Scientific Journals
of the Maritime University of Szczecin

Zeszyty Naukowe
Akademii Morskiej w Szczecinie

2023, 75 (147), 79–88
ISSN 2392-0378 (Online)
DOI: 10.17402/576

Received: 18.10.2022
Accepted: 12.04.2023
Published: 30.09.2023

The impact of the modified ships' routes in the Kattegat on the safety of navigation at the entrance to the Baltic Sea

Agnieszka Kerbrat[1]✉, Sambor Guze[2]

[1] https://orcid.org/0000-0003-2660-3961
[2] https://orcid.org/0000-0003-1635-1924

Gdynia Maritime University, Faculty of Navigation
3 Jana Pawła II Ave., 81-345 Gdynia, Poland
e-mail: [1]a.kerbrat@wn.umg.edu.pl; [2]s.guze@wn.umg.edu.pl
✉ corresponding author

Keywords: safety of navigation, Kattegat, IWRAP, traffic density, COLREG, routes

JEL Classification: C30, L91, L95, N74

Abstract

Since the 1970s, ships in the Kattegat area and the Baltic Sea entrances have been advised to use one of the routes established by the Danish Maritime Safety Administration. As time passed, traffic increased significantly, demanding adjustments to the introduced solutions to accommodate new volumes of ships passing through the entrances to the Baltic Sea. It is estimated that about 70,000 vessels are passaged via Kattegat yearly. Additionally, an increase in the traffic of fishing vessels and small pleasure crafts of different types has been observed, necessitating regulation to ensure the safety of navigation for everyone involved. Therefore, on the 1st of July 2020, a new routing system was introduced in the area of Kattegat by the decision of the International Maritime Organization (IMO). This paper focuses on the exact changes made and how those changes may influence the safety of navigation in Kattegat and the Sound, considering the COLREG rules and human factors in planning and executing passage via this area. A short presentation of recent accidents, and a study of difficulties arising from the new traffic organization, will be given. Brief traffic analysis is conducted using IWRAP MK II software, and historical AIS data from research will advance a more detailed examination and simulations. Finally, the introduced routing system's effectiveness is compared using density plots from chosen periods. Furthermore, the analysis of the influence on the safety of navigation, as the introduced solution, is observed to be unusual. New routings have been in force for over two years and are accepted and used by most merchant vessels operating in Kattegat. Even so, this period is too short to clearly state that it is completely safe.

Introduction

The Kattegat area is one of many restricted areas in the world, with unique geographical, hydrological, and meteorological conditions that make it difficult to navigate, even for very experienced navigators. Sailing Directions (NP 18, 2020) provides useful information about prevailing wind, visibility, and sea currents. Additionally, Kattegat has been listed as a particularly sensitive sea area (PSSA) by the IMO since 2005, which means it must be protected from environmental harm, such as pollution from ships that includes oil spills and garbage pollution. One way of protecting the PSSA is by establishing routing systems, and the one used in Kattegat was established in the 1970s and was only nationally approved by Denmark and neighboring countries. The new routing system was adopted by the IMO, which means it must be followed by all traffic. Denmark and Sweden can implement additional, more restrictive measures since it is located in their territorial waters.

To implement the new routing, an extensive IWRAP analysis was prepared by an appointed

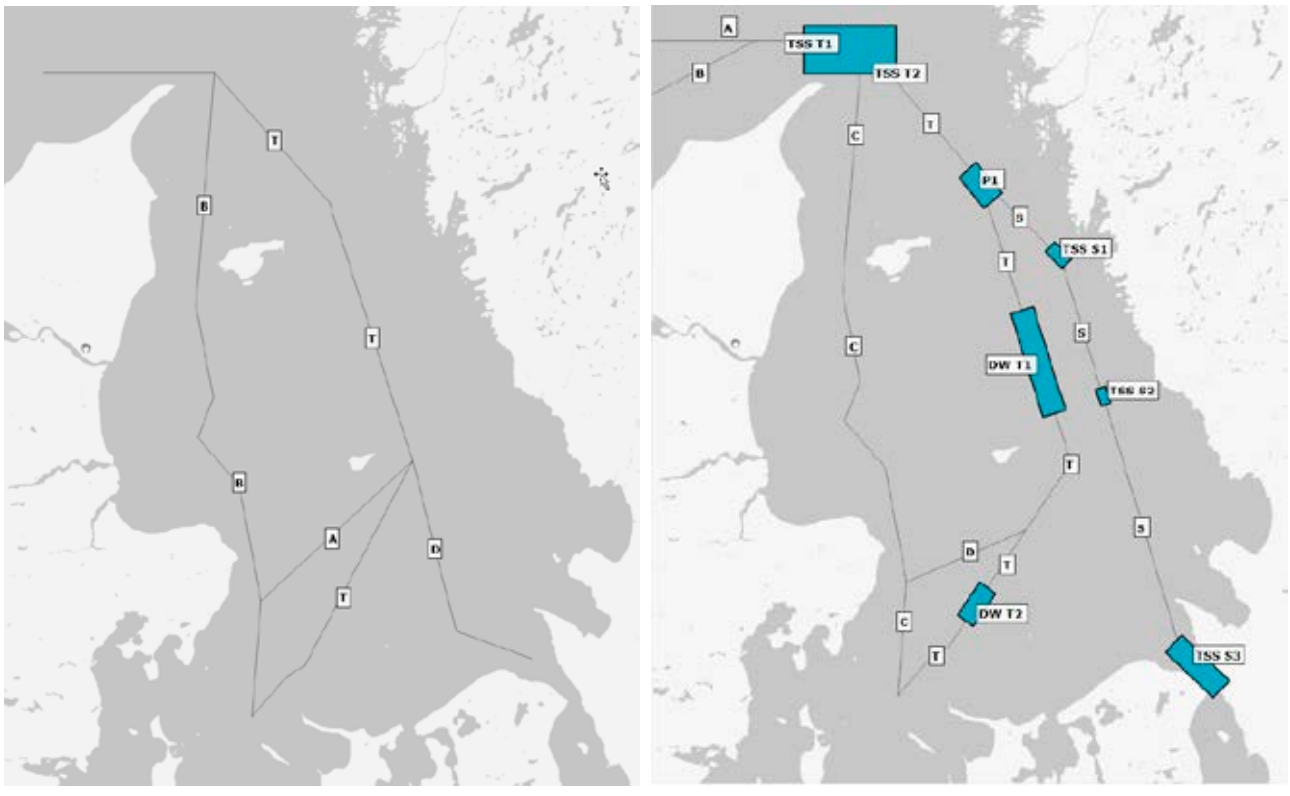
company on the Danish and Swedish governments' demands. IWRAP is software developed by the International Association of Lighthouse Authorities (IALA), and it is a modeling tool useful for maritime risk assessment. IWRAP allows users to analyze traffic information and estimate the frequency of collisions and groundings in a given waterway based on information about traffic volume/composition, route geometry, and bathymetry. The authors chose to use the area of Kattegat as a sample due to the ease of access to AIS traffic data information and familiarity with the natural and traffic conditions, since one of the authors has repeatedly sailed in Kattegat. Furthermore, modeling and simulation options are available for future development of the studies.

