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**Baltic Sea Special Edition**

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## Editorial

Welcome to a special edition of the International Hydrographic Review (IHR). This edition comprises Articles and Notes submitted by members of the Baltic Sea Hydrographic Commission (BSHC). This edition has also been published one month earlier than usual to be available for the 5<sup>th</sup> EIHC.

The BSHC requested the opportunity to publish a special edition and the support of the individual authors representing many of the HOs and affiliated agencies has been outstanding. I believe the content of this edition provides an excellent example for how other regional hydrographic commissions can learn from one another and cooperate. The issues facing most HOs are similar and sharing of knowledge is paramount in this climate of reducing budgets and staffing, expectations to do more with less, etc. It is through such cooperation by HOs supported by the guidance of the IHB that enables the hydrographic community to maintain excellence in hydrographic and geospatial information.

This edition would not have been possible without the help of Mr. Juha Korhonen from Finland. Juha rallied the authors and kept them accountable to ensure the papers were submitted within the tighter timelines than usual. I hope that other RHCs will see the benefit of undertaking similar ventures and I look forward to seeing further special RHC editions in the future.

This Edition will also be my last as Editor. I am stepping down from this role due to increased work and family responsibilities. It has been a wonderful experience and I have enjoyed cooperating with the many authors to publish their contributions. I would also like to thank the Editorial Board for their support, IHB Directing Committee (past and present) for their oversight and in particular the publishing team at the IHB.

Ian W. Halls  
Editor

I have participated in the Baltic Sea Hydrographic Commission (BSHC) Conferences since 2001 and it is always a great pleasure and honour to be a part of such a cooperative and productive community. The benefits and the successful work of the Commission has been proven by a number of activities and projects, just to name some of them – Baltic Sea Re-Survey Scheme, Harmonisation of Baltic Sea ENC's, Baltic Sea Depth Model, harmonisation of vertical references, INT Chart Scheme, MSDI activities and others.

Such a number of activities and tasks require a lot of human and technical resources. Therefore the activities seem to be slower and longer, however we are confident that substantial progress is achieved and we are on the right track. Working in a truly friendly and cooperative manner and concentrating on technical issues only, the BSHC has managed to improve the excellence and proficiency of participating HOs by sharing the experiences, best practices and knowledge. Most of the BSHC activities and tasks are long term issues therefore I am sure that progress will continue in a friendly and cooperative spirit and we have a lot to achieve in order to improve the safety of shipping.

Over the last decade the use of hydrographic data is steadily growing and demand for high quality data is substantially increasing as exploration of world oceans develops further. Several international, regional and local activities, policies and initiatives will

## Editorial

foster demand for standardised high quality data and services covering not only territories of one particular state but even larger areas than the Baltic Sea. Such data and services can be obtained by close cooperation among the states and respective HOs. The BSHC over the years have proven that such cooperation is not a dream – it is feasible and realistic. The future challenge for the BSHC will be to maintain excellence and proficiency in cooperation and to be at least a small step ahead of future development.

This IHR Baltic Sea Edition is an excellent opportunity to provide information on the work in progress, achievements and future plans to the wider community and prepare grounds for cooperation with other regions.

Jānis Krastinš  
Chair, Baltic Sea Hydrographic Commission (BSHC)

On behalf of the Editorial Board and the BSHC, Jānis and I hope that this edition is of interest to you. Thank you to the authors for your contributions and to our colleagues who provided peer reviews for the articles in this edition.



### Affiliated Agencies



Baltic Marine Environment Protection Commission



## BALTIC SEA HYDROGRAPHIC RE-SURVEY SCHEME

***“To ensure that safety of navigation is not endangered by inadequate source information”***

By Juha KORHONEN (Finnish Transport Agency)



### Abstract

In the early 2000s, it was realised that the status of hydrographic surveys of the Baltic Sea was not satisfactory. The Baltic Marine Environment Protection Commission (HELCOM) requested the Baltic Sea countries to jointly develop a scheme for systematic re-surveying of the areas used by shipping in order *“to ensure that safety of navigation is not endangered by inadequate source information”*. The Baltic Sea countries have developed this Scheme in 2002. This work is coordinated by the Baltic Sea Hydrographic Commission (BSHC). Based on this Scheme extensive sea areas have been re-surveyed. The revised and extended Scheme with time schedule estimations was approved in 2013. The re-surveys have proved to be most useful. This article describes the background and main features of the Re-survey Scheme.



### Résumé

Au début des années 2000, on a pris conscience du fait que l'état des levés hydrographiques de la mer Baltique n'était pas satisfaisant. La commission d'Helsinki pour la protection du milieu marin de la mer Baltique (HELCOM) a demandé aux pays de la mer Baltique de développer conjointement un programme de nouveaux levés systématiques des zones de navigation *« pour s'assurer que la sécurité de la navigation n'est pas menacée par des données sources inadéquates »*. Les pays de la mer Baltique ont développé ce programme en 2002. Ces travaux sont coordonnés par la commission hydrographique de la mer Baltique (CHMB). En application de ce programme, de vastes zones maritimes ont été hydrographiées à nouveau. Un programme révisé et étendu avec un échéancier prévisionnel a été approuvé en 2013. Les nouveaux levés se sont avérés des plus utiles. Cet article décrit l'historique et les principaux éléments du programme de nouveaux levés.



### Resumen

Al principio de los años 2000, se tomó conciencia de que el estado de los levantamientos hidrográficos en el Mar Báltico no era satisfactorio. La Comisión de la Protección del Medio Marino del Mar Báltico (HELCOM) solicitó a los países del Mar Báltico que desarrollasen conjuntamente un esquema para una repetición sistemática de levantamientos hidrográficos de las zonas utilizadas por la navegación para *“garantizar que la seguridad de la navegación no esté comprometida por información de fuentes inadecuadas”*. Los países del Mar Báltico desarrollaron este esquema en el 2002. Este trabajo es coordinado por la Comisión Hidrográfica del Mar Báltico (CHMB). Basándose en este esquema, amplias zonas marítimas han sido nuevamente levantadas. El esquema revisado y ampliado con un cronograma estimado fue aprobado en el 2013. La repetición de los levantamientos ha demostrado ser sumamente útil. Este artículo describe los antecedentes y las características principales del Esquema de los nuevos Levantamientos.

## 1. Background and development process

Hydrographic surveys are long term activities. In the early 2000s, it was recognised that the status of hydrographic surveys of the Baltic Sea was not satisfactory. Whilst precise satellite based positioning is widely available, many areas in nautical charts are based on surveys up to 100 years old often with poor positional accuracy. Navigation with electronic charts is increasing and IMO has approved Electronic Chart Display and Information System (ECDIS) to be a mandatory navigation tool within a few years. The increasing size and speed of ships today set new requirements for chart information. In exceptional cases (e.g. ice conditions or accidents, environmental protection), there are many needs for accurate depth information also outside the main shipping routes. Thus there are clear needs for re-surveying the areas used for shipping with modern technology.

Following a serious tanker incident in March 2001 on the southern Baltic Sea, an ad-hoc Expert Group of the HELCOM was established to evaluate possible means to avoid this kind of accidents and to prepare a Minister level meeting to be held on 10 September 2001. This group proposed e.g. to achieve full Electronic Navigational Chart (ENC) coverage by 2004, a recommendation to promote the use of ECDIS, and to foster hydrographic re-surveying on the Baltic Sea.

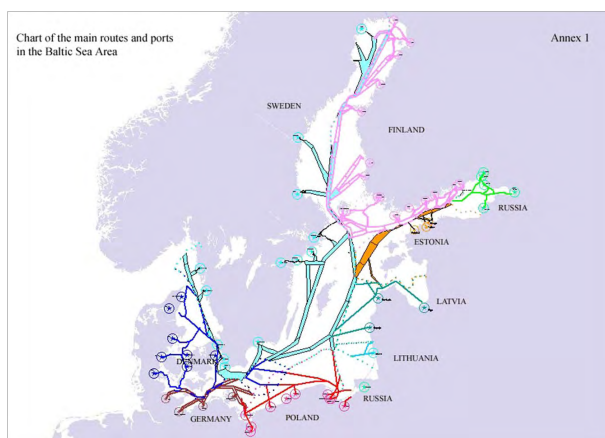
At the **BSHC 9<sup>th</sup> Conference June 2001**, the need for re-surveys was recognised. Noting the increase in deep draft ship traffic and the increase of the size of ships and the vulnerability of the marine environment in the Baltic Sea, the BSHC 9<sup>th</sup> meeting in June 2001 adopted the recommendation: *recommended that areas of concern to be re-surveyed at a regular basis in accordance with the highest standard set by the latest edition of IHO S-44. The re-survey should be based at a scheme elaborated jointly by the hydrographic services responsible for the area in question*, (BSHC, 2001).

The **HELCOM Copenhagen 2001 Ministerial Declaration** was adopted on 10 September 2001 by the HELCOM Extraordinary Ministerial Meeting (HELCOM, 2001a). It was included into the HELCOM Convention entering into force on 1 December 2002 (HELCOM, 2001b). The Copenhagen Declaration 2001 requests the following:

### a) *Re-surveying of major shipping routes and ports*

*- by requesting the Governments of the Contracting Parties to develop a scheme for systematic re-surveying of major shipping routes and ports in order to ensure that safety of navigation is not endangered by inadequate source information. The survey shall be carried out to a standard not inferior to the latest edition of IHO S-44. The scheme shall be elaborated jointly by the hydrographic services responsible for the areas in question not later than by the end of 2002 with the aim to begin implementation by 2003.*

The BSHC established the Re-survey Monitoring Working Group (MWG) to develop the Harmonised Hydrographic Re-Survey Scheme. There were no fixed time schedules for these re-surveys. Each country specified the primary and secondary routes and ports in its area of responsibility. Originally these routes were based on the list of main ports used as a background document for Copenhagen Declaration (HELCOM, 2001c). See **Figure 1**. These routes and areas are included in the re-survey database. [Later on some of the routes and areas have been updated and extended by the MWG members. These areas are later referred to as Category I areas]. The BSHC approved Version 1.0 of Harmonised Hydrographic Re-Survey Plan in December 2002. This was widely communicated i.e. via a press release as included in IHO CL 12/2003 (IHO, 2003).



**Figure 1:** Version 1.0 (2002) of the Baltic Sea re-survey scheme.

**BSHC Vision 2009.** Since 2002, it has been realised that the original scheme needs to be revised, e.g. new routing measures approved or planned, there are recognized high priority areas outside original routes, Automatic Identification System (AIS) data enables accurate tracking of ship



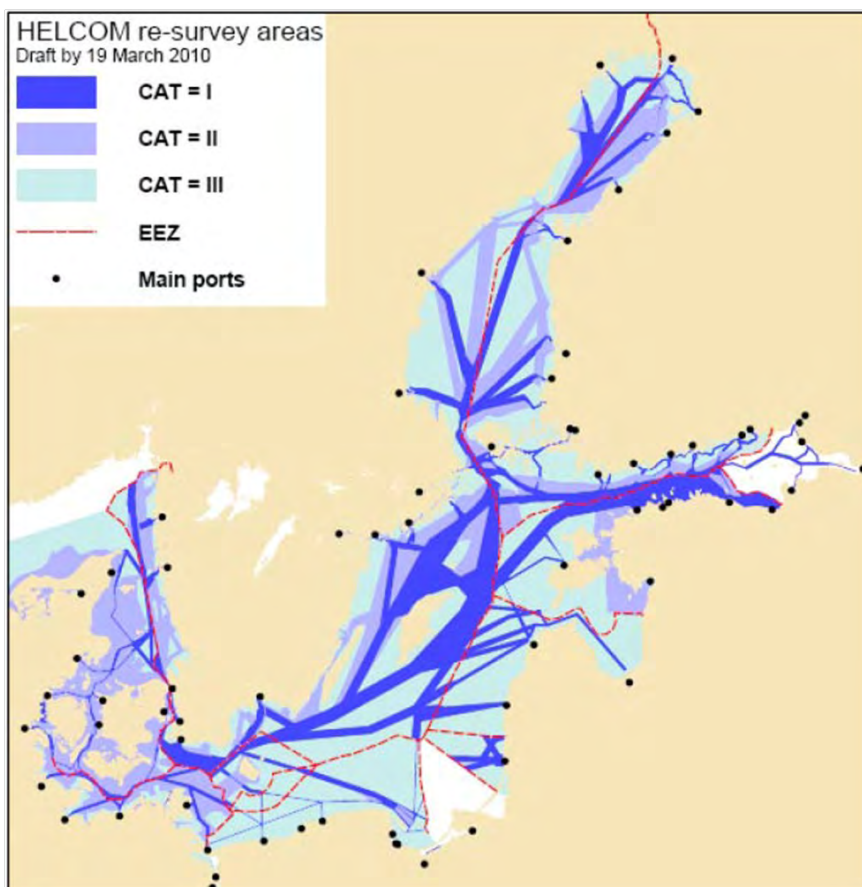
routes, and needs other than safety of navigation. The BSHC 14<sup>th</sup> Conference in 2009 approved a new Vision for revised re-survey scheme to extend the original scheme to cover the whole Baltic Sea area. The re-survey areas (see **Figure 2**) are categorized into three Categories: CAT I for original re-survey scheme, CAT II for extension needed for the safety of navigation, and CAT III for areas to be re-surveyed for other reasons than safety of navigation (e.g. for environmental purposes).

**The HELCOM Moscow 2010 Ministerial Declaration** agreed to extend the scope of the HELCOM Copenhagen Declaration and present time schedule estimations for re-surveys. The Moscow Declaration 2010 and its supporting documents can be found in references (HELCOM, 2010a), (HELCOM, 2010b) and (HELCOM, 2010c). The Moscow 2010 Declaration specifically requests the HELCOM Contracting Parties (Baltic Sea States) to:

- *Develop the Revised Baltic Sea Re-survey Scheme to cover the whole Baltic Sea according to the BSHC 2009 Vision*
- *Include CAT I and II re-surveys to cover all routes and other areas used for navigation*

- *Include CAT III re-surveys for other areas than for safety of navigation purposes (e.g. environmental)*
- *Specify time schedule estimations for CAT I and II re-surveys*
- *Present their national re-survey plans preferably by 2013, but not later than 2015*
- *Undertake necessary measures to ensure that sufficient funding, including external funding, will be available for the re-surveys*
- *Undertake measures to improve mariners' abilities to assess and interpret hydrographic content in nautical charts and publications either in printed or digital form, especially in the Electronic Chart Display and Information System*

Autumn 2012, the BSHC reported that the Revised Re-survey Scheme is already quite complete and proposed to report the status of its implementation to the HELCOM Ministerial Meeting on 3 October 2013. The BSHC also emphasised that hydrographic surveys provide useful information for several sectors in society.



**Figure 2:** BSHC 2009 Vision on the Baltic Sea re-survey scheme.

**The HELCOM Ministerial Meeting on 3 October 2013** (HELCOM, 2013a) adopted the Baltic Sea Harmonised Re-survey Scheme. The Ministerial Declaration and the Supporting Document of the Ministerial meeting are available at HELCOM web sites. The **2013 Ministerial Declaration ADOPTED** the Re-survey Scheme as:

- *HELCOM-BSHC Harmonised Re-Survey Scheme 2013 (HELCOM, 2013b), with time schedule estimations and funding arrangements, bearing in mind that these are likely to be modified when new national needs or priorities arise;*

The Ministers “*FURTHER AGREED the following specific approaches and measures*” and under titles *Shipping and activities at sea* and *Safety of navigation* on page 15 there are 14(M) and 15(M) including actions to ensure the completion of re-surveys.

*Finally, WE AGREE to fully implement the 2007 Baltic Sea Action Plan [BSAP] by 2021. With this Declaration with its general and specific approaches, actions and measures WE FURTHER AGREE to step up efforts for further strengthened implementation of the BSAP WE NOTE WITH APPRECIATION the following further general and specific approaches, actions and measures. WE WILL continuously REVIEW and REPORT how these commitments are implemented.*

**14 (M).** *RECALLING the HELCOM Copenhagen 2001, Krakow 2007 and Moscow 2010 commitments on hydrographic re-survey and COMMENDING WITH APPRECIATION the subsequent substantial progress made in systematic re-surveying of major shipping routes and ports in the region according to the HELCOM-BSHC Re-survey Scheme aimed at ensuring that safety of navigation in the Baltic Sea region is not endangered by inadequate source information;*

**15 (M).** *WE AGREE to take actions to ensure the completion of the re-surveys for areas used by navigation (CAT I and II) within the time schedules estimated in the 2013 Re-survey Scheme, to promote wider use of accurate and reliable depth information by e.g. developing existing and/or new products including an enhanced and freely accessible Baltic Sea Depth Model, and to foster CAT III re-surveys of other areas not primarily for safety of navigation purposes, e.g. for environmental protection;*

The supporting document **HELCOM-BSHC Re-survey Scheme** is regarded to be a part of the 2013 Ministerial Declaration. This document includes the time schedule estimations for completing resurveys for CAT I and II, which are referred to in the Declaration. The statistics are based on the status of late August 2013. The situation has already changed due to updates in the re-survey database. Updated statistics could be created when needs arise.

The Re-survey Scheme, the status of re-surveys and future plans have been reported together with some other hydrographic co-operation activities annually to **HELCOM MARITIME** Group. MARITIME highly appreciates the BSHC work and co-operation for increasing safety of navigation on the Baltic Sea and thus reducing risks for accidents and pollution.

**The European Union Strategy for the Baltic Sea** has an **Action Plan** which includes the Flagship project “*Speed up re-surveys of major shipping routes and ports*” within the Priority Area on Maritime Safety and Security (EUSBSR, 2013). The development of the Re-survey Scheme and progress of the re-surveys have been reported bi-annually to the Steering Committee of this Priority Area. The Steering Committee appreciates this activity and endorses the future plans.

## 2. Main principles of the harmonised Re-survey Scheme

In 2002 the BSHC Re-survey Monitoring Working Group (MWG) agreed to some practical, basic principles for developing the re-survey scheme and re-survey database. Later on slightly updated and extended principles are listed below:

**Responsibility of the development and implementation of the Scheme.** Each Baltic Sea Hydrographic Office (HO) is responsible for developing and implementing their National Re-survey Plans in its area of responsibility. The composition of National Plans will form the Baltic Sea Harmonised Re-survey Scheme. Necessary co-operation between the HOs will be discussed in bilateral negotiations and agreed on Bilateral Arrangements.

**Role of National Re-survey Plans.** The BSHC has a common understanding that even if the re-survey Plans will be approved by the BSHC and adopted by HELCOM, these plans are not fixed.

They are likely to be modified when new needs or priorities arise.

#### **General Principles for the Re-survey Scheme.**

This Scheme has been prepared according to the following General principles:

- This Scheme will concentrate only on the hydrographic surveys.
- Common understanding of the HELCOM Copenhagen Declaration is: All routes are to be re-surveyed, if the old survey data cannot be interpreted according to the IHO S-44 standard.
- For CAT I and II the new IHO S-44 Ed.5 will be applied in future surveys with the principle that where Order 1 survey is required, the survey should fulfil new Order 1a requirements.
- Each country is responsible for the interpretation of the IHO S-44 and compliance of its data regarding its own surveys.
- The main and secondary routes and ports are defined mainly by the traffic volumes of dangerous goods and passengers.
- As a general guideline the width of the routes in coastal areas should be at least two nautical miles; for open sea areas 6 nautical miles. The actual width of the routes and areas will be described in the Scheme.
- The S-44 feature detection requirement for Order 1a up to 40 metres should be interpreted bearing in mind the maximum draft of the Danish straits.

**Prioritized time schedules of Re-surveys.** Each HO is responsible for setting prioritised time schedules for re-surveys under its responsibility. Especially the following general principles should be considered:

- importance for international and regional traffic
- depth and expected shallows or obstructions
- quality and up-to-dateness of previous surveys
- importance for other uses

#### **Harmonisation of National Re-survey Plans.**

There are still issues to be harmonised, e.g. differences on the width of routes and disjointed sections. All Hydrographic Offices will make necessary actions to harmonise the routes and areas between neighbouring countries. Bilateral or

multilateral negotiations between the Hydrographic Offices of the neighbouring countries may be needed.

#### **Principles of distribution of the re-surveys data.**

The re-survey data will be processed as soon as possible and be included in the appropriate nautical charts and products, basically to printed charts and ENC's. The quality of information on data should be transferred with the data. Other possible exchange and distribution of the re-survey data should be agreed within the Bilateral Arrangements between the HOs.

#### **Principles of presentation of the re-survey data.**

Wherever possible, a common symbology (based on IHO specified symbology) for presenting re-surveyed areas on printed nautical charts should be used.

#### **Funding of re-surveys.**

All BSHC Members are planning to fund their national re-surveys through their government. There are some fixed plans for some countries to complete their CAT I and CAT II re-surveys. Some countries are also using external co-funding for speeding up their re-surveys, e.g. Finland and Sweden are using European Union TEN-T co-funding. There are plans to seek future European Union co-funding for 2014 - 2020.

#### **Implementation of re-survey plans.**

The BSHC has identified the following actions to ensure the implementation of National re-survey plans according to the estimated time schedules:

- All BSHC members commit to the implementation of their re-survey plans
- Seek External funding, where feasible
- The BSHC Monitoring Working Group to continue its work

#### **Follow-up actions.**

The BSHC has identified some follow-up actions to monitor the implementation of the National re-survey plans, e.g. BSHC will monitor the progress of implementation at its annual Conferences and report annually to HELCOM on the progress of implementation.

### **3. Re-survey Database**

Sweden has volunteered to develop and maintain the re-survey database and its web-based user interface. The first version was released in 2002. Some updates were made during 2003 – 2011. The latest version is Version 2 allowing to load and update the revised scheme.

**Data model.** The database contains metadata of the re-survey areas and the status of their re-surveys. The main object class is called **Section**. It represents a homogenous re-survey part of a route. The name is unique. There is only one member country responsible for each section. The geometry for the sections is stored in WGS84. The size of Section has not been limited in anyway and it is up to the operators to define it. A section has altogether 36 attributes including several internal system attributes. The main attributes meaningful to the users are: **Country, Section name, Route/Area name, Route type, Status, S-44 compliance, Priority, Category, Length, Width, Area, Re-survey work, 6 Date attributes for planned and actual work, Remarks and Geometry.** All of these could be updated via the Restricted User Interface. Some of them may be used for filtering the data on displays or database extracts.

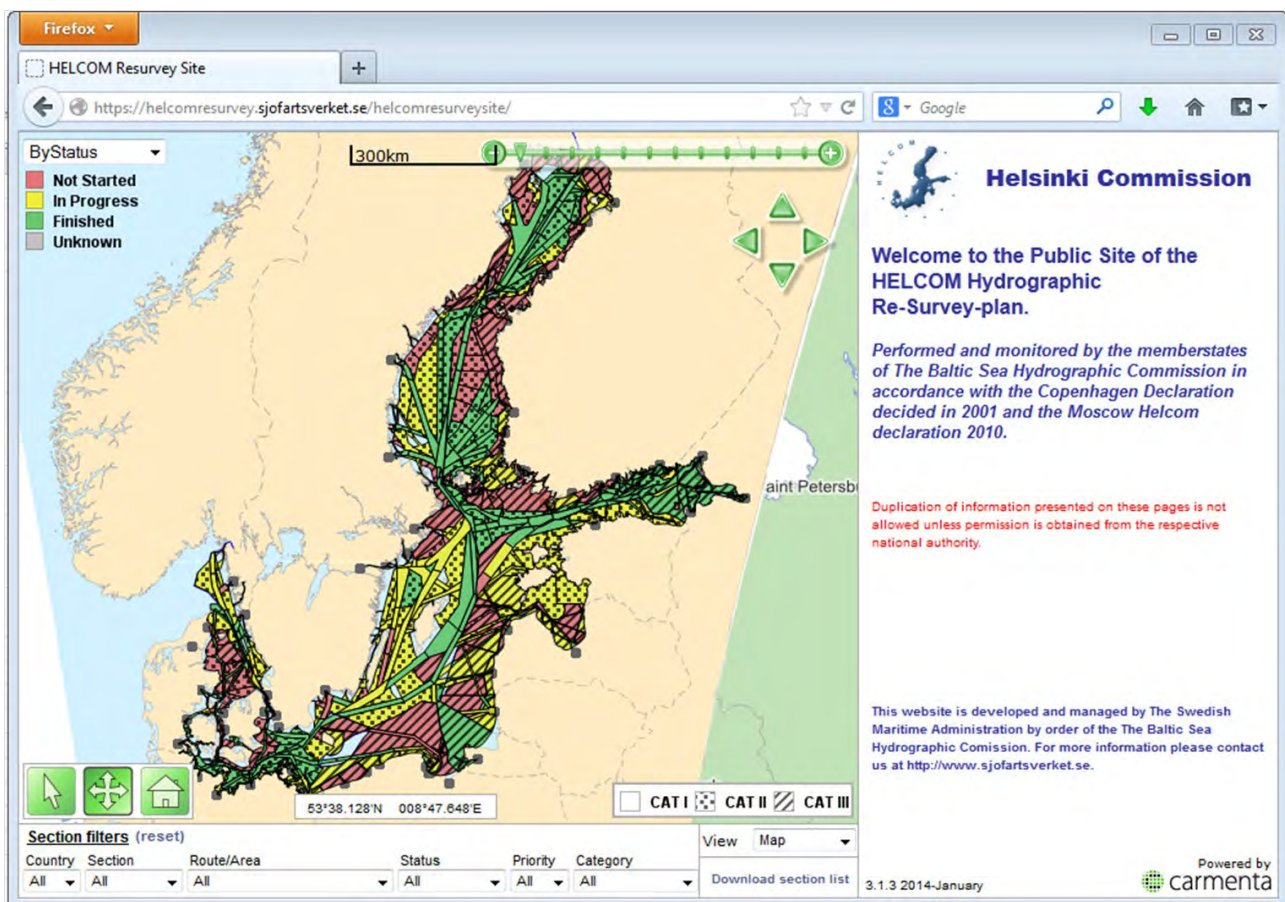
The web-based **Browser Interface** to the database (see **Figure 3**) is open to all via the link: <http://helcomresurvey.sjofartsverket.se/>

[helcomresurveysite/](http://helcomresurveysite/).

With the web-based **Restricted Interface** (see **Figure 4**) the metadata of re-survey routes and areas can be loaded and updated in this database. The re-survey data is processed and stored by each HO by nominated *National Database Operators*. Examples of editing tools of the Re-survey database can be seen in **Figure 5**.

The user interfaces include both **List view** and **Map view** to the database. The restricted interface also includes **Help functionality** which gives definitions of the data model and guidance to the operators on the main functionality of the software.

**Download functionality** allows extracting the content of the database to a text file. Extracted files contain information based on active selected options. Extracted files could be loaded into *MS Excel* tables and various statistics could be derived by the *Excel* tools.



**Figure 3.** Browser interface to the HELCOM-BSHC Baltic Sea Re-survey database.

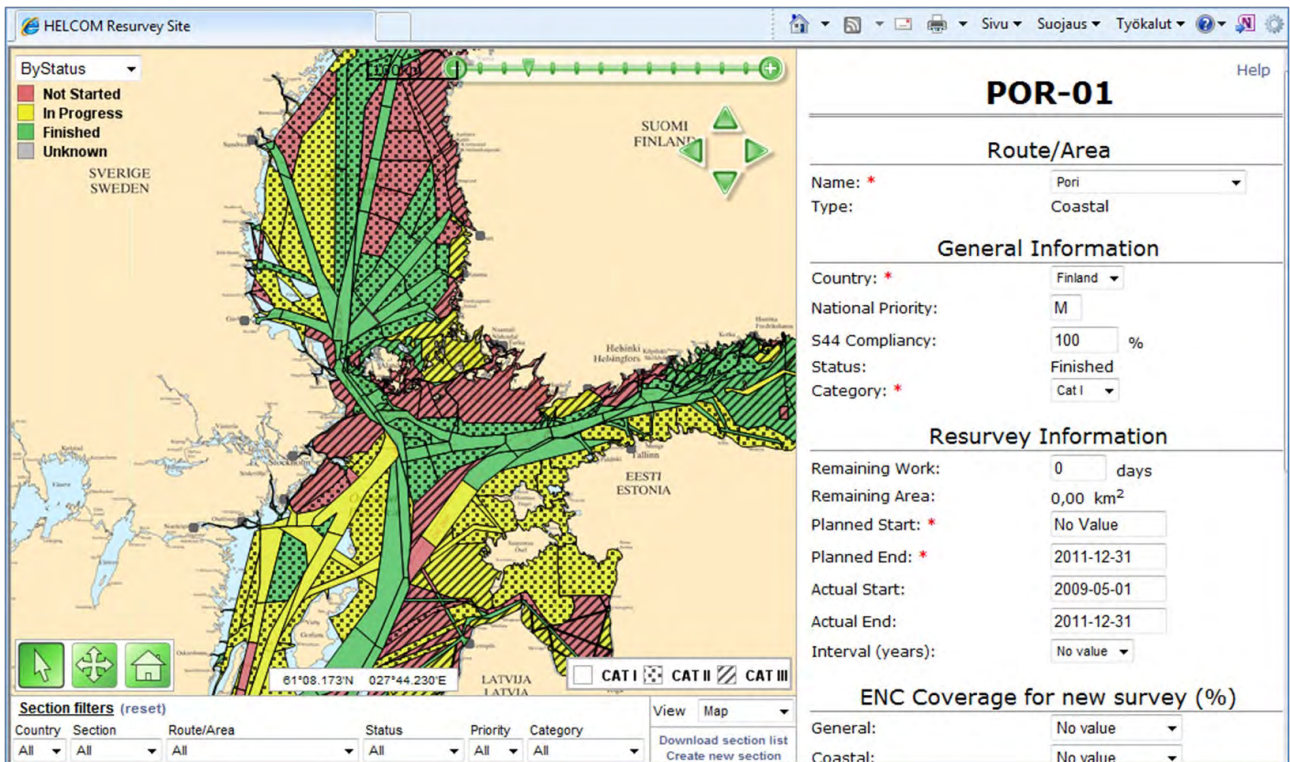


Fig. 4. Restricted interface to the HELCOM-BSHC Baltic Sea Re-survey database.

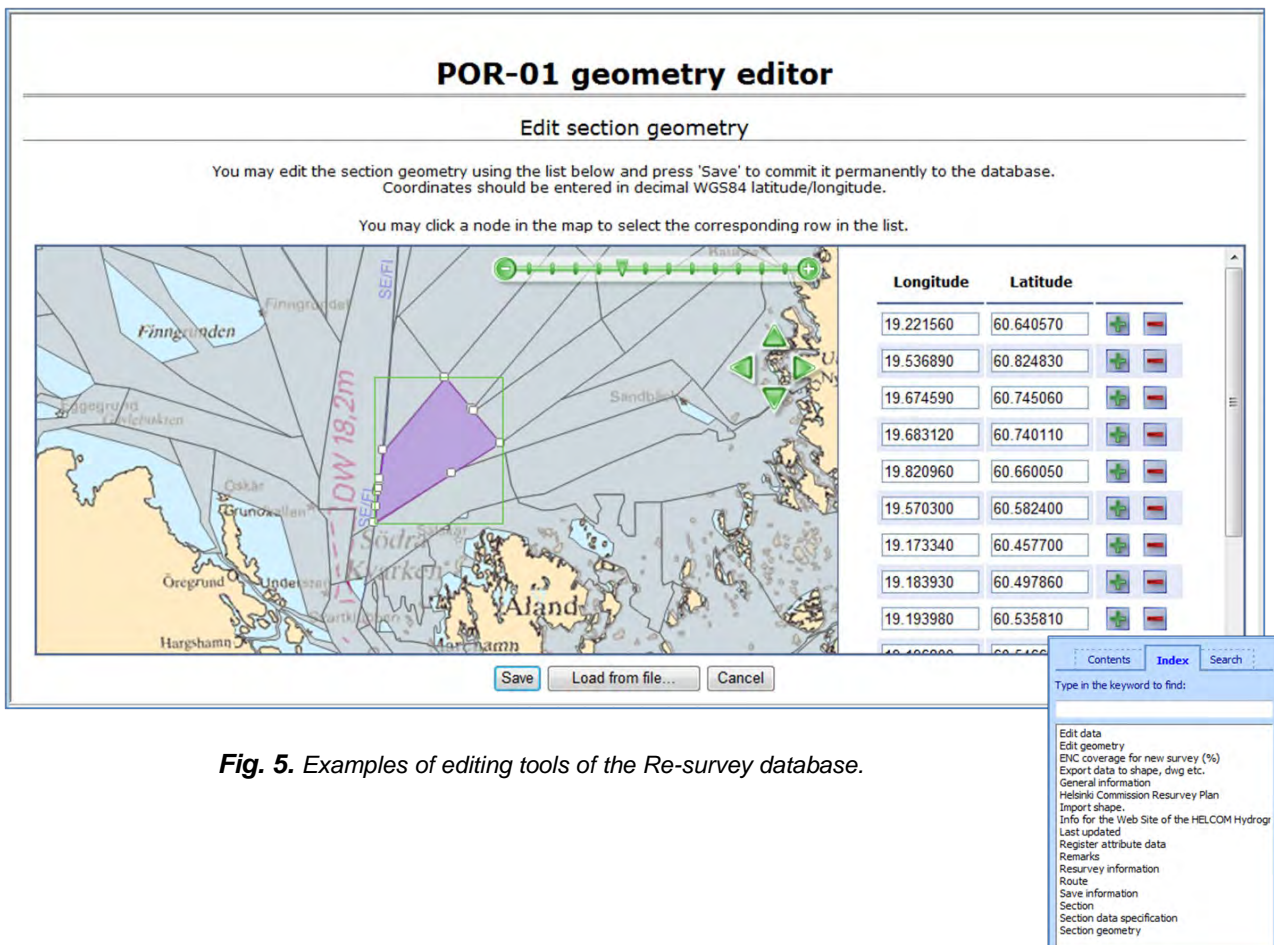


Fig. 5. Examples of editing tools of the Re-survey database.

This database is also linked to BSHC web pages, <http://www.bshc.pro/index.php/services/gis-resurvey>. The HOs are invited to make links to this Scheme on their national web pages. The database has been linked as a regional extension to the IHO C-55 database. In the HELCOM Web pages there is also a link to this database.

**Future development plans.** The re-survey database is based on more than 10-years-old technology. It runs reliably and all necessary data management operations can be performed with reasonable ease. However, several development issues for the database have been identified, e.g. to update the software based on modern GIS tools, to allow enhanced displays, more flexible uploading geometry and updating data, add printing capabilities, etc. Further developments have been postponed in order to wait for future IHO C-55 development and the Re-survey database could be intended to be a regional extension to that capability. Also, future development will be harmonised with the plans of the neighbouring North Sea re-survey database.

#### 4. BSHC Re-survey Monitoring Working Group (MWG)

In 2002, the BSHC established the **MWG** to coordinate and monitor the implementation of the re-survey schemes. All BSHC members are participating in the work of the MWG.

Each Member State has also nominated their **National Database Operators** who have updating rights to the re-survey database via the restricted interface.

The MWG has developed the principles for the Re-survey Scheme as well as guidance and best practises for uploading and updating the re-survey database. During MWG meetings, the progress of re-surveys, the harmonisation of national re-survey plans, the status of re-survey database and reporting are addressed. So far the MWG has had 10 meetings and arranged some database Workshops. MWG reports yearly to BSHC Conferences. It has also reported to HELCOM Ministerial Meetings, HELCOM MARITIME Group and European Union Strategy for the Baltic Sea Region.

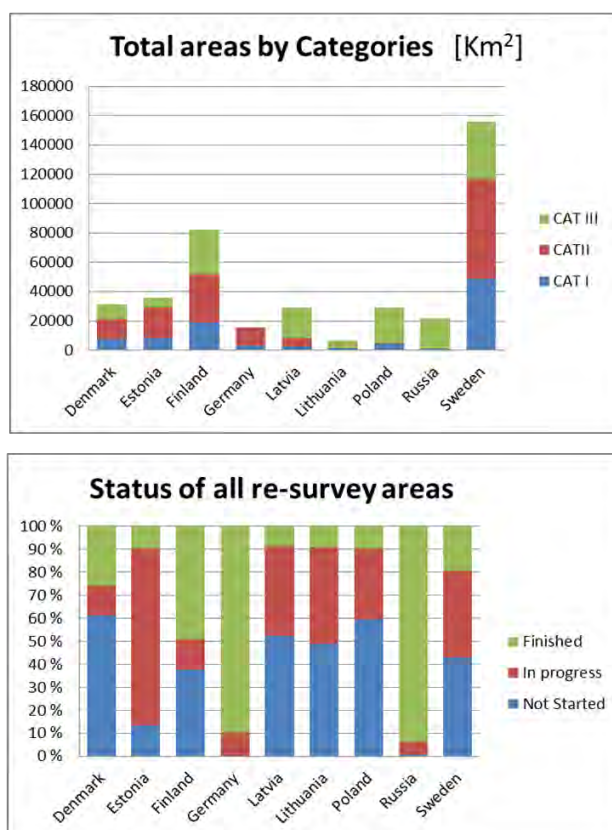
#### 5. Current status of Scheme

According to the re-survey database, the total amount of re-survey areas is currently (May 2014)

408,000 km<sup>2</sup>. The total amount of areas still to be resurveyed is 230,000 km<sup>2</sup>. See more details in **Tables 1 to 3** and in **Figure 6 to Figure 8**.

