Published in the proceedings of the 18th International Conference on Ships and Shipping Research, Lecco, Italy 24-26 June 2015.

DISTRIBUTION AND DISPLAY OF MARITIME SAFETY INFORMATION IN AN E-NAVIGATION CONTEXT

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ABSTRACT

This paper presents the work being done in the two EU projects EfficienSea and ACCSEAS on integrating Maritime Safety Information (MSI) and Notices to Mariners (NM) into the Electronic Chart and Display Information System (ECDIS). The purpose has been cognitive off-loading of the human bridge operators who work in an environment with risk of information overload due to diverse and unintegrated information systems. This project is intended as an example of the International Maritime Organizations e-Navigation's concept of collection, harmonization, integration, exchange, presentation and analysis of marine information. The service has been tested on both the ship borne end users as well as the land based editors of MSIs and MNs with positive results.

1. INTRODUCTION

At 17.15, April 14, 1912, the Atlantic Transport Line's bulk carrier 'Mesaba' sent off a telegram to the White Star Lines passenger ship 'Titanic' saying: "In lat 42N to 41.25N long 49W to long 50.30W saw much heavy pack ice and great number of large icebergs also field ice. Weather good, clear." The telegram never reached the bridge of 'Titanic' and two hours later she struck the fatal iceberg that was to end her voyage. We do not know why the telegram never reached the bridge of Titanic or if this, in such a case, would have changed the fate of the passenger liner. We know that the telegram lacked the prefix "MSG" (Master's Service Gram) which meant

that the master was personally to acknowledge receiving the telegram. The telegram instead carried the prefix “Ice report” and it is speculated that maybe the Marconi wireless radio operator onboard put the telegram aside while trying to clear up a backlog of unsent passenger telegram because his ship had just come within radio range of the Marconi wireless station at Cap Race at the south-eastern tip of Newfoundland. All previous telegrams prefixed MSG had been delivered and acknowledged by Captain Smith but not this one, and no one which could explain why this telegram never reached the bridge survived the accident. In those days the new wireless invention was drifted onboard by the Marconi Wireless Telegraph & Signal Company with their own radio operators and was a service aimed for the wealthy passengers to communicate with land. However, the ‘Titanic’ accident was to change all that and in January 1914 the convention of the International Conference of Safety of Lives at Sea (SOLAS) was signed.

The SOLAS convention among other things stated that “The master of every ship fitted with a radio-telegraph installation, on becoming aware of the existence of an imminent and serious danger to navigation, shall report it immodestly in a manner described by Article II in the Regulations annexed hitherto.” (Chapter III Safety of navigation, Article 9, SOLAS, 1914). The Regulations concerning safety at sea, Article II stated: “Safety Signal. The radiotelegraph stations which have to transmit to ships information involving safety of navigation and being of an urgent character (icebergs, derelicts, cyclones, typhoons, sudden changes in the position or form of fixed obstructions or of land marks) shall make use of the following signal, called the safety signal, repeated at short intervals ten times at full power: T T T (Morse code). [---]” The convention also mandated all ships with more than 50 persons onboard to be equipped with a wireless telegraph with a round-the-clock watch. The wireless had become a safety service for the ship, not only a convenience service for the passengers.

The purpose of referring to the anecdote above is to show how important safety information failed to reach its intended receiver. But also to point at reactive policy making within the maritime domain: new regulations often being the result of serious accidents. We are now, a century later, faced with a rapid development of ICT services also in the maritime domain. While the ‘Titanic’ crew often faced lack of information, today’s navigator suffers information overflow: we know just about all there is to know, but the information is shown on the bridge in an unintegrated, disorganised manner that threatens the expected benefits.

1.1 Maritime information yesterday and today

Before maps became common onboard ships by the end of the 18th century, sailing descriptions was the normal repository for nautical information. They were verbal description of the voyage from one port to another and sometimes including drawn coastal views to help with identification of particular landmarks (see for inst. Cotter, 1971). With the introduction of paper maps, it became possible to integrate more information which allowed the mariner a better overview. Hutchins (1995, p. 111) writes that “a navigation chart represents the accumulation of more observations that any one person could make in a lifetime. It is an artefact that embodies generations of experience and measurements”. But the paper chart can only contain more or less static information. It has to be replaced with new editions to provide for changes like new beacons and buoys, new soundings and newly discovered reefs. By the 19-hundreds this system was quite developed in the western countries. However, new chart editions came only sparsely and between editions “chart corrections” where sent out by mail allowing the navigation officer to update the paper chart by hand. Urgent information, like an unlit lighthouse or a drifting buoy was sent out first as a Navigation Warning by radio. If some warning was more persistent

it would also be published in the Notice to Mariners which was a weekly, or biweekly publication containing new temporary or permanent information that would later go into the Chart Corrections.

