Evolution of Beach Morphodynamics in light of Sediment Budget Assessment with the Coast of Joetsu, Niigata, Japan

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1. Introduction

In the past thirty years, flood-control and soil conservation works have been performed

Fluvial area

Coastal area

Imbalance between incoming and outgoing fluxes of sediment in a littoral dispersal system

Coastal erosion has became serious issue.

In fact, it has recently undergone the loss of aerial beach area at a rate of approximately 160ha per year (Tanaka et al., 1993),

This study aims to provide a clearer picture of seabed topographical evolution in the typical example of Joetsu Coast, in terms of high-resolution bathymetry

2. Features of Joetsu Coast

The Joetsu Coast is featured by

- ○28km-long
- ○sheltered by Noto peninsula and Sado Island
- ○prevalent wave directions are normal to shoreline
- ○significant wave height $H_{1/3}$=9.24m was recoded on (20/12/2003)

The fluvial supply is principally due to the Seki River

The factors responsible may include･･･

- ○development of extensive breakwater system
- ○deployment of wave-dissipative or wave-defense structures

3. Long-term evolutions of shoreline and subaerial beach area

Based on the geographical maps on a scale of 1:25000

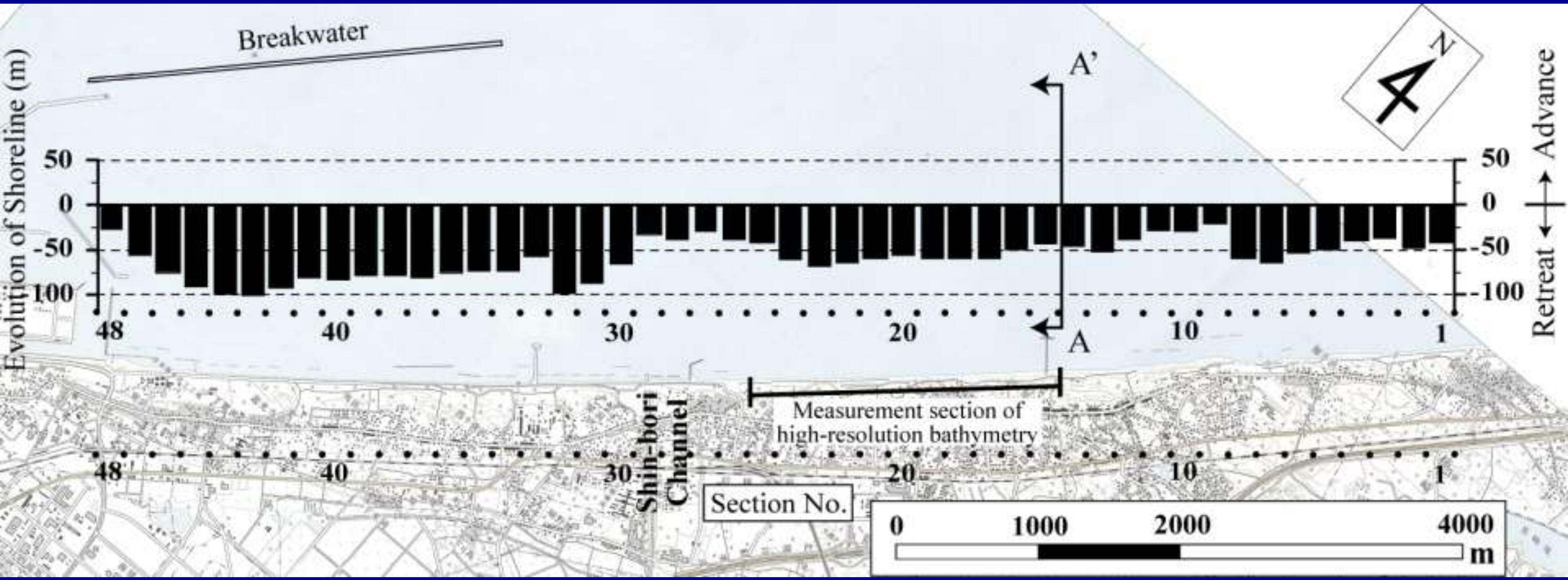


Fig. 02 Evolution of shoreline to the east of the Naoetsu Port in the period from 1914 to 2002

- In the nearly 90 year-period, the shoreline retreated over the 9.6km-long section.
- Particularly, in section Nos.32, 43 and 44, the recession of the shoreline was significant, amounting to 100 meters or so.