This article aims to investigate how the change of routing in the Kattegat has influenced the safety of navigation at the entrances to the Baltic Sea. Specifically, the impact of modified ships' routes on the safety of navigation in this region will be analyzed. This analysis is based on a review of available historical AIS and statistical data and an assessment of the effectiveness of the new routing measures. Data will be processed and analyzed with IWRAP MK II software.

This article is structured as follows. First, we provide background information on the changes to shipping routes in Kattegat, including the impacts they have had on shipping traffic. Second, we describe the methodology used to investigate the safety of navigation at the entrances to the Baltic Sea, including data sources. Third, we present the results of our analysis, including a short description of accidents, as well as any other relevant findings. Finally, we interpret the results and discuss their implications for navigation safety in the Baltic Sea.

Traffic organization in Kattegat after the 1st of July 2020

Together, the Danish Maritime Authority (DMA) and the Swedish Transport Agency (STA) have developed a proposal for a new routing system in the Kattegat area, which includes a new transit route, new traffic separations schemes (TSS), and other new routing measures such as deepwater routes. The two authorities intended to establish the proposed measures through the IMO. The proposal included modifications of the existing Route T in Kattegat and the introduction of an additional route (NCSR 5/3/3, 2017; Kerbrat, 2018). The purpose of the proposed routing system was to enhance ship traffic safety, by relieving traffic from Route T and reducing the number of crossings by recommending Route S for ships



(a) (b)

Figure 1. General overview of (a) old and (b) new traffic arrangements in the area of Kattegat (NCSR, 2017)

to/from the Sound with a draught of 10 meters or less (NCSR 5/3/3, 2017; Kerbrat, 2018; DMA, 2020).

On the 1st of July 2020, planned routing changes in the area of Kattegat came into force. Planned changes started in Skagerrak, where two approach routes to Skagen were implemented: Route A, with a minimum depth of 23 meters outside of Danish territorial waters, and Route B, located 6 nm from the coast and with depths of at least 14 meters. They join before the Skagen peninsula and direct all traffic easterly towards the traffic separation system (TSS). Two TSSs and the precautionary area between them off Skagen were established (TSS T1 & TSS T2 in Figure 1b). Then Route T leads traffic south-easterly towards the precautionary area at Kummel Bank (P 1 in Figure 1b) near Læsø Island. After the Kummel Bank, the waterways then part. Route T continues closer to islands Læsø and Anholt, and Route S is starting to lead traffic closer to Swedish shores. Route T is advised for vessels of draught 10 meters or more, and Route S for all those with less than 10 meters of draught. Along Route T, two deepwater routes were established (DW T1 and DW T2 in Figure 1b). One is located between islands Læsø and Anholt (DW T1), and the second one is at the entrance to the Great Belt (DW T2), both with a charted depth of 19 meters. Northbound traffic not restricted by ships' draught is recommended to use the area east of the deepwater routes, and southbound is recommended to use the area west of deepwater routes. Route S is leading traffic in and out of The Sound. Three TSSs were established along it: TSS Fladen (TSS S1), TSS Lilla Middelgrund (TSS S2), and TSS The Sound (TSS S3). Previously existing Route A, between Grenaa and Anholt, is adjusted to the south, and its name has been changed to Route D. Previous Route D from Anholt to The Sound is canceled and replaced by a recommended direction for traffic, which is intended for the few ships to and from The Sound with a draught more than 10 meters. Route B from Figure 1 has been renamed Route C.

In Table 1, the comparison of old and new traffic organizations is presented in detail.

