

Investigating
maritime community
perceptions of ammonia
as a marine fuel



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Table of Contents

Executive summary.....	3	05 Knowledge and training requests.....	24
01 Introduction.....	5	06 Safety concerns and safer ship designs.....	30
1.1 About this project.....	6	07 Closing remarks.....	35
02 Methodology.....	7	08 Project team and acknowledgements.....	37
2.1 Questionnaire.....	8	Abbreviations.....	38
2.2 Sampling and recruitment.....	8	Appendix: Survey questionnaire.....	40
2.3 Data analysis.....	9		
03 Respondents' profile.....	10		
3.1 Age profile.....	11		
3.2 Positions of respondents.....	12		
3.3 Vessel segment.....	13		
3.4 Experience with gas-fueled vessels or ammonia as cargo.....	14		
04 Willingness to sail on or work with ammonia-fueled ships.....	15		
4.1 Seafarer perspectives.....	18		
4.2 Ashore perspectives.....	21		



Executive summary

Decarbonization of the shipping industry will require widespread uptake of new low- or zero-carbon alternative fuels. Ammonia has been identified as a promising alternative shipping fuel in the mid to long term, with the development of ammonia-fueled marine engines and ship designs ongoing.^{1,2} However, the characteristics of ammonia, including its toxicity and gaseous nature, mean that its implementation as a marine fuel will require much more than technical readiness: the industry will also need a strong focus on safety, human factors, and new training requirements relating to ammonia as a fuel.

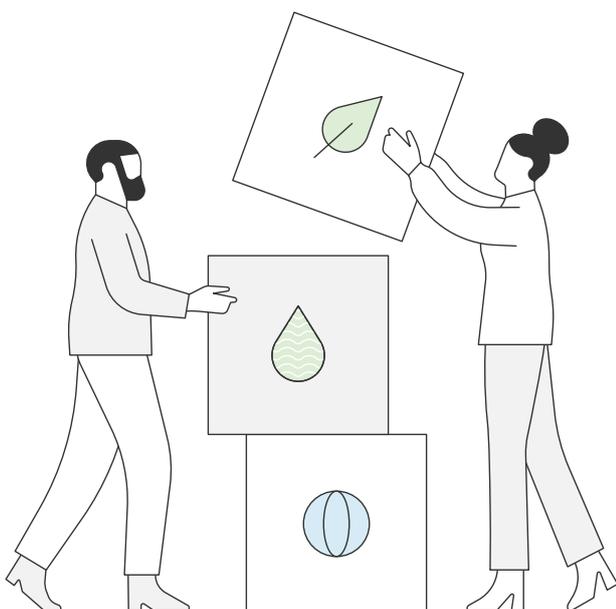
To support this focus, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) has undertaken a survey of over 2,000 respondents across the maritime community to better understand their perceptions, concerns, and requests relating to ammonia as a marine fuel. Throughout the multiple-choice questionnaire, the respondents had the option of sharing their thoughts in the (optional) open fields. More than 1,500 comments were compiled from these open-field responses.

The survey reached respondents covering a range of different ages, positions, vessel segments, and level of experience with gaseous fuels or ammonia as cargo. Over half (58.6%) of the total respondents agreed that they would be willing to sail on or work

with ammonia-fueled vessels, while 24% were unsure and 12% reported that they would not be willing. More specifically, 59% of seafarers and 57% of ashore personnel who responded to the survey agreed that they would be willing to work with ammonia. While more than half of the respondents were willing to sail on or work with ammonia-fueled vessels, these respondents nevertheless raised some specific concerns, especially regarding training and safety.

Key takeaway 1: The majority of respondents from across the maritime community are willing to sail on or work with ammonia-fueled vessels.

Many of the survey responses emphasized the desire for more knowledge and training about ammonia. When asked about what knowledge they needed regarding ammonia as marine fuel, respondents highlighted many topics relating to safety, such as ammonia's impact on humans and the environment, firefighting and other emergency response procedures, and ammonia characteristics. Respondents also expressed a desire for comprehensive training – including on safety-focused topics such as leakage management, emergency response, and risk analysis, but also on new engine procedures and maintenance, regulation, and gas as fuel.



Continuing on the theme of safety, the survey sheds light on the primary safety concerns of both seafarers and ashore personnel. The respondents' basic perception of the characteristics (e.g., toxicity) and safe handling of ammonia seems to be generally accurate and reflects a good understanding of the possible risks involved. However, the survey showed a lack of knowledge regarding some technical aspects of ammonia handling and operations. Further study, communication, and training on these topics are, therefore, important. The survey responses also highlighted the importance of safer technology and design to support ammonia's introduction as a marine fuel.

Key takeaway 2: Acceptance of ammonia as a marine fuel is conditional on a comprehensive level of training and certification.

Another area of concern for survey respondents was the effectiveness and readiness of regulations – that is, whether regulations would be ready in time to appropriately protect seafarers from ammonia-related safety risks. Respondents additionally called for strict safety standards surrounding the design of the fuel systems.

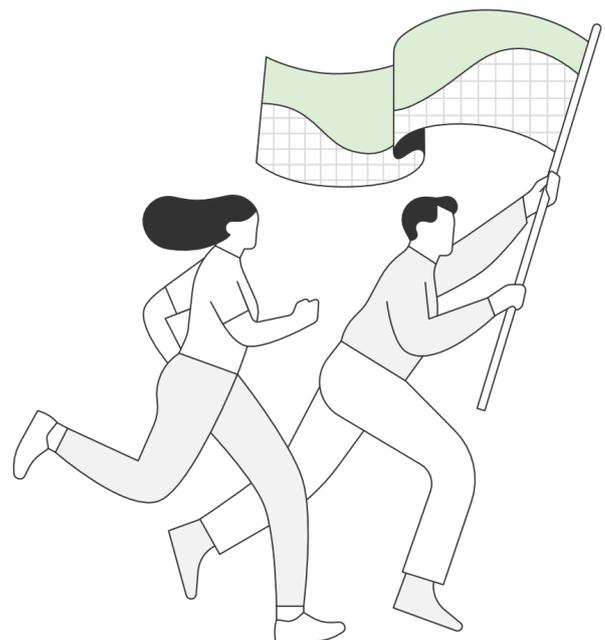
Implementation of ammonia as a marine fuel will also require additional investments, such as costs associated with upskilling and training of seafarers. In the survey comments, some seafarers expressed their desire for monetary compensation due to the potential risks involved with the operation of ammonia as a marine fuel and the added complexity to their job.