With the advent of the Global Positioning System in the 1980's the Electronic Chart and Display Information System (ECDIS) started to be developed. This system allowed for the integration of the ships own position into the nautical chart. This was a great step forward. Gone were the tedious work of taking bearings to landmarks or astronomical bodies to construct a position fix in the chart. Gone were the dependency on clear sky and good visibility. The ship's position would be automatically plotted in real-time. In the beginning of the third millennium the Automatic Identification System (AIS) was introduces. This system mandated ships to transmit ship data and position to other vessels within radio range. Now you could not only see your own ship, but also other ships' position in real-time on your ECDIS. But there was still a lot of maritime, safety related information left out there that needed to be integrated.

In an effort to mitigate this the International Maritime Organization (IMO, 2006) is undertaking the development of an 'e-Navigation concept' defined as *the harmonized collection, integration, exchange, presentation and analysis of marine information onboard and ashore by electronic means to enhance berth to berth navigation and related services for safety and security at sea and protection of the marine environment* (IALA, 2014). The driving force behind this initiative was a concern among many stakeholders that lack of standards made development of new applications difficult and that the possible benefits of integration could not be reached. The important aspects were safety and efficiency and in the centre stood the human element that had to deal with a plethora of unintegrated systems. Much information necessary to solve real world problems was already out there, but needed to be made available in a human friendly way. Some of the misunderstandings leading to accidents could perhaps avoided by presenting the information in a more effective way.

Although "Integrated Navigation Systems" (INS) is on the market by most manufacturer of maritime bridge equipment integration of information is easier said than done. Integration heavily involves the human part of the human-machine interface: it is not only a question of integrating the information in the computer displays, but it is a question to make sure that the human operator can get the right information at the right time in a user friendly, easy to read and unambiguous manner. Of course Captain Smith and the watch going officer at the bridge of 'Titanic' should have gotten the "Ice report" straight away. Still the format, referring to an area describes by "In lat 42N to 41.25N long 49W to long 50.30W" meant that they would need to plot the positions on the nautical chart in order to determine if the warning was of any relevance to their own journey. Manually sending numbers that has to be transcribes in many steps by humans is not a very safe method. Numbers can be misread, the process is time consuming and prone to human error – as indeed was the case that evening in1912.

1.2 Maritime safety information

How is this done today? There are three information types: *Maritime Safety Information* (MSI), *Notices to Mariners* (NM), and *Chart corrections.* MSIs are navigational and meteorological warnings, meteorological forecasts and other urgent safety-related messages, and are transmitted by voice radio on the VHF and MF bands at any time or, if not so urgent, during regular, scheduled, readings. They are also sent by Narrow Band Direct Printing Telegraphy which is received onboard by NAVTEX receivers, see figure 1.

Figure 1. Two modern Narrow Band Direct Printing Telegraphy receivers, commonly called NAVTEX (curtesy of Hanshin, left, and McMurdo, right.). Navigational warnings are received as text messages either on a paper print, or on the display.

The print out from these receivers still has to be “manually” integrated: read from the list, a decision has to be made weather that information is of any concern to me (it might be an unlit light many hundred miles away). If it is of interest you might need to go to the ECDIS and manually type in the coordinates to see what area the information is valid for.

Not so urgent information is distributed as *Notices to Mariners* (NM) in order to keep nautical charts and publications, as far as possible, up to date in-between new editions. Temporary and Preliminary NMs, T&P, advise mariners of important matters affecting navigational safety, including new hydrographic information, changes to routing measures and aids to navigation, and other important categories of data. The ECDIS uses Electronic Nautical Charts (ENCs) which are distributed in cells from national Hydrographic Offices. Originally these cells were updated by CD’s, now new online methods of distribution allow ENC cells to be updated in short intervals. Still not all ENCs include T&P information currently.

