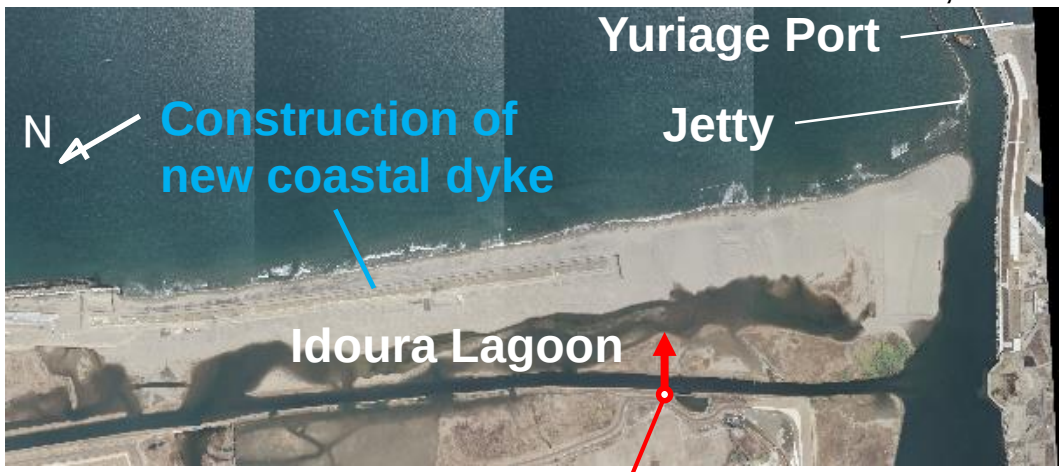
Maximum run-up height: approx. 4 m

Lower than the previous height of the coastal dykes (before the 2011 tsunami event: 5.2 m from MSL)

2. Field Survey ~ C: Natori River Mouth

Natori River Mouth

Photo: Mar. 4, 2016



Wave overtopping of sand dune

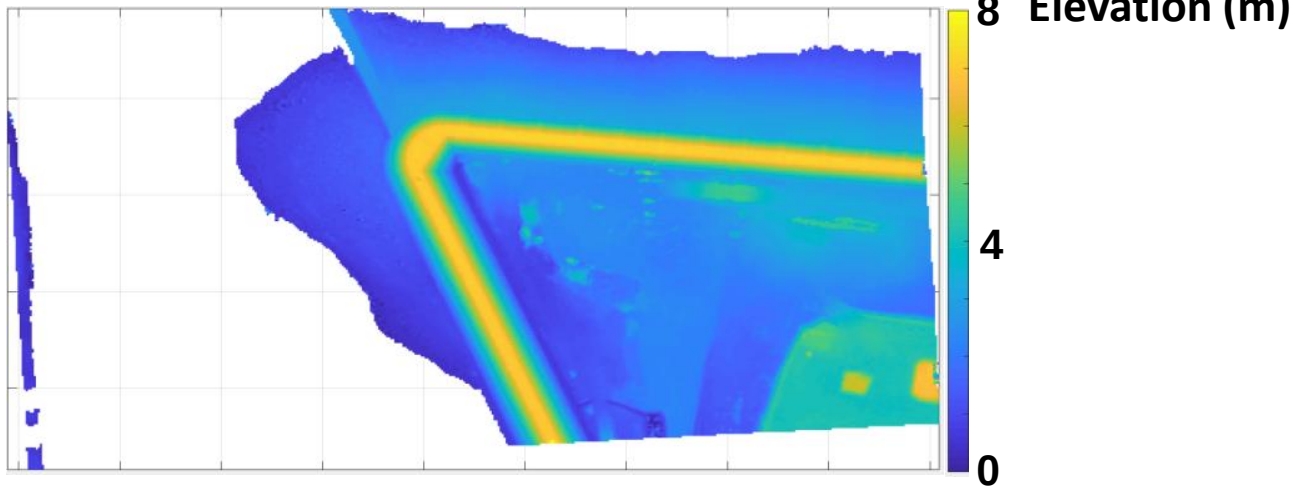
3. Aerial photo Analysis ~ Stereo Image Analysis