3. Long-term evolutions of shoreline and subaerial beach area

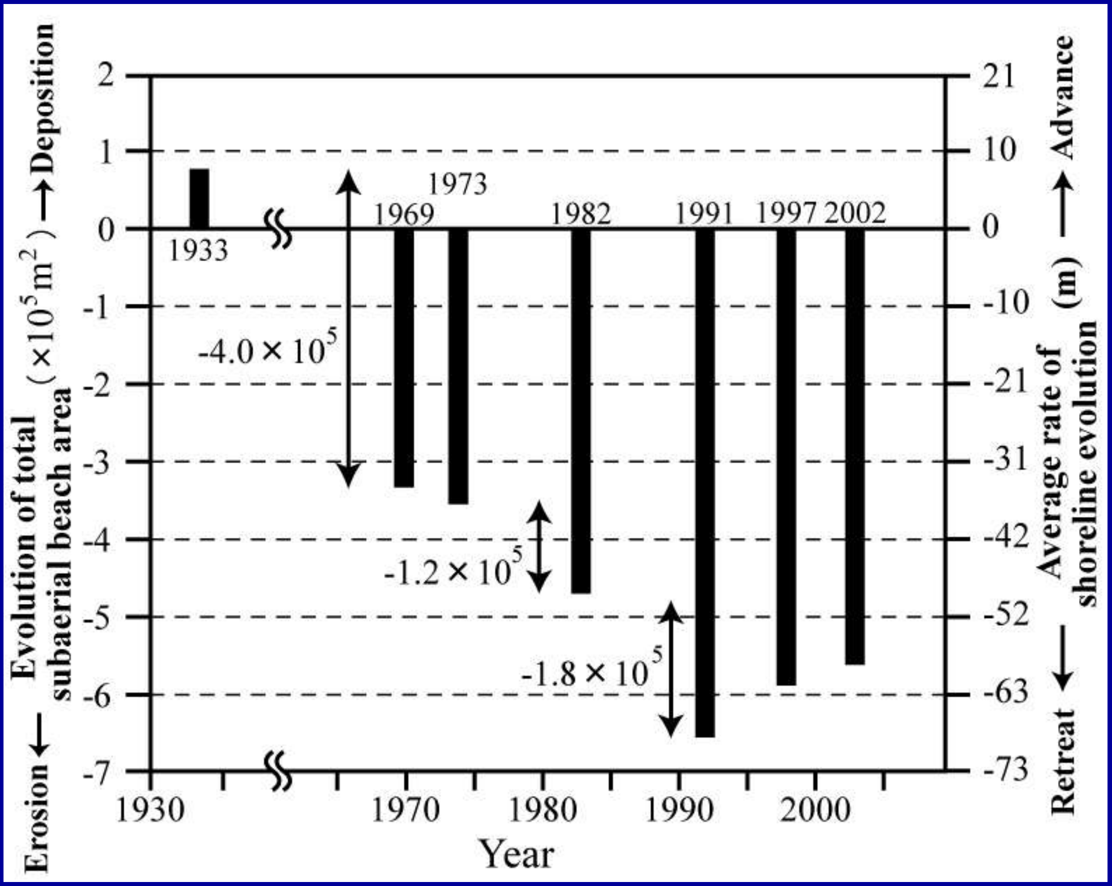


Fig. 03 Evolution of total subaerial beach

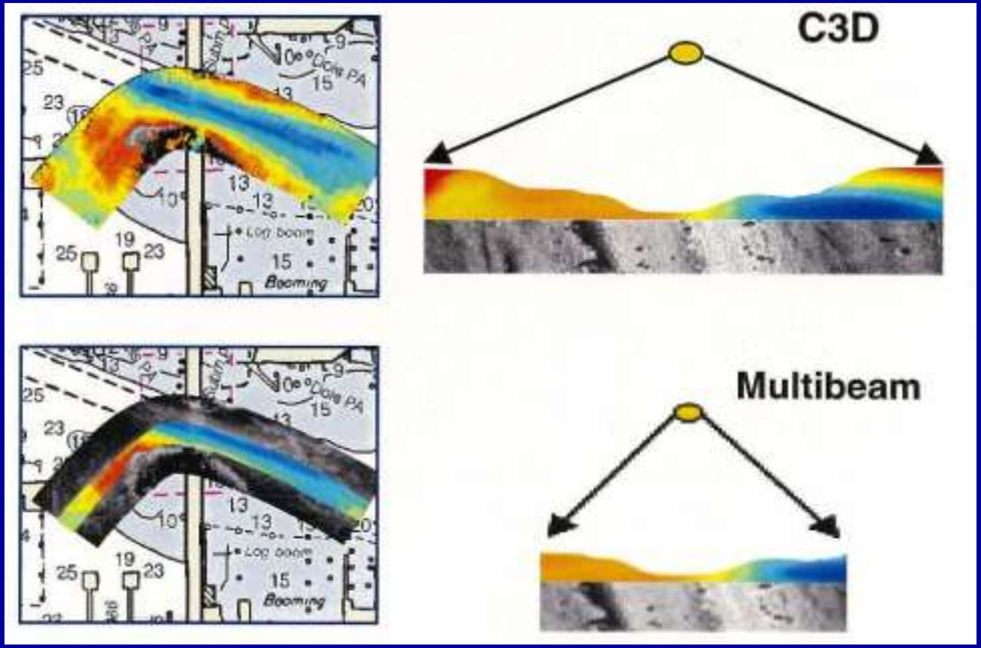
The question now arises as to how the seabed topography has evolved under the these circumstances

- Before 1960
  Natural beach
- After 1960
  Naoetsu Port has been developed rapidly
  ↓
  Shoreline had started to retreat
- In the period 1998-2005, substantial lengths of groins and shore-protection works were deployed.
  ↓
  Shoreline was fixed by structural measures (no sand beach left in most of the coastline)

4. High-resolution bathymetry using multibeam and side-looking echo sounding

Acoustic imagery
+
Bathymetry data

Fig.04 Multi-angle swath bathymetry system (C3D, Teledyne BENTHOS) mounted on broadside of boat



The swath width of C3D is wider than traditional multibeam bathymetry
↓
Topography in shallower depth area can measure effectively

Fig.05 A comparison with C3D (present method) and traditional multibeam bathymetry