Total areas by Categories [Km <sup>2</sup> ]				
	CAT I	CAT II	CAT III	Total
Denmark	7690	13562	10278	31530
Estonia	8362	20476	6999	35837
Finland	19157	32470	31037	82664
Germany	3454	11895	0	15349
Latvia	2481	5668	20684	28833
Lithuania	1585	26	4819	6430
Poland	4103	902	24303	29308
Russia	1202	8	20720	21930
Sweden	48572	67847	39462	155881
<b>Total</b>	<b>96607</b>	<b>152854</b>	<b>158301</b>	<b>407763</b>
%	<b>24</b>	<b>37,5</b>	<b>38,8</b>	<b>100</b>

**Table 1:** Re-survey areas in the database by Categories (by May 2014).



**Fig. 6.** Re-survey areas in the database by Categories (by May 2014).

Re-survey areas remaining by Categories [Km <sup>2</sup> ]				
	CAT I	CAT II	CAT III	Total
Denmark	202	11225	10278	21705
Estonia	2452	13518	6950	22920
Finland	181	12148	26980	39309
Germany	171	607	0	778
Latvia	0	4216	20485	24701
Lithuania	353	0	4698	5051
Poland	2338	902	20206	23446
Russia	1126	8	221	1355
Sweden	10193	41336	39422	90951
<b>Total</b>	<b>17016</b>	<b>83960</b>	<b>129241</b>	<b>230216</b>
%	7	36,5	56,1	100

Table 2. Re-survey areas remaining to be surveyed (by May 2014)

The HOs have various time schedules to complete the re-surveys (see Table 3). Possible means to enhance and foster the implementation of the re-surveys should be studied. These could lead to utilizing the capacity more effectively, and to obtain extra funding to expedite the re-surveys, etc.

Time schedules for completion of National Re-survey Plans				
Country	CAT I	CAT II	CAT III	Remarks
Denmark	2013	2030	Not spec	
Estonia	2018	2028	2032	
Finland	2015	2015	2030	
Germany	2019	2025	N/A	Periodical 5 – 25 years
Latvia	2010	2022	2045	
Lithuania	2016	2010	2036	
Poland	2015	2017	2020	Periodical 5 – 25 years
Russia	2018	2018	2017	
Sweden	2020	2020	Not spec	
Latest year	2020	2030	See Notes	

Table 3. Summary of time schedules for completion of National Re-survey Plans, by May 2014.

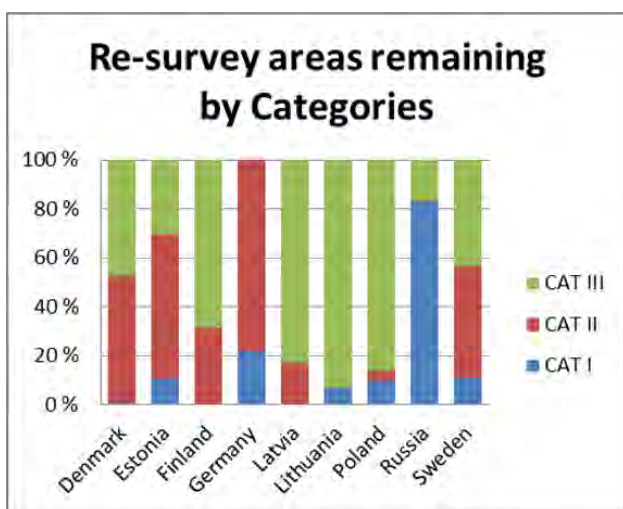
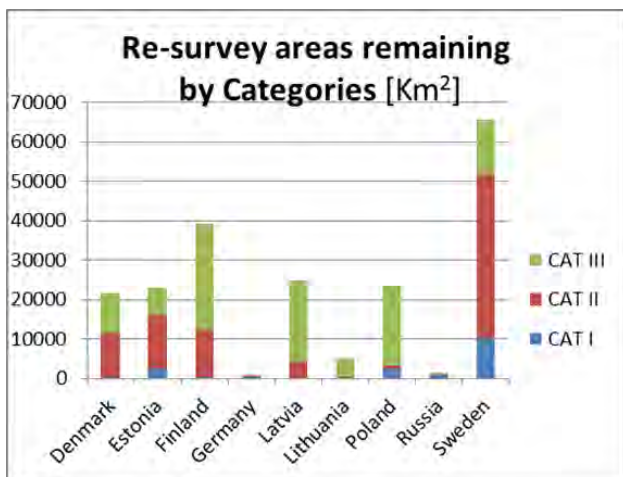
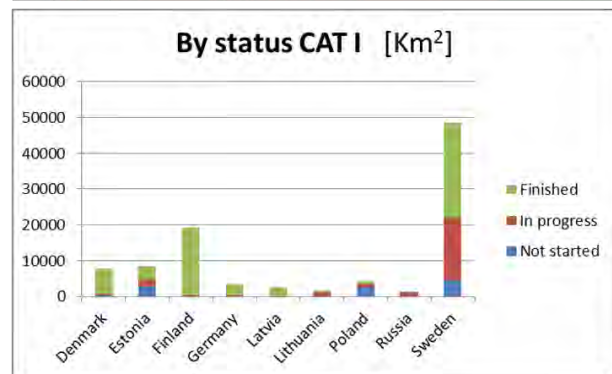
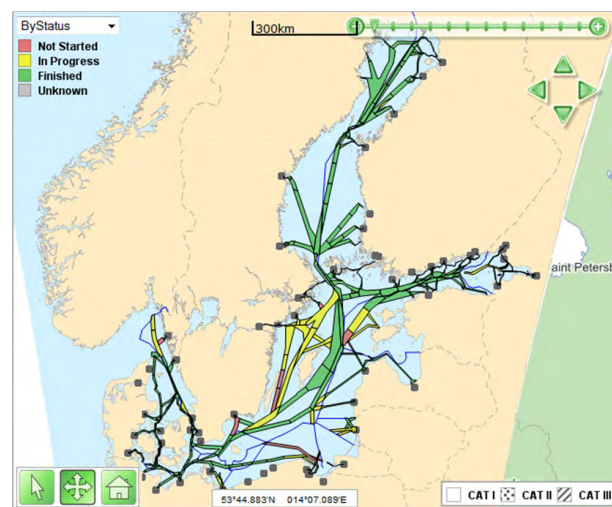
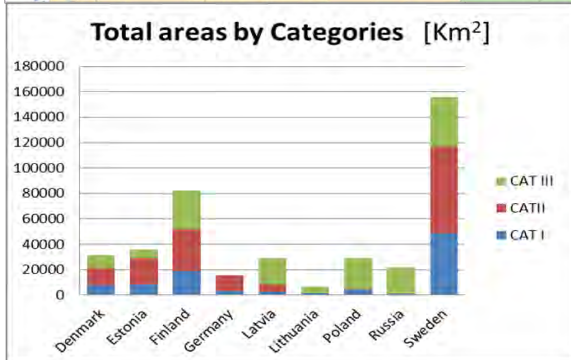
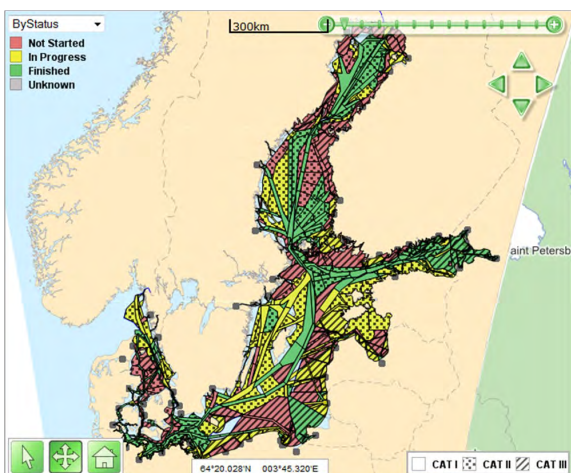
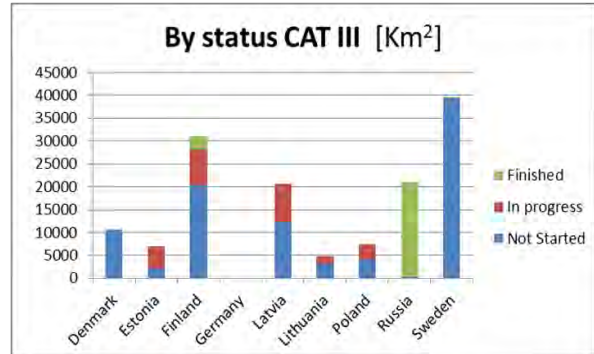
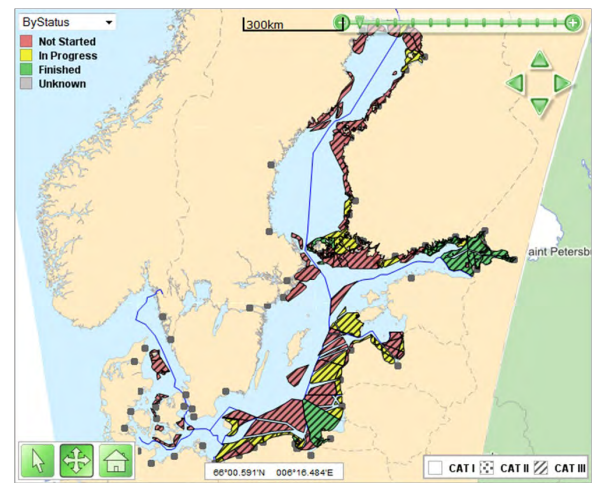
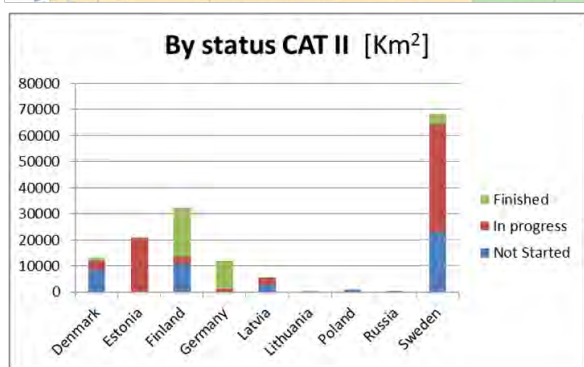
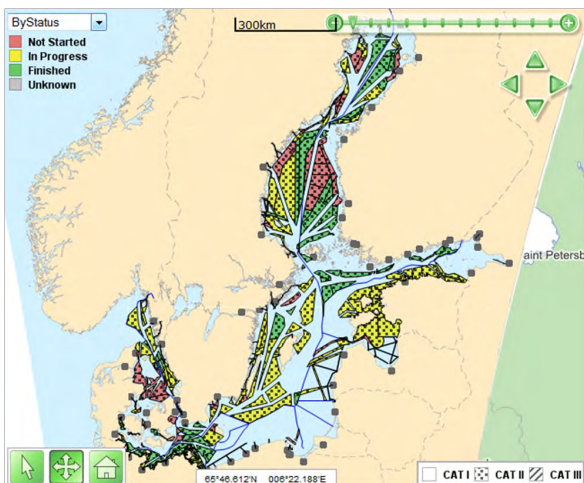


Figure 7: Re-survey areas remaining to be surveyed (by May 2014)





**Figure 8:** Summary status of CAT I, II and III and all re-survey areas (by May 2014).



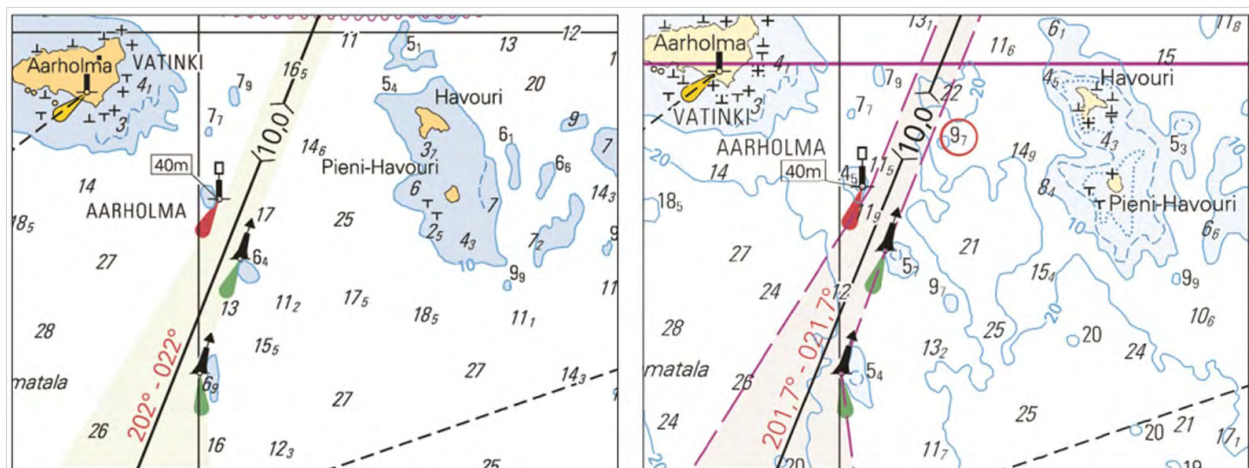
## Discussion

**Benefits of Re-surveys.** The re-surveys have already proved useful and beneficial. Whilst the overall goal for the re-surveys is to increase safety of navigation, other benefits are being realised:

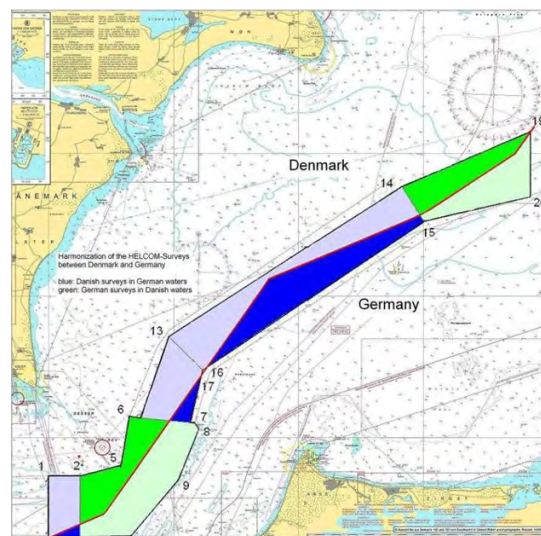
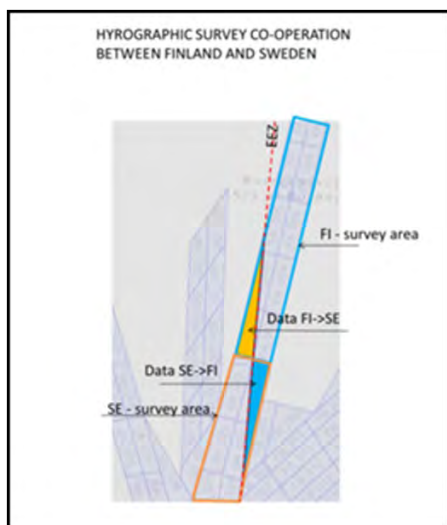
- The re-surveys cover areas used by shipping where old or otherwise inadequate depth information currently exists, and will thus allow safer sea areas for shipping and increase the protection of the marine environment.
- Accurate and reliable full bottom coverage of surveys allow for more flexible route planning, more precise navigation and more flexibility to utilise the increased loading of ships, and thus increasing the economic efficiency of shipping.
- During the re-surveys, critical new shallows or shallows shallower than previously known have

been found and appropriate actions have been launched (see **Figure 9**)

- Well planned re-surveys enable revisions of fairways or routes, and planning of modified or new Traffic Separation Schemes.
- The efficiency of the re-survey work has increased. These activities have enhanced systematic planning and co-operation between neighbouring HOs regarding surveys along border areas and allowing surveys in each other's areas of responsibility, and thus enabled more feasible re-survey tasks and more efficient survey operations (see **Figure 10**)
- Modern, full coverage, accurate and reliable depth information enables, in full scale, the benefits of the next generation S-100 based ECDIS systems and enhanced navigation practices with new ECDIS functionality (e.g. 3D navigation with real time dynamic water level information, precise warnings).



**Figure 9:** Example of a Nautical Chart before and after re-surveys. After re-surveys, more detailed depth contours can be seen on the chart and a critical shallow 9.7 m found very near to a fairway of 10.0 m draft.



**Figure 10:** Examples of co-operation of re-survey work between neighbouring countries (Finland/Sweden, Denmark/Germany).

- It is often more feasible and productive to completely re-survey the sea areas where old survey data exists than try to use old data and estimate where it will be useful. Old datasets are in many cases inhomogeneous and partial re-surveys are inevitable. New re-surveys will give homogenous data across national borders.
- There are growing needs for high density, accurate and reliable depth information also for other purposes than safety of navigations, e.g. for protection and monitoring of marine environment and for maritime spatial planning. New surveys will be a basis for a high density Baltic Sea Depth Model (see **Figure 11.**)

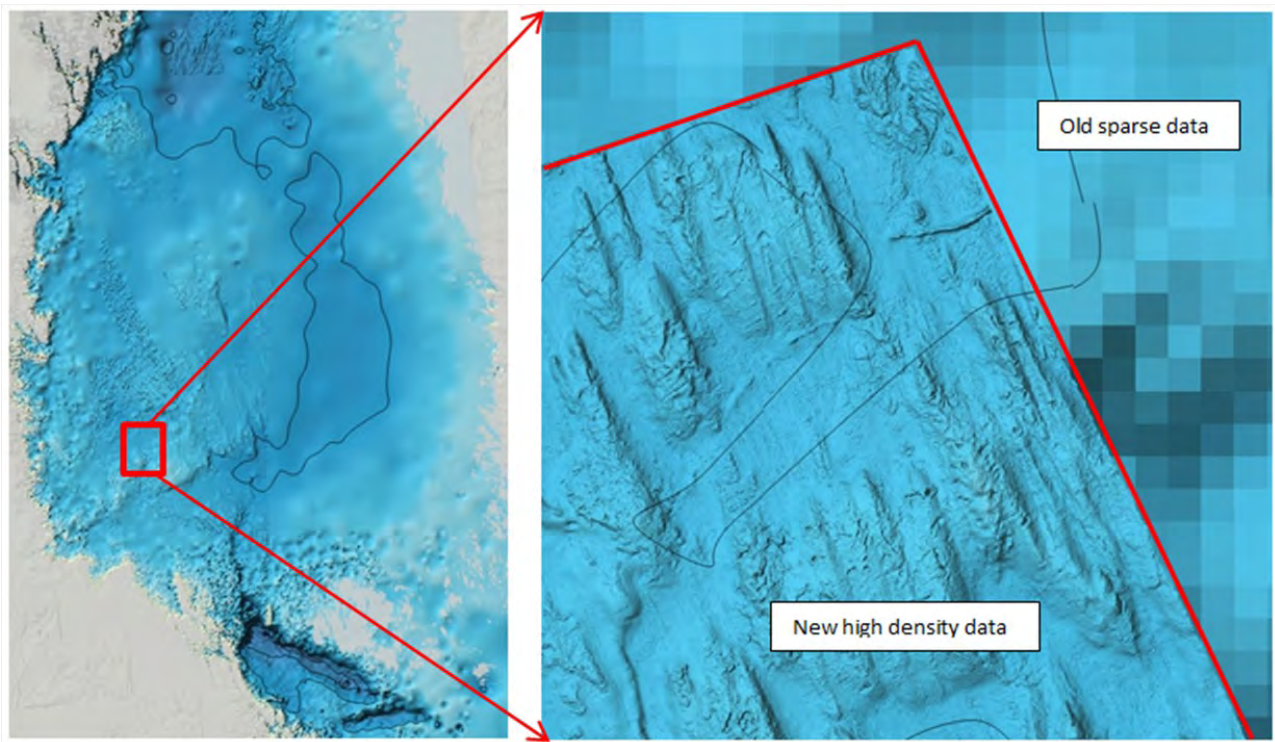
**BSHC Co-operation** has been active, friendly and fruitful. Practical and simple solutions have tried to be found whenever possible.

**HELCOM Co-operation** and especially the reporting to HELCOM MARITIME and EUSBSR PA SAFE Steering Committee have been fruitful. The **high level political support** from these bodies has been important, e.g. setting priorities and seeking funding for re-surveys both via national budgets and external sources.

**Communication.** The development and implementation of the Harmonised Re-survey Scheme has been communicated to BSHC, and neighbouring Regional Hydrographic Commission (NHC and NSHC) meetings, HELCOM MARITIME meetings, European Union Baltic Sea Strategy meetings, IMO NAV 51 meeting 2005, IHO Circular Letter 12/2003, IHO CHRIS/20 meeting, PIANC 2004 meeting. Also there have been presentations at the XVII IHO Conference 2007 and Hydro2010 Conference.

**Future Actions.** The BSHC and the Baltic Sea Hydrographic Offices have the tasks to take actions to ensure the completion of the re-surveys for areas used by navigation (CAT I and II), to promote wider use of accurate and reliable depth information, and to foster CAT III re-surveys. Below are listed some of the actions which are on-going or planned:

- Re-surveys are long-term activity and are continuing by all BHSC Countries, mainly with national resources.
- The European Union TEN-T *MonaLisa* project 2011-2013 has been completed and remarkable survey results have been achieved.



**Fig.11.:** Examples of the Baltic Sea Depth Model of the Bothnian Sea with varying density of survey data. The resolution in the overall dataset from the Baltic Sea Bathymetric Database is 500 m, but in re-surveyed areas it could be 25 m or more dense. The rectangle area on the right demonstrates how detailed the sea floor features (e.g. drumlins) can be seen with a 4 m grid.

- A new joint application to the European Union for co-financing the completion of CAT I and II re-surveys within the European Union 2015 - 2020 financial perspective is in preparation under the name "FAMOS". Sweden is coordinating this project.
- The BSHC has arranged a LIDAR Seminar in May 2014 for evaluating the state-of-the-art laser bathymetric survey systems and their feasibility for shallow water surveys, especially on the Baltic Sea.
- The BSHC has established its own web site (<http://www.bshc.pro/>) where information on BSHC activities and plans will be uploaded, e.g. links to the Re-survey Scheme and the Bathymetric Database. This web site could be linked to other web sites. Data density in the Bathymetric Database will be improved when new survey data is available.
- The MWG will continue its work according to the Work Plan 7.0 as agreed at BSHC 18<sup>th</sup> Conference in September 2013. The main tasks are to ensure the implementation of the National re-survey plans according to the estimated time schedules, to monitor the progress of the implementation, to foster actions for harmonisation of National plans, and to update and develop further the re-survey database. The MWG will report to BSHC at its annual Conferences and annually to HELCOM.

## 7. Conclusions

Since 2001 the goal has been to improve safety of navigation on the Baltic Sea. The Re-survey Scheme has enhanced planning and harmonisation of national re-survey plans. It has fostered completion of many re-survey areas. It has been useful for including re-survey priorities into national budgets. Clear harmonised plans have been successful at seeking external funding from the European Union.

The co-operation between all Baltic Sea countries has been open and friendly and is done on a completely voluntary basis.

Re-surveys are long term activities. By extensive re-surveys a huge amount of modern high density depth information has been collected. The main shipping routes and areas of the Baltic Sea will be re-surveyed by 2020 and all areas used for shipping will be re-surveyed by 2030.

Modern, accurate, reliable and high density depth information allows achieving the full benefits of the future generation S-100 based navigation systems.

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## Biography

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## A NEW BATHYMETRY MODEL FOR THE BALTIC SEA

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### Abstract

The Baltic Sea is a good example of a marine region with a complex coincidence of interests ranging from research, administration, environmental protection and exploration. Detailed bathymetry data is necessary for many applications in these fields, and can be used for much more than ensuring safety of navigation at sea. The Baltic Sea Bathymetry Database (BSBD) has been developed to provide a harmonized bathymetry grid of the Baltic Sea, from survey data provided by the surrounding hydrographic offices. In this article we discuss the background on the BSBD production, and its reception by the public after its release.



### Résumé

La mer Baltique est un bel exemple de région maritime ayant une convergence d'intérêts complexe couvrant la recherche, l'administration, la protection et l'exploration environnementales. Des données bathymétriques détaillées sont nécessaires pour de nombreuses applications dans ces domaines et peuvent être utilisées à bien d'autres fins que pour assurer la sécurité de la navigation maritime. La base de données bathymétrique de la mer Baltique (BSBD) a été élaborée pour fournir un quadrillage bathymétrique harmonisé de la mer Baltique, à partir des données des levés fournies par les services hydrographiques riverains. Dans l'article qui suit, nous présentons l'historique de la production de la BSBD, et son accueil par le public, après publication.



### Resumen

El Mar Báltico es un buen ejemplo de región marina con una compleja coincidencia de intereses, que incluyen la investigación, la administración, la protección y la exploración del medio ambiente. Los datos detallados de batimetría son necesarios para muchas aplicaciones en estos campos, y pueden ser utilizados para mucho más que para garantizar la seguridad de la navegación en el mar. Se ha desarrollado una Base de Datos de Batimetría del Mar Báltico (BSBD) para proporcionar una retícula de batimetría armonizada del Mar Báltico, a partir de los datos de levantamientos proporcionados por los servicios hidrográficos circundantes. En este artículo discutimos las bases de los antecedentes de la producción de la BSBD, y respecto de su recepción por el público después de su publicación.

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## Introduction

There are many fields other than safety of navigation at sea that have a need for detailed bathymetry. These fields include for example research, marine spatial planning, oceanographic modeling, offshore exploration, defense and environmental protection, just to name some important ones. Depth data is also being collected by various different stakeholders from fishermen to hydrographers and with very different levels of accuracy and quality control.

However, our seas are still far from being sufficiently mapped. This makes it vital that the best existing depth data is made available to the broadest possible audience.

In the Baltic Sea, an estimated 30% to 50% of the area is surveyed to modern standards, with the majority of surveying being conducted by the hydrographic offices of the surrounding states. Surveying activity has increased in recent years, and forecasts predict that the current intensity of surveying effort will be maintained for the foreseeable future (Korhonen, 2014).

Still, the majority of the bathymetry data is only being used for the production of nautical charts. Apart from the problems of actual data discovery, in some countries, detailed depth information is withheld for military security concerns or the hydrographic offices have an economic interest in selling data. Researchers have been forced to rely upon coarse depth models compiled mostly from soundings on published charts and data collected during sporadic research cruises. The IOWTOPO dataset compiled by Seifert et. al. (2001) is the most prominent example in the Baltic Sea. It accounted for two thirds of the bathymetry data citations in the scientific literature (Hell et. al., 2011). For anyone working in public administration, finding and accessing appropriate data has been laborious, and the general public are often not aware of the fact that topography continues to exist under the sea surface.

Not least considering the fragility of the Baltic Sea environment, it is now time to open the archives and unleash the potential of this hidden data treasure to spread knowledge of this marine region and thereby strengthen efforts to protect it. The Baltic Sea Bathymetry Database (BSBD), released in September 2013, is one step in this direction.

## Methods

The work which has led to the development of the BSBD is based on a detailed survey of the end users' needs (Hell et. al., 2011). To summarize that article:

- Users demand a high spatial resolution on the order of 5m to 50m – higher with decreasing water depth and decreasing distance to the coast.
- Bathymetry data for the shallow waters very close to the coast is most important from the end users' perspective.
- A lack of data or problems accessing to data imposes severe and costly restrictions for administrative as well as research activities. Access restrictions limit the usefulness of the data being collected.

These factors were the basis for the compilation of the BSBD, and were taken into account in all decisions made. However, as shown below, the combination of high spatial resolution and coastal vicinity is a demanding requirement.

## The Baltic Sea Hydrographic Commission

Since 1983, the Baltic Sea member states of the International Hydrographic Organization (IHO) have formed close ties under the umbrella of the Baltic Sea Hydrographic Commission (BSHC). In recent years the collaboration has intensified, leading to a number of projects tackled by BSHC working groups, as exemplified in this publication.

In 2009, Sweden took the initiative to restart a working group with the goal to produce and release a common digital bathymetry model, based on the best possible data from hydrographic surveying in all participating countries. The Swedish government was willing to fund the establishment of a pilot web portal for a publicly available bathymetry database of the Baltic Sea, in line with the EU INSPIRE directive. Data access would be provided at no cost and with limited use restrictions.

The working group includes members from all BSHC states and meets regularly to discuss the availability of data and determine the parameters for data release acceptable to all member states, such as grid resolution and terms of use. The work undertaken in compiling the model is mostly

carried out at the Swedish Maritime Administration (SMA), which also hosts the BSBD web site. Being backed by the BSHC proved to be a prerequisite for the work with the BSBD, especially with regard to gaining access to data from many different countries and organisations.

## Problems and challenges

At the beginning of the work in compiling the BSBD, it became clear that several challenges would have to be dealt with in order for the project to be successful: (1) Detailed depth information is withheld for defense reasons in Sweden and Finland. (2) The business models of several BSHC hydrographic offices have placed an economic value on depth data, requiring the data to be sold rather than distributed as open geodata. (3) The restrictions and caveats placed on the release of data by the individual Baltic Sea states vary significantly, which inevitably leads to compromises, such as when determining the possible grid resolution.

### Agreement means compromises

As one of the main tasks was to produce a homogeneous model of the entire area, the only way to achieve this result is for the database to adopt the lowest common denominator for each of its compilation parameters, especially with regard to grid resolution. It is on a level that all Baltic Sea states could accept, without being restricted by legal, commercial or security reasons. The possibility of higher resolution grids covering specific areas is an option for future BSBD releases.

### Security classification of depth information

In both Sweden and Finland, detailed information about the bathymetry along the coast of the Baltic Sea is considered critical for the defense strategy. Therefore, the release of such data for the territorial waters of these countries is restricted, and requires prior approval by the armed forces or responsible authorities. Even for users from other state authorities, the procedures to obtain the release of this data have been proven to be complex, restrictive and costly (Hell et. al., 2011).

For the BSBD, in Sweden a spatial resolution of 500m was deemed to be sufficiently general so as not to provide any military advantage, and received general approval for release. In the future it will be

possible to use higher resolution source data as input for the Swedish territory, but the final data will be distributed at the same 500m resolution as used today.

For the Finnish territorial waters, however, no such approval for release could be obtained. Therefore, these areas are only based on depth soundings taken from Finnish Electronic Nautical Charts (ENC), which are publicly available but problematic as a data source from which to compile a bathymetry model of high quality. The spatial resolution of selected chart soundings is rather low, they do not portray the sea floor morphology very well, and they introduce a shallow bias to the depth model in the areas where they are used.

In the exclusive economic zone (EEZ), no such defence restrictions apply in any of the participating countries.

### Business with depth data

For some years open geodata have been a topic for political discussions in many countries. In the European Union the INSPIRE directive has resulted in a substantial number of data sets being distributed in standardized formats by administrative bodies, often at no cost and with minimal use restrictions. The situation looks very different from country to country, and a large proportion of state-owned data cannot be shared freely due to various restrictions imposed by each state.

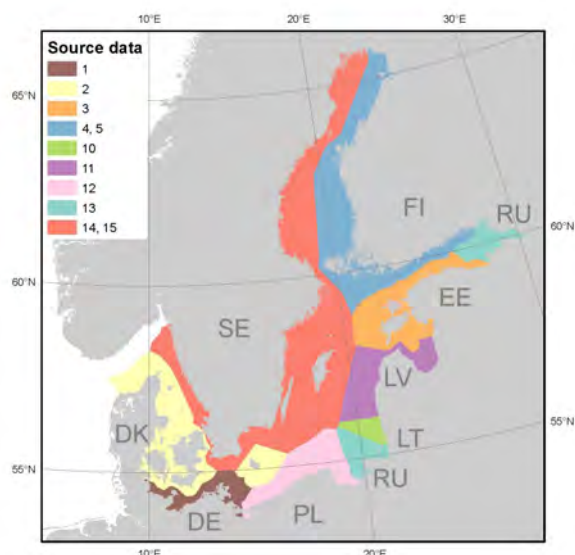
In the Baltic Sea region, only the German federal government and the Estonian authorities distribute all their geodata openly, without cost and with minimal use restrictions. In Denmark, access to land data is open but access to most marine data remains restricted, at least for commercial applications. The Swedish and Finnish hydrographic offices are required by their respective business policies to sell high-resolution depth data, which makes it highly unlikely that they will undercut their commercial offerings with a no cost option at a higher resolution than the present 500m.

### Data used

For the compilation of the BSBD, each BSHC hydrographic office has the responsibility to supply the most appropriate source data from the national hydrographic survey archives (**Figure 1**). The data listed in **Table 1** range from medium resolution gridded multi-beam measurements to excerpts of soundings from ENCs. Preferably the source data



has a higher resolution than the final 500m grid, is not interpolated between measurements, contains mean or median depths instead of minimum depths so as not to introduce a shallow bias, and uses Mean Sea Level as vertical datum. Its quality should also be known.



**Figure 1.** The areas of the various BSBD data sources. Refer to Table 1 for details and numbering.

Additional data was also used in order to constrain the BSBD grid at its edges:

- In the North Sea: points were extracted from the GEBCO\_08 grid (General Bathymetric Chart of the Oceans, 2010)

- At the coast line: nodes were extracted from the coast line used in charts produced by the Swedish Maritime Administration
- On land: points were extracted from the GMTED2010 7.5 arc second global elevation model (Danielson and Gesch, 2011)

This additional source data ensures that the BSBD grid has zero depths along its edges after being clipped at the coast line. Furthermore, it will seamlessly blend with GEBCO\_08 at its edge towards the North Sea.

Apart from the fact that large areas of the Baltic Sea are not yet surveyed to modern standards, various constraints exist in different countries, such as security issues, data usage restrictions or the lack a survey database from which the data can be easily extracted.

As mentioned previously, less than half of the Baltic Sea has been mapped to modern standards. The density of the existing older surveys varies substantially, depending on their age and location. In the open sea, sounding separations of several kilometers are not uncommon in deeper areas, and distances up to 16km between soundings can be found on rare occasions.

Therefore, the BSBD source dataset is inhomogeneous, imperfect and incomplete, and it will probably always remain so. Nevertheless, the data listed in **Table 1** is the best data currently available for this work. As discussed below, it still yields results far superior to the depth models previously available.

**Table 1.** Source data sets used for the compilation of BSBD version 0.9.3. See the BSBD web site for more information about these data sets and references.

	Country	Data set	Point spacing in original data source	Coverage	Source
1	DE	Gridded excerpt from national depth database	50m mean value grid	German territorial waters and EEZ	Bundesamt für Seeschifffahrt und Hydrographie
2	DK	Gridded depth data from 2006	50m grid made from TIN model based on data available 2006	Danish territory and EEZ	Danish Geodata Agency
3	EE	Mean value excerpt from national depth database	Varying, up to 50m in surveyed areas	Estonian territorial waters and EEZ	Estonian Maritime Administration
4	FI	Chart soundings	Approach level spot soundings of varying density	Finnish territorial waters	Finnish Transport Agency
5		Gridded survey data and chart soundings	200m grid of survey data and spot soundings	Surveyed areas in Finnish EEZ	Finnish Transport Agency
6	International	Chart soundings	Varying, up to several kilometers	Entire Baltic Sea	Swedish Maritime Administration
7		GMTED2010 land elevation	7.5 arc seconds gridded digital terrain model	Land areas close to Baltic Sea coast	U.S. Geological Survey
8		Coast line nodes	varying	Baltic Sea coast line	Swedish Maritime Administration
9		GEBCO_08	0.5 arc minutes	Norwegian Skagerrak and North Sea boundary	GEBCO
#	LT	IOWTOPO2	ca. 2km	Lithuanian territorial waters and EEZ	Institut für Ostseeforschung Warnemünde
#	LV	Excerpt from national depth database as of 2006	Varying, up to several kilometers	Latvian territorial waters and EEZ	Maritime Administration of Latvia
#	PL	Gridded data based on excerpt from national depth database	50m grid modeled from both dense and coarse data	Polish territorial waters and EEZ	Polish Hydrographic Office
#	RU	IOWTOPO2	ca. 2km	Russian territorial waters and EEZ	Institut für Ostseeforschung Warnemünde
#	SE	Median value excerpt from national depth database	Varying, at best 100m	Swedish EEZ	Swedish Maritime Administration
#		Median value excerpt from national depth database	Varying, at best 500m	Swedish territorial waters	Swedish Maritime Administration

## Data compilation

The source data is gridded using the *Stacked continuous curvature splines in tension* method (Hell and Jakobsson, 2010). In summary, the process works as follows:

- Each grid cell is median filtered, keeping only one sounding corresponding to the median depth of all data points in the cell.
- These data points serve as input to compute a continuous surface with one value for every grid cell, using the spline in tension algorithm (Smith and Wessel, 1990). This surface connects the data points and interpolates values for cells devoid of data.
- Depending on the source data coverage in each place, interpolated grid cells with insufficient data support are deleted, i.e. the ones too far away from the closest data points. Specifically, each grid cell itself and at least two of the cells next to it must each contain a data point.
- In order to fill these now-empty cells, the entire gridding process is repeated, but on a grid with double the cell spacing. With larger grid cells the data support is generally better and larger areas can be kept.
- This process is repeated until the entire area is filled, resulting in a series of increasingly coarser grids with a decreasing number of holes.
- In a last step, all the grids are stacked together, with values originating from smaller grid cells taking precedence over those from larger ones.
- The result is a uniform 500 m grid covering the complete area.

In the stacking process a grid showing the parent cell resolution of each place is also produced. This gives an indication of the underlying source data density at a point and may serve as one way to judge the quality of the final grid.

For the online presentation of the grid, it is further combined with the GMTED2010 land elevation dataset, as well as the GEBCO\_08 bathymetry grid covering waters outside the Baltic Sea. Finally, the data is colored for depth and shaded, and map imagery is rendered.

The grid is produced in a Lambert Azimuthal Equal Area projection, centered on the European continent, ETRS89-LAEA (EPSG:3035), following the INSPIRE recommendations for pan-European

maps. It is being distributed in a variety of coordinate systems, including WGS84 geographic coordinates and all relevant UTM projections.

## Results

The first public version 0.9.1 of the BSBD grid was published online 10 September, 2013. It featured a 500m grid based on data covering the areas of Denmark, Sweden, Finland, Estonia, Latvia and Germany. Today's version 0.9.3 (**Figure 2**) also includes data from Poland. The areas of the two remaining countries, Lithuania and Russia, are still based on the GEBCO\_08 grid. As new source data becomes available the grid is updated. Currently the approximate update frequency is two times per year. All grids are version numbered and a history of earlier versions of the BSBD is being kept on the web site, including possibilities to download legacy data.