Chart corrections are permanent corrections to paper and digital nautical charts. Chart corrections and the way they are promulgated have evolved the past 10 years, and are in many ways very different from traditional MSI and NM T&P today. Chart corrections are georeferenced and portrayable by nature. MSI and NM T&P are often georeferenced but not necessarily portrayable with text and symbols.

The main differences between MSI and NM today are the way of promulgation, speed of handling and quality assurance. The content of the two message types are on the other hand more or less the same and they solve the same user need. As mentioned above, MSIs are transmitted in text or voice via SafetyNET, NAVTEX, coastal radio stations and are in some countries accessible on the Internet. NM T&P’s are distributed on paper weekly, fortnightly or monthly and are often accessible on the Internet in pdf format. In addition Hydrographic Offices are encouraged to include as many NM T&Ps in their ENC updates as possible.

In two EU projects, the EfficienSea (2009-2012) and the ACCSEAS (2012-2015) we have tried to integrate these types of information seamlessly into the ECDIS, based on the IMO e-Navigation concept. This will be described in the following.

2. METHOD

The general approach was twofold: first, to automatically integrate the MSI and MN information into the ENCs and, secondly, to allow the mariner to filter out the information valid for their location, type of ship and task at hand. By displaying georeferenced information at the actual location a natural filter was invoked. The unlit beacon hundred miles away would no longer distract the watch keeper as it would not be seen (unless it was on the planned track of the vessel, in which case it would be shown). A cargo ship in transit should not be informed of new fishing restrictions in the area, and drifting timber in an area just passed should not give an alert. However an ice warning in the area ahead of the vessel would give an alarm and would need to be acknowledged. The aim was to do this in a user friendly way, not adding to the workload (but instead reduce it) and not cluttering the ECDIS screen. See figure 2. Much of this work was done already in the EfficienSea project.

Figure 2. Example of portrayal of MSI integrated in the ECDIS display. Left, two Area MSIs and a point MSI, right, an unacknowledged MSI (top) and an acknowledged MSI (bottom).

2.1 The combined MSI-NM model

No longer depending on two different methods of distribution, radio and paper, efforts were made in the ACCSEAS project to develop a combined model for MSI and NM T&P. A web application were designed in order to effectively test the combined model, the portrayal and promulgation of the messages. The MSI-NM system included features such as:

- An editor for MSI and NM T&P messages (see section 2.3).
- Management of message life cycles and base data such as categories, areas, charts, etc.
- Web interface and API's for searching and filtering MSI-NM T&P messages.
- Map-based portrayal of MSI-NM T&P messages.

The combined MSI-NM model needed to cater for the IHO-IMO-WMO S-53 standard on MSI and the IHO S-4 standard which covers NM T&P.

The overarching idea has been to generalize the constituent parts and fields of MSI and NM T&P messages, and make the format both backwards compatible and future-proof by e.g. adding support for:

- Multi-language support. All messages must be localizable to any number of languages.
- Rich text support. NM's in particular, can contain a rich layout features such as tables, links, embedded pictograms, etc. By supporting HTML descriptions this can be accommodated.
- Support for attachments. Attachments can be binary files, such as a picture or a pdf, and optionally they may be embedded in the rich text descriptions as links or nested images.
- New identifier format. In a system containing both NM and MSI, possibly from several authorities, the existing NM and MSI identifier format is not adequate. A new more complete identifier format is proposed and used in the MSI-NM model.
- Base data. Part of a combined MSI-NM model is to define a relationship between messages and base data such as charts, categories and areas. Previous proposals have opted for rigid solutions with a fixed number of area and category levels, and with enumerated category values.
  This approach has been discarded as too inflexible. Rather, categories and areas have been defined as hierarchical base data of named categories and areas respectively, and it is left as an administrative task to fill out the specific data in each implementing system (i.e. for each country).

Additionally, the MSI-NM model needs to be backwards compatible and provide support for promulgations such as NAVTEX, which has many restrictions on the format of the message.

The approach to solving backwards compatibility and promulgation to various existing and future channels, has been to extend the MSI-NM model with *publications*. Example publications are NAVTEX, mailing lists, Twitter, Voice broadcasts and Maritime Cloud Messaging Service.

Whereas the base MSI-NM model is intended to be a common model with a standardized interchange format, the list of publications is extendable and may vary from implementing system to implementing system.

