30th
International Maritime Lecturers Association Conference
Split Croatia
www.imla30.org

International Maritime Lecturers Association
FACULTY OF MARITIME STUDIES

COMPREHENSIVE EVALUATION OF THE ECDIS TWO- AND FOUR-DEPTH SHADES COLORING OF THE SEA AREAS

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Abstract. The ECDIS firmly became the cornerstone of marine navigation. The shipping industry will not accept any return to the paper chart for several reasons. The electronic system offers many ways to enhance safe navigation by providing various options and settings that play an active role during watchkeeping. This article explores a specific option of the ECDIS: two and four depth shades of sea coloring. This study aims to share user experience and insights, enhance ECDIS usability, and align with navigational needs. The method of this research is a survey conducted among serving navigation officers. The responses of 56 mariners were recorded and analyzed. The results came directly from the ECDIS operation field. The evaluation indicated that both two- and four-color depth shading have their advantages. Users may choose either option depending on navigational circumstances. They complement each other to some degree, but in other cases, they may mislead the ECDIS operator. Finally, based on the analysis, the study proposes a method for effective management of depth-shade sea coloring. This can serve as a guide that may enhance user confidence when operating an ECDIS.

Keywords: ECDIS; ECDIS Depth Shades; Safety Contour; Safety Depth; Shallow Contour; ECDIS Sea Areas.

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https://doi.org/10.7225/imla30.13

1. INTRODUCTION

The primary function of the ECDIS is to contribute to the safe navigation, outlined in the Resolution MSC.232(82) (IMO, 2006). Mariners are therefore expected to adhere to its principles to ensure vessel safety. To maintain safe operational standards, mariners begin their training with formal education. Education serves as the foundation upon which experience is built to achieve the level of performance expected and respected by the maritime industry. Conducting a safe voyage is a complex task that requires a wide range of knowledge. This knowledge begins with motivation and is shaped by both education and experience. Performance outcomes also depend on human factors such as individual work style, accuracy, time management, and fatigue. Ultimately, the results, which vary by individual, should answer one question: Is your work contributing to safe navigation or introducing an unacceptable risk? In the context of ECDIS, the question may be posed as: Is your use of ECDIS contributing to safe navigation or introducing a risk? Returning to the initial premise, safe navigation is the primary function of ECDIS to which mariners must conform. The shipping industry would not accept any return to the paper chart for many reasons, such as cost effectiveness, flexibility of chart delivery, track control, and so on (UK Hydrographic Office, 2024). The ECDIS course (IMO model course 1.27, 2010) provides a foundational curriculum for mariners operating the system (Brčić et al., 2017). In addition, a type-specific course is mandatory, although no formal standards for such courses have yet been established (Komitov & Angelova, 2023). This lack of standardization may lead to training gaps and inconsistencies (Komitov & Belev, 2021).

There are several aspects of ECDIS functionality that can enhance navigational safety. One of its core technical features is the so-called "ECDIS safety settings". These settings define parameters regarding the ship's static and dynamic characteristics. They are input by users into a dedicated submenu and must be determined correctly and configured appropriately (Pipchenko et al., 2021). There are 3 contours and one depth setting, each with a specific function: shallow contour, safety contour, safety depth, and deep contour (IHO, 2012). A contour line is a line of equal depth that separates the depth area below and the depth area above the indicated value. The contours typically appear at intervals such as 5, 10, 15, 20, 30, or 50 meters, depending on the resolution and compilation of the ENC (Nautical Institute, 2010).

A shallow contour is an indication of shallow water for the vessel's actual draft. It is a depth value below which the vessel may run aground and should correspond to the ship's maximum draft. This contour outlines the waters from the set value to the shore line. This sea area is not navigable for a vessel's actual draft.

Safety contour is a value above which a vessel may operate without concern for the water depth. If the user's set contour value is less than the available one, the SENC will automatically jump to the upper one. On the screen, it is visualized with an extra-wide isoline. Crossing the safety contour, within a time specified by the mariner, will indicate an alarm to notify the operator.

Deep contour is a value below which the vessel may have several restrictions, like vessel engine excessive load, ballast intake limitation, squat effect, etc.

Safety depth is a value of great importance entered by the user in the ECDIS safety settings. The value of safety depth will mark in bold all depths equal to or below its number.

Safety depth shall respect the vessel's required UKC (under keel clearance). Calculation of the required UKC should be implemented as part of the company navigation procedures. It is important to clarify that the waters below the safety contour are not always non-navigable. The vessel is often forced to sail over depths below the safety contour. This happens when the vessel enters the port approaches and channels. In any case, the vessel is to remain within the areas of safety depth.

