



**BALTIC SEA
HYDROGRAPHIC
COMMISSION**



Baltic Sea Chart Datum 2000

**NKG General Assembly
Copenhagen**

7 September 2022

Thomas Hammarklint

Baltic Sea Hydrographic Commission (BSHC)



BALTIC SEA HYDROGRAPHIC COMMISSION



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The Baltic Sea Hydrographic Commission,

which is an integral part of the International Hydrographic Organisation (IHO), promotes the technical co-operation in the domain of hydrographic surveying, marine cartography and nautical information among the neighboring countries of the Baltic Sea region.

The main objectives of the Commission are the coordination of the production of the Baltic Sea INT Charts, the coordination of hydrographic re-surveys, harmonization of chart datums, harmonization of Baltic Sea ENCs, and the exchange of information and the harmonization of practices with regard to various issues related to hydrography.

The most recent development is the [Baltic Sea Bathymetric Database](#) – accessible via this portal.

International Hydrographic Organization

The International Hydrographic Organization is an intergovernmental consultative and technical organization that was established in 1921 to support safety of navigation and the protection of the marine environment. The object of the Organization is to bring about:

- The coordination of the activities of national hydrographic offices
- The greatest possible uniformity in nautical charts and documents
- The adoption of reliable and efficient methods of carrying out and exploiting hydrographic surveys
- The development of the sciences in the field of hydrography and the techniques employed in descriptive oceanography

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Chart Datum Working Group (CDWG)



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BSHC Chart Datum Working Group

"To implement a common reference level in the Baltic Sea"



Photo: Chart Datum Working Group 13th meeting, 7 September 2021, VTC

<http://www.bshc.pro/working-groups/cdwg>

Members of CDWG:

Denmark Mrs Gitte Hauerberg Iversen
Estonia Mrs Gabriela Kotsulim
Finland Mr Jarmo Mäkinen
Germany Dr Patrick Westfeld
Latvia Mr Bruno Špēls
Lithuania Mr Mindaugas Zakarauskas
Poland Mr Witold Stasiak
Russia Mr Leonid Shalnov
Russia Dr Sergey V. Reshetniak
Sweden Mr Thomas Hammarklint (Chair)
Sweden Mr Lars Jakobsson
Sweden Mr Henrik Tengbert

Observers and Experts:

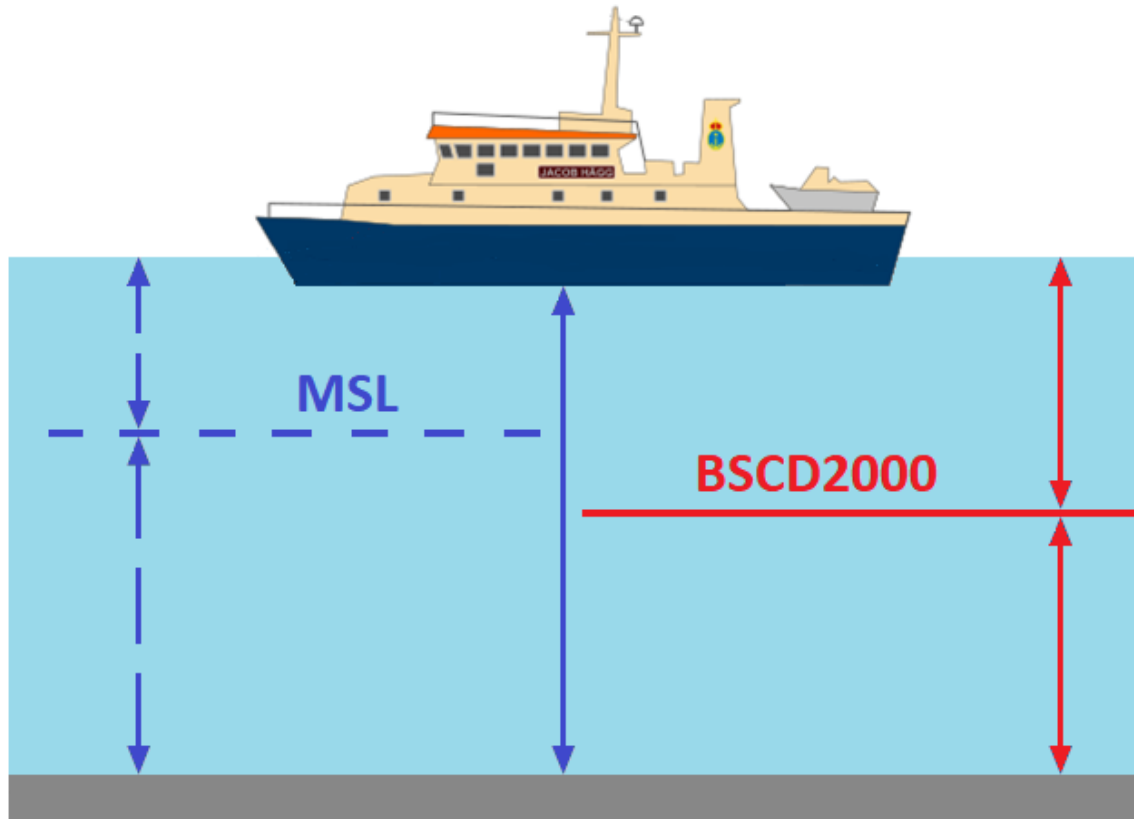
Estonia Prof. Artu Ellmann
Estonia Mr Sander Varbla
Finland Mrs Mirjam Bilker-Koivula
Finland Mrs Anni Montonen
Germany Dr Gunter Liebsch
Germany Dr Joachim Schwabe
Norway Mr Aksel Voldsund
Poland Mr Krzysztof Pyrchla
Poland Mrs Małgorzata Pająk
Poland Dr Monika Wilde-Piórko
Poland Dr Małgorzata Szelachowska
Sweden Dr Jonas Ågren
Sweden Dr Per-Anders Olsson
Sweden Mr Mikael Stenström

Representative of BOOS:

Sweden Mr Thomas Hammarklint



New reference level



The water level remains!

Baltic Sea Chart Datum 2000 (BSCD2000)

➤ Definition:

The datum refers to each Baltic country's realization of the European Vertical Reference System (EVRS) with land-uplift epoch 2000, which is connected to the Normaal Amsterdams Peil (NAP).

➤ Justification:

The Baltic Sea is an international shallow, non-tidal area in the northern part of Europe with dense traffic. IHO BSHC has approved the name and the adoption of the Baltic Sea Chart Datum 2000.

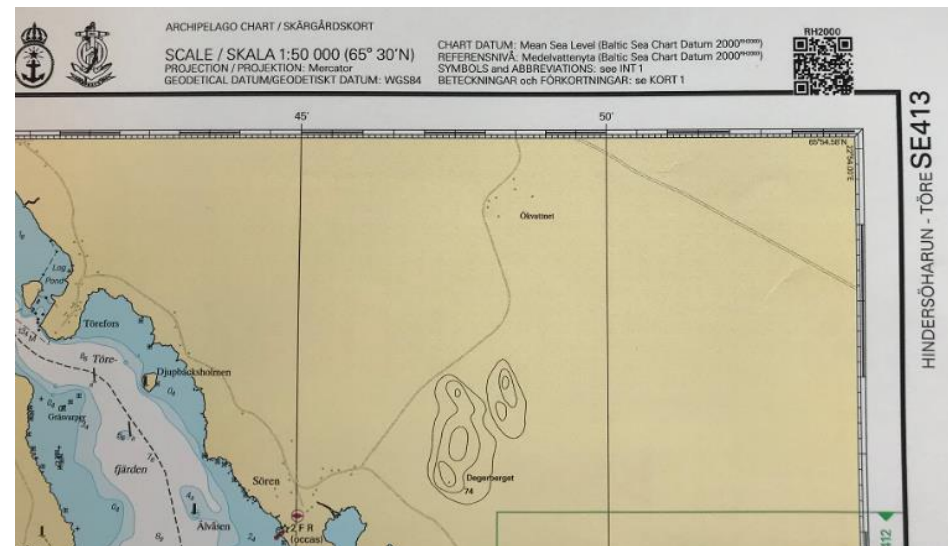
➤ Height systems used as national realization of BSCD2000 (EVRS-based):

Sweden RH2000	Denmark DVR90	Germany DHHN2016
Poland PL-EVRF2007-NH	Lithuania LAS07	Latvia LAS2000,5
Estonia EH2000	Finland N2000	Norway NN2000

➤ Chart datum name to be shown in paper charts:

Mean Sea Level (Baltic Sea Chart Datum 2000^{national realization name})
or

Mean Sea Level (Baltic Sea Chart Datum 2000)



International Hydrographic Review Article

An article about the CDWG work and the implementation of the Baltic Sea Chart Datum 2000 has been published in the International Hydrographic Review (IHR) in May 2020, page 63-83: https://iho.int/uploads/user/pubs/ihreview_P1/IHR_May2020.pdf

INTERNATIONAL HYDROGRAPHIC REVIEW MAY 2020

Articles

THE BALTIC SEA CHART DATUM 2000 (BSCD2000)

Implementation of a common reference level in the Baltic Sea

By J. Schwabe¹, J. Ägren², G. Lejtsch³, P. Westfeld⁴, T. Hammankir⁵, J. Mononen⁶ and O. B. Andersen⁶

1. Federal Agency for Cartography and Geodesy (Germany)
2. University of Gävle (Sweden) and Lantmäteriet, the Swedish mapping, cadastral and land registration authority (Sweden)
3. Federal Maritime and Hydrographic Agency (Germany)
4. Swedish Maritime Administration (Sweden)
5. Finnish Transport Agency (Finland)
6. DTU Space (Denmark)

Abstract

The Baltic Sea Chart Datum 2000 (BSCD2000) is a geodetic reference system adopted for Baltic Sea hydrographic surveying, hydrographic engineering, nautical charts, navigational publications and water level information. It is based on the common geodetic standards for the height system (EVRS) and the spatial reference system (ETRS89) in Europe. In particular, the zero level of BSCD2000 is in accordance with the Normal Amsterdam Peil (NAP). BSCD2000 is about to be adopted as unified chart datum by all the countries around the Baltic Sea. It agrees with most national height realizations used on land. BSCD2000 will facilitate effective use of GNSS methods like GPS, GLONASS and Galileo for accurate navigation and hydrographic surveying in the future.