As a result, the length of the main shipping transit corridor (Route T) changes from 120 nm to 123 nm (a longer route by 2.5%) (NCSR 5/3/3, 2017). A modification in length results in changes in the consumption of fuel and emissions. Quantitative analysis, made by an appointed company, resulted in estimations of consumption and emissions. According to their predictions, the elongation of the route will not have a significant influence on consumption

Table 1. Comparison of old and new traffic arrangements by areas (NCSR, 2017)

Area	Before 1/07/2020	After 1/07/2020	Limitations
Approach to Skagen from the North Sea	One route leading traffic from east to west	• Two routes (A & B) leading traffic towards TSS (TSS T1 & TSS T2)	• Route A – max depth 23 m • Route B – max depth 14 m and inside Danish territorial waters
Skagen	Beginning of Routes T & B	• Precautionary area "Off Skagen" between two traffic separation systems beginning of Routes T & C	
From Skagen to Læsø Island	Route B – west of Læsø Island Route T – east of Læsø Island	• Route C passing west of Læsø Island (replacing Route B) • Route T leading to the precautionary area "Kummel Bank" (P1) • Separation/ beginning of Route S (leading traffic closer to Swedish shores)	• Route T – max depth 19 m • Route S – max draught 10 m
From Læsø Island to Anholt Island	Route B – west of both islands Route T – east of both islands Route S – east of both islands, close to Swedish shores	• Route C – west of both islands (replacing Route B and with corrected waterway) • Route T – deep water route established (DW T1) • Route S – traffic directed between two traffic separation systems (TSS S1 & S2)	• Route T – max depth 19 m • Vessels restricted by draught surrounded by smaller vessels traffic when in DW • Route S – max draught 10 m
From Anholt Island to Great Belt entrance	Route A to Grenaa Route T to Great Belt Route B from Grenaa to Great Belt, joining with Route T	• Route D to Grenaa separating from Route T more south • Route T with deep water route (DW T2) • Route C from Grenaa to Great Belt, joining with Route T	• Route T – max depth 19 m • Vessels restricted by draught surrounded by smaller vessels traffic when in DW
From Anholt Island to The Sound entrance	Route D	• Route S leading to TSS S3 "The Sound" with inshore traffic zones on its sides	• Max draught 10 m

and emissions since the traffic will only be distributed differently (NCSR 5/3/3, 2017; Kerbrat, 2018; DMA, 2020). Additionally, changes to the routing system have resulted in some confusion and potential dangers to shipping in the area. Navigators must now follow new routes and be aware of the changes made to existing ones. The new routing system has forced larger ships to pass or overtake each other with smaller distances between them, creating potential safety risks.

Overall, the new traffic organization in Kattegat aims to improve the safety and efficiency of shipping in the area, but it has also created some challenges for navigators. It will be important for all stakeholders to work together to ensure that the new system is implemented effectively and that shipping in the area remains safe and sustainable.

Accidents reported in the area of Kattegat in the years 2011–2022

There were several navigational accidents in the Kattegat and its approaches from 2011 to 2022, and 9 of them are described in this article. Only accidents investigated by the Danish Maritime Authority Investigation Board (DMAIB) that involve at least one merchant cargo vessel are included, since the main focus of work is to develop tools and solutions for a merchant fleet traveling along established routes. One accident is still under investigation since it occurred in January 2022. It is worth noting that DMAIB only investigates accidents involving commercial vessels on Danish territorial waters or Danish-flagged vessels. Therefore, accidents involving fishing vessels and recreational crafts, both motor and sailing, are not analyzed.

Figure 2 presents accidents reported in the northern part of Kattegat and its approach. The numbers on the navigational chart refer to reports listed in the bibliography. Number 8 is a collision between the fishing boat ORION and the vehicle carrier NECKAR HIGHWAY that occurred on July 1, 2015. As a result, the fishing boat foundered. The crew of the vehicle carrier was not aware of the collision until the next day and, therefore, did not render assistance to the fishing boat crew. The fishing boat sunk within 20 minutes after the collision, and the skipper was lifted from the water by a helicopter.

Number 9 was a collision between the fishing vessel BUSTER and the general cargo ship STAVFJORD on May 16, 2021. In this collision, the vessels were damaged, but none of them sunk, and no persons were injured. Number 10 is a collision between the fishing boat INGER MARIE and the general cargo vessel RIG that occurred on July 10, 2014. As a result, the INGER MARIE sank, and her skipper perished. His body was recovered from the water by a coast guard helicopter; he had no safety equipment on him. It is essential to mention that RIG was in a similar collision situation with a fishing

