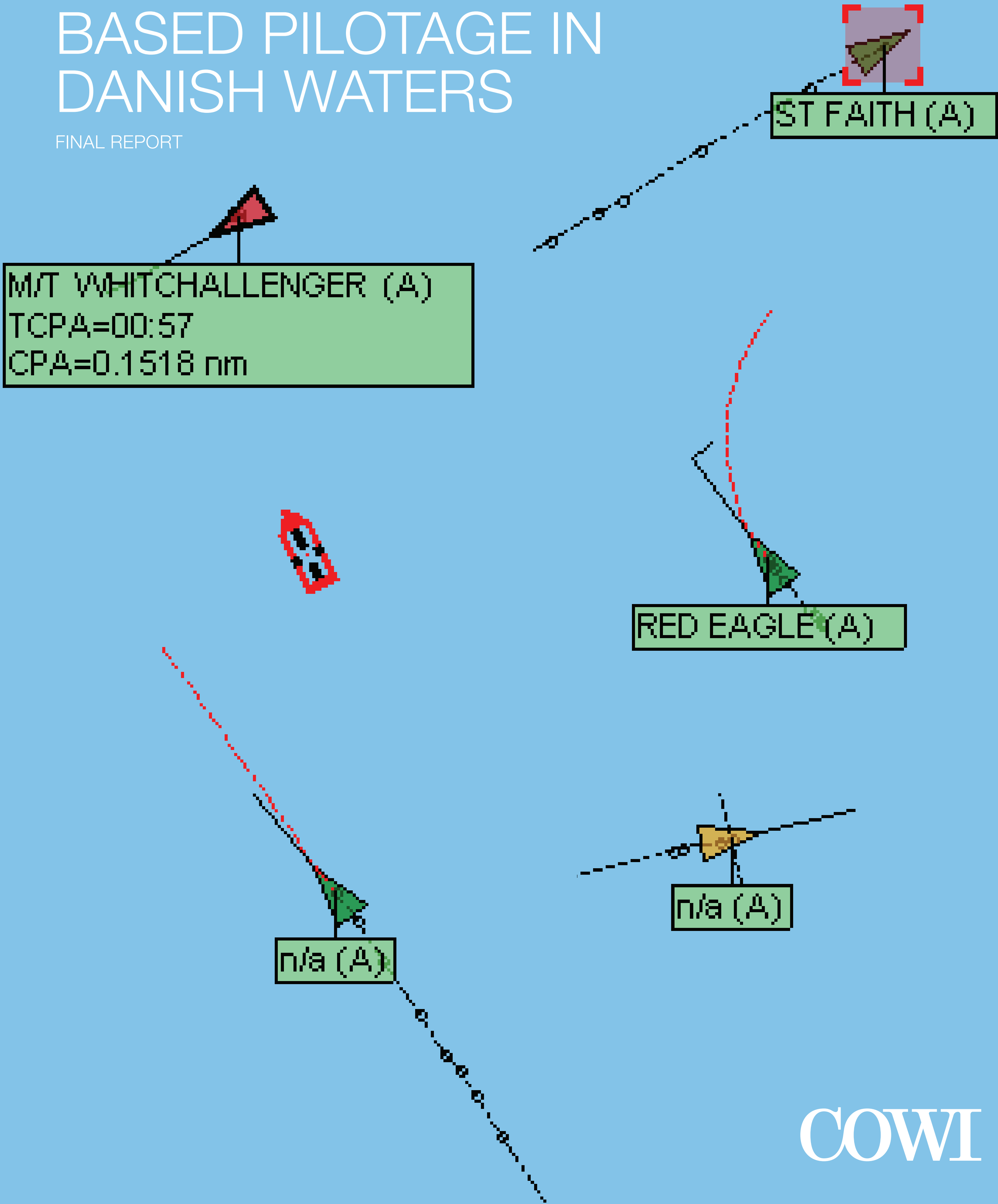
NOVEMBER 2014
DANISH MARATIME AUTHORITY

TECHNOLOGICAL ASSESSMENT ON THE POSSIBILITY OF SHORE BASED PILOTAGE IN DANISH WATERS

FINAL REPORT



COWI

ADRESSE COWI A/S
Parallelvej 2
2800 Kongens Lyngby

TLF +45 56 40 00 00
FAX +45 56 40 99 99
WWW cowi.dk

NOVEMBER 2014
DANISH MARATIME AUTHORITY

TECHNOLOGICAL ASSESSMENT ON THE POSSIBILITY OF SHORE BASED PILOTAGE IN DANISH WATERS

FINAL REPORT

PROJECT N0.
DOCUMENT NO.
VERSION
PUBLICATION DATE
PREPARED CELL, SSAS, NVBE, IBK
CONTROLLED NVBE, PMSO
APPROVED CELL

CONTENTS

1 Summary

This assessment evaluates the options for shore based pilotage in Danish waters. By shore based pilotage we mean piloting with the assistance of, and guidance from, qualified pilots situated on land. Based on earlier studies, statistical data, interviews and workshops with key players we have analysed the conditions necessary to implement shore based pilotage. This has been done using three different scenarios:

1 In sea/shipping lane in outlying waters – Allinge to Kadetrenden (Gedser) and from Grenå to Skagen

2 The entire sea passage from Allinge to Skagen)

3 To, from and in ports (port piloting)

There is little information on shore based pilotage replacing traditional piloting. Those areas with some experience in shore based pilotage have primarily used it as a supplement to traditional piloting. This is due to the safety factor provided by a traditional pilot, which is considered better than that of a land based pilot. In spite of this, the use of land based pilots offer an interesting opportunity to increase efficiency.

We will briefly summarise the conclusions of the report's three main sections, and then present a brief synopsis of the report's overall conclusion and recommendations.

Technology and shore based pilotage

Our research shows that, today, it is technologically possible to implement shore based pilotage. This section presents a "technological package", which supports shore based pilotage. The few technological barriers we have identified are the following:

› There is possibly insufficient information on the waters surrounding Denmark, such as lack of its currents; swells etc., in the most frequently navigated waters.

- Vessels need to have navigation instruments installed that can transmit specific, essential information to land. The technology is available but is not standard equipment on all vessels.

- Technology is not yet able to relay all relevant information on an actual situation to the pilot allowing him/her to provide competent and effective advice. The fact that the pilot is unable to stand on the bridge – with the actual "feel" of the ship – will always result in a different approach to that of sea-based piloting. More information about this under 'Safety'.

- It is crucial to ensure that there are sufficient back-up systems in place, both at sea and on land, so that a loss of function on devices does not make piloting impossible.

The section on technology also deals with navigational technology in the future, specifically E-navigation. E-navigation will add vital elements via the technological platform, which will facilitate shore based pilotage. One element is that all information and visibility will be on the same screen, which will allow the pilot, and the navigator, to visualise the actual sailing situation 'concurrently'. Another element is that it will be possible for the shore based pilot to suggest a new route or change of speed, which will improve navigation and communication between land and sea.

Safety and the shore based pilotage

The report concludes that shore based pilotage will have a negative impact on safety, however, in certain situations this impact will be minimal.

Apart from the fact that the technological platform must be present, two additional factors are relevant when examining the opportunities of shore based pilotage. The first factor is safety: the water condition and the route and any challenge, which could influence navigation, should be suitable for shore based pilotage. This means that the navigational complexity and the collective risk factor must allow the shore based pilot to provide effective and safe advice.

Of the three scenarios we have assessed, we find that scenario 1 – the outlying waters of the passage is the most realistic option for shore based pilotage within the near future. If experience with this type of shore based pilotage proves to be successful, we do not exclude that it would be possible to replicate it to other situations as well. Nevertheless, the report simply does not recommend it at present. The report does point out that it is unlikely that automated piloting in ports will be possible any time soon (scenario 3).

The other factor is staff competency and language proficiency. Briefly, the analysis concludes that there can be major differences between the aptitude and language proficiency of a ship's crew. Therefore, the navigational competency and language proficiency of a crew would need to be of a certain standard in order to ensure that advice and commands given from a shore based pilot are understood and interpreted correctly.

Economy and shore based pilotage

One of the aims of the report was to assess whether or not shore based pilotage could lead to a reduction in costs. As the economy related to the use of pilots is complex, the reports' calculations are based on several assumptions. The basic conclusion, however, is that there is a significant potential for cost reduction. Based on our assumptions, we assess that shore based pilotage can result in savings of up to 50 percent. Based on the specific assumptions we have applied, we predict savings of up to 60 percent.

Any reduction will, however, be influenced by other factors, such as, whether or not shore based piloting should contribute to financing of piloting elsewhere (forsyningspligten). It has not been possible to define these factors, and they are, therefore, not included in our analysis.

We are also not able to evaluate the demand for shore based pilotage. Some vessel owners have said that safety would be a vital factor, for instance will oil carriers most likely demand a pilot on board.

The project did not request a socio-economic analysis. It cannot simply be assumed that every organisational model for shore based pilotage will generate socio-economic profit. This issue is discussed in the financial section and the conclusion.

Conclusions and recommendations

The overall conclusion, based on the three analytical levels, is that it is possible to implement shore based pilotage in outlying waters with relatively little effect to safety. Implementing shore based pilotage, in this scenario, will reduce the expenses of the shipping industry.

Due to the limited empirical experience with shore based pilotage, we would suggest that careful and selective testing and development of shore based pilotage should be carried out. Tests carried out in relatively simple environments in order to gain experience. Based on the results of our studies, we would suggest carrying out pilot tests in the Allinge to Kadetrenden passage and the Grenå to Skagen passage. Based on current practice it would seem to be easier to carry out tests in the Skagen to Grenå passage than in the passage between Kadetrenden and Allinge. Pilot tests could be combined with the development of E-navigation, where test ships have already been selected and where the software is tailor-made for this purpose. In this way, a synergy will be achieved whereby new technology can enhance everyday processes and practices for (shore based) pilotage.

No matter what, the pilot tests must adhere to basic safety precautions:

- Vessels must not carry dangerous substances.
- Vessels and their crew must have access to relevant data and information.
- Vessels and crew must be of a certain (high) standard in order to participate.
- Feedback routines between the bridge and the shore based pilot must be established and optimised.
- Standard procedures, work and communication routines must be established and optimised.

- Pilots must be trained to manage and implement shore based pilotage.

Further development and implementation of shore based pilotage in Danish waters will depend on how successful the testing period mentioned in scenario 1 is, and on an operational period in which both pilots and navigators adapt to the new working and communication methods. Only then will it be possible to determine whether shore based pilotage can be carried out with a minimal safety risk. The study indicates that there is little to be gained from testing port pilotage at present.

This report has been written by the following consultants from COWI: Stine Skouby Asnæs, Inger Birgitte Kroon, Mikkel Kromand, Nis Vilhelm Benn and Carsten Ellegaard (project manager). Poul Vibsig Pedersen from SIMAC and Arne Funch Mejer from FORCE Technology have also contributed to the report.

2 Introduction

This report assesses the advantages and disadvantages of shore based pilotage in Danish waters. Based on earlier studies, interviews and workshops[1] with relevant key players we will uncover the complex problems encountered during the analysis. Our analysis encompasses three analytical topics and three scenarios. The three topics are:

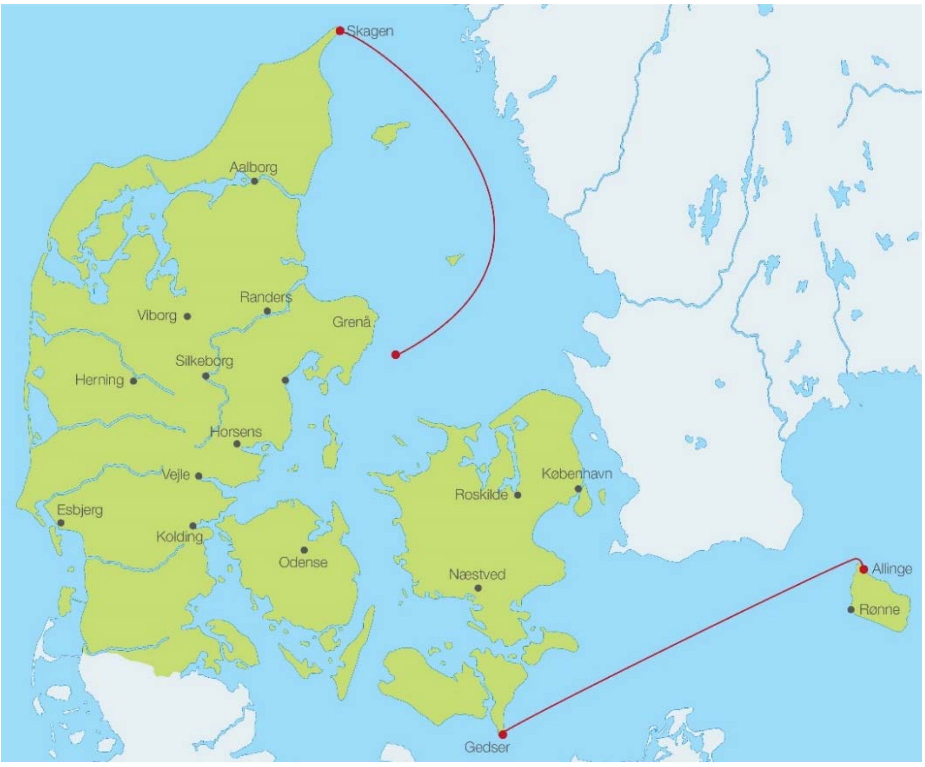
- **Technological opportunities and barriers to shore based pilotage** – description of what is/is not possible with today's technology, and what future technology can make possible.
- **Safety measures for shore based pilotage** –where, and under which conditions, is shore based pilotage viable without jeopardising life, cargo and the environment – and where is it hazardous?
- **Economic consequences of establishing shore based pilotage** – providing that the technological knowhow and the safety factor are in place, it is further elaborated how the price for shore based pilotage is compared with the price for on-board pilotage.

As previously mentioned, the assessment of shore based pilotage in Danish waters, covers three scenarios:

[1] See the list of interviews in Appendix B

Scenario 1

Scenario 1 covers the sea/shipping lane from Allinge to Kadetrenden (buoy 74) south east of Gedser, and the sea/shipping lane from Grenå to Skagen.



Scenario 2

Scenario 2 covers the entire passage, as shown in the map below. This scenario is more ambitious and complex than scenario 1.

Scenario 3

Scenario 3 covers the possibility of introducing shore based pilotage to and from ports throughout Denmark. We have not selected individual ports or passages but have looked at the possibility from a general perspective.

In addition to the summary and introduction, the report includes three sub analyses on three topics: technological opportunities and barriers (chapter 3), safety measures (chapter 4) and economic conditions (chapter 5). The report's chapter 6 provides a summarized conclusion with suggestions for areas of development within shore based pilotage.

3 Technological opportunities and barriers to shore based pilotage

The aim of this section is to clarify whether or not the technical knowledge is available to carry out shore based pilotage. Thereafter, it will present a technical package, which could provide a shore based pilot with the best, and most comprehensive, information necessary to provide a professional service.

The analysis is based on the activities/functions usually carried out by a pilot, and in on the information that he would have if actually on board a vessel.

The conclusion of this technological section has certain limitations:

Key information, necessary to carry out shore based pilotage, can be provided with existing and/or future technology, but it is difficult to simulate the fine distinction between actual presence and navigation from shore. A pilot's presence on the bridge gives access to information and impressions not easily transferred via technology

The sections are as follows:

1. Firstly, a definition of the data, which a shore based pilot must have access to.
2. Secondly, an outline of existing technology.
3. Thirdly, introduction of future technology, such as E-navigation, and assessment of how this could contribute to shore based pilotage.
4. Finally, we define a realistic technological package (a system definition), subject to a lower safety factor, including those issues, which technology cannot solve.

3.1 Data for shore based pilotage

Technology must be able to collect an extensive range of information and make it available to the pilot on shore. The most important information for a shore based pilot is:

- **Weather** (wind direction, wind force and visibility).
- **Information on state of water/sea** (actual water conditions, swell height and direction, and direction and speed of current).
- **Information about the vessel** (sailing plan 'pilot card' on ship's equipment and manoeuvrability, any defects, information on bulk, vessel length, depth and position and Rate Of Turn (ROT)).
- **Information on other ships in the proximity of the vessel in question** (same as above).

3.2 Examining technology

Here we look at available navigation technology, which can be used in piloting or shore based pilotage, today. A summary of the most common navigation aids are listed in Table 1.

Table 1 Summary of relevant technology for shore based pilotage

	Weakness of the system in relation to shore based pilotage	Precision and reliability
Electronic Chart Display and Information System (ECDIS) or similar.	None	Very good
The Defence Force's coastal radar coverage correlated with VTS	Any 'black holes', e.g. bad weather can affect coverage in certain areas. Furthermore, the Defence Force control radar positioning to suit MAS and VTS needs[2]	Fairly accurate. Good reliability
Automatic Identifica-	Human factor – incorrect registrations of data navi-	Very good

[2] In interviews with MAS, VTS Øresund and the Great Belt we were informed that there are no black holes. However, this does not apply to redundancy. If the radar system fails the Defence Force sends ships to inspect and collect information. This is an option, which the pilot service does not have.

tion System (AIS)	gation equipment	
E-navigation	Technology under development	Precision, accuracy and operation will be improved when data is dynamically updated, and navigator and pilot share the same information
Direct communication equipment	Must have a back-up-system (some merchant ships already require several VHF radios on board)	Good
Re-evaluate markers – more measuring stations	None	Precision improves with more data

In the following paragraphs we give a more detailed description of the various navigational aids.