A publication will typically contain a publication-specific description of the message in a particular language, created by aggregating and formatting the core MSI-NM model fields in a particular way.

2.2 Message Portrayal

The map-based portrayal of the MSI and NM T&P messages were done in the EfficienSea project, where integration of MSI in navigational charts was explored and input produced for proposed standardization by the International Electrotechnical Commission, IEC.

The magenta MSI symbol has been supplemented with an analogous NM symbol. Also, a cluster symbol has been chosen to represent a cluster of MSI and NM messages and may be used in order to avoid clutter in maps, see figure 3.

Figure 3. Symbols for MSI, NM and clustered messages

When the message location is given by a polygon, a polyline or a circle, the actual geographical shape will be used for portraying the message. Irrespective of the kind of symbol or view mode used to display a message list, clicking a message will always display the details of the message in a Message Details dialog, see figure 4.

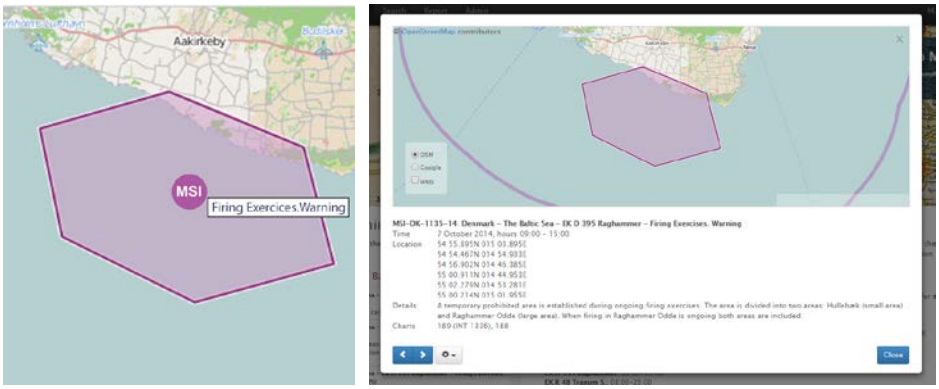

Figure 4. Mouse over on an MSI shows a short description (left), clicking opens the Message Details Dialog (right).

2.3 Message Editor

The MSI-NM T&P system provides an editor that allows qualified users to create and edit MSI and NM messages. All aspects of the MSI-NM model, as detailed in the earlier section, can be edited, and hence, the editor page is quite extensive, see figure 5.

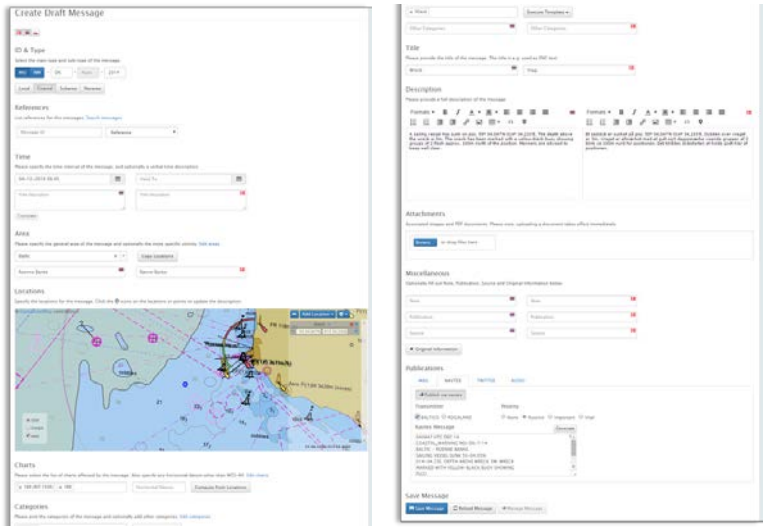

Figure 5.The Message editor.

2.4 Integration into the EPD test platform (E-navigation Prototype Display)

The combined MSI-NM T&P model devised in the ACCSEAS project is conceptually an extension of the MSI system explored earlier in the EfficienSea project, where integration of MSI in navigational charts was tested, including portrayal and filtering of MSI messages. It was extended to display MSI messages using standardized icons and graphics (see the Message Portrayal section). Furthermore, methods and schemes for relevance filtering was implemented and tested, taking into account various information types such as time and position.