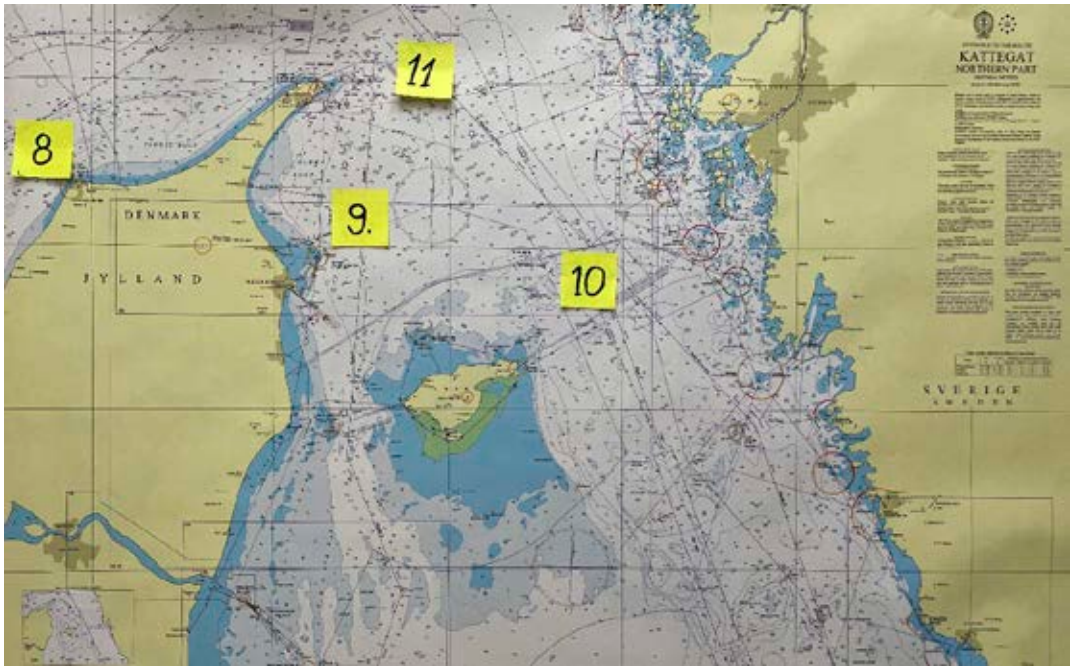


Figure 2. Collisions reported in the north part of Kattegat and Skagerrak for the years 2011–2022 (DMAIB, 2011a, 2014a, 2015, 2021))

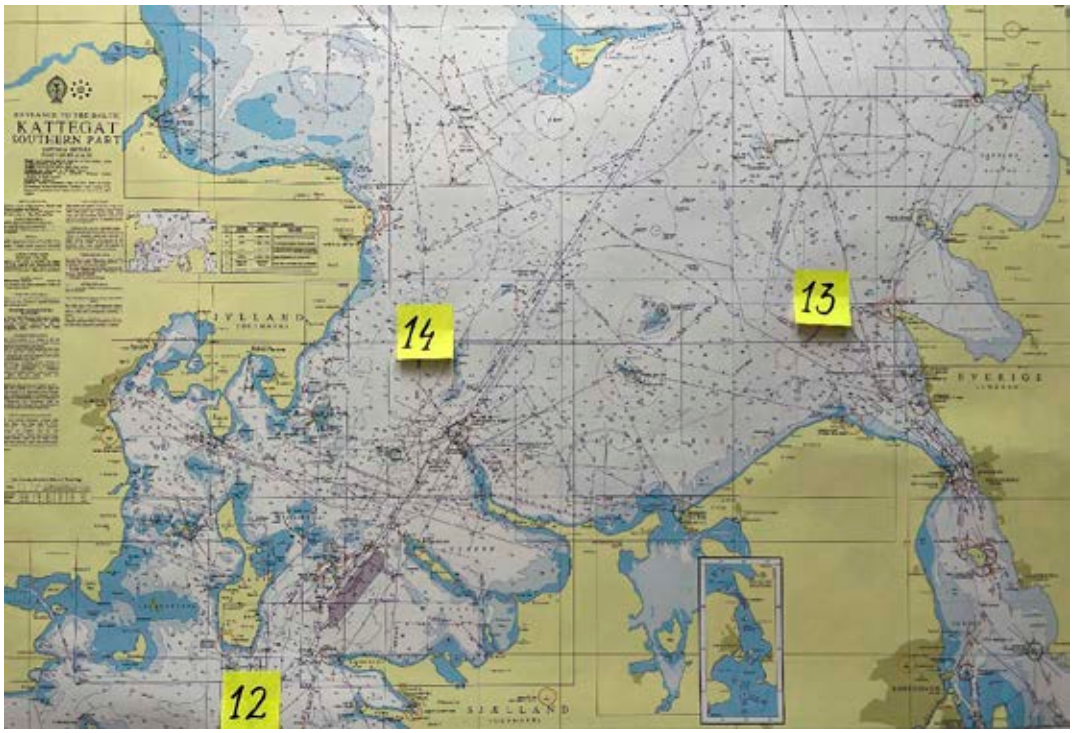


Figure 3. Navigational accidents reported in the south part of Kattegat for the years 2011–2022 (DMAIB, 2011b, 2017, 2022)

boat five miles earlier on its route, and it managed to avoid it at the last moment.

Number 11 is an accident that occurred on June 26, 2011. Two vessels collided with each other, namely, the fishing boat LILLY, which was returning to the port of Skagen from fishing grounds, and the general cargo vessel FRANK W, on its way to Halmstad, Sweden. The vessels noticed each other's presence at a very short distance, and the actions taken to avoid collision were insufficient. As a result, the fishing boat sank within 30 minutes after the collision. Two fishermen from LILLY were lifted to safety by a pilot boat that came to their assistance.

As stated above, all of the collisions that are mentioned involve fishing vessels. According to the information given in "Sailing Directions, vol 18" (NP 18, 2020), the northern part of Kattegat and Skagerrak is a commonly used fishing ground, with many fishing boats passing between these grounds and ports on the west coast of Kattegat. This traffic must cross Routes T and C, and most of the accidents occur at the crossing places.

There are three accident locations presented in Figure 3, all of which occurred between 2011 and 2022 on established routes or in their direct vicinity.

The accident marked by number 12 is the grounding of the container vessel VICTORIA on February 10, 2017. The vessel was about to turn into the Lillegrund deepwater channel when the grounding occurred. The ship was proceeding at a speed of 15 knots, and the crew was aware of the shallow waters in the area. The grounding resulted in serious damage to the ship's hull, and several fuel oil and ballast tanks ruptured, causing spills and pollution to the environment. The accident was considered serious since there was a risk of harm to the marine environment.