Résumé

Le Baltic Sea Chart Datum 2000 (BSCD2000) est un système de référence géodésique adopté pour les levés hydrographiques, l'ingénierie hydrographique, les cartes marines, les publications nautiques et les informations sur le niveau de l'eau de la mer Baltique. Il est basé sur les normes géodésiques communes au Système de Référence Vertical Européen (EVRS) et au Système de Référence Terrestre Européen (ETRS89). En particulier, le zéro hydrographique du BSCD2000 est conforme au Normal Amsterdam Peil (NAP). Le BSCD2000 est sur le point d'être adopté en tant que niveau de référence des cartes commun par l'ensemble des pays bordant la mer Baltique. Il correspond à la plupart des mesures de hauteur nationales utilisées à terre. Le BSCD2000 facilitera l'utilisation efficace des méthodes du GNSS comme le GPS, GLONASS et Galileo pour une navigation et des levés hydrographiques précis à l'avenir.

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4. Practical implications

New nautical products that use BSCD2000 are identified by the chart datum name BSCD2000¹⁰⁰, where ¹⁰⁰ denotes the respective national height system realization according to Table 2 (e.g., BSCD2000¹⁰⁰⁰ for Sweden).

The main consequence for the mariner is that the charted depth in BSCD2000 changes by a constant value compared to the old zero level. The offset is individual per country or per map sheet, depending on the former MSL-related chart datum. In most cases, this offset will be negative, since the new zero level of the BSCD2000 is in general below the present day MSL for the Baltic Sea (see Figure 6 for a generalized visualization and Figure 7 for a map of the national MSL realizations currently in use). However, for charts of areas strongly affected by postglacial uplift and referring to very old MSL realizations, the change to BSCD2000 may be considerable. Figure 1 gives an impression of the land uplift rates according to the model NKG2016LU (Vestel et al. 2016).

Figure 6: Schematic cartoon of the old MSL-based chart datum and the new BSCD2000

At the same time, real-time water level information (water level observations, corrections to the charted depths, forecasts, etc.) will also be changed accordingly to comply with the new chart datum. This also allows for a better and easier monitoring and prediction of the current and future sea states out at sea, since real-time oceanographic models can be simply interpolated (Figure 8), whereas switching between the sometimes far-distant manographs and their local references may introduce a large error margin (Figure 9).

The transition from the numerous MSL-based chart datums of each country to BSCD2000 is a complex and stretched process from the first decisions to the final implementation in the chart products. In particular, paper charts need longest to be switched due to the long production cycles. Some countries, like Estonia, have already informed mariners about the changes to BSCD2000 and have published the first products. Others, like Denmark, are about to formally

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adopt BSCD2000 as the name of their chart datum without having to actually change their charted depths. Therefore, this section only gives an overview about the general situation in the respective countries. Table 2 summarizes the national geodetic reference frames, positioning services and HRS realizations that can be used with BSCD2000. Regularly updated details about the implementation status as well as instructions for users, e.g. leaflets, are provided via the CDWG website (<http://www.bsdc.pro/working-groups/cdwg/>).

In Sweden and Finland, a calculated MSL has been used as reference level (chart datum) for nautical charts and water level information. The reference level for regularly updated epochs (estimated present-day MSL) was estimated from long time series of annual mean values of manograph observations. Depths from printed charts needed to be converted semi-automatically by means of a correction formula in order to correct for the time difference and to make the charted depth compatible with the provided water level information. As motivated in Section 2, this two-step approach implied a lot of work to keep the nautical products updated and consistent. At the same time, it was not straightforward and error-prone for the mariner.

Thus, decisions to make a transition to BSCD2000 in Sweden and Finland have come a long way. In Sweden, both water level information and 50% of all nautical charts are now using BSCD2000. In Finland, part of the bathymetric and chart data have already been transformed to BSCD2000. Water level information is ready to be provided in BSCD2000 when first charts will be published in the new datum. Figure 7 details the estimated height of the current calculated MSL relative to BSCD2000 for selected manographs in Sweden and Finland.

Figure 7: Differences between the reference levels of the old national chart datums with respect to Baltic Sea Chart Datum (BSCD2000) in Sweden and Finland; the old reference levels are equal to the calculated MSL in the year 2020 (according to different national conventions). The values from Norway shows the MSL over the period 1998-2014, relative BSCD2000¹⁰⁰⁰. In Estonia, Latvia and Lithuania, the Kronstadt reference level is used as old chart datum. In Poland, the local Polish Height System-Amsterdam Peil is used as chart datum. Notice how postglacial rebound reduces the magnitude of the calculated MSL relative BSCD2000 in the Bay of Bothnia; it is now just a few cm close to the location of maximum uplift. The values are taken from BOOS (2020).

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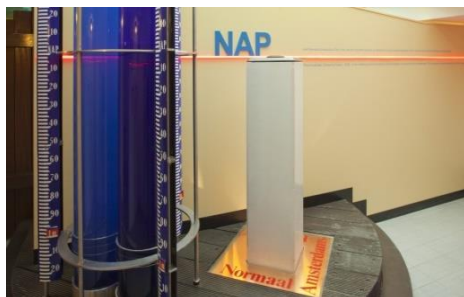
Swedish height systems



- **RH00 National height system 1900**
Official national height system until 1970
Zero-level defined by:
Normal height point in Stockholm from 1886
Placed +11,800 m above mean sea level in Stockholm 1900



- **RH70 National height system 1970**
Official national height system 1970-2005
Zero-level defined by:
Normaal Amsterdams Peil (NAP), a reference point in Varberg placed +4,234 m above NAP



- **RH 2000 National height system 2000**
"Baltic Sea Chart Datum 2000 (BSCD2000)"
Official national height system since 2005
Zero-level defined by:
NAP is the reference point in the European Vertical Reference System (EVRS)
Epoch year 2000

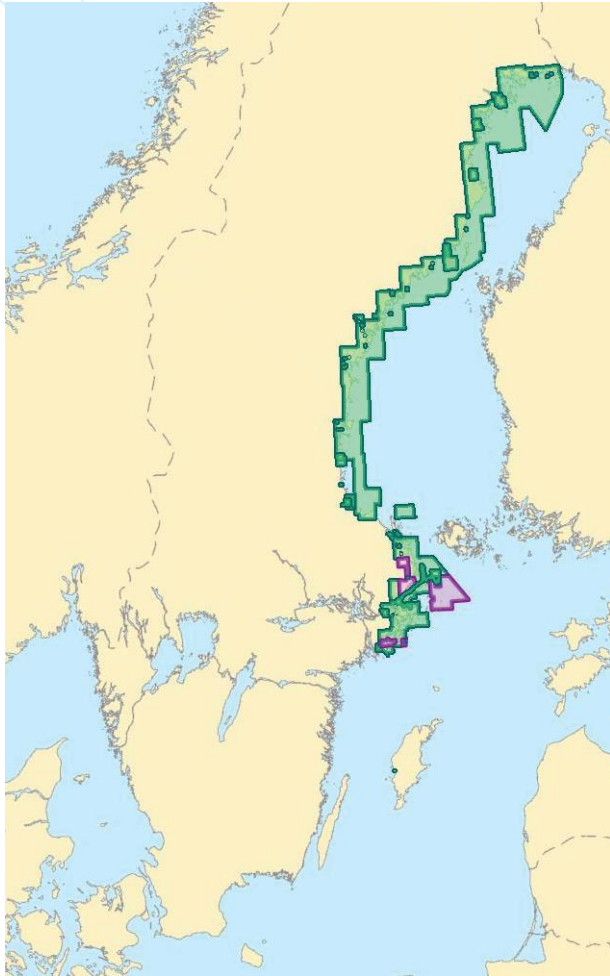
Swedish Chart Improvement project



CHART DATUM: Mean Sea Level (Baltic Sea Chart Datum 2000^{RH2000})
REFERENSNIVÅ: Medelvattenyta (Baltic Sea Chart Datum 2000^{RH2000})
SYMBOLS and ABBREVIATIONS: see INT 1
BETECKNINGAR och FÖRKORTNINGAR: se KORT 1