Stereo Image Analysis around Nanakita River Mouth

Aerial Photos on Sep. 1, 2016

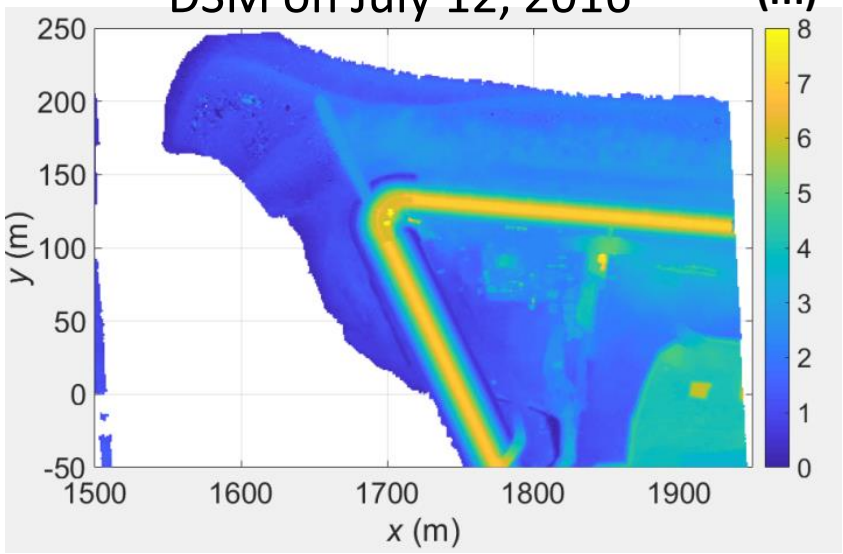
3D Topographical Data

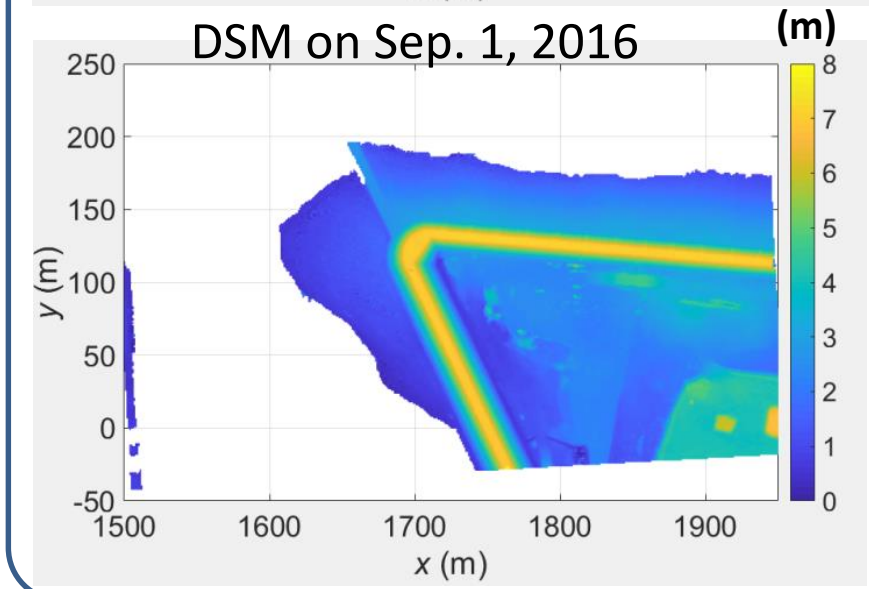
DSM (Disital Surface Model): 1m-mesh

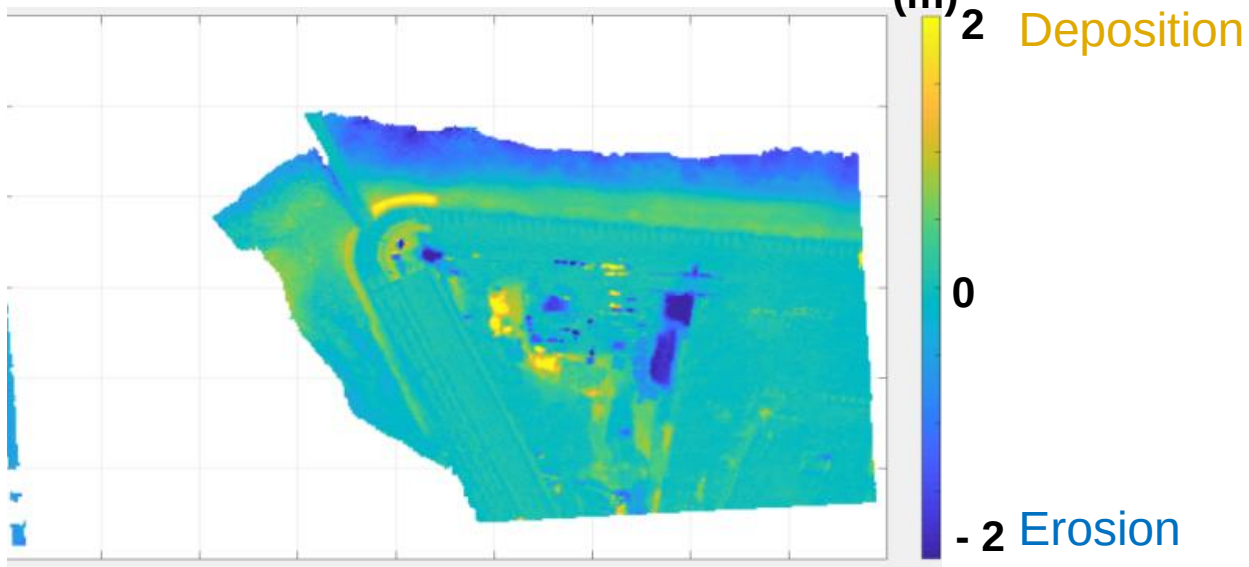


3. Aerial photo Analysis ~ Stereo Image Analysis