3.2.1 ECDIS

Description

Using current, updated navigational charts, ECDIS (Electronic Chart Display and Information System) can provide a comprehensive, detailed outline of an area. Graphically, it indicates shipping lanes, traffic separations, light houses and buoys; it shows depth curves, the coast line, bridges, etc. ECDIS or a similar product is absolutely necessary if one intends to rely on shore based pilotage

When using shore based pilotage

In order to use ECDIS for shore based pilotage, the vessels position must be visible on the ECDIS chart. This can be done by using 'radar overlay' and 'AIS overlay'. Often, there can be minor discrepancies between these overlays, mainly due to the position of an antenna or radar beam's width and wavelength. For maximum safety, both overlays should be utilised to monitor any variations.

The VTS (Vessel Traffic Service) has a setup that resembles that of ECDIS. This program has the same options as the basic ECDIS programme, but it is easier to programme a sailing plan and mark hazardous or difficult areas. Buoys and beacons are clearly marked on the ECDIS chart and it is possible to programme the system to provide warning signals. A VTS interface should definitely be applied in shore based pilotage.

Limitations of ECDIS re - shore based pilotage

ECDIS is a useful technological aid which simplifies navigation and provides a full overview of the sailing situation. The limitations in using ECDIS could be that, the navigational charts used are not updated, or that some vessels do not have ECDIS installed (ECDIS will not be fully operational before 2018). Most importantly, it will require that all crew members are trained to operate ECDIS. According to information from our interviews, ECDIS material varies in quality and some versions do not function optimally.

3.2.2 AIS

Description

AIS stands for Automatic Identification System. AIS-data and its graphical programme are absolutely necessary for shore based pilotage. AIS-data is divided into three categories:

- Static data, which identifies the vessel (name, call sign, IMO number, length, width and category of vessel)
- Dynamic data, which provides information of the vessel's position and movement (course, speed and ROT (Rate Of Turn))
- The vessels course and manifest data includes data on vessel depth and length, if hazardous cargo, its destination, and whether the vessel is in a special situation (e.g. limited ability to manoeuvre).

Information on weather and water conditions can be transmitted from the vessel via the AIS-system to the shore based pilot. AIS is already in use, e.g. by VTS to monitor whether or not a vessel turns at the correct time and place. An AIS signal is automatically sent from the vessel at specific intervals, dependent on whether the vessel is at anchor or on route. Information is transmitted via shore based monitors and/or satellites. More and more satellites are being sent in orbit to relay AIS.

Limitations of AIS - shore based pilotage

The AIS-system supports a certain amount of data/messages per minute. If there are more ships sending more information than the system can manage (overload), the system is programmed to exclude those elements furthest away from the receiving antenna. This might be suitable for a vessel, but is somewhat problematic for land based antennas. As the use of AIS becomes more common, e.g. as basic equipment for yachts, speedboats, etc., there are occasions where one could have information overload. This challenge can be relatively easily overcome by establishing additional monitoring stations.

AIS-data can be incorrect on several parameters: from incorrect programming by crew to more serious mistakes such as incorrect information on vessel draft and/or incorrect readings from nautical instruments such as the gyro system and ROT indicator. Most common are incorrect GPS readings.

3.2.3 Radar

Radar coverage is absolutely necessary, in areas using shore based pilotage, and by that we refer to shore based radar systems. The radars we refer to are the standardized maritime radar systems (3 and 10cm radars). Standard radar systems used in VTS and on merchant ships, are stable.

Standard radars can, under virtually all weather conditions, produce an echo image of objects within the radar's line of sight/detection radius. From the radar image, information on an object, such as course and speed, can be calculated using ARPA (Automatic Radar Plotting Aid). The SOK / MAS' coastal radars provide coverage in Danish waters[3]. VTS radars cover the Great Belt, the Sound and, soon (early 2016), the Fehmarn system will be operational. Interviews with MAS, VTS Øresund and VTS Storebælt have confirmed that radar coverage in Danish waters is good and that there are no 'black holes'. In bad weather, radar images can, in some areas be poor (notably in the Baltic Sea).

Development of future radar systems

Already now, in 2014, there are, still at an experimental stage, automated systems that incorporate ECDIS, AIS and ARPA data and calculate the risk of running aground, or colliding with other vessels/objects. It is anticipated that these systems will be commercially viable by 2016, and will incorporate HiCASS (Hyundai intelligent Collision Avoidance Support System). These systems are, primarily, intended for use on board vessels, but this technology should also be considered for shore based monitoring/pilotage.

Limitations of shore based pilotage

Currents, tides and wind all affect a ship's course, and there will always, to a greater or lesser degree, be a difference between the set course and that, which a vessel actually sails. To carry out pilotage services from shore only by means of radar is a challenge because the course/route sailed is based on the sailing position of the vessel on the radar. Navigation based on radar has several uncertainties – information from radar systems changes within a micro-second whereas, information about the movement of other vessels is delayed. Small yachts crossing a sailing land are difficult to see on radar, an often are only detected at the last minute.

3.2.4 Communication Equipment

Communication between ship and shore needs to be direct, consistent and preferably person to person. If VHF radios are used, it should be on a frequency not utilised by others or for other purposes. A shore based pilot must be able to contact the vessel at all time, such as when it turns. Another option would be satellite based communication equipment using a separate line/frequency. General consensus is that cellular phones do not have full coverage in all areas. Communication equipment must be tested prior to commencing shore based pilotage; back up equipment must be available and back up frequencies agreed upon. In other words, there must be at least two VHF radios, on the agreed frequency, one on board the vessel and one on shore.

Nowadays, vessels often have cameras, strategically placed, usually to document basic operations, in case of an accident. The possibility for live transmission from ship to shore would be beneficial. All information generated on the bridge is usually logged and kept on the vessel. At the moment it is rarely possible to transmit this information. The amount of data can be excessive and vessels' line of communication are often unreliable.

E-navigation – future technology

[3] As of 1. October 2014, SOK no longer exist and it is therefore to as MAS (Maritime Assistance Service)

This section presents E-navigation – a technology to come. At present, this technology is being developed and tested, and will in the foreseeable future be available. We briefly explain how this technology could contribute to shore based pilotage.

3.3.1 E-navigation

The basic idea behind E-navigation is the collection of information on vessels, currents, wind, water levels, ports, and any other information, which could contribute to an integrated, user-friendly system, which could be displayed on ECDIS. E-navigation is at present in use on a few test vessels, and is not yet ready for commercial use.

E-navigation-services could be the following (DMA 2014):

- METOC – meteorological information
- MSI in chart (maritime safety instructions)
- Route exchange / route suggestion
- Dynamic risk index
- No-go area.

E-navigation will supplement dynamic, navigational charts (ECDIS) with more information than is available today. The most important fact is that data will be visible on one screen (the navigation chart) and not in numerous databases. In situations where shore based pilotage is an option, E-navigation can provide a common image on ship and shore. If shore based pilotage is to be viable, E-navigation is imperative.

There are some barriers regarding E-navigation, basically because it is a new technology. There are no agreed IMO standards and the commercial aspects, e.g. suppliers, are unresolved.

3.4 Summary on technology

The technological chapter leads us to defining a technological package (see below) for both shore and ship. This technological package applies, in our view, the most up to date technology for shore based pilotage.

As a minimum, the following should be in place to ensure a safe shore based pilotage:

Table 1 Table listing technology needed to carry out shore based pilotage

The following must be available on shore	**The following must be available at sea**
A system, similar to that of ECDIS/VTS.	Two functional radars.

Radar image as interface overlay.	Approved ECDIS system with concurrent/up to date navigation charts.
AIS data system integrated to computer.	At least two, independent VHF-systems.
A stable and direct communication line/channel (VHF) with backup.	Technical equipment and steering mechanisms must not be defective.
Access to meteorological data in sailing area – primarily current, wind and visibility.	The crew on the bridge must have situational awareness and preferably be experienced.
Line of communication (e-mail) to exchange information on the vessel (Pilot card) and intended course.	The crew on the bridge must be able to communicate in English.

Already today, one can collect all vital information via various technological systems. What is lacking is the means to integrate and update this information in an all-round user-friendly system. E-navigation is the new technology platform, which can/will accomplish this, in the near future, once it has been tested and fully functional. With E-navigation, it will be unnecessary to utilize and collect data from several systems. This will alleviate the workload for crew and pilot. In or opinion E-navigation is the technology best suited to shore based pilotage. **We recommend that further tests be made and that development continues on E-navigation in relation to shore based pilotage.**

Technological limitations

The technological drawbacks are mostly confined to what could be called the "human factor" – use of technology and the standard of information are only as good as those entering, analysing and interpreting the information. Competency, whatever the technological solution, is essential, both on shore and at sea, when using shore based pilotage. It is imperative that the crew and the pilot can use available technology properly.

4 Safety implications for shore based pilotage

We start this chapter with a short paragraph on general safety factors for navigators and pilots. We will then analyse the safety perspectives of the three scenarios, based on statistics and results from qualitative data obtained during a workshop for pilots, navigators and owners. The workshop took its point of departure in possible situations in each of the three scenarios, and considered what safety measures should be applied during traditional pilotage and what would be needed in shore based pilotage. Information from the various interviews shows that the safety factor often features as an independent/important subject.

4.1 Safety factors

There are a number of interrelated factors that influence safety in Danish waters. Most often, safety will be affected by numerous factors. These are shown in *Table 2* below:

Table 2 List of safety factors (examples)

Information on vessel	Factors on waters	Sailing situation	Human factors
Size	Water depth and draft restrictions	Traffic	Competency
Manoeuvrability	Current	Manoeuvrability (limitations)	Communication
Equipment	Weather and visibility (fog, wind, waves etc.)	Speed (both own and others)	
	Marking (or lack thereof)		

In most maritime literature, a safety requirement allocated to navigators is the ability to asses a given situation (the socalled situational awareness)[4]:

1 To observe and identify possible risks, either visually, via AIS or radar (e.g. a vessel on a collision course)

2 To understand and anticipate possible situations, such as consequence of certain actions (e.g. which vessel should change its course)

3 Command and communication – (clear indication of intent, and communication to oncoming vessels)

4 Ensure that the chosen action has the desired effect (collision avoided).

Pilotage is a service, which increases the vessel's situational awareness, and one, which the captain of a vessel is entitled to use. The following paragraphs highlight the pros and cons between ship based / shore based pilotage.

Our assessment focuses on the inter-relation between communication, the ability of the crew and a visual overview.

Communication

A major difference between shore based pilotage and traditional pilotage is communication. When a pilot is on board, he/she has visual command over a situation and can communicate directly with the navigator. This is not possible in shore based pilotage.

In Danish waters, pilotage is carried out in English or Danish. When a pilot is on board, he is able to assess whether or not the navigator fully comprehends instructions. On board the pilot does not need to rely completely on the navigators' descriptive ability or ability to communicate vital information. If the navigator's English comprehension is poor, information relayed by the pilot could be misunderstood. This would definitely be an added risk factor and in certain circumstances could be dangerous.

Based on interviews, the VTS has mentioned that continuous verbal contact, via e.g. VHF can be difficult. COWI has heard recordings that are incomprehensible. VTS' task, and that of the shore based pilot, would require concise and effective communication.

There are international standards for communication with/between vessels - SMCP (Standard Marine Communication Phrases), however, according to our interviewees is not used systematically. Among trained navigators, English language proficiency can vary from incomprehensible to fluent.

Taking the above into consideration, the navigator on watch would be required to document his language skills before shore based pilotage was offered. Communi-

[4] Such as, Koester, T. (2007). Terminology work in maritime factors – situations and socio-technical systems. Aarhus University and Force Technology.

cation must be limited to brief, precise, polite and professional commands. All commands must be repeated by the recipient (”read back”) to ensure that they are correctly understood. The same applies to communication with other vessels. Today, a pilot is able to intercept and take over communication with the other vessel if the crew does not possess the necessary language proficiency.

Navigational competence

Both the pilots' and navigators' ability plays a major role in pilotage today and will continue to do so in the future.

There was consensus, among the interviewees, that the pilots' qualifications should, as a minimum, be the same as they are today. A prerequisite for safe shore based pilotage is that the pilot can carry out traditional pilotage duties. The instruments and information to be used in shore based pilotage will, for the most part, be the same as today. The difference is that the pilot does not have the advantages of being on board the ship. This implies a form of blind navigation. This is something shore based pilots should be trained in. They should also be trained to communicate clearly and precisely (see the section on the challenges in communicating with ship crews).

The crews’ ability – particularly that of the navigator on watch – is paramount to the safety of shore based pilotage. Formulating the necessary qualifications is difficult and not within the scope of this particular project. That the topic is relevant is evident from reactions during the workshop and responses to the interviews. Quality pilotage is defined as either purely professional skills, experience in navigating the waters, or a combination of both. Some have pointed out that most ships requesting pilot services today, would find shore based pilotage a challenge that could compromise safety. A captain from a large Danish shipping company told us that he would not feel comfortable navigating difficult passages without a pilot on board his vessel. This was due to the level of competence of his first and second mate.

Many feel that the level of competency is generally good amongst those vessels, which use pilot services. A greater problem is those who do not make use of pilot services and additionally have minimal navigational competency. Opinions vary on whether or not crew competency is a challenge.

Barring this difference, there is a general consensus that shore based pilotage can be accomplished safely. There is, however, apparently a need to set standards for crew members to ensure that the ”wrong” (less competent) crew members do not decide to use a shore based pilot instead of a sea based pilot.

Visual awareness of surroundings

We have already touched upon this topic, but it is bears repeating: Pilots are used to having a visual image of the vessel and the surrounding waters. Navigation is dependent on a visual assessment of land, markings, ships, wind and weather. A shore based pilot will not have this input to supplement the data and information from navigational instruments. In many situations, a pilot relies on his/her visual impression and not instrument readings. A shore based pilot would have to learn to evaluate situations by other means. There are of course situations where, due to impaired visibility (e.g. bad weather) the actual presence of the pilot has little influence.

It is not only the visual image, which is important. Pilots, captains and others with sailing experience have told us that once on board you have a physical impression of the vessel and can feel how it is affected by the weather, currents, etc. One can, for example, feel vibrations from the hull and sense whether one risks running aground. It can also be difficult to gauge the vessel's reaction to current if one is not actually on board.

Preliminary summary

The sections on technology and safety have touched on several issues, which must be present in order to ensure that safety risks related to shore based pilotage are kept to a minimum. Whether or not one should create a *white list* for vessels/shipping companies who qualify to use shore based pilots or whether one should evaluate each case cannot be decided at this point. However, the following criteria must be present:

› The vessel must have specific technological equipment, and it must be fully functional.

› The vessel's navigator on duty must possess sufficient English to be understood and to comprehend instructions.

› The vessel's navigator on duty must have navigational qualifications and experience of a certain standard.

We have not looked at specific processes to minimise the safety risks of shore based pilotage.

4.2 Safety assessment of shore based pilotage for the three scenarios

In the following paragraphs, we assess safety risks and requirements for the three scenarios. We look at the challenges to navigational technology and the possible risks for each scenario.

We have evaluated the safety factors using the following.

› Quantitative data from accident statistics, AIS data and charts,

› Qualitative data from the workshop with pilots, navigators and ship owners as well as meetings/interviews with other key players.

4.2.1 Quantitative data for the three scenarios

In *Figure 1* we show accident statistics for the period 1989 to 2012 in connection with sailing passages for scenarios 1 and 2. It is evident that the majority of accidents occur along the inner part of the Grenå to Gedser passage, only relevant for scenario 2.

Of particular note is the number of vessels that sail aground due to shallow water and/or other difficult water conditions.

Traffic density in this area, as seen in *Figure 2*, clearly shows that the concentration of vessels passing through the Great Belt passage is large. This information indicates that navigation along this section of the sailing route is far more difficult than in the outer lying areas. It is also evident that there are several accidents in the Sound - not included in the scenarios here – but which could be compared with the Grenå to Gedser route.

The accident statistics are based on HELCOMs statistics for the period, but are not necessarily complete.