4. High-resolution bathymetry using multibeam and side-looking echo sounding

:Performed on July 27-30, 2008

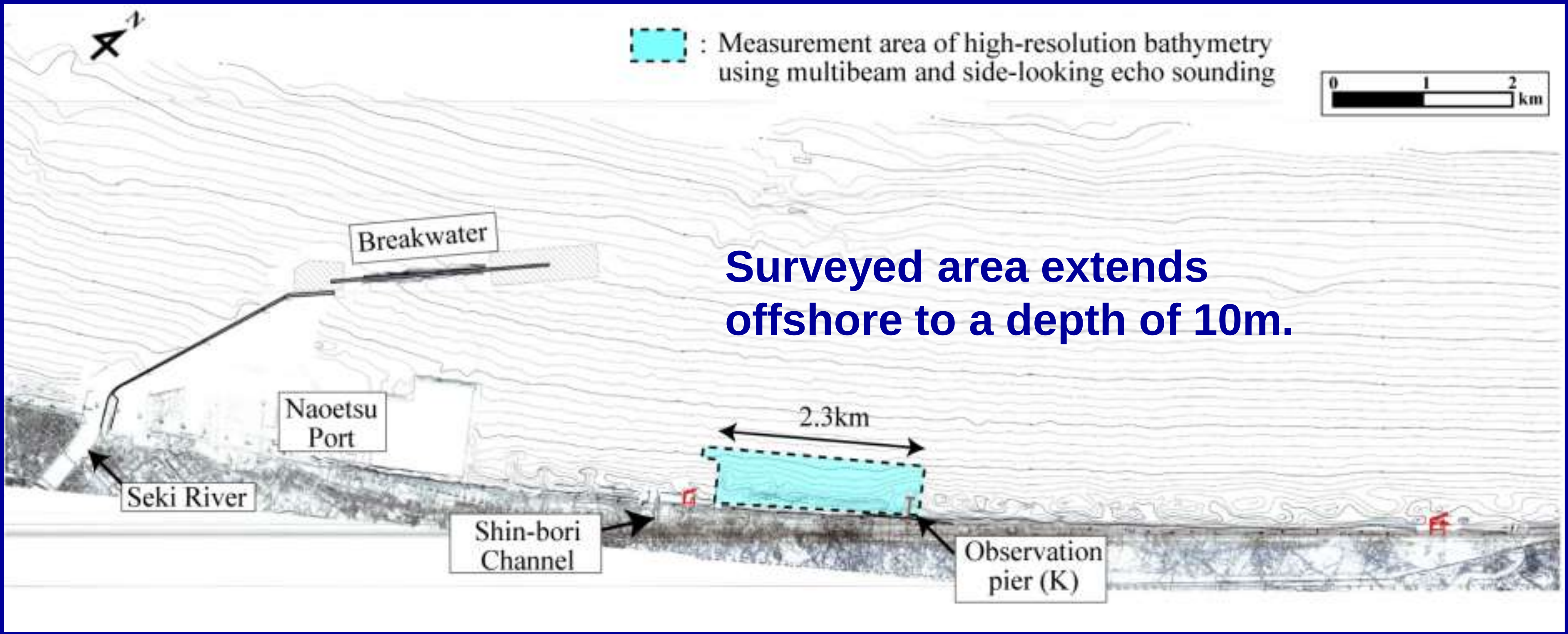


Fig. 06 Measurement area of high-resolution bathymetry

The bathymetry data was a cloud of points in three-dimensional coordinate space; with a horizontal grid spacing of 2m.

Photo 1: Serious beach erosion associated with severe winter storm from Jan. 27 to 30, 1989 (adapted from Hirano (2008)).

Photo 2: Affected seawall and slope due to severe winter storm (Photograph taken on Apr. 1, 2002: adapted from Hirano (2008)).

A large-scale erosional signature in the area offshore of the artificial reefs

This topo… eper
than clos… ast

A semi-circular large bar . Crest line of bar corresponded to the 7m depth.
Trough of the bar was 9m depth or more .

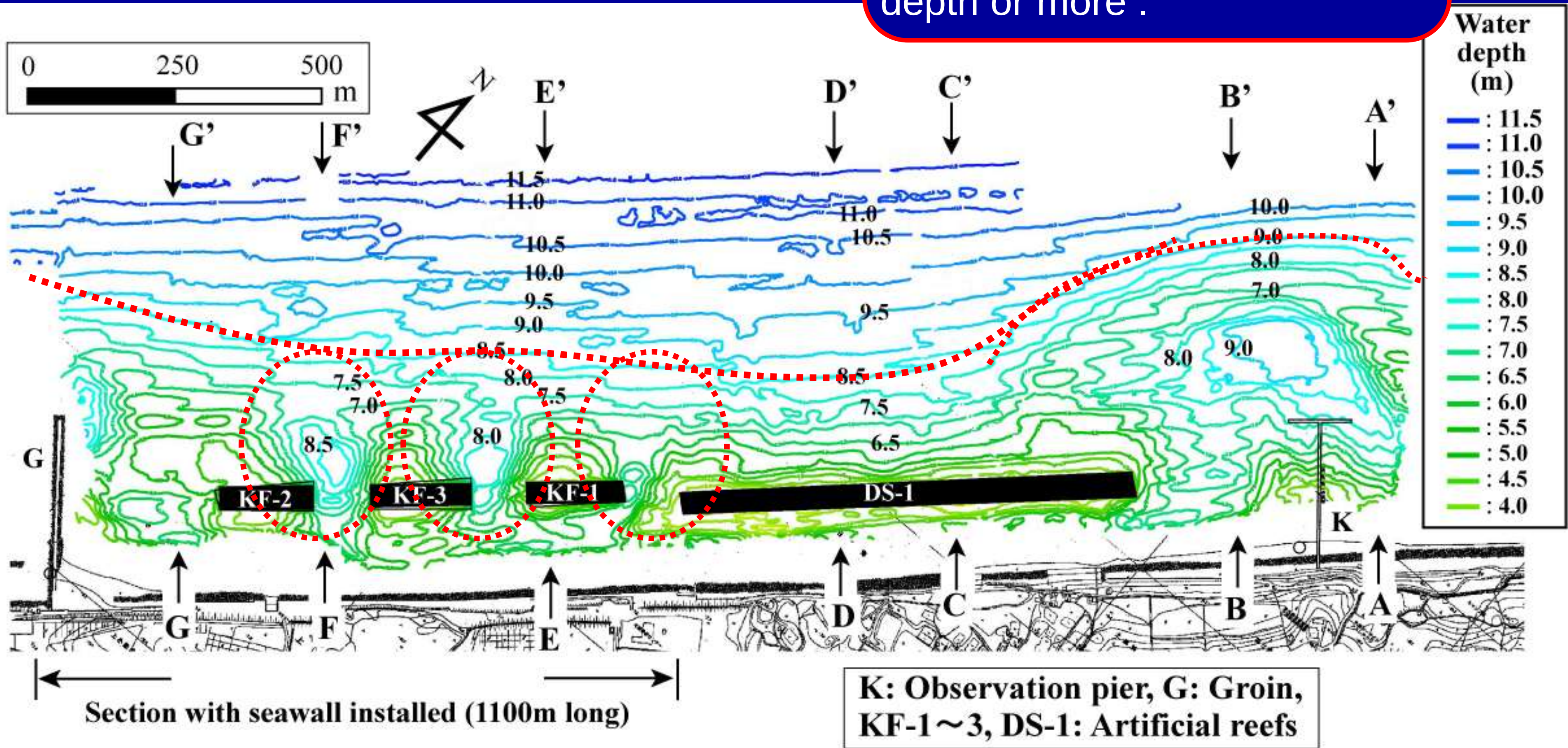


Fig. 07 Bathymetric chart in terms of multibeam and side-looking echo sounding: 0.5m as to contour interval

Local scouring in the gaps between the artificial reefs

Table 1 Results of sediment volume analysis by subbox model

	Volume evaluated ($\times 10^4 m^3$)
Dataset 1998	399
Dataset 2008	349
Volume of erosion	50

○The decadal loss of volume amounted to 50×10^4 m^3 (in the analyzed area of 100 ha)

○The corresponding rate of erosion per running meter alongshore was equal to 24 m^2/year on average

Let us employ a simple shoreline-retreat model with a constant closure depth

Using the assumed closure depth 8m, the rate of equivalent shoreline retreat was equal to 3m per year.

This order of erosion would bring about serious consequences, if no provisions for shore protection were operational.