The data is freely available under a Creative Commons Attribution license, with the provision that it may not be used for safety of navigation purposes. The BSBD is a non-shoal biased, interpolated and blended grid of limited cell size which is unsuitable for navigation. The grid is being distributed through a dedicated web site (<http://data.bshc.pro/>) featuring an interactive map with functions to download a specified area in a variety of formats; as well as metadata according to the ISO 19115 and ISO 19139 standards; and further documentation. The data is also published through several Open Geospatial Consortium (OGC) services, namely a standard Web Map Service (WMS) for map imagery and a still more exotic Web Coverage Service (WCS) for client side grid processing.

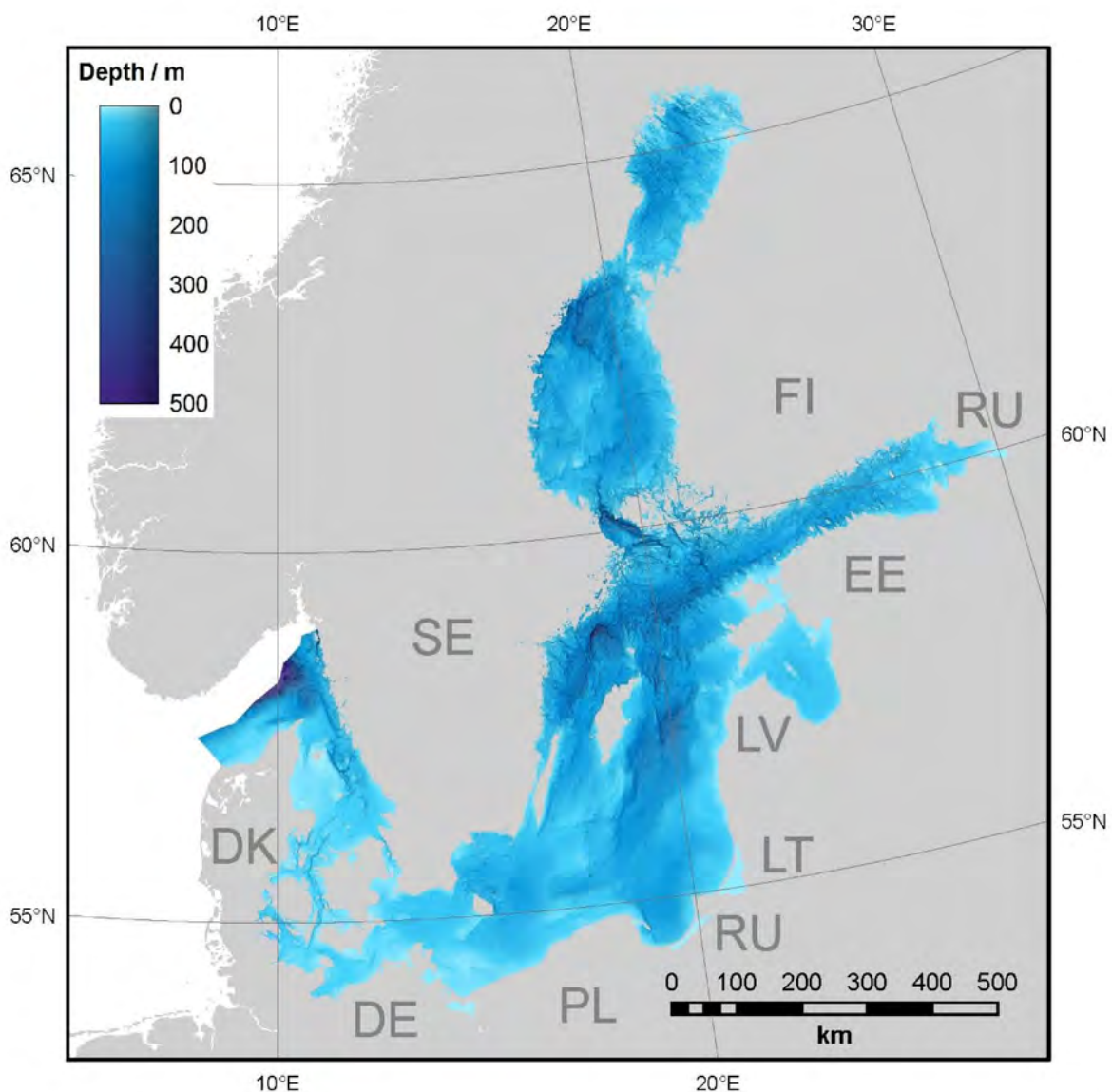
The grid homogeneously covers the entire Baltic Sea area, including Kattegat, Sound and Belts, as well as the Danish parts of Skagerrak, at a spatial resolution of 500m. Future versions will also include data for the Norwegian Skagerrak, and thereby cover the entire area of IOWTOPO2. Because of the varying density of the source data used, only part of the area is sufficiently covered with data to allow for this resolution without the need to interpolate between sparse data points. Many grid cells are interpolated between sparse data points. In order to give an indication about the underlying data coverage, a map showing the gridding resolution at each point is available alongside with the data grid (see methods above).

## Discussion

### Data quality

Compared to the IOWTOPO data sets, which often have been used for applications requiring complete and homogeneous coverage of the Baltic Sea, the BSBD grid is a major improvement regarding spatial resolution; precision and accuracy; and being compiled from the most complete and comprehensive set of source data available to the BSHC.

At a grid resolution of 500m, BSBD can convey 4 to 8 times more information as IOWTOPO1 and IOWTOPO2, with their resolutions of approximately 1km and 2km, respectively. Where the source data permits, much smaller morphologic details can be resolved. Many of the morphologically interesting features of the Baltic Sea are rather small, e.g. the deep channels through the Belts or remnants of ice age glaciations. But even larger features, such as the Landsort Deep, are portrayed in much higher clarity than previously available.



**Figure 2.** The Baltic Sea Bathymetry Database (BSBD) version 0.9.3, with the Baltic Sea Hydrographic Commission member states highlighted. Note that the BSBD comprises parts of the North Sea, namely the Danish and Swedish areas of Skagerrak (the Norwegian Skagerrak will be included in the near future), in order to entirely contain the water area covered by the IOWTOPO data sets.

As the BSBD is entirely based on quality-controlled data from the archives of the BSHC member hydrographic offices, one can expect a high accuracy regarding both the lateral placement of features and the depths reported. However, a large portion of the area has not yet been mapped to modern standards. As a consequence, the accuracy of the BSBD source data varies and thereby also the accuracy of the BSBD grid, even though the best possible data is included for the majority of the coverage.

As described above, the source data is as complete as possible with regard to producing a 500m grid resolution product. In many places, surveys with much higher resolution have been down sampled to a level sufficient for the target resolution. This does not depreciate the value by any means of the final grid at its given resolution, and simplifies handling of the large source data set. However, in limited places additional and better data may exist, e.g. where high-resolution industry data has not been supplied to the respective hydrographic office. It is not a regulatory requirement in all countries for industry to supply the national hydrographic authority with hydrographic data from surveys performed in that country's area of charting responsibility.

## Public reception

The BSBD web site, where data can be viewed and downloaded, has been visited by more than 10,000 unique users between its launch in September 2013 and June 2014. About one third of the visitors have returned to the web site at least once. The visitors come from more than 100 countries, with a large majority from Sweden, the other Baltic Sea states, France, the United Kingdom, Norway and the United States. The large proportion of Swedish visitors can be accounted for by the fact that the BSBD is being developed and hosted in Sweden, and has been promoted most actively here. The site has been referenced by hyperlink from about 100 different World Wide Web sites. Search engines account for only 10% of the site's traffic to date.

There have been approaching 4000 downloads of data from the web site. The following statistics are being collected through the download form on the web site:

- timestamp
- data format

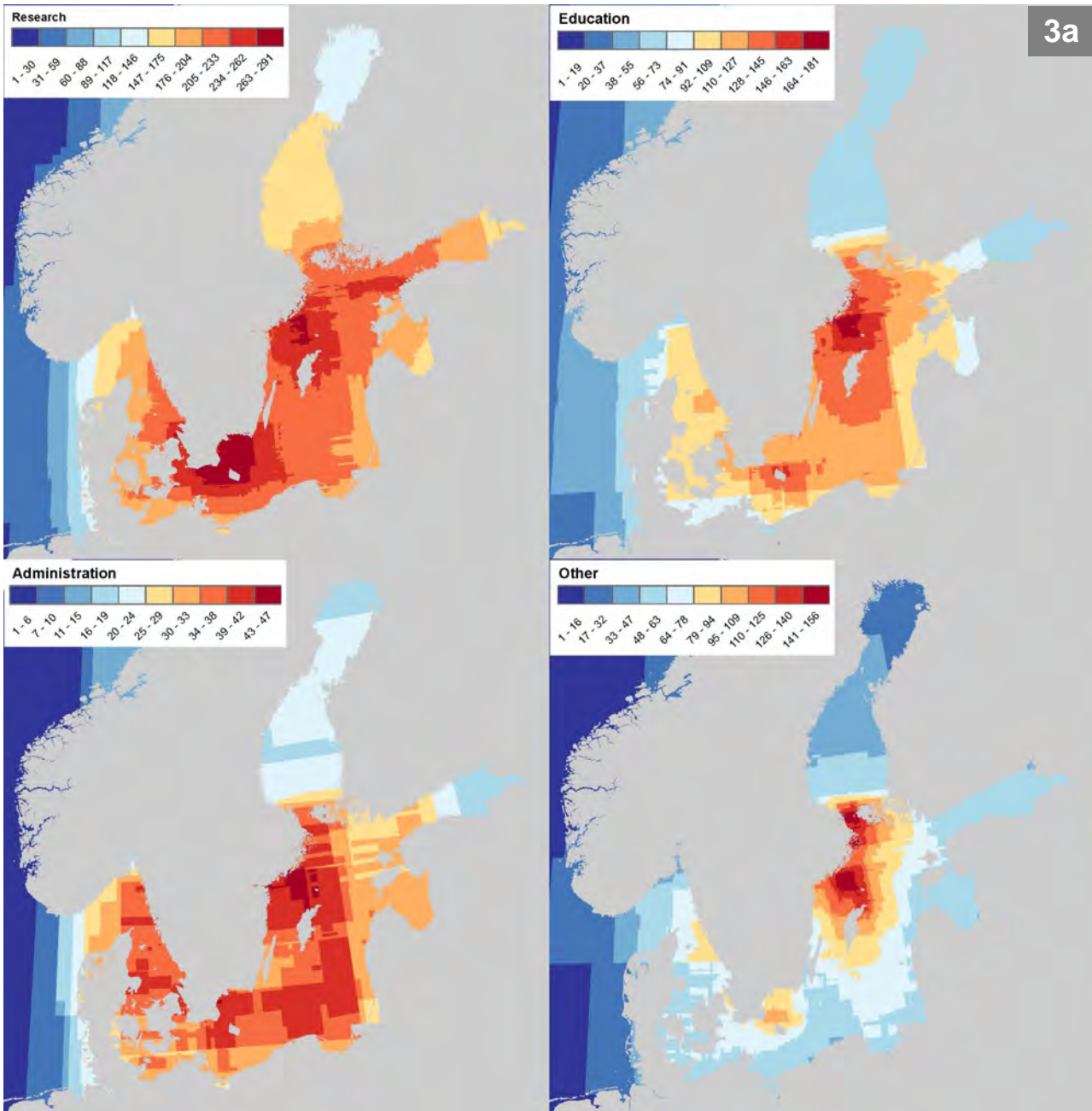
- use category (research, administration, education, other)
- downloaded area

**Figures 3a-c** summarize (a) how frequently a specific area has been downloaded for each use category; (b) data use; and (c) format of the downloaded data. Note that this only includes the downloads requested through the web site, and not utilization via the OGC services, for which it is more difficult to obtain accurate usage statistics.

The maps showing the frequency with which areas of the BSBD are downloaded (**Figure 3a**) is quite similar to the research intensity map published by Hell et. al. (2011), namely in showing a much higher interest in the Southern Baltic, as opposed to say the Bay of Finland or Bay of Bothnia. The comparably higher interest in the Swedish part of the Baltic Proper is probably due to the fact that the largest portion of BSBD users are from Sweden, whereas there has been a bias towards Germany for the IOWTOPO grids.

As shown in **Figure 3b**, most of the data is being downloaded for academic purposes, namely research and education. Administrative use accounts for only 5%. Apparently almost one-third of the download requests do not fit into the predefined use categories. The areas where data is downloaded most frequently varies between the use categories (**Figure 3a**): Research is most spread over the entire Baltic Sea area and most intensive between the Swedish south coast and the island of Bornholm. Administrative uses are quite homogeneously distributed, except for the Bothnian Sea and the Gulf of Finland. Data downloaded for education is focused around the Landsort Deep. The deepest point of the Baltic Sea also attracts most downloads that do not fall into any of the previously named categories. Probably a lot of these downloads originate from the general public, which would explain the high interest in prominent regions such as the Landsort Deep or the Stockholm archipelago.

Regarding download formats (**Figure 3c**), almost two-thirds of the download requests are for imagery (GeoTIFF colored and shaded relief; PNG), rather than actual data grids (ASCII XYZ; Arc ASCII Grid; GeoTIFF single channel 32-bit depth data). ASCII XYZ data is the most commonly requested data format of the formats offered. There have, however, been requests for NetCDF, which now is supported by Web Coverage Service.



3a

Figure 3a. Download frequency in a specific place for different use categories

Figure 3b. Usage categories for downloaded data.

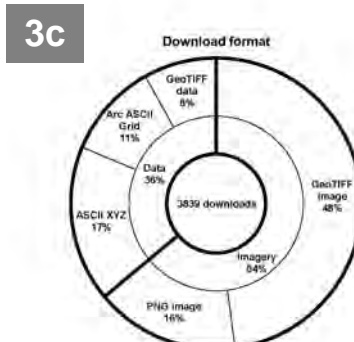
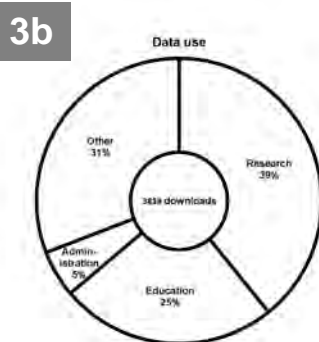


Figure 3c. Data formats downloaded through the web interface. Note that the GeoTIFF format can be used for both geo-referenced images and as a container for gridded data.

## Collaboration with other data compilation initiatives

After its release, the BSBD has quickly gained interest from other bathymetry data compilation efforts, namely the IHO/IOC General Bathymetric Chart of the Ocean (GEBCO) and the European Marine Observation and Data Network (EMODnet).

GEBCO is an international group of experts who provide a global bathymetry grid of the World Ocean at a resolution of one arc-minute. It was established in 1921 and is governed by both the UNESCO's Intergovernmental Oceanographic Commission (IOC) and the IHO. Until now, most of the Baltic Sea in GEBCO was derived from IOW-TOPO2. BSBD version 0.9.3 has been delivered to GEBCO for inclusion in the upcoming GEBCO 2014 model.

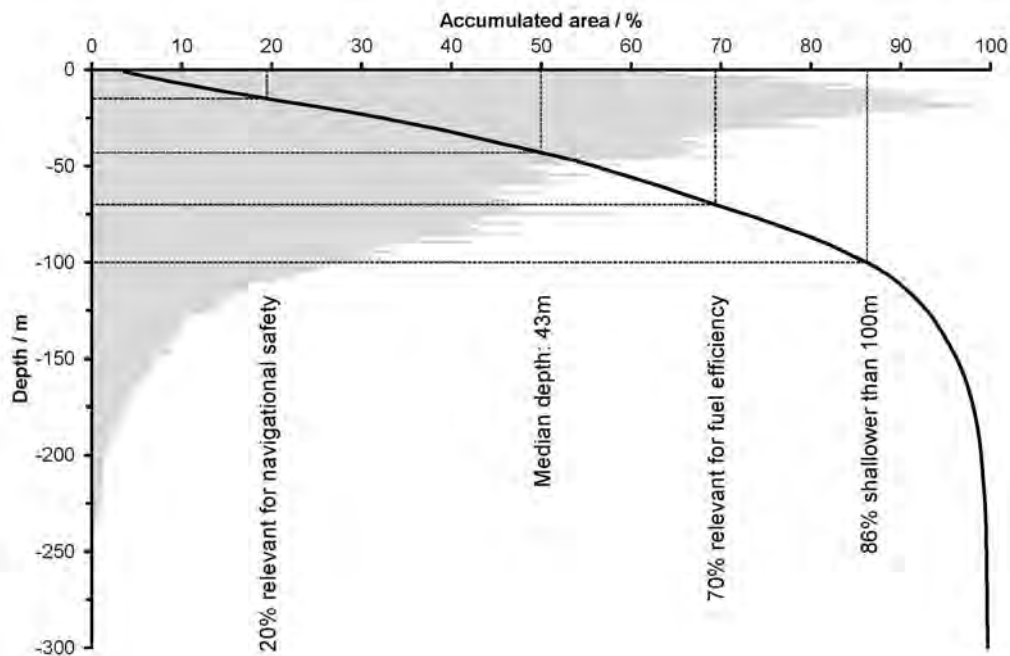
During phase 2 of the EU initiative EMODnet, a one-eighth arc-minute bathymetry grid of the European seas is being developed. BSBD represented by the BSBD working group acts as data provider

for the Baltic Sea and data derived from the BSBD will be included in EMODnet at a spatial resolution of one-quarter arc-minute.

## The hypsometry of the Baltic Sea

**Figure 4** shows the hypsometry derived from the BSBD grid, i.e. the total area of each specific depth value. Even though the deepest point in the Baltic Sea reaches 456.5m in the Landsort Deep, 86% of the Baltic Sea is shallower than 100m. The median depth of the Baltic Sea is 43m, only a little more than one per cent of the World's oceans median depth.

Approximately 20% of the Baltic Sea is shallower than 15m, the maximum draft of vessels navigating in the Baltic. Almost 70% of the area is shallower than 70m, about the maximum depth for squat effects to be relevant for the fuel consumption of large vessels. Even these relatively shallow areas are yet to be completely mapped. More hydrographic surveying needs to be done to ensure safe vessel navigation can occur with minimal environmental impact.



**Figure 4.** The hypsometry of the Baltic Sea. Depths are binned into 1m intervals. The gray shaded histogram represents the relative frequency of a certain depth to occur (no units). The black line shows the accumulated area shallower than a certain depth, as a percentage of the entire Baltic Sea area. The calculation includes the Danish and Swedish parts of the Skagerrak.

## Conclusions

The Baltic Sea Bathymetry Database (BSBD) presented in this article is one significant step forward since our study of the needs regarding bathymetry data in a highly vulnerable but economically important and shallow sea such as the Baltic (Hell et. al., 2011). With the release of the BSBD grid, a single access point for detailed Baltic Sea bathymetry data has been established. Nevertheless, the work is far from finished with large parts of the area yet to be sufficiently mapped. Furthermore, legal, defence and economic aspects prohibit releasing a depth model with higher resolution at no cost at this time. Such a model would be required to fully satisfy the users' needs as outlined in our previous study.

Therefore, the BSBD must be seen as ongoing work. It will receive regular updates — up to a few times per year — as better source data becomes available, or when legal, defence or economic circumstances change.

Already today, the Estonian and German hydrographic offices would allow their data to be re-distributed in much higher resolution than the present 500m. Although this would imply the BSHC abandoning the concept of a homogeneous model for the entire Baltic Sea, an additional high resolution model is being considered for these countries.

## Acknowledgements

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## Biographies

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## FEASIBILITY OF LASER BATHYMETRY FOR HYDROGRAPHIC SURVEYS ON THE BALTIC SEA

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### Abstract

Airborne laser bathymetry (ALB) is considered to be a new technology for hydrographic purposes in shallow waters. However, previous tests have shown greater problems especially regarding point density and the detection of obstructions. Before introducing this technology as a regular means of surveying, it is necessary to identify its possibilities and limitations, especially in the shallow waters of the Baltic Sea. New tests have been carried out in several of the Baltic Sea's coastal states. The first results demonstrate that the accuracy of the surveys is not a major issue for using ALB in modelling the sea floor. However, point density remains a limit in deeper waters, where small obstructions cannot to be detected.



### Résumé

La bathymétrie laser aéroportée (ALB) est considérée comme une nouvelle technologie répondant aux besoins de l'hydrographie en eaux peu profondes. Toutefois, des tests précédents ont mis en évidence des problèmes plus importants, notamment en ce qui concerne la densité des points et la détection des obstructions. Avant l'introduction de cette technologie en tant que moyen courant d'exécution des levés, il est nécessaire d'identifier ses possibilités et ses limites, notamment dans les eaux peu profondes de la mer Baltique. De nouveaux essais ont été effectués dans plusieurs Etats côtiers de la mer Baltique. Les premiers résultats ont montré que la précision des levés n'est pas un problème majeur pour l'utilisation de la bathymétrie ALB dans la modélisation du fond de la mer. Néanmoins, la densité des points reste toujours une limite en eaux plus profondes, là où les petites obstructions ne peuvent pas être détectées.



### Resumen

Se considera que la Batimetría Láser Aerotransportada (ALB) es una nueva tecnología para fines hidrográficos en aguas poco profundas. Sin embargo, las pruebas anteriores han mostrado mayores problemas especialmente en lo que respecta a la densidad de los puntos y a la detección de obstrucciones. Antes de incorporar esta tecnología como un medio regular para efectuar levantamientos, es necesario identificar sus posibilidades y limitaciones, especialmente en las aguas poco profundas del Mar Báltico. Se han llevado a cabo nuevas pruebas en varios de los estados costeros del Mar Báltico. Los primeros resultados demuestran que la exactitud de los levantamientos no es un tema fundamental para utilizar la ALB en la modelización del fondo marino. Sin embargo, la densidad de los puntos sigue siendo un factor limitante en aguas más profundas, donde no pueden detectarse las pequeñas obstrucciones.

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## Introduction

Airborne laser bathymetry (ALB) has been used in the very clear waters of Australia and other regions for a few decades [Banic et al., 1987]. Similar to topographic airborne laser scanning, ALB uses optical laser distance measurements, but normally with two laser beams (red and green). The red laser is reflected from the water surface, and the green primarily from the sea floor. The difference between the two values is the slant distance in the water, and provides the water depth. The green laser also gives a response from the water surface, and this has led to development of a new compact system that only uses the green signal to calculate the slant distance. The systems are now receiving full waveform data and analysing the full waveform and extracting further information about the water column and the seabed seems to have a great potential for enhancing the final outcome of Bathymetric LiDAR.

Although the turbidity of the Baltic Sea is considerably higher than the Australian waters, several hydrographic services in the Baltic Sea region have investigated whether it makes sense to use this technology in shallow coastal areas. Test campaigns in recent years provided quite disappointing results. The seabed was not reached in deeper areas, there were many gaps in the data, and the obstruction detection was poor.

Recently, new systems have been developed, and more recent test campaigns have resulted in greatly improved results in European waters. Of particular note are several surveys with ALB along the French coast [Pastol, 2011], which has inspired new test projects in several European countries. To initiate better coordination and awareness of the potential value of this new technology, the Baltic Sea Hydrographic Commission tasked Germany to host a seminar on LiDAR bathymetry. This seminar took place in May 2014 in Hannover; this paper will highlight some of the relevant discussions from that seminar.

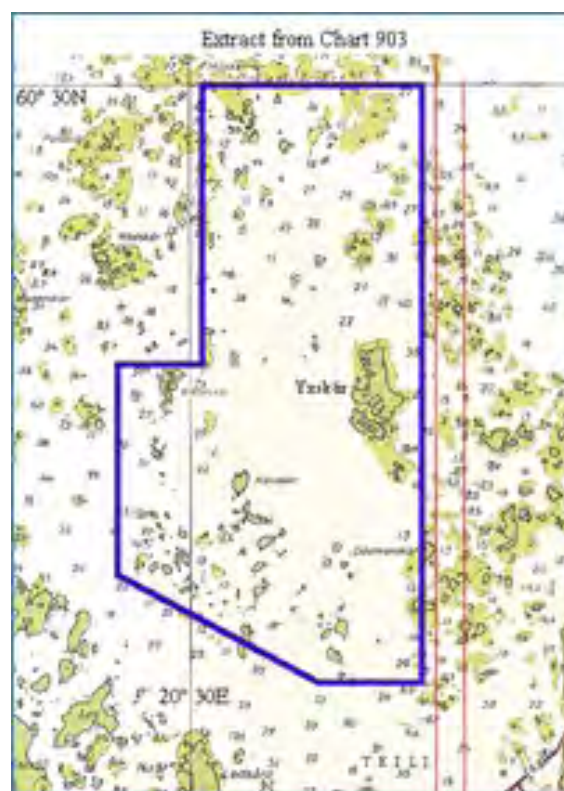
## Finnish Laser Bathymetry test in 1999

An early test of LiDAR bathymetry in Finnish waters was performed in 1999. LADS Corporation Ltd. from Adelaide, Australia performed a laser bathymetry survey for Finnish Maritime Administration (FMA) Hydrographic Surveys Division in the Finnish Archipelago Sea.

The test area was shallow and previously uncharted, and is located to the northeast of Åland Island. **Figure 1** is an earlier chart extract from the survey area. The size of the survey area was 160 km<sup>2</sup>; after taking into account the line ends and swath coverage, about 190 km<sup>2</sup> were actually surveyed.

About 27 km<sup>2</sup> of the area is dry land (islands).

Prior to the survey, a reconnaissance survey was performed in the end of July 1999, and gave 6-7 meter Secchi disc depths. The same Secchi results were obtained in a second survey in September. The survey itself was conducted in November, and took two full eight-hour survey flights to complete due to short lines; patching and reruns were done on a subsequent third flight. Some of the survey lines were resurveyed from the opposite direction, as the presence of islands and dry areas shut the laser down automatically. The survey was able to record depths between 3 – 15 meters, and covered about 82 km<sup>2</sup>, about 50% of the total survey area.



**Figure 1:** LiDAR test survey area on Finnish Archipelago, 1999

The survey resulted in a total data amount of 10 GB, consisting of about 5 million depth values. The

values covered a 5 m x 5 m grid, and values for a 15 m x 15 m grid were automatically generated from the raw data. The sounding rate of the LiDAR system was 900 soundings per second, which is considerably lower than modern systems can achieve. The operating height was 500 m and 370 m, and the survey speed was 175 knots. Kinematic GPS was calculated during post-processing of the data, in which the position of the plane's GPS antenna was accurate to 0.2 m (2 drms).

The survey results demonstrated that the laser beam had penetrated about two to two and a half times the measured Secchi depths. The laser beam could be detected at 15 meter depths and, occasionally, at 16 to 17 meter depths. Following a northerly storm during the survey, the Secchi depths were reduced to 3-4 meters, and laser depths to maximum 7-8 meters.

Processing the survey data constituted a laborious process, especially in the very shallow waters of the 5 m x 5 m grid, as compared to 15 m x 15 m grid.

### Conclusions of the Finnish survey

As a result of the test in 1999, it was deemed that the data were good for most purposes and it was considered that IHO S-44 Order 1 had been achieved for both position and depth measurement. However, some problems were encountered at shallow water. When the laser hit dry land, the red pulse lost the water level reference surface and there was difficulty regaining the reference surface instantly. Also, the reflection from the water surface was so strong that the reflections from the shallowest depths (0 m-3 m) were either overpowered in calm weather or were not accepted by the model algorithm as proper depth values.

Water clarity was an issue in the Baltic Sea and necessitates a comprehensive Secchi-depth measurement before performing LiDAR bathymetry surveys. Also environmental conditions have to be taken into account as they have an evident effect on the visibility in water. From an economic point of view LiDAR bathymetry was not considered to be cost-effective enough in Finland for hydrographic purposes.

### The German laser bathymetry project

In the intervening years, ALB was not seen as an appropriate tool for hydrographic surveys in the

Baltic. The main reasons were the poor clarity of the water, limited penetration of the laser beams, low density of reflected beams, large gaps and reduced detection of objects on the seafloor. Several coastal states carried out initial tests that showed rather poor results. Among these was a simple test performed in Germany in 2008.

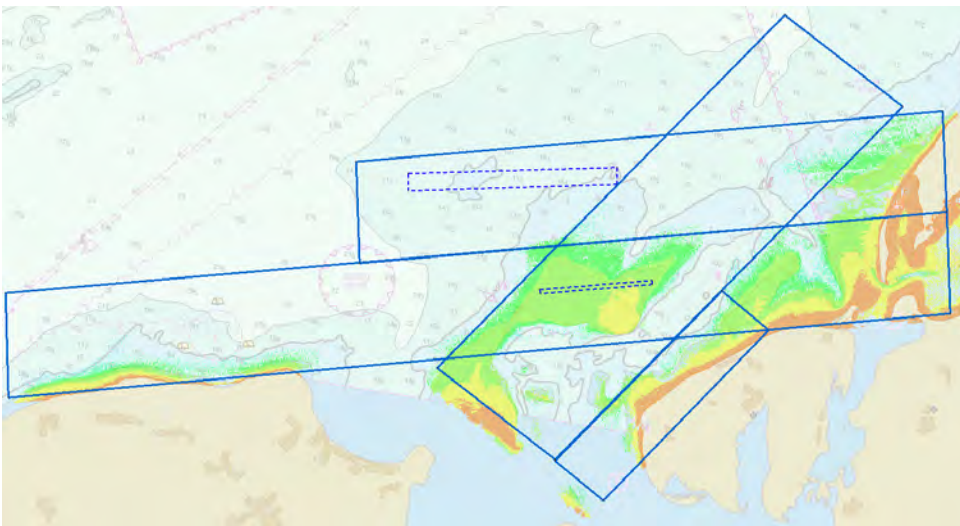
More recent developments in ALB technology have made it necessary to review the former findings and to perform more comprehensive investigations as to the current possibilities and limitations. This can be done by conducting test survey campaigns that include a significant number of flight lines. The German Bundesamt für Seeschifffahrt und Hydrographie (BSH) has launched a research project consisting of three flight campaigns and a scientific partnership of the Institute of Photogrammetry and Geoinformation, Leibniz Universität Hannover [Niemeyer et al., 2013 and 2014]. Parallel to the project, a close cooperation with other ALB stakeholders has been established. The main stakeholders include coastal protection authorities, the German Navy, the Water and Shipping Administration, which is responsible for maintaining the fairways, the land survey authorities and scientific institutes such as the Leibniz Institut für Ostseeforschung.

The main goal of the research project is to answer the question: In which areas of the German part of the Baltic, and to what extent, does it make sense to add ALB to the portfolio of hydrographic surveying techniques? And is it reasonable from the economical point of view? This also leads to some further questions:

- For modelling of the sea bottom:
  - What is the role of the environment (visibility, sea grass, etc.)?
  - What is the maximum depth for a reasonable survey?
  - Does it make sense to do ALB in the shallow lagoons behind the coast?
- For identification of obstructions:
  - Are 2 m objects defined by IHO S-44 detectable?
  - What size of an object is certainly detectable?
  - Is the detectability dependent on the depth?
- For the determination of the coastline:
  - Is it possible to determine a DTM in the region of -1m to +1m (referred to chart datum)?

- Can the coastline be determined from such a DTM?
  - Are the data gaps in very shallow water a problem for the determination of the coastline?
- For the tendering process of an ALB survey:
- What are the possible flight parameters for the different purposes, modelling of the sea bottom, detection of obstructions, and determination of coastlines?
  - What has to be considered when writing a call for tenders?
  - How to calculate a price for budget planning?

The first campaign was tendered as a high resolution flight and took place in November 2012. The flight was done by the company MILAN using a RIEGL VQ820G system, the area can be seen in **Figure 2**.

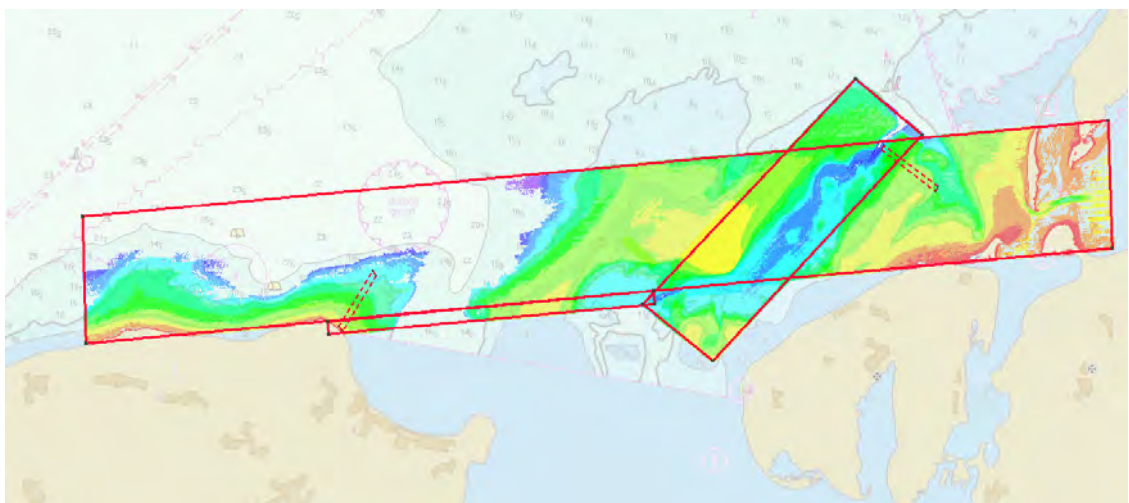


**Figure 2:** Area of the first flight 2012

Although it was a high resolution flight, obstructions could not be detected. Areas of seabed deeper than 5 m could not be modelled with a sufficient data density. However, the question, what density is sufficient, should be examined in more detail.

The second campaign took place in September 2013. Due to the fact that the first campaign only reached 5 m depth, this flight was tendered as a combined flight: one high resolution system together with a second system with higher penetration into the water column. The flight was done by AHAB together with the German company Top-Scan using the Systems Chiroptera and Hawkeye II.

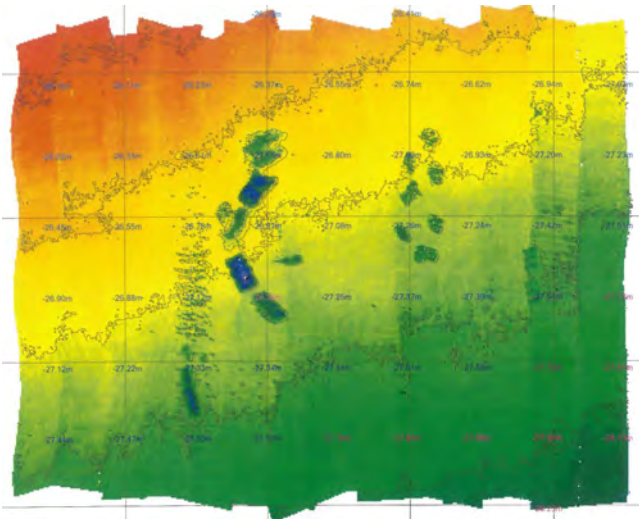
Unfortunately, only a small airplane was available, so the two systems had to be used in two separate flights. **Figure 3** shows the areas covered by both systems. Compared to the first campaign, the results reveal a much better coverage; however, the



**Figure 3:** Area of the second flight 2013

point density in deeper areas is much lower than in shallow areas. The processing of the data has required significant resources and is still underway at the time of writing.

Additionally, it was decided in 2013 to survey two small areas with artificial reefs. These areas have been surveyed quite accurately with a multi-beam system (**Figure 4**), and may later be used as reference areas, and for checking the accuracy of a survey.

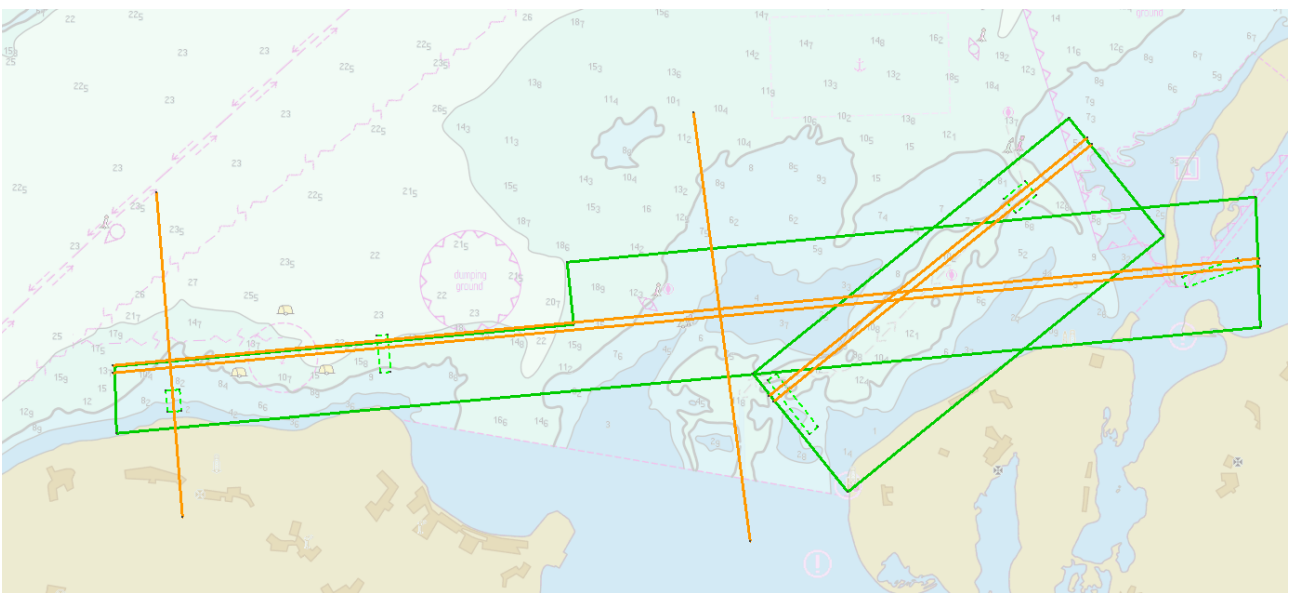


**Figure 4:** Artificial reefs close to Rostock, here Nienhagen reef with surrounding depths of about 11 to 12 m

The third campaign in 2014 was tendered similar to the second one. The flight had to be done during the small window of good seasonal conditions in the spring. One goal is to compare surveys accomplished under different seasonal conditions. The flight has been offered by AHAB together with the Dutch/German company Aerodata using the new Hawkeye III. It has two green laser channels, one for shallow water (like Chiroptera), and one for deeper water (almost like Hawkeye II). However, this system was not available in April or May, so it was decided to fly in April/May with Chiroptera again and to repeat some flight lines in autumn, when Hawkeye III is available, cf. **Figure 5**. The Chiroptera data will be compared with the autumn data from 2013.