In addition, a valuable option for two- or four-depth shades may be chosen. In ECDIS, depth shading is essential for representing marine areas. Their application is going to be compared in this article. ECDIS offers two primary depth-shading configurations. In the two-shade mode, blue indicates areas below the safety contour and white represents areas above it (Figures 10 and 11). In the four-shade mode, dark blue marks depths below the shallow contour, light blue spans between the shallow and safety contours, grey covers the area between the safety and deep contours, and white designates depths above the deep contour (Figures 13 and 14). The safety contour typically lies between the blue and white in two-shade mode, or between light blue and grey in four-shade mode. This clear separation assists mariners in planning and executing safe voyages. Ultimately, the human factor remains critical in regard to user input and interpretation, which directly influence the system's effectiveness (Komitov, 2019). This article aims to compare and evaluate the ECDIS two- and four-depth shade sea coloring. By highlighting their main benefits and exploring their application in different navigational contexts, it seeks

to demonstrate how these features can enhance user awareness during voyage planning and execution. Notably, a lack of situational awareness is frequently cited as a contributing factor in navigation incidents (AIN Journal, 2023).

2. METHODOLOGY OF THE RESEARCH

This article aims to compare and evaluate the ECDIS two- and four-depth-shade sea coloring. The study employs both quantitative and qualitative research methods, combining a structured questionnaire with subsequent data analysis to evaluate user perceptions and practical implications of the two- and four-depth shade sea coloring in ECDIS. Several measures were implemented to ensure the validity and reliability of the research. The study was carried out among active navigation officers. It was conducted over a three-month period between the 20th November 2024 and the 26th of February 2025. The questionnaire was created using Google Forms and distributed online, with responses automatically recorded in a digital format. This approach eliminated potential transcription errors and facilitated efficient data processing. The timing of the data collection (November 2024 to February 2025) represents recent operational practices, ensuring the findings reflect current maritime industry standards and technologies. The demographic data collected included professional role, years of experience, certification status, and current position, providing a comprehensive profile of the participant pool and enabling more nuanced interpretation of the results. The instrument included a combination of multiple-choice questions to gather quantifiable data. The survey questions were structured to progress from demographic information to specific operational practices and preferences, ensuring a logical flow that helped participants provide comprehensive responses. The sampling approach was purposive, targeting professionals with relevant experience rather than seeking a random sample of the general maritime population. Participants of various nationalities were invited to complete the questionnaire. To ensure ethical research practices, participation was voluntary and completely anonymous, with no personally identifying information collected. The responses from 56 participants were recorded. The demographic composition included a majority of participants (97%, Fig.1) who were active ship navigation officers with on-board experience, including Ship Masters, Chief Officers, and Junior Officers. Their graduation spans a wide range of time. According to the study, 92% of the participants had at least one year of experience in their current position (Figure 2). The study aimed to explore a specific aspect of ECDIS in depth — comparing the visual display when using either two- or four-depth-shade sea coloring. The questionnaire specifically addressed how participants interact with ECDIS depth shading in various navigational scenarios, including deep-sea passages, coastal navigation, and port approaches. This contextual information is crucial for understanding when and why certain configurations are preferred over others. The study also examined the influence of organizational policies on individual practices, revealing how company standards shape operational decisions regarding ECDIS configuration.

3. RESULT ACHIEVED

The results of the study are presented below with questions and a summary of participants' answers.

1. WHAT IS YOUR PRESENT RANK ON BOARD?

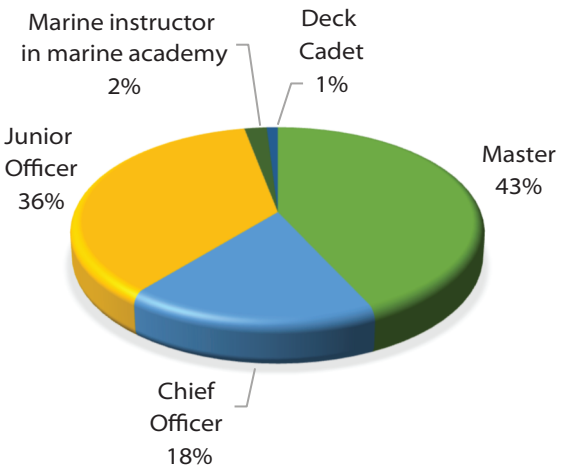

Figure 1.