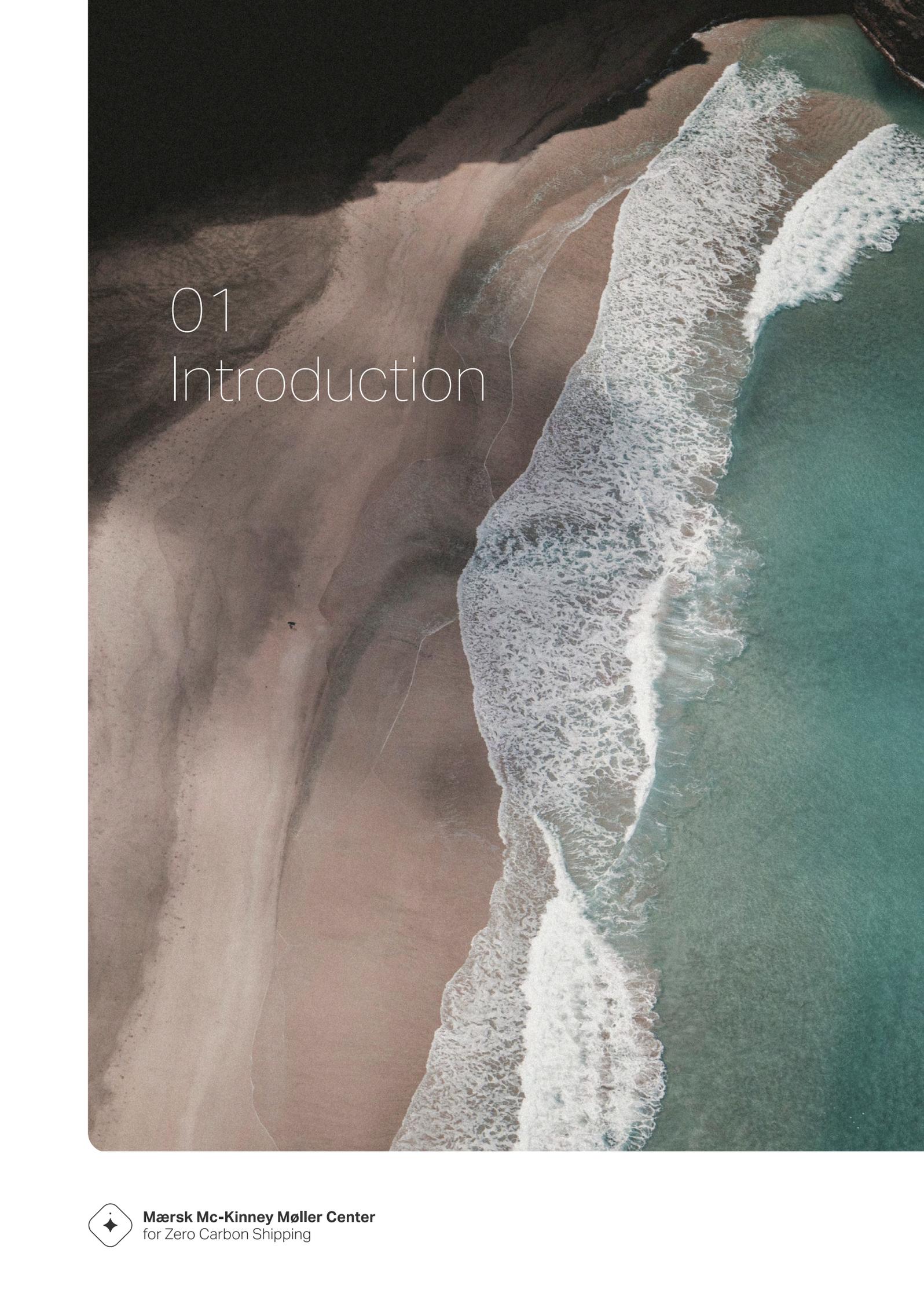
Overall, the survey results suggest that the majority of the maritime community is willing to sail on and work with ammonia-fueled vessels. With that said, several barriers remain that will have to be addressed, including comprehensive training and safer ship and system designs. Some of these topics will be addressed

in current or future MMMCZCS projects, including a project linked to future revisions of the STCW Tables relating to the International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code) in the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Code).³

In publishing this survey report, we aim to share the opinions, concerns, and suggested ways forward raised by the community who will be most directly impacted by the use of ammonia as a marine fuel. The knowledge shared in this report can help the industry to address the concerns and misperceptions raised by first-in-line operators. In addition, the survey findings can be used to shape future training content and address upcoming ship and fuel systems designs, as well as guidelines for safe bunkering and in-port handling of ammonia.

Key takeaway 3: Enhanced, reliable, and safe onboard fuel systems and inherently safer ship designs are seen as critical safety elements.





01 Introduction



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

The International Maritime Organization's (IMO) 2023 Greenhouse Gas (GHG) Strategy has three interlinked ambitions: a reduction in carbon intensity of international shipping by at least 40% by 2030 with an indicative checkpoint of reducing the total annual GHG emissions from international shipping by at least 20%, striving for 30%, by 2030, compared to 2008; the uptake of zero or near-zero GHG emission technologies, fuels, and/or energy sources representing at least 5% of the energy used by 2030; and GHG emissions from international shipping to reach net zero by or around 2050.⁴

Decarbonization of all vessels in the worldwide shipping sector is critical for reaching the IMO ambitions and will be achieved by using alternative fuels and reducing fuel consumption. Ammonia is one of the promising fuels for zero-emissions ocean transport.

Implementation of ammonia as a marine fuel is expected to be technologically feasible by 2025-2026, but this implementation will create new challenges for the maritime community. In particular, ammonia's toxic nature requires the industry to develop new approaches to safety. Fortunately, some sectors of the industry already have extensive experience in handling and transporting ammonia as cargo at sea, with approximately 18-20 million tonnes of ammonia traded annually through about 120 global ports.^{5,6} The safe use of ammonia as a fuel will draw heavily on this experience.

The Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) has been studying ammonia safety since 2021. A 2023 publication jointly produced by the MMCZCS and Lloyd's Register presents a quantitative risk assessment analysis and preliminary account of the human factor considerations that will be impacted by the transition to ammonia fuel use.⁷

In October 2023, the MMCZCS organized a roundtable dedicated to ammonia safety with multiple key stakeholders from the shipping and ammonia industries. This meeting highlighted the need to assess the risk perception regarding ammonia as a marine fuel across onboard and ashore maritime communities, which could have a significant impact on ammonia's uptake as a marine fuel.

The MMCZCS has therefore undertaken a survey on ammonia risk perception and acceptance with the goal of hearing the direct voice of the maritime community. Our objective is to help the industry lift the barriers to implementation of ammonia as a marine fuel in a collaborative way and facilitate a safe transition to alternative fuels.