Thus three flights have been completed within the project, except for the additional flight in autumn 2014. The 2013 data still under evaluation and the 2014 data are just in the first phase of being processed. One of the first lessons to be learned is that processing and quality control of the data takes much more time than expected. Therefore, only very preliminary conclusions can be provided here.

The quality of the data is dependent on many factors. Accuracy seems not to be the most important one. The accuracy demands of S-44 order 1b can be reached in most cases if the data is processed carefully enough. But it is hard to describe what a careful processing means, and to find criteria that can be used when to decide on the acceptance of a processing result.



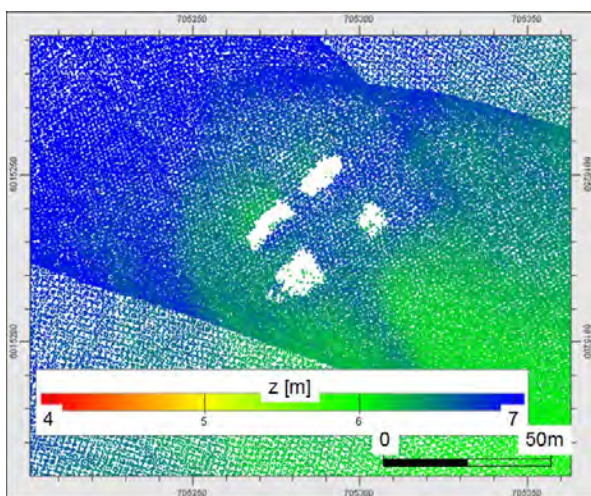
**Figure 5:** Area of the third flight 2014 (green), and the additional lines provided for the autumn 2014 with Hawkeye III (orange)

Further attention has to be directed to the data gaps. In greater depths the density of the data points becomes poorer. It is not easy to determine the density needed to calculate an appropriate DTM, or to derive the maximum depth to which the data can be used. This shall be an important outcome of the project, when all data are evaluated. Even in shallower areas there are larger gaps, each year almost at the same place. During the project some of these places have been inspected by diver. On all these places sea grass has been found abundantly, one example is shown in **figure 6** (with *Zostera marina*). So it seems that optical absorption is the reason for the data gaps.



**Figure 6:** One of the positions with larger gaps in laser data

The same reasons may have led to data gaps on the positions of obstructions at the artificial reefs “Nienhagen” and “Rosenort” (**Figure 7**) - if it is not just the problem that the shallow depth data are considered as outliers during the processing. Processing the full waveform analysis will hopefully provide a clearer explanation.



**Figure 7:** Gaps on the artificial reefs “Rosenort”

## Lessons learnt from Danish LiDAR Bathymetry

### BLAST-project and the need for surveys in shallow water

Large areas of the inshore waters of Denmark are categorized as shallow water. Almost all of these shallow waters have only been surveyed by historically outdated technologies and methodologies. A significant number of these surveys date more than 100 years. Today, multi-beam can measure depth wherever surface navigation is possible, but experiences in Danish surveys show that it is not economically or practically feasible to measure Denmark’s shallow waters from the coastline out to 6 meters depth with multi-beam.

The numbers of stakeholders who have interest in the shallow waters are increasing due to new legislation, the need for administration and emergence of new opportunities and activities in the coastal zone. The Danish Geodata Agency (GST) has therefore taken an interest in new technologies that can survey the shallow waters in Denmark.

GST had the opportunity to test and evaluate bathymetric LiDAR as a tool for surveying shallow waters through the EU-project BLAST from 2009-2012 - “Bringing Land and Sea together” (<http://www.blast-project.eu>). BLAST was a regional project for better integration of information across the coastal margin in the North Sea region and focused on addressing the needs of marine spatial planning and the instruments to support coastal zone planning and management (ICZM).

Bathymetric LiDAR appears to be a potential tool for gathering data that can support ICZM in general. Most often, a smooth seabed model is sufficient for this kind of general use, but for navigational purposes precise and robust object detection is a critical parameter for the credibility of a survey technology. These two perspectives have been the focus for the test and analyses described below.

The main goal with this investigation for GST is to find an economical feasible methodology for closing the gap between multi-beam surveys and the coastline and learning when and where to use it.

### Pilot sites for acquisition of bathymetric LiDAR data in Denmark

When choosing pilot sites for LiDAR surveys, different strategies can be used. Choosing the ideal environment enables the opportunity to see

different strategies can be used. Choosing the ideal environment enables the opportunity to see the full potential of the technology but may not reveal its limitations. Choosing a too rough environment may only show limitations.

For the Danish tests, the goal was to find representative areas that would demonstrate bathymetric LiDAR's potential and limitations. In short, GST wanted to test the bathymetric LiDAR systems under realistic circumstances in a realistic environment. The areas that were selected are all representative of Danish waters in order to ensure the results and findings can be used for making the right decisions on when and where to use bathymetric LiDAR, and when and where not to.

The project was planned to survey 2 test sites - Rødby and Hirtshals - but due to many delays in the survey and the problematic environmental conditions of Hirtshals, it was decided to extend the number of test sites to also include Flensborg

Fjord on both the Danish and German sides. This corresponded very well with 2012 multi-beam production, when GST and BSH together surveyed the whole of Flensborg Fjord to the 6 meter depth contour.

Rødby (test site A): Typical Danish low land inshore area with dykes and a mix of coastal protection and small natural beach areas. The sedimentation transport is limited. The sea bottom is primarily sand covered with marine vegetation. The inland consists of both cultivated areas and flooding areas.

Flensborg Fjord (test site B): Well protected Danish and German inshore area with natural protection and small natural beach areas. The sedimentation transport is limited. The sea bottom is primarily sand and clay covered with marine vegetation. The inland consists primarily of cultivated areas.



**Figure 8** : The Danish Test sites: A – Rødby, B – Flensborg Fjord, C – Hirtshals.



Hirtshals (test site C): Dynamic sand area with a lot of sedimentation transports both of sea and on land. The area is exposed to strong westerly winds and sometimes big waves and comprises a flat, wide sand beach with inland vegetation covered dunes. The sea bottom is primarily sand with limited marine vegetation.

### Process for data acquisition

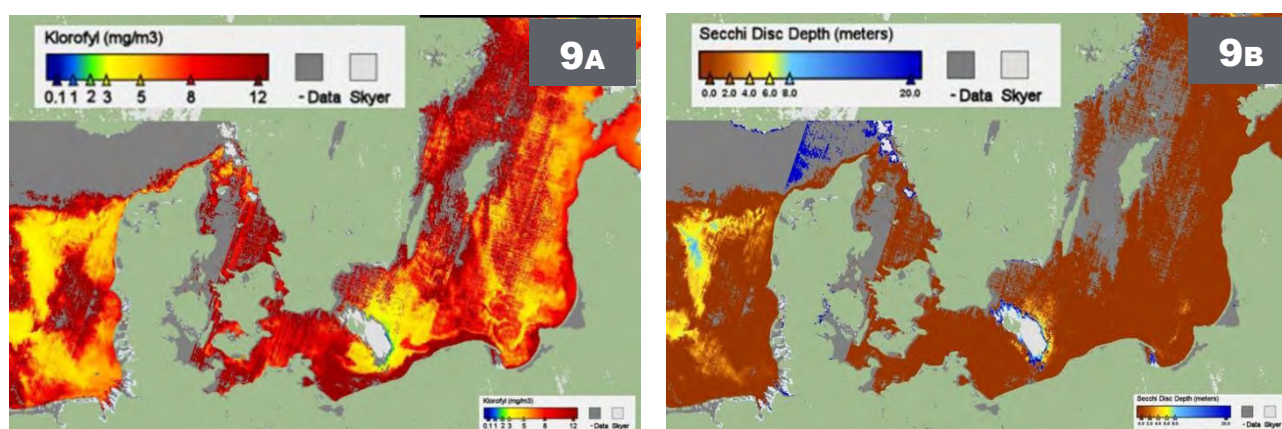
According to both experiences from the GST surveyors and environmental managers at the Danish Nature Agency, the best visibility in general in the inshore Danish waters occurs from February to April before the marine vegetation blooms. However, planning a Bathymetric LiDAR data collection task and then executing one are two different things. As shown in **table 1** both technical and local environmental issues were a challenge and caused several delays.

The environmental challenges were by far the greatest. GST experienced an unexpected *Chatonella* algae bloom, low hanging clouds, strong winds and waves and high turbidity that all made acceptable data acquisition impossible. Using satellite information on chlorophyll concentration (<http://marcoast.dmi.dk>) gives valuable information when not to survey since it is almost directly correlated to the turbidity in the water - as illustrated in **figure 9A & 9B** when the first Danish survey was postponed in April 2011.

In deciding when to survey, it is necessary to have both up-to-date and local knowledge of the environment. Using knowledge and observations from GST surveyors and harbor masters in the areas and even local divers from the Danish Emergency Management Agency all added valuable insight to the decision making process. But most important were the actual Secchi depth measurements in the survey area – at least in the Danish waters due to significant local variations.

Rødby – test site A	Flensborg Fjord – test site B	Hirtshals – test site C
April 2011 – Algae bloom		April 2011 – Algae bloom
June 2011 – Technical issue		June 2011 – Technical issue
February 2012 – Low clouds		February 2012 – Low clouds
April 2012 – Success		April 2012 – Strong winds and waves
	July 2012 – Success	July 2012 – High turbidity
		August 2012 – Partial success
	April 2013 – Success	

**Table 1:** Illustration of the different attempts of surveying the 3 test sites (*Failed, Hawkeye II and Chiroptera*)



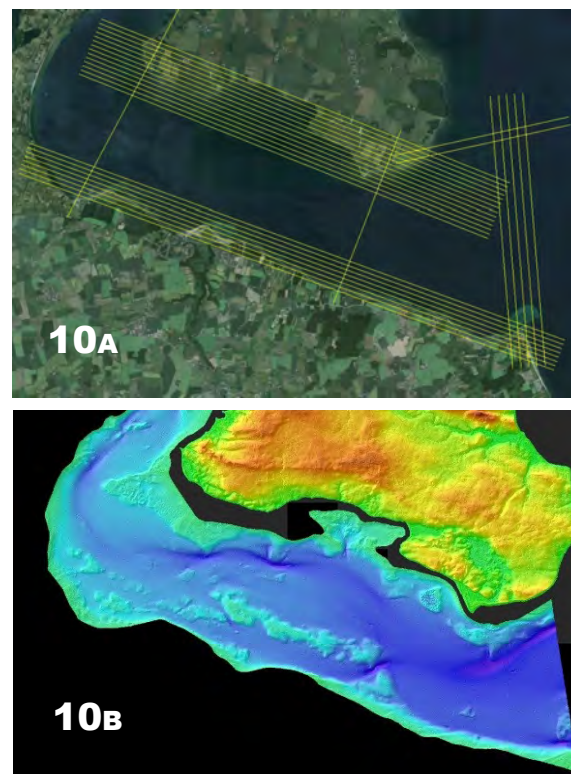
**Figure 9A & 9B:** Satellite information on chlorophyll concentration and derived Secchi depth April 2011

When GST initiated contact to potential subcontractors in early 2010, only one supplier was interested in surveying minor test areas in Northern Europe. Few bathymetric LiDAR surveys in the region meant that new surveys required due to delays by either the local environment or technical problems, could not be rescheduled right away but had to wait until a logistical and an economically feasible opportunity appeared. Today, new systems have been launched and more subcontractors express interest in supplying bathymetric LiDAR services. Both the lack of system robustness and relative market immaturity seem to be less of an obstacle now in Northern Europe.

### The data collected and the first findings

Two different subcontractors managed to survey all the three pilot sites using either Hawkeye II or Chiroptera. (See [www.airbornehydro.com](http://www.airbornehydro.com) for further specifications). Part of Flensborg Fjord has been surveyed with both systems (**Table 2**). The most significant specification for the systems was the expected penetration depth, which for Hawkeye II is around 2½ times the Secchi depth and Chiroptera is around 1-1½ times the Secchi depth. Chiroptera compensates to the lack of penetration with much higher point density collected. In this section of the article, Hawkeye II is referred to as “Deep scan” LiDAR while Chiroptera is referred to as “High density” LiDAR.

By combining existing multi-beam data and topographic data with bathymetric LiDAR data, it has been possible to “close the gap” along the coastline and to establish a coherent elevation model for Flensborg Fjord – **Figure 10**.

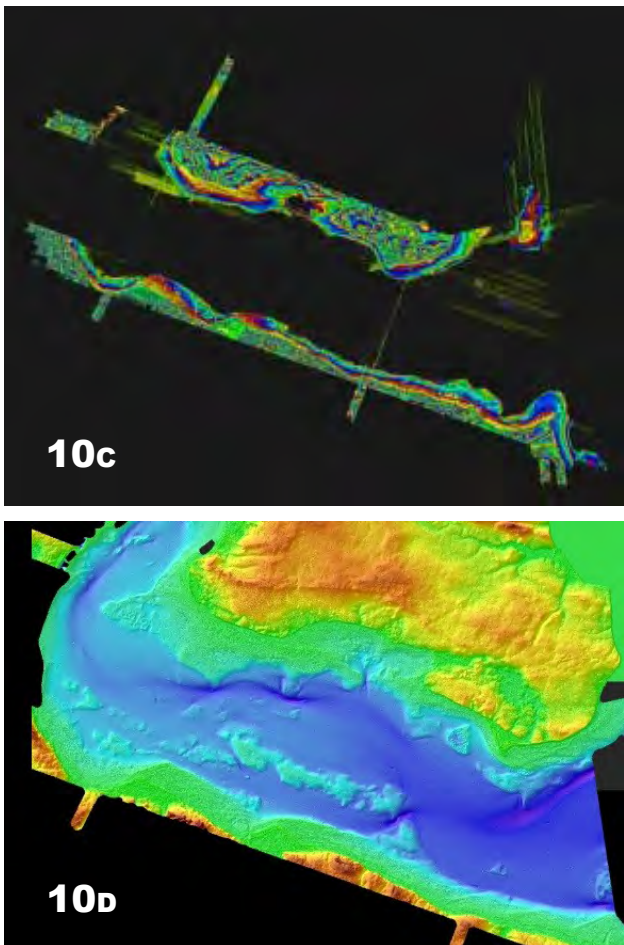


	Rødby Test site A	Flensborg Fjord Test site B	Flensborg Fjord Test site B	Hirtshals Test site C
System	Hawkeye II Deep Scan	Hawkeye II Deep Scan	Chiroptera High Density	Chiroptera High Density
Flying height	450 m	450 m	400 m	400 m
Side overlap	20 %	20 %	20 %	20 %
Planned point density	0,35 point/m <sup>2</sup>	0,35 point/m <sup>2</sup>	1,4 point/m <sup>2</sup>	1,4 point/m <sup>2</sup>
Area collected	55 km <sup>2</sup>	61 km <sup>2</sup>	30 km <sup>2</sup>	28 km <sup>2</sup>
Secchi depth	6 m	5-6 m	5 m	3-5 m
Surveyed depth	10-13 m	8-10 m	3-5 m	(3-4 m)
Surveyed density	0,25 point/m <sup>2</sup>	0,25 point/m <sup>2</sup>	0,6 point/m <sup>2</sup>	~

**Table 2:** Specifications for the 4 different surveys with Bathymetric LiDAR and the achieved results.

The surveys in Rødby and Flensborg Fjord were successful even though the expected surveyed depths did not always correspond to the measured Secchi depth. This is primarily due to great local variations of turbidity. The measured Secchi depth may in general be representative for the area, but local strong current can have a negative influence on visibility.

On the other hand, Hirtshals on Denmark’s west coast proved to be “just too rough” an environment for LiDAR bathymetry. Only the protected area northeast of the harbor produced a useful data set after a sixth attempt.



**Figure 10:** Closing the Gap in Flensburg Fjord : A)Planned survey, B) the Gap, C) Collected data, D)Coherent model.

**Data analysis and evaluation - accuracy and precision**

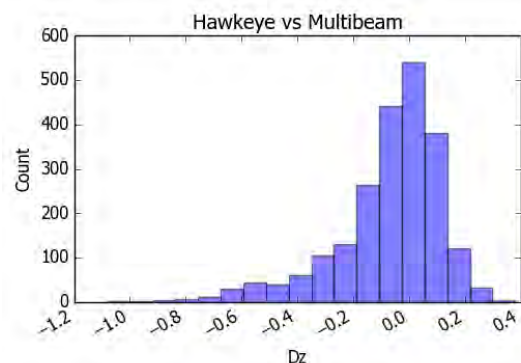
Accuracy tests have shown that the data without ground control points are well within 10 cm with an RMS of 30-40 cm compared to multi-beam data. The tests were done on a 0.5 km<sup>2</sup> area at the Rødby location, which has a mainly sandy bottom. This result is well within what is deemed usable. The challenge is that we have a multi-beam surface at the deeper areas of the survey, but no submerged control points. Based on the comparison between the multi-beam data and the Bathymetric LiDAR data and tests of the associated topographic LiDAR data set against very well defined points on land, which revealed an accuracy of 8 cm with an RMS of 10 cm, we choose to conclude that the general horizontal and vertical accuracy is within the usable range.

Looking at precision (i.e. inner accuracy), another test was performed at the Flensburg fjord location. In this test, the surveyed bathymetric LiDAR data

sets were tested against a multi-beam reference data set. The test was done in the shallow end of the multi-beam data set at 4-6 meters depth covering a 0.2 km<sup>2</sup> area with sandy bottom and more than 150 rocks.

First we look at the Hawkeye / “Deep scan” data. The table in **figure 11** shows a standard deviation of 19 cm, which is reasonable for the area being mapped. But in the histogram, there is a slight asymmetry in the bell curve. An investigation into this asymmetry seems to correlate this finding with the fact that the rocks observed in the multi-beam data are almost completely missing in the LiDAR data. Although the rocks should have been mapped and should be represented in the point cloud through the footprints covering the seabed, they are missing. This can to a certain extent be explained by the fact that the data from the Hawkeye system have a lower point density and produce less coverage of the seafloor.

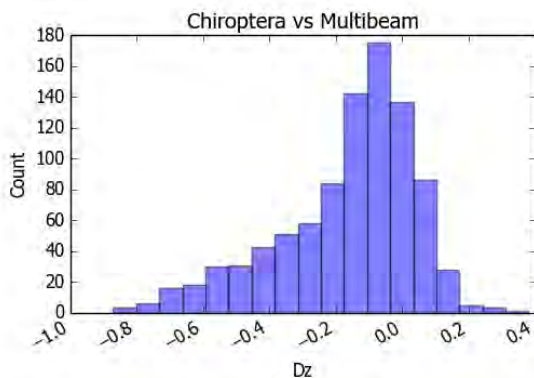
Parameter	Value
Count	2215
Unique values	117
Minimum value	-1.080000
Maximum value	0.380000
Range	1.460000
Sum	-160.800000
Mean value	-0.072596
Median value	-0.030000
Standard deviat...	0.190500
Coefficient of V...	-2.624115



**Figure 11:** Data comparison between Multi-beam and “Deep Scan” LiDAR

Second we look at the Chiroptera / “High density” data – **figure 12**. Again, we see a reasonable 20 cm standard deviation, but the histogram reveals again an asymmetry that indicates the rocks are missing in the data set. A further investigation has revealed this to be the case. However, the point density and resolution in this data set should be good enough to map individual rocks. Issues with depth and turbidity appear to be the cause because, although the Chiroptera has a high point density, it deteriorates rapidly in these waters. The result is low point density at 5 m depth, and an inability to detect rocks that are two meters in size.

Parameter	Value
Count	917
Unique values	104
Minimum value	-0.870000
Maximum value	0.380000
Range	1.250000
Sum	-151.210000
Mean value	-0.164896
Median value	-0.110000
Standard deviat...	0.208249
Coefficient of V...	-1.262908



**Figure 12:** Data comparison between Multi-beam and “High Density” LiDAR

### Data analysis and evaluation - density and distribution

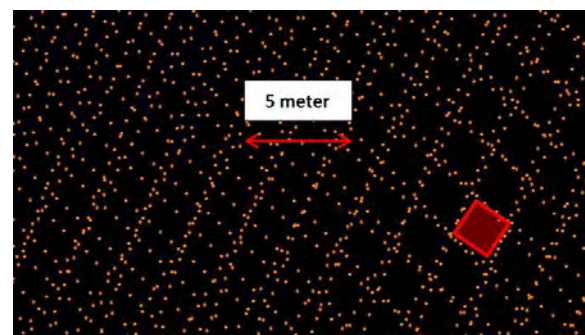
When working with discrete measurements, as LiDAR provides, density and uniformity of distribution go hand in hand. A data set can have an adequate point density, but if the uniformity of distribution is poor, it can result in some areas with lots of points and others with no points at all. This is an issue that will always have to be evaluated, no matter what use the LiDAR data is intended for. In some cases, uniformity is of less importance. For

example, surfaces of smooth undulation are less afflicted by poor distribution, as they can easily be modeled with simple algorithms. Areas with erratic surfaces can be hard to model; in these cases, having poor distribution can be very problematic.

In the specific case of seafloor mapping, these two situations come into play. When mapping movement of sediment, the distribution is of less importance. Sand deposits in semi-predictable ways and can easily be modeled. In contrast, when mapping navigational routes, the general seafloor is of great interest and, in particular, the presence of rocks and other obstacles that can damage passing vessels. In locating rocks and obstacles, point distribution is of very high importance. It is not sufficient to locate *most* of the rocks; when mapping for navigation, it is critical that *all* rocks of a certain size are identified.

The two test data sets for Flensburg Fjord include one “Deep scan” data set and one “High density” data set. Because the ability to scan deeper provides lower point density, the deep scan data are of less interest. The density of this data set is simply too low to locate rocks that are two meters in size (IHO S-44, order 1). At its best, the data-set’s point density is around 1 point per 2x2 meter (0,25 point/m<sup>2</sup>).

In the “High density” data set, the point density is 2.6 points per square meter in areas where overlap between flight lines exists. This should be adequate for identifying rocks, depending on the size of the actual footprint of the returning signal. The point distribution (**fig. 13**) shows an uneven distribution that can affect the number of rock returns. If the footprint and the following data extraction are insufficient, the number of points might not be adequate for a robust classification of an object.



**Figure 13:** Point distribution from “High Density” scan including red 2 meter object.

A comparison has been conducted, where a number of rocks in the area that have been clearly located with multi-beam were sought in the “deep-scan” and “high-density” data. The area evaluated extends from the coast to deeper water and the rocks are 3.4 meters deep on average. This depth is well within the working area of both scanners. However, as seen in **table 3**, the density is quite low below 3 meters, and this is most likely due to local turbidity. The density is, in fact, so low that even object detection of larger rocks cannot be guaranteed.

Depth	“Deep scan” Point/m <sup>2</sup>	“High density” Point/m <sup>2</sup>
1 m	0,25	1,4
2 m	0,25	1,16
3 m	0,24	0,21
4 m	0,09	0,010
5 m	0,07	0,008
6 m	0,06	-
7 m	0,05	-
8 m	-	-

**Table 3:** Point density related to depth

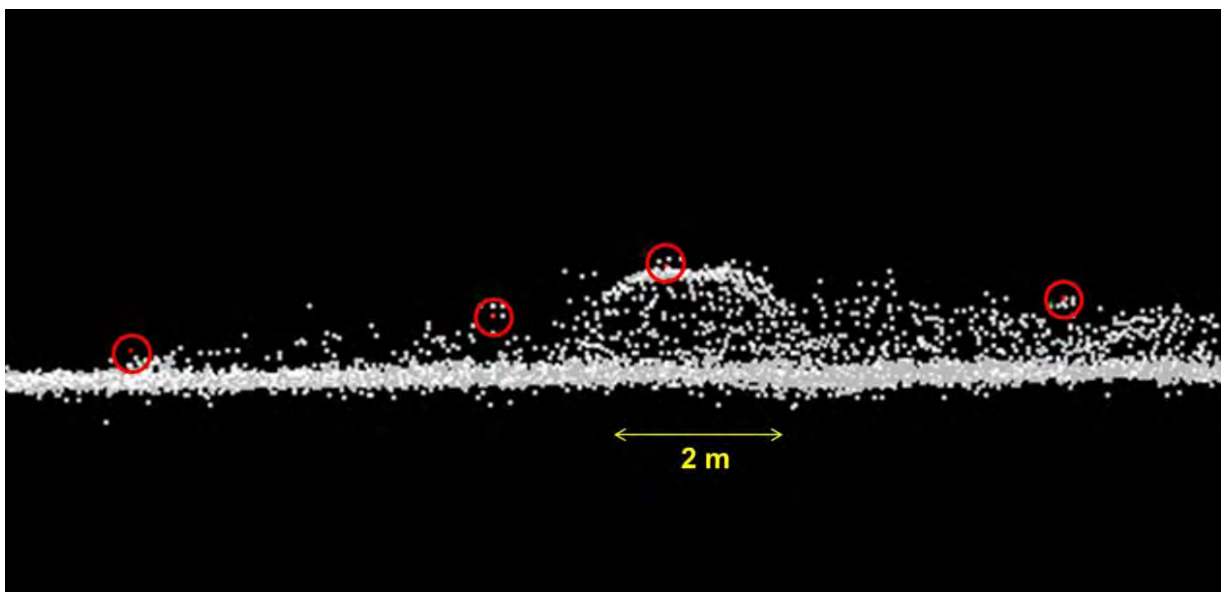
Even with the “high-density” scanner at this depth, the point density is reduced to 0.2 points per square meter, which is more or less the same as the “deep-scan” data set.

There remains a question as to how many observations with bathymetric LiDAR are needed to ensure positive object detection. The challenge is often sparse distribution in the data set. As **figure 14** illustrates, a representative observation may identify a rock in the bathymetric LiDAR data set, whereas multi-beam returns a far more detailed image of the sea floor. If only one or two observations occur, there is no guarantee that they will be classified as an object rather than as outliers.

### Full Waveform and the steps ahead

It has become increasingly evident that, in order to fully utilize the power of bathymetric LiDAR for object recognition, the waveforms returning from the sea column must be investigated more closely. It is clear that some objects return no discrete points, but it is unclear whether this is because no signal is received or because a returning waveform has been misinterpreted. Since the density in the point cloud is so sparse, it is crucial to use all the available information and extracting information from the waveform. Using the full waveform can also help in understanding how the footprint is represented in the discrete points derived from the returning waveform.

GST has not yet begun this waveform analysis and evaluation, but it will be the agency’s next step in the process. One of the most significant challenges is a lack of standardized formats for waveforms and tools to analyze them.



**Figure 14:** 3m wide area of seabed including rock, captured by multi-beam (white) and bathymetric LiDAR (red)

## Evaluation of the Danish test

Thus far, preliminary results show that bathymetric LiDAR has potential in the shallow waters around Denmark. Both the horizontal and the vertical accuracy appear to fit well within the needs for a model of the seabed that can be used for a variety of purposes, not least for coastal zone management. However, the technique appears to have more limited value in object detection for nautical charting.

Two issues remain to be addressed in this context. First, there is a need for better, standardized tools for working with and analyzing the full waveform in evaluation of bathymetric LiDAR data. This is expected to yield a more comprehensive understanding of the data themselves and to ensure that all available information are displayed and analyzed when working with a sparse data set. Second, data managers must become reaccustomed to work with data sets that are substandard in their density compared to multi-beam. Through a change in mindset, data managers can relearn how to extract vital data from a sparse data set.

The environment appears to be the biggest constraint when surveying with bathymetric LiDAR in Danish waters. Local information is vital, and a high degree of operational flexibility in the surveying campaign is needed. Local divers from the Emergency Management Agency in Hirtshals provided critical local information on wind direction, where three days of dominantly southeasterly winds could render visibilities of ten meters or more. Unfortunately, these conditions did not occur at any time during the Danish test when both plane and equipment were available. The easiest means of handling challenging areas appears to be having an adequately large area to survey over a sufficient time interval, thereby giving the possibility to move the survey according to local conditions.

When the above challenges have been overcome, bathymetric LiDAR has the potential to be a relevant supplement to the traditional ship-based surveys in charting the shallow waters in Denmark and thereby closing the gap to the coastline.

## Swedish experiences of Laser Bathymetry

### Laser bathymetry surveys in Swedish waters, 1996-2002

In the early 1970s, the Swedish Defence Research Institute (FOI) started to develop a laser system for submarine purposes. Subcontractors including SAAB in Sweden, Feary in Australia and Optech in Canada were contracted to build the first test system called FLASH, which was tested in 1989-92. The positive results from the tests with the FLASH system led to further technical improvements and a new system, Hawk Eye, was developed by SAAB. Two Hawk Eye systems (200 Hz) were delivered to the Swedish Maritime Administration (SMA) and the Swedish Navy in 1993 and were fully operational in 1996. (**Figure 15**)



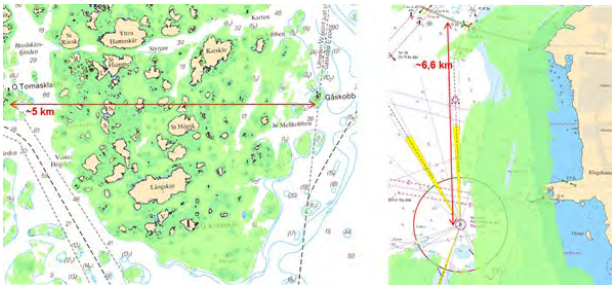
**Figure 15:** Helicopter Bell 212 equipped with Hawk Eye (I) system

Between 1996 and 2002, SMA carried out laser bathymetry surveys along the Swedish coast for nautical charting purposes. 36 separate areas of about 2150 km<sup>2</sup> were surveyed in the Swedish archipelago and near the coast. Water clarity varies greatly in the Baltic Sea and on Sweden's east coast, depths of between 1 to about 20 meters were achieved. On the west coast, where the waters are clearer, depths down to about 30 meters were recorded.

The minimum depth of 0.7 meters recorded by the system, paired with the restrictions of the surf zone, limited the minimum collected depth to about 1,0 meter. The low transmit rate of 200 Hz resulted in a low sounding density of about 5 soundings per 5 m<sup>2</sup> at best, and only fulfilled S44 Order 2 in object detection. Even though a single sounding may have depicted an object, it was very difficult to verify whether an object had been detected or whether the data point was an outlier.

In these early days of using a new survey system for nautical charting, there was also some cartographical resistance to trusting this new LiDAR

method. Therefore, any existing depths/contours shallower than the Hawk Eye system identified were kept in the chart. (**Figure 16**)

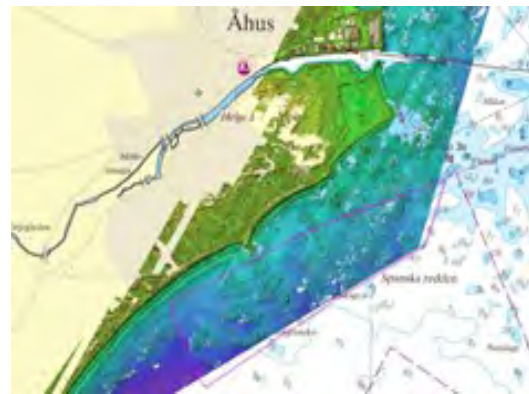


**Figure 16:** Left - Combined LiDAR and multi-beam surveys in the archipelago. Right - LiDAR surveys along the coast in Öresund.

**Recent LiDAR Bathymetry projects in Sweden**

The results of two recent LiDAR projects, the research program EMMA (Environmental Mapping and Monitoring with Airborne laser and digital images on land and at sea, 2010-2013) and an ongoing mapping project of near-shore erosion

around the south coast of Sweden (2013-2014), have been compared to SMA's high density multi-beam survey data from 2013. A survey area outside the port of Åhus in southern Sweden containing both Hawk Eye II and Chiroptera survey has also been surveyed by multi-beam. The Hawk Eye II reached a maximum depth of about 13 meters and Chiroptera about 4-6 meters. Unfortunately, the Chiroptera survey did not reach very deep, and thus the area overlapping with the multi-beam survey was very small. (**Figure 17**)



**Figure 17 A:** Hawk Eye II survey 2010



**Figure 17B:** Chiroptera survey 2013

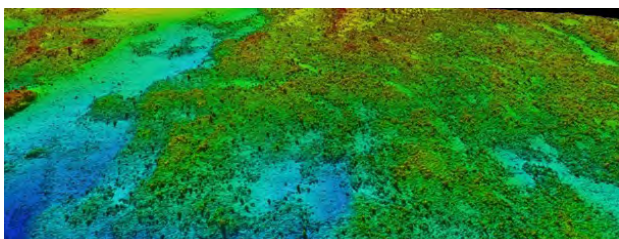
**Figure 17: 17A - 17B - 17C**  
Comparison of three surveys covering the same area outside the port of Åhus.



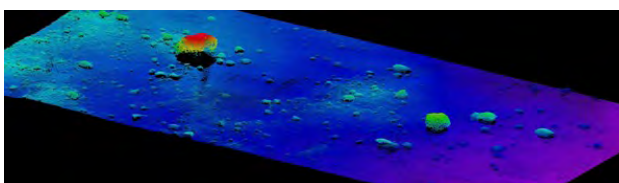
**Figure 17C:** Multi-beam survey 2013

The dense multi-beam survey contained numerous of rocks and boulders. The Hawk Eye II survey showed, in general, the same sea floor except for the absence of features and rocks. There were also several data gaps in the Hawk Eye II and Chiroptera surveys. The general depths of all the three surveys were reasonably consistent. (**Figures 18 to 20**)

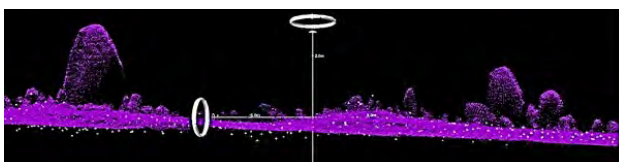
In general neither Hawk Eye II nor Chiroptera detected any rocks of about 1 to 5 meters in size. However, it should be noted that the wave forms in the LiDAR surveys were not analysed. To be able to use LiDAR surveys not just for general depth but also for nautical charting, it is essential to acquire the skills and experience to analyse LiDAR data as well as the waveforms in the raw data.



**Figure 18:** Upper picture from multi-beam, grid size 1x1 meter, containing numerous rocks/boulders; lower picture of the same area from Hawk Eye II, grid size 5x5 meter, containing some data gaps



**Figure 19:** Left, boulder 5x5 meter, 3 meter height and right, 3x3 meter, 2,2 meter height



**Figure 20:** Purple points from multi-beam and white points LiDAR. No LiDAR hit any of the boulders

## Study project "Surveying the Swedish coastal zone"

The project is funded by a grant from the Swedish Civil Contingencies Agency (MSB). The cooperation partners are the Swedish Maritime Administration, the Geological Survey of Sweden (SGU), the Swedish Land Survey and the Swedish Geotechnical Institute.

The project aim is to conduct a methodological study to find cost-effective tools for measuring the shallow waters of the coastal zone as well as lakes and rivers. In the project, "shallow water" refers to the shoreline down to an approximate depth of 10 meters.

In this area, there is a substantial need for high-resolution data in order to create reliable flood and dispersion models, detect and calculate erosion damage, and conduct analyses of climate impacts on the sea level. A prerequisite for this is a coherent terrain model for the coastal zone and other waterways. A modern high-resolution elevation data from the national elevation database can be used for a terrain model on land, but this ends at the shoreline. Today there are very few high-resolution data for these shallow waters, largely because traditional measurement methods are very costly in shallow areas.

New developments have enhanced the technology and may enable a more cost-effective measurement of depths in shallow waters, including various types of airborne LiDAR systems, interferometric sonar, etc. An analysis of the different measurement methods and their effectiveness in shallow water areas will be performed as part of this study. Measurement efficiency, particularly of LiDAR technology but also of acoustic methods, in large part depends on the water's physical characteristics (quality). These factors will be included in the project's analysis section in order to identify how planning can be done and which method can provide the best quality, time and cost (efficiency). The project will run for two years, where the first year is devoted to technical test activities and inventory of experiences from a variety of LiDAR measurements. The second year is devoted to analysis and to create a general planning.

As test operations with airborne technology are very costly, the study will primarily investigate and analyse the results from previous surveys with LiDAR systems in Sweden and internationally. The experiences will be analysed with reference to the specific conditions in the Swedish waters.



Tests with sonar technology will be performed using existing systems aboard SGU vessel "Ugglan" and SMA vessel "Petter Gedda", and possibly also using other equipment on the market. Tests will also be conducted in the shallowest areas from an even smaller vessel equipped with a small mobile multi-beam sonar.

Locations for testing equipment and methods will be selected from different types of shallow areas along the Swedish coast in order to determine whether survey methods and equipment show different results in different areas.

Since Swedish Maritime Administration hydrographic surveys are normally concentrated on fairway areas, as funds for surveying only come from the fairway dues, the results of the study method will form the basis for a discussion on the needs and funding for establishing a national coastal zone mapping program.

The depth database can, when supplemented with shallow survey data, be used together with the national elevation database to create a seamless digital terrain model over the Swedish land and water areas. The project started in January 2014 and will end in December 2015.