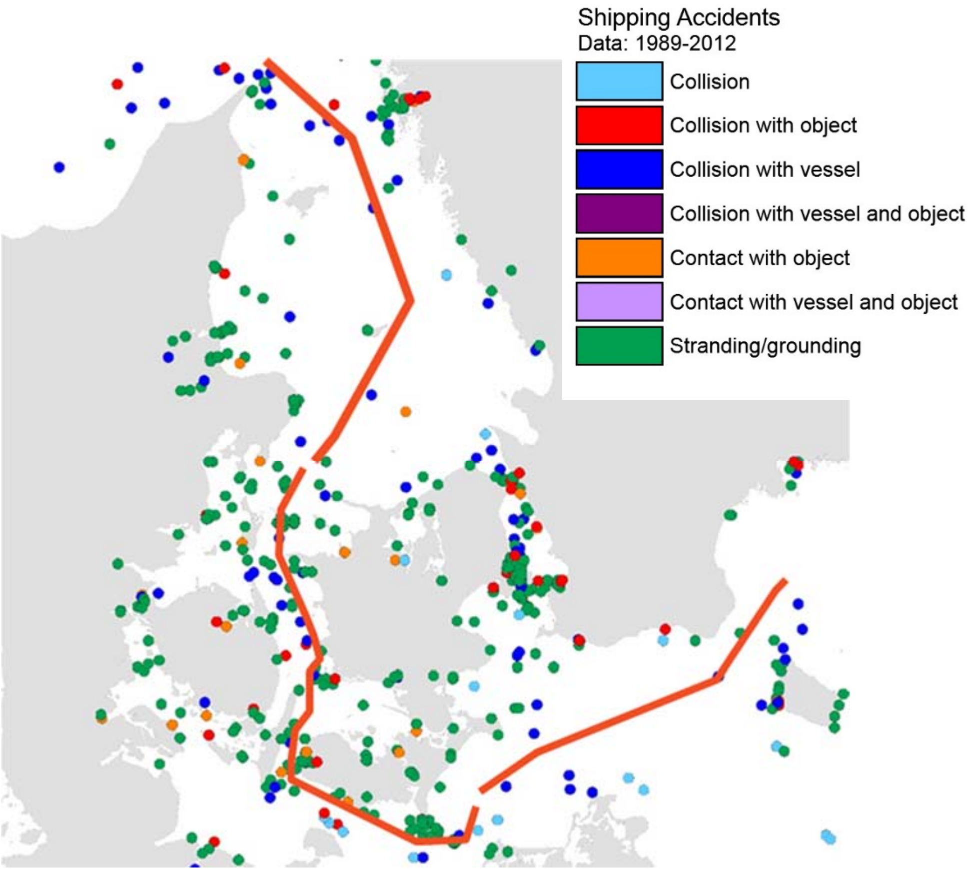


Figure 1 Accident data in Danish waters 1989-2012

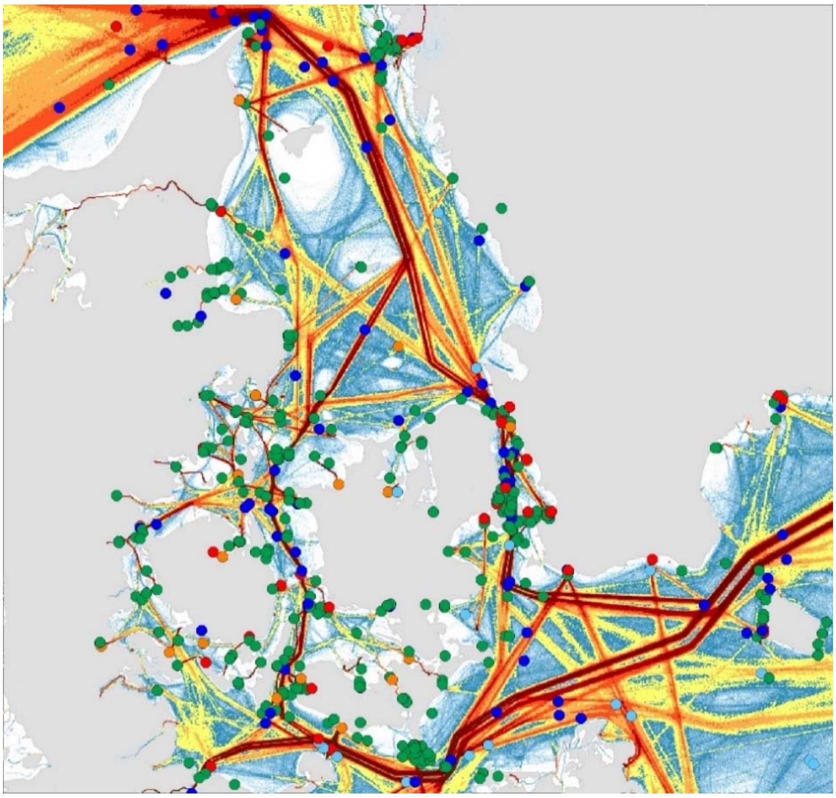


Figure 2 *Traffic density in Danish waters, based on AIS, incorporating accident statistics for 1989 to 2012*

Scenario 1

The first part of the sea/shipping lane is the route from the pilot point at Allinge to the pilot point near Gedser, close to buoy 74 before Kadetrenden. This route is relatively uncomplicated, in both directions, and there are not many accidents. One of the most difficult areas is the traffic intersection near the Bornholmsgat (reef), particularly for vessels leaving the Sound and which have taken a pilot on board at Allinge. In addition, there is a stretch around buoy 80, where shifting water levels create a problem for larger vessels and, therefore, there is a greater concentration of traffic in certain areas, as seen in Figure 3.

The pilot point at Gedser is quite exposed, and it can sometimes be difficult for a pilot to embark or disembark here and therefore the first part of the route in scenario 1 can present a problem for shore based pilotage.

The second part of the route included in scenario 1 is Grenå to Skagen, or more specifically the pilot point near Grenå with regard to embarkation or disembarkation of the pilot. There are not many accidents on this route. The difficult areas are the narrow straits at buoys 8 and 9 and the passage east of Anholt, where routes A, T and D meet. The crossing northeast of Læsø at Tønneberg Banks, which is not particularly difficult to navigate is, nonetheless, a site where vessels have run aground. Both Skagen and Grenå have pilot points where embarkation and disembarkation can take place under most weather conditions. This passage is, in principle, suited for shore based pilotage.

Scenario 2

This scenario covers the central part of the passage, as well as the sections described in Scenario 1. The passage starts at the pilot point at Gedser, just before

Kadetrenden, and ends at Grenå. From the chart under Appendix A we can see that most accidents occur near Route T, the strait near Hatter Reef/Hatter Barn, Agersø Flak and Kadetrenden, all of which are extremely difficult stretches. The passage through the Great Belt is covered by VTS Storebælt. If, as one would suppose, anti-collision initiatives affect accident statistics positively, this stretch is then difficult to navigate. Figure 2 shows that traffic density is high due to the water depth, and the route also has ferry crossings and vessels entering and exiting the Kiel Canal.

Statistically, the central area of the passage is not suited for shore based pilotage, unless the standard is as good as that of traditional pilotage. If this is not possible it can be expected that shore based pilotage will affect accident statistics negatively.

Scenario 3

It is not possible to draw a conclusion on scenario 3 based on statistical evidence. It is most likely that information on contact damage in Danish ports is not often registered in available statistics.

4.2.2 Qualitative analysis of the three scenarios

Based on information from the workshop with pilots, captains and managers from shipping companies' navigational departments, we have assessed the three scenarios. The aim of the workshop was to gain an idea of the challenges facing shore based pilotage in the three scenarios.

Participants were specifically selected, partly because they possessed a comprehensive navigational background, partly because they represented the three aspects of navigation. There was general consensus among the three groups with regard to the pilots' role in ensuring safety. The following sums up the pilot's role in ensuring safety in Danish waters today:

› **A pilot on board a vessel provides additional safety and peace of mind for the crew.** Shore based pilotage will reduce safety. The degree of reduction will depend on the crews' skill and ability to communicate. The degree of safety will be influenced by prevailing conditions and will thus be reduced in difficult navigational situations,

› **Pilots, and their skills, instil confidence.** Often, the pilot is left in charge of navigation while the captain assumes a more overall role on the bridge or delegates command to his first or second mate. This will not be possible for shore based pilotage,

› **Port pilotage requires pilots.** It is almost always the pilot who docks a vessel in port. Everything else is deemed unsafe by pilots, captains and ship owners alike. It is also the pilot who communicates with e.g. tugboats. Communication with tugboats can be difficult for a foreign captain as one cannot simply assume that the crew speak fluent English.

Scenario 1: Allinge – Kadetrenden

The route stretches from Allinge on Bornholm to Kadetrenden east of Gedser, and is regarded as a relatively simple passage. There are, however, some areas where one needs to be aware of possible safety risks.

The first area where safety can be at risk is the intersection near Bornholmsgattet. The intersection is relatively easy to navigate without a pilot. The pilot point lies in the inshore zone and there is an added risk when the vessel re-enters the sailing lane. This particular area does, in fact, increase the safety risk when using traditional pilotage contra shore based pilotage as it adds a critical situation.

From this point, the passage is easy to navigate. There is plenty of space and water until buoy 80, see Figure 13 in Appendix D. The water surrounding buoy 80 is relatively shallow and the traffic is dense. Ships with a deep draft must be careful. A pilot will invariably choose Route T to the south of buoy 80, where the water is deeper and traffic less dense. Few navigators, if left to rely on shore based pilotage, would opt for this route but would stick to the allocated sailing lane even if it is congested and the waters are shallow in places. It is situations like this that an experienced pilot with local knowledge can read danger signals and choose a safer route.

Captains and pilots feel that it could be difficult for a shore based pilot to exercise sufficient authority to make the navigator aboard the vessel leave the sailing lane. If the pilot point is moved to a position before buoy 80 (east), it will probably reduce the number of critical situations, which could arise when using shore based pilotage. It does, however, mean that the pilot boats would have a greater sailing distance, and greater exposure to poor weather conditions than today.

Scenario 1: Grenå – Skagen

From Grenå to Anholt, traffic crosses in several places, but it is mainly around Anholt that there is a safety risk. This is due to intersecting traffic, where if unobservant one risks being caught. This is most relevant for Route A, coming from Grenå, where a pilot would usually embark/disembark. Here it is necessary to follow the traffic and, using two-way communication, find out what other vessels intend to do. A pilot will often navigate slightly south of route A, where the passage is easier to navigate in. Workshop participants felt that it could be difficult to get navigators to deviate from route A, if the pilot was not on board. The problem is similar to that around buoy 80.

Around buoys 8 and 9 on Route T towards Anholt, ships with a large draught should be observant. This place is narrow, and some ships without a large draught choose also to use this route though it is not necessary. Normally, the pilots would navigate these ships around the area and thereby reduce the overall risk. In other words, some decisions that may be taken well in advance can contribute to reducing the risk. Also in this situation, it would be difficult for a shore-based pilot to instruct the navigator on board the ship and, furthermore, communicate with other ships without having a visual overview, but solely based on AIS and radar.

After buoy 4 there is intersecting south bound traffic from Gothenburg. This area can be a challenge in bad weather with poor visibility, but not necessarily more difficult to navigate from shore. From Læsø onwards, navigation is fairly simple.

Scenario 1 poses a few challenges but is suitable for shore based pilotage.

Scenario 2: The entire passage

Scenario 2 supplements scenario 1 with the route from Gedser to Grenå.

Kadetrenden east of Gedser is, historically, one of the areas where most accidents have occurred and most ships have run aground. At the workshop, there was general consensus amongst the participants that the Kadetrenden was decidedly unsuitable for shore based pilotage due to the magnitude and complex nature of the traffic in the area.

In the Fehmarn Belt near Lolland, all traffic to and from the Kiel Canal appears to cross the sailing lane, which could cause problems – particularly for eastbound ships using the T-Route

Hatter Horn and Agersø Flak are two of the most problematic areas as regards shore based pilotage. In both areas, the sailing lanes are narrow and the waters shallow. Possibly the most important factor is that several sailing lanes intersect here. For example at Agersø Flak there are two routes, which meet (route T and route H) from the south, near the Omøsund exit. Simultaneously, vessels are coming from the north along route T. Vessels with wind aft could find it difficult to manoeuvre. Pilots informed us that here it is necessary to break in order to allow vessels coming from the north access. Again it could be difficult to convince a navigator using shore based pilotage to follow the instructions.

The passage through the Great Belt does not appear to pose any problems.

At the northern end of the passage, there is intersecting traffic, which one would need to consider. Here, both pilots and captains feel that the presence of a pilot on board contributes with his/her experience, and can make the necessary navigational corrections in relation to traffic in difficult waters. Participants assessed that a shore based pilot would find it difficult to navigate and contribute in such a situation.

Seen in this perspective, scenario 2 is not optimal for shore based pilotage – at least not without affecting safety negatively. In time, and with experience - possibly gained from scenario 1 – one could perhaps introduce shore based pilotage on this passage.

Scenario 3 – To/from and in port

The third scenario, which was discussed at the workshop, was shore based pilotage in and around ports. Although ports may differ, a scenario based solely on shore based pilotage was categorically excluded due to safety.

Pilots, captains and ship owners all felt that most captains would be unsure and/or unable to berth their vessel with shore based pilotage. It would require that a captain had an extensive knowledge of each individual port. Today, in cases where a captain has such knowledge, a pilot is exempted. Shore based pilotage is unlikely to improve safety in port, as it is largely based on reactions to the visual situation, a vital element when berthing a vessel. Just as there is little time for discussion between pilot and captain/mate on where /how to berth. Lack of actual presence would be a major drawback in shore based pilotage.

An additional factor would be communication with both the port authorities and tug boats, where misunderstandings could occur if the captain were unable to communicate in Danish or not acquainted with the locality.

4.3 Summary

There are certain safety issues, which technology is not yet able to address. Shore based pilotage requires much of the crews' and the pilots' skills, experience and ability to communicate in Danish and/or English. When a pilot is on board, he has the ability to assume control of the vessel and react to situations as they arise. This option will not be possible with shore based pilotage and the crew's ability will become a decisive factor. By not being on board, the pilot will be unable to gauge a vessel's manoeuvrability and/or be aware of any potential dangers such as visual impressions. A shore based pilot will not be in a position to guarantee navigational safety in Danish waters.

In reviewing the three scenarios, COWI concludes that there is not one of the scenarios where shore based pilotage, will not, at present, present a problem to navigational safety. We can, based on the results from the analysis of safety, conclude that:

› Scenario 1 - will, under ideal conditions, provide an acceptable safety level for shore based pilotage.

› Scenario 2 – we feel it is, at present, not suited for shore based pilotage.

› Scenario 3 - we feel it is not suited for shore based pilotage.

Consequently, in the next section, we will focus on the economic aspects of scenario 1.

5 Economic analysis on the cost of shore based pilotage

In order for shore based pilotage to be viable, the costs must be lower than for traditional pilotage. If this is not the case, shore based pilotage will not be a suitable alternative to traditional pilotage.

In this section we will look at the cost of pilot services in the outlying parts of the passage (scenario 1) as this is best suited for shore based pilotage.

This section looks at a number of simple calculations, which document potential savings resulting from shore based pilotage.

Please note that we have not examined whether or not there is a real demand for shore based pilotage. COWI has received comments from safety conscious, Danish ship owners who have stated that they would not use shore based pilotage unless assured that affects to safety standards were minimal. There are several reasons for this, inter alia that some ship owners simply see it as a market demand. There are, however, many other reasons why ships owners would not wish to jeopardise safety.

5.1 Assumptions

5.1.1 Pilotage efficiency

Among the most important assumptions is the change in efficiency of pilotage. Shore based pilotage means that the pilot does not spend time on transport to and from a vessel. This improves efficiency.

One would also assume that the pilot’s working day would be more normal (e.g. 7.5 hours a day instead of seven day shifts), because a pilotage from shore can be passed on from one colleague to another as a pilot's shift ends. Pilots would not need to rest during working hours, which would also increase efficiency.

We assume that a pilot only navigates one vessel at a time, although, in principle, it would be possible to navigate several from shore.

We have, during the assessment, asked Danpilot if it was possible to access information on pilot efficiency. Danpilot did not wish to supply us with specific information. They did, however, inform us that they have statistics, which show that pilot efficiency has risen in recent years. To assess current pilot efficiency of Danpilot, we have used the “Farvandsvæsnets”/now Danish Maritime Authority’s annual report from 2010 which contains information on both 2009 and 2010. Here, pilot efficiency is given as 23.6% and 23.3% with a target of 30%. In our calculations, we assume that Danpilot has achieved its goal of 30%

We expect that this could reach 65% with shore based pilotage. However, this figure is uncertain and sensitivity analyses have been made to corroborate this assumption.

5.1.2 Demand

It is uncertain how many vessels will make use of shore based pilotage because language, skill or technical requirements will exclude some ships. It is assumed that between 10% and 25% of DanPilot’s 19,801 services (in 2013) could be piloted from shore, depending on whether one is referring to partial routes or entire passages.

Our calculations assume that 25% of present customers would use shore based pilotage. We have not allowed for new customers who previously did not use pilot services. These assumptions do not affect the actual equation.

It is assumed that a piloted vessel is a tanker sailing with an average speed of 11 knots, or a container ship sailing at 14 knots. This has implications for pilotage costs. A slow-moving ship uses more pilot hours to cover the distance and therefore results in higher salary costs - and thus shore based pilotage provides a potential saving.

In our calculations in scenario 1 we have used two options: one of 99 nautical miles from Allinge to Gedser (buoy 74), and one of 81 nautical miles from Skagen to Grenå.