For the ACCSEAS project, the EPD has been extended again with the following features:

- The EPD now fetches MSI and NM T&P messages from a test MSI-NM T&P system via the Maritime Cloud Messaging Service, see http://maritimecloud.net
- MSI-NM T&P messages have been integrated in the EPD Notification Centre (warnings and alarms).
- MSI messages are portrayed as before, and NM T&P messages are portrayed in an identical manner, except for the use of an NM icon.
- The MSI relevance filtering now also applies to NM messages.

The MSI-NM T&P Notification Panel displays an MSI or NM T&P message similar to the way message details are displayed on the MSI-NM T&P system website, including linked references, rich-text descriptions and downloadable attachments.

2.5 Technical Implementation

This section outlines the technology underlying the MSI-NM T&P system, focusing on an MSI-NM interchange format and the API's used for integration and promulgation of messages. For a detailed S-100 product specification of the proposed MSI-NM interchange format, please refer to the "ACCSEAS MSI-NM S-100 Product Specification".

One of the main tenets of the MSI-NM system is that it is open source. The project is available to all on GitHub: https://github.com/dma-dk/MsiNm

By design, MSI-NM T&P is highly customizable, and it is exceedingly simple to develop implementations for additional countries, by creating a new sub-project that overlays the main MSI-NM T&P web application and overrides system properties such as the list of supported languages, the authority, base data for administrative users, areas and charts, and as much or as little of the user interface graphics and mail templates as desired.

Furthermore, the MSI-NM system has a plug-in architecture that makes it relatively easy to develop additional country-specific message publications, such as NAVTEX, Twitter, and mailing lists, see figure 6. For details on this, see the eport "ACCSEAS WP6 Working Group: MSI/NM (T&P) Service Description"

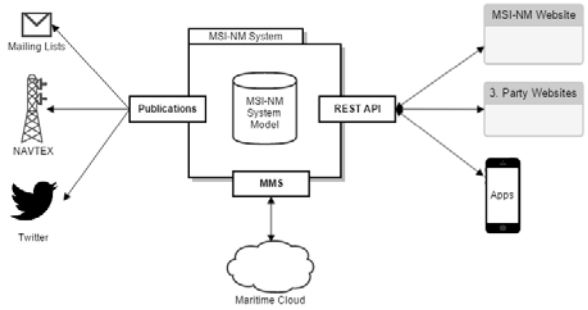

Figure 6. Overview of MSI-NM T&P promulgation.

2.5 User testing

A Danish legacy MSI-NM T&P test bench was set up and configured to continually import MSI messages from the Danish legacy MSI production system, and indeed to import production MSI messages from years back in time. The test bench was also extended with a function for importing legacy NM T&P messages by scraping weekly NM pdf digests. The purpose of this test bench was to test the breadth of a combined MSI-NM T&P model, to verify that the model is backwards compatible and the ability of the MSI-NM T&P system to handle many thousands of messages.

A user test was then conducted in the second half of October 2014 with participation of relevant maritime authorities from Denmark, Sweden, Norway and the Netherlands. An MSI-NM T&P test bench was set up for each country, by creating customized versions of the MSI-NM system tailored to the specific countries in terms of supported languages, authority identifier and base data for administrative users, areas and charts. Participants were asked to test various aspects of the MSI-NM T&P system, and in particular, to create, edit, publish and manage the life cycle of MSI and NM T&P messages. The user test was concluded with a workshop at the premises of the Danish Maritime Authority to discuss the feasibility of a combined MSI-NM T&P model and the experiences obtained from using the MSI-NM T&P test bench.

3. RESULTS AND DISCUSSION

The MSI system had previously in the EfficienSea project been tested on mariners using an on-line version of the EPD on live vessels in the Kattegat as well as in simulator trials with good results. A focus group including 8 active seafarers, one pilot and 7 officers and masters from three vessel types (tanker, buoy tender and passenger ferries) all part of the EfficienSea test fleet. The test users all had practical experience in use of the MSI service from their respective vessels. Their experience with the MSI system were positive. The strengths identified by the focus group were linked to the overall concept of making MSI messages available to the Mariner on the navigation system automatically, receiving updated information on chart display which actually makes the mariner read the MSI messages. The weaknesses all relate to specific details in the portrayal of MSI in the prototype; e.g. that a pop-up window hides parts of the

chart area, weak chart presentation of acknowledged MSI messages and missing navigational warning ID number when displayed on chart. All participants were of the opinion that the MSI service was valuable and should be developed further. The service fulfilled a current information gap and if the weaknesses are worked with, the service will improve and assist the navigators in their daily work. For more details on this see the “EfficienSea MSI Technical Report” (2012).