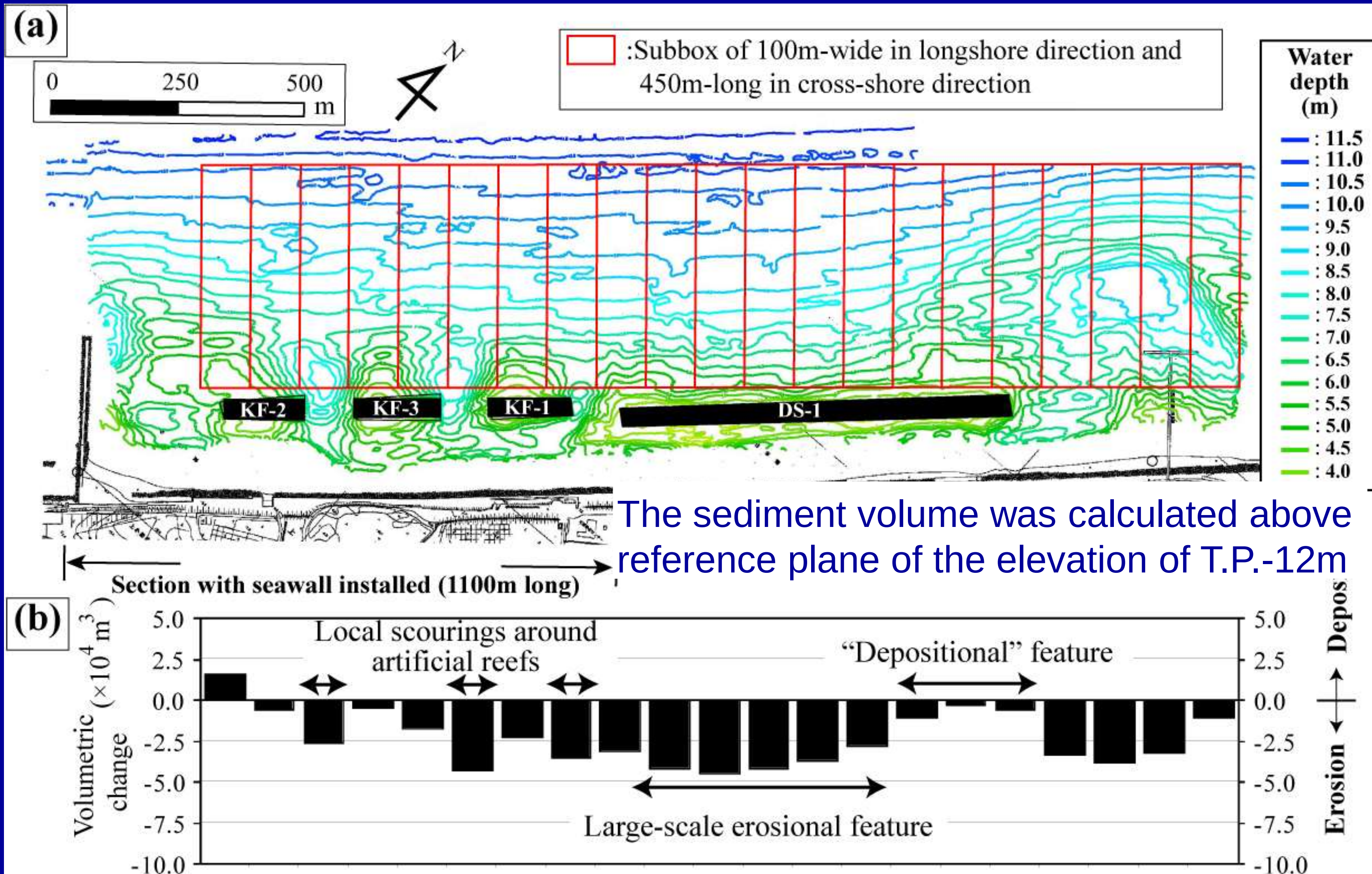
8. **Conclusions**

The principal conclusions of this study drawn are as follows:

- **The 9.6km-long section** of the Joetsu Coast underwent the **significant retreat of shoreline**, but that the shoreline location **thereafter** has essentially **stayed fixed by deployment of the extensive countermeasures**.
- The sediment budget analysis has permitted the **recent decadal loss of sediment to be evaluated at $50 \times 10^4 m^3$**.

- The marked local scouring in the gaps between the artificial reefs implies **the occurrence of strong water motions through them during storms**. However, there were no apparent signatures of accretion behind the artificial reefs, which could otherwise add to the safety of the shoreline structures such as the vertical concrete seawall.