5.1.3 Costs

DanPilot’s financial statements for 2013 form the basis of cost assumptions. We have used the cost of pilot boats, travel and maintenance of pilot stations. In addition, according to DanPilot’s website an estimated 218 million DKK was spent on salaries in 2013. Pilot salaries are reckoned at 1 million/year for 1700 hours. This, together with the figures on pilot efficiency, gives us a salary rate per bridge hour.

		Sea based	Shore based
Pilot salary	DKK/year	1.000.000	1.000.000
Working hours	hours/year	1.700	1.700
Pilot efficiency	%	30 %	65 %
Hourly cost	DKK./bridge hours	1.961	905

An important factor, which can influence the cost of shore based pilotage is the extent to which one would need to invest in new infrastructure, for example radar, which is necessary to ensure safety. In the interviews carried out, MAS/VTS have indicated that their radar system could cover the relevant passages and supply supplementary information to a vessel's radar system. We have also been informed that more receiving stations for AIS may be needed, if congestion is to be avoided. It is uncertain whether this is actually necessary. No specific requirements for additional technology, in relation to shore based pilotage have been identified.

An organization supporting shore based pilotage will have fixed costs, some of which will be administrative costs. It is with regard to investment in technical installations and possibly new pilot centre(s) that shore based pilotage will incur expenses. It is difficult to guess the extent of these costs, but they will probably be limited to computers and communication equipment. We estimate an average annual cost of 1,000,000 DKK, merely to reflect that equipment is not free.

The costs for the individual vessel will vary considerably. Standard requirements for navigational equipment are necessary if a vessel is to use shore based pilotage. Some companies will install this technology off their own account, and the cost cannot be attributed to shore based pilotage. We therefore estimate a cost of 0 DKK to meet the technical requirements for shore based pilotage on board vessels.

5.2 Methodology

The method used to calculate the savings to be gained from shore based pilotage is based on the cost of a full pilot service/trip. Calculations are split into four parts:

- **Pilot costs**, such as pilot salary divided by number of hours on a vessels bridge i.e. DKK/bridge hour;
  - Pilot costs will drop with shore based pilotage as efficiency should increase.
  - Pilot costs per trip are calculated as pilot costs per bridge hour times the number of hours for an individual trip (which again is calculated as distance in nautical miles divided by speed in knots).
- **Travel expenses**, which are basic costs per pilot assignment for travelling trip (excl. salary), pilot boat, crew, and fuel.

   - Travel costs will cease with shore based pilotage[5].

- **Administrative costs**, such as administrative personnel, rent, etc. are calculated as an average cost per pilotage assignment.

   - Administratives cost remain unchanged with shore based pilotage.

- **Technical equipment** for shore based pilotage e.g. radar equipment, equipment on vessels and for pilots, calculated as an average cost per shore based pilotage;

   - The costs for technical equipment will only be covered by vessels buying shore based pilot services.

5.3 Results

Below we calculate the savings gained through implementing shore based pilotage compared to traditional sea based pilotage.

For the two passages utilized in our scenario 1, savings will amount to 63% for both tankers and containerships.

Passage	%-saving	Absolute saving – tanker	Absolute savings – containership
Skagen – Grenå	59 %	12.992	11.326
Allinge – Kadetrenden	58 %	14.720	12.684

The main expense in pilotage is time. Therefore the absolute saving is related to the time a pilot spends navigating. In those instances where a vessel requires a pilot for a longer period of time, the absolute saving is greater. 55-66 % of the savings above relate to reduced salary costs for pilots.

With the relatively low costs used in our calculations, the proportion of vessels using pilots has little effect. We have assumed that 25% will use a shore based pilot. There will only be a moderate increase in costs if we instead assume that only 10% will make use of a shore based pilot. The fixed annual costs attributed to shore based pilotage would, according to our calculations, need to be about, or a little

[5] As the costs of pilot boats and crew remain unchanged (pilot boats will still be needed), there is no real saving. The fixed costs of pilot boats and crew will continue to be allocated to sea based pilotage and port pilotage. Obviously a contribution towards upkeep can be included in the cost of shore based pilotage, but we have not calculated with this.

above, 10 million DKK before they would lower relative savings to 50%, if 25% are carried out by shore based pilots. If 10% are carried out by shore based pilots and the cost is 10 million DKK savings would drop to approximately 33%.

We have, as previously stated included costs for pilot boats and crew in the shore based pilotage calculations. Somewhere between a third and a quarter of any savings will vanish if the fees are the same as for sea based pilotage.

In a sensitivity analysis, where pilot efficiency is set at 75%, savings increase to 62%, according to the calculations used.

Appendix C contains tables showing the calculated results.

5.4 Conclusions

Based on the assumptions presented and the calculations carried out above, one can conclude that shore based pilotage has the potential of reducing direct costs related to pilotage in outlying passages by 50% to 60%. This is a scenario where basic costs are low and where shore based pilotage does not cover costs associated with pilot boats and crew (and thus the pilotage service duty).

There is, however, some uncertainty regarding this result. The main uncertainty is the impact on pilot efficiency, from which most savings stem. There is also some uncertainty about costs, however, these would need to be considerably higher than our estimations to change the conclusions and the overall cost reduction potential. In addition, the share of traffic/vessels, which can make use of shore based pilotage, is crucial. The greater the number of vessels enabled to use shore based pilotage, the lower the cost per pilotage. This is of little consequence as the cost of shore based pilotage is low.

5.4.1 Limitations

There are a number of limitations regarding the interpretation of the above results, which can potentially have a major impact on the cost structure of pilot services, which cannot be carried out from shore.

- Due to the pilotage service duty and the 24-hour staffing duty, regional pilot stations may be overstaffed compared to the average number of pilotage assignment carried out by the station. At present, this problem is managed by relocating regional staff to assist with piloting in, and through, the major sailing passages. If shore based pilotage prevents these pilots from participating in this, the efficiency of regional pilots will be lower. This will thus have a negative effect on economy and result in higher tariffs for regional piloting. If regional pilots can, however, be placed so that they can carry out shore based pilotage, their efficiency will increase compared to today, and costs can be reduced. It has not been a part of this assessment to analyse these consequences.

› In relation to shore based pilotage and pilot boats, savings only affect fuel consumption as these boats will still need to be maintained due to the pilotage service duty, and the crew will still need to be paid. The analysis does not address the increased average cost of maintaining remaining sea-based pilotage.

This analysis is not a socio-economic analysis, and the savings mentioned are thus not an expression of a general potential advantage for Denmark. The benefits would be for ship owners and their customers, many of whom have no relation to Denmark. Conversely, any negative effects (such as increased tariffs for pilot services and a possible deterioration in efficiency in regional areas) will most likely affect marine transport customers who do have a relation to Denmark. So, even if the calculations, taken separately and assessed without taking the context into account, show a cost advantage from implementing shore based pilotage, it is possible that shore based pilotage seen in a broader context can be economically disadvantageous for the Danish maritime transport sector.

6 Conclusion

In the previous three chapters we have analysed the technological, the safety and the economic aspects of shore based pilotage. Below we will briefly summarise the results of the analysis.

Shore based pilotage is technologically possible today

Our technological study indicates that already today, with available technology, we have access to information that enables shore based pilotage. The technological package we have presented could be the starting point for shore based pilotage.

Technological equipment for shore based pilotage	Technological equipment on board vessels
A system compatible with to ECDIS/ VTS.	Two functional radar.
Radar image as overlay on user interface.	Approved ECDIS system with recently updated maps.
AIS data as overlay on user interface.	Minimum two independent VHF systems.
A stabile and direct line of communication (VHF) with back-up.	The vessel must not have defective equipment or navigational system.
Access to meteorological data in the area – primarily current, wind and visibility	
A line of communication (mail) to transmit ship-to.ship information (Pilot card and the ships sailing plan).	

The technology/equipment in question can already be found on many vessels in Danish waters, and the vessels thus meet the standards required to make use of shore based pilotage. There can, as with all technology, be areas or situations where the precision is, momentarily, insufficient or there is a fallout.

This technology provides those on the bridge with valuable input and decision making tools necessary to navigate the vessel. The challenge with this technological solution is that it requires that navigators make use of several different technological platforms simultaneously. This is not particularly user friendly in situations where one navigates only on the basis of these instruments.

E-navigation is in the process of testing, and will become a new technological platform, which will support and enhance shore based pilotage, providing more opportunities than today's technology allows.

E-navigation's advantage lies in its ability to update information dynamically in a single user interface, which is simple and intuitive, and can be used by navigators as a decision aid tool. Another advantage is that E-navigation shows the position and route of other vessels using E-navigation and/or any changes to their intended sailing course. Thus E-navigation, within a given passage, could foresee potential risks/hazards and navigate accordingly. In relation to shore based pilotage, E-navigation has a tremendous advantage in that the captain and the shore based pilot share the same image and data. It is our opinion that E-navigation would contribute towards better and safer shore based pilotage than is the case today.

E-navigation as a technological testing platform for shore based pilotage in the future

With E-navigation's dynamic and improved information system one is close to having the optimal technological solution for shore based pilotage, provided that the IMO and manufacturers/suppliers can agree on requirements, standards etc. In the development and testing of E-navigation, a tailor made programme for shore based pilotage should be included as one of the services. It is COWIs opinion that **E-navigation, or a similar system, will be the technological platform best suited for efficient shore based pilotage**

Technological limitations

Technological development and better technology can provide navigators and pilots with sufficient information on which to base their navigational decisions. However, as long as humans are involved in the actual sailing, skill level will always be a critical factor. By skill we mean the ability to analyse and process information, both the visual and that stemming from technological aids, and with this input predict traffic, risk etc., thereby navigating the vessel accordingly. Shore based pilotage will demand even greater skills from a competent crew.

With statistical data and qualitative statements from navigators, in their role as pilots, captains or administrative staff, we carried out an assessment of the possible safety risks in the three scenarios.

To summarise, our study indicates that, in the near future, shore based pilotage can be implemented, but with a consequence of reduced safety. Nowadays, on many vessels, the crews are competent and experienced and the pilots' contribution to safety is minimal. With traditional pilotage, in situations such as this, a pilot on board provides breathing space for the navigational crew. However, another group of vessels navigate Danish waters, where shore based pilotage could be a hazard and result in vessels running aground, collisions, etc. if a pilot is not on board to compensate for lack of skill, equipment, experience, etc. The only option where shore based pilotage will increase the safety factor is in cases where, today, no pilot is used. If shore based pilotage, as a cheaper alternative to traditional pilotage, becomes an option, we can only guess at whether or not this group will use the service. If services are requested by this group it would increase safety in Danish waters. Today, about 90% of the vessels with pilot recommendation use pilots when sailing through Danish waters so this possible positive safety effect could outweigh the negative effects of shore based pilotage for other vessels.

The safety factor for shore based pilotage will vary according to the number of vessels sailing in Danish waters.

At scenario level, there are also differences in the safety assessment. Whether or not shore based pilotage is safe on a given passage is dependent on two factors:

1 **Risk** – navigational challenges (traffic, narrow channels, shallow waters, sharp bends, fluctuating currents, other factors and the combination hereof).

2 **Manoeuvrability** – this relies on time and space – time to communicate with those involved (i.e. pilot and other vessels), action and possible reaction to a specific risk/hazard.

Our assessment highlights a connection between risk and manoeuvrability in all three scenarios. The axes do not show absolute levels, only the placement of the three scenarios.

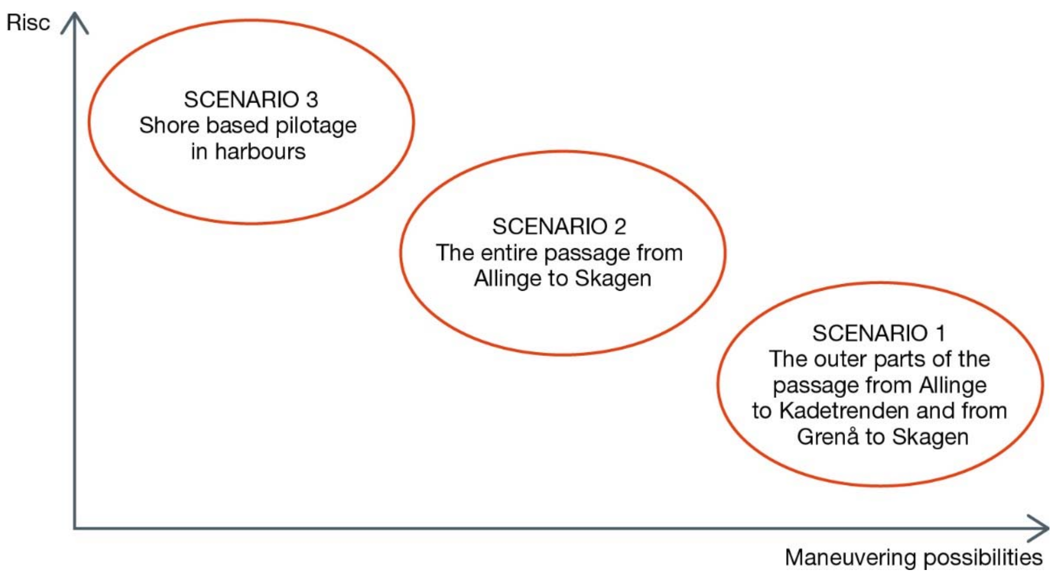


Figure 3 Safety assessment of shore based pilotage in the three scenarios

Scenario 1 is, according to our assessment, the option most suitable for shore based pilotage.

A characteristic for this scenario is that there are few risks and there is both time and space (water) to navigate/manoeuvre in. From a safety perspective it is, at present, the only scenario, which is acceptable. This will need to be tested under real conditions and procedures such as, optimising standard processes, job descriptions, communication between the bridge and the pilot, (procedures, which cannot be acquired via theoretical supposition) and needs to be documented and included in training.

Scenario 2 is not entirely suitable for shore based pilotage because the inner sections of the passage pose navigational challenges where the actual presence of a pilot on board and his experience and local knowledge are crucial. If results/experience with shore based pilotage in scenario 1 is positive, one could consider extending shore based pilotage in this scenario at a later stage but at present there is a great deal at risk.

Scenario 3 is least suited for shore based pilotage. Port pilotage demands, for most ports, thorough knowledge of the port and its specific challenges. Then some clients (mainly tankers) have requirements, which stipulate the use of pilot services on entering/exiting a port.

Our analysis of the economy in implementing shore based pilotage shows significant potential savings based on price per individual pilotage. Based on several assumptions, we have calculated savings of up to 60 per cent on outlying passages, i.e. in scenario 1. It would take a lot to bring this saving below 50 per cent, provided one does not include services and maintenance expenses in the fee for shore based pilotage.

Although the economic analysis shows an isolated financial benefit from shore based pilotage, it also shows (see section 5.5) that the economic gain is likely to go to foreign shipping clients while domestic clients could, potentially, pay more for regional pilot services. A socio-economic analysis would describe this problem, but that is not within the scope of this project.

6.1 Shore based pilotage – the next steps

Due to the limited empirical experience with shore based pilotage we suggest a conscious, careful, step by step test and development of shore based pilotage, where one gradually gain experience in safe surroundings. Based on our studies, we feel that the passages from Allinge to Kadetrenden and from Grenå to Skagen are best suited for tests with shore based pilotage. At present, taking on a pilot appears less problematic in the Skagen to Grenå passage than in the Kadetrenden-Allinge passage. Pilot tests could be coupled with tests on E-navigation, as test ships have already been selected and software is in the process and adapted to suit the purpose. This promotes synergy, between the development of new technology and everyday procedures and processes for (shore based) pilotage.

It would be prudent to adhere to some cautious/ sensible principles and avoid taking risks during the initial tests:

1 Vessels and crew must have a certain standard of skill to participate.

2 Vessels must not carry hazardous substances.

3 Vessels and crew must have access to relevant data and information.

4 Feedback processes between thebridge and shore based pilots must be established and optimised.

5 Standard procedures, work and communication routines must be established and optimised.

6 Pilots must be trained in shore based pilotage.

Future development of shore based pilotage in Danish waters will depend on the success of the testing period in scenario 1 and an operating period where pilots and navigators adapt to new procedures and means of communication. Only then will one be able to determine whether shore based pilotage is viable in other passages. The study indicates that testing port pilotage is not really an option within the foreseeable future.