Status transition to BSCD2000 in nautical charts



Updated 2021-11-19

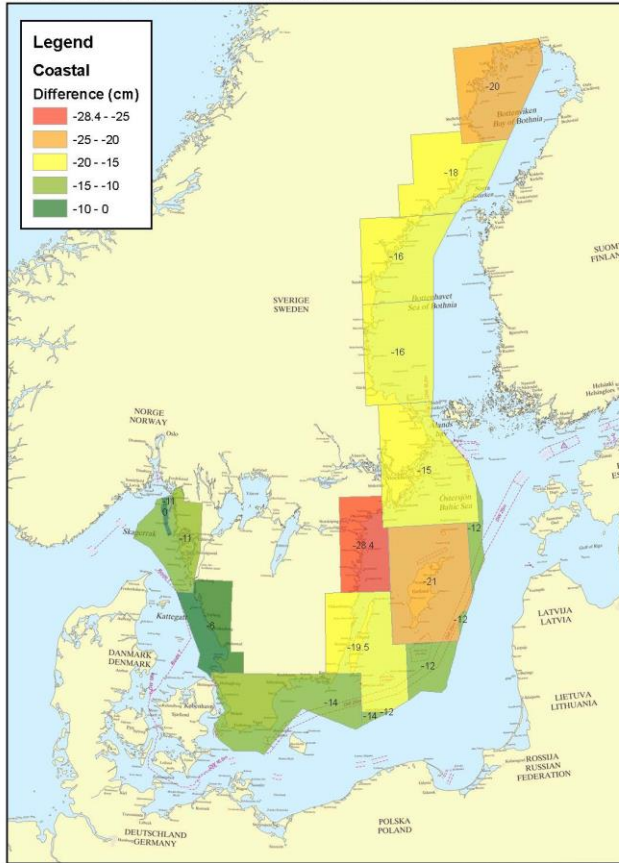
Difference between old chart datum and BSCD2000

Annex 1 To Questionare, BSHC CDWG

Page 2 (4)

Difference between existing chart datum and RH 2000 - Coastal

Swedish Maritime Administration, Hydrographic Office, May 16, 2013



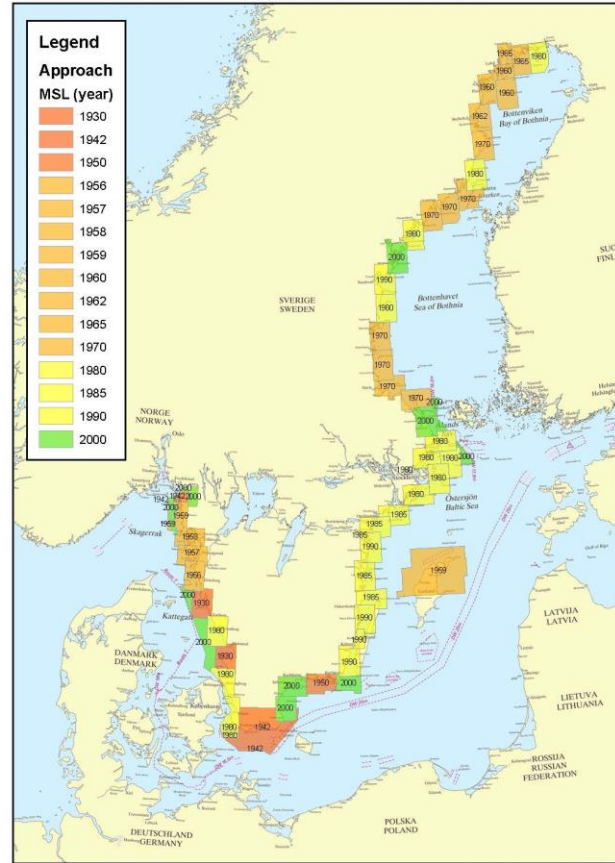
1 centimeters = 60 kilometers

Annex 1 To Questionare, BSHC CDWG

Page 3 (4)

Year of MSL in Swedish chart database - Approach (Swedish water)

Swedish Maritime Administration, Hydrographic Office, May 16, 2013

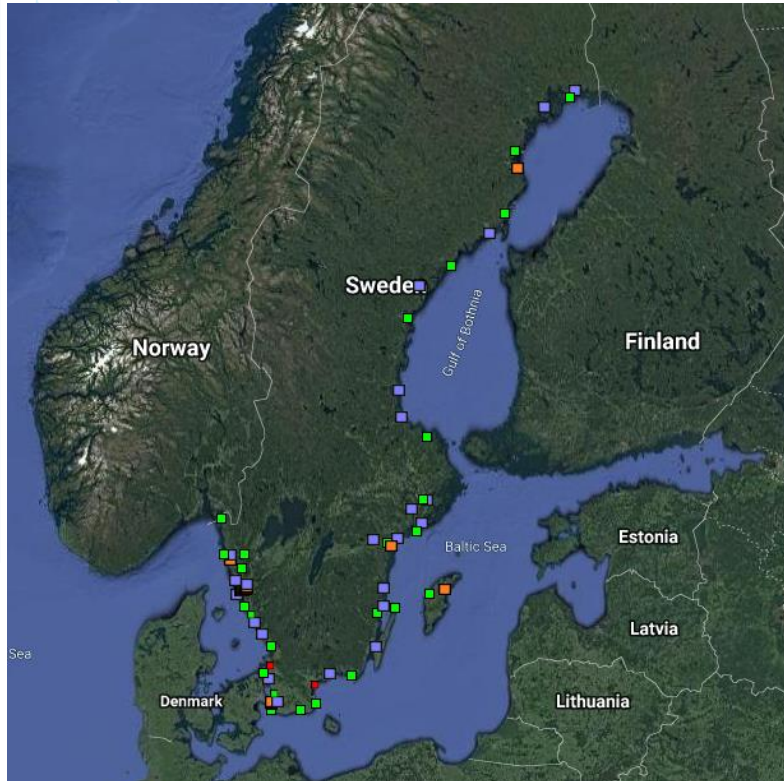


1 centimeters = 60 kilometers



Swedish Sea Level Network

- Real-time data relative BSCD2000 from 60 stations
- 1-minute values with 1 cm accuracy
- Real-time and delayed mode quality control



Class I Upgrade with battery backup

Class II Upgrade without battery backup

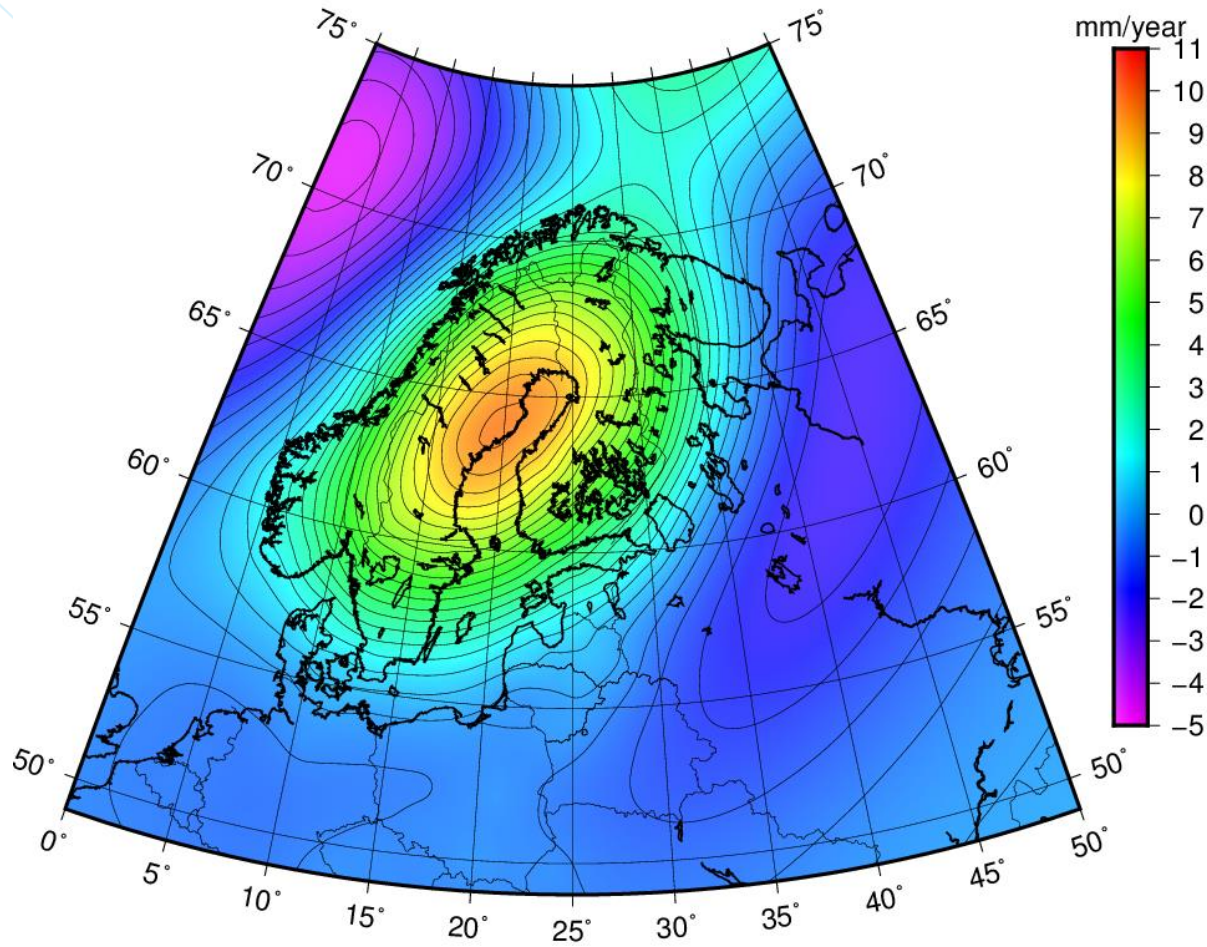
Class III Unchanged, temporary

27 stations (23 SMHI + 3 SMA + 1 CTH)