2. HOW MANY YEARS OF EXPERIENCE DO YOU HAVE AT YOUR CURRENT RANK?

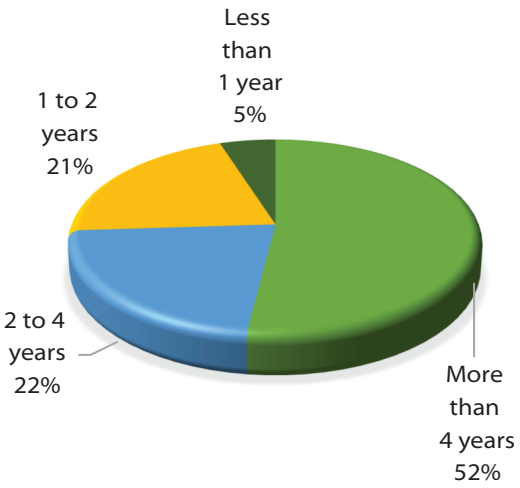

Figure 2.

3. HAS YOUR MANAGEMENT COMPANY ESTABLISHED STANDARDS REGARDING ECDIS DEPTH SHADES IN ITS MANAGEMENT SYSTEM?

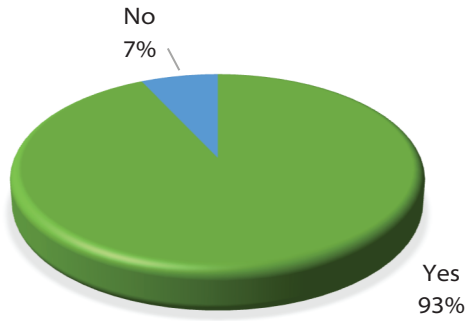

Figure 3.

4. IF YOU ANSWERED "YES" ABOVE, WHAT IS YOUR COMPANY REGULATION OR RECOMMENDATION FOR ECDIS DEPTH SHADES?

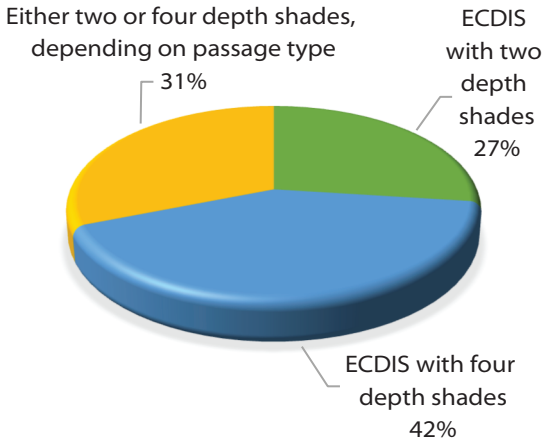

Figure 4.

5. IN REGARDS OF ECDIS TWO AND FOUR SHADES OF SEA COLOURING, WHAT IS YOUR PREFERENCE OF USE?

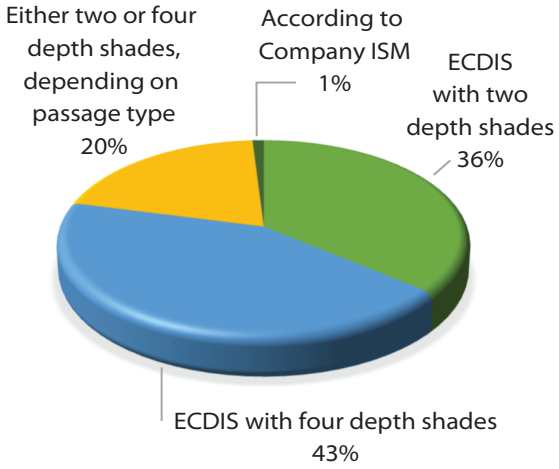

Figure 5.

6. IN YOUR OPINION, WHAT ARE THE BENEFITS OF USING TWO DEPTH SHADES IN ECDIS?

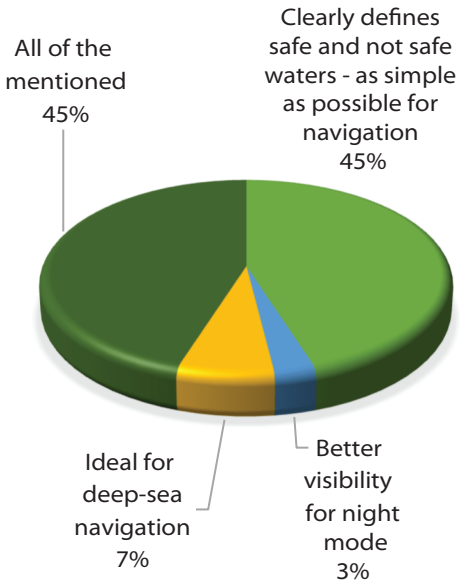

Figure 6.