Appendix A Literature

Bruno K. (2008). Piloting control - An explorative study on pilotage from shore.
Bruno, K., & Lützhöft, M. (2009). Advanced navigational assistance.
Bruno, K., & Lützhöft, M. (2009). Shore based Pilotage: Pilot or Autopilot? Piloting as a Control Problem.
Bruno, K., & Lützhöft, M. (OD). TALK AND TRUST BEFORE TECHNOLOGY - FIRST STEPS TOWARD SHORE BASED PILOTAGE.
Cerelius, N. E., & Bees Rings, F. S. (2014). Privatisation and the consequences to the pilots' skills and safety.
Det Norske Veritas. (2001). Remote solutions from traffic centres.
Force Technology, the Maritime Authority. (2007). Decision support for navigation, draft report.
Grundevik, P. (2006). Swedish Pilotage.
Harati-Mokhtari et al. (OD). Automatic Identification System (AIS): A Human Factors Approach.
Kystverket. (2004). Trials with shore based pilotage.
Patraiko, D. (2009). Ship / shore coastal relationships - effective maritime domain awareness.
Danish Maritime Authority. (2014). E-navigation, Arctic Web & The Maritime Cloud.
Whittingham, R. B. (2004). The Blame Machine: Why Human Error Causes Accidents

Appendix B Interviewees

Organisation	Participants interviewed
Danish Ship Owners	Head/Chief consultant Morten Glamsø
DanPilot	Director Lars Ahrendtsen and Head Pilot Peer Bøje Brandenborg
Danish Ports	Deputy Head Nete Herskind and Deputy Director Tom Elmer
The Association of Danish Pilots	Head pilot Ivar Svane og Chairman Bjarne Cæsar Jensen
DTU Space	Professor Per Knudsen
Force Technology	Team Leader for Simulating Arne Funch Mejer (Captain and Navigator)
Hamburg Harbour Pilots	Deputy Chairman Donatus Kulisch
International Maritime Pilots' Association	General secretary Nick Cutmore
Lotsenbrüderschaft Elbe	Captain Ben Lodemann
Nautical Institute	Project Direktør David Patraiko
Norske Kystverket	Jan Magne Fosse (Chairman for Norwegian Pilot Association)
Port of Rotterdam	Senior advisor Dept. Harbourmaster Rotterdam Jan Willem Verkiel
Søfartens Ledere	Director Fritz Ganzhorn
Danish Maritime Authority	Chief Consultant Morten Brix Laursen
Søværnets Operative Kommando (VTS Storebælt and VTS Øresund)	Navigator/manager Niels Jacob Mygind, Chef for VTS Storebælt Jørgen Brandt, Manger for VTS Øresund Per Bæk Hansen and Manger in MAS René Fuglsig
World Maritime University Malmø	Ph.D. Aditi Kataria, Ph.D. Gesa Praetorius, Naval Captain from US Coast Guard Jarrod DeWitz and Ass. Prof. Michael Baldauf

Participants in workshops	
Captains appointed by the Ship owners Association	Niels Vestergaard Pedersen, Mærsk Line Flemming Dahl Jensen, Norden
Pilots	Peter Herskind, Danpilot Bent Søndergaard, Danpilot
Employees from ship owners nautical departments	Jens Vester Pedersen, Torm Jørgen Andreasen – Norden

COWI contacted the insurance company SKULD, but they did not wish to participate

Bilag A Appendix C Detailed economic calculations

A.1 Requirements

Cost for travel and maintenance		Sea based
Total annual cost	DKK/year	107.313.000
- Salary	DKK/year	40.000.000
- Maintenance pilot centres	DKK/year	9.759.000
- Maintenance pilot boats	DKK/year	15.985.000
- Travel expenses	DKK/year	26.850.000
- Fuel	DKK/year	14.719.000
Number of trips	trip/year	19.801
Average cost	DKK/year	5.420
Marginal cost	DKK/year	2.099

Note: Salary is estimated. Total labor costs for pilots, boat staff and other comes to 218 million DKK which is DanPilot's salary costs for 2013

Assumptions on administration		Sea based
Number employees	number	46
Salaries	DKK/year	25.000.000
Other expenses	DKK/year	25.000.000
Average costs	DKK/trip	2.525

Note: Salary is estimated. Total labor costs for pilots, boat staff and other comes to 218 million DKK which is DanPilot's salary costs for 2013

Assumptions on pilot salary		Sea based	Shore based
Pilot salary	DKK/year	1.000.000	1.000.000
Pilot working hours	Hours/year	1.700	1.700
Pilot efficiency	%	30 %	65 %
Hourly rate	DKK/bridge hour	1.961	905

Note: Salary is estimated. Total labor costs for pilots, boat staff and other comes to 218 million DKK which is DanPilot's salary costs for 2013. Assumptions on pilot efficiency are described in chapter 5 of the report.

Appendix D Accident Statistics

Accident statistics, shown on the chart support the findings of the various scenarios in section 4.2.2. Map references are given in Figure 4

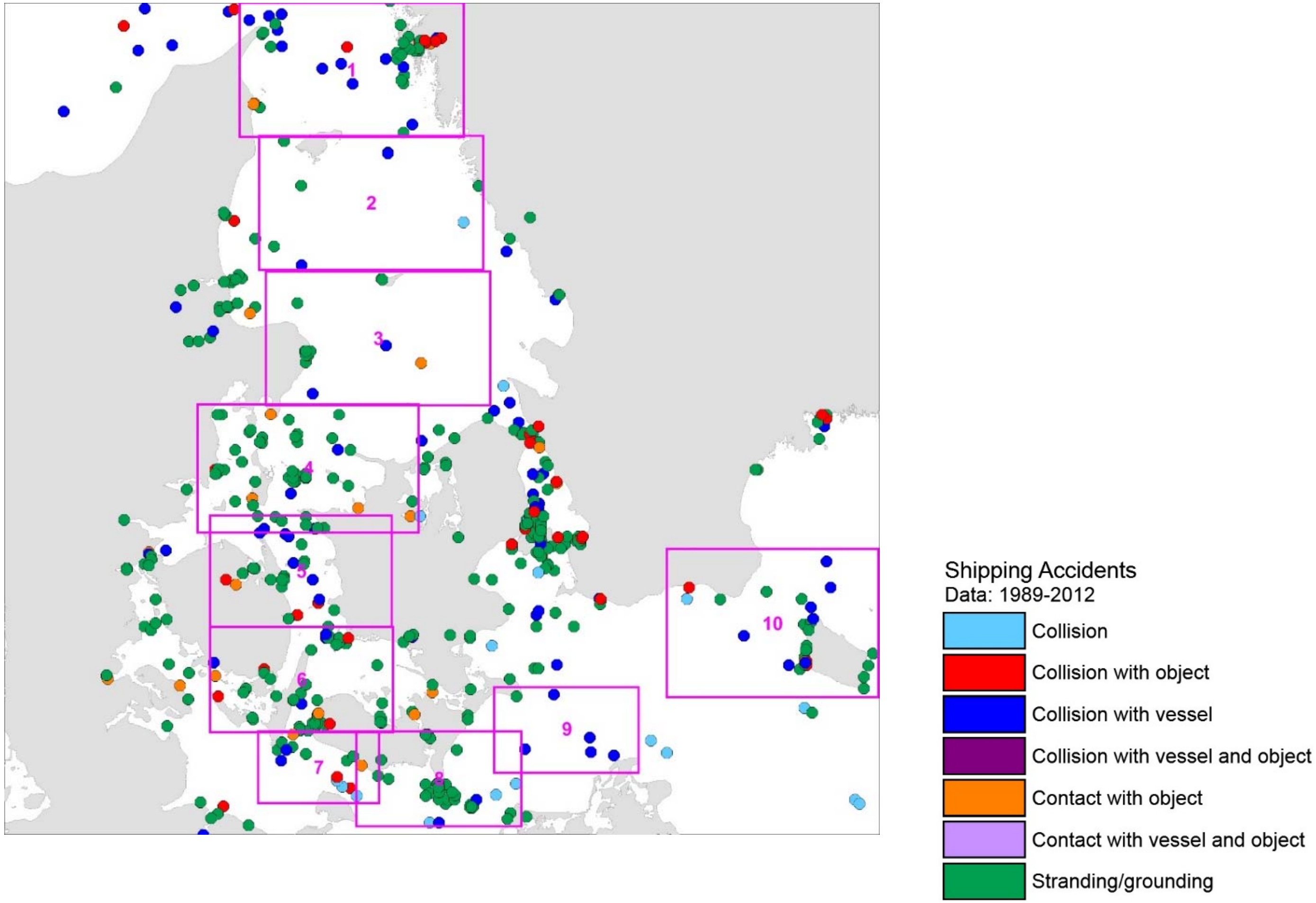
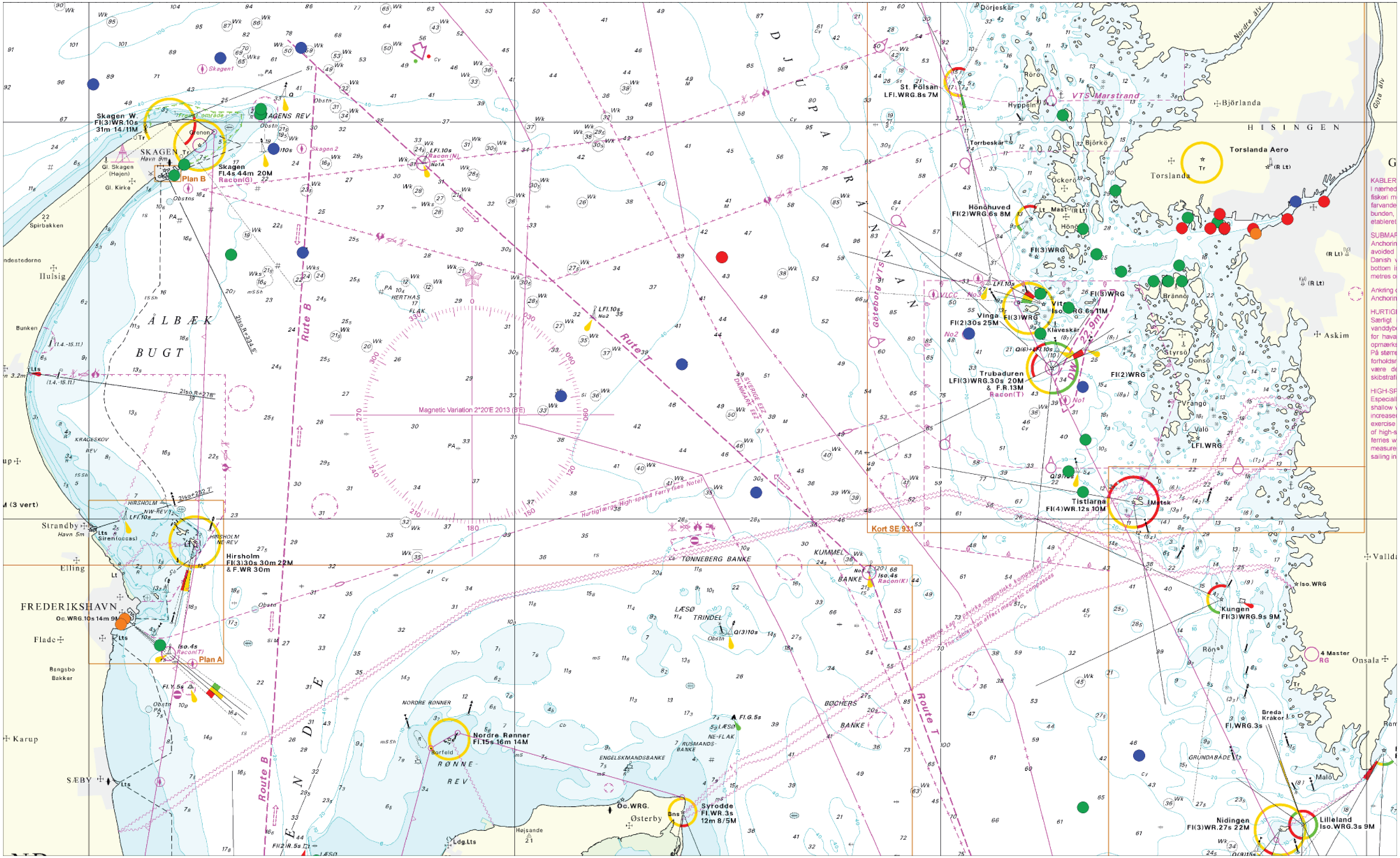
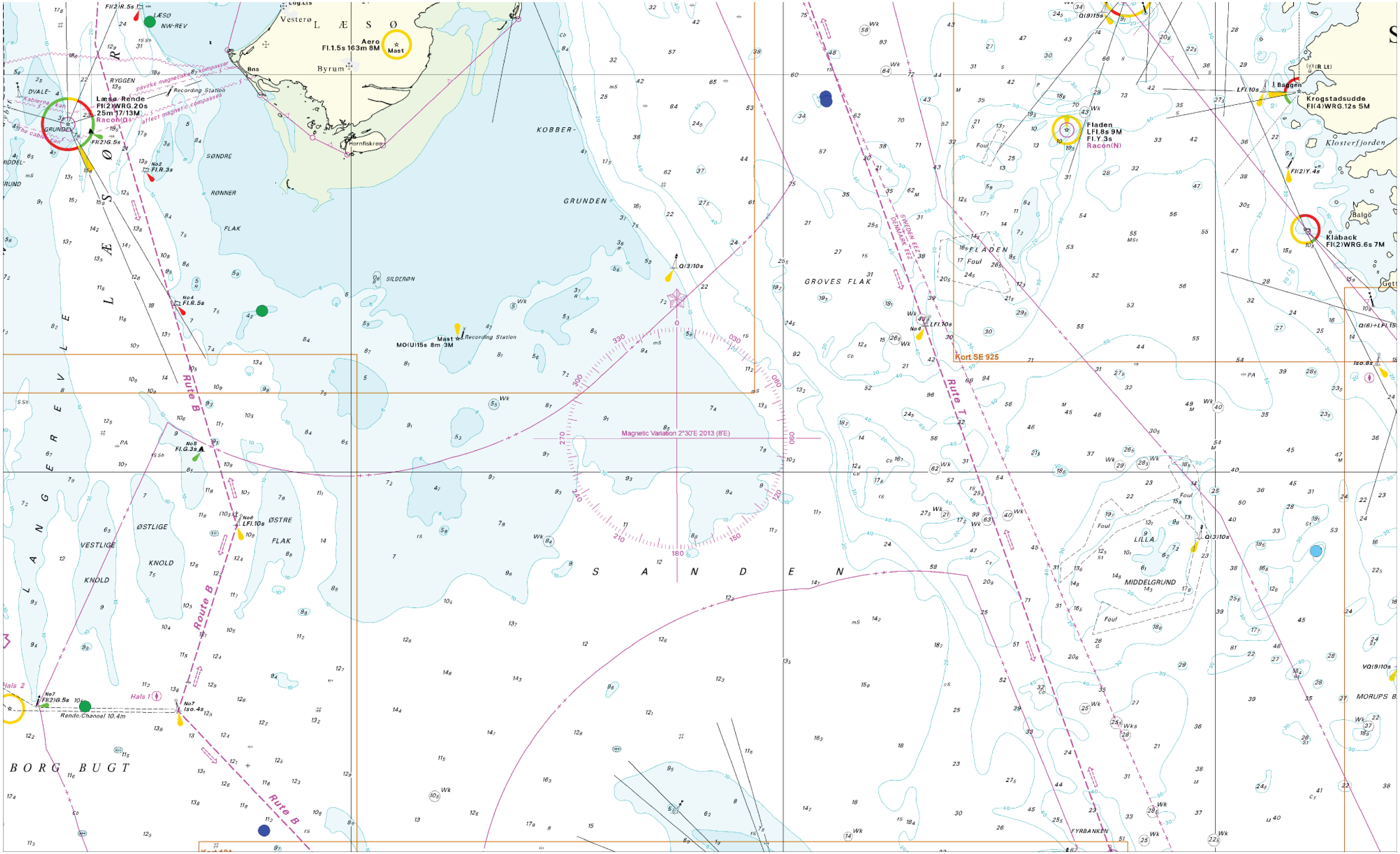
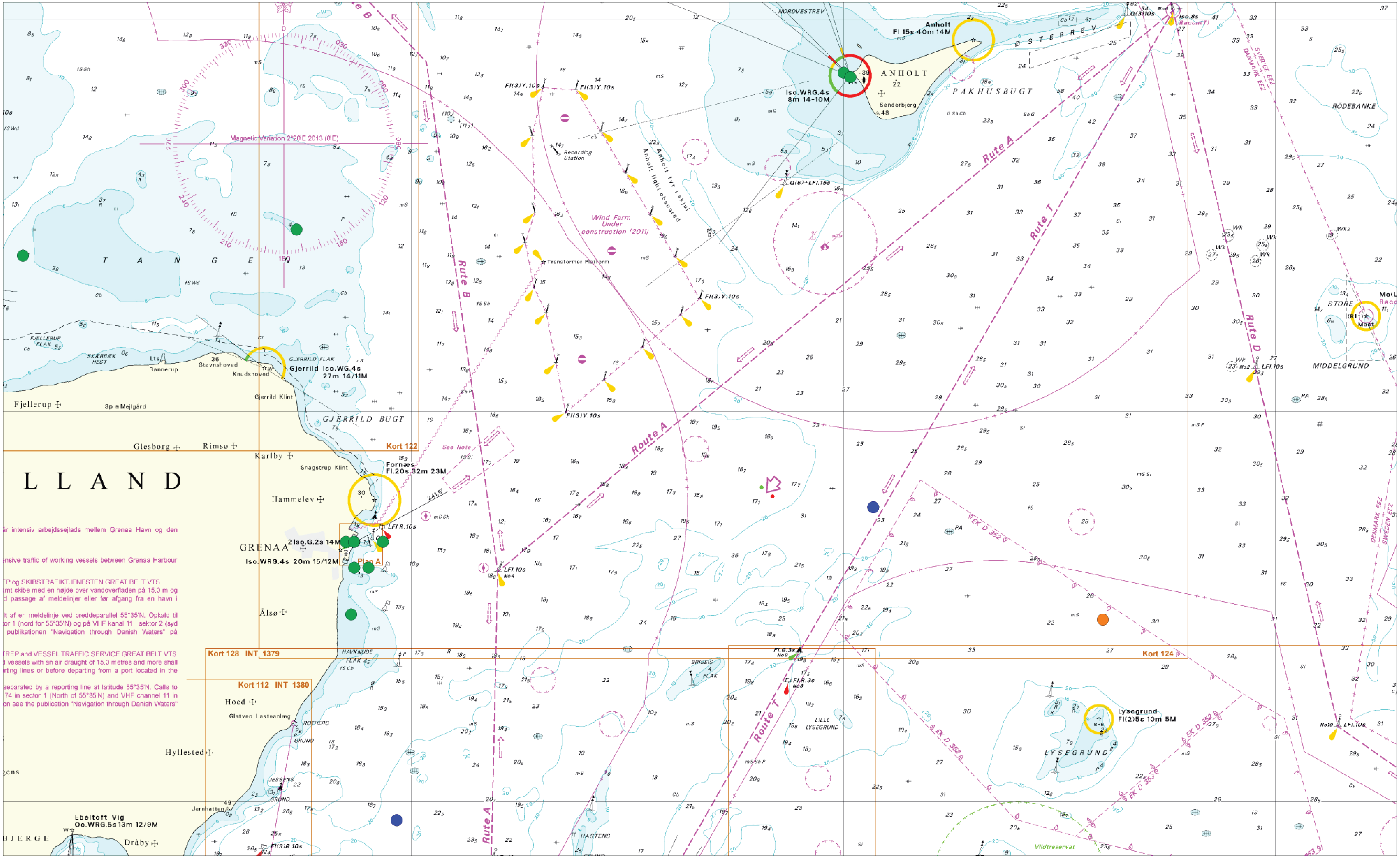