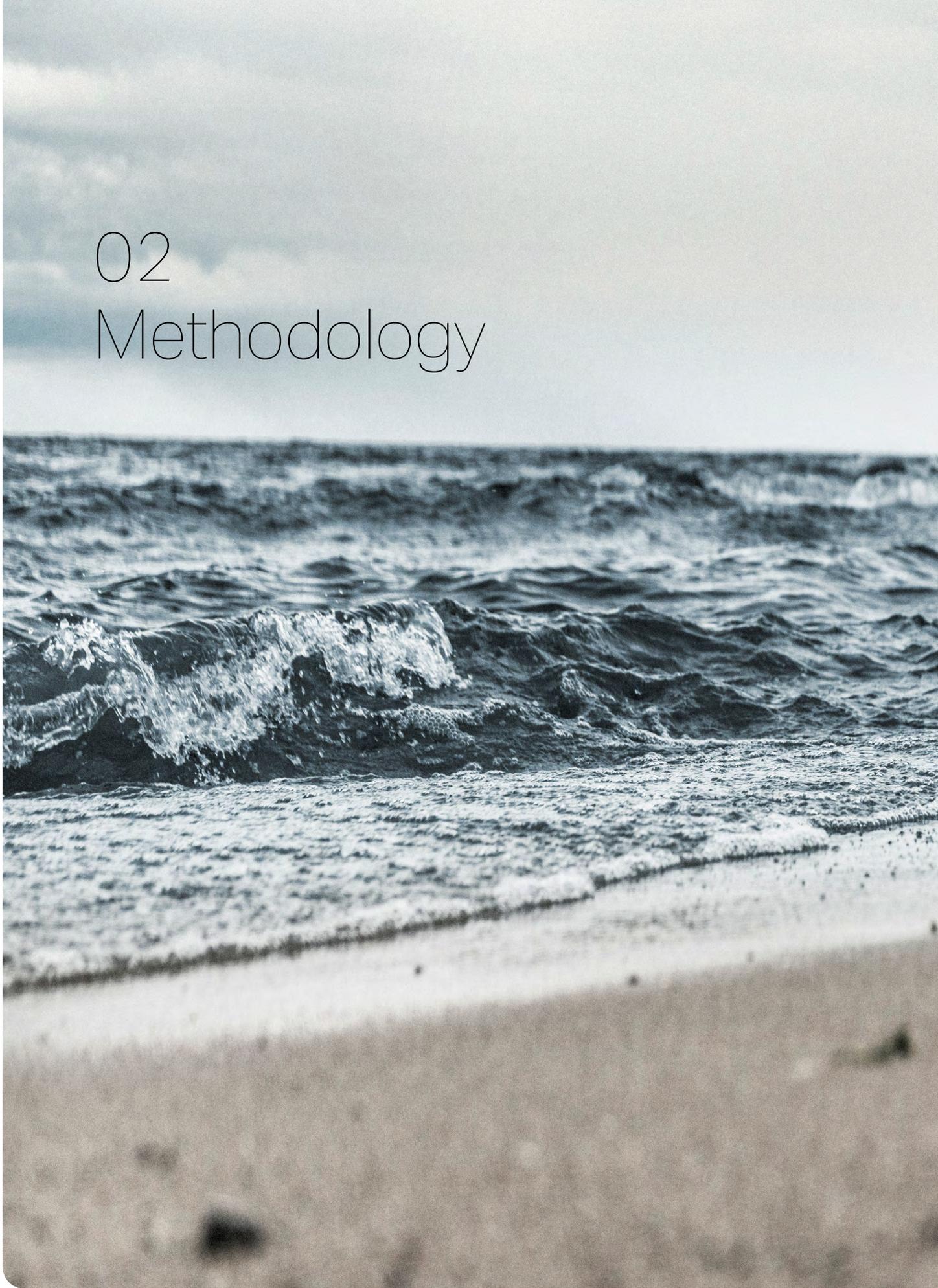
1.1 About this project

This project was led by the MMCZCS. The project team wishes to sincerely thank all survey respondents for their participation and for taking the time to answer our questions.

We also extend our heartfelt thanks to the MMCZCS's partners and external organizations for their great help in spreading the survey on board vessels and enabling the seafarer community to share their views.



02 Methodology



2.1 Questionnaire

To understand the perception and acceptance of ammonia as a marine fuel across the maritime community, the MMMCZCS designed an online survey. Our survey was launched in February 2024 and remained open until mid-April 2024. The survey questions primarily focused on (a) the prevalence and nature of safety concerns related to use of ammonia as a marine fuel, (b) desires for knowledge and training regarding ammonia as a marine fuel, and (c) actual and perceived willingness to sail on or work with ammonia-fueled vessels. The questions were primarily multiple choice, but respondents were able to optionally share additional reflections on the topic at hand via open comment fields, via the prompt 'Please add any additional input you might have here'. The full questionnaire is included as an appendix to this report.

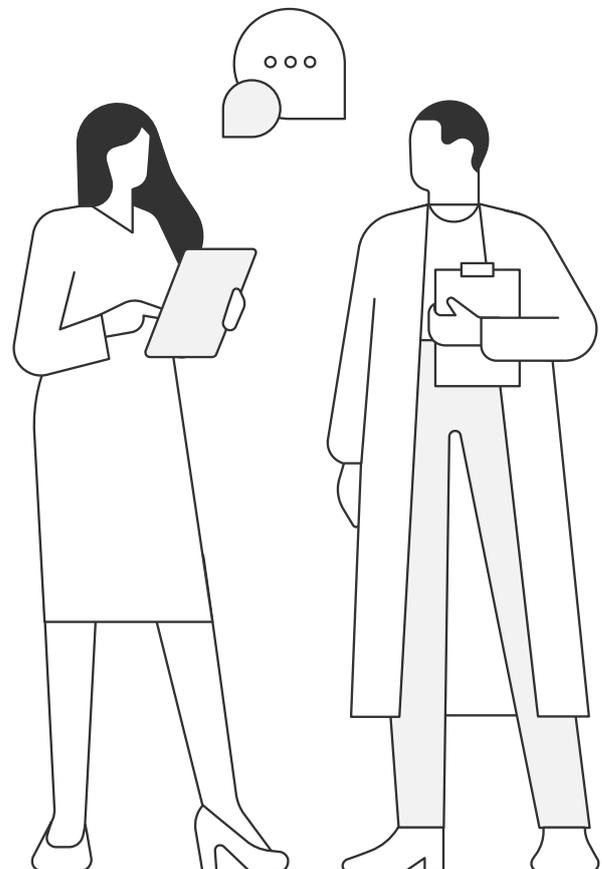
The exact wording of survey questions varied slightly depending on the respondent's reported position (e.g., seafarer versus ashore personnel), but the same multiple-choice response options were included for all respondents. One question was retrospectively discarded from the data due to concerns over ambiguity in its phrasing (see Appendix for more details).

2.2 Sampling and recruitment

We used a mixed sampling strategy to recruit respondents to our survey, with the aim of reaching a broad cross-section of the maritime industry in terms of both stakeholder groups and vessel segments. The sampling strategy was designed to overcome barriers to direct contact with seafarers in particular, such as a lack of reliable internet access at sea. We initially

conducted mapping exercises to identify organizations associated with different public and private stakeholder groups as follows: unions, shipping companies, shipowners, flag states, insurers, manning companies, ship management companies, public organizations, and seafarers.

We reached out to these respondents directly via email to share the survey and request their participation. Where contact information was available, most emails were also followed up by a phone call from a member of the MMMCZCS project team to explain the objective and context of this research. We expanded our initial contacts using a snowball sampling strategy, in which we invited organizations and individuals contacted directly by our team to recommend others to contact or to forward the survey link directly to their own networks. The survey is based on 2,004 respondents.



To protect anonymity and encourage participants to share their honest opinions, we deliberately did not collect information about respondents' names, gender, location, nationality, or employer. Our team therefore paid special attention to including as much diversity as possible when recruiting potential respondents, especially in terms of vessel segments, geography, and positions. However, the achieved regional representation may introduce bias into the data. This anonymity also means that the survey results represent individual standpoints about ammonia as fuel, rather than any corporate position on ammonia as marine fuel. One of the strengths of this survey, therefore, lies in the absence of any intermediary between the voice of the respondents and the results.