7. IN YOUR OPINION, WHAT ARE THE BENEFITS OF USING FOUR DEPTH SHADES IN ECDIS?

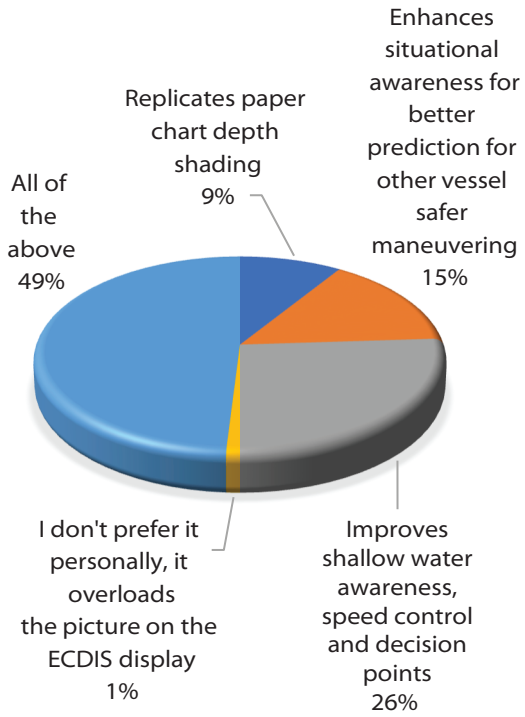

Figure 7.

8. HOW OFTEN DO YOU ADJUST ECDIS DEPTH SHADING SETTINGS BASED ON SPECIFIC VOYAGE CONDITIONS?

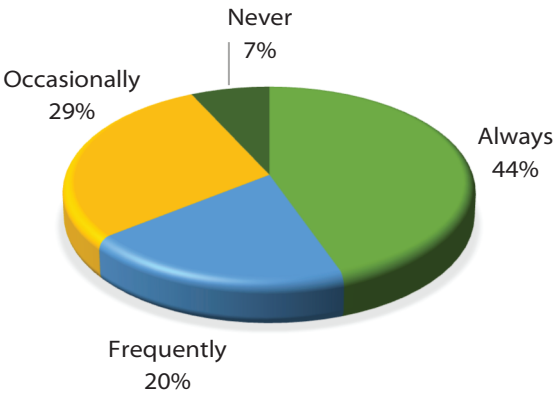

Figure 8.

9. HOW IMPORTANT IS ECDIS SHADING CUSTOMIZATION TO YOUR NAVIGATIONAL DECISION-MAKING?

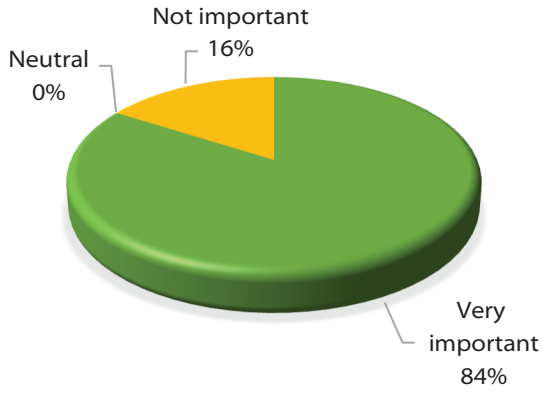

Figure 9.

4. ANALYSES OF THE RESEARCH

The analysis of the collected data provides insights not only into the individual preferences of navigators but also into the operational realities and company practices influencing the use of ECDIS depth shading. The responses regarding ECDIS certification showed that all participants were ECDIS certified. Therefore, a pie chart was deemed unnecessary. Nevertheless, the findings further validate their technical competence to evaluate the nuanced aspects of depth shade configurations. The questionnaire showed that 97% of the participants (Figure 1) were ship navigation officers with on-board experience, which adds weight to their shared operational perspectives. Their responses are derived from practical sea service. Approximately two-thirds of the respondents were senior officers, which adds credibility to the study. Moreover, at least 95% (52%, 22%, and 21%) had served in their current positions for over one year (Figure 2). This indicates that participants were expected to be familiar with ECDIS operation. Furthermore, the study highlights the gap between company policies: while many have adopted shading standards, others have not, introducing variability in officer practices. According to Figure 3, 93% of the participants reported that their management company had implemented standards regarding ECDIS depth shading in its Safety Management System (SMS). This pointed out an additional way to increase the safety levels in the navigation of their managed vessels. Such organizational commitment to standardization represents an industry-driven approach to enhance navigational safety beyond minimum regulatory requirements. Only 