Figure 4 Survey chart with reference to detailed charts

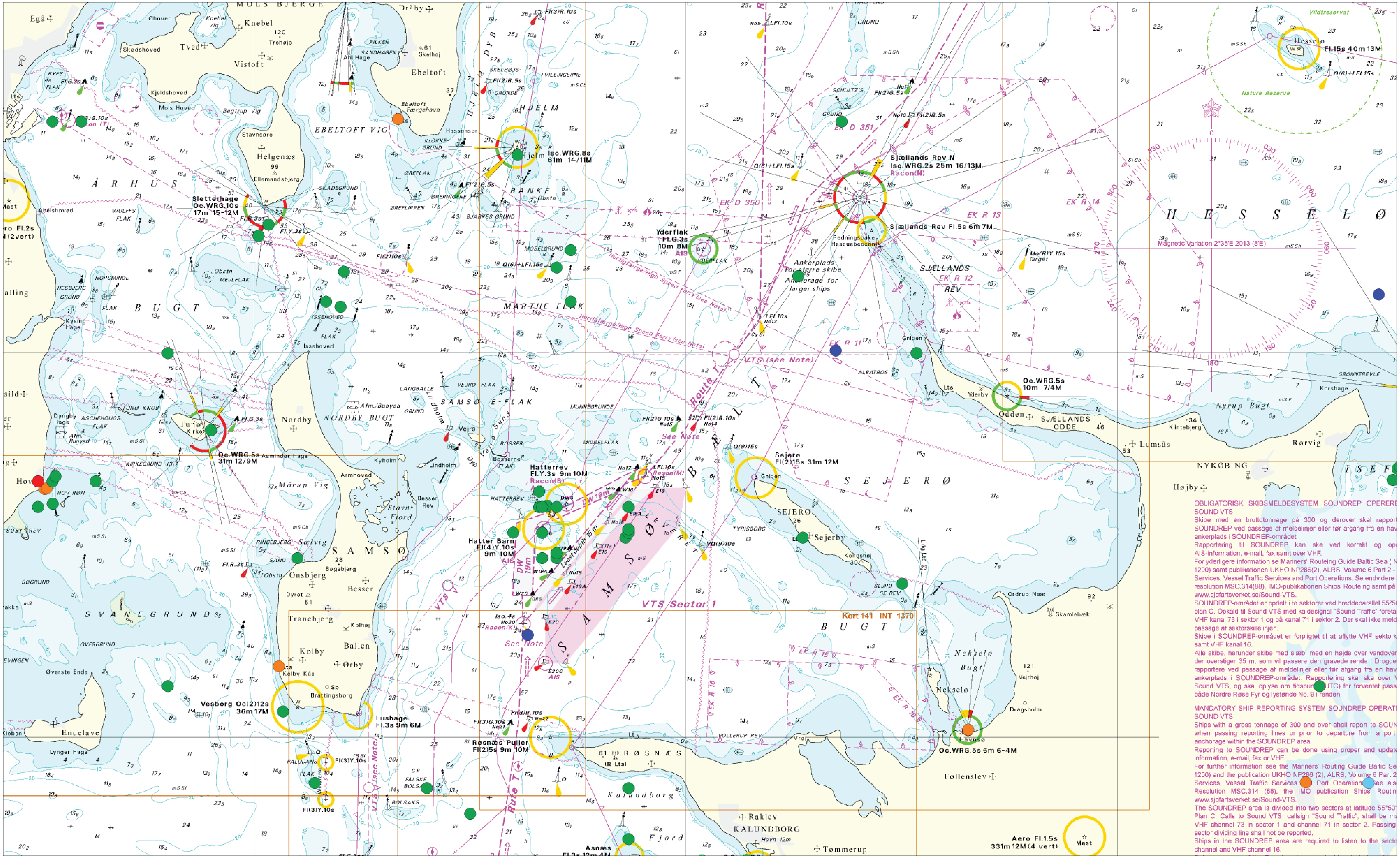
On detailed charts, we can see that the passages with the highest accident rate are those near to Route T, the passage from Hatterrev/Hatter Barn, Agersø Flak and Kadetrenden. These are all included in scenario 2 but not in scenario 1. In the final report, all maps will be produced in high resolution and in size A3.



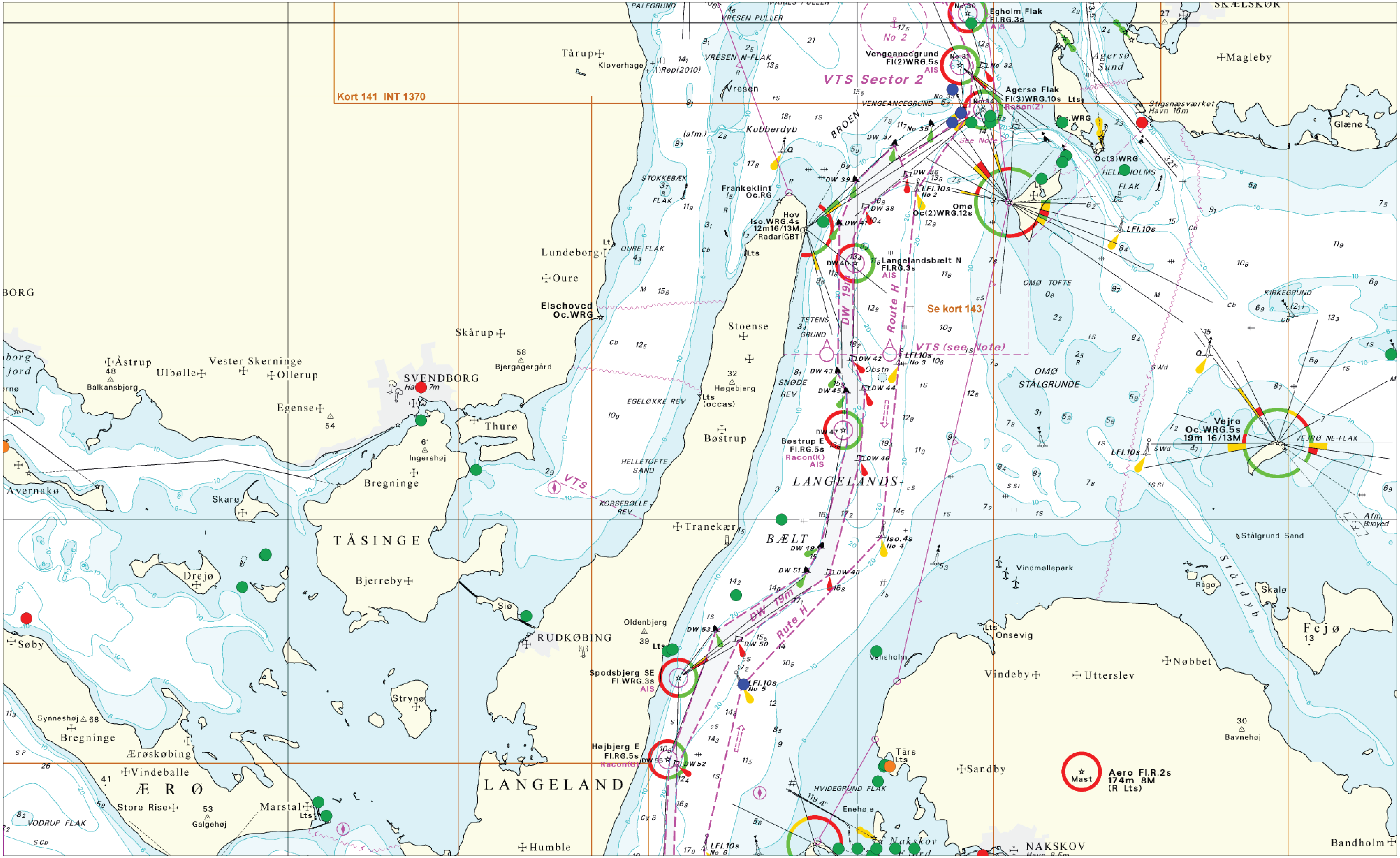

LÆSØ
Vesterø
Byrum
Aero
Fl.1.5s 163m 8M
Mast
Hornfiskrøn
Læsø Rende
Fl(2)WRG.20s
25m 17/13M
Racon(Q)
GRUNDE
RYGGEN
DVALE-
SØNDRE
RØNNER
FLAK
KOBBER-
GRUNDEN
SILDERØN
MO(U)15s 8m 3M
Recording Station
LÆSØ
NW-REV
påvirke magnetiske kompasser
affect magnetic compasses
Rute B
Route B
ØSTRE
FLAK
ØSTLIGE
VESTLIGE
KNOLD
LANGERENDE
BORG BUGT
Hals 1
Hals 2
Rende/Channel 10,4m
Magnetic Variation 2°30'E 2013 (8'E)
S A N D D E N
GROVES FLAK
SWEDEN EEZ
DENMARK EEZ
Rute T
FLADEN
Fladen
LFl.8s 9M
Fl.Y.3s
Racon(N)
Kort SE 925
LILLA
MIDDELGRUND
FYRBANKEN
Baggen
Krogstadsudde
Fl(4)WRG.12s 5M
Klosterfjorden
Balgö
Kläback
Fl(2)WRG.6s 7M
MORUPS B
Q(3)10s
Q(9)15s
VQ(9)10s
LFl.10s



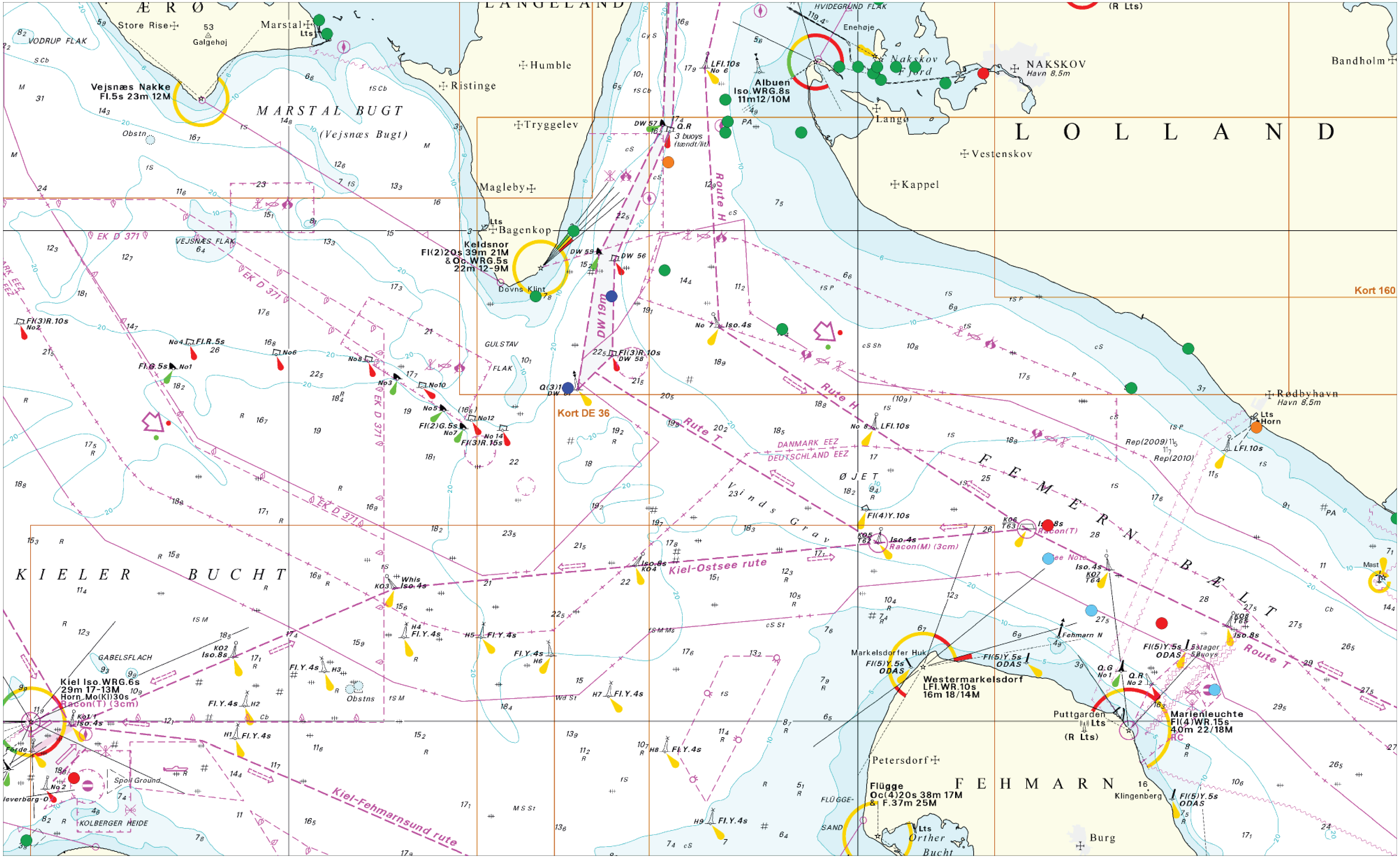
NORDVESTREV
Anholt
Fl.15s 40m 14M
Ø S T E R R E V
ANHOLT
Sønderbjerg
PAKHUSBUGT
Iso.WRG.4s
8m 14-10M
Q(6)+LFl.15s
Fl(3)Y.10s
Recording Station
Anholt tyr i skjul
Anholt light obscured
Wind Farm
Under
construction (2011)
Transformer Platform
Magnetic Variation 2°20'E 2013 (8'E)
T A N G E
FJELLERUP FLAK
SKÆRBÆK HEST
Bønnerup
Stavnshoved
Knudshoved
GJERRILD FLAK
Gjerrild Iso.WG.4s
27m 14/11M
Gjerrild Klint
Fjellerup
Mejlgård
GJERRILD BUGT
Glesborg
Rimsø
Karlby
Kort 122
L L A N D
Snagstrup Klint
Fornæs
Fl.20s 32m 23M
Hammelev
See Note
Rute B
Rute A
Route A
Rute T
Route T
Rute D
GRENAA
2Iso.G.2s 14M
Iso.WRG.4s 20m 15/12M
Plan A
LFl.R.10s
LFl.10s
No4
Ålsø
Kort 128 INT 1379
Kort 112 INT 1380
HAVKNUDE FLAK
Hoed
Glatved Lasteanlæg
ROTHERS GRUND
Hyllested
JESSENS GRUND
Jernhatten
Ebeltoft Vig
Oc.WRG.5s 13m 12/9M
Dråby
BJERGE
Fl(3)R.10s
HASTENS
BRISEIS FLAK
Fl.G.3s
No9
Fl.R.3s
No8
LILLE LYSEGRUND
Kort 124
Lysegrund
Fl(2)5s 10m 5M
LYSEGRUND
EK D 352
EK D 353
Vildtreservat
STORE MIDDELGRUND
RÖDEBANKE
SVERIGE EEZ
DANMARK EEZ
Mast
No2
LFl.10s
No10
No6
Iso.8s
Racon (T)
Q(3)10s
ær intensiv arbejdssejlads mellem Grenaa Havn og den
ensive traffic of working vessels between Grenaa Harbour
EP og SKIBSTRAFIKTJENESTEN GREAT BELT VTS
TREP and VESSEL TRAFFIC SERVICE GREAT BELT VTS

