Postseismic crustal movement of the 2011 Tohoku Earthquake and its impacts on hydrographic surveys and charts

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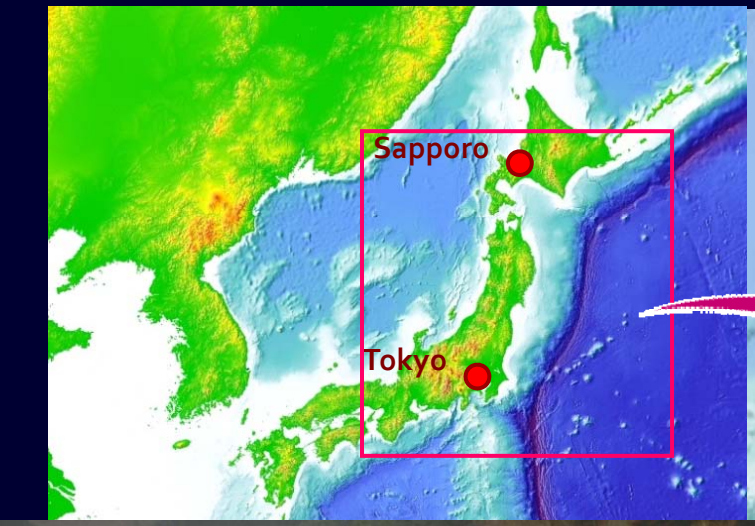
2. Issues related to postseismic crustal movement and JHOD's actions

2011 Tohoku Earthquake



North American Plate

Kuril-Kamchatka Trench

Tohoku Region

focal region

Shiogama

Sendai

M9.0

11 March 2011

Nuclear Power Plant

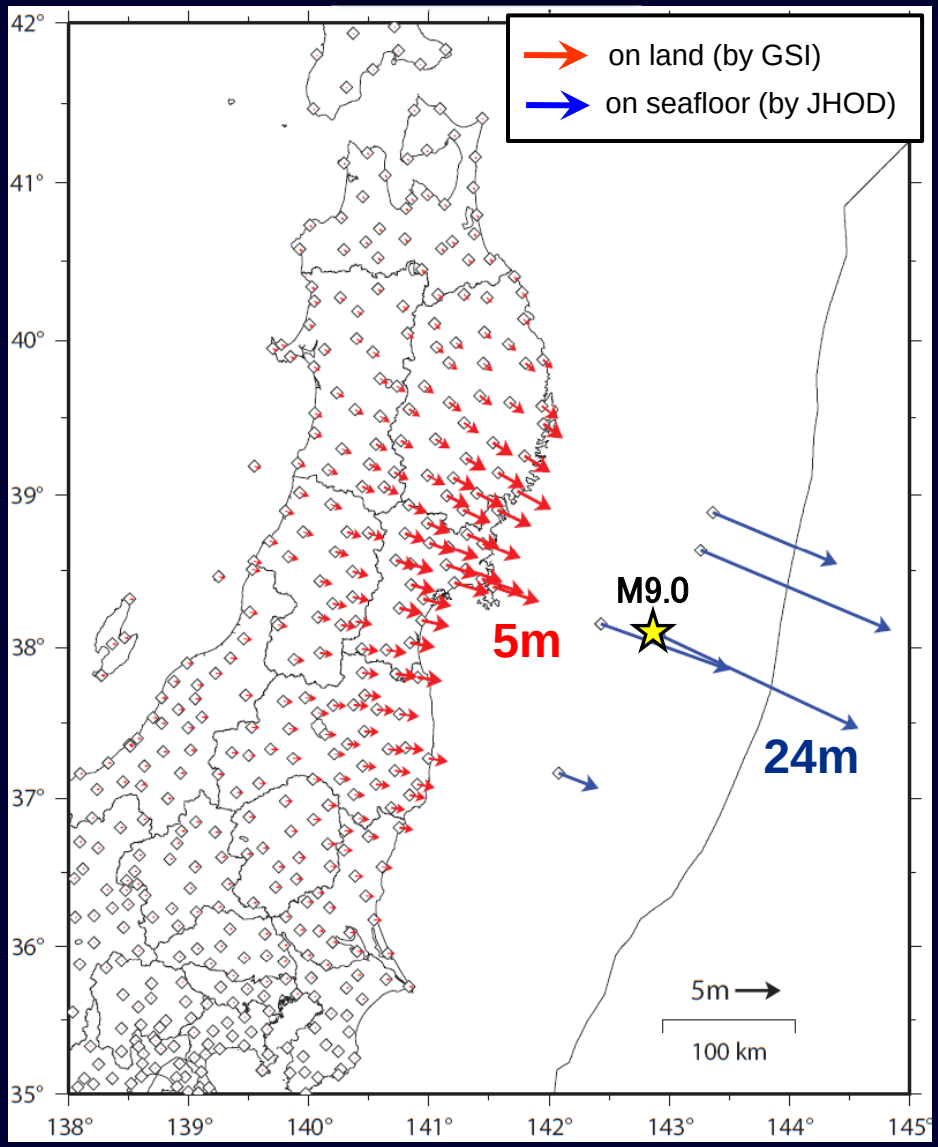
Japan Trench

Tokyo

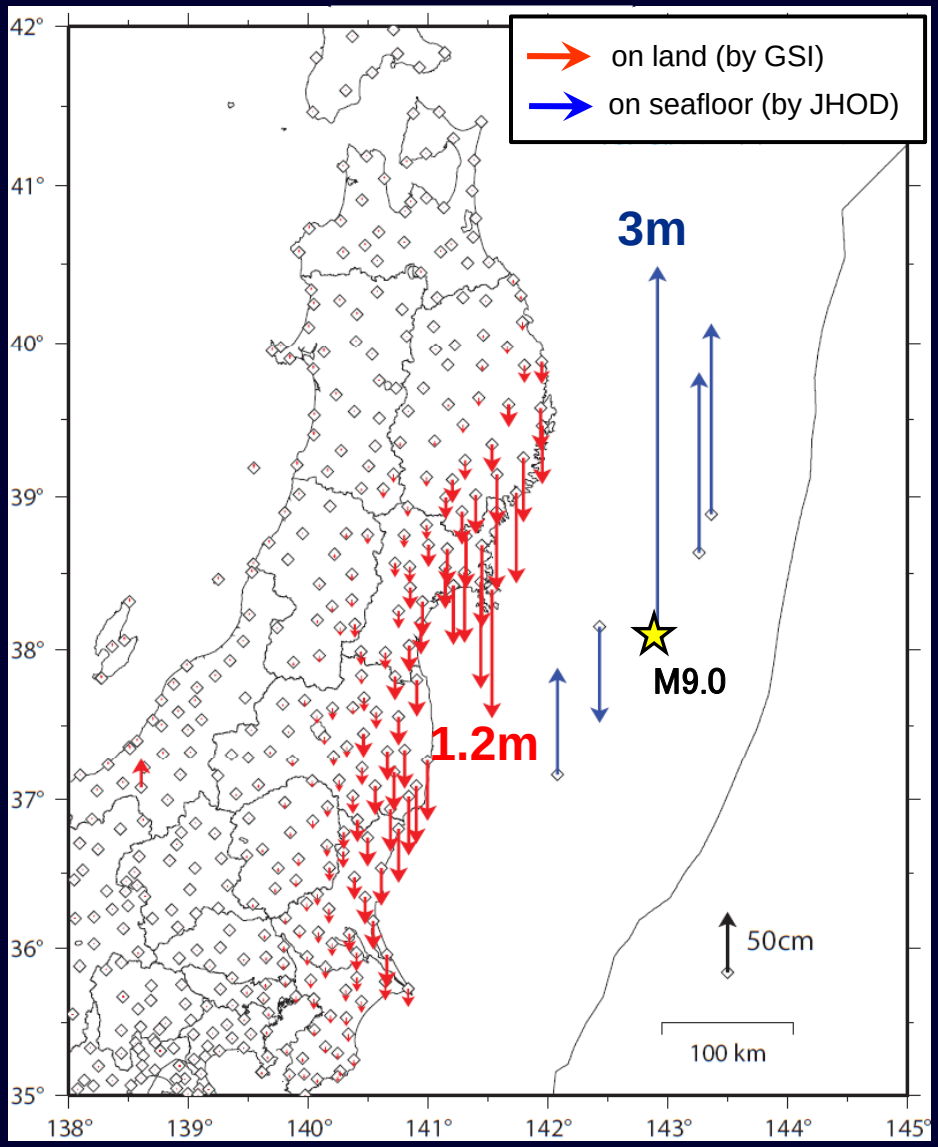
Pacific Plate

Coseismic movement

Horizontal



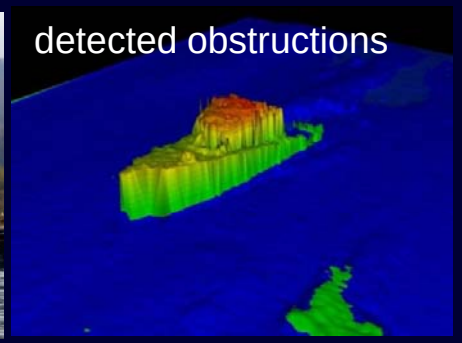
Vertical



JHOD's Responses

1. Phase 1 (March - April 2011)

Obstruction surveys for re-opening damaged ports



All the ports were re-opened **within 15 days** after the earthquake.