Number 13 in Figure 3 indicates the approximate position of the foundering of the Norwegian coaster BJUGNFJORD on January 20, 2022. The ship developed a heavy list and foundered. The accident is still under investigation, and its exact cause remains unknown. Five crew members were rescued. Number 14 is the collision between the general cargo ship VINGA and the trawler N.A. HANSEN on January 18, 2011. The ships were on almost head-on courses and did not observe each other before the collision, so no action to avoid the collision was taken. As a result, the trawler foundered within minutes after the collision, and two fishermen on board perished.

Examples from the southern part of Kattegat demonstrate the variability of accidents in the area and how difficult navigation can be, even when factors such as depth and proximity to the coast are not at play. One grounding incident occurred when a vessel was navigating on instruments due to night conditions, while the weather conditions for two other accidents are unknown.

Figure 4. Navigational accidents reported in the Sound for the years 2011–2022 (DMAIB 2014b, 2020)

Figure 4 shows two accident locations that occurred in channels marked by buoys, with restricted visibility due to dense fog. The accident marked by number 15 was a collision between the refrigerated cargo vessel ATLANTIC LADY, which was going under ballast towards fishing grounds in Norway, and the chemical/product tanker KRASLAVA, which was going under ballast to St. Petersburg in Russia on November 1, 2014. A pilot from the Copenhagen port was still onboard KRASLAVA when the accident occurred. The vessel was exiting the Drogden channel where the pilot was to disembark. Both vessels suffered substantial damage, but none of the crew members were injured, and no environmental harm was reported. Details of the accident can be found in the report prepared by DMAIB (DMAIB, 2014).

The second accident marked by number 16 is a collision between the refrigerated cargo vessel ICE ROSE and the Russian Navy ship KAZANETS 311 on September 23, 2020. The navy vessel was exiting the buoyed channel Flintrannan heading towards the Baltic Sea, while ICE ROSE was approaching the channel from Falsterborev TSS. Both vessels failed to notice each other on their radars until minutes before the collision. The restricted waters and uncertainty of the navy ship's plans caused ICE ROSE's maneuvers to be insufficient and ineffective, while KAZANETS did not take action to avoid the collision. After the collision, KAZANETS left the scene, and the statement received from it by DMAIB did not match the line of events established during the investigation into the ICE ROSE. The detailed accident report is available on the DMAIB website (DMAIB, 2020).

Both of the mentioned accidents in The Sound did not cause environmental harm, but they brought substantial damage to all the involved ships and forced them to halt their operations and proceed with repairs. The official reports from DMAIB do not cover collisions between recreational/sports crafts that are also present in this area. As is visible in Figures 2, 3, and 4, all navigational accidents occurred directly on or in the close vicinity of advised routes and traffic schemes. All of the marked accidents included at least one merchant cargo vessel. Most of the mentioned accidents are collisions between cargo/passenger vessels and small boats, such as fishing boats and crew vessels for wind farms located in the area. Accident no. 12 represents the grounding of cargo vessel VICTORIA. Kattegat and The Sound are known for their foggy weather, which makes navigation into narrow passages even more demanding and dangerous (Gucma, 2009; Bąk, Gucma & Przywarty, 2020; NP 18, 2020). The currents and common strong winds that cause the waves to build up also make the voyage difficult not only for navigational reasons but also may cause stability problems for some smaller cargo and recreational crafts. A detailed case study has been presented in an article entitled "Analysis of navigational casualties within European waters and case study" (Kerbrat, 2021).

Traffic in Kattegat before and after implementing changes

In this section, IWRAP visualizations of traffic density are used to analyze three cases: two weeks of April 2016 (before changes in ship routing), July 2020, and July 2022 (after changes were implemented).

The density plot created by the IWRAP is a so-called traffic density plot, i.e., it divides the region into a number of cells and counts the number of visits to each cell. A counter is maintained for each cell and increased by one every time a ship

visits the cell. If a ship emits more than one position report in the same cell (i.e., without leaving the cell in between), the counter will only be increased by one. The algorithm also interpolates between cells if the distance between consecutive reports is below time and distance thresholds.

April 2016 – before proposing changes in the ship's routing

Figure 5 shows the IWRAP visualization of traffic density based on AIS data from the area, which was used to create new traffic rules. It is a visualization of traffic density from May 2016, made by a company preparing a detailed analysis for the Danish Government before proposing changes to the IMO.

Figure 5 shows a density plot for two weeks of April 2016 created in IWRAP MK II software by the appointed company. The root data used was AIS records made by the Danish government. As is seen in the visualization, the mainstream was mostly condensed around Routes T and B, but there are visible amounts of traffic not organized and passing through Kattegat waters differently. Traffic entering and exiting Kattegat in the north (to and from Skagerrak) was dense and took up all available areas. Ships passing with a variety of courses to and from Skagerrak were joining one recommended route (Route T) just before/after the Skagen Peninsula. From a navigational point of view, this was creating a large problem of crossing and overtaking situations, potentially leading to dangerous collision situations. After passing Skagen, numerous fishing vessels could be encountered, moving between ports on the Swedish and Danish coasts on random patterns, creating another problem for navigators of the merchant fleet traveling along Routes T and B.