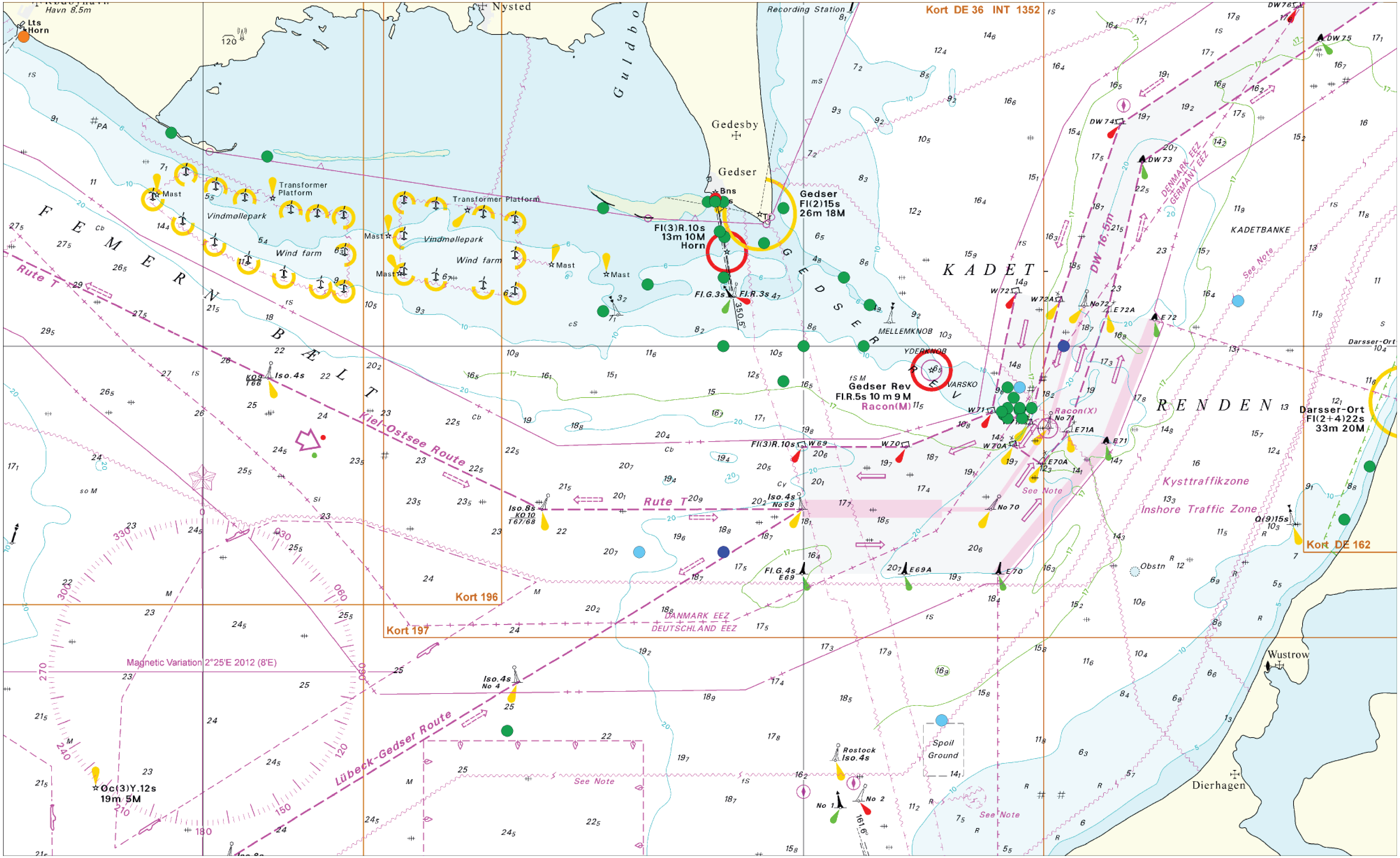

MOLS BJERGE
Knebel
Tved
Vistoft
Ebeltoft
EBELTOFT VIG
Helgenæs
ÅRHUS BUGT
Sletterhage Oc.WRG.10s 17m 15-12M
Hjelm Iso.WRG.8s 61m 14/11M
HJELM BANKE
MARTHE FLAK
Sjællands Rev N Iso.WRG.2s 25m 16/13M Racon(N)
Sjællands Rev Fl.5s 6m 7M
SJÆLLANDS REV
HESSELØ
Hesselø Fl.15s 40m 13M
Nature Reserve
Vildtreservat
Magnetic Variation 2°35'E 2013 (8'E)
Yderflak Fl.G.3s 10m 8M AIS
Ankerplads for større skibe
Anchorage for larger ships
VTS (see Note)
Tunø Oc.WRG.5s 31m 12/9M
NORDBY BUGT
SAMSØ E-FLAK
Hatterrev Fl.Y.3s 9m 10M Racon(B)
Hatter Barn Fl(4)Y.10s 9m 10M AIS
SAMSØ
SAMSØ BÆLT
Route T
VTS Sector 1
SEJERØ BUGT
Sejerø Fl(2)15s 31m 12M
Oc.WRG.5s 10m 7/4M
Odden
SJÆLLANDS ODDE
Nyrup Bugt
Rørvig
Lumsås
NYKØBING
Højby
ISEFJORD
SVANEGRUND
Endelave
Vesborg Oc(2)12s 36m 17M
Lushage Fl.3s 9m 6M
Røsnæs Puller Fl(2)5s 9m 10M
RØSNÆS
Kalundborg Fjord
KALUNDBORG
Nekselø
Havnsø Oc.WRG.5s 6m 6-4M
Aero Fl.1.5s 331m 12M (4 vert)
Kort 141 INT 1370
OBLIGATORISK SKIBSMELDESYSTEM SOUNDREP OPERERE
SOUND VTS
Skibe med en bruttotonnage på 300 og derover skal rapport
SOUNDREP ved passage af meldelinjer eller før afgang fra en hav
ankerplads i SOUNDREP-området.
Rapportering til SOUNDREP kan ske ved korrekt og op
AIS-information, e-mail, fax samt over VHF.
For yderligere information se Mariners' Routeing Guide Baltic Sea (IN
1200) samt publikationen UKHO NP286(2), ALRS, Volume 6 Part 2 -
Services, Vessel Traffic Services and Port Operations. Se endvidere
resolution MSC.314(88), IMO-publikationen Ships' Routeing samt på
www.sjofartsverket.se/Sound-VTS.
SOUNDREP-området er opdelt i to sektorer ved breddeparallel 55°50
plan C. Opkald til Sound VTS med kaldesignal "Sound Traffic" foreta
VHF kanal 73 i sektor 1 og på kanal 71 i sektor 2. Der skal ikke meld
passage af sektorskillelinjen.
Skibe i SOUNDREP-området er forpligtet til at aflytte VHF sektork
samt VHF kanal 16.
Alle skibe, herunder skibe med slæb, med en højde over vandover
der overstiger 35 m, som vil passere den gravede rende i Drogde
rapportere ved passage af meldelinjer eller før afgang fra en hav
ankerplads i SOUNDREP-området. Rapportering skal ske over V
Sound VTS, og skal oplyse om tidspunkt (UTC) for forventet pass
både Nordre Røse Fyr og lystønde No. 9 i renden.
MANDATORY SHIP REPORTING SYSTEM SOUNDREP OPERATE
SOUND VTS
Ships with a gross tonnage of 300 and over shall report to SOUN
when passing reporting lines or prior to departure from a port
anchorage within the SOUNDREP area.
Reporting to SOUNDREP can be done using proper and update
information, e-mail, fax or VHF.
For further information see the Mariners' Routing Guide Baltic Se
1200) and the publication UKHO NP286 (2), ALRS, Volume 6 Part 2
Services, Vessel Traffic Services and Port Operations. See als
Resolution MSC.314 (88), the IMO publication Ships' Routing
www.sjofartsverket.se/Sound-VTS.
The SOUNDREP area is divided into two sectors at latitude 55°50'
Plan C. Calls to Sound VTS, callsign "Sound Traffic", shall be ma
VHF channel 73 in sector 1 and channel 71 in sector 2. Passing
sector dividing line shall not be reported.
Ships in the SOUNDREP area are required to listen to the secto
channel and VHF channel 16.

VTS Sector 1
Asnæs
Fl.3s 12m4M
Aero Fl.1.5s
331m 12M (4 vert)
Aero Fl.2s 152m 10M
Aero Fl.2s
217m 10M(3vert)
Asnæsværket
Tømmerup
Rørby
S J Æ L L A N D
ASNÆS REV
LILLEGRUND
FL.G.3s
FL.R.3s
Fyns Hoved
Horseklint
RYGGEN
STUBBERUP KNOLD
SNAVE RØN
AGERNÆS FLAK
Nørreby Hals
Spoil Ground
Klinte
Krogsbølle
Hasmark
Orritslev
Hindsholm
Digerbanke
Gabet
Enebærodde
Fl.WRG
Oc(2)WRG
Dalby
Radar(GBT)
Kort 114 INT 1377
ODENSE FJORD
2°00'E 2012 (8'E)
ODENSE
Romsø Tue
Fl.WRG.3s
10m 11-7M
Racon(T)
AIS
POLYPHEM
TORSKEPLADEN
ROMSØ NW-REV
Romsø
Q(3)10s
ROMSØ PULLER
ALEREVET
Stavreshoved
Kerteminde
Kerteminde Bugt
MØLLEGRUND
Revninge
Rising Hoved
Bovense
Skalkenbjerg
Ankerplads for større skibe
Anchorage for larger ships
VTS (see Note)
L Y S E G R U N D E
ELEFANTGRUND
Jammerland
Bugt
SVALLERUP BANKE
Svallerup
Urhøj
Reersø
Musholm
Musholm Bugt
Drøsselbjerg
VTS Sector 2
Gas (see Note)
SLETTINGS GRUND
Kirke Stillinge
Se kort 143
Route T
Øster-
renden
Vemmelev
Halsskov
Wind Farm
Fl(3)Y.10s
Sprogø
Fl.5s
Racon(N)
Korsør
Havn 8m
NYBORG
Havn 7m
Lindholm Havn 11m
Vester-
renden
SPROGØ PULLER
Knudshoved
Oc.WRG.10s
Østerrenden S
Fl(3)R.10s
Racon(O)
Femhøje
Kort 142 INT 1368
Stevnshøj
DRONNING MARIES PULLER
PALEGRUND
SKÆLSKØR
F Y N
OBLIGATORISK SKIBSMELDESYSTEM BELTREP o
SKIBSTRAFIKTJENESTEN GREAT BELT VTS
Skibe med en bruttotonnage på 50 og derover sam
skibe med en højde over vandoverfladen på 15,0 m o
derover skal melde til BELTREP over VHF ved passag
af meldelinjer eller før afgang fra en havn
BELTREP-området.
BELTREP-området er opdelt i to sektorer adskilt af e
meldelinje ved breddeparallel 55°35'N. Opkald til Grea
Belt VTS foretages på VHF kanal 74 i sektor 1 (nord f
55°35'N) og på VHF kanal 11 i sektor 2 (syd f
55°35'N). For yderligere informationer se publikatione
"Navigation through Danish Waters" på www.sofart.dk.
MANDATORY SHIP REPORTING SYSTEM BELTRE
and VESSEL TRAFFIC SERVICE GREAT BELT VTS
Vessels with a gross tonnage of 50 and more ar
vessels with an air draught of 15.0 metres and mor
shall report to BELTREP on VHF when passing reportin
lines or before departing from a port located in th
BELTREP area.
The BELTREP area is divided into two secto
separated by a reporting line at latitude 55°35'N. Calls
Great Belt VTS shall be made on VHF channel 74
sector 1 (North of 55°35'N) and VHF channel 11
sector 2 (South of 55°35'N). For further information se
the publication "Navigation through Danish Waters" o
www.sofart.dk.

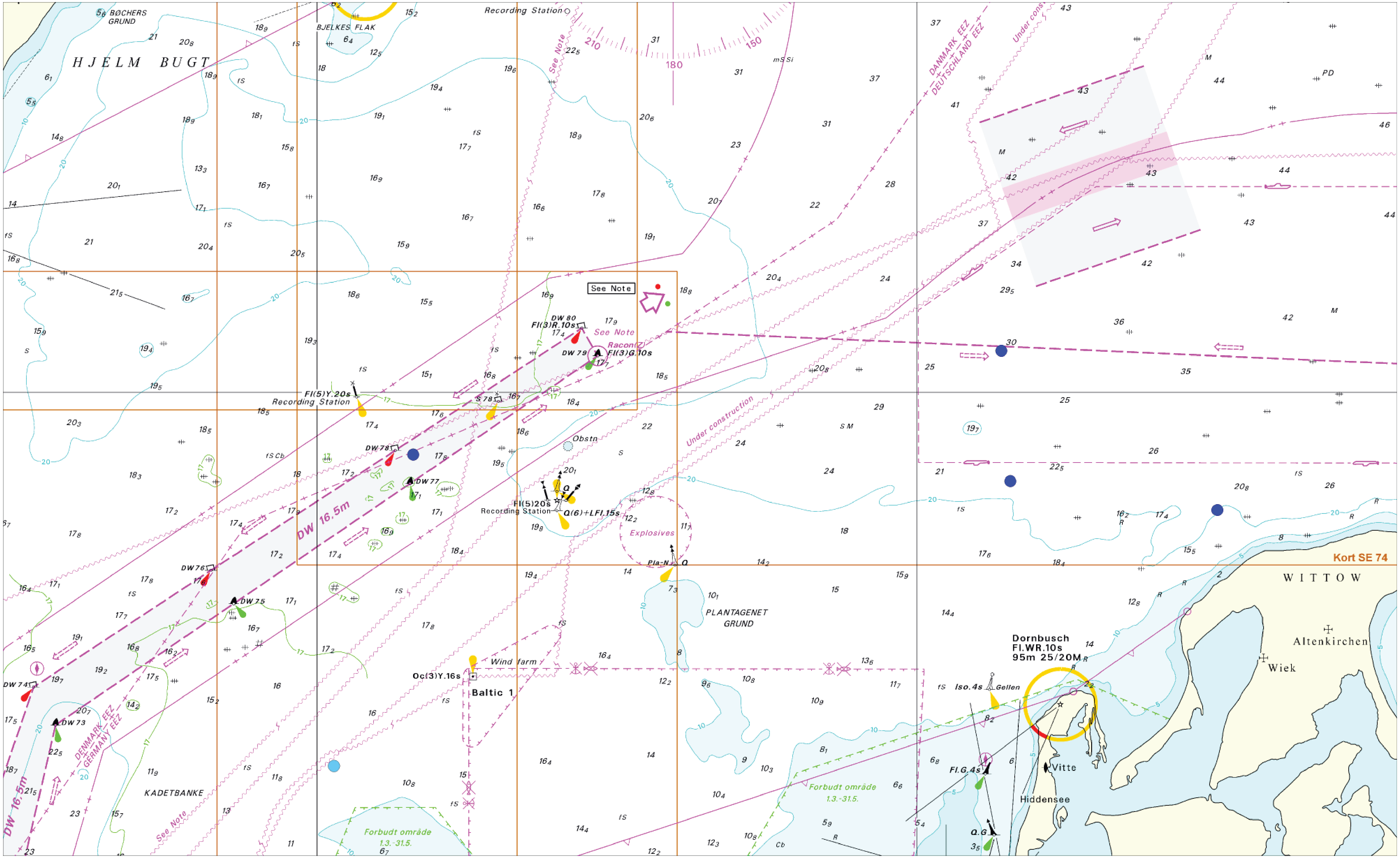


Kort 141 INT 1370
Se kort 143
VTS Sector 2
VTS (see Note)
Tårup
Kløverhage
Vresen
VRESEN PULLER
VRESEN N-FLAK
Kobberdyb
BROEN
STOKKEBÆK FLAK
OURE FLAK
Lundeborg
Oure
Elsehoved Oc.WRG
Skårup
Bjergagergård
Frankeklint Oc.RG
Hov Iso.WRG.4s 12m16/13M Radar(GBT)
Vengeancegrund Fl(2)WRG.5s AIS
Egholm Flak Fl.RG.3s AIS
Agersø Flak Fl(3)WRG.10s Lts Racon(Z)
Agersø Sund
Magleby
SKÆLSKØR
Stigsnæsværket Havn 16m
Glænø
HELLEHOLMS FLAK
Omø Oc(2)WRG.12s
OMØ TOFTE
Langelandsbælt N Fl.RG.3s AIS
DW 19m
Route H
TETENS GRUND
SNØDE REV
Stoense
Høgebjerg
Lts (occas)
EGELØKKE REV
Bøstrup
Bøstrup E Fl.RG.5s Racon(K) AIS
OMØ STÅLGRUNDE
KIRKEGRUND
Vejrø Oc.WRG.5s 19m 16/13M
VEJRØ NE-FLAK
LANGELANDS-
BÆLT
HELLETOFTE SAND
KORSEBØLLE REV
Tranekær
Stålgrund Sand
Vindmøllepark
Rågø
Skalø
Stålldyb
Fejø
SVENDBORG
Åstrup
Vester Skerninge
Ulbølle
Ollerup
Balkansbjerg
Egense
Thurø
Ingershøj
Bregninge
Skarø
Avernakø
TÅSINGE
Drejø
Bjerreby
Siø
RUDKØBING
Oldenbjerg
Spodsbjerg SE Fl.WRG.3s AIS
Søby
Strynø
Synneshøj 68
Bregninge
Ærøskøbing
Vindeballe
Æ R Ø
Store Rise
Marstal
Galgehøj
VODRUP FLAK
LANGELAND
Humble
Højbjerg E Fl.RG.5s Racon(G)
Onsevig
Vensholm
Vindeby
Utterslev
Nøbbet
Bavnehøj
Tårs Lts
Sandby
Aero Fl.R.2s 174m 8M (R Lts)
HVIDEGRUND FLAK
Enehøje
Nakskov Fjord
NAKSKOV
Bandholm