2. Phase 2 (May 2011 -)

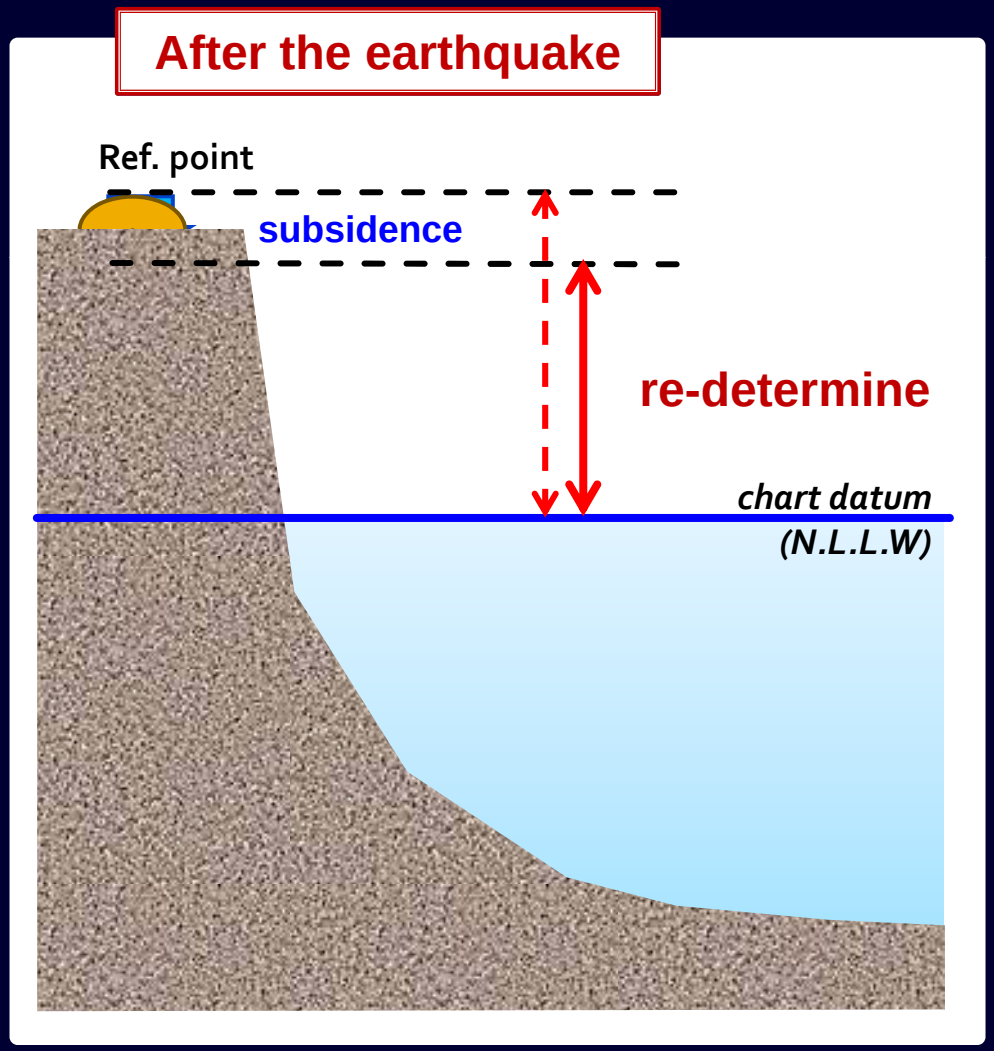
Hydrographic surveys for chart revision

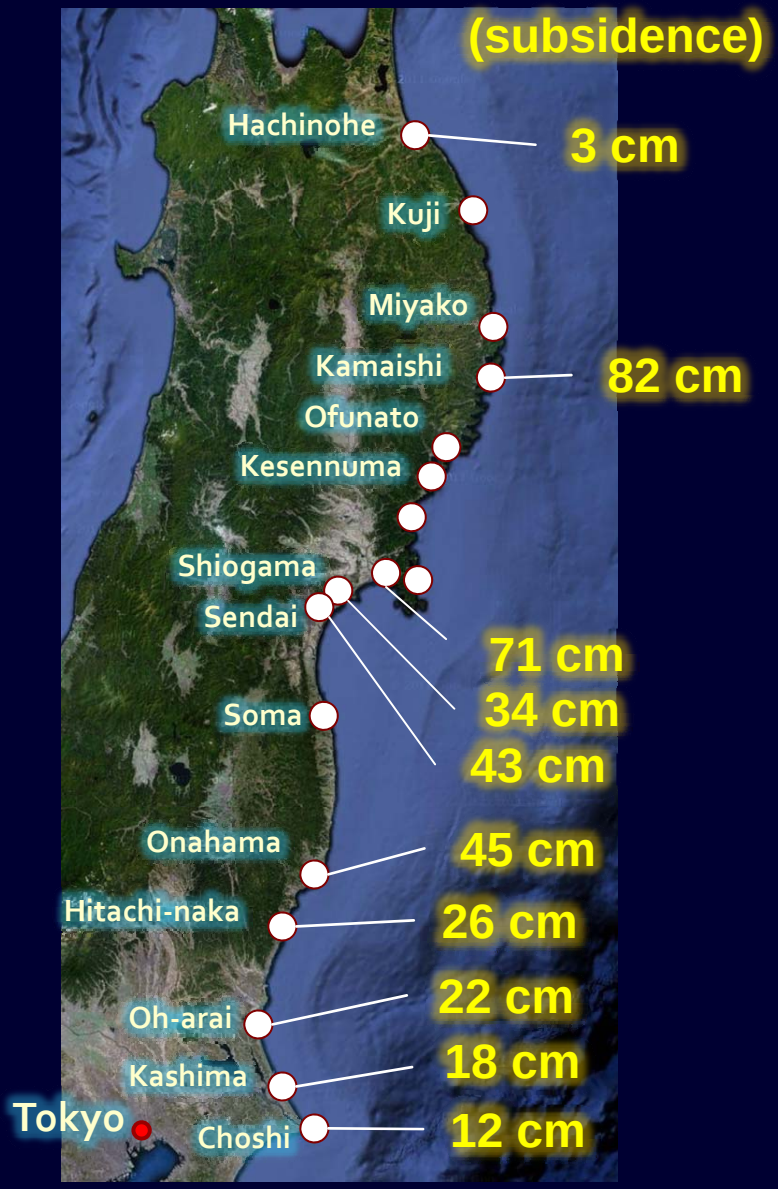
1st stage : high-priority areas in a port