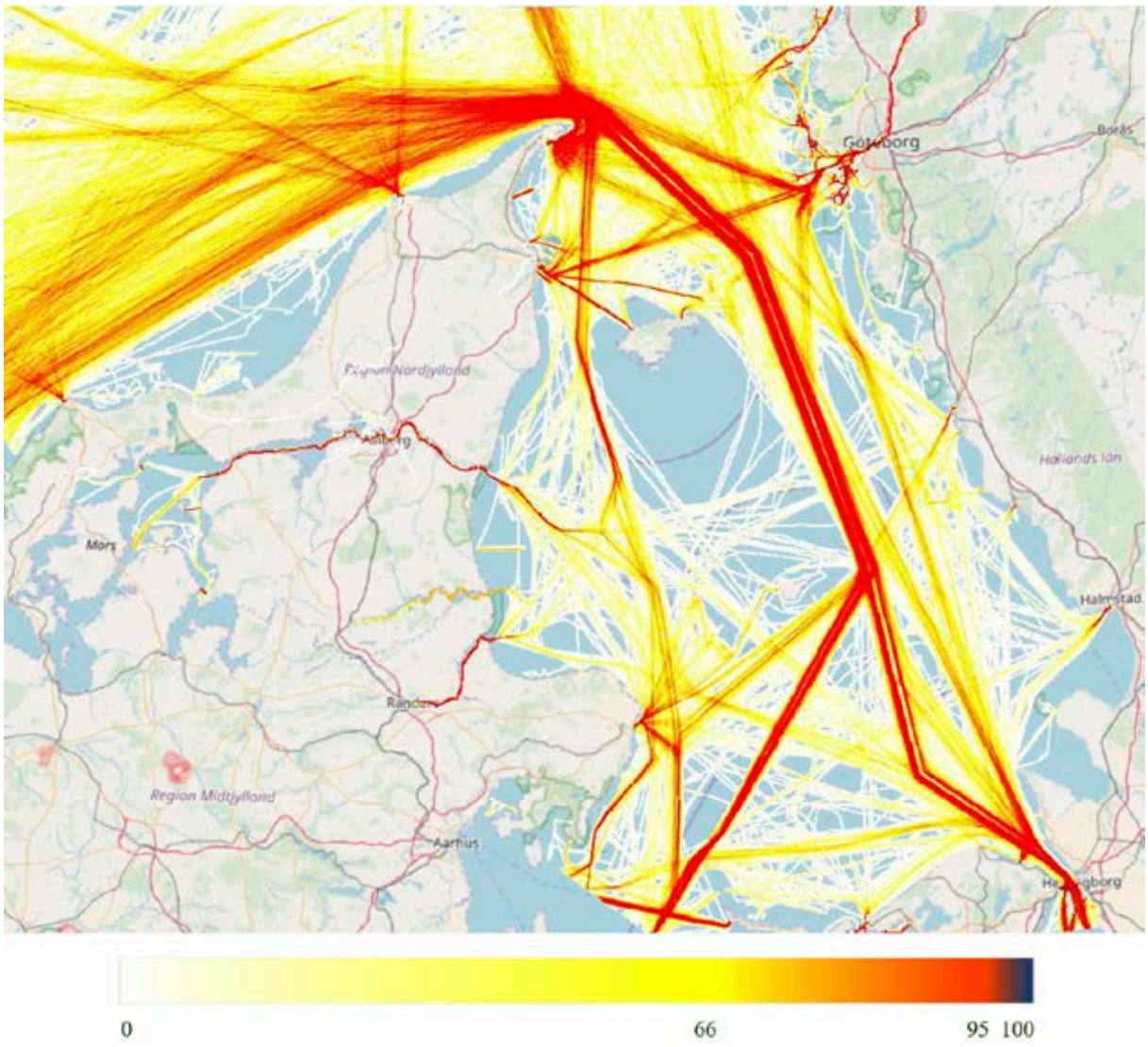


Figure 5. Traffic density plot for 11-24 of April 2016 (IWRAP MK II) – before proposing changes (NCSR 5/3/3, 2017)