25 stations (21 SMA + 3 GBG + 1 SKB)

7 stations (6 SMA + 1 SMHI)

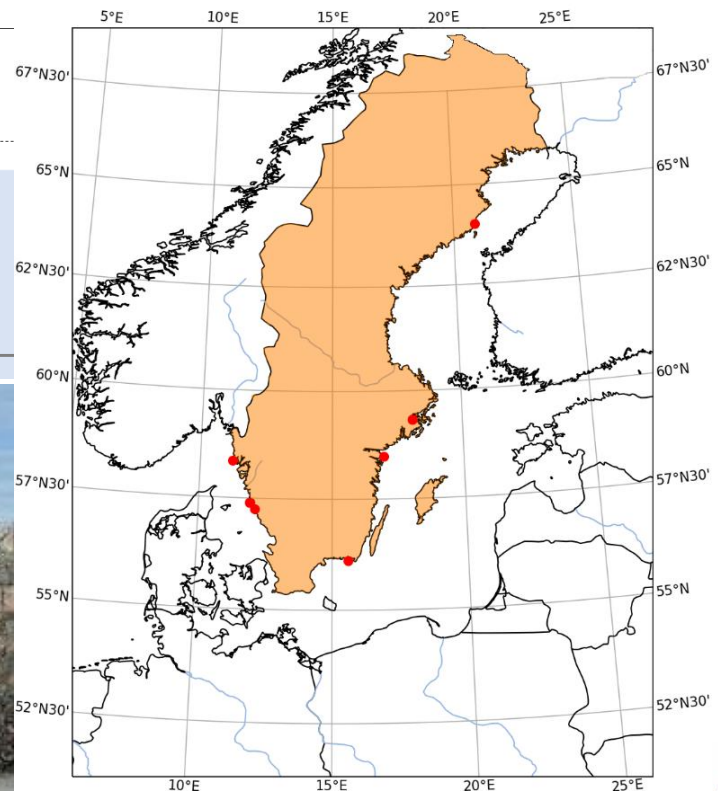
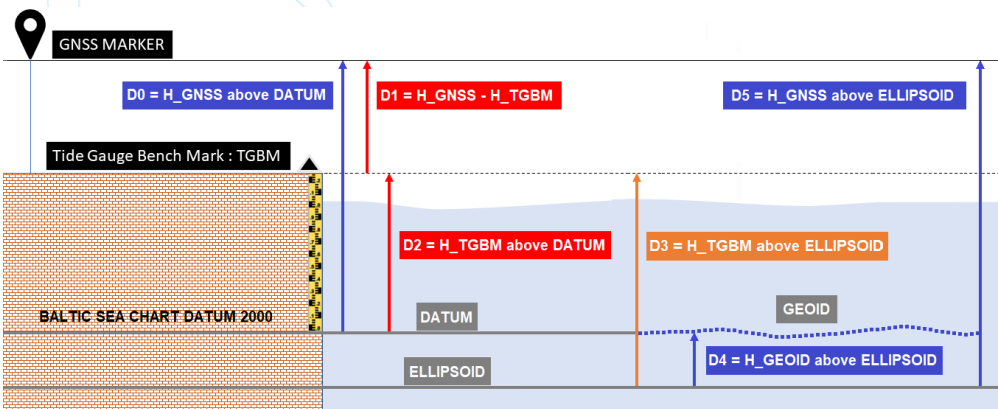
The land-uplift lowers the mean sea level



Co-location of sea level stations and GNSS in Sweden

RESPONSIBLE AGENCY		TIDE GAUGE COORDINATE		CO-LOCATED INSTRUMENTS			GNSS COORDINATES		CO-LOCATED CRITERIA		LEVELING INFORMATION	
RESPONSIBLE FOR GNSS	RESPONSIBLE FOR TG	LONG	LAT	TIDE_GAUGE	GNSS_SONEL	GNSS_SWEPOS	LONG	LAT	INSTALLED	GNSS->TG HORIZONTAL DISTANCE (m)	TGBM_ID	DATUM DEFINITION
SWEPOS-LMV	SMHI	20.895031	63.986056	RATAN	RATO	RATA.0	20.89556580	63.98558831	2006-06-09	58	h	BSCD2000/RH2000
SWEPOS-LMV	SMHI	18.081944	59.324167	STOCKHOLM	OMOS	MOSE.0	18.07420578	59.31842324	2013-07-11	373	a (LMV 108*2*6503)	BSCD2000/RH2000
SWEPOS-LMV	SMHI	16.960556	58.484167	ARKO	OARK	ARKO.1	16.96265021	58.48327049	2019-08-26	158	101	BSCD2000/RH2000
SWEPOS-LMV	SMHI	15.589444	56.105278	KUNGS HOLMSFORT	KUNO	KUNG.0	15.58903022	56.10423868	2004-12-31	108	a (LMV 035*2*3704)	BSCD2000/RH2000
SWEPOS-LMV	Chalmers	11.919167	57.391944	ON SALA	ONSA	ONSA.0	11.92551310	57.39529604	1993-07-01	533	827a	BSCD2000/RH2000
SWEPOS-LMV	Chalmers	11.919167	57.391944	ON SALA	ONS1	ONSA.1	11.92453692	57.39533058	2012-01-28	496	827a	BSCD2000/RH2000
SWEPOS-LMV	SMHI	11.217778	58.353611	SMOGEN	SMO0	SMOG.0	11.21792382	58.35346156	2002-08-26	18	g	BSCD2000/RH2000