2.3 Data analysis

We used Microsoft Excel and PowerBI to analyze the responses to the multiple-choice questions. For analysis, the responses were typically divided into those from seafarers versus ashore personnel. In some cases, we also examined differences between respondents with and without experience working on or with gas-fueled vessels or with ammonia as cargo, or based on responses to one of the survey questions (for example, willingness to sail on or work with ammonia-fueled vessels). Given the relatively small proportion of people who have worked with gas-fueled ships and/or ammonia as cargo across the global maritime community, there is a risk that this may create bias within the data and influence how it can be interpreted.

We also received about 1,500 unique comments in the open response fields. These comments were collated and reviewed by the project team to identify trends and points of interest. A selection of illustrative comments from respondents (lightly edited for grammatical correctness) is included where relevant throughout this report.



03 Respondents' profile





As far as possible, we aimed to hear from a broad cross-section of the maritime community, covering different ages, fleet segments, and ranks and positions both onboard and ashore. We were able to reach a large group of survey respondents for all the above criteria.

This section summarizes demographic information about the survey respondents and how their profile compares to that of the broader maritime industry. This information serves as important context for the generalizability of the survey results.

3.1 Age profile

Figure 1 shows that 50% of the total respondents were under 40 years old. They will be the ones who will gain experience with ammonia as a marine fuel in the course of their careers.

27% of the respondents are between 40 and 50 years old, and 23% are over 50. They will be the ones who are more likely to hold high-ranking positions with extended responsibilities when ammonia is adopted as a marine fuel.

3.2 Positions of respondents

In total, 1,435 seafarers answered the questionnaire, representing 72% of the total respondents (Figure 2). The seafarers' positions included engineers, officers, ratings, and cadets (Figure 3).

The remaining 569 respondents, or 28% of the total, were shore personnel (Figure 2). Figure 3 shows that many different ashore positions are represented among the survey respondents.



Figure 1: Summary of respondents' age profile (all respondents).

What is your age?

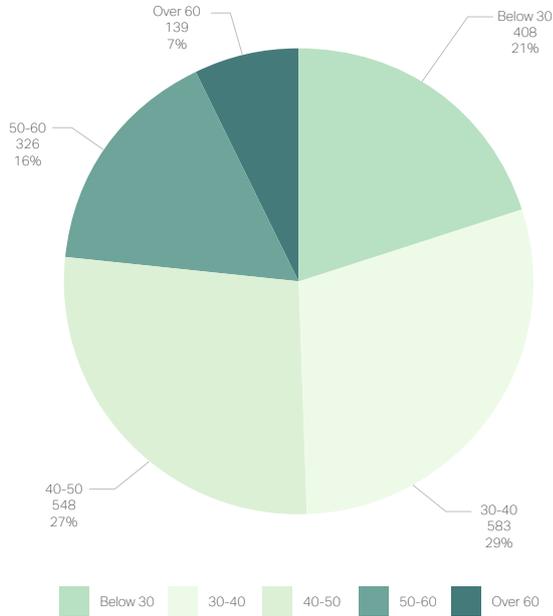


Figure 2: Summary of respondents' profile (job position).

Respondents profile

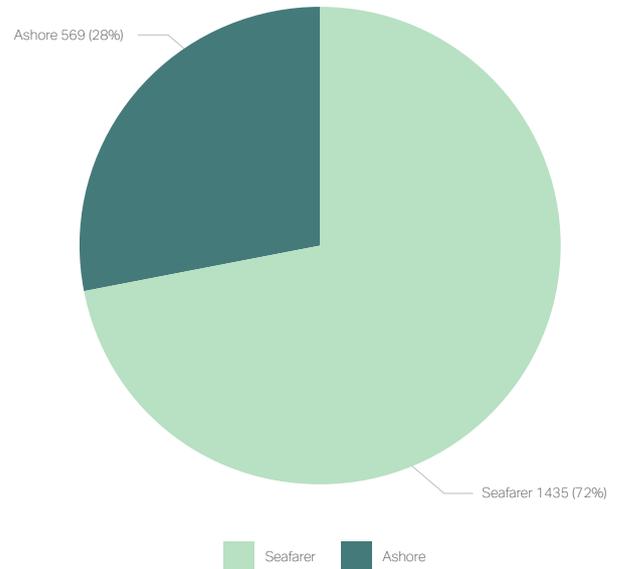
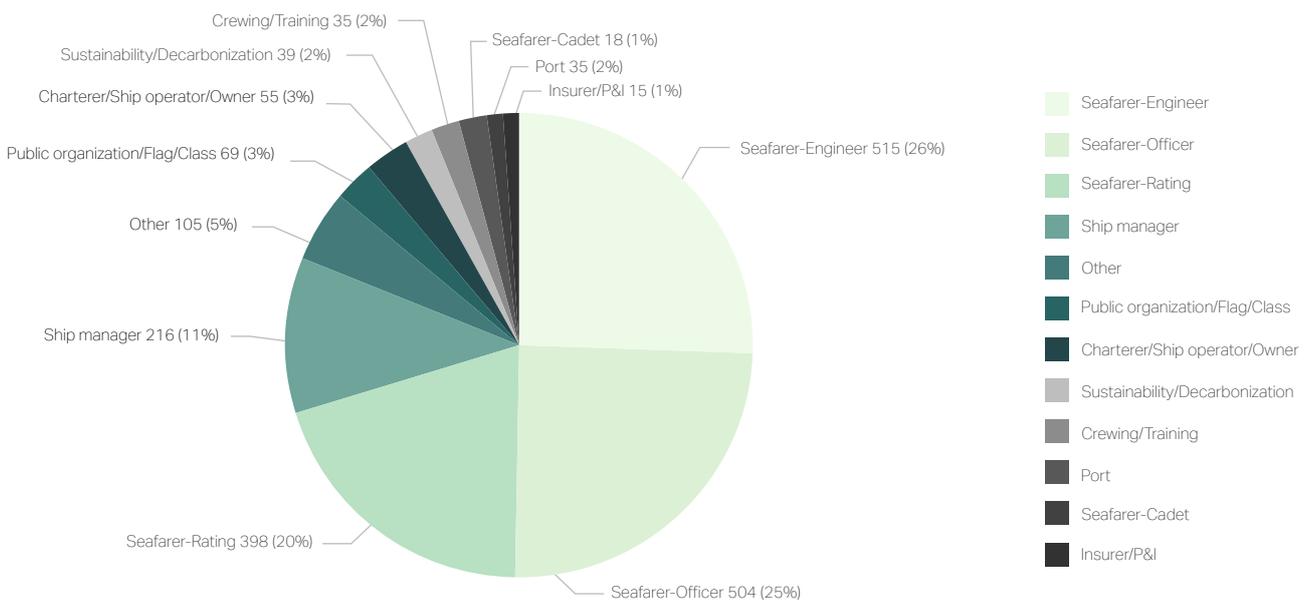


Figure 3: Summary of survey respondents' specific positions.

What is your position?



3.3 Vessel segment

The survey aimed to gauge the perception of ammonia as a marine fuel from all ship segments in the worldwide fleet (see Figure 4 for reference).