Stereo Image Analysis around Nanakita River Mouth

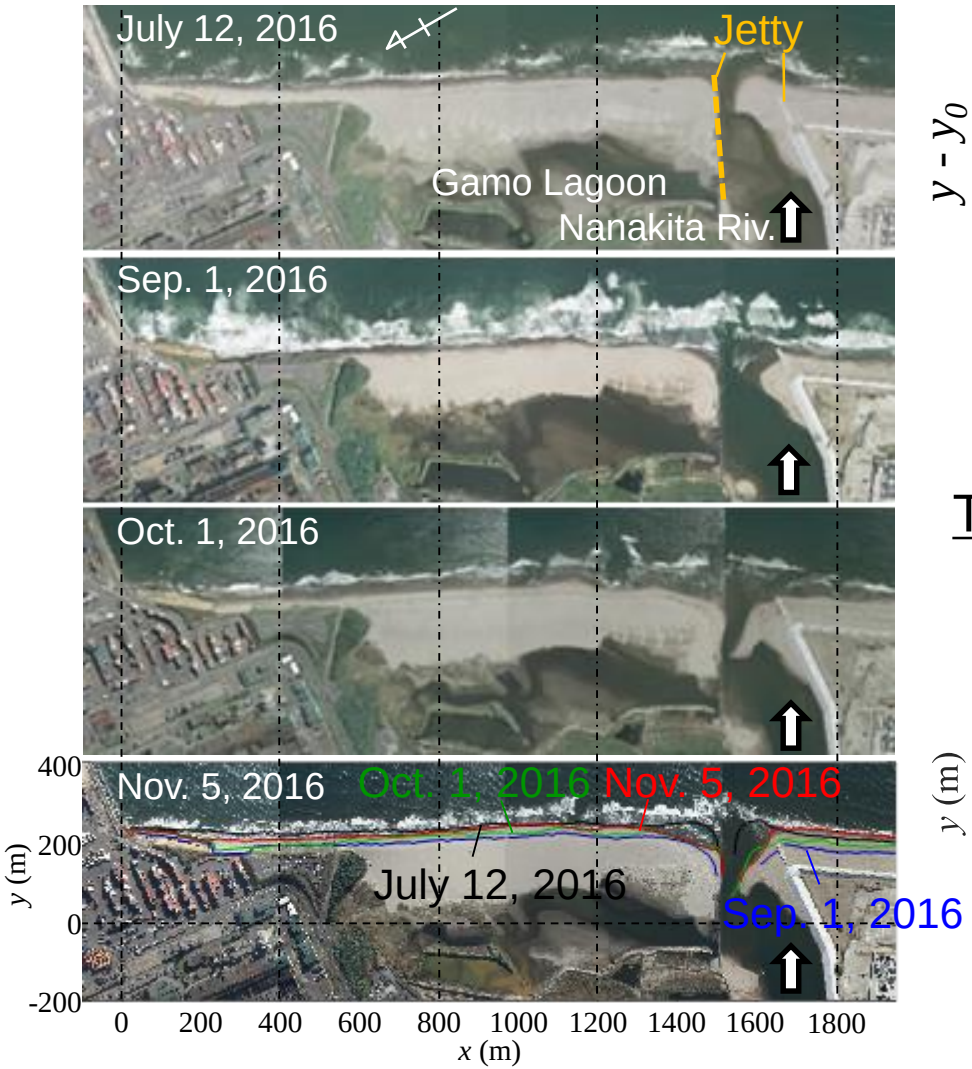






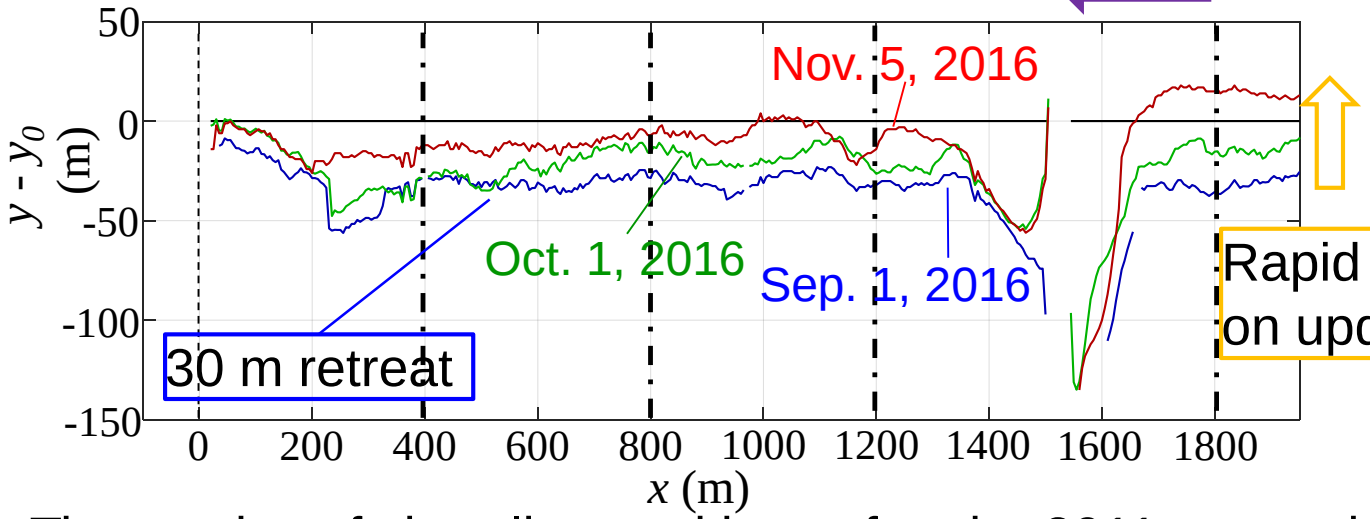
3. Aerial photo Analysis ~ Shoreline Analysis

Sendai Port ~ Nanakita River Mouth



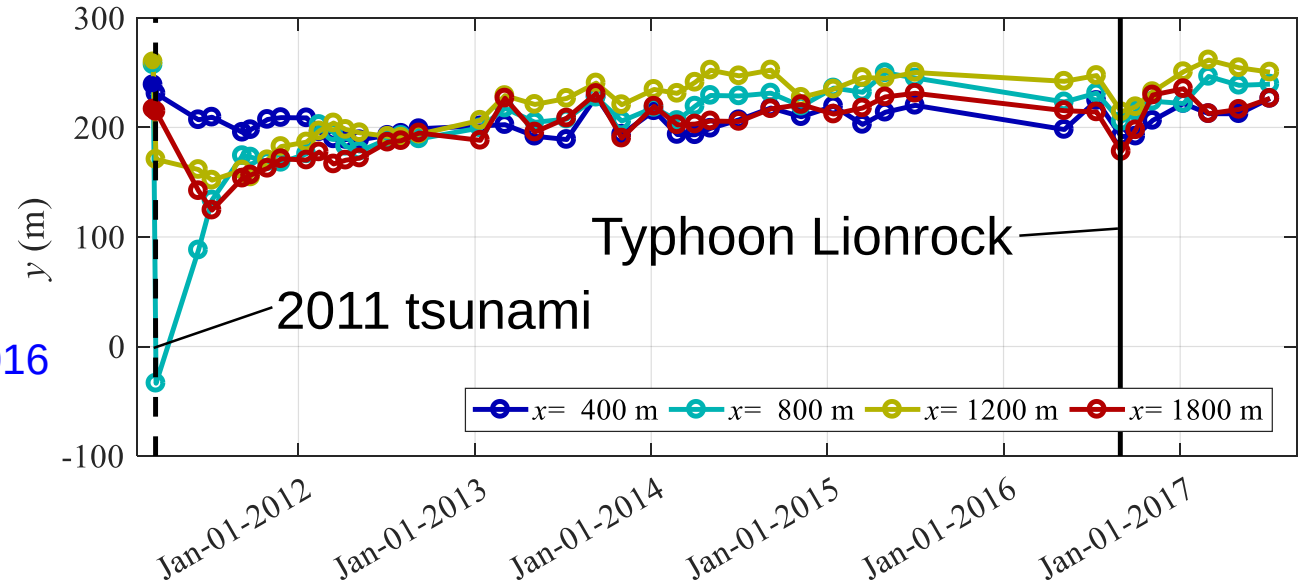
Shoreline Change (y_0: shoreline position on July 12, 2016)