2nd stage: other areas in a port

Re-determination of chart datum levels

"CDL-11"
= postseismic chat datum level determined in 2011





1st-stage survey:
high-priority areas in a port

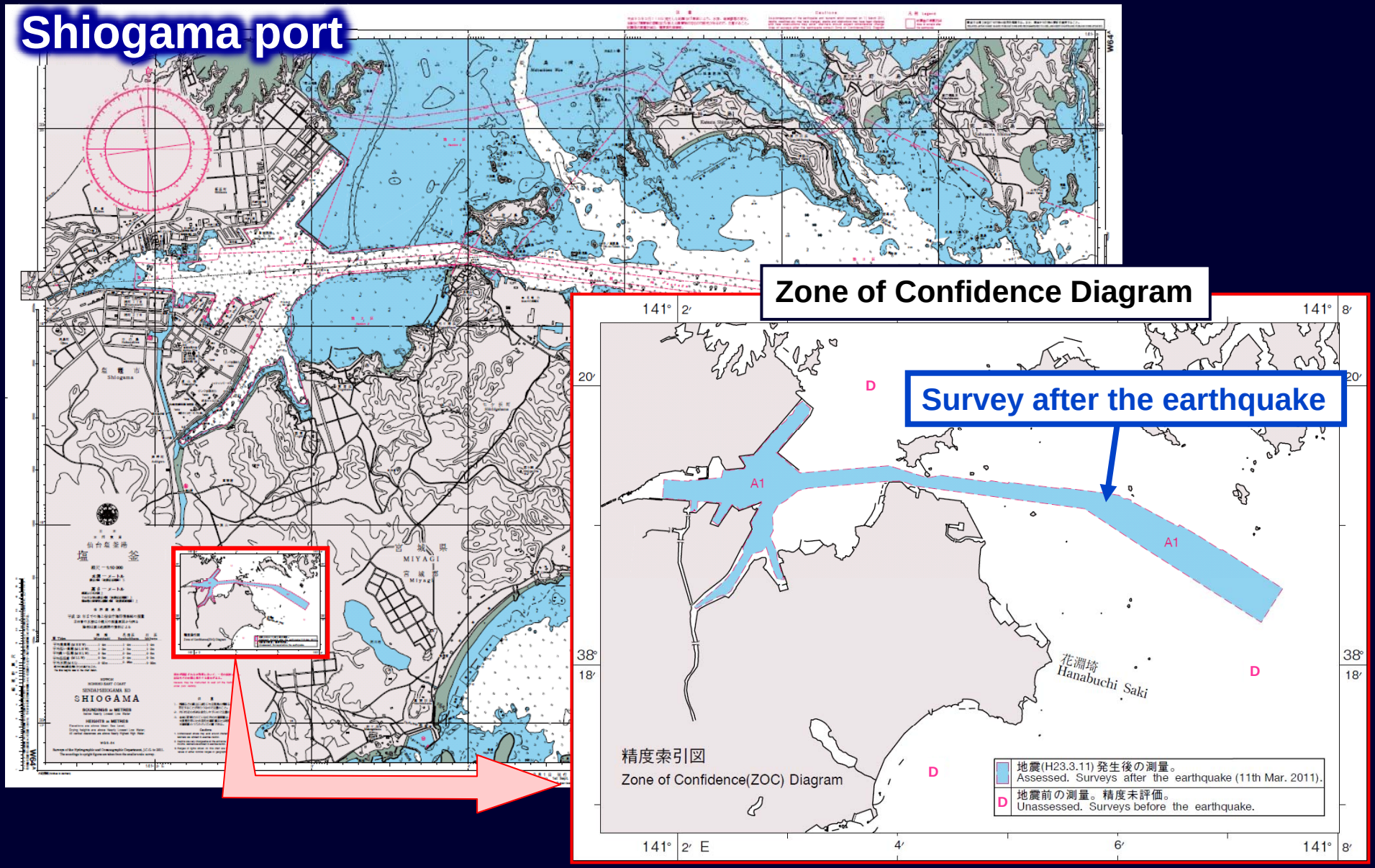
(May-June 2011)

Shiogama port

SEABEAM 1180

SEABAT 8125

New edition chart (Sep. 2011)



2nd-stage survey: other areas in a port

Shiogama Port

surveyed (2012)

surveyed (2011)

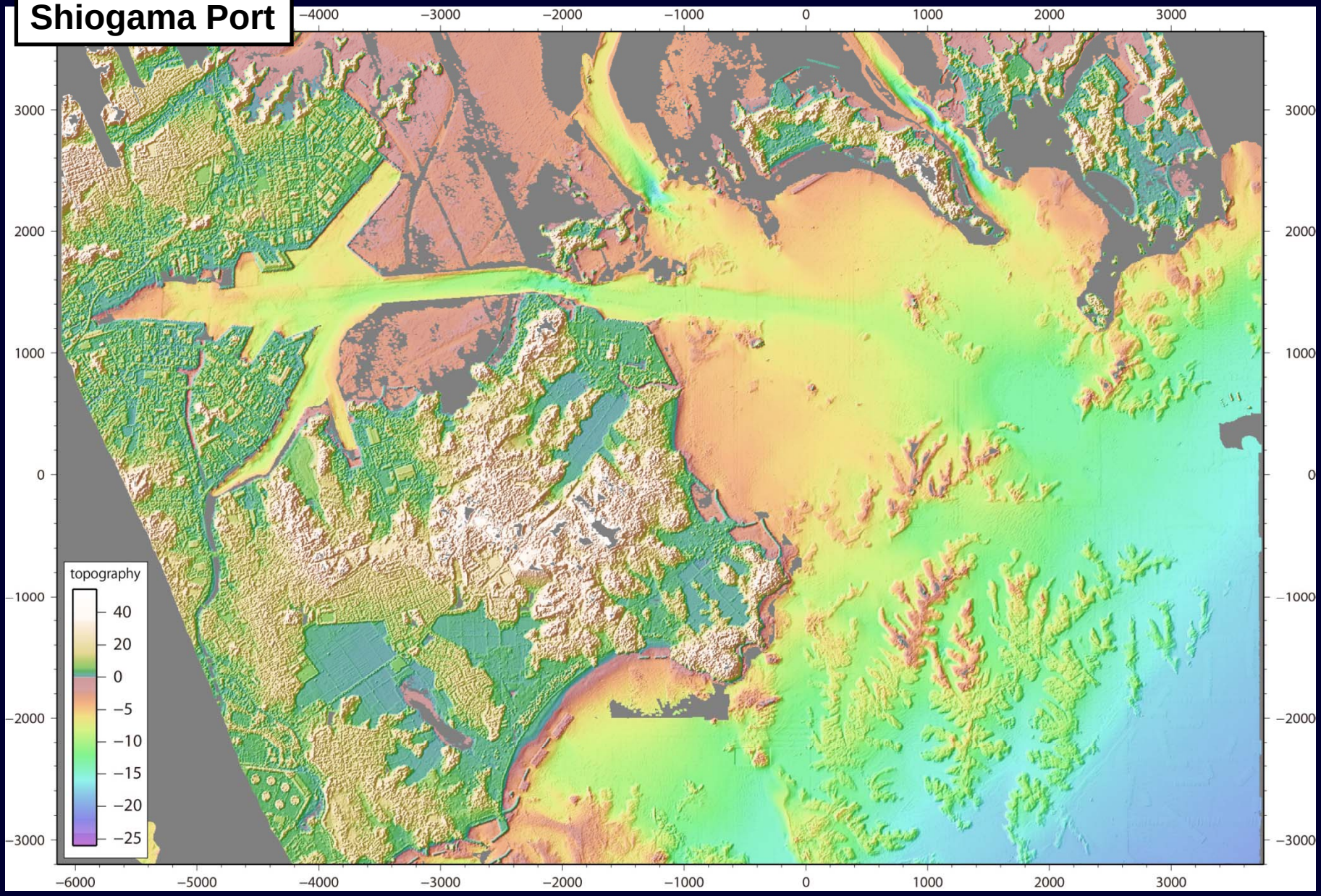
surveyed (2011)

Airborne Lidar survey (2011-12)
Areas shallower than the water depth of ~3 m:

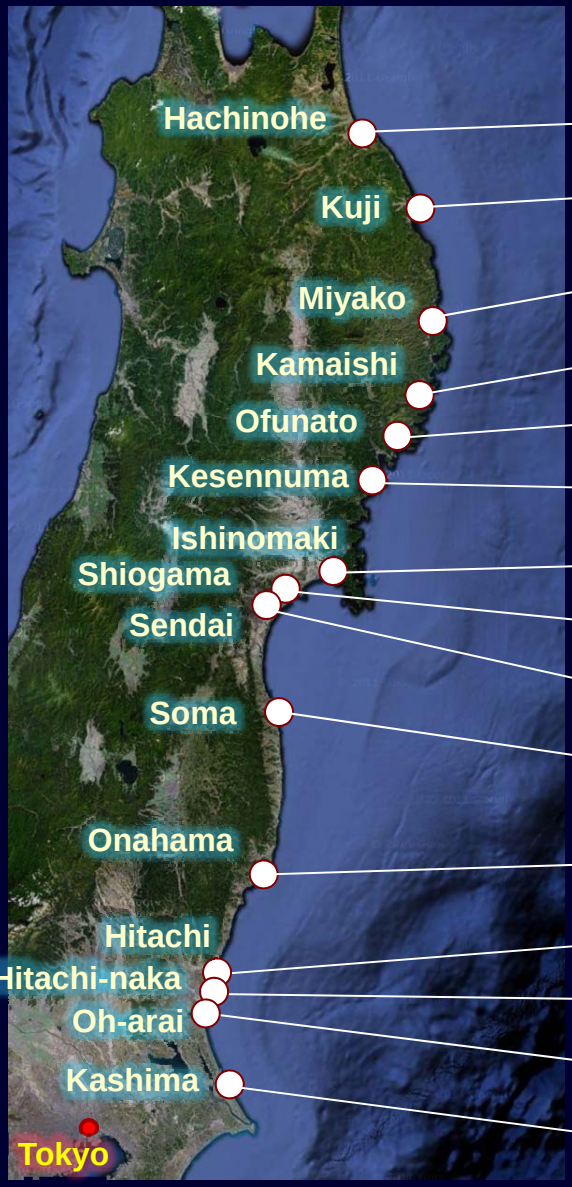
surveyed by other organization (2011)

surveyed (2012)

All data merged (June 2012)



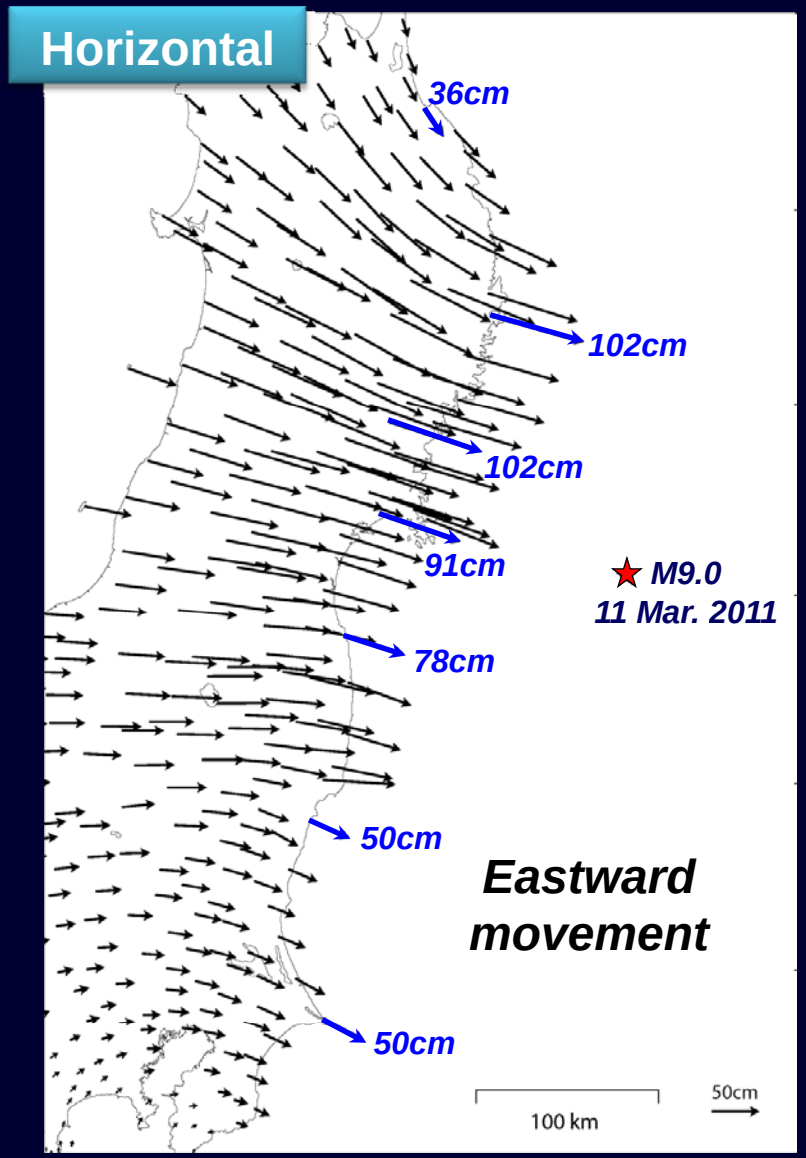
Progress as of Oct. 2013

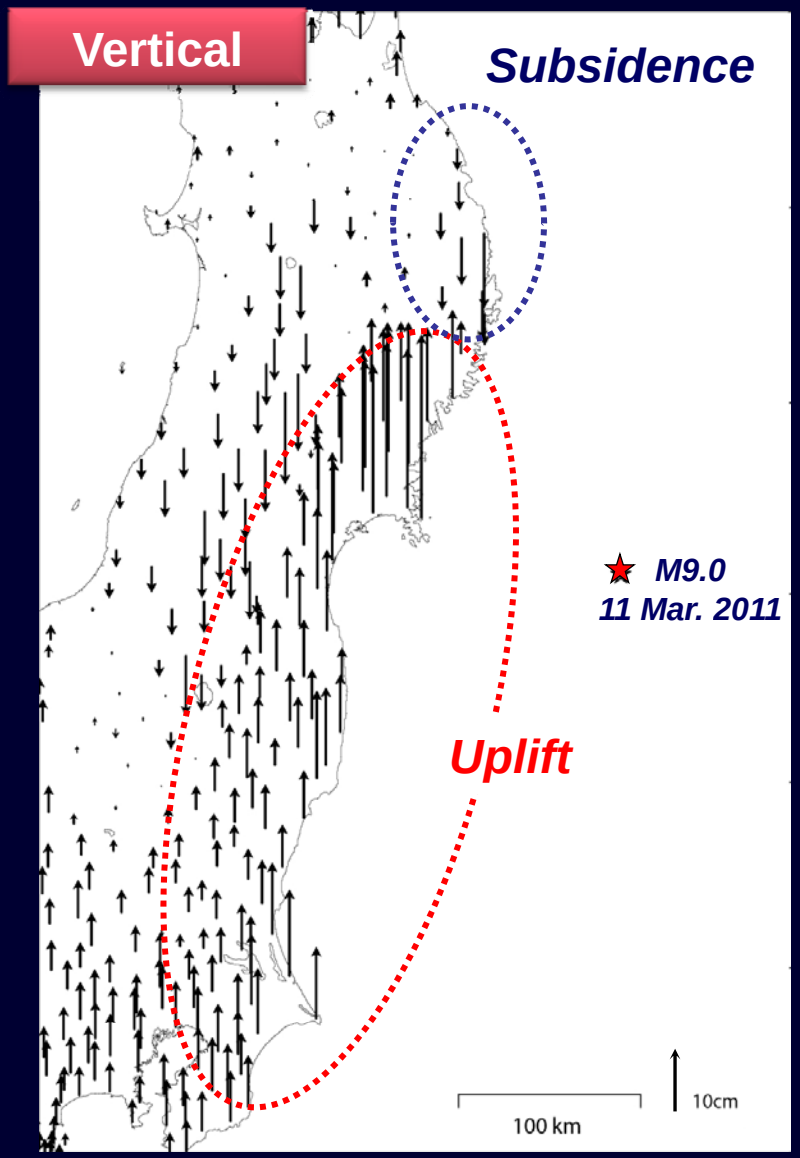


	2nd-stage survey completion	2nd-round chart revision
Hachinohe	FY2012	*FY2013*
Kuji	*FY2013*	*FY2014 -2015*
Miyako	*completed in the 1st stage*	
Kamaishi	*FY2014*	
Ofunato	FY2012	
Kesennuma	*FY2013*	*FY2013*
Ishinomaki	FY2012	Sep. 2013
Shiogama	FY2012	*FY2013*
Sendai	FY2012	*FY2013*
Soma	*FY2013*	*FY2014 - 2015*
Onahama	*FY2013*	
Hitachi	FY2012	*FY2013*
Hitachi-naka	FY2012	*FY2013*
Oh-arai	FY2012	FY2012
Kashima	FY2012	*FY2014*