In the ACCSEAS project the further developed MSI-NM T&P service was tested on the users that add information to the system, the editors of MSIs and NMs.

Whereas the quality of the legacy production MSI import was very high (MSI data was scooped directly from database tables), the quality of the imported NM messages was not so high. Parsing extracted textual descriptions from a PDF into structured data is always an error prone task, and so, imported NM messages needed to be manually post-edited in the MSI-NM Editor to improve their quality. The conclusion after importing many thousand MSI’s and hundreds of NM’s was that the proposed underlying MSI-NM model is sound. Before using the MSI-NM T&P system operationally, there needs to be an effort to harmonize base data, such as categories and areas, since that has never been a priority or important for the legacy data. Performance-wise, the MSI-NM T&P system can easily cater with the years’ worth of imported messages. The underlying technology is highly optimized for geographical searches in large volumes of messages, and the presentation of message lists adopts techniques such as paging and clustered map symbols. For details on this and other features, see the report “ACCSEAS WP6 Working Group: MSI/NM (T&P) Service Description” (ACCSEAS, 2012-2015)

Feedback from the MSI-NM editors indicated that there were indeed clear benefits of a combined MSI-NM model/system to the mariner. A pending task is to flesh out the work process for editors, such as quality assurance. In general, there is a need to harmonize naming conventions between MSI and NM messages, and harmonize base data such as areas and categories. There is also a clear need for compatibility with existing systems, such as NAVTEX, for the foreseeable future. Before using the MSI-NM system is operationally, it needs lots of user interface tweaks and polishing, plus better robustness and browser compatibility.

As an aside, it was discussed if area names could be left out of the model altogether, since messages are assigned geographical coordinates. However, the conclusion was that a textual area description is still an important part of a message presentation (if you cannot name an area you cannot talk about it on the bridge or on the VHF).

It was concluded that a priority marker (e.g. “routine”, “important”, and “vital”) should not be part of an MSI-NM T&P message – it is left to the client (ship) to prioritise the messages. Note, however, that the NAVTEX publication of a message still carries such a priority marker.

In editors map view mode, message information should be displayed via mouse-over tooltips. It was also proposed to have the option to show MSI and NM messages in separate layers and to consider making the icons more distinguishable. Another suggestion was to facilitate integration with real-time information, e.g. by linking messages to the contractor working on the issue that the message pertains to.

It was agreed that, once published, a message should not be editable. If changes are required, the original message must be cancelled and a new one issued.

It was concluded that there was a massive need for simplifying the creation of MSI messages. The vast majority of MSI messages are written in a completely standardized way that is tied to the category/hazard of the message; this also ensures that the messages adhere to the strict

NAVTEX standards and guidelines. After the user test was completed, the MSI-NM T&P system has been extended with an extensive template system to address exactly this point.

It should be investigated how to present messages with no geographical information on graphical clients such as ECDIS, and ensure that they are read by the Officer of the Watch (OOW). It was debated if the OOW should be allowed to delete MSI-NM messages, and how to ensure that the next OOW see all relevant messages. This could possibly be handled by requiring all new OOW's to start their watch by reloading all MSI-NM messages. Or indeed if an authentication system as proposed in the MONALIS project is used, where the OOW has to insert an identification card into the system as he takes over the watch, then the new MSI-NMs not acknowledged by him could become active again.

5. CONCLUSIONS

This paper has presented e-Navigation work related to the integration of Maritime Safety Information (MSI) and Notices to Mariners (NM) into the Electronic Chart and Display Information System (ECDIS). The purpose has been to relieve the mariner of unnecessary cognitive work having to map georeferenced text information to the map. The technical implementation has been successful and the Danish Maritime Authority have had an implementation service running on test equipment for several years now. Response from mariners that have tested the serves has been very positive as well as the response from the editors from the national maritime administrations of Denmark, Sweden, Norway, The Netherlands and the U.K.

AKNOWLEDEGMENTS

This research has been possible thanks to funding from the European Union's InterReg IVB Baltic (EfficienSea) and North Sea (ACCSEAS) programs.

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