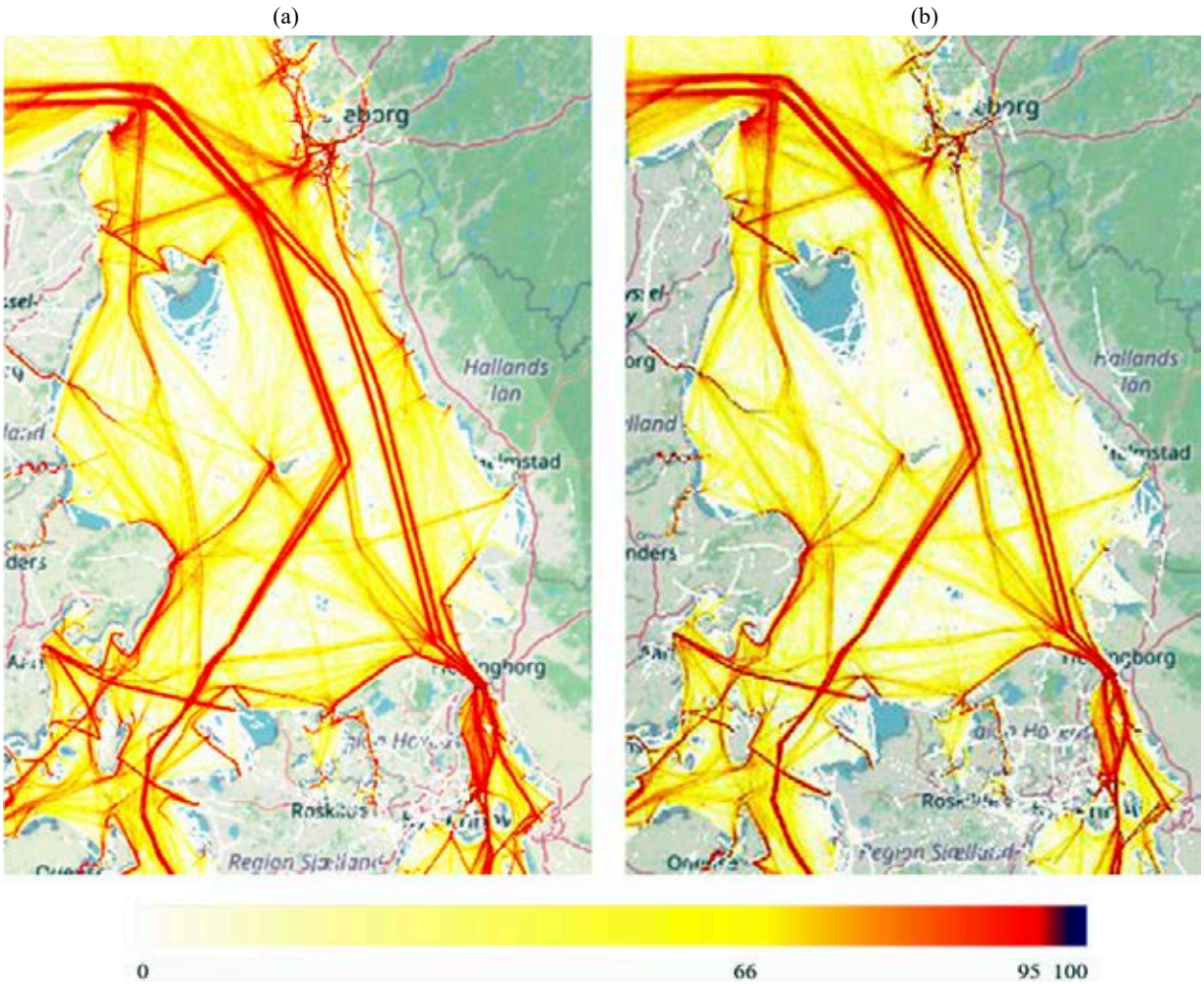


Figure 6. (a) Traffic density plots for July 2020 (IWRAP MK II) and (b) traffic density plot for July 2021 (IWRAP MK II) (own analysis based on IWRAP MK II visualization and AIS data from Danish Authorities (DMA, 2022))

As is visible on the density plot of Figure 5, in the middle part of Kattegat, traffic was mostly focused along routes advised by DMA and closer to the Swedish shores. After passing Anholt Island, traffic was again directed and mostly followed the advised Route A, T, or D. In the southern part of Kattegat, traffic from different directions was forced to enter the Sound or The Great Belt passage to the Baltic Sea. As there was not a strictly regulated approach to The Sound, navigators had to be extremely cautious about surrounding traffic and the navigational situation in their vicinity. Additionally, strong currents and a lot of small boats and recreational crafts traffic at the narrow entrance were further complicating the situation.

July 2020 & July 2021 – after implementing changes in the routing

Figures 6 depict more organized traffic patterns in key areas such as Skagen, around Anholt Island, the entrance to The Sound, and the entrance to the Great Belt compared to Figure 5. Although the majority of traffic now follows the new traffic scheme and routes (depicted in red), it is still noticeable that general traffic is spread throughout the Kattegat area (depicted in white and yellow).

Most changes in traffic patterns are visible around the old Route D (from Anholt Island to The Sound). In July 2020, some ships were still using the old Route while others were passing along the newly advised directions of traffic. The issue of traffic joining the Sound entrance from different directions remains unresolved, since the possibility of arriving from different directions creates crossing traffic that can lead to collisions. Small craft traffic was mostly directed to inshore traffic zones on both sides of the TSS, but there are still some crossings between the Danish and Swedish shores. The lack of traffic on the previously existing Route A and the adjustment to new Routes S and T are also visible, making traffic patterns clearer. However, potentially dangerous

situations can still arise in the precautionary area of Kummel Bank, where Routes S and T intersect. Visible patterns of approach to Skagen from both Skagerrak and Kattegat directions are also evident (IMO, 2019).

Conclusions

To maintain an unchanged estimated time of arrival (ETA), a higher speed is required that would affect fuel consumption. Calculations show an estimated 9.4% fuel consumption increase for traffic in Route T and DW routes, should the lengthened distance be compensated by increased speed. Considering the total transit traffic through Kattegat, including both the Great Belt and the Sound directions, the calculated fuel consumption and associated emissions are estimated to become around 0.9% lower than today, provided that transit speed is kept unchanged (NCSR 5/3/3, 2017).

As the new system became more familiar, traffic became more focused on designated routes, which was the main objective of the implementation. However, this has led to more ships being present in closer proximity to each other, resulting in passing, overtaking, and crossing situations that may pose a risk of collision. Additionally, the authors raise concerns about the deepwater routes implemented along Route T. Most of the traffic is on the outside borders of the deepwater route, creating a barrier and limiting maneuvering options for larger vessels. Collision avoidance maneuvers are difficult in such limited space, and navigators must make prompt and appropriate decisions to avoid collisions. The situation is even more complex at the other deepwater channel at the entrance to the Great Belt, where waters are shallower, and all the traffic is even more concentrated around the deep water and Route T. Given these parameters, timely and proper decision-making by navigators is crucial. In addition to a more in-depth analysis of the risks arising from the new traffic arrangement in the Kattegat and The Sound areas, the authors aim to develop tools to assist navigators in making the safest possible decisions in such a restricted area.