6. Sediment budget analysis in a littoral cell



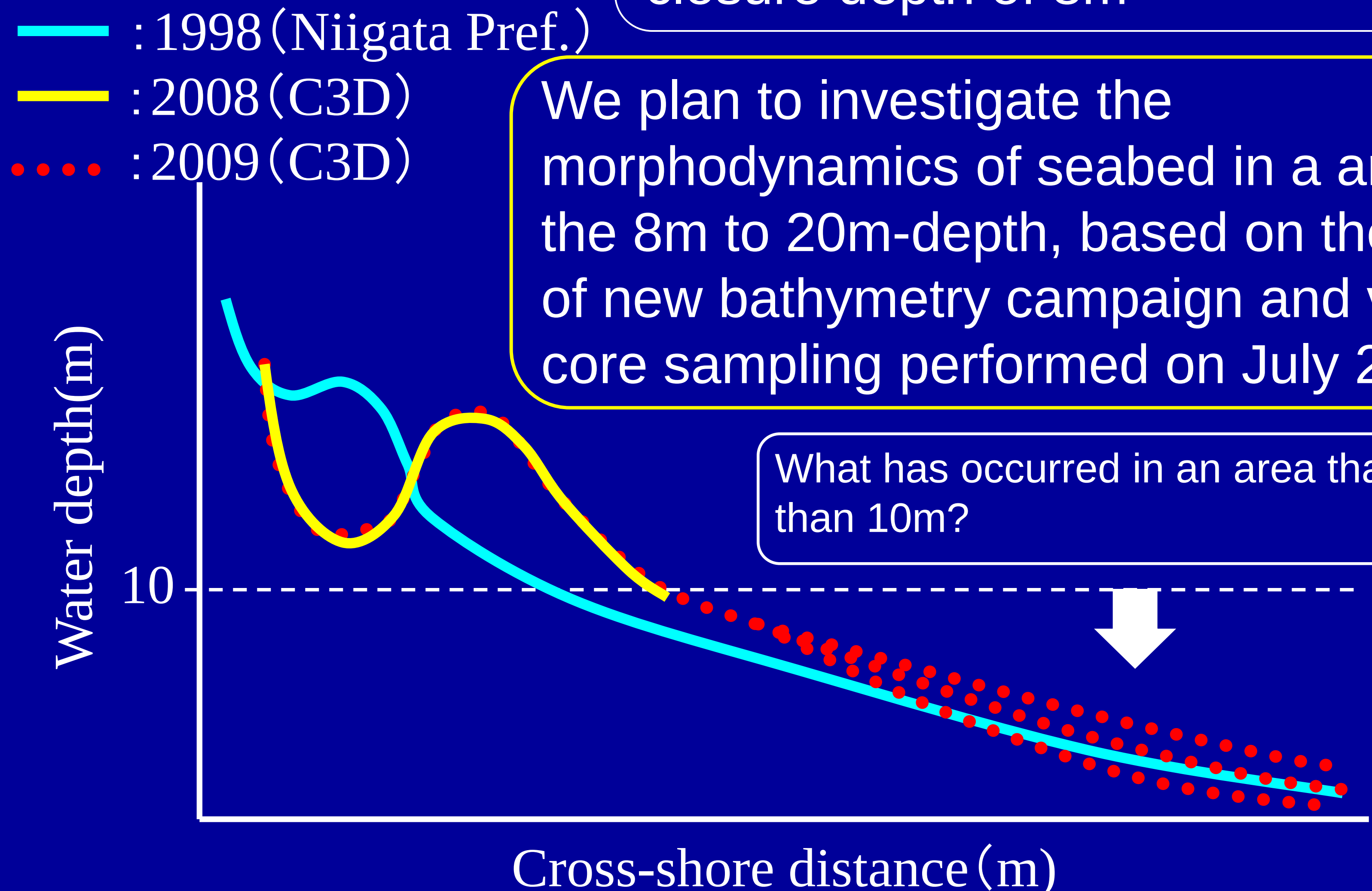
The sediment volume was calculated above reference plane of the elevation of T.P.-12m

Fig. 10 Sediment budget analysis by means of a box model; (a) arrangement of subboxes and (b) alongshore distribution of sediment volumetric changes

7. Future perspectives

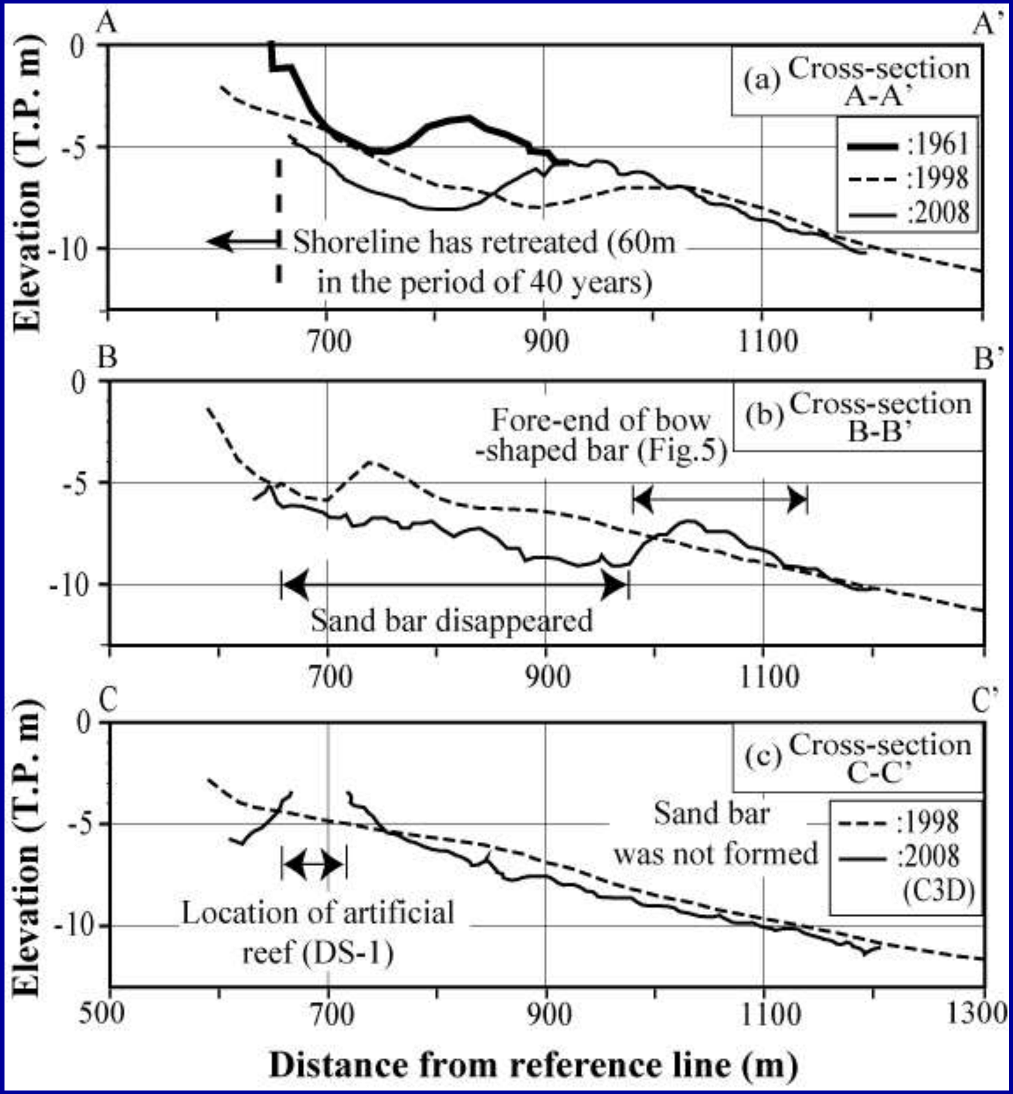
The topographical change of seabed was occurred in a deeper area than closure depth of 8m

We plan to investigate the morphodynamics of seabed in a area from the 8m to 20m-depth, based on the results of new bathymetry campaign and vibro-core sampling performed on July 2009 .



We want to reexamine the meaning of the closure depth of topographical change.