### **Summary from the all the bathymetric LiDAR projects**

LiDAR and data processing technologies have been under continued development in recent years, and LiDAR bathymetry is beginning to appear to be an operational method for surveying the waters of the Baltic Sea.

Some preliminary conclusions can be drawn from a number of test activities in the region, and final results are expected to be collated in reports in mid-2015. Among the preliminary conclusions is a finding that LiDAR can become an interesting and valuable survey method for shallow waters. This is especially due to the fact that traditional methods of hydrographic surveying have disadvantages in shallow areas: single-beam data have too large gaps between the survey lines, while multi-beam surveys in shallow areas require too many survey lines and therefore prove too expensive. Laser bathymetry is suitable for large areas where access by launch or ship is difficult due to weather conditions or low keel clearance. A large area can be surveyed with LiDAR in a short time, but when post processing is taken into account, the final data delivery can take time. Long flight lines are necessary for operational effectiveness, but difficult in complex archipelago considering the net

efficiency.

LiDAR surveys are an alternative method, especially in shallow areas, where surveys are needed not only for navigation purposes, but also for coastal zone management. The method does not yet provide an alternative to traditional hydrographic surveys, but can be complementary. In these shallow areas, LiDAR surveys can provide a combination of land and sea data in one datum and in almost the same quality.

In recent years, bathymetric LiDAR surveys have been acquired by organisations other than Hydrographic Offices; co-operation between the different organisations is necessary when considering the operational use of LiDAR bathymetry. For strategic purposes, it is necessary to establish a wider scope of the possible use and users of these data – including but not limited to safety at sea, nautical charting and coastal protection – in order to identify a common data capture that can provide data for several purposes. This is in line with the theme for World Hydrography Day 2014: "Hydrography – much more than nautical charting".

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## Biographies

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**Co-financed by the European Union**  
**Trans-European Transport Network (TEN-T)**

## EU TEN-T MonaLisa ACTIVITIES IN THE BALTIC SEA

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### Abstract

The wider benefit European Union Trans European Network - Transport (TEN-T) Motorways of the Sea (MoS) project MonaLisa (2010 – 2013) aims at contributing to the promotion of continuous improvement and the development of efficient, safe and environmentally sound maritime transport in the Baltic Sea. This is accomplished by the implementation of a series of measures which are also in line with the EU's Baltic Sea Region Strategy. This article concentrates on Activity 3 dealing with hydrographic re-surveys on shipping routes. Some future plans are also described.



### Résumé

Le projet MonaLisa (2010 – 2013) des « autoroutes de la mer » du programme de l'Union européenne (UE) « réseau transeuropéen de transport » (RTE-T) vise à contribuer à la promotion de l'amélioration continue et au développement d'un transport maritime efficace, sûr et écologique dans la mer Baltique. Ceci est réalisé grâce à la mise en œuvre d'une série de mesures qui sont également alignées sur la stratégie de l'UE dans la région de la mer Baltique. Cet article se concentre sur l'activité 3 qui traite des nouveaux levés hydrographiques sur les routes maritimes. Certains plans pour l'avenir sont également décrits.



### Resumen

El objetivo del Proyecto de interés general MonaLisa (2010-2013) de Autopistas del Mar (MoS) de la Red de Transporte Transeuropea de la Unión Europea es contribuir a la promoción de una mejora continua y al desarrollo de un transporte marítimo eficiente, seguro y respetuoso del medio ambiente en el Mar Báltico. Esto se consigue mediante la implementación de una serie de medidas que están también en conformidad con la Estrategia de la UE para la Región del Mar Báltico. Este artículo se concentra en la Actividad 3 que trata sobre la repetición de los levantamientos hidrográficos en las rutas de navegación. Se describen también algunos planes futuros.

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## Introduction

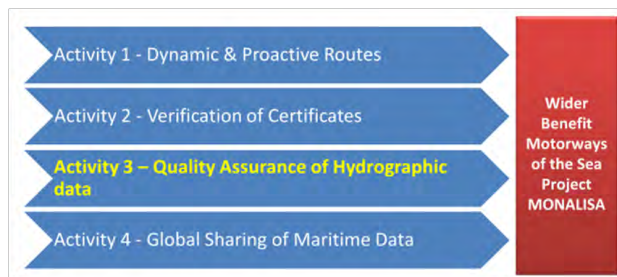
The Baltic Sea is an almost closed basin located between Central and Northern Europe. Shipping is of vital importance for import and export for the nine countries surrounding the Baltic Sea. The surrounding countries are Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russian Federation and Sweden. At the Baltic Sea Entrance, there is a passage of 60 000 – 65 000 commercial ships every year and another 30 000 ships enter and exit the Baltic Sea through the Kiel Canal. The amount of ships has increased over the last 10 – 15 years. In combination with an almost closed sea basin, where the passage of sea water from the North Sea is limited, and very limited actions for protecting the environment during the mid-20<sup>th</sup> Century, the environmental problems in the Baltic Sea have increased to a very serious state.

The Baltic Marine Environment Protection Commission - Helsinki Commission (HELCOM) was established in Helsinki 1974 to protect the marine environment of the Baltic Sea. The contracting partners are all the countries surrounding the Baltic Sea. HELCOM's vision for the future is a healthy Baltic Sea environment with diverse biological components functioning in balance, resulting in a good ecological status and supporting a wide range of sustainable economic and social activities, which includes safe maritime transportation. Most parts of the Baltic Sea are defined as a Particular Sensitive Sea Area (PSSA).

## MonaLisa Project 2010 - 2013

Within the Baltic Sea Hydrographic Commission (BSHC), the HELCOM and EU Strategy for the Baltic Sea Region, the importance of updating hydrographic surveys to current standards is seen as a major priority in promoting safe shipping. The EU Trans European Network - Transport funding program 2010-2013 provided the opportunity to enhance this hydrographic survey work significantly. The MonaLisa project was established with public, private and academia participants from Sweden, Finland and Denmark, with the Swedish Maritime Administration (SMA) as the lead partner.

The project took the form of pilot actions and studies and encompasses the following four activities, **Figure 1**. This article focuses on Activity 3, but first an overview of all activities is given.



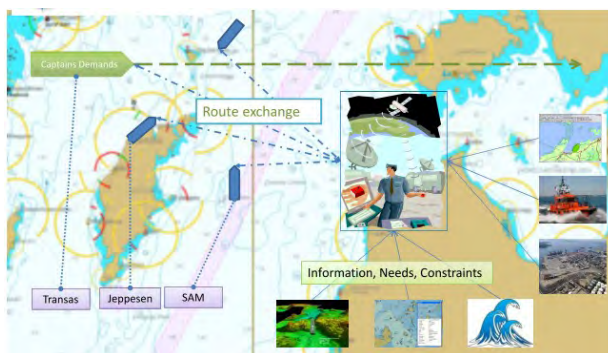
**Figure 1:** MonaLisa Project

### Dynamic & Proactive Route planning

#### [Activity 1]

This activity developed a new methodology in marine route planning, similar to air traffic management, based on the mandatory AIS system. This will improve the quality of maritime transport and safety at sea. It will provide:

- optimize and exchange routes and voyage plans -> effect on safety between ships as well as efficiency on local knowledge, pilot and berth availability;
- assistance and monitoring;
- decision support to prevent collisions, less radio communication;
- effective surveillance;
- legal impact study, looking in various convention instruments, e.g. COLREGs, SOLAS, STCW and UNCLOS;
- reduced costs and emissions;
- Big Data analysis: utilizing data from various sources in voyage planning (**Figure 2**);



**Figure 2:** MonaLisa project Activity 1, Dynamic & Proactive Route planning

Activity 1 also covered the human interaction and legal aspects of using such a method and system. The activity has been widely presented to the maritime community all around the world and it has also resulted in the MonaLisa 2.0 project with a wide interest amongst the maritime nations, not

least due to the grounding of Costa Concordia in January 2012 in the Mediterranean Sea.

A definite conclusion for Activity 1 is the EU TEN-T project MonaLisa 2.0 - to extend the test bed of MonaLisa, prepare for Sea Traffic Management and further focus on safety of navigation, safety in coastal waters and safety in ports. The MonaLisa Activity 1 identified the necessity for the introduction of Route exchange and Sea Traffic Management.

### **Verification System for Officers Certificates**

#### **[Activity 2]**

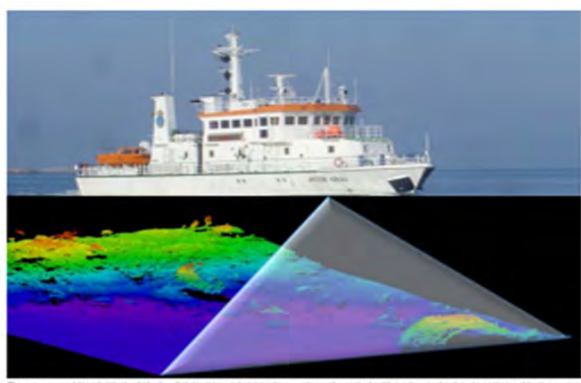
This activity investigated possible ways to verify, develop and test remotely, in an automated manner, different certificates held by on-board personnel that are of importance for a specific voyage. Also, studies on fatigue related questions on the officer on watch have been done.

A conclusion on Activity 2 are the safety of qualified watch-keeping personnel and occupational health to avoid fatigue and to constrain responsibilities. The study indicates a positive reception in the shipping industry, but not all flag states are supportive. A test and demonstration were performed successfully. Several studies were published addressing the various tasks, e.g. on human factors, legal and liability issues.

### **Ensuring the Quality of Hydrographic Data on Shipping Routes and Areas**

#### **[Activity 3]**

To improve safety of shipping, Activity 3 completed extensive areas of hydrographic surveys in the northern parts of the Baltic Sea by conducting re-surveys of HELCOM fairways and relevant port areas in the Baltic Sea. Re-surveys were performed with modern full coverage multi-beam method, **Fig.3**. Also a study was conducted towards a common vertical reference for the Baltic Sea. A Baltic Sea Bathymetric Model was built and it is freely available for uses other than safety of navigation.



**Fig.3.** Re-surveys were performed with modern full coverage multi-beam method.

### **Global Sharing of Maritime Information**

#### **[Activity 4]**

Activity 4 tested regionally how to share maritime data on a global scale based on the experiences gained from HELCOM AIS, SafetSeaNet and Stires systems. The scenarios tested were using a high volume AIS throughput and using the proxy for open source SQL database management.

A conclusion on Activity 4 is wider public availability of common shipping data and common formats agreed in the International Association of Marine Aids to Navigation and Lighthouse Authorities (IALA), as the software and system are declared operational with the Maritime Data Exchange in Alaska and the IALA system hosted at Danish Maritime Authority. Additional test are in progress in Ireland and Canada.

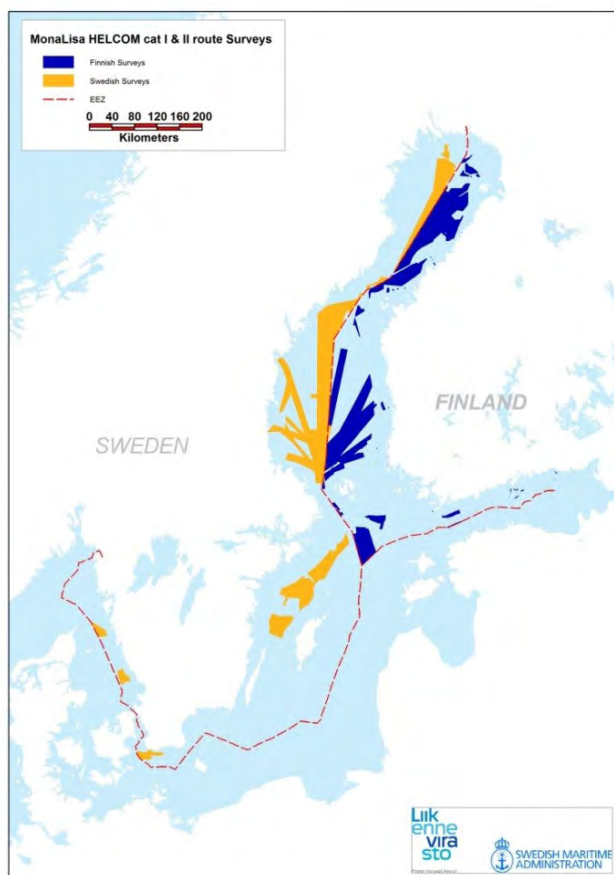
This article concentrates on Activity 3, hydrographic surveys and some depth data related issues. The results of the other activities are available at <http://www.sjofartsverket.se/en/MonaLisa/>.

### **Speed up HELCOM re-surveys and ensuring the quality of hydrographic data**

One of several key elements to reach a healthy Baltic Sea is safe navigation, which is not sufficient alone. It is equally vital to create knowledge about the bathymetry in the Baltic Sea through hydrographic surveys. In co-operation with the BSHC, plans for hydrographic surveys have been established within HELCOM Ministerial Declarations; see also a separate article in this issue of the IHR (Korhonen, 2014). In the HELCOM Scheme the surveys are referred to as re-surveys, since most areas are surveyed to some degree but up to 150 – 200 years ago. The sea area has been divided into three classes where category I and II (CAT I and II) are areas used by commercial shipping and category III (CAT III) are areas mostly used by leisure craft and are also important to survey for environmental purposes. The re-surveys have been conducted in areas according to the HELCOM Copenhagen 2001 and Moscow 2010 Ministerial Declarations.

During 2011 – 2013, the re-surveyed areas have covered about 50 000 km<sup>2</sup> of HELCOM CAT I and II areas (from about 10 m depth contour and deeper) around Finland and Sweden, larger than the size of the entire land area of the Netherlands, see **Figure 4**. Areas vary in depth, bottom structure, water turbidity and weather vulnerability, which in turn had a direct effect on the difficulty

and time spent on the field work and data post processing, as well as costs per surface area.



**Fig.4.** Areas surveyed in 2011 – 2013 within MonaLisa project.

The areas being surveyed in this activity had previously not been surveyed with modern methods and according to international standards. In many areas, the only previously existing depth data was the result of lead line surveys being conducted over 100 years ago with very sparse depth information and several hundred metres between the spot soundings. After these modern surveys have been conducted, according to the IHO Standard for Hydrographic Surveys, S-44 ed. 5, full sea floor coverage has been obtained.

Good co-operation in the procurement process has been established and also benefitted both the Finnish Transport Agency (FTA) and the Swedish Maritime Administration (SMA):

- Common procurement documentation based on the Norwegian Hydrographic Office earlier procurement documentation (MAREANO), fine-tuned for the area and the Buyer. Each Hydrographic Office made a separate

contract, due to national legislation regulations. (EU-TED 2010)

- In order to have clear requirements FTA and SMA have together agreed, with other relevant national authorities, upon a common Finnish and Swedish implementation of the IHO S-44 standard for hydrographic surveys. The implementation is called FSIS-44 (Finnish and Swedish Implementation of the S-44). To have a cross-border common implementation of the S-44 standard has proven to be a strong platform of requirements.
- Common test, start-of-work and work supervision procedures are honoured cross border.
- Exchange of work procedures and experiences in data verification to obtain quality data.
- Comparison of data on borders to enhance the ENC cell and paper chart quality and to avoid any data discontinuity steps.
- All this has contributed to the procurement transparency and data quality, which are further utilized in upcoming procurements and work processes.

In open procurement, several tenders were received. The decision was made such that in the first phase the requirements of the tenderers and the tenders had to be fulfilled. That is a typical public authority requirement, such as for social security fee and pension payment records. In the second phase price envelopes were opened and the lowest bidder received the work, after the contract had been signed. Some national security issues did apply for some of the work in territorial waters.

The quality of the work was good, after first delivery scrutiny and discussions. Sufficient time was provided for the tenderers, but some delays and delay penalties did occur due to the tenderers choice of vessels and work priorities.

About 20 Million Euros have been used for these hydrographic re-surveys during the three years 2011-2013. Of this amount about 65% has been for open public procurements, about 20% for services of general economic interest order (EU SGEI regulations) and about 15% for public administration work.

These hydrographic surveys have contributed to the safety of navigation providing full coverage bathymetric information and ensuring adequate water depth. Wider benefits include an excellent record on avoiding groundings, environmentally friendly shipping, base data for all activities and utilization for ice-breaker routing. Of course the

data is used in producing new and updating existing ENCs and paper charts.

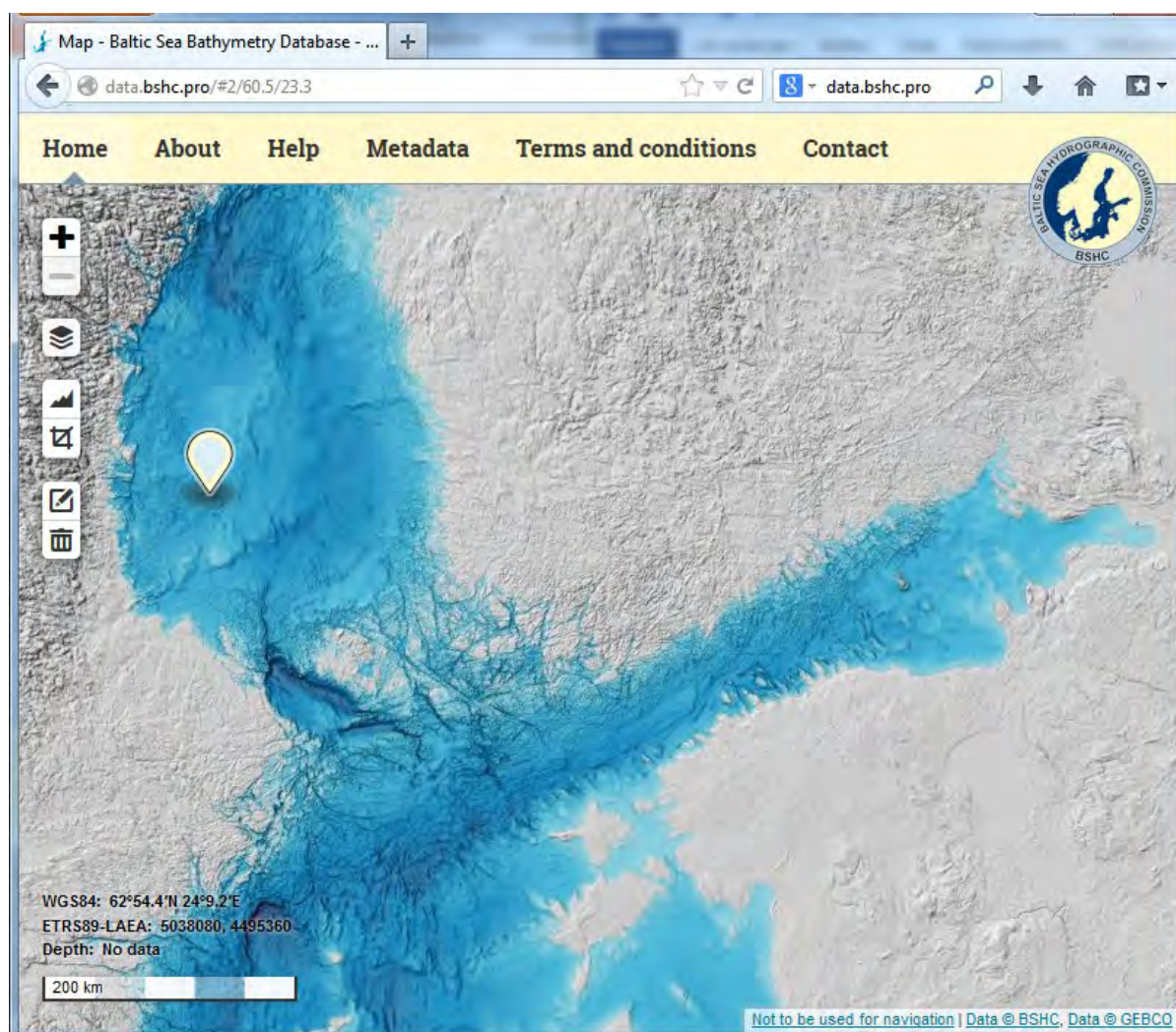
Further plans to continue and complete the HELCOM CAT I and II hydrographic surveys exist and CAT III survey plans are being drafted within the HELCOM Re-survey Scheme, as described in a separate article in this issue of the IHR (Korhonen, 2014).

### Baltic Sea harmonized bathymetry model

A common database of bathymetry data for the Baltic Sea Area has been established by BSHC and is hosted by the Swedish Maritime Administration. Data has been submitted from all Baltic Sea countries, except Lithuania and Russia, based on

their legislation and availability of common data. For Lithuanian and Russian areas, data from the General Bathymetric Chart of the Ocean (GEBCO) is presently being used. The depth data and derived imagery is freely available under a Creative Commons Attribution license, including commercial use but not allowing use for safety of navigation purposes.

Readers are encouraged to visit: <http://data.bshc.pro/>. In **Fig.5** there is an example view of the user interface. The bathymetric model is also available as OGC service that is used as background charts in GIS tools and on other websites. The work on the Baltic Sea Bathymetry Database is further described in detail in a separate article in this issue of the IHR. (Hell, Öiäs, 2014)



**Fig.5.** Example of the user interface to the Baltic Sea Bathymetry Model.



## A common harmonized vertical reference for the Baltic Sea

A common harmonized vertical reference model follows the work performed in the BSHC member states Hydrographic Offices in co-operation with the national Meteorological Offices and Geodesy / Land Survey authorities.

Participation in the IHO Tidal and Water Level Working Group (TWLWG) and the EU INSPIRE Evaluation work has brought a wider viewpoint and encouragement to proceed with the work. The work requires a high level of expertise in geodesy and this has been a limited resource in both Finland and Sweden.

The common harmonized vertical reference, tied to EVRS, was decided at the BSHC17 conference in September 2012, and the national path in BSHC member states was approved in BSHC18 in September 2013. Each HO has committed to a transition into a harmonized chart datum within the Baltic Sea. The BSHC Chart Datum Working Group is fostering and monitoring this transition. There are more details on this work in a separate Note of this issue of the IHR (Mononen, 2014).

Within the MonaLisa project a study on the effects of a new harmonized vertical reference, based on the wider perspective on international work participation, has been made in the Swedish Maritime Administration and the conclusions were summarized in a report in April 2014. The report is: *Förstudie byte av referensnivå i SJKBAS*, (Seiron, P-O., 2014) – only available in Swedish.

The conclusion from the report shows that implementation of a new vertical reference in Swedish official navigational chart products will result in some major changes. The coastline, the depth contours and the soundings (depth figures) in the navigational chart products must be changed to be in line with the new reference level. This will be a heavily resource consuming task. It is however a very important task to do in order to improve safety for the shipping.

The situation, especially in the northern coast of Sweden, is today somewhat confusing for the mariners. During the ice age the pressure from the masses of ice pressed the land down and since then there is an effect of land uplift (post-glacial land uplift) in northern Scandinavia. Understanding this present situation is very complicated for the users. As an example, a depth which is presented

in the chart as 10 m could actually be 9.5 m in reality. To implement the suggested new vertical reference level will be considerably simpler for the users.

In order to be able to adjust all the depth contours in the Swedish chart products, the existing depth data will be used to recalculate the depth contours according to the new chart datum. Due to the source and quality of the existing hydrographic surveys, different tolerances will be applied in different areas. In an area where S-44 is fulfilled, very tight tolerances will be used. If a depth contour, according to the new chart datum, is more than 2 meters outside the existing depth contour in the chart, this depth contour must be changed. In an area where S-44 is not fulfilled, tolerances from 20 to 21.5 meters will be accepted (depth dependant). The change to the new chart datum will lead to an important quality improvement in Swedish ENCs and paper chart products, since a new modern surveyed coast line will be implemented and a standard set of depth contours according to the modern vertical reference will be used.

## Conclusions of Activity 3 and re-surveys:

Within Activity 3, the following experiences have been noted:

### **Procurement procedures:**

#### Prerequisites

The overall experiences show that in order to sign a contract ensuring depth data delivery in time and with a quality in accordance with the requirements in the S-44, the organisation is dependent on experienced senior staff surveyors familiar with the latest technology. SMA and FTA have together with other concerned national authorities agreed upon a common implementation of the S-44 named FSIS-44 ([http://www.transportstyrelsen.se/Global/Sjofart/Dokument/Sjotrafik\\_dok/Svensk-Finsk-realiserig-av-S-44.pdf](http://www.transportstyrelsen.se/Global/Sjofart/Dokument/Sjotrafik_dok/Svensk-Finsk-realiserig-av-S-44.pdf)) in order to make it possible to make a common procurement and to make it easier for the tenderers.

To maintain the level of competence required within SMA, it is of their opinion that the organization needs to continue surveying with its own resources. In Finland Hydrographic Survey Data Management at FTA in turn has to be active in field supervision, but on the other hand is lacking resources.

The senior staff surveyors need to be involved in the process of writing the specifications of requirements. This is a very time consuming process. During the latest public procurement SMA used approximately 3500 hours within 9 months from starting writing the specifications to signing the contracts. This involves mostly senior surveyors, but also purchasing and legal experts as well.

#### Procurement

In some of the procurements, a “fixed sum” has been used and the tenderers have put in offers for the size of the areas they were willing to survey for that sum. It has shown that there is a real need to make good estimates of the time consumption/cost of the prepared sub-areas in order to have large enough areas for the tenderers to bid for. All risks have been handed over to the contractors; hence weather standby and other reasons for standby have to be taken into account by the tenderers.

SMA carries out procurements in accordance with applicable regulations. The primary law governing procurement processes in Sweden is the Public Procurement Act, which is based on several EC directives. Some differences exist between the Swedish and Finnish legislations and also somewhat larger differences in the actual routines used. Finland has also the General Terms for Public Service Procurement for the Government of Finland (2009) supporting the procurement process.

#### *Hindrances during procurement*

According to both Swedish and Finnish law a “Tender” is valid only if it is without reservation. In all procurements, we have been forced to disqualify some of the tenderers due to reservations similar to: “*Our tender is subject to vessel availability at the time of the contract award*” or “*Vessels, systems and personnel are subject to availability*”. These reservations appear to be standard terms for several companies but if they are not removed they will be disqualified according to the Finnish and Swedish Procurement regulations. Both Finland and Sweden have specific legislation on hydrographic surveys in territorial sea areas, which complicate the procurement process for such areas.

#### Market

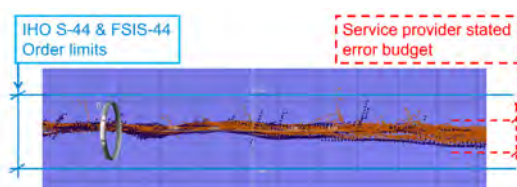
The number of companies within the hydrographic surveying market is fairly limited. Many of them are involved in the lucrative offshore oil and gas industry. Some foreign companies have also sent in ten-

ders, but it is assumed that mobilization costs have made it difficult for them to present winning bids. On the other hand these types of hydrographic surveys for hydrographic offices are long term work providing tasks for many years.

### **Quality and Delivery experiences**

The foundation for getting depth data delivered in time and with a quality in accordance with S-44 is the Specification requirement. FTA and SMA have gained experience each time a public procurement has been made. However it is very complicated to foresee every possible upcoming situation when writing the specifications. Both FTA and SMA have experienced continuous problems with data quality in accordance with S-44. In order to secure depth areas shallower than 20 m (Special Order), which have been a very limited amount of areas in the MonaLisa project, SMA has placed on board one of their own senior surveyors as an observer. This is to emphasize the importance of safeguarding the higher quality required within Special Order and make sure that the accurate procedures in the contract are followed.

It has become a rule of thumb that service providers are given a vertical tolerance that is about half of the given order in S-44 ed. 5 / FSIS-44 (see **Figure 6**). This will leave some room for vertical offset errors that cannot be visualized and verified in relative data sets. All visual systematic errors shall be flagged, of course. (Hughes Clarke 2000)



**Figure 6:** Error budget relation to the S-44 and FSIS-44 Order limits

When it comes to the error budgets requested in the tender, it seems that many survey companies use only the input values from the system manufacturer’s data sheets. As an example, it seems normal to use an error value of 0.1 m/s for the sound velocity, as stated by the manufacturer, whilst the real errors, taking into account also spatial and temporal variations, rather might be around 2-3 m/s as the taken profiles only are valid at the specific point and time it was taken.

In all procurements FTA and SMA have requested that each vessel has to prove that the complete

survey system fulfils the requirements by surveying over a fixed geodetically surveyed manmade bottom object prior to commencing the survey. The Buyers have also demanded that a small test area (eight short run lines) in the survey area should be used as a horizontal and vertical reference to be surveyed in the beginning and as a final check so to see that nothing has changed in the system setup during the surveys.

If the surveying company has had a break in the surveying, then the test area has been surveyed prior to the ship leaving and at return to the area. Survey over a manmade bottom object has in some cases resulted in revealing static depth errors of up to 46 cm. The companies have been unaware of this and also unknown in their previous surveys.

SMA and FTA have also realized the importance of keeping a strict policy regarding the approval of a vessel survey system and its importance to calibration before the start of a survey. Approval procedures must be clearly explained and written in the specifications as well as the circumstances and cases when the system or calibration are not accepted and must be rectified. The contractors are of course eager to start the field survey as soon as they have arrived in the survey area and, in order not to cause any costly delays in approval procedures, one must have qualified personnel on standby 24/7 for reviewing the reports and as on-board overseer. In some occasions unnecessary and time consuming disagreement occurred between the contractor and the buyer whether the survey system or calibrations met the qualifications according to the specifications.

All surveying has been carried out using traditional tidal corrections and, for that reason, both FTA and SMA have requested that tables of dynamic draft/squat should be used. This does not seem to be a standard procedure for the surveying companies because on all the vessels used, the depth dependent squat has been significantly higher than the companies had expected. FTA and SMA's opinion is that the vessel's dynamic draft and squat needs to be taken into account both when using traditional tide correction and in order to make it possible for a direct comparison of traditional tides to tides derived using GNSS technology.

It is also fundamental to have experienced in-house staff that can take care of and evaluate the delivered depth data in order to ensure that it meets the specified requirements. Many data sets

have been rejected after the first delivery, and there have been several discussions regarding differing interpretations of the specifications. SMA has also encountered gaps in delivered depth data which in some cases has arrived several months after the vessel left the area and therefore, in these cases, it was very complicated to arrange infill in these areas.

FTA and SMA have also experienced several problems with the companies' abilities to deliver data according to an agreed delivery schedule. There are examples where the contracted company, probably in order to reduce costs, has minimized their post processing staff which has led to much delays in data deliveries. In some cases maximum penalties for delays have been assigned to the service providers.

#### General Cost Levels

Comparison of cost between different vessels and different depth areas is extremely complicated. The Finnish and Swedish coastal areas are filled with islands and varying bottom topography. Using contracted companies has set focus on cost efficiency. In order to achieve the same survey costs (or lower) compared to contracted companies, SMA has utilized its own vessels in a more cost efficient way. Surveying 24/7 is now standard on vessels which are of sufficient size and are surveying in suitable areas. The Finnish Maritime Administration outsourced all its internal fleet when the Finnish Transport Agency was established (amalgamated).

Today, SMA has lower costs using their own vessels than when purchasing surveying services. The contracting survey costs are generally higher due to the companies' necessary profit margin and the added costs for specification writing, procurement costs, quality assurance and approval procedures with experts and specialists as senior surveyors and post processing personnel.

### **Conclusions from the MonaLisa project**

The possibility to get co-financing from the TEN-T program for this MonaLisa project has made it possible to survey much larger areas in Sweden and Finland, which had not been possible earlier with just ordinary resources. In the case of Sweden, 30 000 km<sup>2</sup> were surveyed during 2011 – 2013. If only ordinary resources had been used, less than 50% of that amount would have been surveyed. In 2013, an area of 15 000 km<sup>2</sup> was

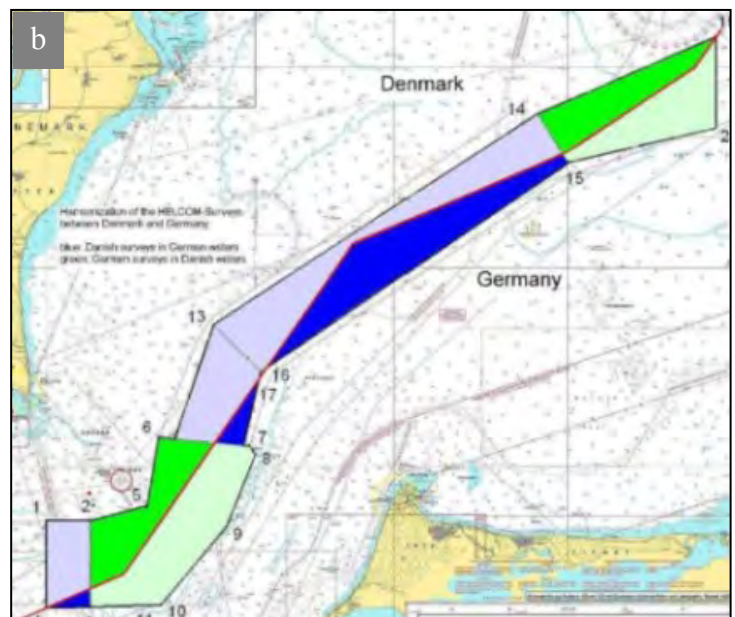
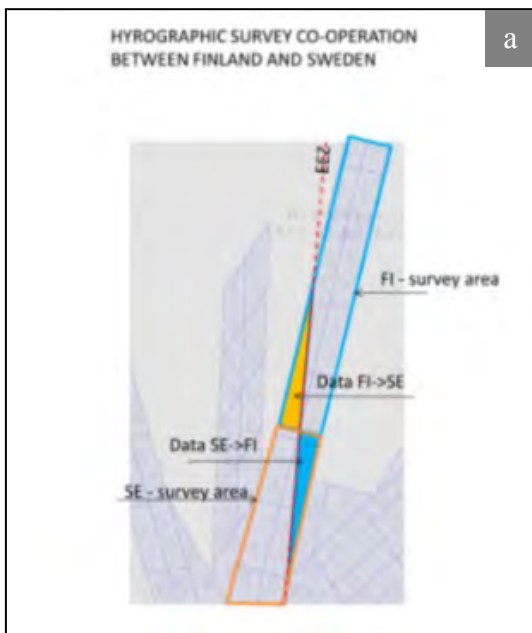
surveyed in Swedish waters. Such a large area of new surveys in one year has never been achieved before. When co-financing was made possible it was extremely important to be able to use contracted companies in order to extend the capacity of surveying.

In Finland some extra 10000 km<sup>2</sup> was put out for open tendering and completed with the support of the MonaLisa grant.

The co-operation between FTA and SMA has been very fruitful during the project. Being able to procure such extensive areas in both Sweden and Finland has probably led to lower surveying prices than would have been the case if just one part had procured smaller areas. FTA and SMA have learned a lot from each other at different levels within the two organisations. This includes project management, procurement procedures, quality assurance and data processing. The Swedish and

Finnish Hydrographic Offices have a long tradition of co-operation and the MonaLisa project has certainly strengthened this close co-operation. A specific important result is that Sweden and Finland now have a common implementation of the IHO standard for surveying S-44; FSIS-44 (Finnish and Swedish implementation of S-44). This is now used by all authorities involved in surveying. When a harbour authority procures a surveying project in its harbour, the requirements in FSIS-44 should be fulfilled.

The efficiency of the re-survey work has increased. These activities have enhanced systematic planning and co-operation between neighbouring HO's regarding surveys along border areas and allowing surveys in each other's areas of responsibility, and thus enabled more feasible re-survey tasks and more efficient survey operations. See two examples in **Figure 7**.

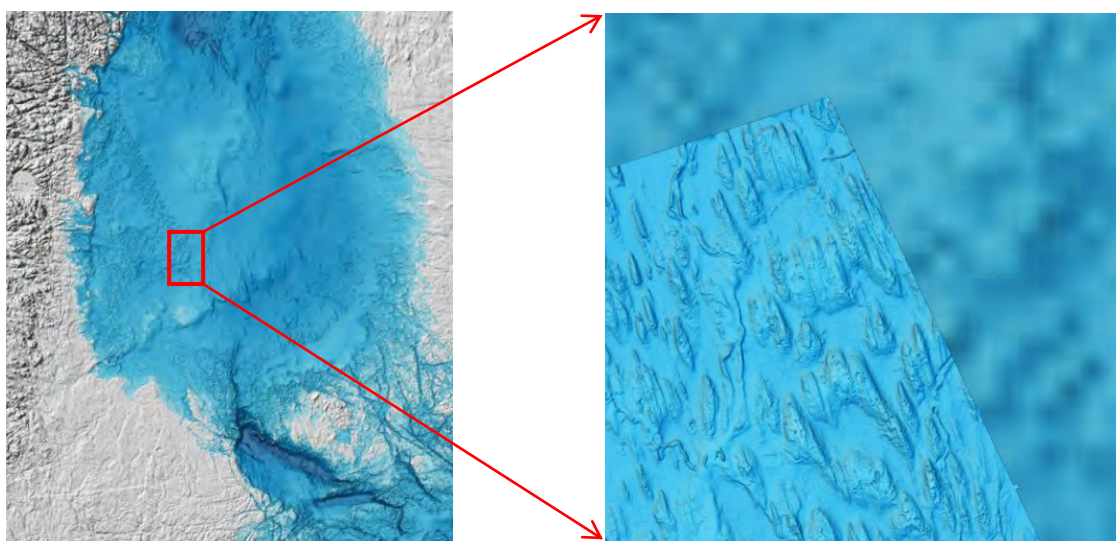


**Figure 7a and 7b:** Examples of co-operation of re-survey work between neighboring countries (Finland/Sweden, Denmark/Germany).