Longshore sediment transport



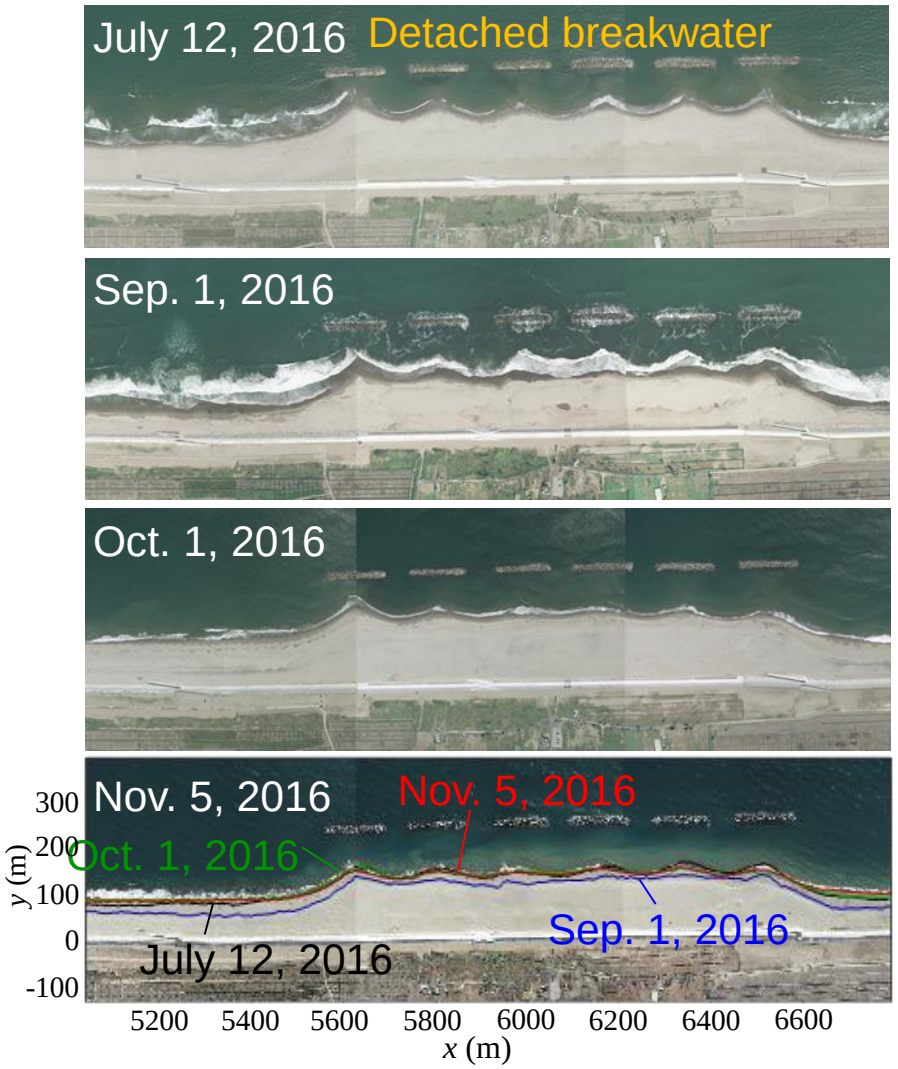
Rapid recovery on updrift side

Time series of shoreline positions after the 2011 tsunami



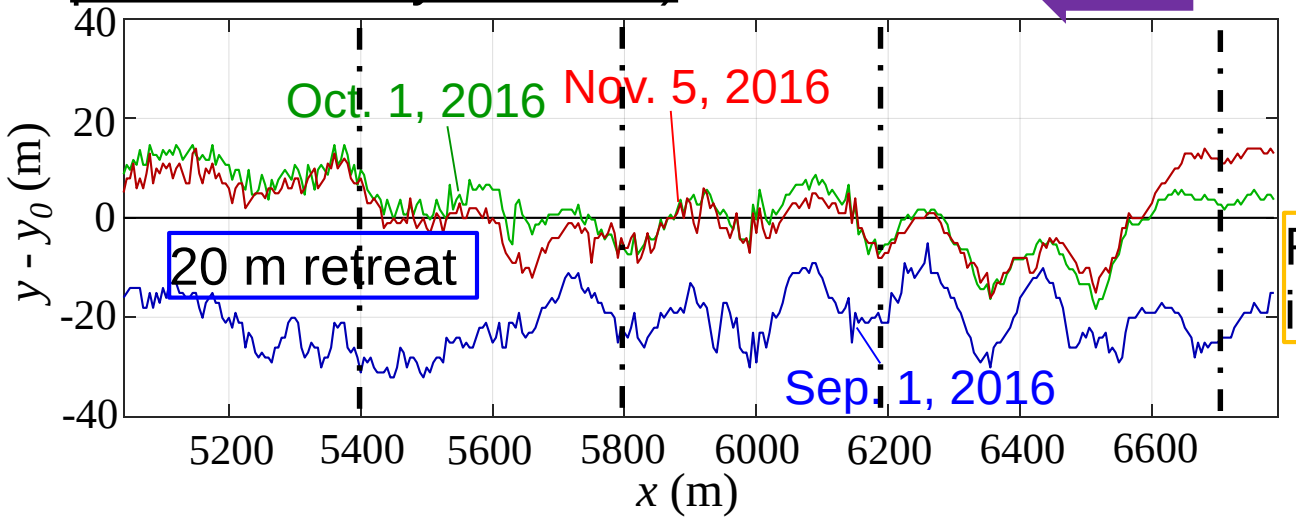
3. Aerial photo Analysis ~ Shoreline Analysis