7% (Figure 3) reported that their management company had not established such standards. Such implementation is not mandatory under the ISM Code. Some Companies bet on two-shade, some on four-shade colors for depths (Figure 4). This means that the vessel's management operators have a relatively different approach to the standards in their management regarding ECDIS depth shades. If an officer transfers to another company, he must adapt to the navigation policy in place, which may include a different ECDIS depth-shading scheme. Therefore, officers should remain flexible and respond accordingly. This finding underscores the importance of officer adaptability and comprehensive ECDIS familiarization when joining a new vessel, particularly regarding the implications of depth shading. Regarding officer preferences, 43% of the responses indicated a preference for the four-depth-shade configuration (Figure 5). This helps assess their operational impressions and navigational visualization preferences. Figure 6 highlights that the main advantage of two-depth shading is the ability to clearly distinguish between safe and unsafe waters. Furthermore, some 45% stated that this configuration allows for clear differentiation of navigable zones, offers better visibility in night mode, and is ideal for deep-sea voyages. This option visually separates areas where the vessel can safely navigate from those that have depths below the safety contour. In continuation, some 45% pointed out that they evaluate two depths shades as the possibility for definition of safe and non-safe waters, better visibility at night mode, and ideal for deep-sea navigation. Fewer colors mean less glare (Figure 10, Figure 11), and better legibility (Figure 12), during reduced lighting conditions on the bridge (NorthStandard, 2024). In open ocean passages where coastal dangers are minimal, the two-shade mode offers a quick assessment of safe waters. The figures below intend to picturize the visual effect of two-shade depth coloring. All depths below safety depth, in bold font, visualized to mark non-navigable waters.