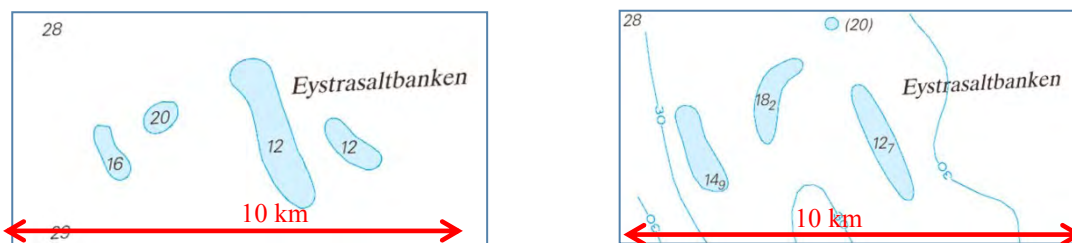
The re-surveys have already proved useful. The overall goal for the re-surveys is to increase safety of navigation and the protection of the marine environment. For instance, the re-surveys covered areas used by shipping where old or otherwise inadequate depth information currently exists. During the re-surveys, critical new shallows or shallows shallower than previously known have been found. Reliable full bottom coverage of surveys allow for more flexible route planning and enable revisions of fairways or routes and planning

of modified or new Traffic Separation Schemes. New data will be available as extensive as possible e.g. via the Baltic Sea Bathymetry model, see an example view in **Figure 8**.

In addition to the above listed conclusions the Activity 3 re-surveys have fostered similar benefits as described in the Articles of the Baltic Sea Re-survey Scheme (Korhonen, 2014) and the Baltic Sea Bathymetry model (Hell, Öiås, 2014) in this IHR issue.



**Figure 8:** Examples of Baltic Sea Depth Model of the Bothnian Sea with varying density of survey data. The resolution in the overall dataset from the Baltic Sea Bathymetric Database is 500 m, but in re-surveyed areas it could be 25 m or more dense. The rectangle area on the right demonstrates how detailed the sea floor features (e.g. drumlins) can be seen with a 4 m grid.



**Figure 9:** Extract of an example chart before and after of re-surveys.

## Future plans

At the HELCOM ministerial meeting in Copenhagen in June 2013, an updated time table for hydrographic surveys in the Baltic Sea was agreed upon. The plan encompasses all areas in the Baltic Sea used by commercial shipping and is very ambitious and challenging for all HOs involved. In order to be able to fulfil this ambitious plan, co-financing is essential. The success with the MonaLisa project surveying extensive areas has led to the conclusion that Sweden, along with the BSHC invited partners involved, plan for a new application to the EU.

The FAMOS project has been established in the beginning of 2014, planning for an application to the EU INEA CEF Transport to finalize the HELCOM CAT I & II hydrographic surveys within participating nations. Some plans for further surveys of HELCOM CAT III areas also exist, but not yet as far in planning as FAMOS.



Figure 10: FAMOS-logo.

## Acknowledgements



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## Biographies

**Seppo H Mäkinen** has a M.Sc in Surveying Engineering at Aalto University (formerly the Helsinki University of Technology) in 1989. He has worked in various duties within the Finnish Hydrographic Office since 1990. Seppo has also attended the University of New Brunswick achieving the theory part of the FIG/IHO Cat A hydrographic certificate. Currently he is responsible for hydrographic survey data procurement and is also acting as head of the Hydrographic Survey Data Management unit. Mr. Seppo H Mäkinen has chaired for MonaLisa activity 1.

**Ulf Olsson** has a Master's degree in Hydrographic Science, at the University of Southern Mississippi, 2003, and has a FIG/IHO Cat A certification. He also has a Master Mariner and Nautical Science education at Malmö Merchant Marine Academy 1982. He has served as Hydrographic Quality Manager and Senior Surveyor 2003-2011 and from 2011 he has been Head of Hydrographic Field Survey at the Hydrographic office at the Swedish Maritime Administration.

**Magnus Wallhagen** is Production Manager at the Hydrographic Office at the Swedish Maritime Administration having production responsibility from surveying to nautical products. Working at SMA since 1991, he has a technical background as Manager of the Chart Database and has also been Project Manager during the 1990s when the Swedish paper charts were digitized. Magnus has also been involved in several development projects within SMA and with neighbouring countries' HOs, as well as being involved in some of the IHOs technical working groups and regional commissions. Education at Higher Course includes Cartography, GIS, English and one year civil service on-board a surveying ship.

**Hans Öiås** has a High School degree in Electric Engineering at the Ebersteinska Higher Technological School in Norrköping. He has also

studied a Higher Course in Computer science specializing in Logistics and Production Management as well as some courses in structured programming and GIS at the Linköping University. He has worked for the SMA since 1986 as a survey systems engineer and hydrographic surveyor. He has experiences in system development, system integration as well as procurements of both survey systems and hydrographic surveys. He was appointed as Project Manager for the development of the Baltic Sea Bathymetric Database within the MonaLisa Project

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## BALTIC SEA HYDROGRAPHIC COMMISSION (BSHC) AND CO-OPERATION ON HYDROGRAPHIC ISSUES WITH OTHER BALTIC SEA ORGANIZATIONS

By Juha KORHONEN (Finnish Transport Agency)

Hermann BACKER (Helsinki Commission)

Thomas HAMMARKLINT (Swedish Meteorological and Hydrological Institute)

Bjarke WIEHE BØTCHER (Danish Maritime Authority)

### Abstract

The Baltic Sea Hydrographic Commission (BSHC) was established in 1982 as an IHO Regional Commission. The BSHC Members are the Hydrographic Offices of Denmark, Estonia, Finland, Germany, Latvia, Poland, the Russian Federation and Sweden. Lithuania is an Associate Member (**Figure 1**). The BSHC foster and coordinates hydrographic Activities on the Baltic Sea area. The Baltic Sea is environmentally sensitive quite closed sea area with intensive passenger, oil and cargo shipping. All Baltic Sea Countries are actively participating in the BSHC work. This paper gives an overview of the BSHC activities and co-operation on hydrographic issues with other Baltic Sea Organisations.

### The Baltic Sea

The Baltic Sea is almost a closed sea area. It is connected to the North Sea via the Danish Straits. The minimum navigable depth is about 18 m which limits the maximum draft of the ships entering the Baltic Sea to 16.4 m and the recommended draft to 14.5 m.

The area of Baltic Sea is roughly 400.000 km<sup>2</sup>. The Baltic Sea is relatively shallow, its median depth is about 43 m and mean depth is about 54 m. About 20% of its area is less than 15 m which create potential obstacles for navigation. About 70% of its area has depths less than 70 m which may influence the fuel consumption of ships. For comparison the mean depth of the North Sea is about 90 m and the mean depth of Mediterranean Sea about 1500 m.

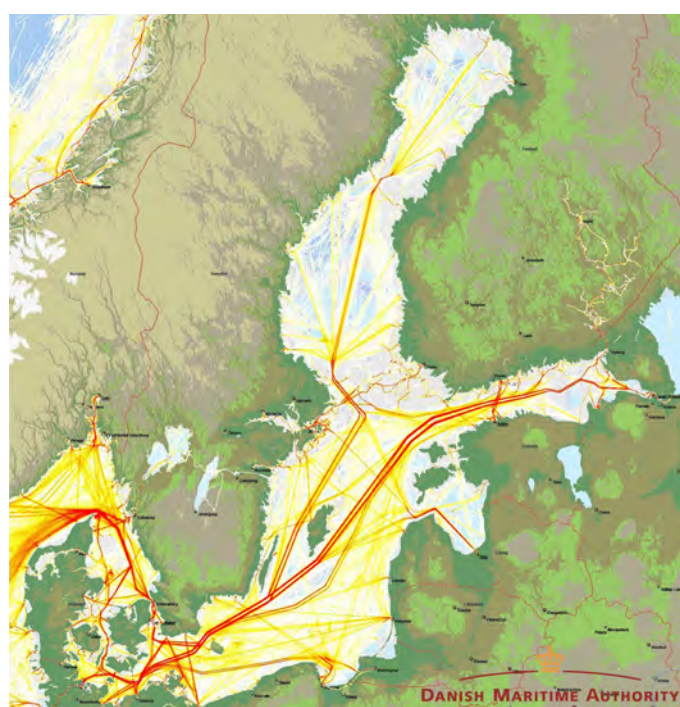
The Baltic Sea is an environmentally sensitive area due the facts that it has brackish waters, the shores are heavily populated and widely used for a broad range of activities. Shipping is very dense on the Baltic Sea. There are intensively used passenger, oil and cargo routes (**Figure 2**). In 2005, the IMO approved the Particularly Sensitive Sea Area (PSSA) status to Baltic Sea (except Russian waters).

There is no remarkable tide on the Baltic Sea; however there are remarkable irregular water level variations due to weather conditions. Large parts of the Baltic Sea are covered by ice during winter time. In the Northern part, there is remarkable land uplift due the previous glacial period.

### Baltic Sea Hydrographic Commission (BSHC)



**Figure 1:** Members and Associate Members



**Figure 2:** Density plot of vessel traffic in the Baltic Sea, June 2014, based on AIS tracks. Image is courtesy of the Danish Maritime Authority.

**Members:** Denmark, Estonia, Finland, Germany, Latvia, Poland, Russian Federation, Sweden.

**Associate Members:** Lithuania.

**Brief History.** The BSHC was established in Helsinki, Finland, on 24-26 May 1983 following a recommendation made by the Hydrographers of the Baltic Sea at a preliminary meeting in Monaco on 19 April 1982. The original initiative came from Sweden and the first Chairman was Commodore *Folke Hallbjörner* (Sweden). The initial activities were to agree on the BSHC Statutes, to establish the Baltic Sea INT Chart Committee, to discuss the Baltic Sea bathymetric charts, the differences between Baltic Sea coordinate systems, the distribution of printed charts, limits of territorial seas, the Baltic Sea Radio Navigational Warning system, and the IHO technical assistance programme. First Statutes were approved in May 1983. The latest version is approved in June 2007.

The main achievements have been 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 ENC's, and the exchange of information and the harmonization of practices with regard to various issues related to hydrography.

BSHC has its Conferences at least bi-annually. However during the last years there have been so many activities that the Conferences have been held every year. There has been 19 BSHC Conferences up to now.

### **BSHC Main Activities**

Below are briefly listed the BSHC Working Groups with their main activities. All BSHC Full and Associate Members are actively participating and contributing to these Working Groups. The activities within the Commission have increased and recently the BSHC has had its Conferences every year.

**Baltic Sea INT Chart Coordinating Working Group (BSICCWG)** coordinates the development and the updating of the Baltic Sea INT Chart Scheme. In addition the BSICCWG coordinates Baltic Sea ENC harmonisation actions. There is a separate Note on some of the BSICCWG activities in this IHR edition.

**BSHC Re-survey Monitoring Working Group (MWG)** has developed and updates the Baltic Sea Re-survey Scheme. The Re-survey Scheme covers the whole Baltic Sea and includes prioritized re-survey plans with time schedule estimations for areas used for navigation. This activity is endorsed and highly appreciated by HELCOM. There is a separate Article on the Re-survey Scheme in this IHR edition.

**Chart Datum Working Group (CDWG)** has fostered the harmonisation of Baltic Sea vertical references. The CDWG has proposed to IHO TWLWG to revise IHO resolution on vertical datums to better reflect the non-tidal and inland waters (IHO Resolution 3/1919 as amended). The CDWG has evaluated the needs and possibilities to move on a harmonised vertical reference. BSHC has agreed in principle to move EVRS. CDWG is developing a Road Map to this transition by 2020. CDWG is establishing a closer co-operation with Baltic Sea Oceanographic Observation System (BOOS). There is a separate Note on CDWG activities in this IHR edition.

**Baltic Sea Bathymetric Database Working Group (BSBDWG)** has developed the Baltic Sea Depth Model. The Depth Model has flexible resolution because the density of the source data varies much. Also some countries have restrictions to deliver high density data. The Depth Model has been released Autumn 2013 and is available via the BSHC web site. The Model has been well received by quite wide variety of users. There is a separate Article on the Baltic Sea Depth Model in this IHR edition.

**Baltic Sea Marine Spatial Data Information Working Group (BSMSDIWG)**. This Working Group works closely together with the HSSC MSDIWG. Currently both Working Groups have the same chair. The intention is to give Baltic Sea regional input to the HSSC MSDIWG. There is a separate Note on some of the BSMSDIWG activities in this IHR edition.

In addition to these Working Groups, the BSHC has a representative to IHO IRCC WENDWG and to IHO -EU Network. BSHC has also endorsed other co-operation activities, e.g. a LIDAR seminar in May 2014.

### **BSHC co-operation with HELCOM**



The BSHC has a close connection to the **Baltic Marine Environmental Protection Commission** (known as the Helsinki Commission and abbreviated HELCOM), the governing body of the Convention on the Protection of the Marine Environment of the Baltic Sea Area. This Convention was originally signed by all coastal countries in 1974 and ratified 1980. Since the revised convention 1992 the Contracting Parties are Denmark, Estonia, the European Union, Finland, Germany, Latvia, Lithuania,

Poland, Russia and Sweden. The Convention is also the legal mandate of HELCOM and its maritime related working groups. Safety of navigation was included early on in the work of HELCOM as can be seen from the Resolutions 3 “Navigation of Commercial Ships Through the Entrances to the Baltic Sea” and 5 “Safety of navigation”, adopted with the Convention in 1974.

In addition to the Commission itself, HELCOM has five main sub-groups with annual meetings, where the MARITIME Group deals with issues related to pollution from shipping and safety of navigation. RESPONSE deals with preparedness and response to accidents at sea and on the shore. HELCOM convenes at the level of ministers approximately every 3 years. Usually Ministers of Environment attend at the Ministerial level, but Ministers of Transport have also convened under HELCOM, and transport agencies attend the HELCOM MARITIME group.

Since the beginning of the cooperation, the contracting states have been aware of the close relationship between the availability of reliable nautical charts and safety of navigation and prevention of pollution of the Baltic Sea as called for by the Helsinki Convention. The work of the hydrographers of the Baltic Sea region and particularly the IHO Baltic Sea Hydrographic Commission (BSHC), also established in Helsinki in 1983, has been one instrumental factor in delivering safer navigation in the Baltic Sea.

The production of more reliable nautical charts (paper as well as electronic), is in many cases only possible through costly re-surveys. However, accidents like the 2001 “*Baltic Carrier*” have demonstrated the cost-efficiency of these investments in the densely trafficked Baltic Sea. Even if the region has developed a high level of preparedness to pollution incidents since the 1970s, the heavy traffic and size of modern ships is a strong incentive to invest in improving safety of navigation in the region (**Figures**).



**Figures:** Ship groundings and all accidents in the Baltic Sea, including tankers over 150 gross tonnage and/or other ships over 400 GT (HELCOM 2014, Report on shipping accidents in the Baltic Sea area during 2012).

As a reaction to the *Baltic Carrier* accident the Declaration on the safety of navigation and emergency capacity in the Baltic Sea area (HELCOM Copenhagen Declaration), adopted on 10 September 2001 in Copenhagen by the Ministers of Transport of the Baltic Sea region, agreed to measures on Re-surveying of major shipping routes and ports (IIIa):

*“requesting the Governments of the Contracting Parties to develop a scheme for systematic re-surveying of major shipping routes and ports in order to ensure that safety of navigation is not endangered by inadequate source information. The survey shall be carried out to a standard not inferior to the latest edition of IHO S-44. The scheme shall be elaborated jointly by the hydrographic services responsible for the areas in question not later than by the end of 2002 with the aim to begin implementation by 2003”*

The national hydrographic offices of the region, working within IHO BSHC, developed, approved and commenced implementation in 2002, the regional Harmonised Hydrographic Re-Survey Plan according to estimations of the main routes used by the ships. The HELCOM maritime related working groups on prevention of pollution and safety of navigation were updated along the way.

The 2001 Declaration on the safety of navigation and emergency capacity in the Baltic Sea area (HELCOM Copenhagen Declaration) requested Baltic Sea Hydrographic offices to present a systematic scheme for re-surveys to major routes and ports in order to ensure that safety of navigation is not endangered by inadequate source information. The same Declaration also established the regional HELCOM AIS system, operational since 2005, which is administered and developed by the HELCOM AIS EWG. The regional AIS system has provided information on the tracks of shipping in the Baltic Sea which has helped influence prioritization of re-survey activities.

The Moscow 2010 Ministerial Declaration extended the scope to cover the whole Baltic Sea and to have time schedules for re-surveys for areas used mainly for shipping. HELCOM-BSHC Harmonised re-survey Scheme was approved by BSHC 18<sup>th</sup> Conference in 2013 and adopted by the HELCOM Copenhagen 2013 Ministerial meeting.

The progress of the regional re-survey Scheme has been reported annually to the MARITIME meetings. In addition, information on other Baltic Sea hydrographic activities has been given. Other cooperation between HELCOM and hydrographic offices include the Mariners' Routing Guide Baltic Sea which presents routing and other safety of navigation related information in chart form, published by the *Bundesamt für Seeschifffahrt und Hydrographie* (Germany) but originally agreed within the HELCOM expert group on safety of navigation.

Within HELCOM, the hydrographic activities have been recognised as highly valuable for enhancing safety of navigation and reducing the risk of grounding and accidental pollution in the region. Hydrography is also recognised as central in order to produce basic bathymetric data, useful for many applications beyond the safety of navigation. HELCOM has provided continuous political support to hydrographic activities to BSHC members.

The high quality hydrographic data resulting from the extensive implementation of these commitments over the last decade has many interesting, and important uses beyond the field of safety of navigation. These include Maritime Spatial Planning, with issues like finding good locations for wind power installations or marine parks, as well as geographic modelling of the distribution, and quality status of underwater life.

More openly accessible hydrographic data products for such non-navigational use in the Baltic Sea region, as indicated by the recent BSHC bathymetry database, would help the implementation of numerous regional commitments related to the marine environment and the development of GIS data with bathymetric components.

Currently ongoing HELCOM work in the field of safety of navigation includes the development of regional recommendations on Under Keel Clearance and implementing a recent Recommendation on e-navigation, both topics which are depending on high quality bathymetric data.

Baltic Sea cooperation between HELCOM and BSHC, in the intersection between environment, safety of navigation and hydrography has always been exciting. *Lets make it even better!*  
More information on HELCOM and its activities can be found at: <http://helcom.fi/>

## **BSHC co-operation with the EU Strategy for the Baltic Sea Region (EUSBSR)**



The European Union Strategy for the Baltic Sea Region (EUSBSR) was adopted in 2009 as the European Union's first so-called macro-regional strategy. The Strategy aims to:

- Save the sea
- Connect the region
- Increase prosperity

The strategy is divided in thematic Priority Areas, The overall goal of the Priority Area on Maritime Safety and Security is for the Baltic Sea Region “to become a leading region in maritime safety and security”. This objective is implemented by means of policy dialogue and flagship projects. These projects cover a wide range of aspects of maritime safety and security, such as e-Navigation, navigation in icy waters, safety in fisheries, transport of dangerous goods, re-surveying of shipping routes as well as the fostering of innovation and initiatives towards creating a common information sharing environment for maritime security information.

Denmark and Finland serve as Priority Area Coordinators for the Priority Area on behalf of the other eight EU Member States around the Baltic Sea. The task is jointly headed by the Finnish Transport Safety Agency and the Danish Maritime Authority. An international Steering Committee has been established to guide and assist the Priority Area Coordinators in their work. The Steering Committee consists of members from maritime authorities in the Baltic Sea States, regional organisations, the European Commission and other relevant stakeholders, which all attend its meetings.

The Priority Area on Maritime Safety and Security includes the Flagship Project entitled “*Speed up re-surveys on major shipping routes and ports*”. Through its Flagship Project status, the HELCOM-BSHC Harmonised Re-survey Scheme gains political support and visibility. The project reports on the progress of its activities biannually. Many of the nautical charts of the Baltic Sea are partly based on inaccurate surveys up to 100 years old, where the depth information is often based on handmade lead casts.

Resurveying of the Baltic Sea with modern technology is expected to bring about a number of advantages for safer and more efficient shipping. In addition, the collected data will also be useful for other maritime applications, such as planning of wind energy or environmental protection. Lastly, it may also serve as base data for the use of the sea in fields still to be explored, and by this provide incentives for *blue growth*. Thus, in a Baltic Sea context, resurveying is believed to contribute to both saving the sea, connecting the region more effectively and as a means to increase prosperity.

Both HELCOM and EUSBSR have recognised the importance of hydrographic activities as a basis for the safety of navigation and numerous other maritime activities. Both organisations have given valuable political support to BSHC Members for them to schedule and finance their re-survey plans and budgets.

As a practical means to foster re-surveys there has been a successful project entitled “*MonaLisa*” co-funded by the EU TEN-T within the Motorways of the Seas programme. Thanks to this project extensive Finnish and Swedish sea areas have been re-surveyed with co-funding from the European Union. Another project entitled *Finalising Surveys for the Baltic Motorways of the Sea (FAMOS)* is being planned, in order to complete re-surveying of areas used for navigation by participating countries. A separate article on the *MonaLisa* project is included in this IHR issue. These projects also enjoy Flagship Project status in the Strategy.

More information on the EUSBSR Priority Area Maritime Safety and Security and its activities can be found: <http://pa-safe,dma.dk> and <http://www.balticsea-region-strategy.eu/>

### **BSHC co-operation with the Baltic Sea Operational Observation System (BOOS)**



The aim of BOOS is to provide integrated marine services to the marine users and policy makers and to improve the safety and efficiency of maritime transport and marine operations.

The BOOS co-operation was formed in 1997 with the aim to promote and develop an operational oceanographic infrastructure including routine collection, interpretation and presentation of *in situ* and

satellite data. This information is necessary in order to improve efficiency of marine operations, reduce risks for accidents, optimise monitoring of marine environment and climate, improve assessment of fish stocks and improve foundation of public marine management. An *operational service* supporting these activities shall focus on observations and model predictions, analyses and scenarios. Products of high-quality which are timely delivered to users in a sustained manner are key factors to success of services.

Modelling activities and observation system on water level uses a wide spread of reference datum. The problem occur when the user starts to compare water level data coming from many countries, for example in the *Öresund* area. In Denmark the reference DVR90 are used, while in Sweden the water level data are often presented relative mean sea level (MSL). This means that the users of water level data need to recalculate the sea level data into a common reference. In the eastern part of the Baltic, almost all stations are related to the *Kronstadt* datum, which is not correlated to the reference datum used at the stations in the western part, which is referred to the European Vertical Reference System which correlates to *Normaal Amsterdam Peil (NAP)*. The difference can be of several dm.

BSHC and BOOS have worked together on issues related to water level observations, predictions and harmonisation issues. Both are fostering actions for harmonisation of vertical references. Since, 2012 BOOS has started to present the relationship between the presented water level value and known reference datum to the users. The common reference datum BOOS are working towards is the European Vertical Reference Frame. The information can either be found inside the data files distributed in the BOOS Data Portal or can be found in a pdf-file, which can be found here:

[http://www.smhi.se/hfa\\_coord/BOOS/dbkust/mwreg\\_boos.pdf](http://www.smhi.se/hfa_coord/BOOS/dbkust/mwreg_boos.pdf)

A Memorandum of Understanding on mutual co-operation between BSHC and BOOS has been signed recently.

More information on BOOS and on its activities can be found: <http://www.boos.org/>.

## Discussion

All Baltic Sea Countries are participating and contributing actively to the work of the BSHC and its Working Groups. Also Lithuania is active, even if it is not an IHO Member State, but an Associate Member to BSHC.

The co-operation between these organisations is constructive and friendly and results are considered fruitful. All of these organisations aim to enhance safety and efficiency of navigation on the Baltic Sea and thus also support the protection of the marine environment.

The outcomes of these efforts are regarded to be beneficial for numerous activities of the societies. Major progress in many issues has been achieved. Good practises have been identified, shared with others and taken into use on the Baltic Sea.

## Biographies

**Juha Korhonen** has been working at the Finnish Hydrographic Office since 1974. He has been involved on software and database development, coordination of different development and organisational projects, and participated to IHO work on different levels. He has MSc on land surveying in the Technical University of Helsinki. [juha.korhonen@fta.fi](mailto:juha.korhonen@fta.fi)

**Hermanni Backer**, since 2012, works as the Professional Secretary of the [Helsinki Commission](#) responsible for groups related to Maritime activities and Response to pollution incidents at sea. During 2011-2012 he coordinated the [Plan Bothnia](#) project - a trans-boundary Sweden-Finland maritime spatial planning pilot in the Baltic Sea. He has M.Sc. (marine ecology) and LL.M (Public International Law), both from University of Helsinki, Finland. [hermanni.backer@helcom.fi](mailto:hermanni.backer@helcom.fi)

**Thomas Hammarklint** is working at the Swedish Meteorological and Hydrological Institute (SMHI). Since 2003 he has been working with exchange of water level data in the Baltic Sea and is the BOOS representative in the BSHC CDWG. [thomas.hammarklint@smhi.se](mailto:thomas.hammarklint@smhi.se)

**Bjarke Wiehe Bøtcher** is working as Chief Advisor in the Danish Maritime Authority. He serves as Coordinator for the Authority's involvement in the EU Strategy for the Baltic Sea Region in the fields of maritime safety and clean shipping. Since 2001 he has been dealing with intergovernmental cooperation in the Baltic Sea Region. [bbt@dma.dk](mailto:bbt@dma.dk)



## ESTONIAN HYDROGRAPHIC INFORMATION SYSTEM (HIS)

By Peeter VÄLING

(Head of Hydrographic Department - Estonian Maritime Administration)



### Abstract

This paper provides a brief description of the Estonian Hydrographic Information System (HIS) as implemented in the Hydrographic Department of the Estonian Maritime Administration (EMA). The paper outlines the purpose, structure and usage of the HIS. The HIS is a seamless depth database, survey maintenance system, survey planner and data provider. The HIS can be accessed over the web.

### Preface

Modern hydrographic surveys have been performed in Estonia since 1995. Surveys with multi-channel and multi-beam systems had led to an increasing amount of data which have to be maintained. Also the need for survey data by different users for different purposes is increasing every year. Compiling sea charts is only one of many uses of the data. Users want to get data quickly, easily and preferably over the web.

These issues, together with other problems have raised the importance of establishing a database-driven system. This capability makes it possible to plan and control different survey stages, store and access data, create automatic backups, prepare and share data for different uses accessible by an intuitive web-based interface.

### Basic Concepts

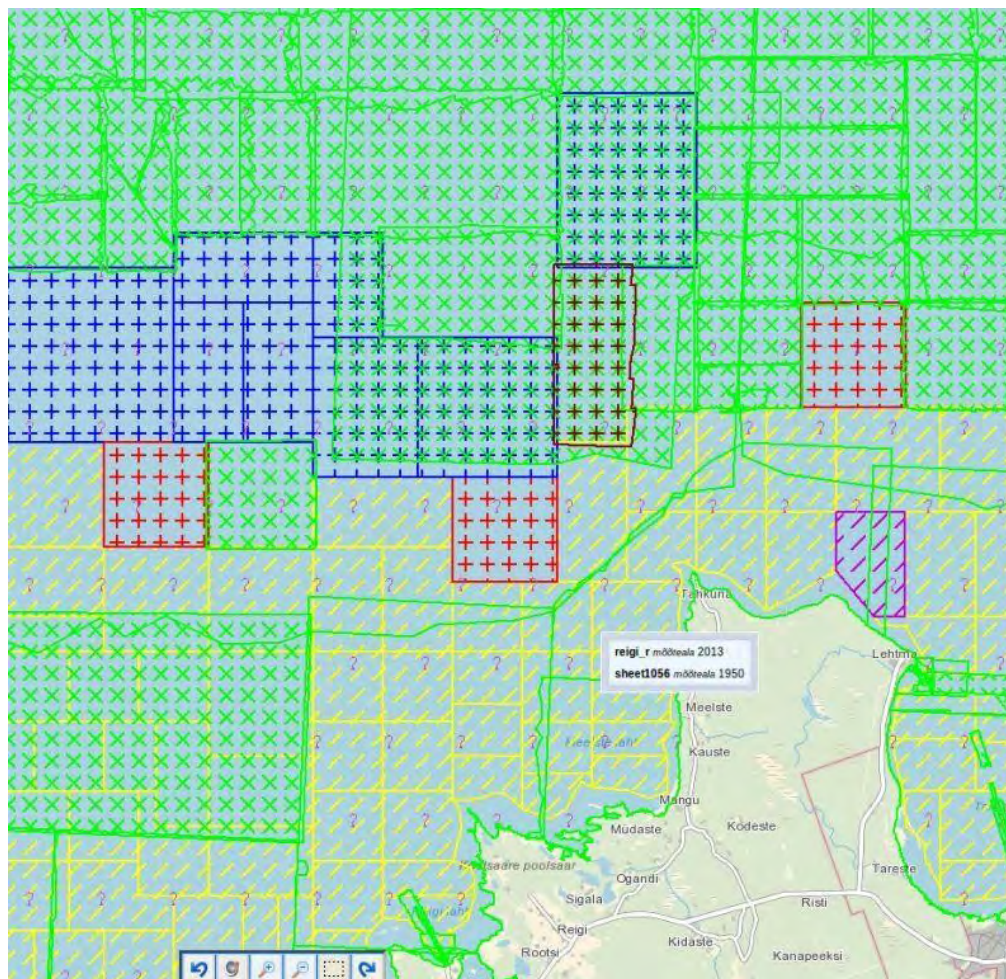
The HIS has been designed considering a number of important spatial concepts such as:

#### Survey Areas:

The most important concept for the HIS is Survey Areas. All Estonian waters including larger inland water bodies are divided into survey areas. A Survey area is a folder with data from survey lines and some additional data files. The additional data files include area borders, statistics, defined underwater objects and all processed depths. These files are in a simple ASCII format enabling the HIS to read these files and automatically populate the databases. Survey areas have different statuses according to their survey stage. The stages define the survey work-flow and include:

- planned;
- under survey;
- surveyed;
- under processing;
- processed;
- under validation; and validated

Only the last status (i.e. validated) makes data from this survey area accessible by users. The areas can be viewed and maintained through the HIS but also in survey and post-processing software. This makes it possible for planning, maintaining and controlling surveys.



**Figure 1:** HIS area status

**Legend of the survey areas:** yellow – planned, purple – under survey, blue – surveyed, red – under processing, brown – under validation, green – validated.

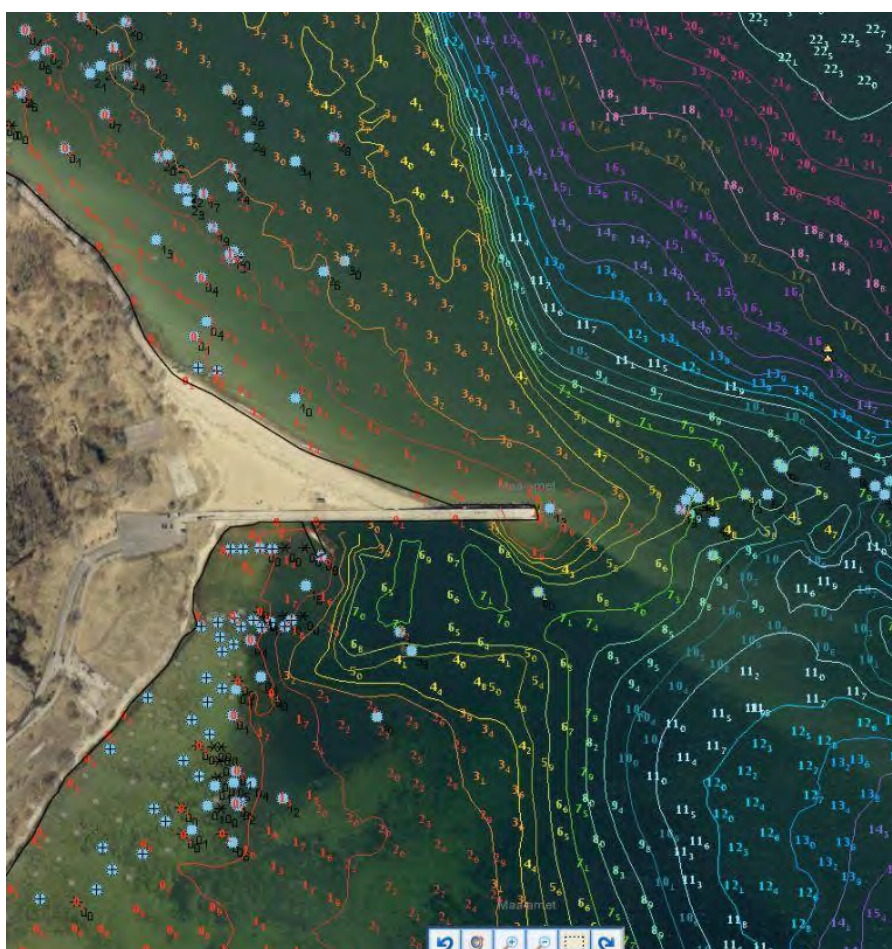
- **Cells:** Estonia is divided into 10x10 km cells, which match exactly with the Estonian base land chart layout. HIS uses these cells for seamless depth and contours database. Depths are stored in cells in different resolutions. Viewing and querying the depth data means getting the data from the relevant cells in the resolution needed. That makes it possible to view data in web mapping services quickly. The same is true about depth contours. The cells are filled automatically from survey areas when new validated data are available.
- **Overlap Handling:** In order to query depths or objects from overlapping survey areas, some automatic procedures have to be performed. First topological analysis of area borders gives exact areas where overlapping occurs. A second procedure analyses relevant survey areas and finds which ones have better quality and/or newer data. These data will have precedence over others. Querying depths from the HIS, provides only the newest and better quality data irrespective of the overlap. The above-mentioned cells are filled the same way.
- **HIS Data:** The HIS does not store all available data. This would be simply too much information. Depths are stored in approximately 1m resolution in depth tables (one table per survey area) and a maximum 4m resolution in cells. Data in full resolution from survey areas are stored as files, so a higher resolution is available if needed. For most uses, a resolution up to 1m has been satisfactory.

## Data

The HIS stores and displays the following data:

- **Survey areas – borders and meta-data:** Meta-data includes area status, area size, total survey line lengths, amount of survey lines, survey time, equipment, ship, surveyor, data cleaner, data validator, statistical data (min/max depths and coordinates, amount of points), quality estimators (standard deviation, mean, IHO S-44 order evaluations). Quality estimation is based on overlapping depths from different survey lines.
- **Depths in up to 1m resolution:** Cells store depths in 11 different resolutions from 4m to 200m. On a web map, depths are shown from cells, so starting from 4m resolution. Cells also store depth contours at 1m intervals.
- **Underwater objects:** These include rocks, wrecks and obstructions. Wrecks can have a number of different information ranging from simple dimensions and coordinates through to lengthy records comprising ship's history and different pictures of the wreck and the ship.

The HIS is also linked to some other databases and this shows information about aids to navigation and harbours. This is useful for getting a complete overview of data in some regions. The HIS also shows WMS data in the background - currently Estonian land maps, orthophotos and S-57 cells from PRIMAR.



**Figure 2:** HIS data

Some data in the HIS: soundings, contours, rocks, aids to navigation, orthophoto background.

The HIS does not store only data collected by the EMA, but also data collected in Estonian waters by private companies. These data needs to be converted into ASCII formats readable by the HIS and the storage procedure is the same as with EMA-sourced data. According to Estonian laws, all private companies doing surveys for navigational purposes in Estonia must get permission for the survey and then provide their data to the EMA. Also any foreign surveyors must provide the collected data to EMA.

For viewing of the map, the data are organized as different layers which can be switched on/off depending on needs.

## Queries

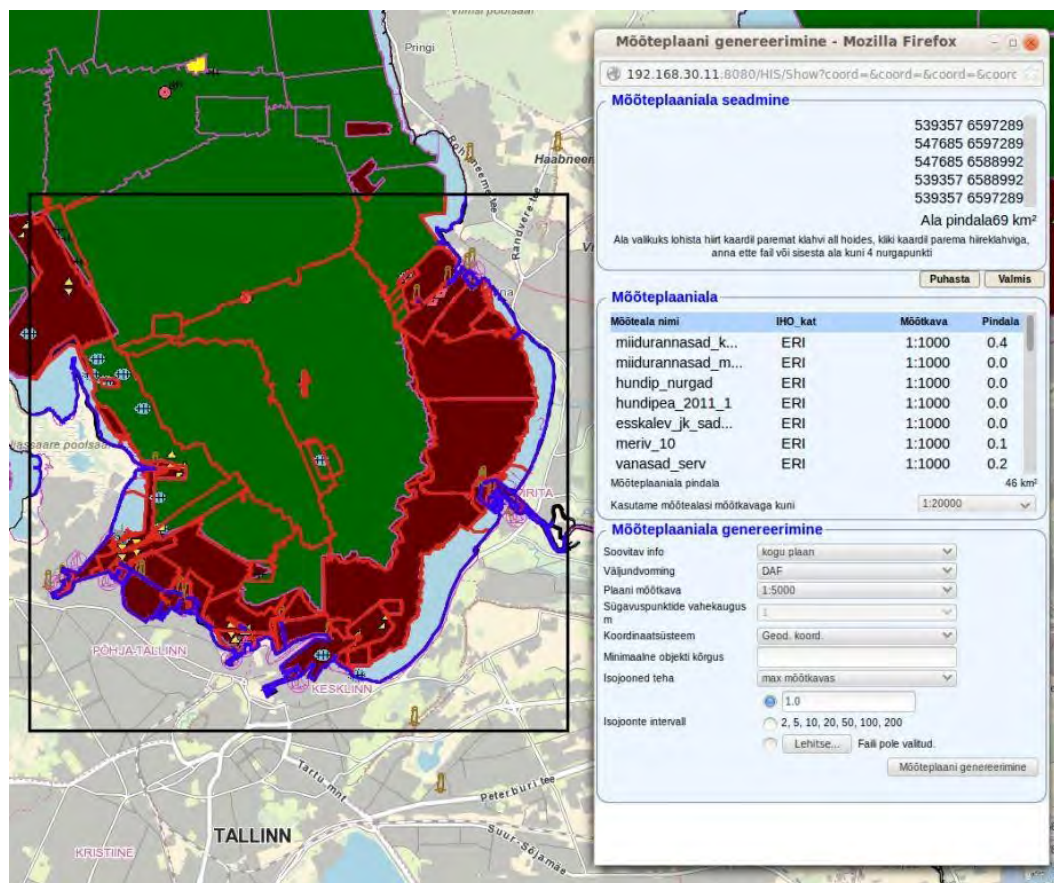
Queries can be textual, spatial and combined. Textual queries are performed using query builders for any data type in HIS. Spatial queries are performed by keying in coordinates or drawing polygons on a map. Such defined areas act as additional restriction to textual query if so desired. Outputs can be redirected to tables on screen or to different types of files.