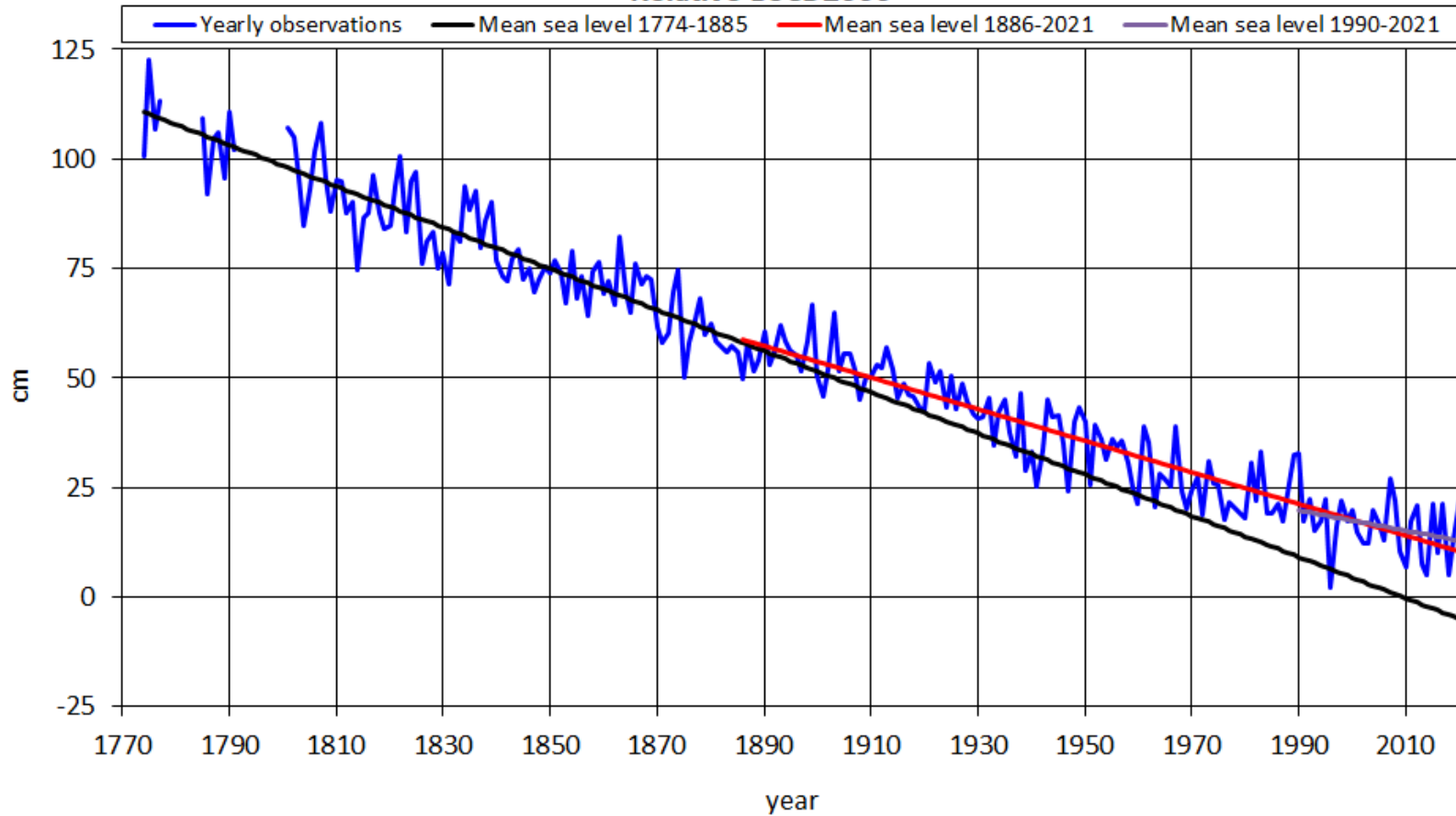
GNSS@TG < 1000.0 m for Sweden



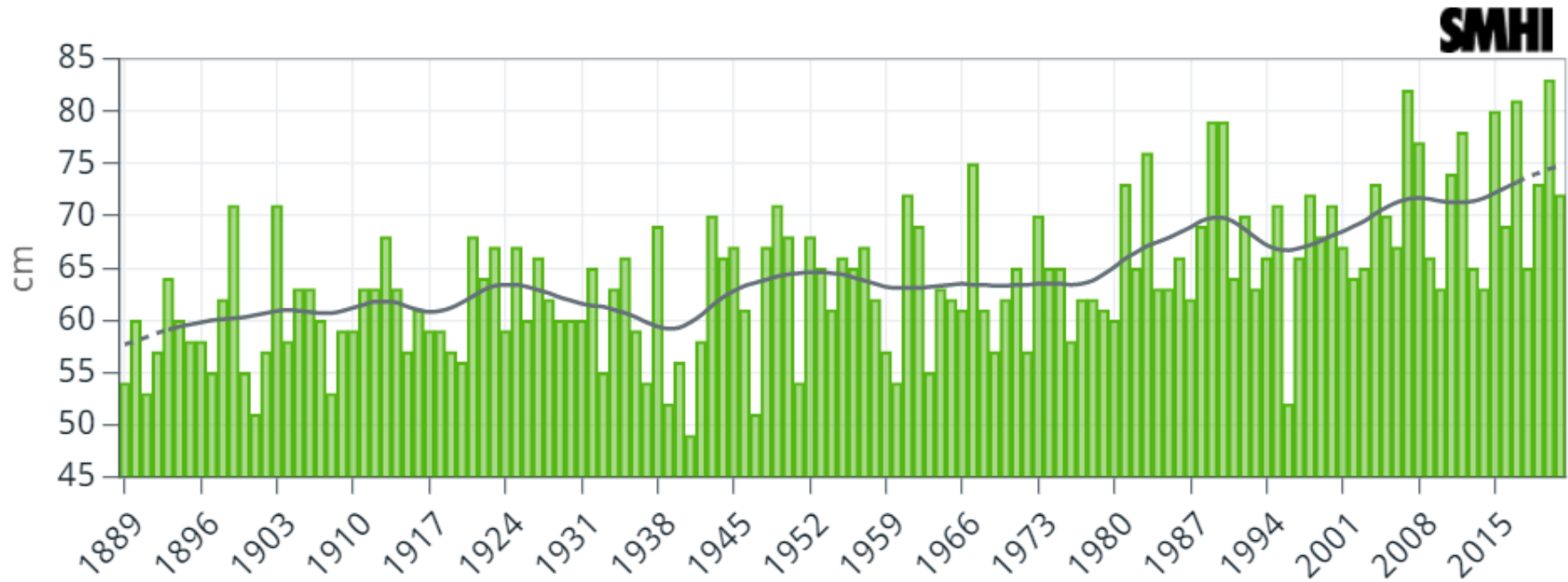
Stockholm

"World's longest sealevel record"

Sealevel Stockholm 1774 - 2021
Relative BSCD2000



The sea level rise raises the mean sea level

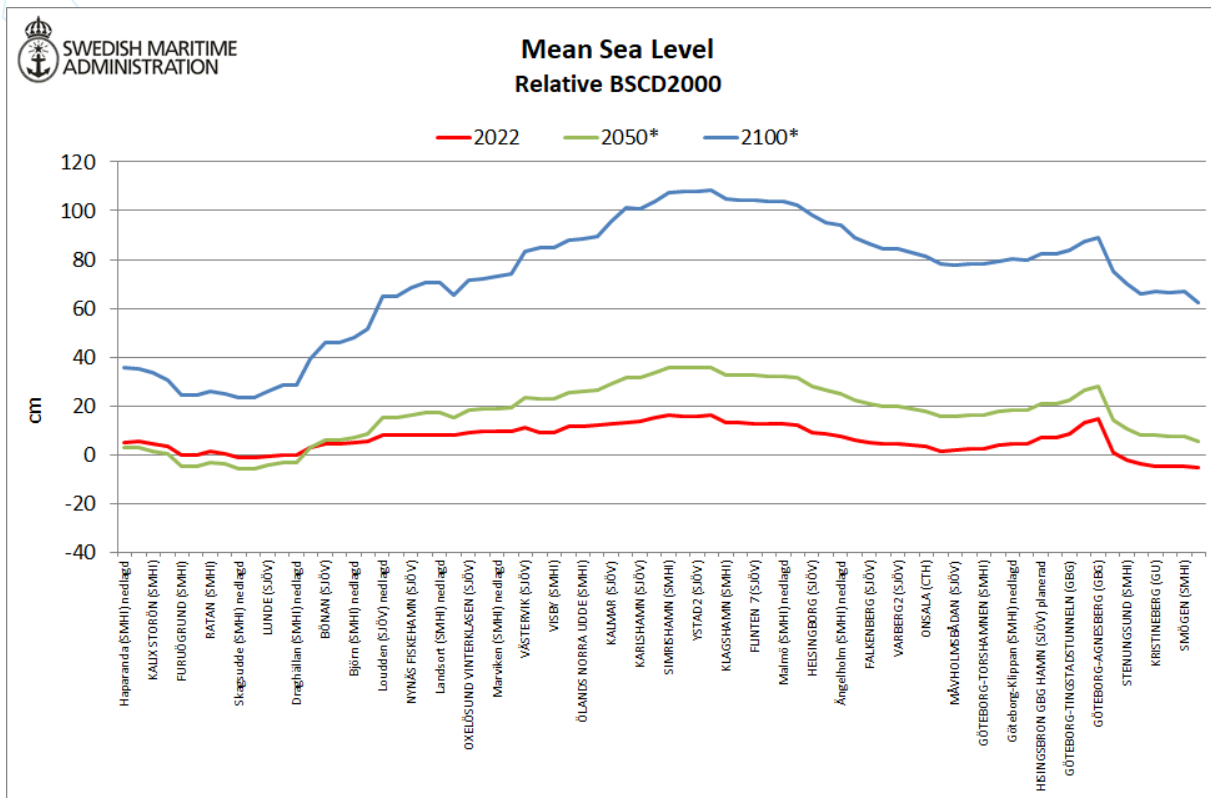


Observed sea level change in Stockholm since 1889

Sea level corrected for the levelled land-uplift (glacial isostatic adjustment)

The black line shows the gauss-filtered (smoothed) average

Changing mean sea level



Calculated mean sea level for the years 2022, 2050 and 2100. * incl. a predicted sea level rise, +1 m over the years 2020-2100 (IPCC 8,5) and correction for the leveled land-uplift.

[Mean sea level relative BSCD2000](#)