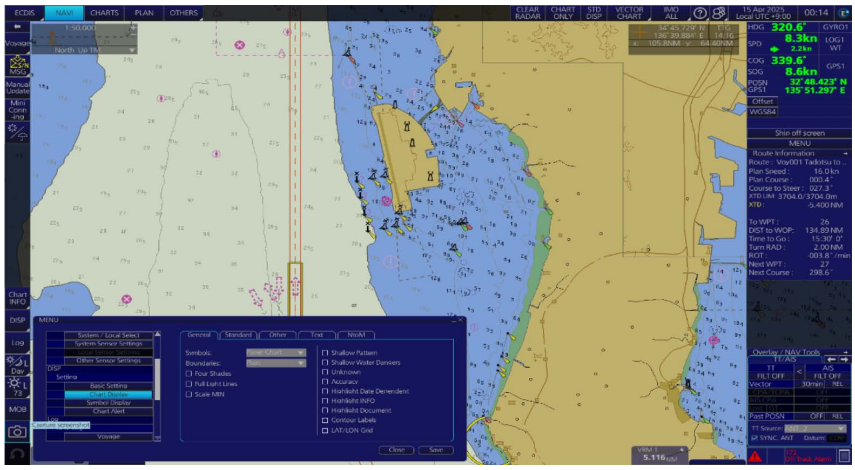

Figure 10. Two-shade day mode. Source: Furuno FMD -3300

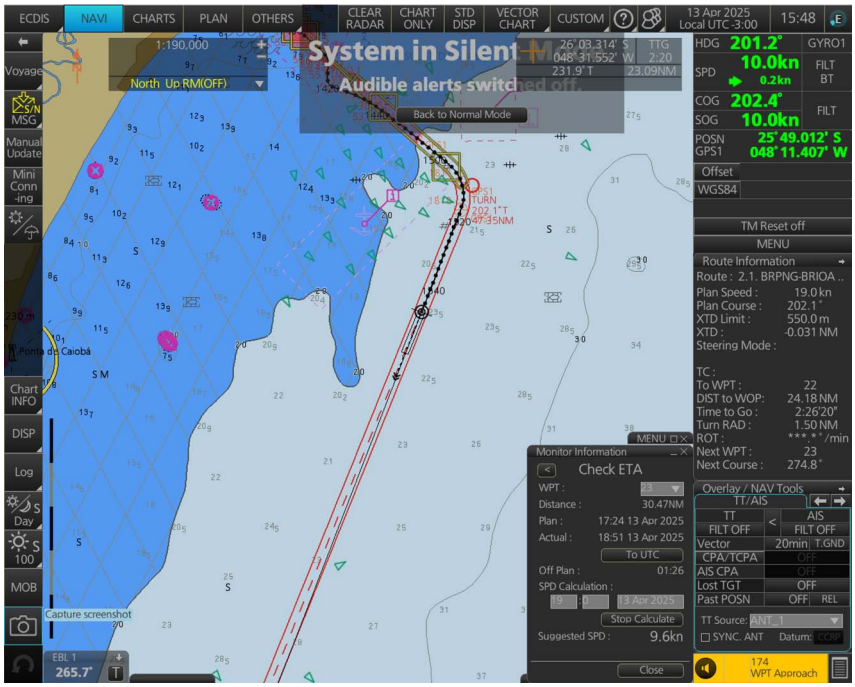

Figure 11. Two-shade day mode. Source: Furuno FMD-3000

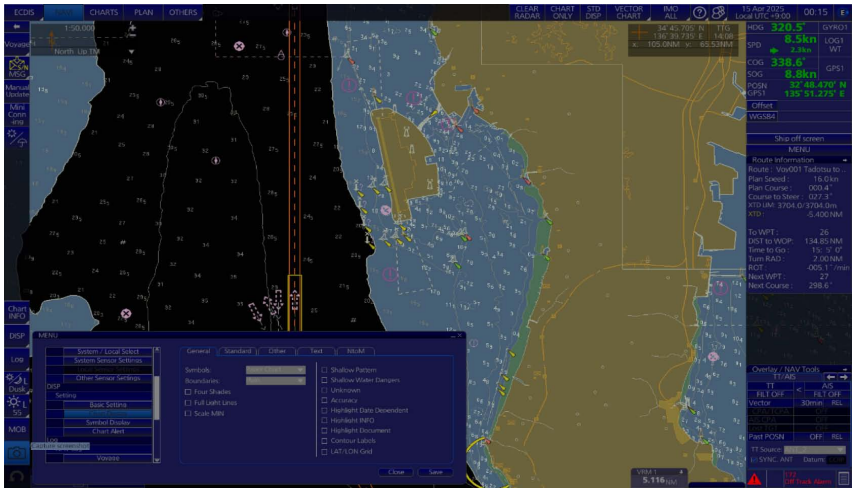

Figure 12. Two-shade night mode. Source: Furuno FMD-3300

The answers in Figure 7 show the benefits of the four depth shades usage. It has various valuable features such as closer resemblance to traditional paper charts, enhanced depth perception**,** better support for voyage planning in restricted waters, and improved situational awareness (Mellor, 2016). That is why most of the operators have preference for four over two shades of the ECDIS depth sea coloring. This helps assess officer operational navigational visualization choice. To get deep in this context, if the mariner uses two depth shades of the ECDIS, to some degree, it may be presumed that this is only for his safety. If the officer uses four depth shades of the ECDIS, this would enhance situational awareness for better prediction of other vessels' safer maneuvering. In certain cases, this can be of ultimate importance as the mariner is not a single participant in the sea, especially in confined waters with heavy traffic. Multiple color gradients allow a more detailed assessment of shallow waters, critical depths, and navigational limits (Marine Public, 2025). It helps identify depth-related restrictions more precisely during complex port entries or coastal navigation. This enables better evaluation of maneuvering options and surrounding vessel activity based on water depth variations. Combining all benefits of the four shades provides a more nuanced and information-rich navigational environment (Figures 13, 14, and 15). The figures below intend to picturize the visual effect of four-shade depth coloring.