Arahama Coast



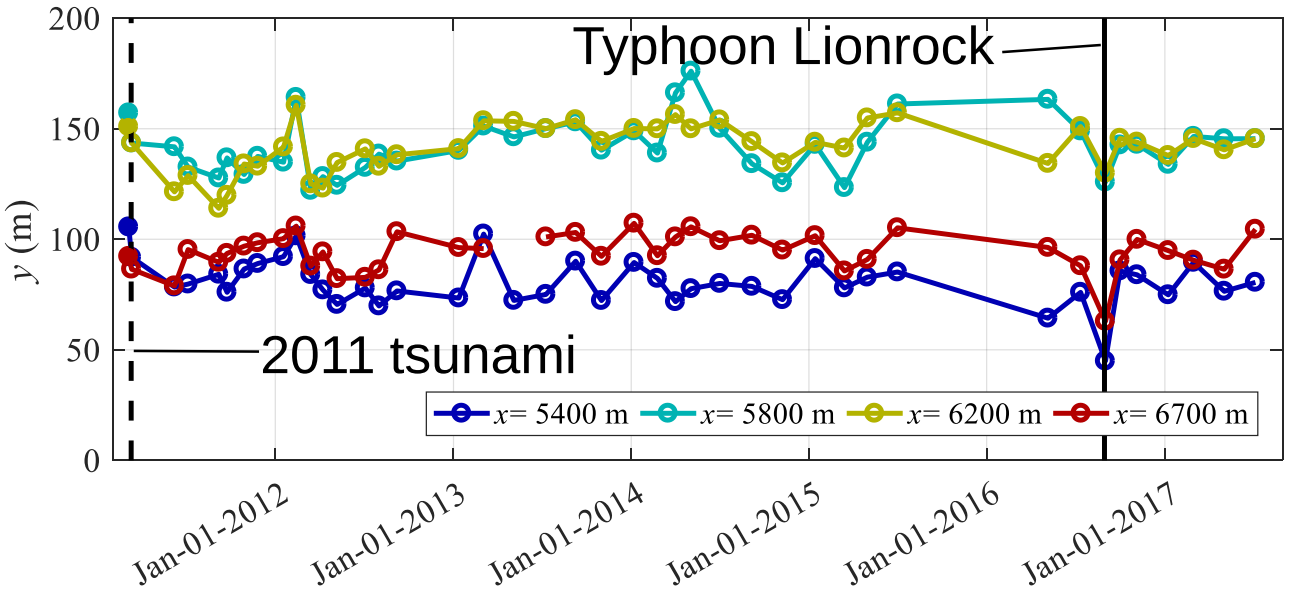
Longshore sediment transport

Shoreline Change (y_0: shoreline position on July 12, 2016)