5. Features of seabed topographical evolution

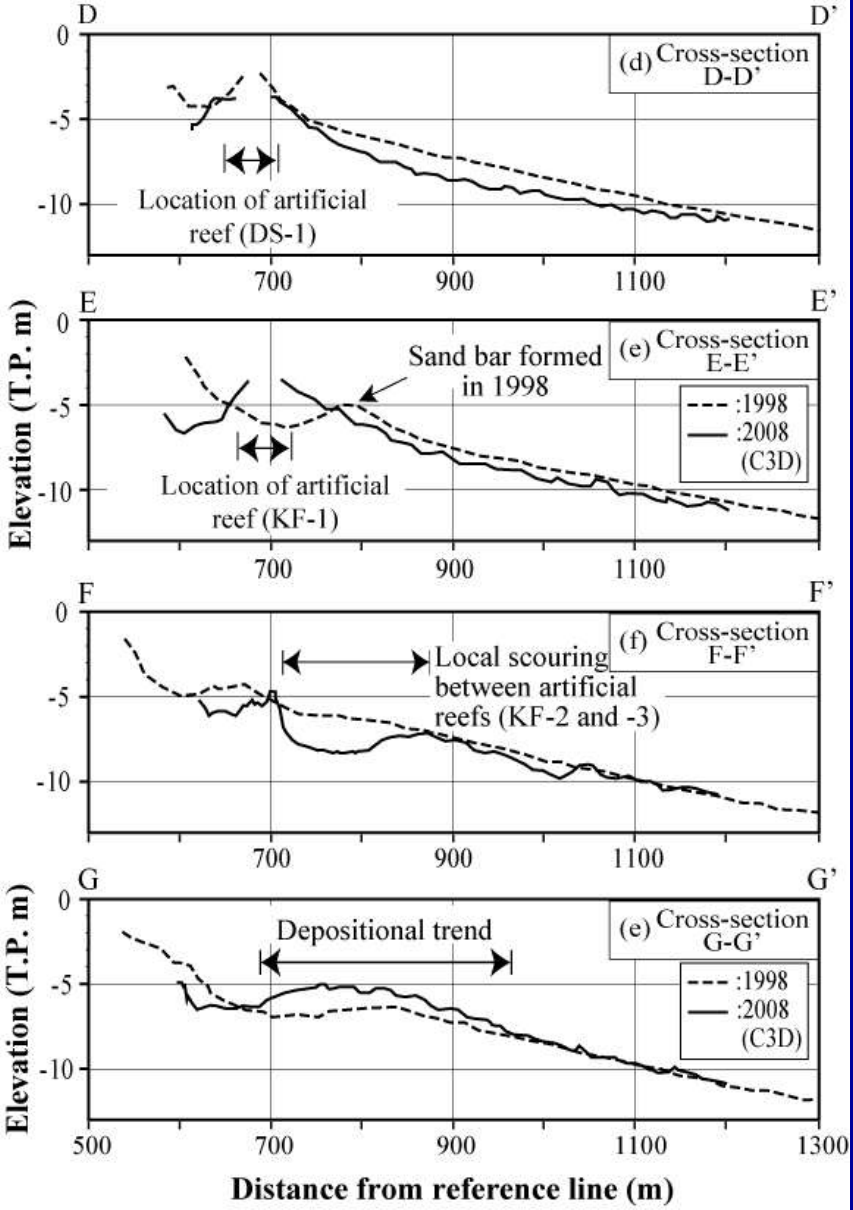


(a): through the site of the gas exploitation pier (demolished in 1986) of the Teikoku Oil Co., Ltd.

(b): through the large semi-circular bar (Fig.07)

(c): through the artificial reef of DS-1

Fig.08 Comparison of the beach cross-section profiles between the high-resolution bathymetry results(2008) and traditional bathymetry results(1998)



(d): through the artificial reef of DS-1

Sand bar was not formed at the offshore area of artificial reef

(e): through the artificial reef of KF-1

(f): through a space between the artificial reefs of KF-2 and -3

(g): through a space between the groin (G) and artificial reef of KF-2

Fig.09 Comparison of the beach cross-section profiles between the high-resolution bathymetry results(2008) and traditional bathymetry results(1998)