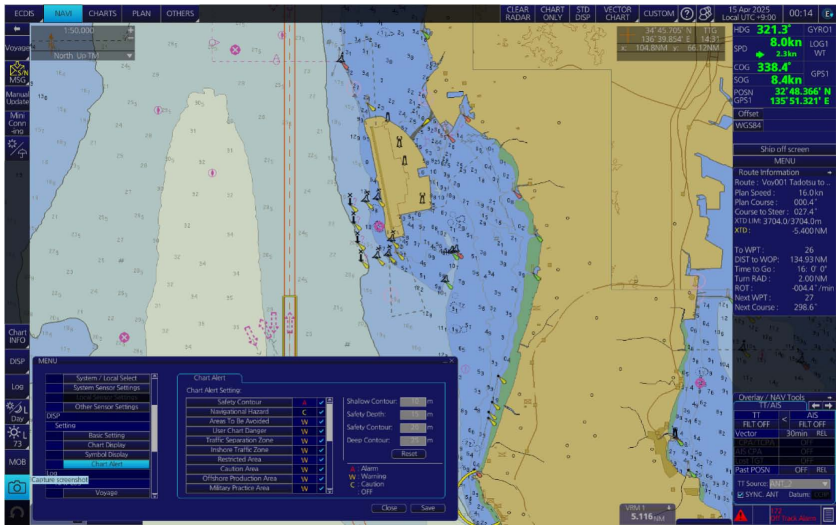

Figure 13. Four-shade day mode. Source: Furuno FMD -3300

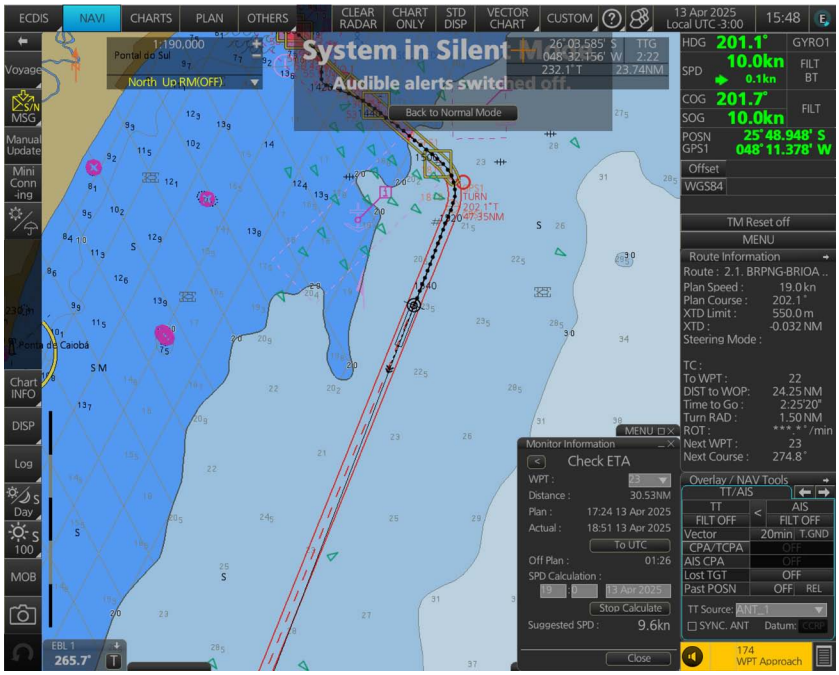

Figure 14. Four-shade day mode. Source: Furuno FMD-3000

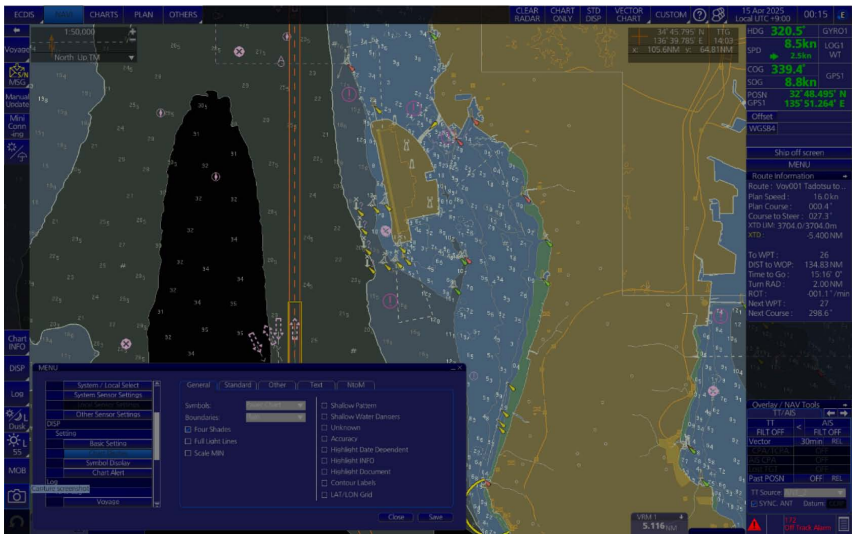

Figure 15. Four-shade night mode. Source: Furuno FMD-3300

The night mode of the four-depth-shade configuration is generally considered less effective than the two-shade alternative. This is pointed out as one of the benefits of the two-shade depth option. Nevertheless, four-shade visualization remains the favorite of most of the ECDIS operators. The pie chart in Figure 8 shows that most respondents confirmed that they "always" (44%) or "frequently" (20%) adjusted the depth shading settings based on specific voyage conditions. This means that officers rely on that option and utilize it regularly. This dynamic use underlines the need for adaptive ECDIS interfaces and further training in optimal configuration strategies. Unfortunately, in some models, shade settings are not easily accessible within the menu structure. The final pie chart (Figure 9) shows that most officers consider ECDIS shading customization to be an important factor in navigational decision-making. This high utilization rate confirms that depth shading is not merely an optional feature but a core navigational tool integrated into officers' regular practice. The ECDIS should not be treated as a passive, but as an interactive system whose configurations significantly shape navigational judgment. Unfortunately, many ENCs do not have enough availa-