Figure 5 shows that the sailing experience of seafarer respondents to our survey is mainly on container ships, bulk carriers, and various types of tankers. However,

many additional ship segments are also represented among our respondents. The results for ashore respondents show a broadly similar pattern.

Respondents might work or have worked with multiple kinds of ships, and therefore could have selected multiple ship types in their response.

Figure 4: Summary of ship segment distribution (excluding tugs) in the worldwide fleet. LPG = liquefied petroleum gas, RORO = roll-on roll-off, PCC = pure car carrier, LNG = liquefied natural gas. Data source: Clarksons Research, 2024.

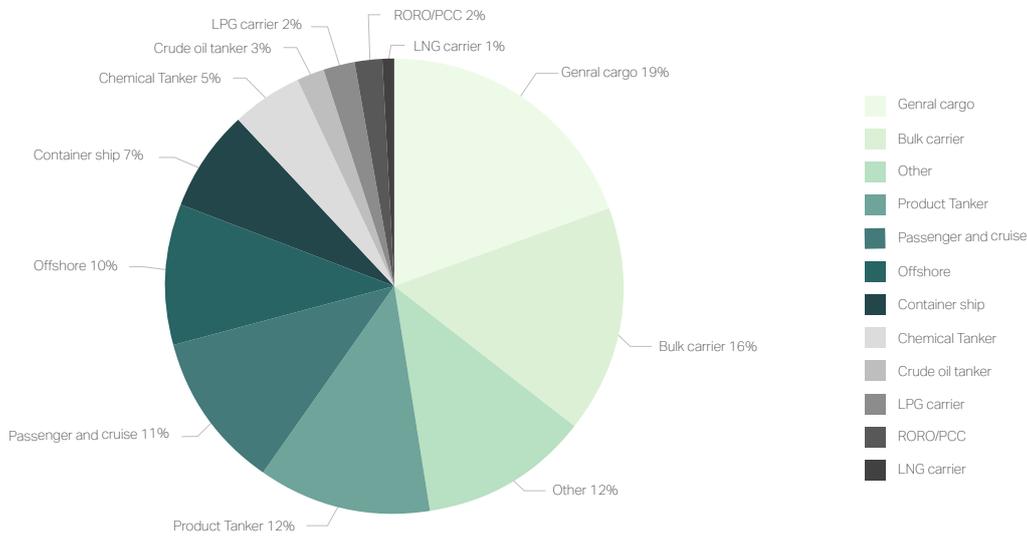
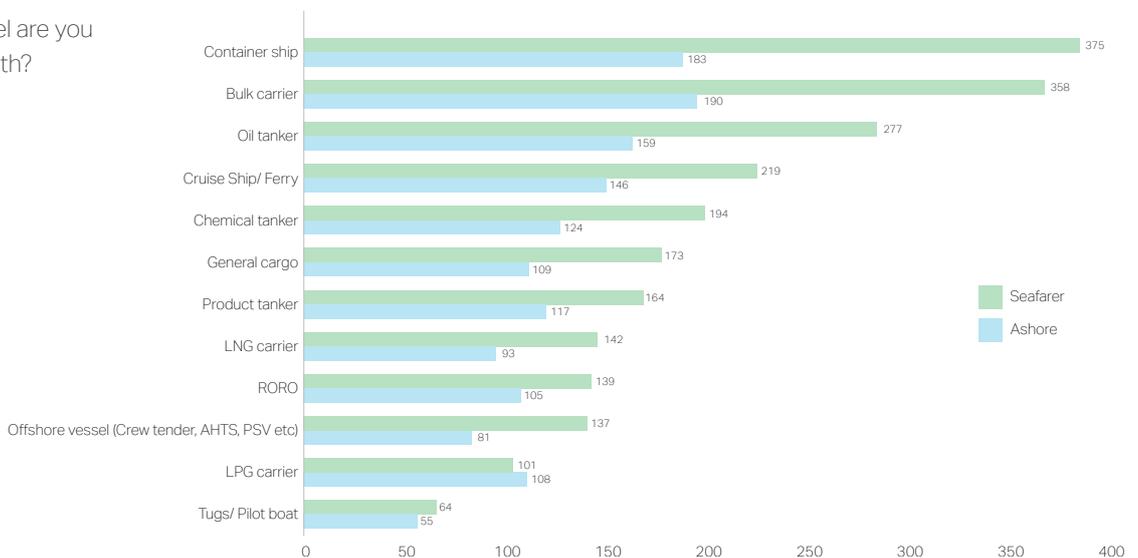


Figure 5: Summary of survey respondents' experience with different vessel segments (respondents were able to select multiple options). LPG = liquefied petroleum gas, RORO = roll-on roll-off, PCC = pure car carrier, LNG = liquefied natural gas

What type vessel are you working on or with?

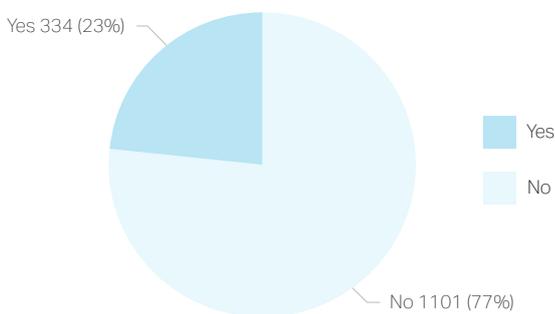


3.4 Experience with gas-fueled vessels or ammonia as cargo

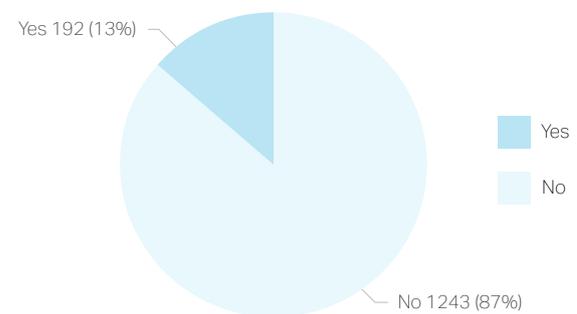
To work on ammonia-fueled vessels, seafarers need competencies both in working with gaseous fuels and with ammonia specifically. The majority of seafarers who responded to our survey had no experience with handling gas fuels (77%) or with ammonia as cargo (87%) (Figure 6). For context, only 6.4% of the global fleet (excluding tugs) is currently alternative fuel capable (i.e., including vessels that can operate on gaseous fuel), and ammonia carriers likewise account for less than 1% of the global fleet.^{8,9}

Figure 6: Summary of survey respondents' experience with gas-fueled vessels or ammonia as cargo. Results for seafarers and ashore personnel are presented separately.

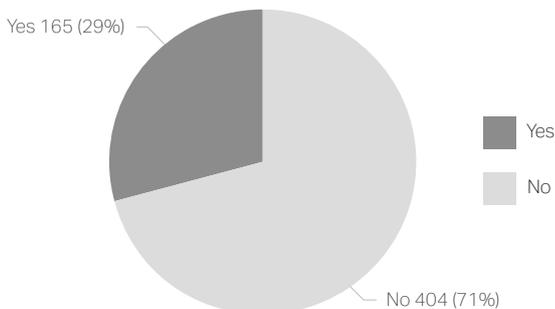
Seafarer - Have you ever sailed on gas fueled vessel?