Postseismic movement (GEONET)

total displacement from 12 Mar. 2011 to Aug. 2013

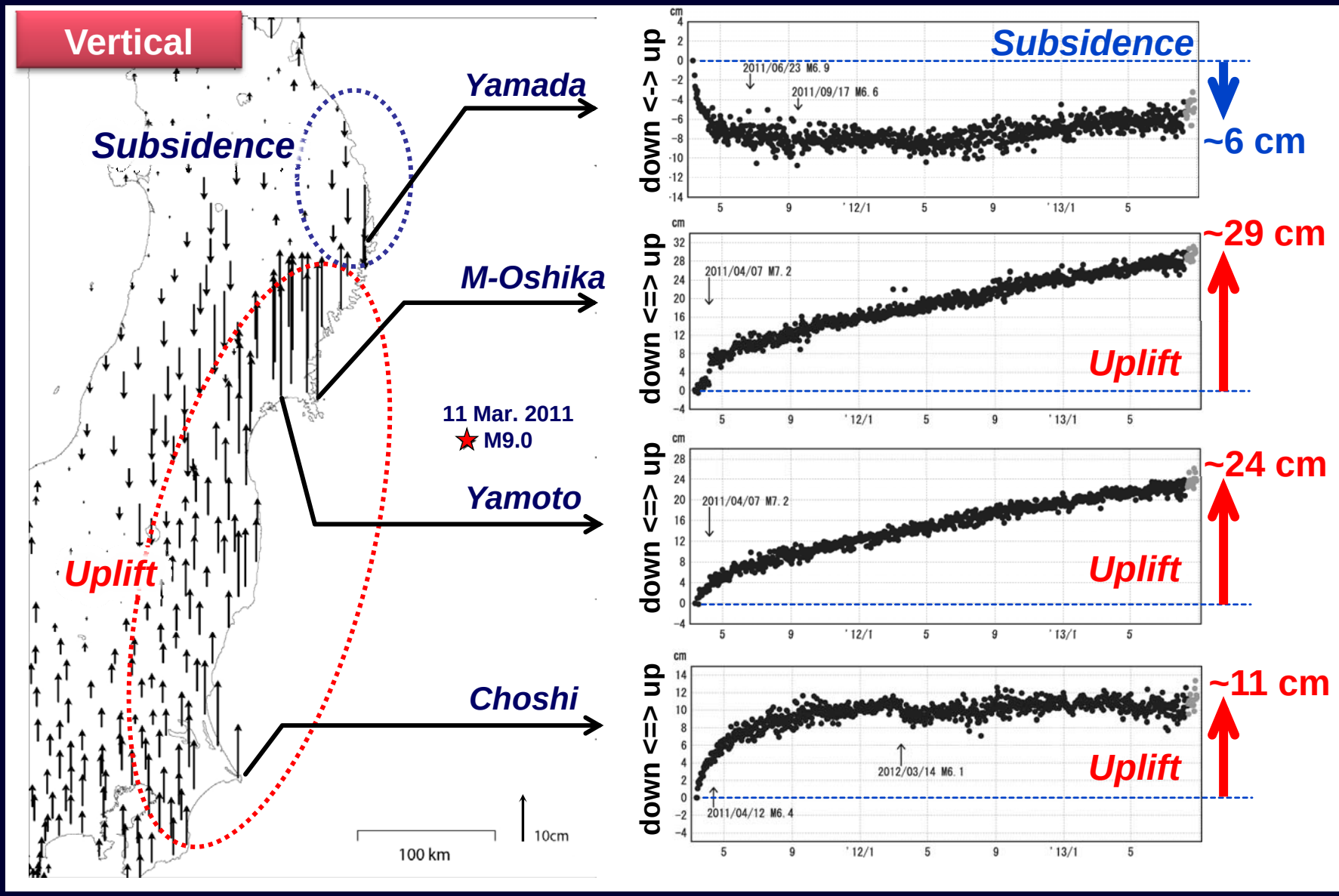




Data: GPS network “GEONET” (by GSI)

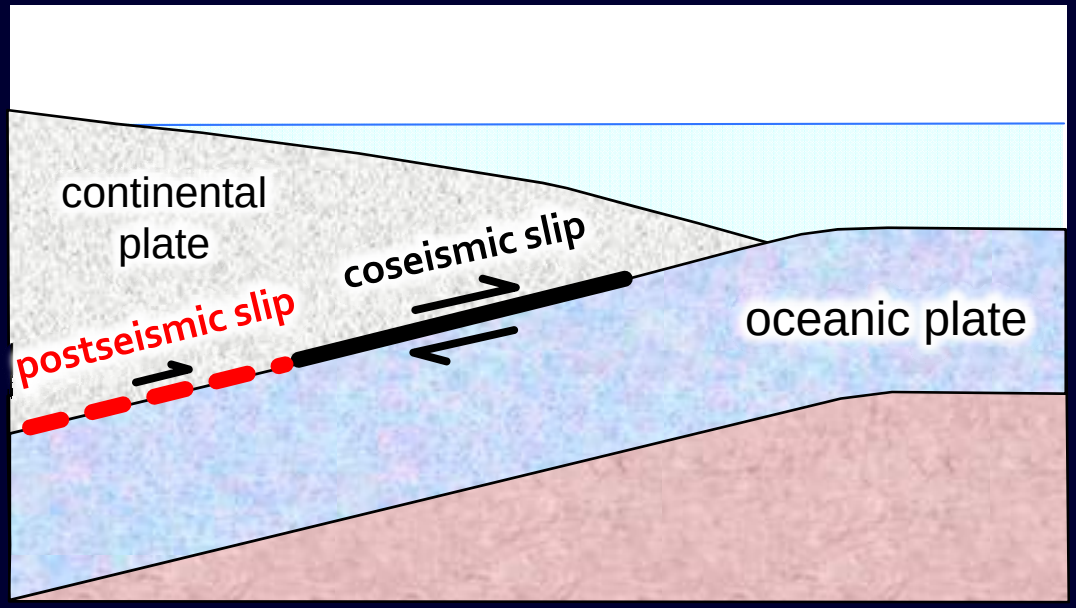
Time series of displacement

Period: 12 March 2011 to August 2013



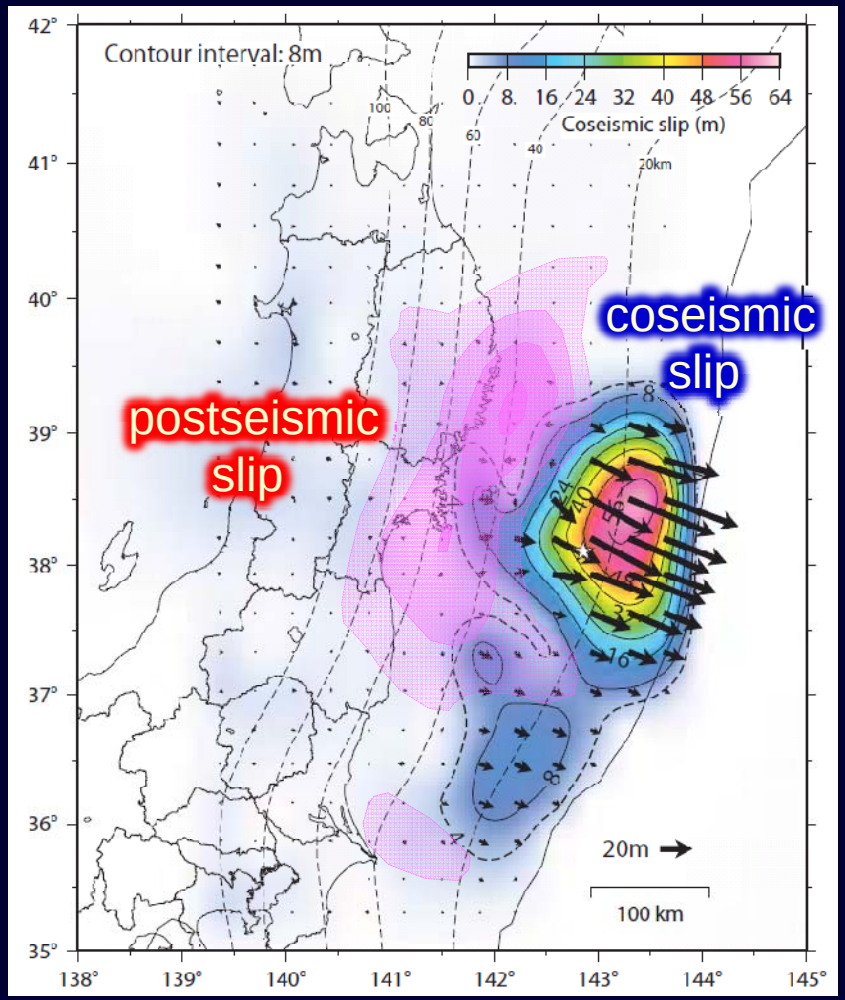
Data: GPS network "GEONET" (by GSI)