Difference between old reference system and BSCD2000

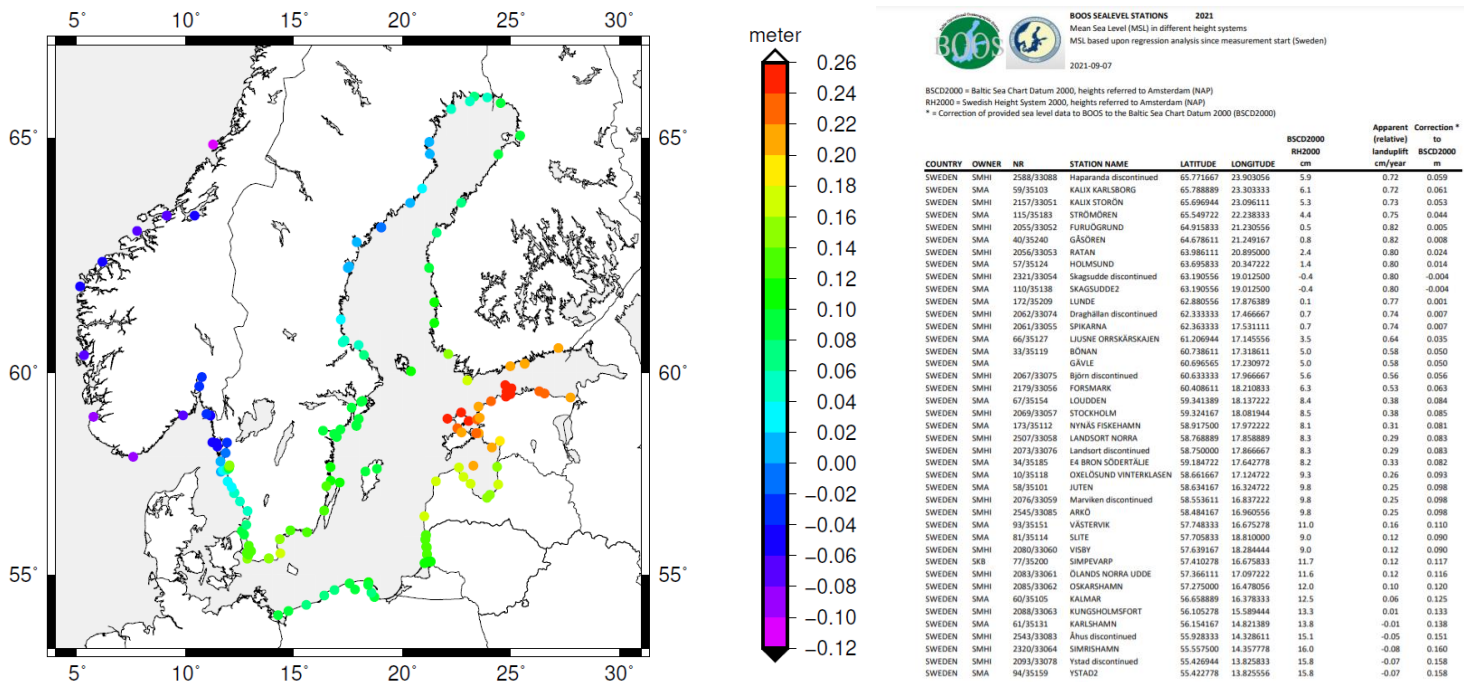
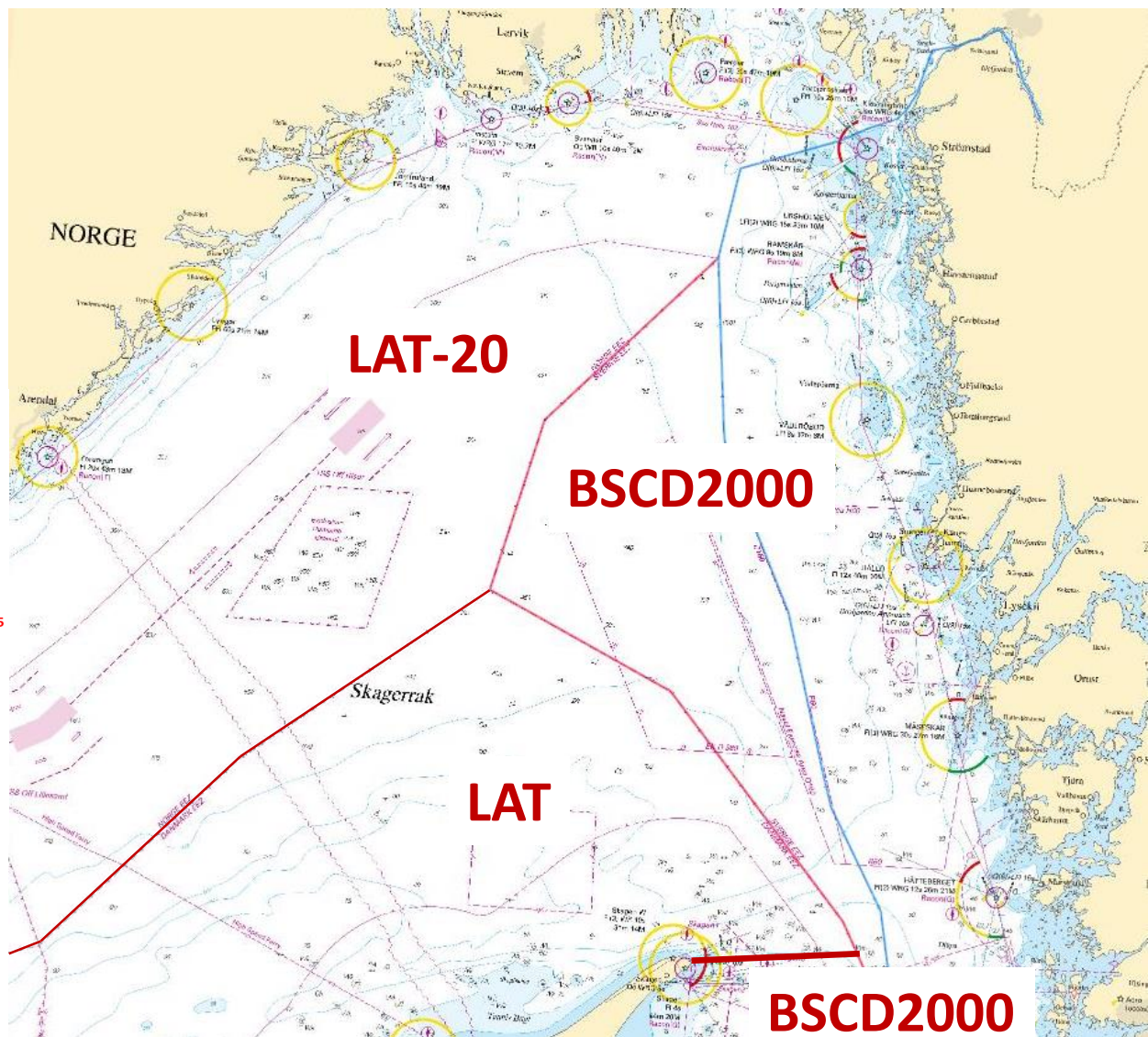
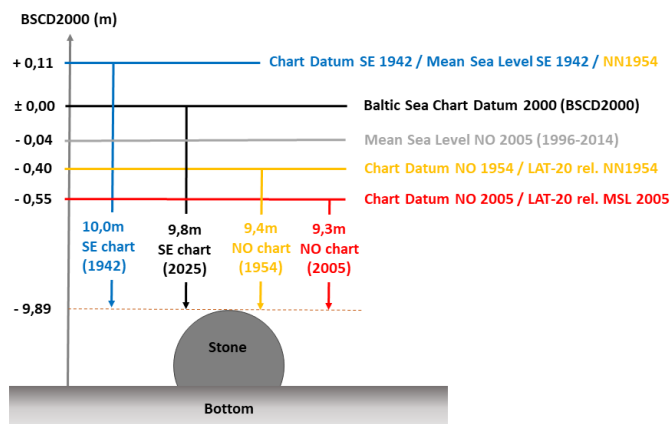


Fig. 4b: Differences between the reference levels of the old national chart datums with respect to Baltic Sea Chart Datum 2000 (BSCD2000). In Sweden and Finland, the old reference levels are equal to Mean Sea Level transferred to year 2022 (according to different national conventions). The values from Norway shows the Mean Sea Level over the period 1996-2014, relative NN2000/BSCD2000. In Estonia, Latvia and Lithuania, the Kronstadt reference level is used as old chart datum. In Poland, the local Polish Height System Amsterdam NN₅₅ is used as chart datum. Notice how postglacial rebound reduces the magnitude of the mean sea level in the Bay of Bothnia; it is now just a few cm near the land uplift maximum. The values are shown in this [Table](#).

Reference levels in Skagerack

- Norwegian reference datum (LAT-20) ca 50-60 cm below BSCD2000
- Danish LAT ca 30 cm below BSCD2000

Chart datum Skagerrak (Swedish-Norwegian border)






New reference level in Sweden

SMA and SMHI presents sea level data relative BSCD2000 since 3rd June 2019



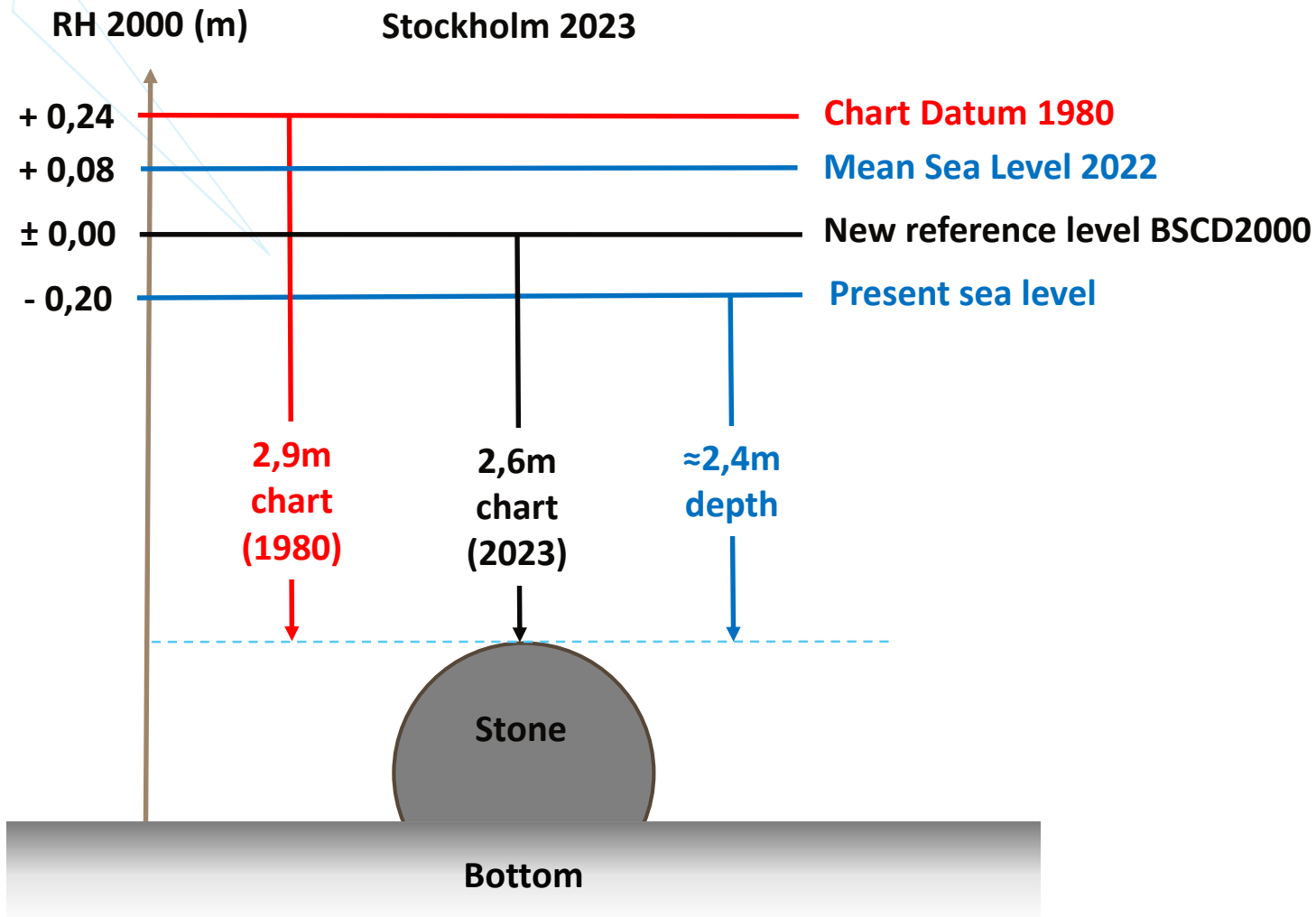
SMHI oceanographic warning and forecasting service

- A transition to BSCD2000 (RH 2000) has been implemented at SMHI, where forecasts, warnings and current sea level are issued relative BSCD2000.
- A new impact-based and regional adapted warning system has also been introduced, which includes yellow, orange and red warning, where red is the most serious.