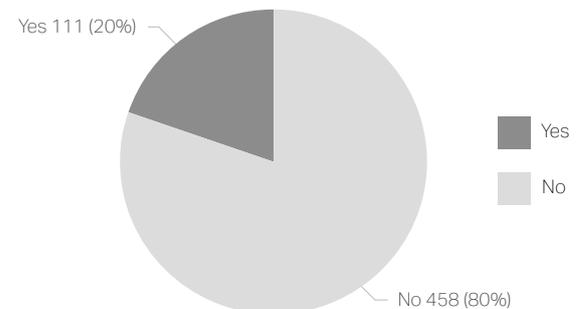
Seafarer - Have you ever worked with ammonia as cargo?

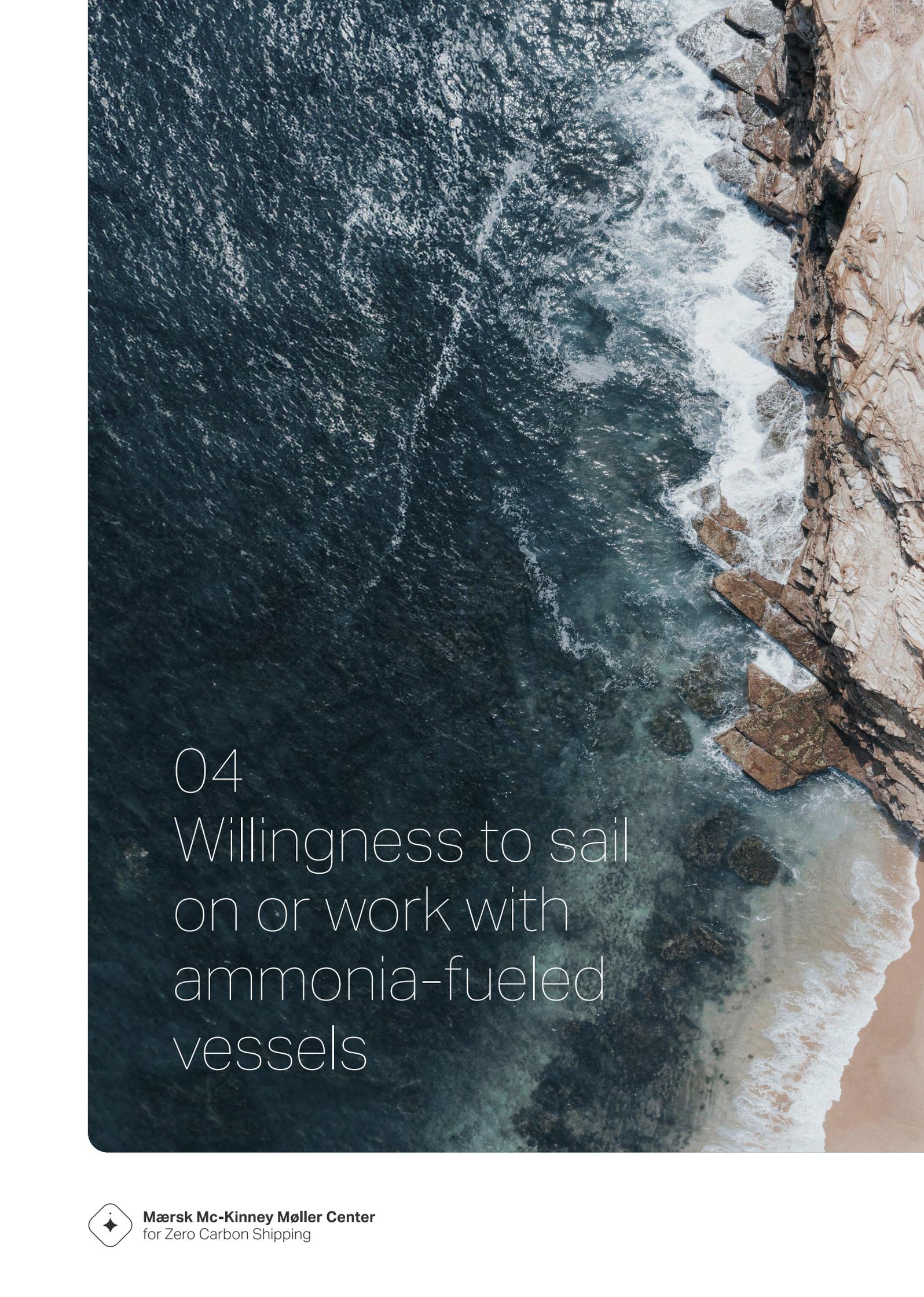


Ashore people - Have you ever sailed on or worked with gas -fueled vessel?



Ashore people - Have you ever sailed on or worked ammonia as cargo?





04
Willingness to sail
on or work with
ammonia-fueled
vessels



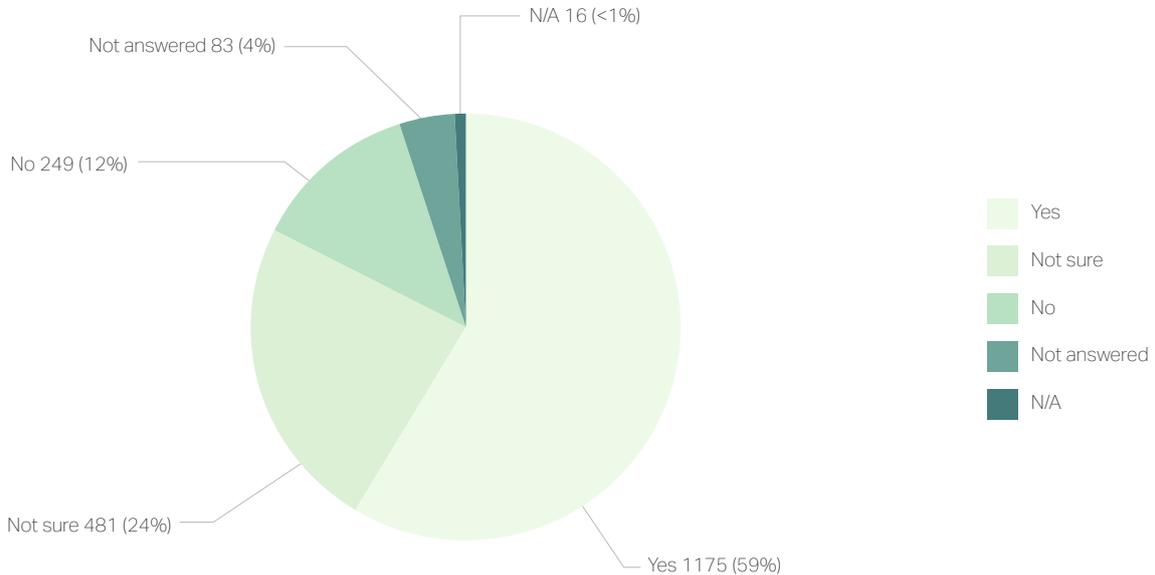
Key takeaway 1: The majority of respondents from across the maritime community are willing to sail on or work with ammonia-fueled vessels.

Our survey received a total of 2,004 responses from individuals representing a broad cross-section of the maritime industry (see Section 3).