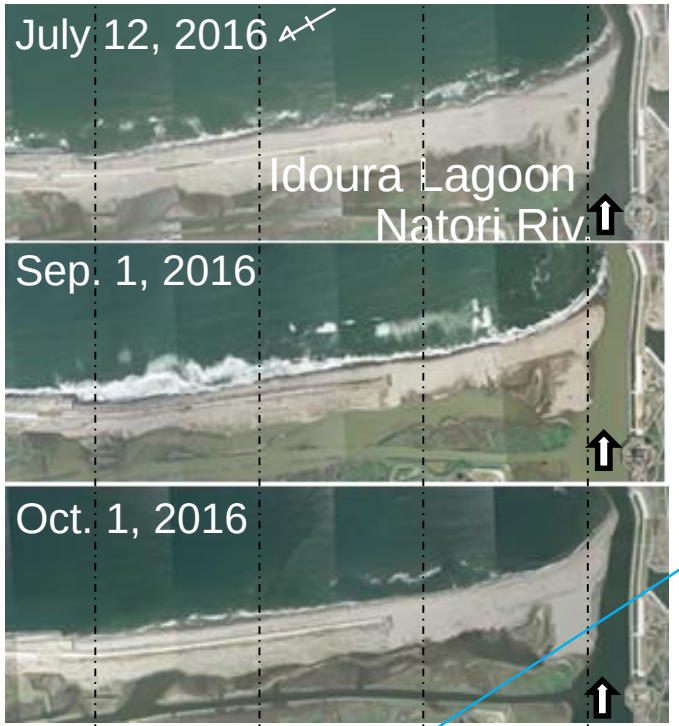
Recovered in 1 month

Time series of shoreline positions after the 2011 tsunami

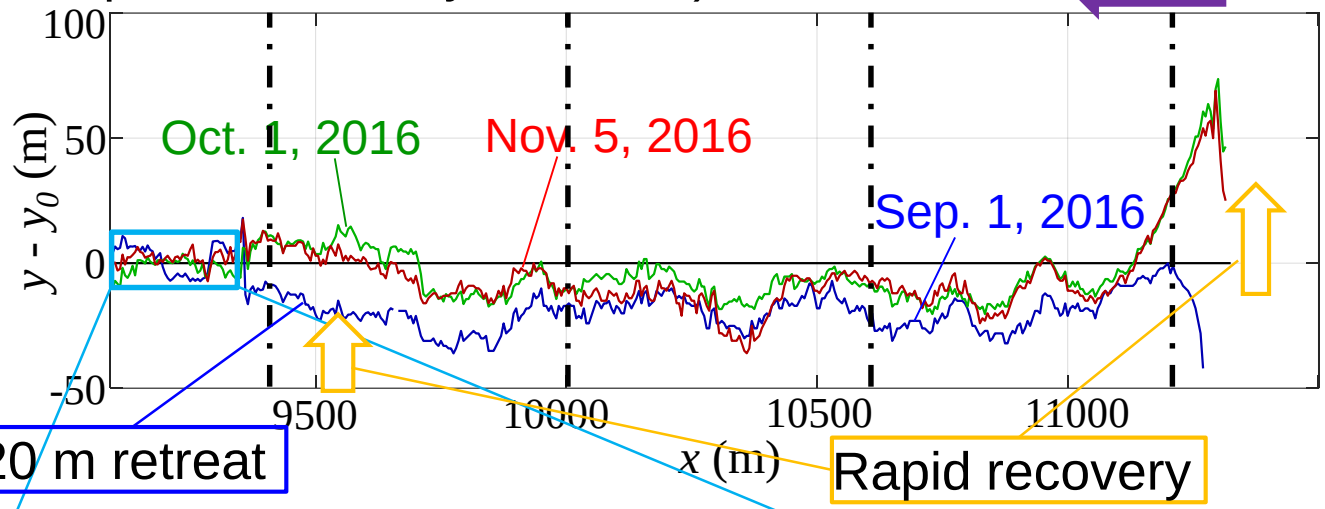


3. Aerial photo Analysis ~ Shoreline Analysis

Natori River Mouth



Shoreline Change (y_0: shoreline position on July 12, 2016)