Mechanism of postseismic movement



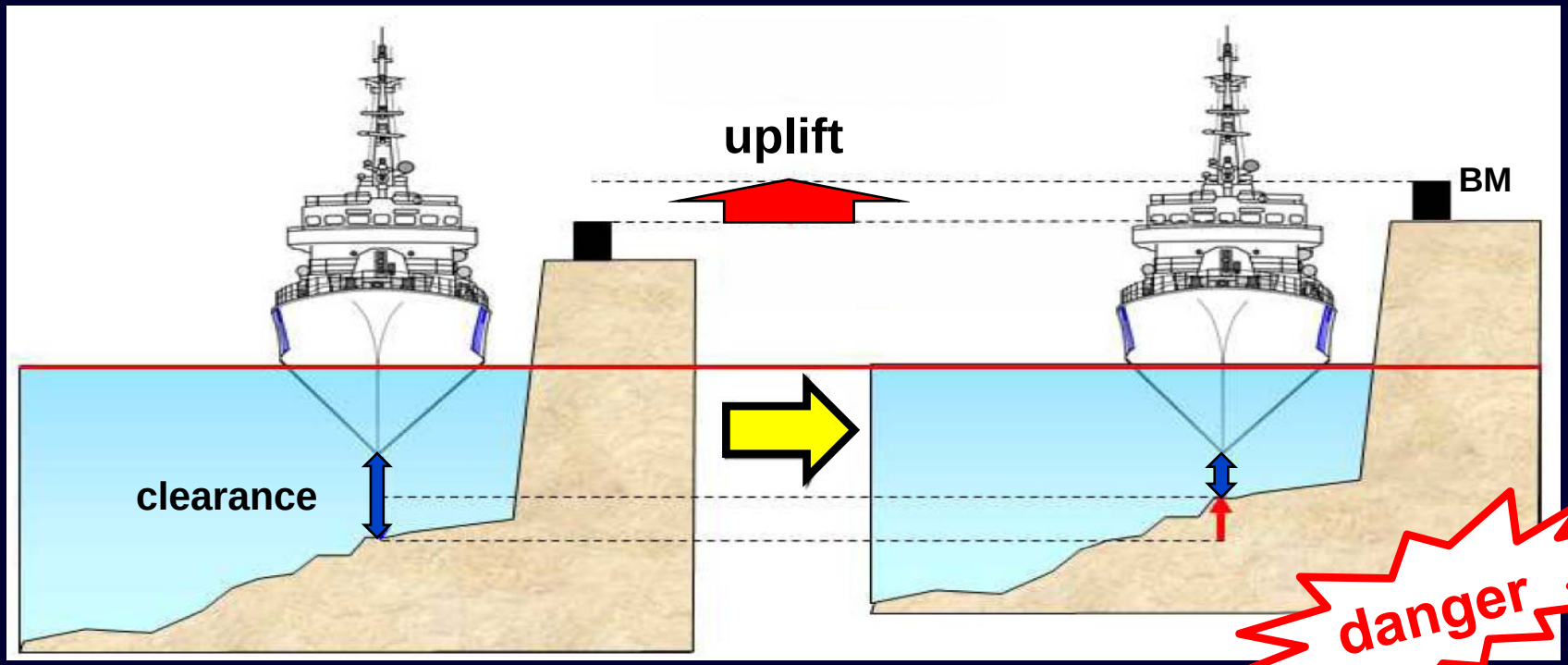
Postseismic movement

- Phenomenon common to major earthquakes
- Due to a slow slip in an adjacent region to a coseismic slip region



Estimated by terrestrial GPS data and seafloor GPS/Acoustic data

Significant uplift will leads ...



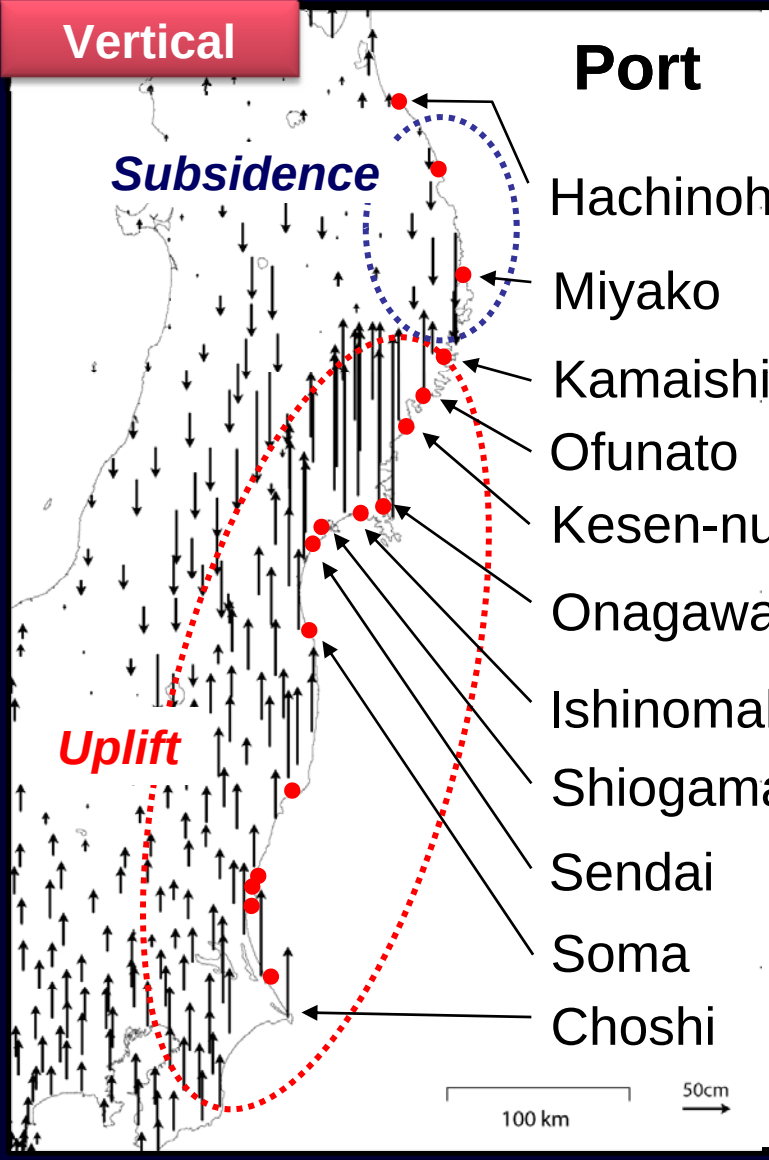
Real depth << Chart depth

Risk to safety navigation

“Re”-revision of chart datum levels (May 2013)

Period: 12 Mar. 2011 to Apr. 2013

Vertical



Port	nearest GEONET station (land)	Tide observation
Hachinohe	+2 cm	
Miyako	-6 cm	
Kamaishi	+6 cm	
Ofunato	+10 cm	
Kesen-numa	+13 cm	
Onagawa	+14 cm	+13 cm (from June 2011)
Ishinomaki	+22 cm	+15 cm (from June 2011)
Shiogama	+14 cm	+13 cm (from June 2011)
Sendai	+14 cm	+14 cm (from June 2011)
Soma	+12 cm	
Choshi	+11 cm	

(from 12 March 2011)

re-determined for 4 ports in May 2013

“CDL-13”

= postseismic chat datum level determined in 2013

Impact on survey data/charts

- a huge amount of existing sounding data collected after the earthquake, based on old chart datum levels
- soundings of nautical charts published after the earthquake

How should we deal with?