The survey responses show that, overall, almost 59% of respondents are willing to sail on or work with ammonia-fueled vessels (Figure 7). An additional 24% are unsure, while about 12% of respondents reported that they would not accept sailing on or working with ammonia.

Figure 7: Summary of all respondents' willingness to sail on or work with ammonia as a marine fuel.

Would you work with or sail on ammonia-fueled vessels?



*The results are a composite of responses to the following survey questions: 12, 20, 29, 38, 47, and 62.



Assessing the open-field responses provides some further insights into respondents' perspectives on ammonia as a marine fuel. While safety was clearly a focus (see also Section 6 for more details on respondents' safety concerns), respondents also touched on financial matters, environmental impacts, and regulatory readiness in their comments.

The upcoming subsections delve further into the perspectives on ammonia as a marine fuel from seafarers and ashore respondents.

Selected comments from respondents highlighting safety, finances, environmental impacts, and regulation

'Too toxic. You know how ships are built and maintained with only money savings in mind. So no way!'



Comment from a seafarer

'I suggest an extra bonus to engineers to handle this toxic and extremely dangerous fuel.'



Comment from a seafarer

'From an owner's point of view, safety record of the engine is important. Owners need to find competent crew and need to protect the crew with big investments. We are working for LNG [liquefied natural gas] DF [dual-fuel] and methanol DF because there is an over several years' safety record for those fuels.'



Comment from a ship manager/superintendent

'Many are concerned about using ammonia in confined, enclosed spaces. Nothing is going to change this, as it's toxic and people will inevitably be more at risk than using fuel oil. Mitigating those risks will make people more comfortable, but the reality of the current situation for pretty much any fuel is that economics is driving which fuel is foremost, and until proper evaluations of FULL environmental impacts of what it takes to produce each fuel are available to show the real benefits of each fuel relative to another, then it makes it hard to justify to crews, engineers, shipbuilders, etc., whether or not there is really any environmental benefit to using ammonia.'



Comment from a flag state representative

'The concept is interesting environmental-wise – however, it is still a lot of technology and regulations to develop. The production processes have to be adjusted to minimize CO₂ emissions.'



Comment from a ship manager



4.1 Seafarer perspectives

The majority (59%) of the 1,435 seafarers who responded to our survey stated that they would accept sailing on an ammonia-fueled vessel (Figure 8). The second-largest group (26%) were not sure, while 15% indicated that they would not accept.

Further, among seafarer respondents, the officers were somewhat more likely than engineers or ratings to express willingness to sail on ammonia-fueled vessels (Figure 9). Willingness to sail on ammonia also seemed to decrease with age, with only 45% of the seafarers over the age of 60 saying that they would accept sailing on an ammonia-fueled vessel, compared to about 64% of those under 40 (Figure 10). Conversely, the 40-50 age group showed the lowest level of outright reluctance to sail on ammonia – 3 percentage points lower than that of the youngest age group (Figure 10).

Figure 8: Summary of seafarers' responses regarding whether they would accept sailing on an ammonia-fueled vessel (results shown for all seafarer respondents).

Seafarer - Would you sail on ammonia-fueled vessel?

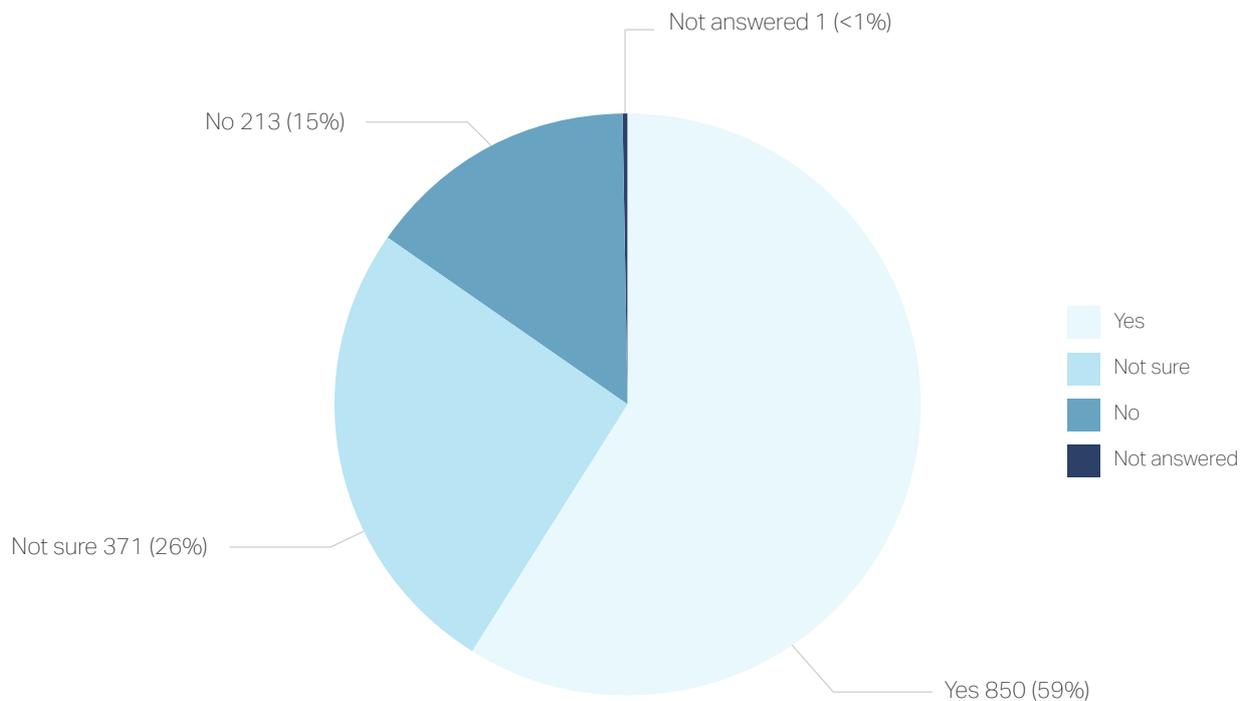


Figure 9: Summary of seafarers' responses regarding whether they would accept sailing on an ammonia-fueled vessel (results broken down by position).

Would you sail on ammonia-fueled vessel?