Longshore sediment transport

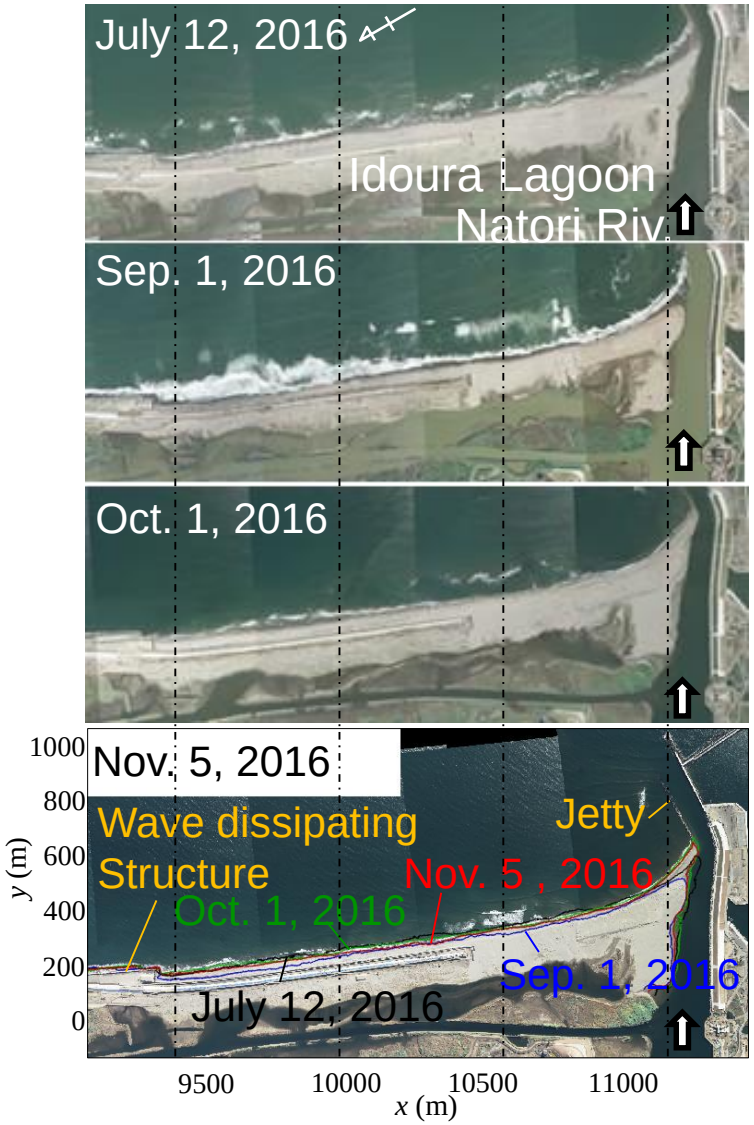
20 m retreat

Rapid recovery

to block longshore sediment transport
=> rapid recovery on the updrift side

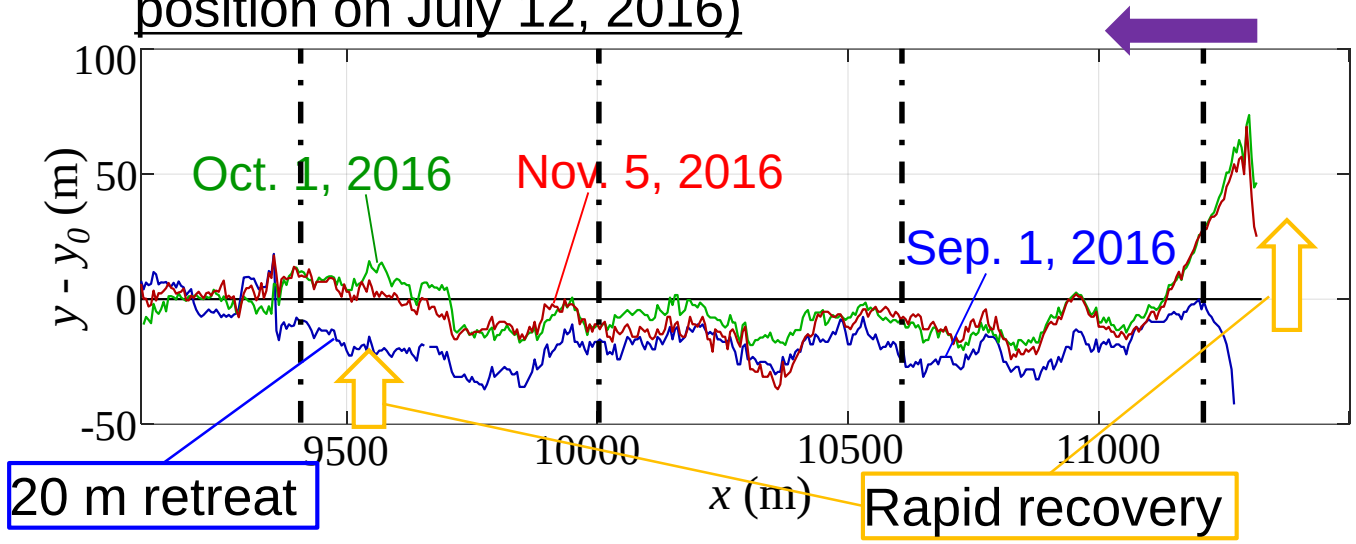
3. Aerial photo Analysis ~ Shoreline Analysis

Natori River Mouth

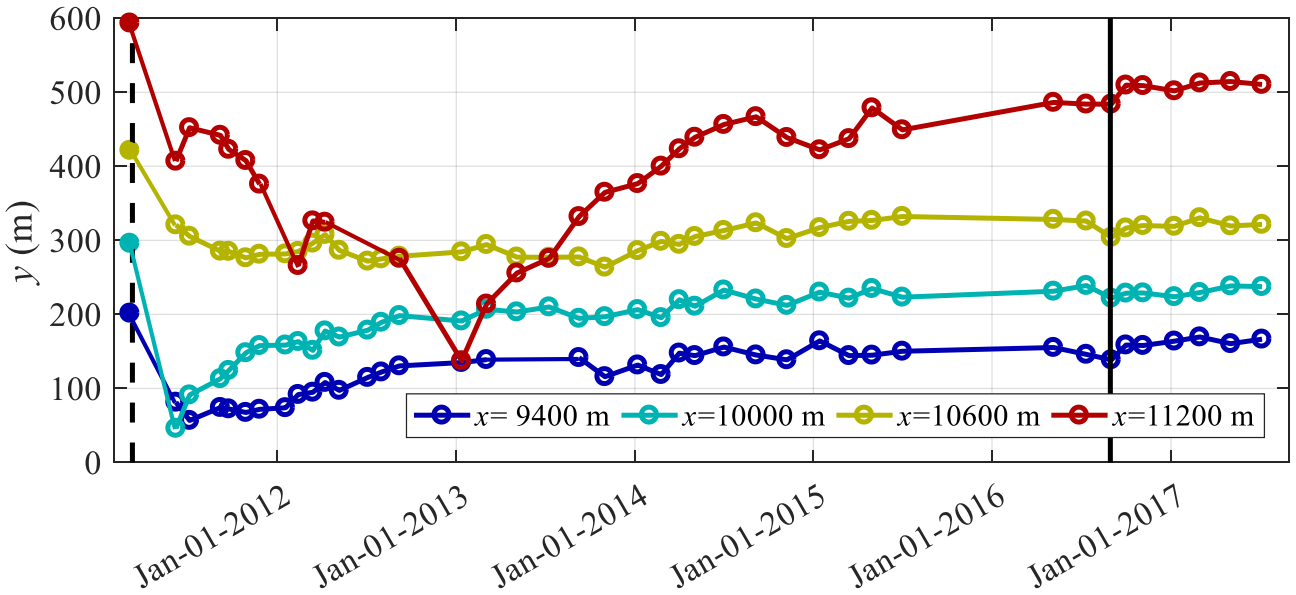


Shoreline Change (y_0: shoreline position on July 12, 2016)