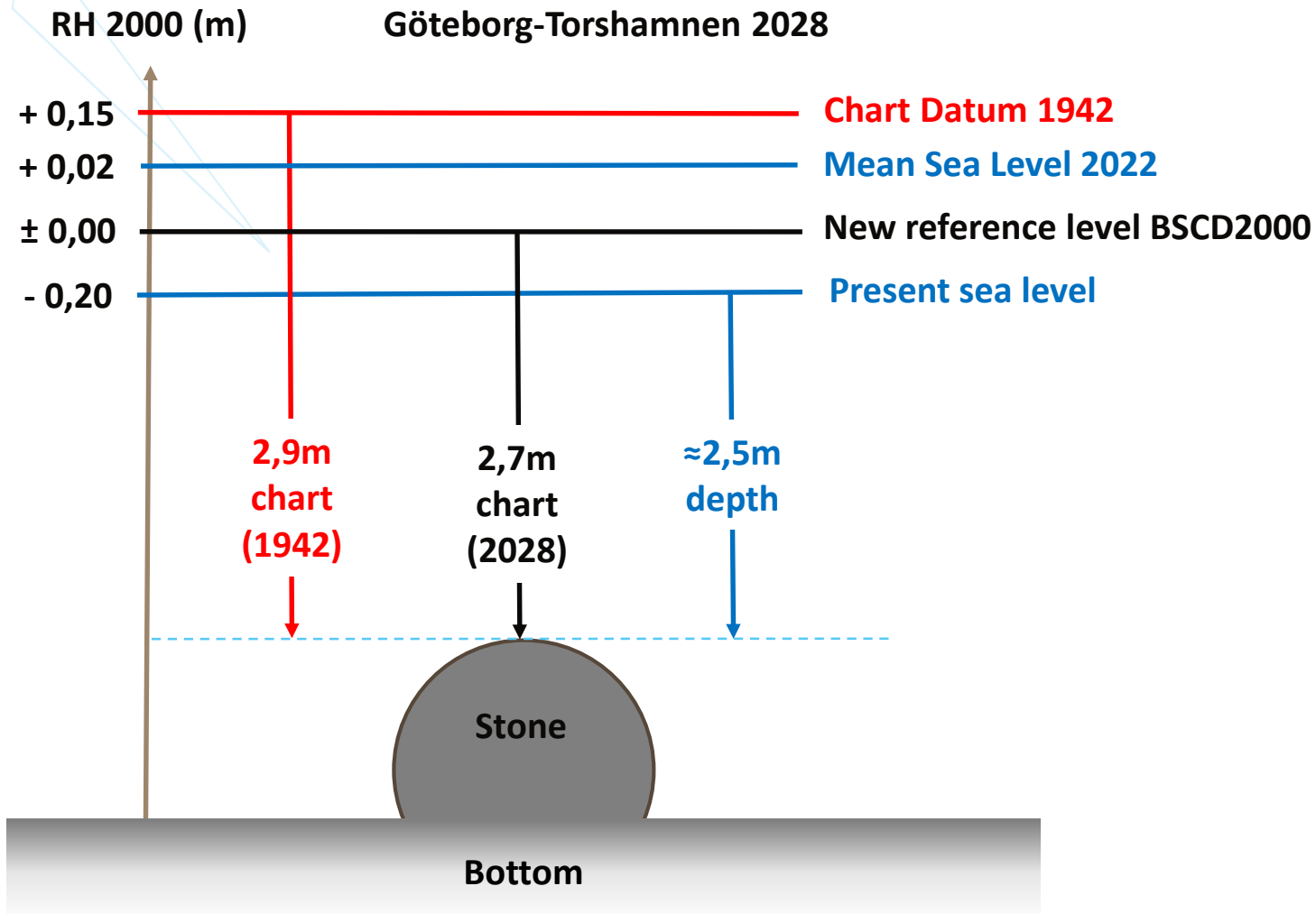
Högt vattenstånd   			
Varningsnivå	Gul	Orange	Röd
Område	cm i RH 2000		
Grupp 1 (Västra Götalands län, Hallands län, Skåne län)	90	130	180
Grupp 2 (Kalmar län, Östergötlands län, Gotlands län, Södermanlands län, Stockholms län)	80	110	-
Grupp 3 (Blekinge län, Uppsala län, Gävleborgs län, Västernorrlands län)	90	130	-
Grupp 4 (Västerbottens län, Norrbottens län)	100	150	-

Lågt vattenstånd 	
Varningsnivå	Gul
Område	cm i RH 2000
Skagerrak, Kattegatt, Södra Östersjön, Mellersta Östersjön, Norra Östersjön, Ålands hav	-80
Sydvästra Östersjön, Öresund, Bälten	-50
Södra Bottenhavet, Norra Bottenhavet, Norra Kvarnen, Bottenviken	-90

Transition to RH 2000/BSCD2000 in charts and sea level



Transition to RH 2000/BSCD2000 in charts and sea level



Notices to mariners

Example from Sweden, 2019-05-15

* 14040

**Sweden. not area bound. New reference system for sea level, nautical charts and warnings.
BSCD2000 / RH 2000.**

Expired notices: 2019:754/13917

See: 2018:716/13140

As of June 3, 2019, the Swedish national height system 'Rikets Höjdsystem 2000', or RH 2000 (international name 'Baltic Sea Chart Datum 2000', BSCD2000) will constitute the reference level for observations and forecasts of the water level in Swedish waters.

The zero level in RH 2000 is fixedly linked to land, and is not affected by land uplift, changes in sea level or geographical variations.

The change means that observations, forecasts, and warnings in the Swedish Maritime Administration's and Swedish Meteorological and Hydrological Institute's (SMHI) viewing services from 3 June 2019, or soon thereafter, refer to the new reference level and no longer to the 'mean sea level'.

The Swedish Maritime Administration is gradually adapting the charts to the new reference system. This is a time consuming process which will take several years to complete. During the transition period, it is important to know which reference level is used in the different charts. If the text 'Baltic Sea Chart Datum 2000', or 'BSCD2000' is printed in the chart, the update has been performed.

More information: www.sjofartsverket.se/RH2000 and www.smhi.se

www.sjofartsverket.se/RH2000 www.smhi.se

SMHI och Sjöfartsverket. Publ. 15 May 2019

New info sheets about the transition to BSCD2000 as the new reference level for sea level, nautical charts and warnings