- to throw them away and do re-survey?
- to leave them as they are?

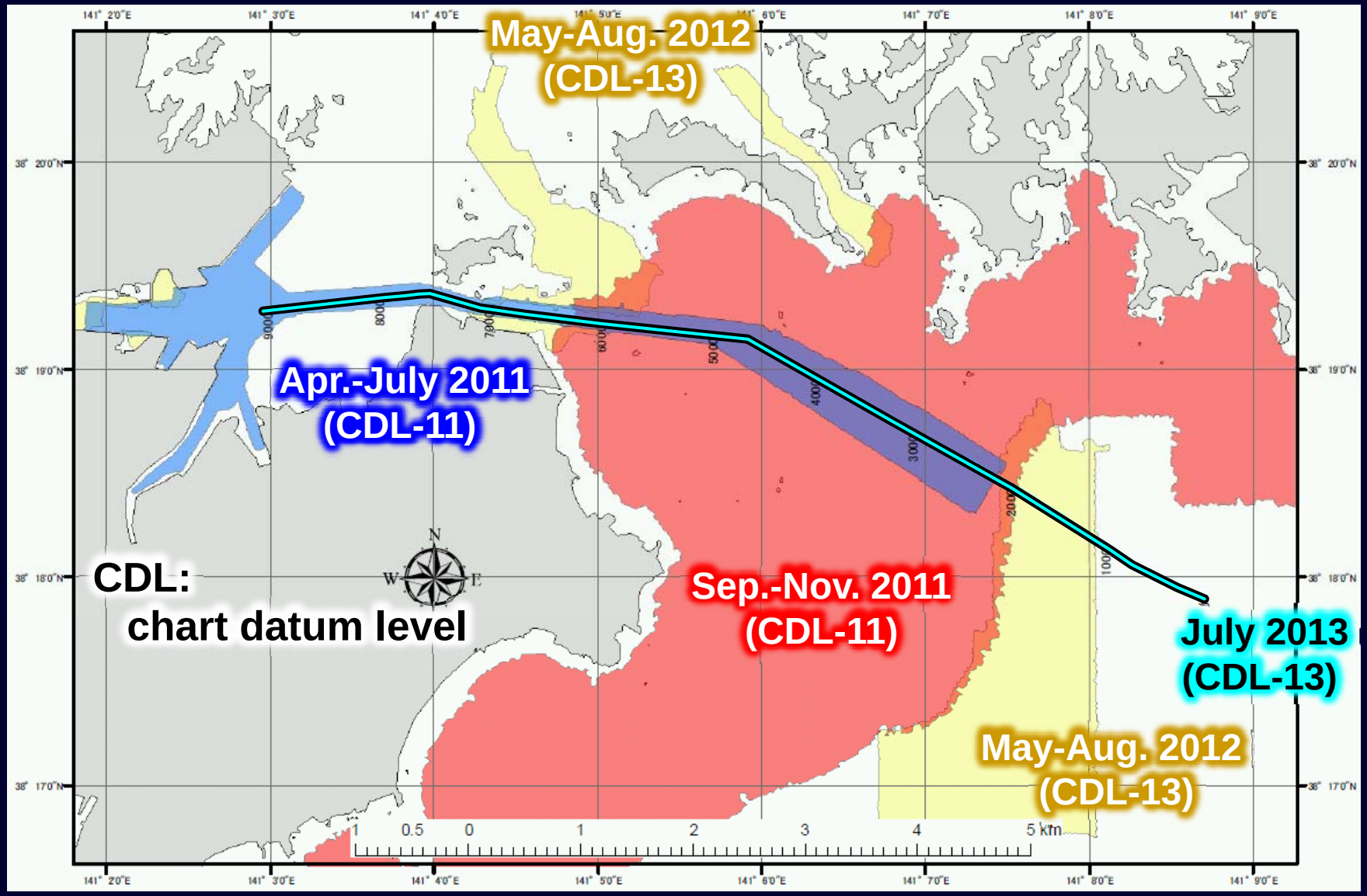
Approaches we took

To do test surveys for checking if water depth change due to postseismic uplift has occurred over a chart area.

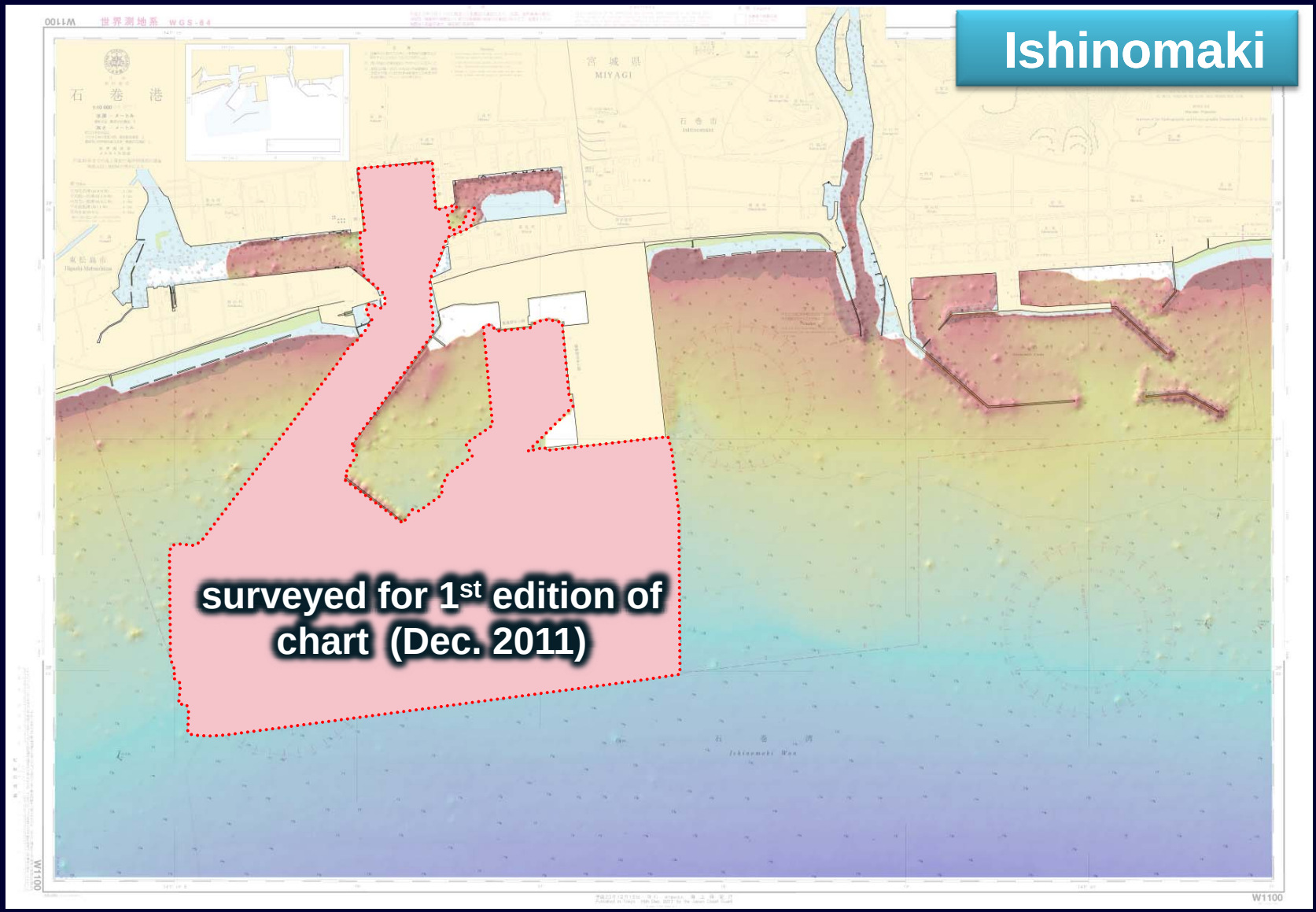
3 ports

- Large uplift has been observed
- New edition chart is to be published soon.