Longshore sediment transport



Time series of shoreline positions after the 2011 tsunami

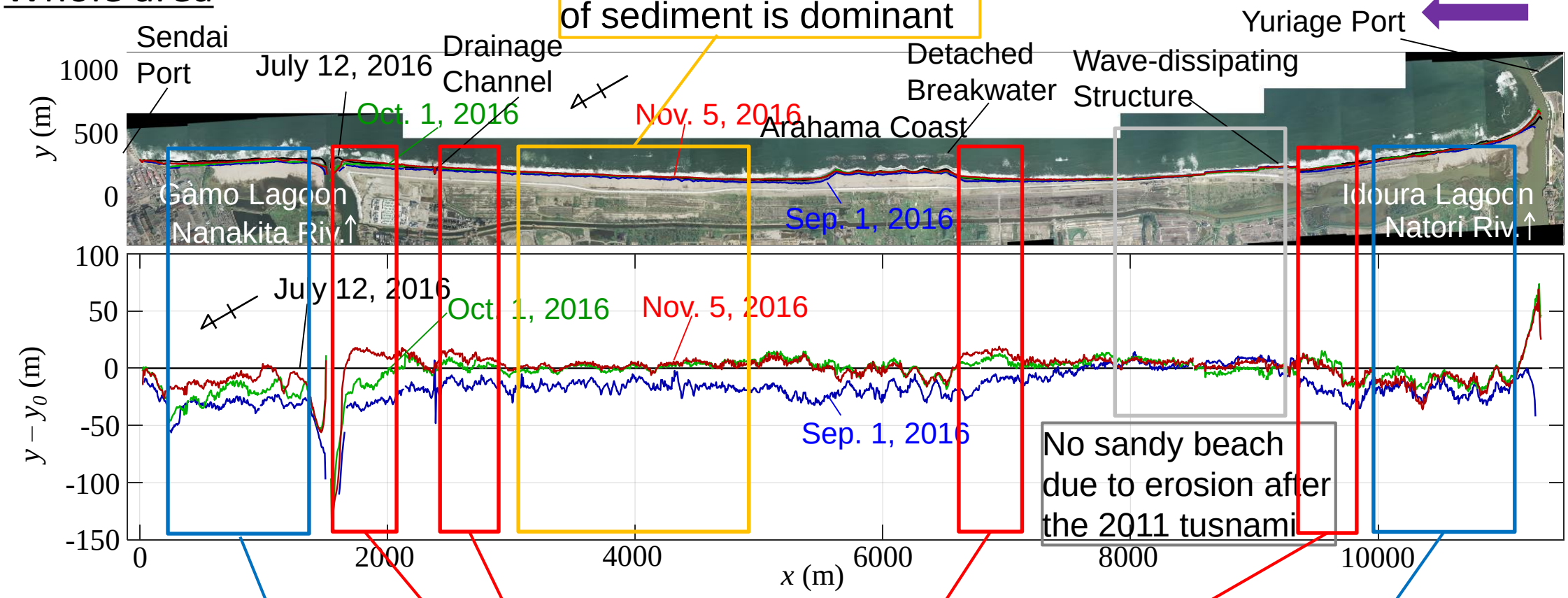


3. Aerial photo Analysis ~ Shoreline Analysis

Whole area

Cross-shore movement of sediment is dominant

Longshore sediment transport



No sandy beach due to erosion after the 2011 tusnami

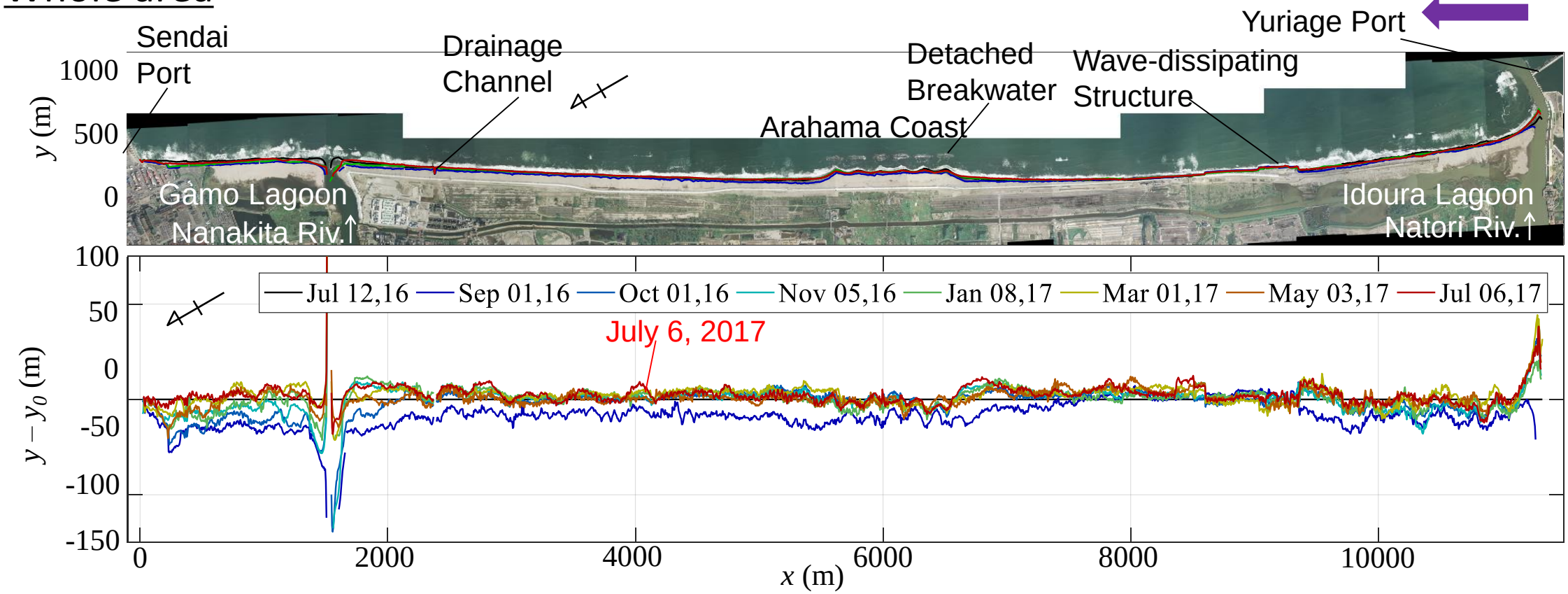
More recovery on the updrift side of the river, the detached break and also the structures intruding into coast line due to the erosion by the 2011 tsunami

Slower recovery due to loss of sediment by wave overtopping

3. Aerial photo Analysis ~ Shoreline Analysis

Longshore sediment transport

Whole area



Including the lagoon areas, shoreline positions recovered in one year and no remaining effect has been observed.

4. Conclusions

Field survey during and soon after the typhoon Lionrock

- Maximum runup height: about 4 m from MSL
  ➡ Lower than the original height of the coastal dykes (5m) in this area
- Severe erosion of the embankment toe near Sendai Port
- Wave overtopping of the sand dunes of both Gamo and Idoura Lagoons
  ➡ Sediment transport over the sand dunes

Aerial photo analysis

- 20 ~ 30 m retreat of shoreline in whole area which is not the most significant after the 2011 tsunami
- More rapid and larger recovery was observed on the updrift sides of river, detached breakwater and structures intruding into coast line due to the effect of the 2011 tsunami
- Deposition of sediment along the seaward toe of the coastal dyke
  ➡ No significant effect on shoreline changes
- Slower recovery around the lagoon areas which seem to be caused by the loss of the sediment due to the sediment transport by the wave overtopping
- No remaining effect of this event was observed after 1 year from the event