Selecting objects on the map brings up the full information about the particular object. Hovering the cursor over objects brings up tool-tips with basic information. Query results can be seen on the map as highlighted objects.

## HIS Usage

The HIS can be accessed in restricted, semi-restricted and public versions.

- **Restricted** version is used by workers of the Hydrographic Department of EMA for loading and accessing raw survey data. Of course, they can do also everything else that the HIS supports. Surveyed areas are loaded into HIS and then are downloaded from HIS for data processing and loaded back after processing. The data is then extracted for validation and loaded back after validation. Each processing stage is recorded in the HIS and this provides transparency and an audit trail on the survey data and which person is dealing with certain survey areas.
- **Semi-restricted** version is used by other EMA workers to obtain validated survey data. The biggest users are the Cartographic Department (CD) for compiling charts and the Waterways Department for planning new waterways and dredging works. For chart compilation, Dkart DAF (Dkart Ascii Format) format is used as it is S-57 in simple ASCII format and the CD uses Dkart for chart compilation. Obtaining data for charting means first defining the required area (by coordinates or interactively from map), scale and contour intervals. The HIS then finds survey areas inside the defined area, analyses overlaps, extracts depths, objects and contours, performs sounding generalization into the desired scale, creates necessary meta-objects from survey areas and saves all data into the DAF format. Alternatively, DXF and ESRI Shape formats are also available but they do not represent S-57 objects, and also do not include meta-objects. Depths and contour output depends on the desired scale or output resolution. Starting from a scale of 1:5000 or depth resolution of 4m, the data are taken from cells instead of depth tables of survey areas. This significantly decreases depth extraction time as data in cells are already prepared into the desired scale. It also makes possible depth extraction from very large areas, even from all Estonia (total area of larger water bodies is around 36,000 km<sup>2</sup>). For example, extracting data in 50m resolution to help populate the Baltic Sea Bathymetric Database ([www.bshc.pro](http://www.bshc.pro)), developed under the umbrella of BSHC and hosted by Swedish Maritime Administration, is done this way. There have been many uses requiring data from large areas in different resolutions, mostly for varying scientific purposes.



**Figure 3:** HIS Selected Areas

Selection of survey areas for chart compilation : red – area borders after topological analysis, blue – coastline, output into DAF format in scale 1:5,000, contour intervals 1m.

- **Public** version is available for the public but currently only for viewing data. Direct downloads from HIS for the public will be allowed. Obtaining data for persons outside EMA is possible by asking HD for data from interested areas. All requests are tracked to know to whom and which data has been prepared. Data are available for free, in all resolutions that HIS supports and in several formats. So far XYZ, DXF and ESRI Shape formats have been mostly used.

The HIS also provides a web map service (WMS). The same data and the same resolutions as on HIS web page are available from this site: <http://195.80.112.238:8080/HIS/WMS?REQUEST=GetCapabilities>

## Technology

The HIS is based on open source technology. HIS consists of the following: PostgreSQL with PostGIS, Apache web server, GMT, GDAL/OGR, Fopen map server. All this runs on a linux server. There are also other linux servers for backups which are done automatically using mostly pgdump and rsync. The HIS has been developed by joint cooperation between EMA and a small Estonian company called R-systems.

## Conclusion

The HIS has for some years been a very valuable tool for many different tasks starting from surveys management and ending with data viewing/extracting for very different purposes. Compilation of sea charts is much easier and less time consuming using HIS as there is no need for dealing with individual surveys. HIS creates a basic chart automatically. The cartographers need only to add additional data and do final compilation.

Processes in the HIS do not consume very much resources, are traceable in all stages and easy to use for both specialists and ordinary persons. The HIS has made dealing with survey data easier for everyone who needs such data.

## **Biography**

***Peeter Väling*** was born in Tallinn, Estonia and graduated from the Tartu University in Geology in 1992. He worked as a marine geologist in the Estonian Geological Survey during 1992 – 1994. Since 1994, Peeter has worked in the Estonian Maritime Administration as a Hydrographer. From 2006 he was the Chief Hydrographer and since 2013 he has been the Head of the Hydrographic Department.

## SWATH HYDROGRAPHIC SURVEY SHIP JAKOB PREI

By Peeter VÄLING

(Head of Hydrographic Department - Estonian Maritime Administration)

### Abstract

This paper describes the SWATH survey ship Jakob Prei and the experiences from the last 2 years of survey activity. The Jakob Prei was built in 2012 by the German shipyard Abeking&Rasmussen (A&R), yard number 6494. The ship's type is SWATH (Small Waterplane Area Twin Hull) and gives very good seagoing capabilities despite its small size. Surveys can be performed with wave heights up to 3 – 3.5m, which means very few days are lost in most conditions.

### Preface

Until 2004, Estonian hydrographers worked only in shallow waters close to the shoreline. However, the HELCOM re-survey scheme demands surveys also in open sea, far from shore and in much deeper waters. There was neither the ship nor survey equipment in possession of the Estonian Maritime Administration (EMA) which could be used for such tasks. Survey equipment could be obtained but the question about the ship remained. As a workaround, a 40 year old buoy-tender EVA-308 was equipped to perform survey tasks. This platform was replaced in 2008 with another buoy-tender Sektori. Both ships were quite big mono-hull steel ships with poor manoeuvrability, low speed and very sensitive to bad weather. If wave heights exceeded 1.5m, both of the ships usually had to stop surveying. This resulted in a large amount of survey time (at least 20-30 %) being lost due to bad weather. Fulfilling the Estonian goals under the HELCOM resurvey scheme was in danger.

### New ship

The idea of building a SWATH type survey ship was considered before 2004. SWATH ships have been known to be stable platforms for different works at sea. Also they can be quite small requiring only a small crew. This led to a project of building a new SWATH survey ship for the EMA. The first design was based on an existing 25m pilot tender built by A&R, but was much bigger – around 33m in length. The ship based on this design was never built because of it being too big and costly. The large size of this design was due to the engine room location in the upper structure of the ship. Therefore, in order to have enough space for accommodation and survey tasks, the ship had to be bigger than the 25m pilot boat.

During 2008, the Administration received good news - first A&R had a new 25m SWATH design, with main and auxiliary engines installed into “pontoons” under the waterline. Second, complete funding of the ship was possible from EU funds.

In October 2009, after a public tender won by A&R, the shipbuilding contract was signed and the ship was delivered to the EMA in April 2012.

## Ship's basic data

The ship had to fulfil these requirements:

1. Unlimited use in sea state 6 with significant wave height of 3.5m;
2. At a sea state of 2m, significant wave height with periods usually met in the Baltic Sea at a speed of 10 to 15 knots in all directions towards the sea, the significant amplitude of both roll and pitch should be less than 4 degrees.

The ship has:

- Aluminium construction with Length 25.65m, width 13m, draft 2.7m, max speed 20 knots.
- Main engines: 2 x 800 kW MAN diesel engines.
- Designed autonomy is 8 days with range of 1550 Nm at a speed of 8 knots.
- Crew is 6 persons (designed for 8), 2 being hydrographers.
- Designed noise levels in wheelhouse and accommodation spaces up to 67 dB(A)
- It has 400V/220V and 24V electrical systems, powered by 2 x 80 kW generators.
- Main engines and generators are installed in "pontoons".
- The ship has all necessary navigational equipment intended for ships of such class and automatic fin stabilizing system for reducing roll and pitch.

Jakob Prei has been built under survey and to the requirements of Germanischer Lloyd.

Some specific features are a MOB lift on the starboard side of the ship, sauna and 6m long container on fore part of the ship. Also VSAT system is installed on the ship for connecting to the internet in areas far from shore. The container contains equipment for taking sound velocity profiles and a winch for side-scan sonar deployment.

## Survey equipment

Jakob Prei is equipped with the following:

- RESON 7125 SV2 multi-beam 200/400 kHz with SVP 70 sound velocity probe and hull mounted transducer
- For multi-beam data collection, Estonian survey software RAN running in linux-based workstation
- Meridata MD DSS 2-8 kHz sub-bottom profiler with hull mounted transducer
- Edgetech 4200 MP side-scan sonar 300/900 kHz with depressor wing, controllable from container, aft part of the ship and wheelhouse
- IXBlue Octans Gyrocompass & motion sensor
- 2 Topcon NET G3A RTK GPS
- Valeport MIDAS sound velocity profiler, controllable from container and connected to survey computer in wheelhouse
- MacArtney Cormac MKI winch for SVP (400 m cable) and MacArtney Cormac MKII winch for side-scan (800 m cable), both installed in container
- All survey equipment except motion sensor, transducers and winches is installed into wheelhouse
- Port side of the wheelhouse is used by hydrographers for performing surveys. Ship's navigation and operating equipment is installed in the starboard side of the wheelhouse. For guiding the ship on survey lines, the helmsman display is installed in front of the steering wheel





*Figure 1: the Jakob Prei*

## Work results

In Estonia, the survey season lasts usually from May to November although in some seasons, April and December are also possible. There are a total of 13 persons in the Hydrographic Department of the Estonian Maritime Administration who are all performing surveys and processing data.

Four survey ships are used - the Jakob Prei, 2x20m catamarans (EVA-320 working at sea and EVA-301 working on inland waters) and a 6m boat EVA-303 working also mostly on inland waters. During mobilisation, 5 persons are working on the ships - 2 on Jakob Prei, 1 on EVA-320, 1 on EVA-301 and 1 on EVA-303. Other staff are processing data if not on vacation. Data processing mainly takes place during winter.

A survey week is from Monday to Friday, 8 hours per day (16 hours on Jakob Prei as there are 2 hydrographers rotating after each 2 hours). During nights, the Jakob Prei usually stays adrift near the survey area and in harbour at weekends. During winter, the ship stays in Tallinn Hundipea Harbour. There are 6 air-bubble making devices installed around the ship to avoid sea ice.

The ship has now worked over 2 survey seasons (2012 and 2013). Surveys have been carried out in HELCOM Cat I and Cat II areas (see <https://helcomresurvey.sjofartsverket.se/helcomresurveysite/>) - being in North-Western and Western sea regions of Estonia. The depth range in this region is usually between 20 and 150m.

The survey speed of the Jakob Prei is usually 11-12 knots. Up to a speed of 12 knots, only half of cylinders of the main engines work. This dramatically reduces fuel consumption. The ship has to stop to take sound velocity profiles but the procedure does not take long as the deployment of the probe is very comfortably done from the container. This also means that bad weather does not make this work unpleasant.

The side-scan sonar cable is guided from a winch in the container over the pulleys on ship's port side and over the crane in the aft. Deployment of the towfish requires a presence in the aft part of the ship. All real work with the side-scan sonar is done from the wheelhouse. Very few days have been lost because of bad weather. Bad weather for the Jakob Prei means wind speeds of 20 m/s and over and waves higher than 3m. It is also difficult to keep the ship on the survey line if sailing in the direction of the waves when wave heights are close to 3m or higher.

**Table 1** is a brief summary of surveys conducted in 2012 and 2013.

Year	Survey period	Survey hours	km <sup>2</sup> covered	km <sup>2</sup> per hour	Days lost due to storm	Fuel consumption during survey period (L/hour)
2012	Jul – Nov	399	1096	2.7	7	110.4
2013	May – Sept	534	1559	2.9	4	110.6

**Table 1:** Summary of 2012 and 2013 survey results

As seen from **Table 1**, the area covered during working hours is quite good. This is mostly due to more than 50m average water depths. In shallow areas, the coverage is much less. For safety reasons, the Jakob Prei usually does not survey in water with depths less than 10m.

Fuel consumption is the total consumption of the main and auxiliary engines and heating system during the survey period and includes the actual survey time, transfers between harbours and survey area and staying during nights and weekends.

As seen from **Table 1**, the Jakob Prei could work only 5 months on both years. The testing period in 2012 (setting up equipment, connecting RESON 7125 to Estonian data collection software etc.) took time and the actual surveys started at the end of July. In 2013, the survey season stopped due to a broken gearbox. The gearbox lasted only 2,000 working hours instead of 30,000 as expected. Unfortunately, the warranty period of the ship was already over and the manufacturer refused to cover any repair costs. This gearbox was considered defective as a secondary shaft usually does not break after so little working time. Repairing the gearbox was very costly to the EMA and 2 months of survey time was lost.

## Conclusions

Despite the above mentioned technical gearbox problem, the Jakob Prei has already proven itself as a very good ship for hydrographic surveys. Its small draught allows visiting most of the bigger harbours in the Estonian shallow archipelago area. The crew is small and fuel consumption low while maintaining quite high survey speeds. It is quiet and comfortable, survey equipment conforms to the highest standards and finally the ship's stability in very bad conditions is truly extraordinary - literally it is possible to sail on 3m waves and keep a full cup of coffee nearby without any spill! Fulfilling Estonian goals defined in the HELCOM resurvey scheme in water depths deeper than 10m is now possible even before the expected deadline.

## Biography

**Peeter Väiling** was born in Tallinn, Estonia and graduated from the Tartu University in Geology in 1992. He worked as a marine geologist in the Estonian Geological Survey during 1992 – 1994. Since 1994, Peeter has worked in the Estonian Maritime Administration as a Hydrographer. From 2006 he was the Chief Hydrographer and since 2013 he has been the Head of the Hydrographic Department.

## MARINE SPATIAL DATA INFRASTRUCTURE IN THE BALTIC

By Peter HARTMANN

(Danish Geodetic Agency and IC-ENC Steering Committee Vice-Chair)

### Abstract

At its 15<sup>th</sup> Conference, the Baltic Sea Hydrographic Commission (BSHC) decided to establish a working group on marine spatial data infrastructure (MSDI) with the task of promoting MSDI in the Baltic Sea region.

The working group's focus is on national coordination of maritime information. Thus far, the group has conducted an in-depth survey of the participating countries' respective approaches to coordinated access to maritime information. The study identifies areas where MSDI implementation is underway and where challenges can be foreseen.

### Baltic Sea Marine Spatial Data Infrastructure Working Group (BSMSDIWG)

#### Background

At a time when the EU INSPIRE Directive (EU, 2009) is fully in its implementation phase across the European countries, and spatial data infrastructures (SDIs) are being developed worldwide at the national, regional and local levels, coordinated access to and management of geographic information has become standard. The IHO's Marine Spatial Data Infrastructure Working Group has published *C-17 - Spatial Data Infrastructures: The Marine Dimension - Guidance for Hydrographic Offices*, which outlines the benefits of developing SDIs to reinforce coordination among maritime authorities (IHO, 2011). However, as the C-17 publication identifies, the integration of maritime data in SDIs has been limited at best, though there can be as many benefits to be gained by coordinated access to maritime information as to terrestrial data.

As coordinated maritime spatial planning also gains increased focus at the EU level, not least through the Integrated Maritime Strategy and the Marine Strategy Framework, the needs for better integration of maritime data are becoming increasingly evident. In Denmark, discussion has begun on the degree to which the maritime-oriented elements of the INSPIRE Directive can be implemented at an accelerated rate. Similar initiatives are expected to be underway across the Baltic Sea region.

In the future, we expect a growing demand for better coordination of the management of maritime information. While a national single window will aid in the reporting process among maritime stakeholders, the flow of information among the authorities is also a critical factor in ensuring the effective and efficient coordination of their work.

An MSDI ensures that relevant maritime authorities are able to contribute their spatial information and related updates in a way that they can be collated with other information to generate and maintain a current operational picture. The infrastructure is expected to support such applications as coastal zone management, planning of energy production at sea, fishery management, marine environmental protection and nature conservation, planning charts, navigation, civil and military preparedness, tourism, and future maritime spatial planning.

## **IHO Recommendations**

The 18<sup>th</sup> International Hydrographic Conference (IHO, 2012) confirmed the importance of marine spatial data infrastructure (MSDI) activities for the IHO and its Member States as established at the 4<sup>th</sup> EIHC (IHO, 2009).

MSDI delivers the instruments for the enhanced scope of hydrographic information users. MSDI can create the framework for future provision of this information beyond the classic field of surface navigation. From an HO perspective, it is important that the IHO takes the lead in addressing MSDI matters for the maritime sphere through its MS; the MSDIWG is seen as an appropriate WG to deal with these opportunities, and the regional hydrographic commissions can be a platform for addressing regional MSDI issues through knowledge sharing, identification of best practice and pilot studies for exploring potential approaches to implementation.

In this context, and in order to promote an increased awareness of maritime spatial data infrastructure both within the Baltic Sea region and at the larger European scale, the BSHC launched its MSDI working group.

## **Responsibilities and activities of the working group**

The remit of the Baltic Sea MSDI working group is to study how its members currently coordinate their national maritime information in order to identify areas where maritime SDI implementation is underway and where challenges can be foreseen. The study will result in a final report to the BSHC. This report is expected to include recommendations on how to proceed with MSDI implementation and an action plan with a specified time schedule for future MSDI actions in the region. The general activities and focus in the working group are further described below.

- Identify and analyse the current status of individual MS MSDI implementation.
- Consider MSDI policies within the related international project e.g. e-navigation, ICZM, INSPIRE, EU Integrated Maritime Strategy, the Marine Strategy Framework and EU Strategy for the Baltic Sea Region.
- Analyse how maritime authorities can contribute their spatial information and the necessary updates, so information can easily be collated with other information to a current overall picture for the region.
- Focus on how BSHC in the future can benefit from a regional approach.
- Monitor the development of SDI that could be relevant for the Baltic Sea.

## **First working group meeting – 2012**

The work group launched its work with a workshop in Copenhagen in September 2012.

The first day of the workshop was intended to be a general presentation of the key elements of SDI, MSDI and INSPIRE. The second day of the workshop focused on the current status of the member countries' MSDI and INSPIRE implementation. This assisted the working group members in addressing the level at which BSHC can benefit from a regional approach to MSDI in the future. Each participating country had the opportunity to give a short presentation on its national MSDI and INSPIRE implementation.

At the workshop, the working group also focused on future initiatives and the most important issues and challenges for future development of MSDI (from national and regional perspective). These were considered to be:

- Lack of awareness of MSDI's importance (and its linkages to INSPIRE) among potential MSDI stakeholders

- Lack of geo-related competence among potential users of an MSDI
- Determining what stakeholders there are for MSDI and assessing their requirements related to MSDI
- Producing adequate governance and agreements for MSDI development
- Lack of funding and human resources necessary for qualified MSDI development
- Finding consensus about which data should be fundamental to MSDI
- Organising and streamlining data sources between the contributors to an MSDI
- Lack of a clear strategy
- Ensuring existing initiatives aren't duplicated
- Where to get started?!

## Second working group meeting – 2013

The 2<sup>nd</sup> meeting of the BSHCMSDIWG took place in Copenhagen in 2013. The overall aim of the meeting was to create a common MSDI framework for the Baltic in order to establish an MSDI work plan for the Baltic Sea that focuses on how the BSHC can benefit from a regional approach to MSDI.

The meeting was conducted in two phases. The first included a general presentation from the IHO MSDIWG, national presentations from members on status of SDI, MSDI and INSPIRE implementation and a presentation of the proposal for a directive of the European Parliament and of the Council on establishing a framework for maritime spatial planning and integrated coastal management. The second phase of the meeting focused on a questionnaire on national use of marine data, the response from MSHC18 about MSDI and the creation of a draft work plan.

The resulting work plan focuses on MSDI-related tasks that are seen to be important and challenging from a regional and a national perspective. It includes seven work items, each of which includes relevant milestones. These are listed below.

Task	Work item	Milestones
1	Hydrographic data and legal aspects	<ul style="list-style-type: none"> <li>- Study and definition on hydrographic data under the respect of INSPIRE and MSP.</li> <li>- Definition of HO role in MSDI</li> <li>- Paper on BSHC MS contribute with relation to MSDI</li> <li>- Study on different laws with relevance to MSDI in the Baltic countries</li> </ul>
2	Liaison with external projects	<ul style="list-style-type: none"> <li>- Establish a list of MSDI relevant projects</li> <li>- Scanning of projects relevant for BSMSDI</li> <li>- Establish a matrix with relevant projects</li> </ul>
3	S-100	<ul style="list-style-type: none"> <li>- Conduct a study on S-100</li> <li>- Evaluate on how to promote S-100 in the Baltic</li> <li>- Prepare paper to HSSC through BSHC</li> <li>- Evaluate the need for a pilot project</li> </ul>
4	INSPIRE	<ul style="list-style-type: none"> <li>- Study on IHO standard S-57 in relation to INSPIRE</li> <li>- Study on legal binding compared to INSPIRE</li> <li>- The difference between S-57 and S-100</li> </ul>
5	MSP and IZM	<ul style="list-style-type: none"> <li>- Conduct a study on national approach to MSP</li> <li>- Prepare paper to HSSC through BSHC if needed</li> <li>- Evaluate the need for a pilot project</li> </ul>
6	Common understanding	<ul style="list-style-type: none"> <li>- Establish a framework for common understanding of MSDI</li> </ul>
7	Technical solutions in the Baltic	<ul style="list-style-type: none"> <li>- Study on the possibility to establish a BSHC metadata base</li> <li>- Study on MSDI impact on E-navigation and how MSDI can contribute to the implementation of E-navigation</li> <li>- Establish use cases e.g. MSP, SAR, Environmental protection</li> <li>- Evaluate the need for updating BS MSDIWG ToR</li> </ul>

The next meeting of the BSMSDIWG is planned to take place in the second half of 2014 in Germany.

## **Maritime spatial planning and integrated coastal management**

The EU has recently published a proposal for a directive on establishing a framework for improved and effective maritime spatial planning in EU waters and integrated coastal management in the coastal areas of Member States. The main purpose of the proposed directive is to promote the sustainable growth of maritime and coastal activities and the sustainable use of coastal and marine resources.

The increasing and uncoordinated use of coastal and maritime areas results in competition for maritime and coastal space and inefficient and unsustainable use of marine and coastal resources. Uncertainties and lack of predictability on appropriate access to the maritime space has created a suboptimal business climate for investors, with potential job losses.

The proposal establishes a framework for maritime spatial planning and integrated coastal management in the form of a systematic, coordinated, inclusive and trans-boundary approach to integrated maritime governance. It obliges Member States to carry out maritime spatial planning and integrated coastal management in accordance with national and international law. The aim of the action is for Member States to establish a process or processes that cover the full cycle of problem identification, information collection, planning, decision-making, management, monitoring of implementation, and stakeholder participation.

The maritime spatial plans and integrated coastal management strategies will not set new sectorial policy targets. They have the purpose to reflect, integrate and link the objectives defined by national or regional sectorial policies, to identify steps to prevent or alleviate conflicts between different sectors and to contribute to the achievement of the Union's objectives in marine and coastal related sectorial policies. Most importantly, the proposal requires Member State action to aim for coherence of management across sea basins, through trans-boundary cooperation in the same marine region or sub-region and related coastal zone and appropriate data collection and exchange.

Implementing acts will ensure consistent implementation of the Directive throughout the EU and facilitate reporting from the Member States to the Commission and, where relevant, the exchange of data between Member States and with the Commission. Article 10 in the proposed directive especially focuses on data collection and exchange of information. Article 12 and 13 describe Cooperation with other Member States and third countries.

## **Discussion**

There are growing needs for better coordination of individual authorities' management of maritime information. While a national single window can aid in the reporting process among maritime stakeholders, information flow among the authorities is also a critical factor for ensuring the effective and efficient coordination of their work.

An MSDI ensures that relevant maritime authorities can contribute their spatial information and related updates, and that this information can easily be collated with other information to generate a current operational picture. As a result, MSDI can support such varied activities as coastal zone management planning of energy production at sea, fishing, marine environmental protection and nature conservation, planning charts, navigation, civil and military preparedness, tourism, and maritime spatial planning.

From a more practical approach, there is a need to focus on and strengthen the maritime approach to MSDI and to insure that maritime information is included. Some of the challenges for BSHC MS in relation to MSDI reside in the needs to:

- Ensuring that Baltic HOs have the possibility to contribute to the development of the Baltic MSDI

- Ensuring the use of data/information provided by Baltic Sea HOs
- Ensuring that the Baltic Sea HOs have the possibility to contribute in creation of an Baltic MSDI reference model - A reference model that represents the component parts of any consistent idea, from business functions to system components
- Rules and rights in relation to the use of vector data between countries
- Establishing a structure to support the Baltic SDI
- Continuous updating of relevant data
- Clarify the financial aspect.

As seen from an HO perspective, the MS now have a direct possibility to actively participate in the development of a well-functioning MSDI within the hydrographic domain and its surroundings. This will generate the possibility to benefit from a national and a regional approach.

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- EU (2009) EU INSPIRE Directive and respective national contributions of the MS, <http://inspire.ec.europa.eu/>

## Biographies

**Mr Jens Peter Hartmann** is Senior Advisor at the Danish Geodata Agency which also contains the Danish Hydrographic Office. He is the agency's primary contact and coordinator for marine activities and involved in the implementation of a Danish Marine Spatial Data Infrastructure and Marine Spatial Planning. He is Chairman of the IHO Marine Spatial Data Infrastructure Working Group (MSDIWG) and Chairman of the Baltic Sea Marine Spatial Data Infrastructure Working Group (BSMSDIWG) under the Baltic Sea Hydrographic Commission.

He has previously been the Head of the Danish Hydrographic Office and served as Head of the Maritime Inspectorate at the Danish Maritime Administration. Jens Peter has also served as chairman for a working group under the Baltic Sea Hydrographic Commission that addresses the harmonisation of ENC's in the Baltic region and as an external lecturer at the Copenhagen Business School. Jens Peter is educated as a naval officer in the Royal Danish Navy and has worked as a master mariner in the commercial fleet and as a commercial pilot. Jens Peter holds degrees in organisation and strategy from Copenhagen Business School. ([jepha@gst.dk](mailto:jepha@gst.dk))

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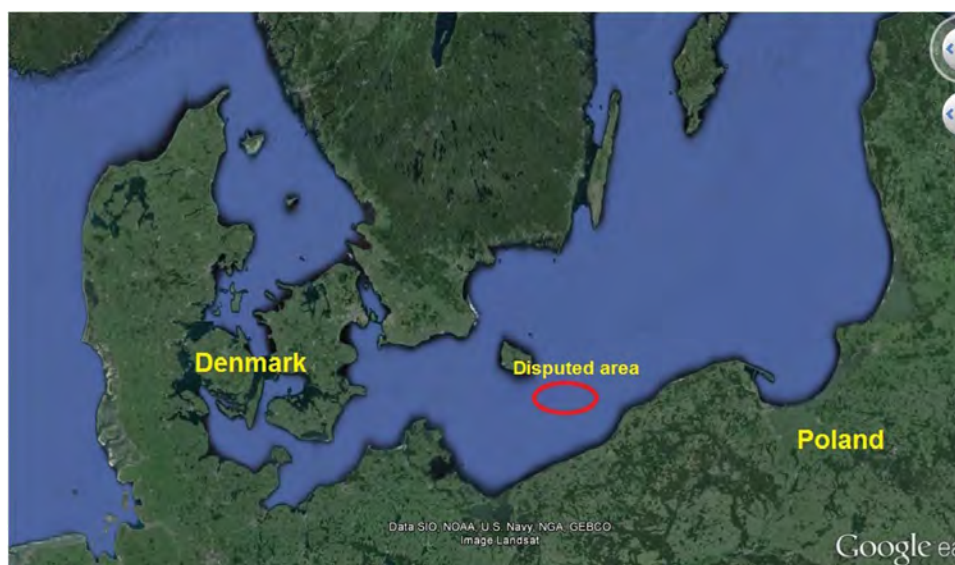


## HYDROGRAPHIC SURVEYS IN DISPUTED AREAS

By Commander Lars HANSEN (Danish Geodetic Agency)  
and Captain Andrzej KOWALSKI (Hydrographic Office, Polish Navy)

### Abstract

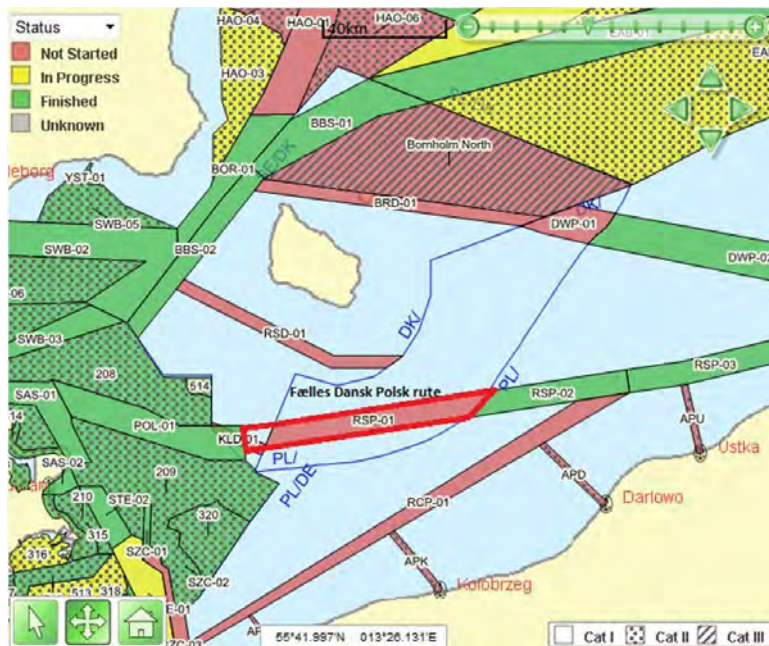
In 2011, during the 16<sup>th</sup> Baltic Sea Hydrographic Commission (BSHC) Conference in Norrköping (Sweden), Poland submitted for discussion and consideration the problem of surveying tasks in sea areas claimed by more than one coastal state. An example of this problem still exists between the Danish Bornholm Island and the Polish Coast in the Baltic Sea (see **Figure 1**). The Polish delegation presented the opinion that procedures for hydrographic surveys and general hydrographic tasks, done in disputed areas, should be worked out. In spite of the fact that Hydrographic Services have not been established to resolve disputes of any kind, which are in the domain of diplomacy, the Services (both Polish and Danish in this respect) remain responsible for surveying such areas. However, how can this responsibility be fulfilled when there are no procedures explicitly regulating particular hydrographic activities in these areas? If such circumstances sustain, sooner rather than later, the safety of navigation will suffer. The mentioned Zone is a result of the unsettled dispute between Poland and Denmark over limits of Exclusive Economic Zones (EEZ).



**Figure 1:** Disputed sea area between Denmark and Poland

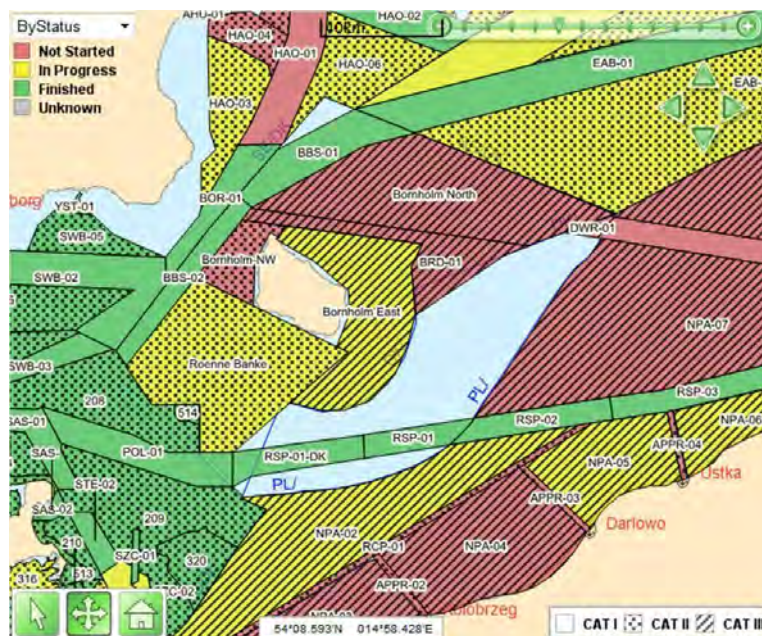
Both Polish and Danish Hydrographic Services are obliged to survey areas where the limits have been established by their respective national authorities. In the case of this particular Zone and unacceptable to each neighboring state, no rules apply. Even with no clear-cut limits, when it comes to paper charts, no problem exists as they not only cover national waters, but frequently waters of neighboring states as well. However, it is not the same when it comes to ENCs, surveys which collect data to update ENCs, or to Navigational Warnings Service. This situation becomes a matter of serious concern, since each state is responsible for its own area. Furthermore, this Conference agenda item was the result of concerns raised by the Hydrographic Office of the Polish Navy some years ago - how sea areas, claimed by coastal states, should be portrayed on paper charts because they have no relevant symbol in the S-4 Publication of the International Hydrographic Organization (IHO).

Due to the cooperation of both national Hydrographic Offices, this problem was solved last year when all the surveys, required to complete HELCOM routes, passing the disputed area, were completed (see **Figure 2**).



**Figure 2:** Planned sea route through disputed area (Source: HELCOM-BSHC Re-survey Database)

As a result of “hydrographic talks”, Denmark and Poland agreed to conduct a common survey of the route passing through the disputed area. Through diplomacy, a correct decision was reached in accordance with safety of navigation rules. They proposed that the best solution was to cut the disputed area into two parts, then survey and finally exchange the data (see **Figure 3**). The common understanding is that the survey effort bears no prejudice to any of the nations with regards to any future claims of the area.



**Figure 3:** Final result of the common surveys. (Source: HELCOM-BSHC Re-survey Database)

This serves as a positive example of cooperation between Hydrographic Services, to solve a practical problem in an effective and successful way, thereby avoiding unnecessary problems for shipping in the area in the future.

## Biographies

**Commander Lars Hansen** is the head of the Hydrographic Service in the Royal Danish Navy. His main field of expertise is shallow water and arctic bathymetry. Lars is currently posted at the Danish Geodata Agency, which is the agency responsible for charting in the Kingdom of Denmark. He has a broad practical experience as a Hydrographic surveyor and naval officer. His office is responsible for the planning and conduct of hydrographic surveys in Denmark and Greenland. Lars has been involved in IHO work since 2004. In this role he serves as an adviser to the National Hydrographer of Denmark and has participated in a number of working groups at the regional level. As a member of four regional Hydrographic commissions, Lars has a broad knowledge of what is going on in his region.

**Captain (PN) Andrzej Kowalski** is the National Hydrographer as the Chief of the Hydrographic Office of the Polish Navy since January 2014. During his naval career he served as Chief of Sea Training of the Polish Navy, Chief of Training and Deputy Commanding Officer of the 8th Coastal Defence Flotilla, Commanding Officer of the Hydrographic Squadron and Chief of Nautical Department and Deputy Chief of HOPN. He has participated in many national and international forums, representing the Polish Hydrographic Service in IHO, IMO and NATO Working Groups as well. He is decorated with numerous military and civilian medals.

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## HARMONISATION OF VERTICAL REFERENCES ON THE BALTIC SEA

By Jyrki MONONEN (Hydrographic Office, Finnish Transport Agency)

### Abstract

Because there is no common vertical reference system for hydrographic or navigational tasks in the Baltic Sea, the Baltic Sea Hydrographic Commission (BSHC) considers this issue to be important to harmonise chart datums in the Baltic Sea. The BSHC Chart Datum Working Group (CDWG) has studied the needs and possibilities to move to a harmonised vertical reference system and evaluated alternatives for it. The European Vertical Reference System (EVRS), has been approved by the BSHC as a harmonised vertical reference system for the Baltic Sea. At the same time, the CDWG has proposed to the International Hydrographic Organization's (IHO) Tidal and Water Level Working Group (TWLWG) to revise the IHO resolution on vertical datums to better reflect the non-tidal and inland waters (IHO Resolution 3/1919 as amended).

The CDWG has developed a roadmap for the transition to the EVRS based harmonised reference system and this has been approved by the BSHC. The goal is to establish the harmonised vertical reference system in use in the year 2020. To make the transition successful, all relevant stakeholders within the Baltic Sea region have to become informed and committed to support the work. To assist this process, the CDWG is also establishing closer co-operation with the Baltic Sea Oceanographic Observation System (BOOS).

### Chart Datum Working Group (CDWG)

In 2005, the BSHC establish the CDWG to study and foster the harmonization of vertical reference systems. CDWG members include representatives from all Baltic Sea Hydrographic Offices, permanent representatives and observers from national geodetic and oceanographic organizations and BOOS.

The CDWG reports to BSHC which also approves the Terms of References and Work Plan of the CDWG. The CDWG has annual meetings for decision making, follow up and to review the current situation concerning harmonisation of vertical references. The CDWG can also prepare questionnaires to the members to study and clarify relevant issues.