5. 高解像度海底地形計測

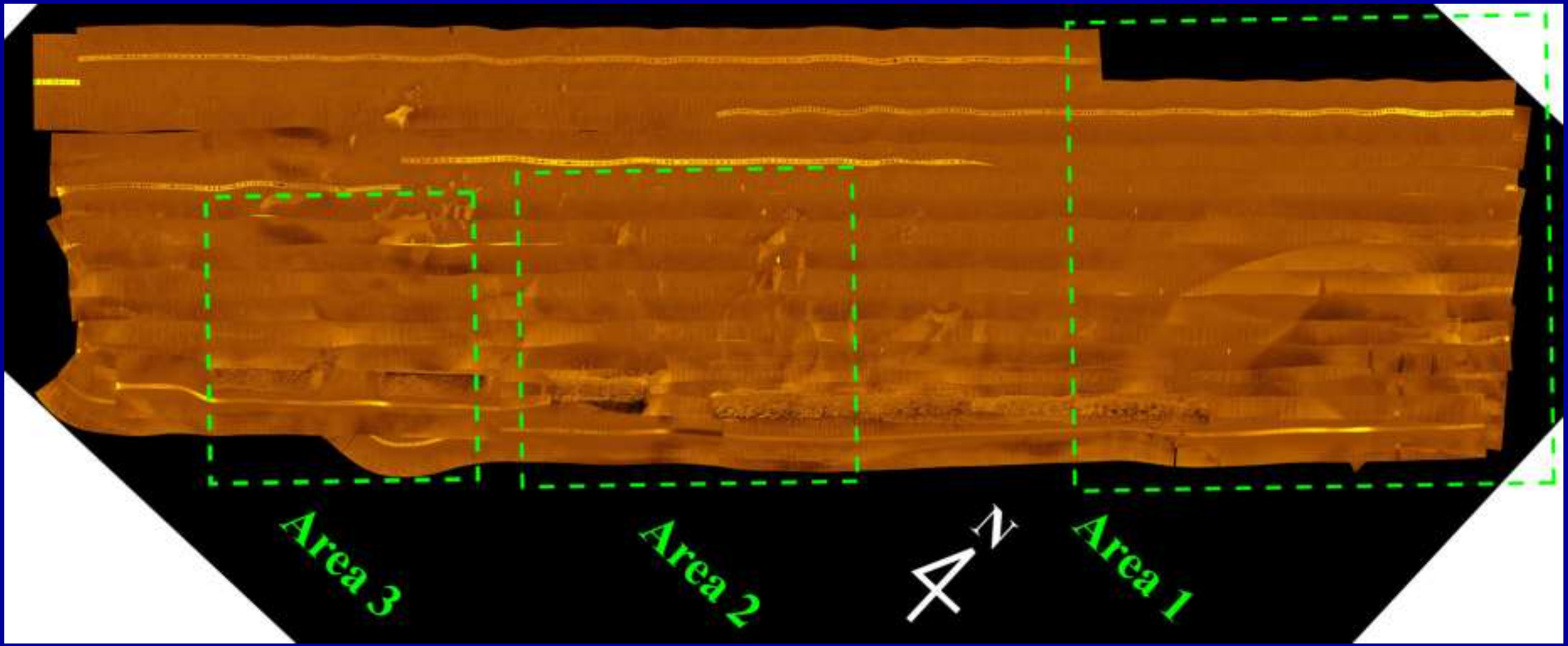
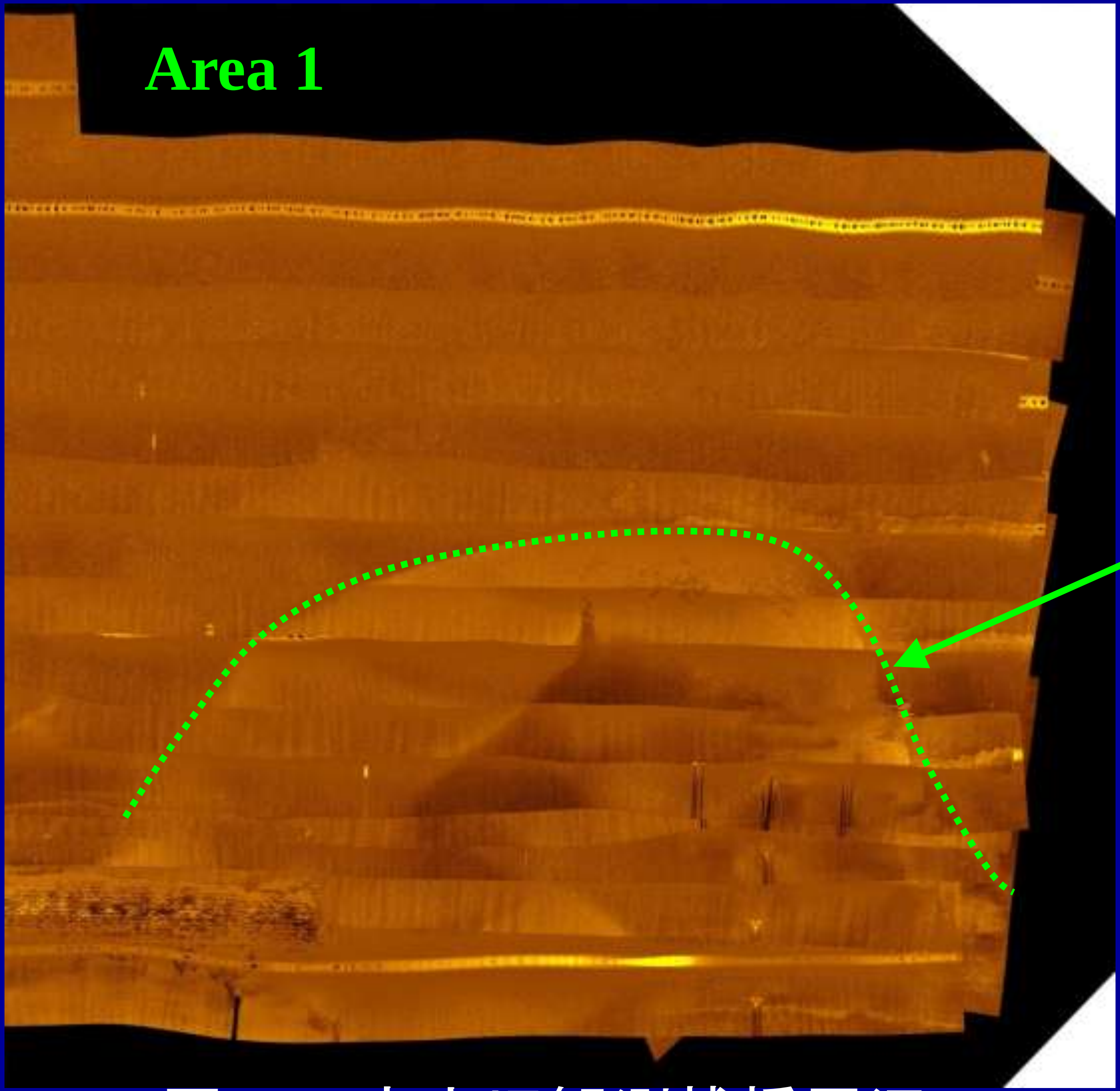


図15　高解像度海底地形音響画像（全体図）

5. 高解像度海底地形計測



大規模な弓状堆積地形が確認できる.

図16　京大旧観測桟橋周辺の海底地形音響画像(拡大図)