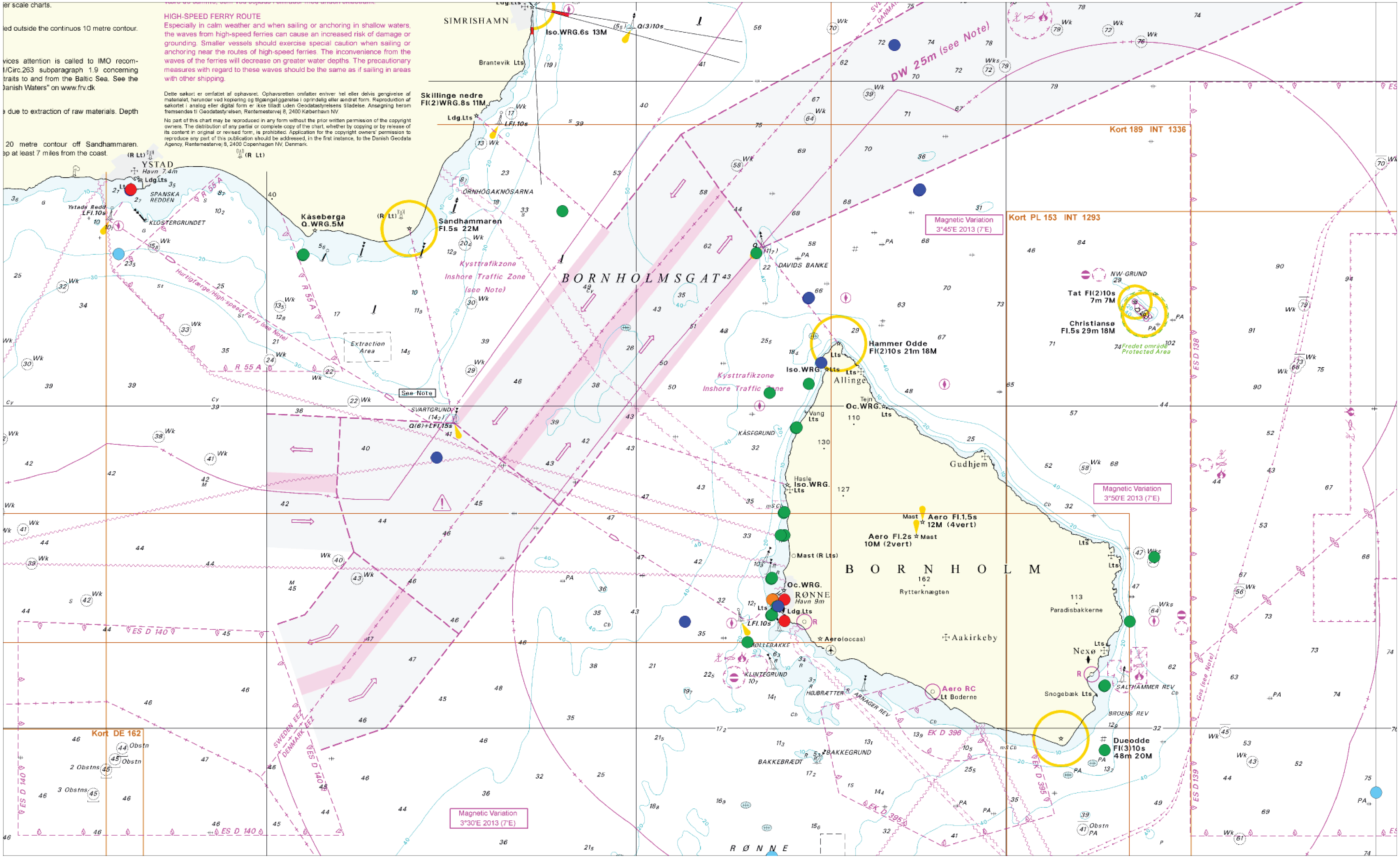

ÆRØ
LANGELAND
LOLLAND
KIELER BUCHT
FEHMARN
FEMERN BÆLT
MARSTAL BUGT
(Vejsnæs Bugt)
Store Rise
Marstal
Galgehoj
VODRUP FLAK
Vejsnæs Nakke
Fl.5s 23m 12M
Humble
Ristinge
Tryggelev
Magleby
Bagenkop
Keldsnor
Fl(2)20s 39m 21M
& Oc.WRG.5s
22m 12-9M
Dovns Klint
VEJSNÆS FLAK
GULSTAV
FLAK
Kort DE 36
Kort 160
NAKSKOV
Havn 8,5m
Nakskov Fjord
Albuen
Iso.WRG.8s
11m12/10M
Langø
Enehøje
HVIDEGRUND FLAK
Vestenskov
Kappel
Bandholm
Rødbyhavn
Havn 8,5m
Lts Horn
Route H
Route T
Rute T
Rute H
DW 19m
DANMARK EEZ
DEUTSCHLAND EEZ
ØJET
Vinds Grav
Kiel-Ostsee rute
Kiel-Fehmarnsund rute
EK D 371
GABELSFLACH
Kiel Iso.WRG.6s
29m 17-13M
Horn Mo(Kl)30s
Racon(T) (3cm)
Spoil Ground
KOLBERGER HEIDE
Markelsdorfer Huk
Westermarkelsdorf
LFl.WR.10s
16m 18/14M
Puttgarden
Marienleuchte
Fl(4)WR.15s
40m 22/18M
Petersdorf
Flügge
Oc(4)20s 38m 17M
& F.37m 25M
Orther Bucht
Klingenberg
Burg
Racon(M) (3cm)
Racon(T)
Obstns



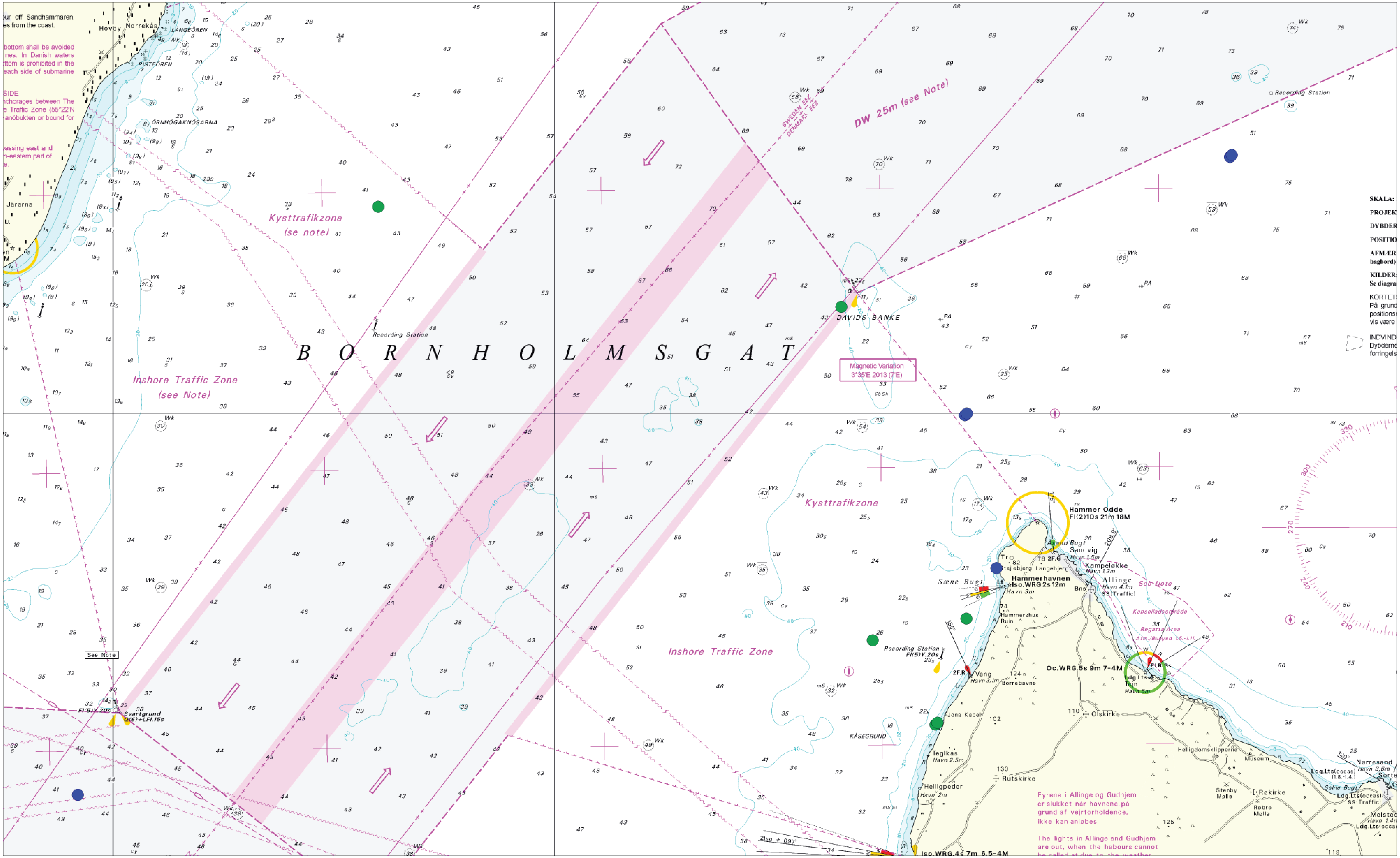
Lts Horn
Nysted
Guldbo
Gedesby
Gedser
Recording Station
Kort DE 36 INT 1352
Transformer Platform
Vindmøllepark
Wind farm
Mast
Gedser Fl(2)15s 26m 18M
Fl(3)R.10s 13m 10M Horn
Fl.G.3s
Fl.R.3s
GEDSER
MELLEMKNOB
YDERKNOB
VARSKO
REV
Gedser Rev Fl.R.5s 10 m 9 M
Racon(M)
KADET-
RENDEN
KADETBANKE
DW 16.5m
DENMARK EEZ
GERMANY EEZ
See Note
Racon(X)
Darsser-Ort Fl(2+4)22s 33m 20M
Kort DE 162
Kysttrafikzone
Inshore Traffic Zone
Q(9)15s
FEMERN BÆLT
Rute T
Kiel-Ostsee Route
Iso.4s
Iso.8s
Fl.G.4s
Kort 196
Kort 197
DANMARK EEZ
DEUTSCHLAND EEZ
Magnetic Variation 2°25'E 2012 (8'E)
Lübeck-Gedser Route
Oc(3)Y.12s 19m 5M
Rostock Iso.4s
Spoil Ground
Wustrow
Dierhagen



BØCHERS GRUND
HJELM BUGT
BJELKES FLAK
Recording Station
See Note
DANMARK EEZ
DEUTSCHLAND EEZ
Under construction
DW 80
Fl(3)R.10s
DW 79
Fl(3)G.10s
Racon(Z)
Fl(5)Y.20s
Recording Station
S 78
DW 78
DW 77
DW 16.5m
Obstn
Fl(5)20s
Recording Station
Q(6)+LFl.15s
Explosives
Pla-N
Q
DW 76
DW 75
DW 74
DW 73
DANMARK EEZ
GERMANY EEZ
KADETBANKE
PLANTAGENET GRUND
Wind farm
Oc(3)Y.16s
Baltic 1
Forbudt område
1.3.-31.5.
Kort SE 74
WITTOW
Altenkirchen
Wiek
Dornbusch
Fl.WR.10s
95m 25/20M
Iso.4s
Gellen
Fl.G.4s
Vitte
Hiddensee
Q.G



ler scale charts.
led outside the continuos 10 metre contour.
vices attention is called to IMO recom-
l/Circ.263 subparagraph 1.9 concerning
traits to and from the Baltic Sea. See the
Danish Waters" on www.frv.dk
e due to extraction of raw materials. Depth
20 metre contour off Sandhammaren.
ep at least 7 miles from the coast.
HIGH-SPEED FERRY ROUTE
Especially in calm weather and when sailing or anchoring in shallow waters, the waves from high-speed ferries can cause an increased risk of damage or grounding. Smaller vessels should exercise special caution when sailing or anchoring near the routes of high-speed ferries. The inconvenience from the waves of the ferries will decrease on greater water depths. The precautionary measures with regard to these waves should be the same as if sailing in areas with other shipping.
Dette søkort er omfattet af ophavsret. Ophavsretten omfatter enhver hel eller delvis gengivelse af materialet, herunder ved kopiering og tilgængeliggørelse i oprindelig eller ændret form. Reproduktion af søkortet i analog eller digital form er ikke tilladt uden Geodatastyrelsens tilladelse. Ansøgning herom fremsendes til Geodatastyrelsen, Rentemestervej 8, 2400 København NV.
No part of this chart may be reproduced in any form without the prior written permission of the copyright owners. The distribution of any partial or complete copy of the chart, whether by copying or by release of its content in original or revised form, is prohibited. Application for the copyright owners' permission to reproduce any part of this publication should be addressed, in the first instance, to the Danish Geodata Agency, Rentemestervej 8, 2400 Copenhagen NV, Denmark.
SIMRISHAMN
Iso.WRG.6s 13M
Brantevik Lts
Skillinge nedre
Fl(2)WRG.8s 11M
Ldg.Lts
LFl.10s
YSTAD
Havn 7.4m
Ldg.Lts
SPANSKA REDDEN
KLOSTERGRUNDET
Ystads Redd
LFl.10s
Kåseberga
Q.WRG.5M
Sandhammaren
Fl.5s 22M
ÖRNHÖGAKNÖSARNA
Kystrafikzone
Inshore Traffic Zone
(see Note)
Hurtigfærge High-speed Ferry (see Note)
Extraction Area
See Note
SVARTGRUNDET
Q(6)+LFl.15s
BORNHOLMSGAT
DW 25m (see Note)
Kort 189 INT 1336
Kort PL 153 INT 1293
Magnetic Variation
3°45'E 2013 (7'E)
DAVIDS BANKE
NW-GRUND
Tat Fl(2)10s
7m 7M
Christiansø
Fl.5s 29m 18M
Fredet område
Protected Area
Hammer Odde
Fl(2)10s 21m 18M
Iso.WRG
Allinge
Oc.WRG.
Tejn
Vang
KÅSEGRUND
Gudhjem
Magnetic Variation
3°50'E 2013 (7'E)
Hasle
Iso.WRG.
Aero Fl.1.5s
12M (4vert)
Aero Fl.2s
10M (2vert)
Mast (R Lts)
B O R N H O L M
Rytterknægten
Paradisbakkerne
Oc.WRG.
RØNNE
Havn 9m
Ldg.Lts
LFl.10s
Aero(occas)
Aakirkeby
Nexø
MØLLEBAKKE
KLINTEGRUND
HØJBRÆTTER
ARNAGER REV
Aero RC
Lt Boderne
Snogebæk Lts
SALTHAMMER REV
BROENS REV
Dueodde
Fl(3)10s
48m 20M
EK D 396
EK D 395
ES D 138
ES D 139
ES D 140
Kort DE 162
SWEDEN EEZ
DENMARK EEZ
BAKKEBRÆDT
BAKKEGRUND
Magnetic Variation
3°30'E 2013 (7'E)
R Ø N N E
Gas (see Note)



B O R N H O L M S G A T
Kysttrafikzone
(se note)
Inshore Traffic Zone
(see Note)
DW 25m (see Note)
SWEDEN EEZ
DENMARK EEZ
DAVIDS BANKE
Magnetic Variation
3°35'E 2013 (7'E)
Recording Station
Hovby
Norrekås
LANGEÖREN
RISTEÖREN
ÖRNHÖGAKNOSARNA
Järarna
See Note
Svartgrund
Hammer Odde
Fl(2)10s 21m 18M
Sandvig
Allinge
Kampeløkke
Hammerhavnen
Iso.WRG 2s 12m
Sæne Bugt
Hammershus Ruin
Vang
Oc.WRG 5s 9m 7-4M
Tejn
Kapsejladsområde
Regatta Area
Jons Kapel
Olskirke
KÅSEGRUND
Teglkås
Helligpeder
Rutskirke
Helligdomsklipperne
Museum
Stenby Mølle
Røkirke
Nørresand
Fyrene i Allinge og Gudhjem
er slukket når havnene på
grund af vejrforholdende,
ikke kan anløbes.
The lights in Allinge and Gudhjem
are out, when the habours cannot
Iso.WRG 4s 7m 6.5-4M