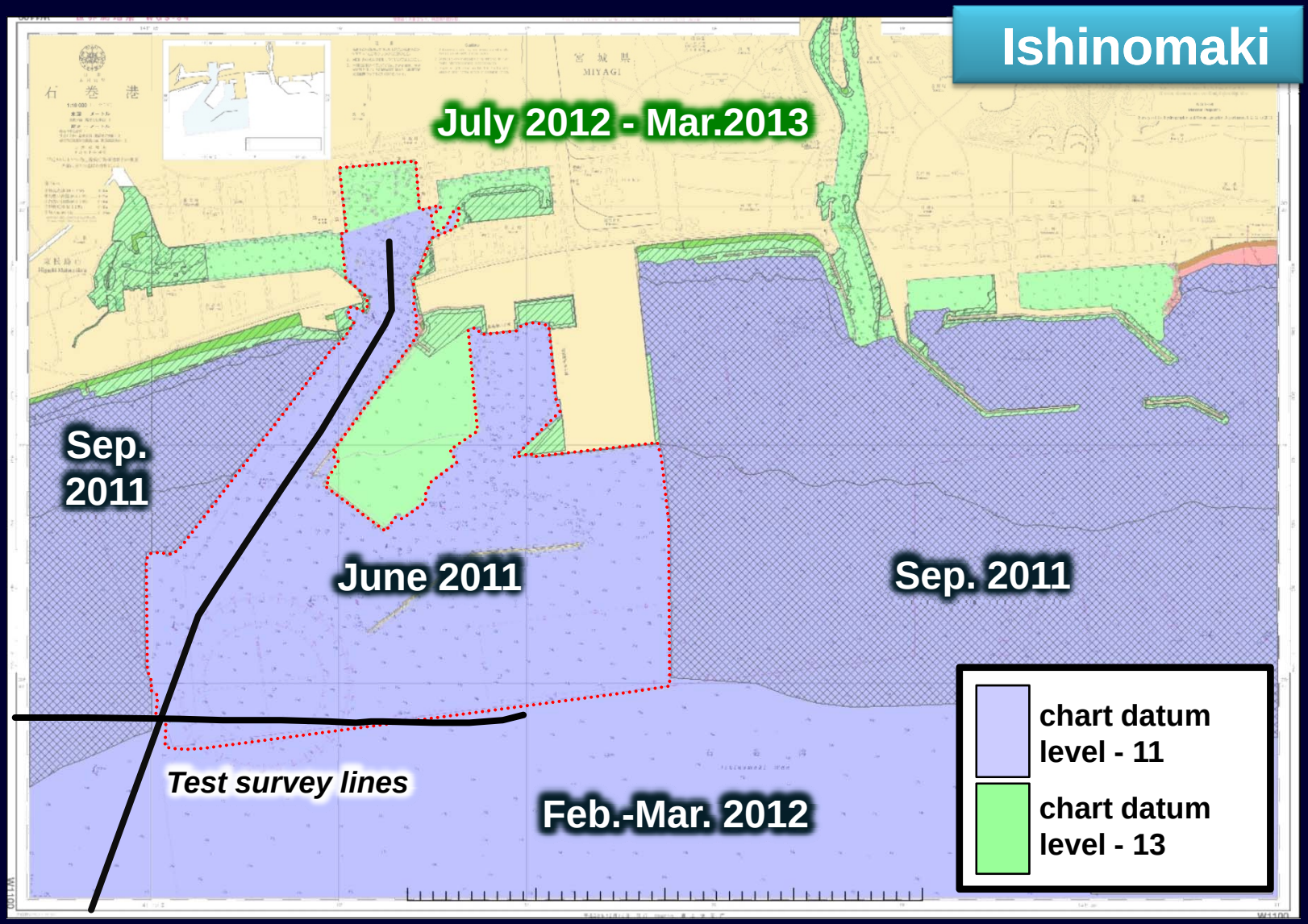
Test survey (Shiogama port, July 2013)



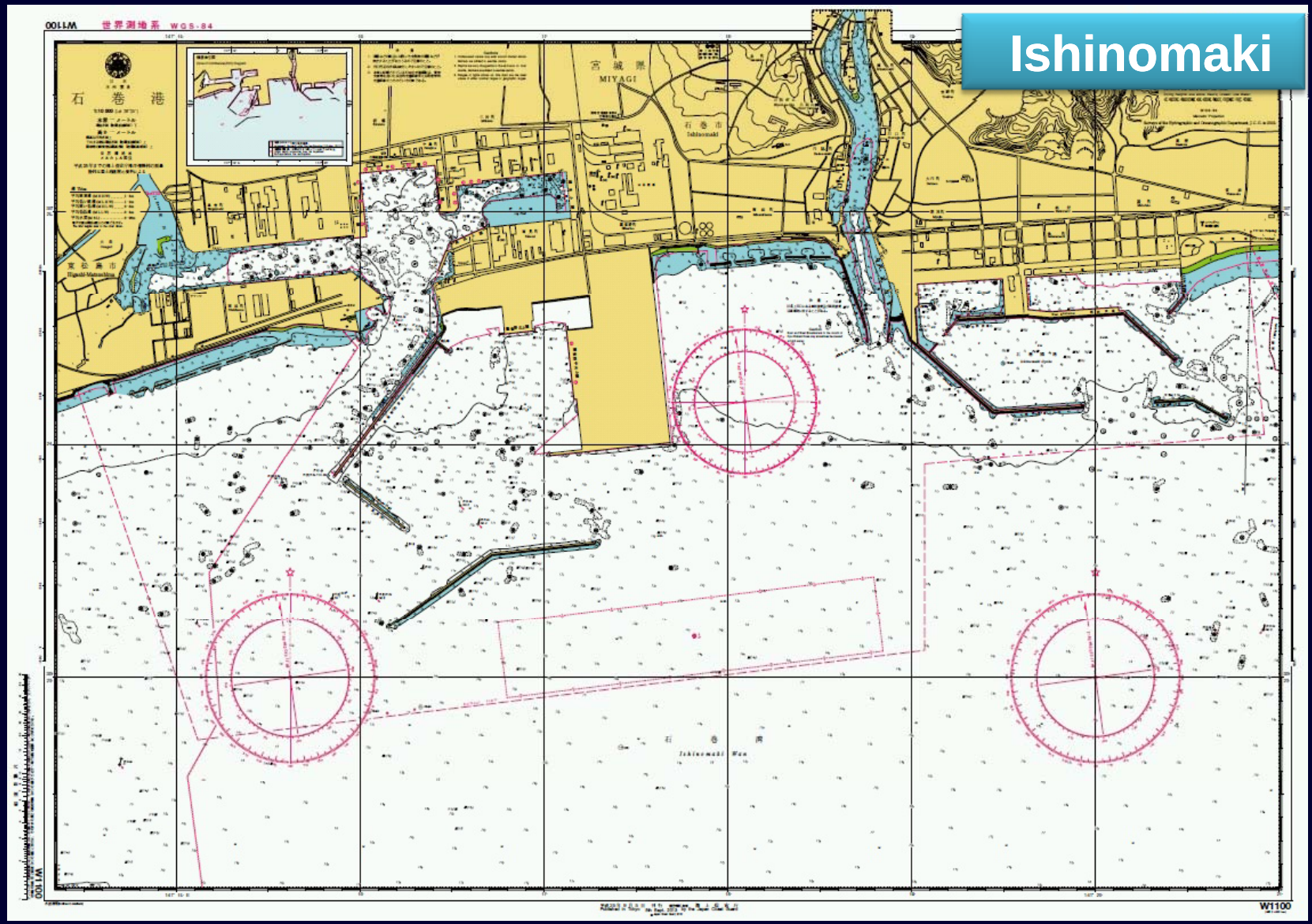
Another example of fully-surveyed port



Another example of fully-surveyed port



2nd edition of chart (Sep. 2013)



Ishinomaki

Concluding remarks

- For the three ports, depth correction was applied to existing older survey data across the board, using values of chart-datum-level change.
- Postseismic movement is anticipated to continue for further several years.
- In near future, similar depth correction may be needed for other ports and/or the above-mentioned three ports.


Thank you for your kind attention!