### Selection of the harmonised vertical reference system

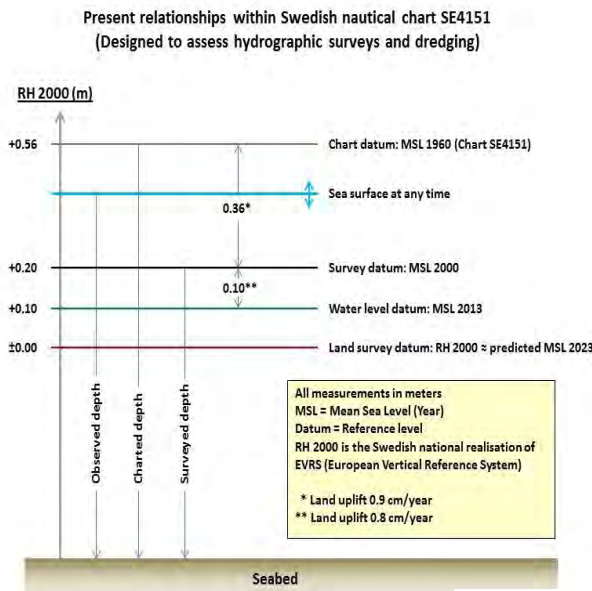
As there is no common vertical reference system for hydrographic or navigational tasks in the Baltic Sea, BSHC has identified the importance to harmonize chart datums in the Baltic Sea. In harmonising the vertical reference system, there will be one common chart datum for the whole area. This provides numerous advantages for mariners, national hydrographic offices and other organisations using bathymetric data. It also allows the future capabilities of the new S-100 based products and water level data.

Today, countries have their own national systems differing from each other. Systems are based principally on mean sea level (MSL), but national realizations of MSL are different. This situation is inconvenient for navigators, for data transfer between Hydrographic Offices and for other users of depth and water level data. There are also some other reasons why MSL is no longer a feasible chart datum. One reason is the postglacial rebound which

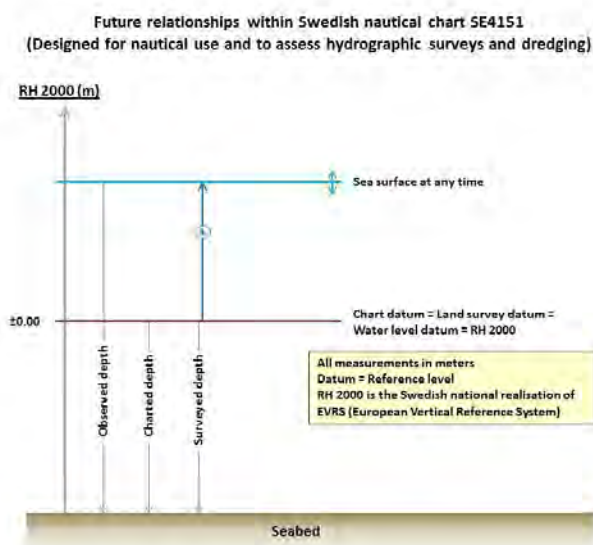
changes the depths around 7-9 mm in a year in the Bay of Bothnia. Another reason is that the prediction of MSL has become difficult because of different climatic phenomena.

**Figure 1a** illustrates the present complex situation with different MSL-based chart datums. In MSL-based vertical reference systems, it has to be taken into account several different vertical reference levels related to MSL of different years. The surveyor and chart-maker need to be aware of the year of MSL used as the chart datum for a chart. Also they have to be aware of the survey datum where 0-level might be different than the MSL of the chart. Also the datum, in which the apparent height of the sea surface is provided, can be different than survey datum. In particular, the navigator, has also to be aware of the differences of chart datum and the datum, in which the apparent height of the sea surface is provided. This also applies to fairway planning and construction.

**Figure 1b** illustrates the clear situation after the EVRS based harmonized vertical reference system has been adopted. For all the navigational and hydrographic purposes there will be one reference level and also the apparent height of the sea surface will be referenced to it. Thus users have to be aware of only one reference level and water level changes can be simply and safely reduced to the correct chart datum.



**Figure 1a.** Illustration of present situation with several MSL based vertical references. Example is based on Swedish nautical chart SE4151 by Lars Jakobsson, Swedish Maritime Administration (2013).



**Figure 1b.** Illustration of future situation after EVRS based harmonised vertical reference has been taken into use. Example is based on Swedish nautical chart SE4151 by Lars Jakobsson, Swedish Maritime Administration (2013).

The CDWG studied the feasibility of the European Vertical Reference System (EVRS) as a principal alternative for a harmonised vertical reference system for Baltic Sea nautical charts. At the same time, the CDWG also studied possible time schedules and the necessary preconditions for each Baltic Sea country to adopt the harmonized datum on their nautical charts. Based on these studies, the CDWG proposed the EVRS as a harmonised vertical reference system to be approved by BSHC.

BSHC accepted the EVRS as a harmonized vertical reference system for the Baltic Sea and there is good commitment among the Baltic Sea countries to adopt this harmonized datum.

There are numerous benefits which can be achieved with a well-defined, international EVRS-based harmonized vertical reference system. All the depth and water level information can be provided in the same datum for the whole Baltic Sea. At the same time, confusion between different chart datums can be eliminated. Data transfer between national Hydrographic Offices and other organisations will become easier and safer. The EVRS is also a common European vertical reference system to which many national height systems are based. Hence, depths on sea and heights on land can be referenced to the same vertical reference system.

### **Transition to the harmonised vertical reference system**

Implementation is a long process and is estimated to be completed by the year 2020. There are several issues to be solved before all nautical information will be referred to the harmonised vertical reference system. The change to the EVRS-based reference system has practically no effect in the southern parts of the Baltic Sea, but in the northern parts it can have around 15 – 20 cm effect on depths. Thus it is important to analyse nationally the present situation to be able to make decisions such as the scope of the transition, technical and legislation issues, data transformation methods, water level information and publication of products. Also, it is important to inform users of navigational data about the change and how it affects them practically.

There are many national and international issues to take into account. To make the process successful and efficient, one of the key issues is to get all relevant national and international bodies to communicate and cooperate together. The CDWG supports the communication and cooperation e.g. by being a forum for all BSHC member countries and other relevant bodies.

One of the most important issues to remember is that the mariner needs the charted depths and broadcasted water level information in the same reference system. To provide all the information safely and reliably to the users during the transition period, it is essential to have good cooperation and communication between different organisations such as the national Hydrographic Offices, geodetic and oceanographic organizations (e.g. BOOS), mariners and other users of depths and water level data both in a national and international context.

The CDWG will guide and follow-up the implementation process of the harmonized vertical reference system by preparing a roadmap time line (**Figure 2**) and monitoring the progress of the implementation process. Recommendations and guidelines on how the transition period could be implemented will be developed and if required, harmonisation actions will be proposed to be approved by BSHC.

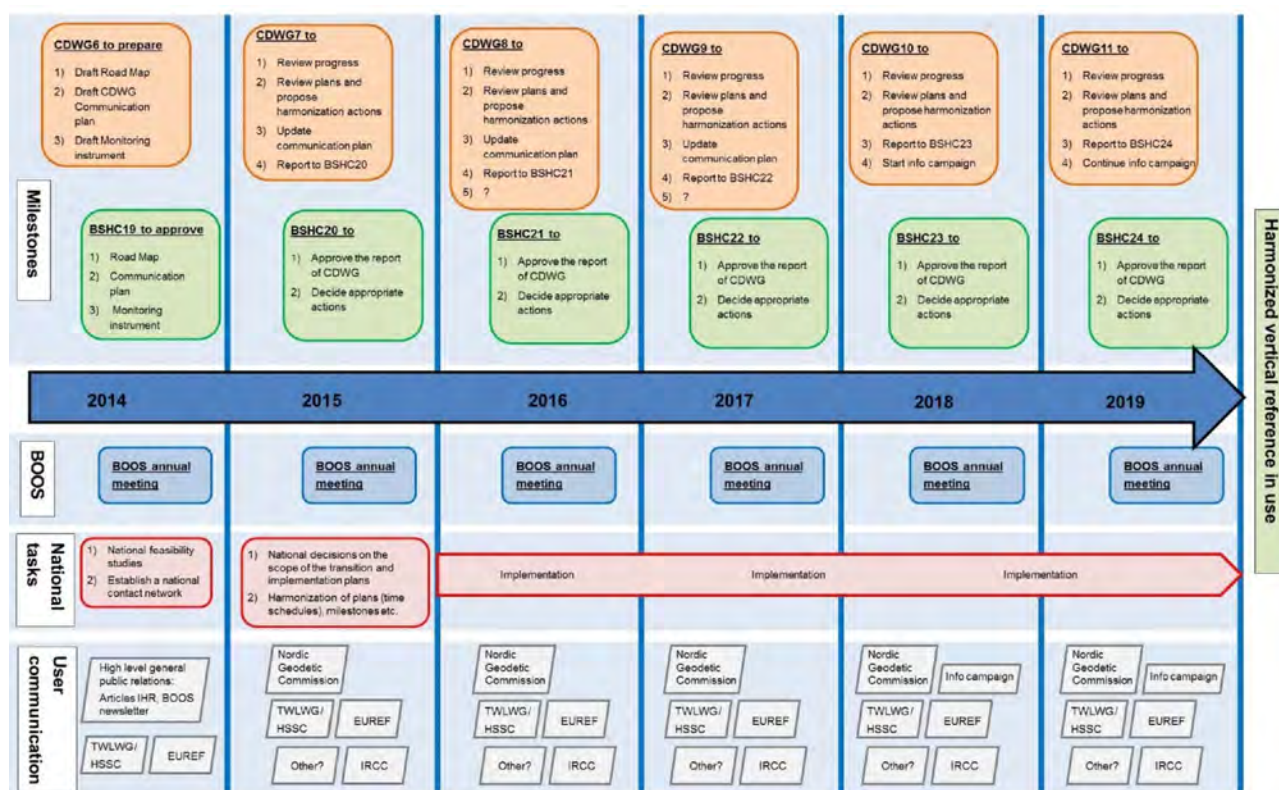


Figure 2. Time line for the transition period including draft plan for international communication.

## Discussion

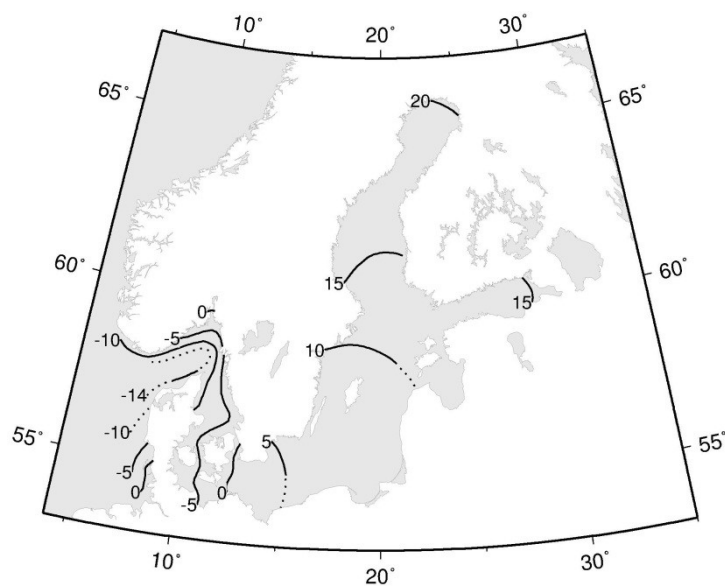
A harmonized vertical reference system enhances wider and easier use of the data in accordance with the INSPIRE directive and enables the full utilization of future enhanced navigation systems based on IHO S-100 standards.

The benefit for adopting the EVRS, is that it is a common European vertical reference system to which many national height systems are based on. Thus depths on sea and heights on land will be referenced to the same vertical reference system. The common levelling network around the Baltic Sea, Baltic Levelling Ring (BLR), computed and adjusted in 2006, provides the possibility to tie all mareographs to this common datum.

In the future navigation realm, i.e. the 3D-navigation can utilise ellipsoidal heights and accurate geoid models. Related to the harmonisation of a vertical reference, the CDWG will also study other water level related issues, e.g. possibilities to develop a common geoid model for the Baltic Sea and foster studies related to dynamic topography of sea surface in the Baltic Sea.

It is also important to understand the dynamic topography of the sea surface and how to predict water level changes to meet the future needs for more efficient and safer shipping. Figure 3 illustrates the Mean Sea Surface Topography. Improved water level information will enable shipping to improve its cargo carrying capacity whilst maintaining safer under keel clearances.





**Figure 3.** Mean Sea Surface Topography (Mean Dynamic Topography, MDT) from tide gauges and levelling, in centimeters at epoch 1960. Zero is NAP, which is the same for the EVRS. Replotted from Ekman & Mäkinen (1996), courtesy of J. Mäkinen.

## Reference

Ekman M. and J. Mäkinen, (1996) Mean sea surface topography in the Baltic Sea and its transition area to the North Sea: A geodetic solution and comparisons with oceanographic models. *Journal of Geophysical Research: Oceans* (1978-2012), Vol. 101, Issue C5, 15 May 1996, pages 11993-11999.

## Biography

**Jyrki Mononen** has been working at the Finnish Hydrographic Office since 2006. He has been involved in acquiring hydrographic surveys, chart datum definitions and being responsible for the Finnish HO's quality management system. Since 2013, he has been acting as the chairman of the BSHC CDWG. He has a MSc in land surveying from the Technical University of Helsinki in 1995.

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## BALTIC SEA INT CHART SCHEME

By Jarmo MÄKINEN (Finnish Transport Agency)



### Abstract

The Baltic Sea Hydrographic Commission (BSHC) recognizes the need to actively develop and maintain official nautical charts, in both paper and digital formats. This supports ships engaged on international voyages in the Baltic Sea region. Accordingly, it appoints and directs a working group to undertake this task. The working group is named the Baltic Sea International Charting Coordination Working Group (BSICCWG).

The Baltic Sea INT Charting Coordination Working Group (BSICCWG) and its main activities in maintaining the Baltic Sea INT Scheme will be described in this note. In recent years the working group's original function to coordinate the paper chart scheme in the Baltic Sea, has been expanded to digital products, especially the ENC.

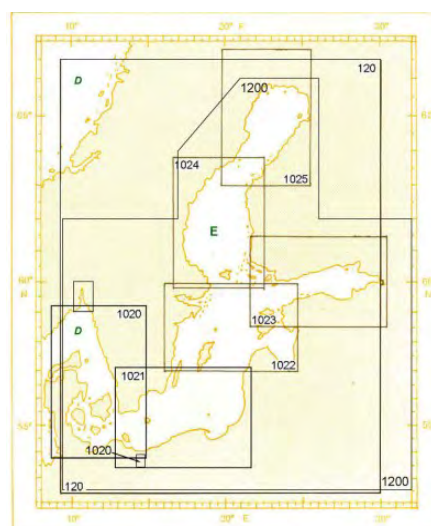
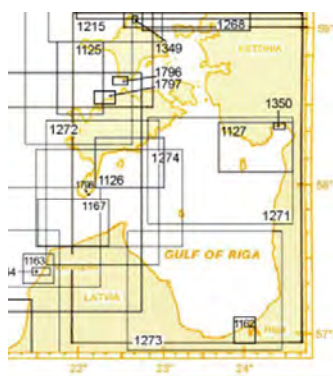
### Baltic Sea International Charting Coordination Working Group (BSICCWG)

#### Background

The Baltic Sea Hydrographic Commission had its first meeting in Helsinki in 1983. In that meeting it was proposed that International charts covering the Baltic Sea, should be produced and that a working group to coordinate this purpose should be established. This was based on decision 26 of the International Hydrographic Conference (IHC) in 1982.

The Baltic Sea International Chart Committee (BSICC) was established to prepare an integrated INT Chart Scheme (medium scale) of the Baltic Sea (see Figures 1 and 2). The Chairman of BSICC has to report to the Baltic Sea Commission. In earlier years, it was the responsibility of all member states to report development of international charting. The first chair was from the Soviet Union (1983), followed by Denmark (1985), GDR (1988), Denmark (1999) and the current chair being Finland since 2007.

**Figure 2.** Example of Baltic Sea large scale INT paper chart index



**Figure 1.** Baltic Sea medium scale INT paper charts

Today, all BSHC Members actively participate in the newly named Baltic Sea International Chart Coordinating Working Group (BSICCWG). The BSICCWG is a subsidiary body of the BSHC. It shall conduct its work in accordance with the IHO general Terms of Reference and the Rules of Procedure for Regional Charting Coordination Working Groups.

### **Tasks of the BSICCWG working group:**

- To study issues related to nautical charting of the region, in particular to coordinate the allocation of production responsibilities for paper and electronic charts (INT charts and ENC), that support ships engaged on international voyages.
- To develop and maintain an integrated international chart scheme for the region.
- To reach decisions on the maintenance and updating of the documents for which it is responsible.
- To provide advice on chart schemes to individual Member States, in order to encourage adherence to IHO charting regulations, specifications and standards, and to promote and coordinate the production of international (INT) charts and ENC.
- To develop proposals for new or amended INT chart schemes to meet evolving user needs, for example, the introduction of new or amended routing measures and the confirmed developments of international ports.
- To report yearly to the BSHC on the status of the implementation of ENC harmonisation actions agreed by the former BSEHWG. The reporting has been tasked to BSICCWG in 2010.
- To act as the custodian and maintainer of official, version-controlled catalogues, depicting the status of published and planned charts, subject to formal review and approval by Member States of the Baltic Sea Hydrographic Commission. However, the ENC catalogues may be maintained by RENCs subject to Baltic Sea Hydrographic Commission's approval.
- To provide advice to IHB on any amendments required to maintain S-11 Part B: Catalogue of International Charts, for example, scale, limits, numbering and, as appropriate, any corresponding ENC catalogue.
- To provide advice to the Chairman of CSPCWG and IHB on any amendments required to maintain S-11 Part A '*Guidance for the Preparation and Maintenance of International Chart Schemes*', in particular its Annexes.
- To provide advice to the chairman of the CSPCWG and IHB on any amendments required to maintain the '*Guidelines for the Preparation and Maintenance of Small / Medium Scale ENC Schemes*', when published.

The Coordinator/Chairman will report the status and progress of the working group's work to the Baltic Sea Hydrographic Commission. Normally the report includes e.g. an updated Regional INT Chart Catalogue (S-11, Part B), changes made to the scheme of INT Charts, status of ENC harmonization recommendations since the last meeting and status of other tasks given by BSHC.

The Coordinator collects all the updates of S-11, Part B (Baltic Sea) from member states and will forward these to IHB once a year.

The BSICCWG work shall be done in accordance with:

- IHO Resolution 1/1997 as amended [K2.19]: 'Principles of the Worldwide Electronic Navigational Chart Database (WEND)', to ensure a world-wide consistent level of high-quality, updated ENC's;
- S-57: 'IHO Transfer Standard for Digital Hydrographic Data';
- S-??: 'Guidelines for the Preparation and Maintenance of Small / Medium Scale ENC Schemes' (when published);
- S-11 Part A: 'Guidance for the Preparation and Maintenance of International Chart Schemes';
- S-4: 'Chart Specifications of the IHO and Regulations for International (INT) Charts', which provides the internationally-agreed product specification for both national and international (INT) charts.

## Meetings

The BSICC Working Group worked for many years primarily through correspondence. The latter part of the 1990s was not a very active period, due to the INT-paper chart scheme being quite stable. Since the early 2000s, large scale INT chart coverage in particular has expanded significantly from the original plan. The new tasks related to ENC's, have made the working group very active once again.

The historic, first BSICCWG meeting was held in Norrköping, Sweden, in June 2011. The main issues were:

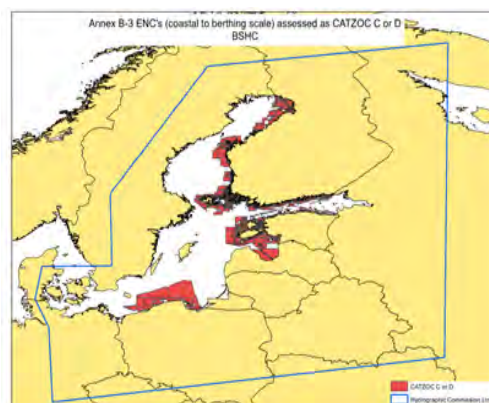
- review of the new TORs and ROPs for BSICCWG;
- changes of production nations;
- proposed new INT numbers;
- updates to S-11;
- principals of naming charts and sea areas;
- development of an INT Chart Catalogue database;
- status of the harmonization of ENC.

The second, very active meeting was held in Helsinki, Finland, in April 2014 (see **Figure 3**). Eleven energetic members took part in the meeting, with Germany participating by video link. It was an honour in having the Chairman of the North Sea ENC Harmonization WG to be an observer in the meeting. Additional issues on the meeting agenda were well illustrated by its Working Group:

- Guidance for using names on INT chart titles;
- Review of the Baltic Sea ENC harmonization recommendations;
- Report from WEND WG;
- Status of gaps and overlaps in Baltic Sea, use of CATZOC (from WENDWG) (see **Figure 4**);
- IHO ENC schemes;
- The possible use of 5 digit INT chart numbers;
- Additional 15m depth contours on ENC's;
- Analysis of depth contour intervals in use (see **Figure 5**);
- Need to change the INT Scheme in the Baltic Sea.



**Figure 3.** BSICCWG Meeting in Helsinki 2014 with video connection to Rostock.



**Figure 4.** Example of WENDWG findings in use of CATZOC in 2013

Depth Contours	0	2	3	4	5	6	10	15	17	20	30	40	50	100	150	200
Denmark		X		X		X	X		(X)	X	X	X	X	X		
Estonia		X			X		X			X			X	X		X
Finland			X			X	X	(X)		X			X	X		X
Germany	X	X	(X)		X	(X)	X		(X)	X	X	X	X	X		X
Latvia		X			X		X	(X)		X			X	X	(X)	X
Lithuania					X		X	X		X	X		X	X		
Poland		X			X		X	X		X			X	X		
Russia		X			X		X	X		X			X	X		
Sweden			X			X	X	X		X		(X)	X	X		X

**Figure 5.** Depth contour intervals in use in Baltic Sea Hydrographic Offices (Yellow columns are recommended in IHO S-4).

## Future work

### The Baltic Sea INT Chart Scheme

The BSICCWG has the responsibility to maintain the INT scheme and the key issues are:

- maintaining production and printer nations;
- updating chart data;
- updating printing schedules;
- allocating new INT numbers.

During the April 2014 meeting, the BSICCWG noted that there are revisions required to the Baltic Sea INT Chart Scheme. Some local proposals have been prepared and this on-going work will be coordinated by the Chair during the next year.

### Development of the Baltic Sea ENC Harmonization Recommendations

It was also noted in the same meeting, that there is a need to revise and update the Baltic Sea ENC harmonization recommendations. For example, the use of CATZOC, depth presentation, eliminating gaps and overlays will be analysed. The meeting established a drafting group to analyse the current 2008 ENC harmonization recommendations. This correspondence draft group, being led by Latvia, will report to the next BSICCWG meeting, planned to be held in April 2015.

There is a separate Note on ENC harmonization in this IHR edition.

## Discussion

As first working group of the BSHC, the BSICCWG has several new tasks to be addressed and provides experienced and active members with new challenges and possibilities. Maintaining the Baltic INT Chart Scheme is still a valid task, especially when there is a need to revise the Baltic Sea INT Scheme in many areas. The development of the IHO GIS database, including INT chart Schemes, is seen as a crucial aid for that work.

Cooperation between neighbouring Chart Coordinating Groups should be increased. For example, cooperation in ENC harmonization actions between the working groups and other RHCs could be closer. The plans for developing a IHO RENC/WENC concept means the possible expansion of tasks for International Chart Coordination Groups.

## Biography

**Mr Jarmo Mäkinen** has worked at the Finnish Hydrographic Office since 1988. He has been involved with various tasks in the hydrographic field. He has many years of competence in leading chart production and experience in working with international working groups and with private chart producers. He is the Chair for the BSICCWG. He has a University Degree in Geography from the University of Helsinki.

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## HARMONISATION OF BALTIC SEA ENCS

By Jens Peter HARTMANN (Danish Geodata Agency)  
and Jarmo MÄKINEN (Finnish Transport Agency)

### Abstract

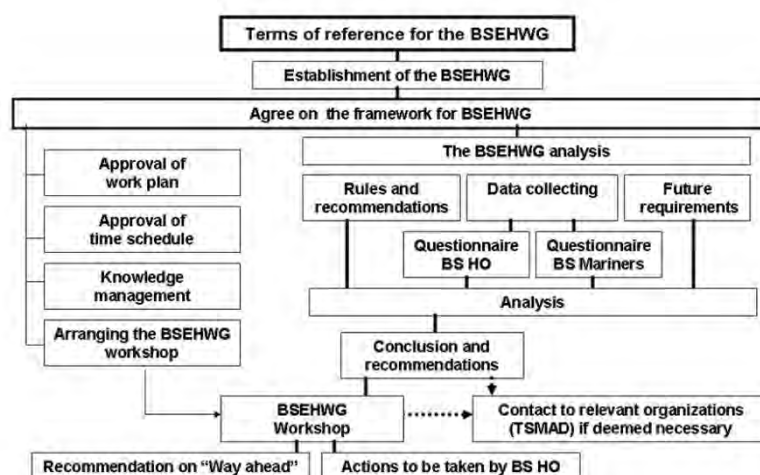
As of 2008, the Baltic Sea Hydrographic Commission (BSHC) had already developed a set of recommendations to harmonise its members ENCs covering the Baltic Sea. Most of these recommendations have now been completed and the implementation process is described below. Several future harmonisation issues are identified and future development plans described, including a FIN-SWE Pilot for harmonising depth presentation.

### Baltic Sea ENC Harmonisation Recommendations 2008

#### Background

In 2007, the BSHC formally recognized the need for harmonisation of the ENCs covering the Baltic Sea. It established an ENC Harmonisation Working Group (BSEHWG) to review the inconsistencies between Baltic Sea ENCs and to propose actions to resolve them. The work resulted in 17 recommendations for improving the member states' ENC consistency, and most were aimed at the ENC producers. In August 2008, the BSHC approved the working group's report and recommendations. It also agreed on an implementation schedule for the majority of the recommendations and monitored their implementation over the following years.

The BSEHWG work plan and time schedule were approved at the 12<sup>th</sup> BSHC Conference in Klaipeda in 2007, as illustrated in **Figure 1**.



**Figure 1.** The BSEHWG Work Plan

ENC coverage of the Baltic Sea was already fairly good in 2008, so it was an appropriate time for the HOs to concentrate on improving the quality and consistency of their ENCs. Therefore, the BSEHWG was able to commence its work with a study of the existing ENCs and identified a large number of inconsistencies between them. Most of the inconsistencies can be seen visually on the ECDIS screen at the border areas between countries. Some example cases are shown in **Figure 2**.



**Figure 2.** Examples of ENC inconsistencies

The Working Group designed and distributed two questionnaires: one for the Baltic Sea Hydrographic Offices and the second for mariners using Baltic Sea ENCs in their ECDIS.

Most of the inconsistencies identified can be found in the *General*, *Coastal* and *Approach* usage bands. There is only one *Overview* cell in the Baltic Sea. *Harbour* and *Berthing* cells are mainly disjointed, so no inconsistencies can be seen between them.

The Working Group evaluated the inconsistencies they and the questionnaire respondents had identified, with a focus on the following issues:

- Use of Compilation scale and Usage bands;
- Use of Scale minimum (SCAMIN);
- Use of Depth contours (DEPCNT) and Depth areas (DEPARE);
- “Across Borders” to cover all features in the border areas;
- Testing for harmonisation before launching ENC;
- Use of up to a 5-meter buffer zone to eliminate gaps.

Addressing these harmonisation issues was prioritised from a mariner’s point of view.

### Clear needs for harmonisation

For mariners, most of these inconsistencies are not strictly critical in safety terms. Inconsistent ENC displays on ECDIS may require that mariners use additional attention to understand the discrepancies and thus experience extra work. Inconsistencies may also decrease mariners’ trust in the ENCs and the use of ECDIS.

There are also many international regulations and recommendations that require harmonisation. These include the following:

- SOLAS V Regulation 9 requests Member states to “co-operate”, “coordinate activities” and provide “greatest possible uniformity”.

- Mandatory ECDIS carriage requirements, which are now in the process of IMO approval, also imply that there is adequate ENC coverage and that their quality and consistency are at an acceptable level.
- The IHO WEND Principles and Guidelines also request uniform and consistent ENCs and regard ENC consistency issues as important as ENC coverage.

### Implementation of Baltic Sea ENC Harmonisation Recommendations 2008

Based on the questionnaires and subsequent analysis, the BSEHWG crafted a set of 17 recommendations that are aimed at helping ENC producers to avoid the most obvious inconsistencies. These included the following:

- All BSHC countries should ensure that all navigational purposes are in harmony with other navigational purposes within the producers' portfolios.
- All BSHC countries should use jointly agreed compilation scales and SCAMIN values for all Baltic Sea ENCs.
- All BSHC countries should harmonise, with their neighbouring countries, features continuing or extending over national borders.
- All BSHC countries should check that there are no gaps between cells at national borders by establishing a buffer zone of up to 5 metres, if necessary.
- All BSHC should check and carry out harmonisation before launching updates or new ENCs or new editions.
- The BSHC agreed that new versions of ENC related standards (e.g. S-101) or new object classes should be adopted according to jointly agreed plans and time schedules.

These recommendations are in line with IHO recommendations, with some deviations on the use of SCAMIN. It was found that it was not possible for all HOs to implement exactly the IHO recommendations, but that a more feasible compromise solution could be implemented by all Baltic Sea HOs.

Further, all BSHC countries were encouraged to make further studies of the use of objects in the Baltic Sea ENCs and report their findings at the following BSHC meetings. Additionally, all BSHC countries were asked to make proposals for further actions to ensure ENC consistency.

The working group also discovered that, even among professional mariners, there still are many misunderstandings regarding the terms 'ECDIS', 'ECS', 'ENC' and 'Electronic chart'. Thus all relevant bodies were encouraged to promote the education of mariners regarding these issues.

At the BSHC 13<sup>th</sup> Conference, the commission's members agreed that these recommendations should be implemented and that they would monitor the implementation at their annual Conferences.

Most of the recommendations can now be regarded as completed or under implementation by all BSHC Members. The current status of implementation is shown in **Tables 1** and **2** at **Annex A**.

## IHO Recommendations

Based on this work, and on similar work done by Canada, the IHO WEND, now WENDWG and CHRIS, now HSSC Committees regard the improving of ENC consistency and thus fostering wider use of ECDIS and ENCs as important for increasing safety of navigation. They encouraged other RHCs to consider similar cooperation and harmonisation actions for adopting regional implementations of IHO recommendations. Also the IHO ENC Production Guidelines will be amended to allow and promote this kind of regional approach. [IHO, 2008]

At their 2008 meetings, the IHO WEND and CHRIS committees recognized regional implementation of the IHO recommendations to be feasible and to increase the safety of navigation and recommended to promote this kind of cooperation to all Regional Hydrographic Commissions.

## WENDWG Analysis and Further Guidance

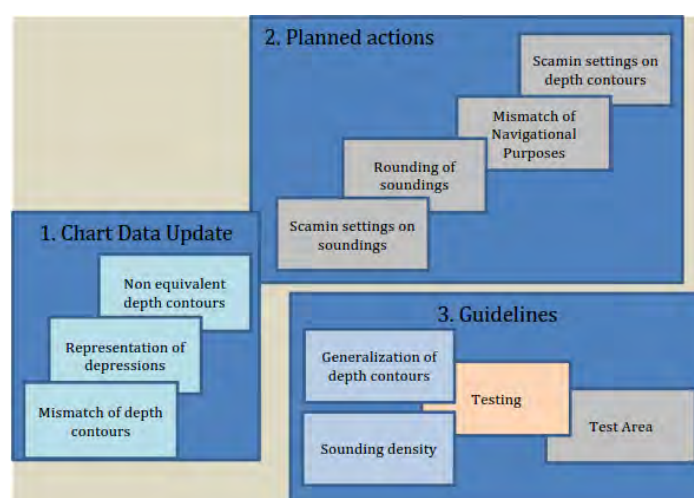
The IRCC WEND Working Group (WENDWG) monitors world-wide ENC coverage, gaps and overlaps, and some harmonisation issues (e.g. use of CATZOC). WENDWG reports the identified ENC gaps and overlaps. In agreement with the IRCC, WENDWG has developed procedures for actions to eliminate gaps and overlaps within 6 months' time.

## FIN-SWE Pilot for harmonising depth presentation

Already in 2008, it was evident that further studies would be required to solve some inconsistency issues, e.g. on conveying and the presentation of depth information. These are highly related to the specifications of production systems and databases, and demand major work to be undertaken. The BSHC established a Working Group to evaluate the depth harmonisation issue further, but the group made no remarkable progress. In 2012, the BSHC established a pilot project between Finland and Sweden for improving the harmonisation of depth information and presentation of both ENCs and paper charts.

The project has identified many inconsistencies, including mismatch of Navigational Purposes, density of soundings, SCAMIN settings on soundings and on depth contours, representation of depressions, mismatch of depth contours, generalization of depth contours, non-equivalent depth contours and rounding of soundings.

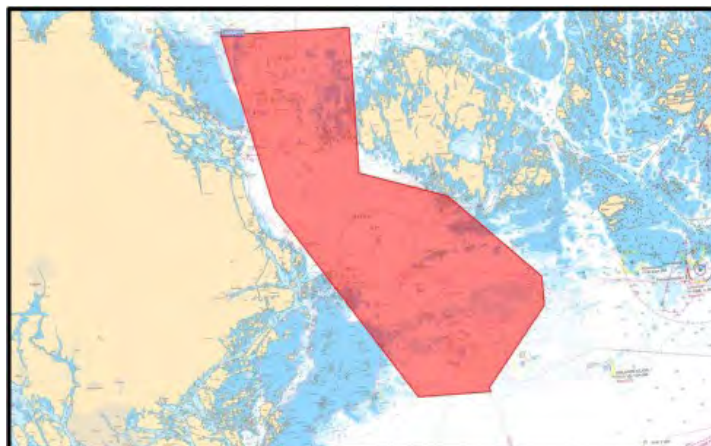
These different types of inconsistencies call for different actions that have now been grouped into three blocks. The first block being an update of the chart data, the second block being already planned actions and the third block being the development of new guidelines. See **Figure 3**.



**Figure 3.** Identified harmonisation actions are grouped into three blocks.

The deliverables of the third block “Guidelines” are finalized guidelines regarding sounding density and generalization of depth contours. A plan for the implementation of the guidelines in the chart products will also be a deliverable for the third block.

A joint chart updating process is being developed within the pilot project. Testing of the procedures will be formalized and the testing is planned to start in August 2014. The Åland Sea has been chosen as the test area partly because of the Traffic Separation Scheme and partly because Finland and Sweden both have Coastal ENC’s of the area. The guidelines will be tested for navigational purposes General, Coastal and Approach on a test area between Finland and Sweden. See **Figure 4**.



**Figure 4.** Test area for testing joint depth presentation and updating procedures.

## Plans to further develop the Baltic Sea ENC Harmonisation Recommendations

Baltic Sea ENC harmonisation issues are coordinated by the Baltic Sea INT Chart Coordinating Working Group (BSICCWG). The BSICCWG noted in its meeting in April 2014 that recommendations need to be further developed and revised - at a minimum for the use of CATZOC, MAGVAR, SCAMIN, depth presentation and eliminating gaps and overlaps. In April 2014, the BSICCWG established a Correspondence Group to study these recommendations in more detail. The Correspondence Group should report to BSICCWG by April 2015.

## Discussion

The aim to have more harmonized ENC data in the Baltic Sea via recommendations to member HOs has been found useful for encouraging HOs to find inconsistencies upon which they must report every year. This has improved ENC consistency in the Baltic Sea area. ENC consistency is better today than in 2008, but still there are issues to be harmonized. Status reports are seen as an important annual means of updating progress on the situation. More closer communication, co-operation and sharing of experiences of other RHCs will be welcome.

## References

IHO (2004) Improving ENC Consistency, IHO Circular Letter 47/2004, [www.iho.int](http://www.iho.int)

IHO (2008) IHO Circular Letter 89/2008, [www.iho.int](http://www.iho.int)

## Annex A: Status of Implementation of 2008 Recommendations

Status	Meaning	Example
<b>Completed</b>	Recommendation completed. No actions to BSHC members. No need to follow up any more.	Recommendation #14 has been completely done. Recommendation may be deleted in the Summary Table.
<b>Adopted</b>	Recommendation included in the ENC production process.	Rec. #9: before releasing new cells or editions to check that there are no gaps or overlaps (over 5 m buffer)
<b>Partially Adopted</b>	Recommendation included partially in the ENC production process (e.g. for some scale ranges or some products).	Rec #3 implemented only for some scale ranges.
<b>Not applicable</b>	Recommendation not relevant to a MS or for the time being.	Rec #10 may be valid e.g. when S-101 is introduced into use
<b>Unclear</b>	No information available or information not clear.	No or unclear status information received from a MS.

**Table 1.** Classification of the status of the implementation of 2008 ENC recommendations.

Rec #	Recommendation	Den	Est	Fin	Ger	Lat	Lit	Pol	Rus	Swe
#1	1a) Overview navigational purpose should be in harmony with other navigational purposes within the producers' portfolios.  1b) The Overview cell should be harmonised with adjacent cells in the North Sea.									
#2	The Harbour and Berthing navigational purposes should be in harmony with other navigational purposes within the producers' portfolios									
#3	On the Baltic Sea, the following values for the compilation scales should be used: General - 180,000; Coastal - 90,000; Approach - 22,000.									
#4	If a Hydrographic Office (HO) wants to use a compilation scale other than those recommended above, it may do so if all the following conditions are met:  i) the value used is in line with the intention of the IHO CL 47/2004  ii) use of it is agreed bilaterally with neighbouring HO(s) concerned, in order to avoid inconsistencies at the border, and  iii) every effort is made to minimise possible inconsistencies due to deviations from the recommended compilation scale.									
#5	BSHC should adopt the guidelines as stated in the Annex J.									
#6	6a) The BSEHWG proposes that the BSHC establishes a Working Group to study possibilities for Harmonisation of the Conveying and Presentation of Depth Information for both ENCs and paper charts.  6b) Meanwhile, if the IHO recommended contour intervals are not applicable, or if additional intervals are needed, implementation should be agreed bilaterally/multilaterally so that possible inconsistencies to the mariners could be avoided.									



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