5. 高解像度海底地形計測

Area 2

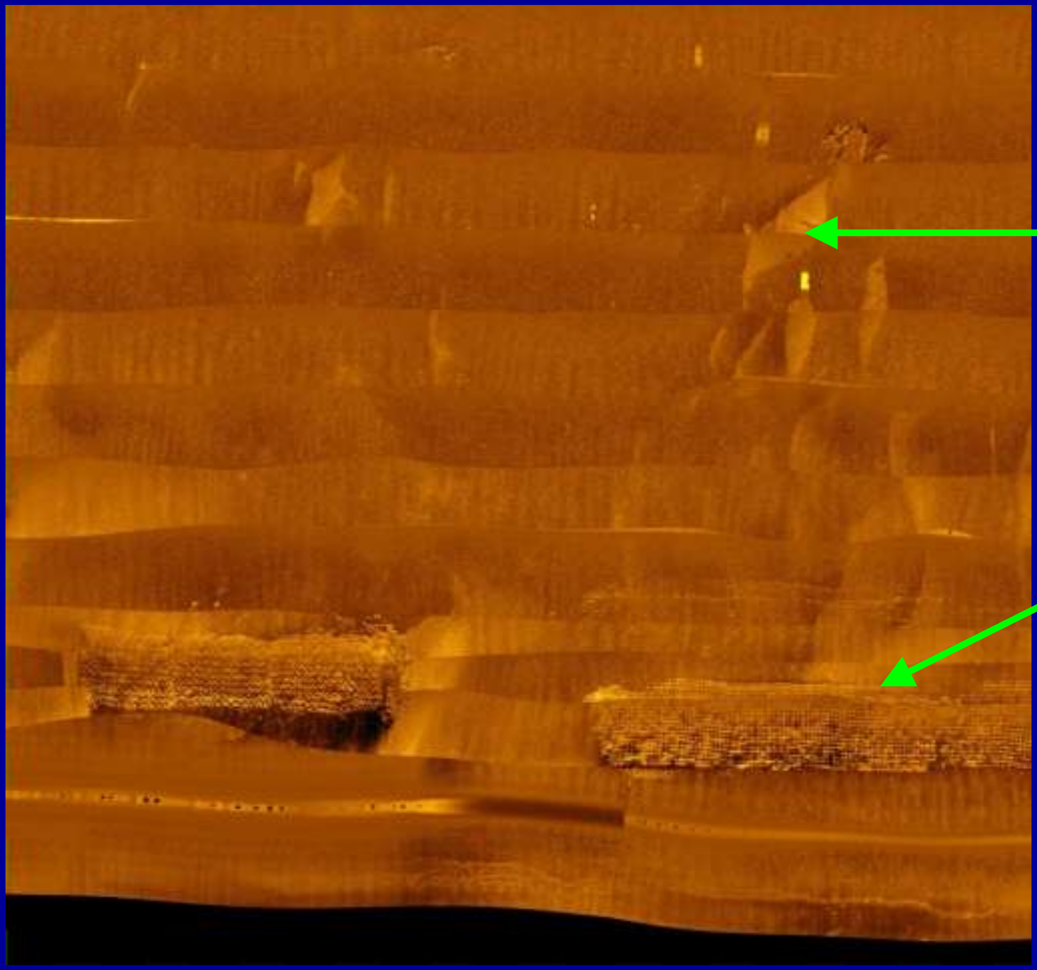
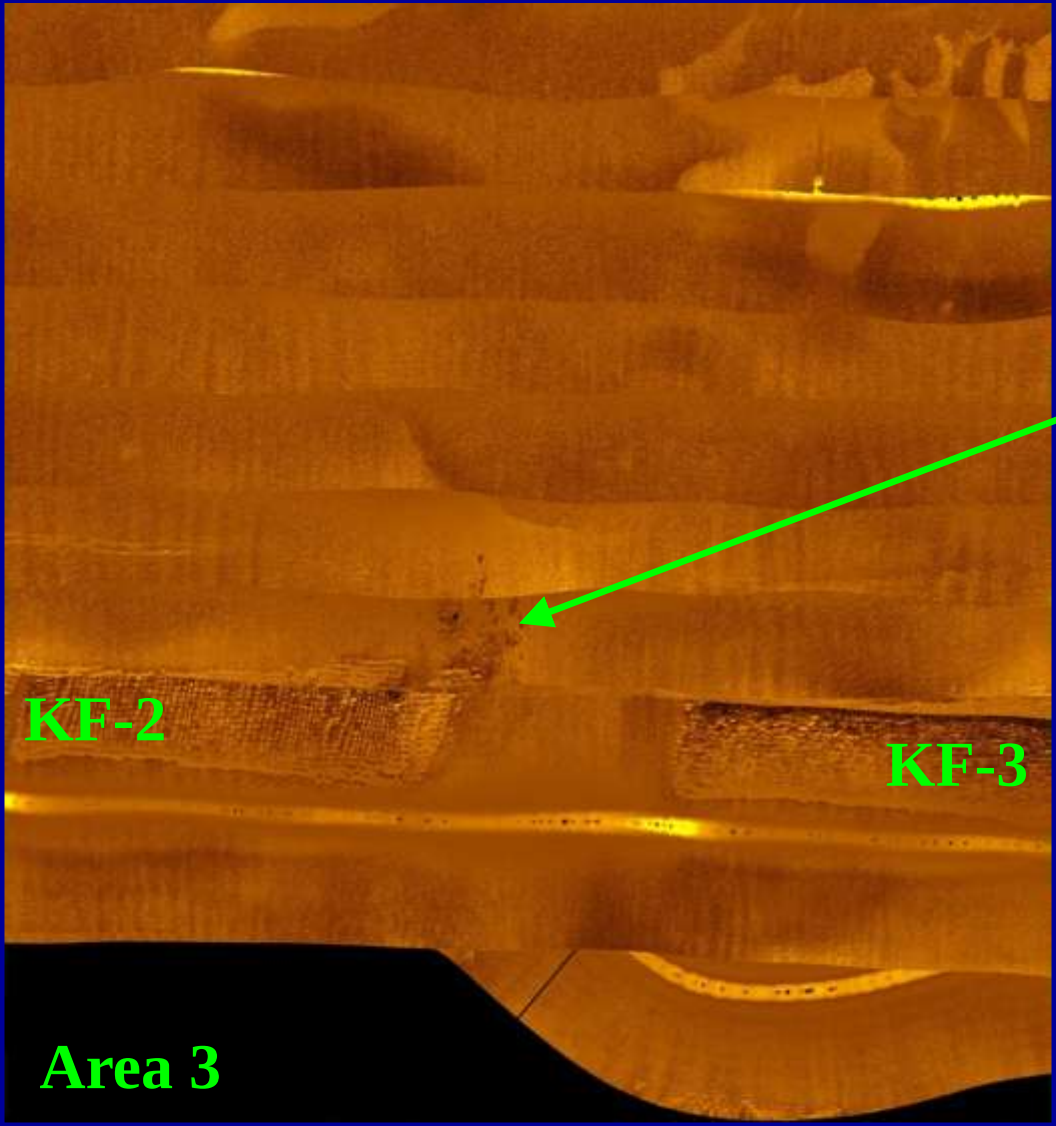


図17　人工リーフ(DS-1, KF-1)周辺の
海底地形音響画像(拡大図)

5. 高解像度海底地形計測



人工リーフのブロックが散乱しているのが確認できる.

図18　人工リーフ(KF-3, KF-2)周辺の
海底地形音響画像(拡大図)