Acknowledgments

This research was funded by the statutory activities of Gdynia Maritime University, grant number WN/2022/PZ/06.

References

1. Bąk, A., Gucma, S. & Przywarty, M. (2020) *Bezpieczeństwo nawigacji na akwenach ograniczonych – metody szacowania i analizy ryzyka nawigacyjnego*. Szczecin: Wyd. Naukowe AM.
2. DMA (2020) *New shipping routes in Kattegat and Skagerrak*. [Online]. Available from: https://dma.dk/safety-at-sea/navigational-information/new-shipping-routes-in-kattegat-and-skagerrak [Accessed: 13th July 2022].
3. DMA (2022) *AIS database*. [Online]. Available from: http://web.ais.dk/aisdata/ [Accessed: 13th July 2022].
4. DMAIB (2011a) *LILLY and FRANK W. Marine accident report – Collision on 26 June 2011*. [Online]. Available from: https://maritimesafetyinnovationlab.org/wp-content/uploads/2017/06/dkmaib-frank-w-fv-lilly-collision-june-2011.pdf [Accessed: July 13, 2022].
5. DMAIB (2011b) *VINGA and N.A. HANSEN. Marine accident report – Collision on 18 January 2019*. [Online]. Available from: https://www.yumpu.com/da/document/view/29872870/n-a-hansen-vinga-kollision-den-18-januar-safartsstyrelsen/7 [Accessed: July 13, 2022].
6. DMAIB (2014a) *INGER MARIE and RIG – Collision on 10 July 2014*. [Online]. Available from: https://dmaib.com/reports/2014/inger-marie-and-rig-collision-on-10-july-2014/ [Accessed: 13th July 2022].
7. DMAIB (2014b) *KRASLAVA and ATLANTIC LADY – Collision on 1 November 2014*. [Online]. Available from: https://dmaib.com/reports/2014/kraslava-and-atlantic-lady-collision-on-1-november-2014/ [Accessed: 13th July 2022].
8. DMAIB (2015) *ORION and NECKAR HIGHWAY – Collision on 1 July 2015*. [Online]. Available from: https://dmaib.com/reports/2015/orion-and-neckar-highway-collision-on-1-july-2015/ [Accessed: 13th July 2022].
9. DMAIB (2017) *VICTORIA – Grounding on 10 February 2017*. [Online]. Available from: https://dmaib.com/reports/2017/victoria-grounding-on-10-february-2017/ [Accessed: 13th July 2022].
10. DMAIB (2020) *ICE ROSE and KAZANETS – Collision on 23 September 2020*. [Online]. Available from: https://dmaib.com/reports/2020/ice-rose-and-kazanets-collision-on-23-september-2020/ [Accessed: 13th July 2022].
11. DMAIB (2021) *BUSTER and STAVFJORD – Collision on 16 May 2021*. [Online]. Available from: https://dmaib.com/reports/2021/buster-and-stavfjord-collision-on-16-may-2021/ [Accessed: 13th July 2022].
12. DMAIB (2022) *BJUNGFJORD – Foundering on 20 January 2022*. [Online]. Available from: https://dmaib.com/reports/2022/bjugnfjord-foundering-on-20-january-2022-ongoing-investigation / [Accessed: 13th July 2022].
13. Gucma, L. (2009) *Wytyczne do zarządzania ryzykiem morskim*. Szczecin: Wyd. Naukowe AM.
14. IMO (2019) Ships' Routeing 2019 Edition, Part B: I/19, I/20; Part C: I/1, I/2, I/3; Part G: I/3, I/4., London.
15. Kerbrat, A. (2018) Traffic rules and environmental conditions in Kattegat and The Sound regarding changes planned for 2020. *Zeszyty Naukowe Uniwersytetu Morskiego w Gdyni, Scientific Journal of Gdynia Maritime University* 107, pp. 59–71, doi: 10.26408/107.04.
16. Kerbrat, A. (2021) Analysis of navigational casualties within European waters and case study. *TransNav – The International Journal on Marine Navigation and Safety of Sea Transportation* 15(4), pp. 729–737, doi: 10.12716/1001.15.04.02.

17. NCSR 5/3/3 (2017) *Routeing measures and mandatory ship reporting system. General overview for the establishment of traffic separation scheme and other routeing measures in the vicinity of Kattegat between Denmark and Sweden*. International Maritime Organization.
18. NCSR 5/3/4 (2017) *Routeing measures and mandatory ship reporting system. Establishment of traffic separation schemes and associated routeing measures in the vicinity of Kattegat between Denmark and Sweden*. International Maritime Organization.
19. NCSR 5/3/5 (2017) *Routeing measures and mandatory ship reporting system. Establishment of deepwater routes, recommended routes and precautionary area in the vicinity of Kattegat between Denmark and Sweden*. International Maritime Organization.
20. NP 18 (2020) Admiralty Sailing Directions. *Baltic Pilot Vol. I.* Taunton, Somerset. United Kingdom Hydrographic Office.

Cite as: Kerbrat, A., Guze, S. (2023) The impact of the modified ships' routes in the Kattegat on the safety of navigation at the entrance to the Baltic Sea. *Scientific Journals of the Maritime University of Szczecin, Zeszyty Naukowe Akademii Morskiej w Szczecinie* 75 (147), 79–88.