Svensk



English



A uniform reference system from land to sea

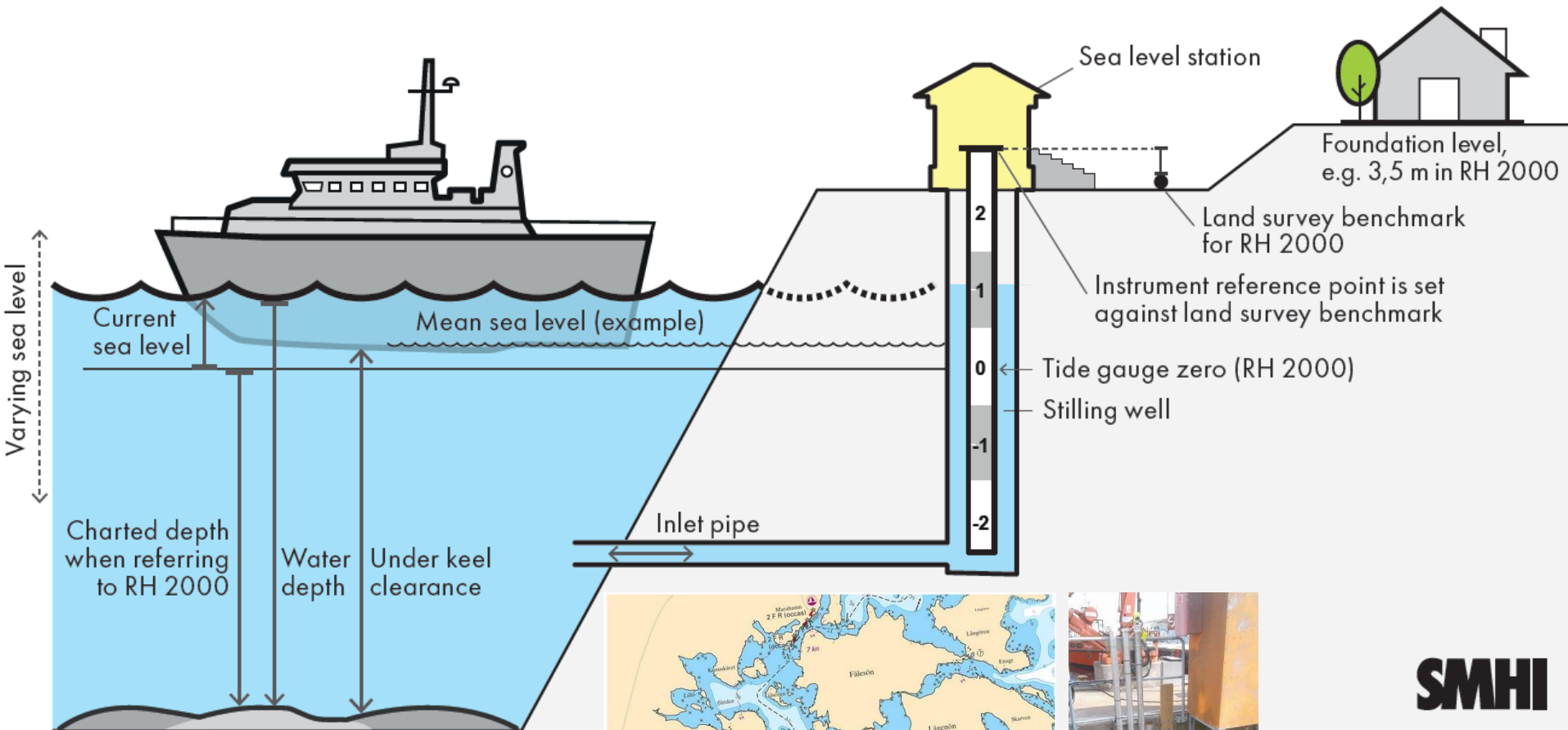


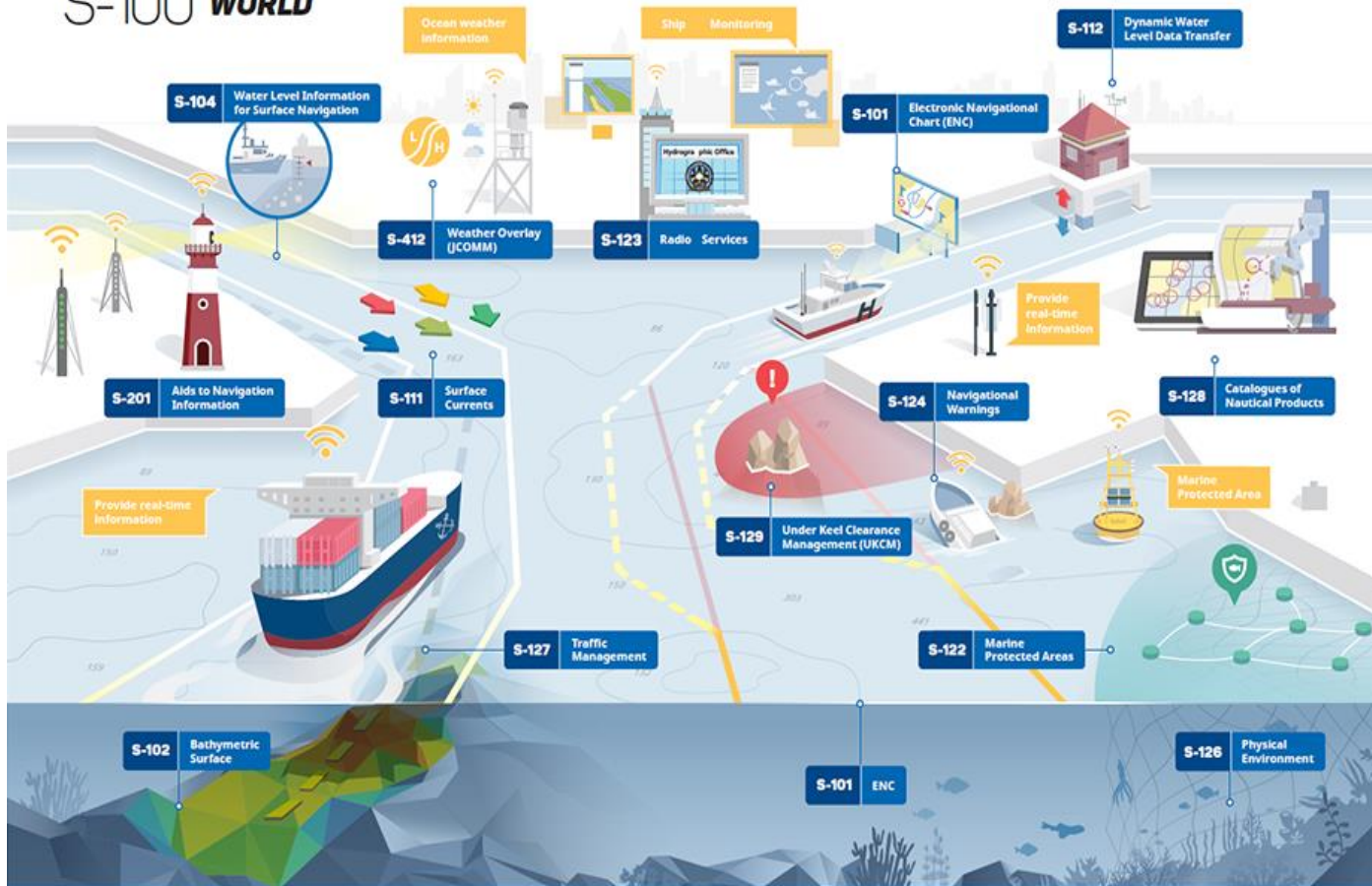
Illustration Veronica Wärm SMHI

Future Maritime Services S-100

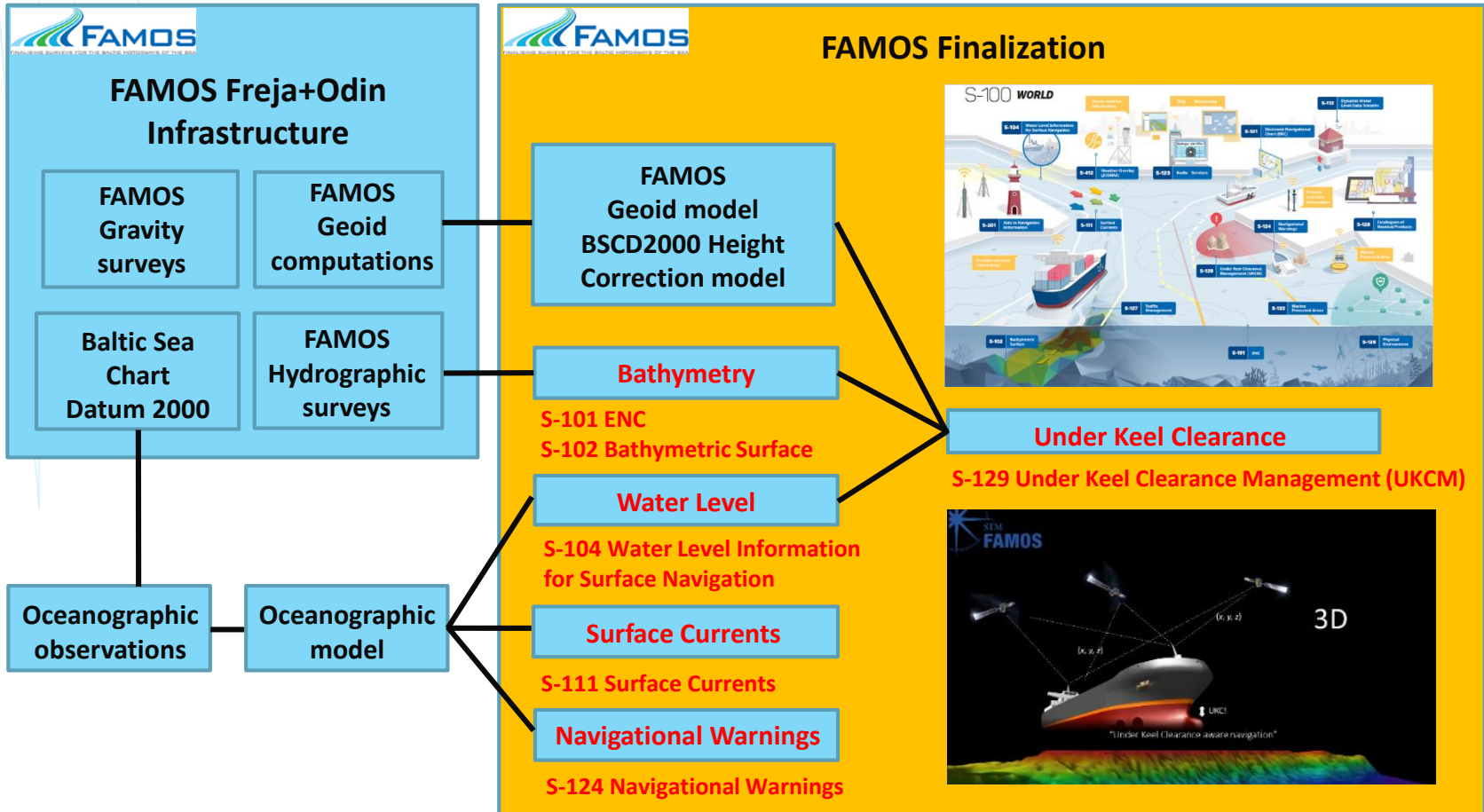


IHO

S-100 WORLD



FAMOS Finalization project (non-funded activity)



Thanks!



Thomas Hammarklint

Swedish Maritime Administration (SMA)

Thomas.Hammarklint@sjofartsverket.se