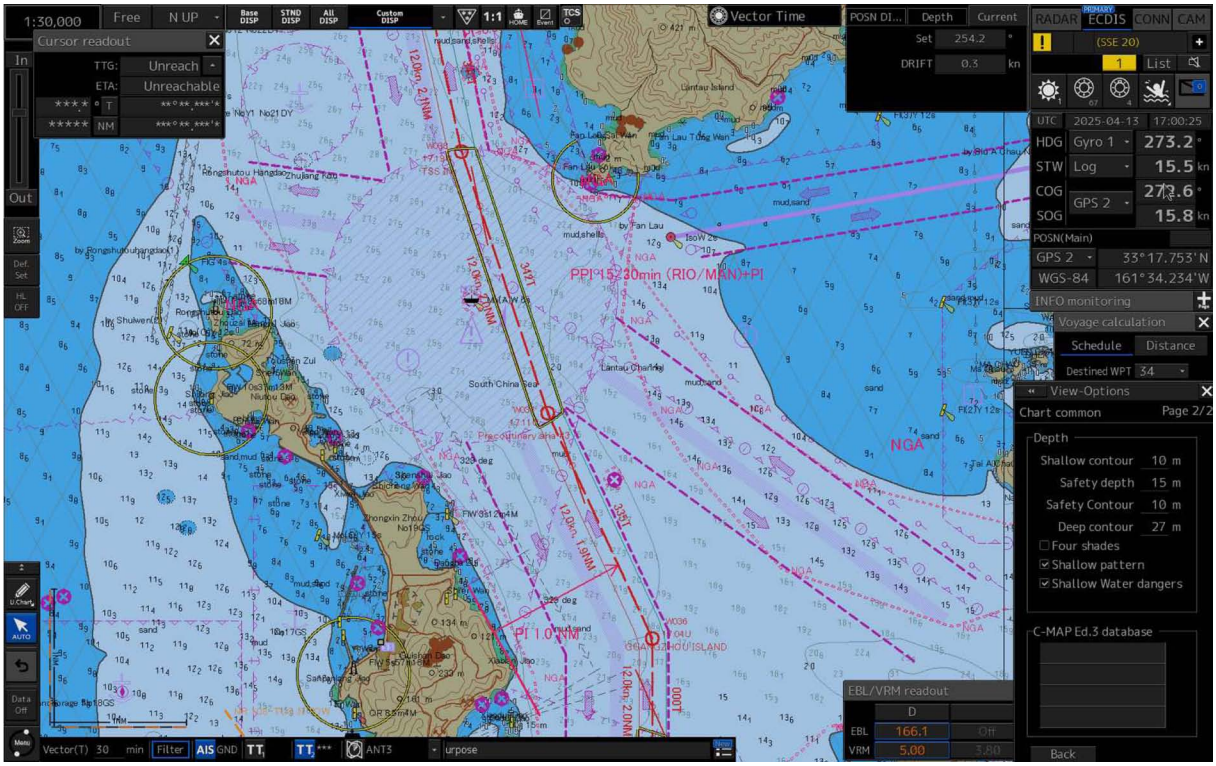

Figure 16. Source: JRC Jan – 9201

ble contours (IHO, 2019). To compensate for this limitation (Figure 16), the ECDIS operator may employ the following strategy. With the 15-meter setting of safety depth and no available 15-meter contour, the operator used the lower available 10-meter contour as the safety contour. The non-navigable depths, marked in bold font, are separated with a user-added feature, using a red pecked line. The style was used on the paper charts, where non-navigable sea areas had been marked with a red pencil. If the operator used the upper available contour in the area shown in Figure 16, most of the sea would be marked in dark blue, which may reduce the visual clarity of the ECDIS screen. The style, upon which, in the safety settings, the value of safety contour is set less than the safety depth, shall be used with extreme caution. A user-defined danger zone should be applied to separate areas with bold-marked depths. In any case, in confined waters, the vessel should remain within pale depth marks and avoid bold-marked soundings as planned below on Figure 16.

5. CONCLUSIONS

ECDIS two- or four-shades is a great option and gives more flexibility to the operators. As stated by the study, the users deal frequently with and consider it very important. Both two- and four-shading have their advantages. Each of them may be chosen to suit the navigation circumstances. To some degree, they complement each other. The study demonstrates that both two-shade and four-shade configurations offer distinct advantages that can be deployed according to specific navigational contexts. On the other hand, some management companies mandate specific shading configurations in their navigation policies. If the OOW uses two depth shades of the ECDIS, to some degree, this is for their navigational safety. Using four-depth shading, however, enhances situational awareness for better prediction of other vessels' safer maneuvering. In certain cases, this can be of critical importance as the mariner is not a single participant in the sea. The two-shade provides faster assessment, simplifying the distinction between safe and unsafe areas. However, it limits the details required in areas with variable bathymetry. The 4-shade scheme enhances bathymetric accuracy but increases visual complexity. It helps identify depth-related restrictions more precisely during complex port entries or coastal navigation. To summarize, it has to be underlined that every navigation officer should be aware of the benefits and be flexible and ready to operate with either option: two- or four-depth shading. ECDIS is not just a chart display but a valuable decision-making tool, irrespective of planning, execution, or monitoring use. Ultimately, empowering officers with knowledge of depth-shading implications and encouraging deliberate configuration can significantly enhance both confidence and safety. This, in turn, promotes good practices, improves situational awareness, and contributes to safer seas.

Conflict of interest: The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgements: The authors are thankful to all navigation officers who participated in this study for their time and their willingness to cooperate with highlighting a specific option of the ECDIS. Their answers are worth much.

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