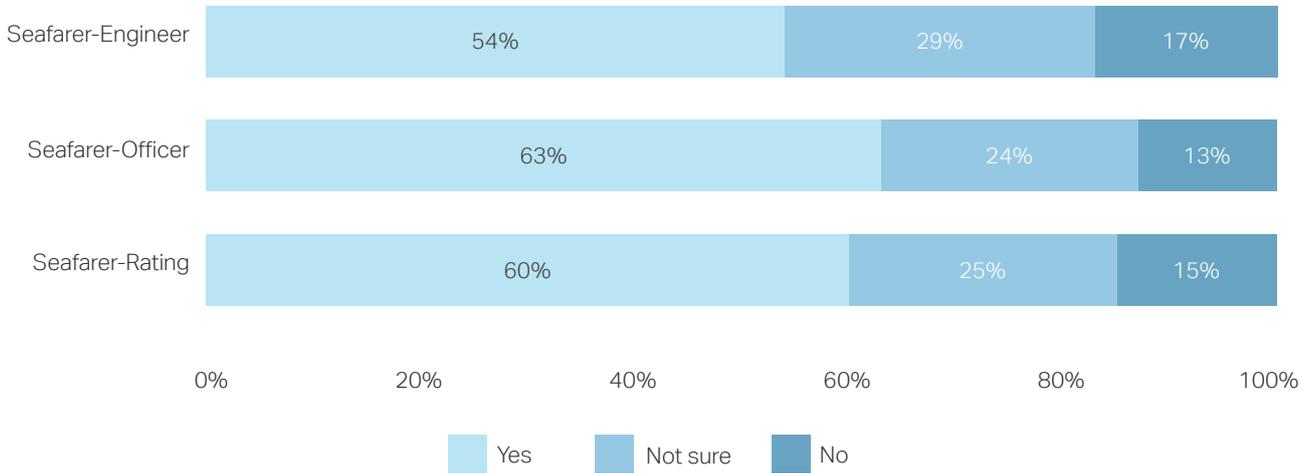
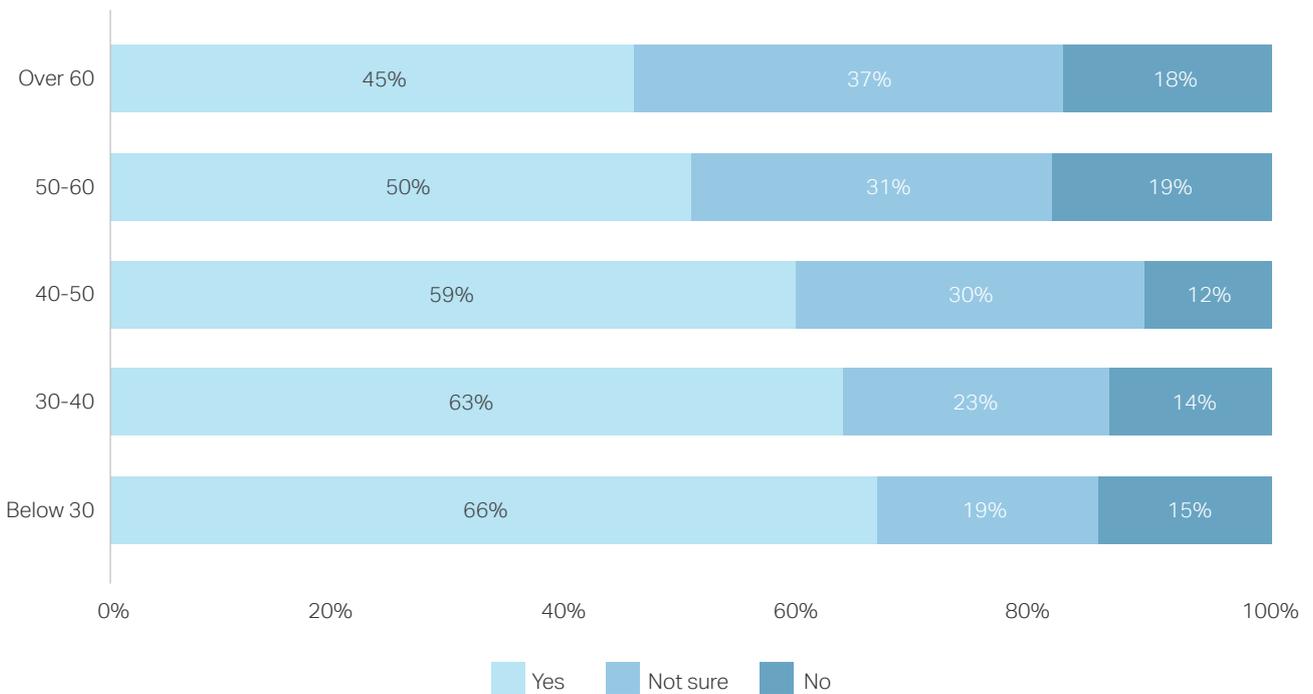


Figure 10: Summary of seafarers' responses regarding whether they would accept sailing on an ammonia-fueled vessel (results broken down by age).

Would you sail on ammonia-fueled vessel?



The open-field comments from the respondents reflected a wide spectrum of views about sailing with ammonia as a marine fuel. Safety concerns, especially related to ammonia's toxicity and impact on humans, were an important theme.

Selected comments from seafarer respondents on willingness to sail with ammonia

'I am not going to sail on an ammonia-fueled vessel, due to its high toxicity.'



Comment from a seafarer

'When there are good risk assessments correctly in place for all crews and better insurance.'



Comment from a seafarer

'I don't want to sail on ammonia-fueled vessels under any conditions.'



Comment from a seafarer

'More knowledge about ammonia as a cargo/fuel and what impact it can have on human beings. When it is proved it is safe to handle, I will have no objection to sailing on ammonia-fueled vessels.'



Comment from a seafarer

'No matter what type of marine fuel used, we do our job as seafarers.'



Comment from a seafarer



4.2 Ashore perspectives

Our results show that 57% of the respondents from ashore positions are willing to work with ammonia as a marine fuel, while only 6% stated that they would not accept working with ammonia (Figure 11). Respondents working in sustainability or decarbonization, ship

managers, and insurers or protection and indemnity (P&I) clubs had the highest proportions of positive responses to working with ammonia (Figure 12). The 6% who answered 'no' to working with ammonia contained no insurers or port authorities (Figure 12).

Figure 11: Summary of ashore respondents' responses regarding whether they would accept working with ammonia as a marine fuel.

Ashore/ Do you accept ammonia-fueled vessel?

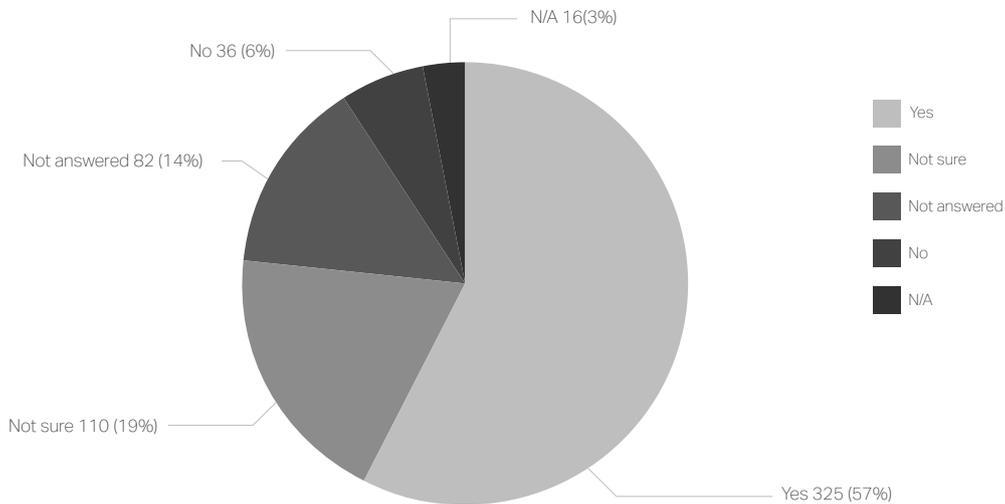
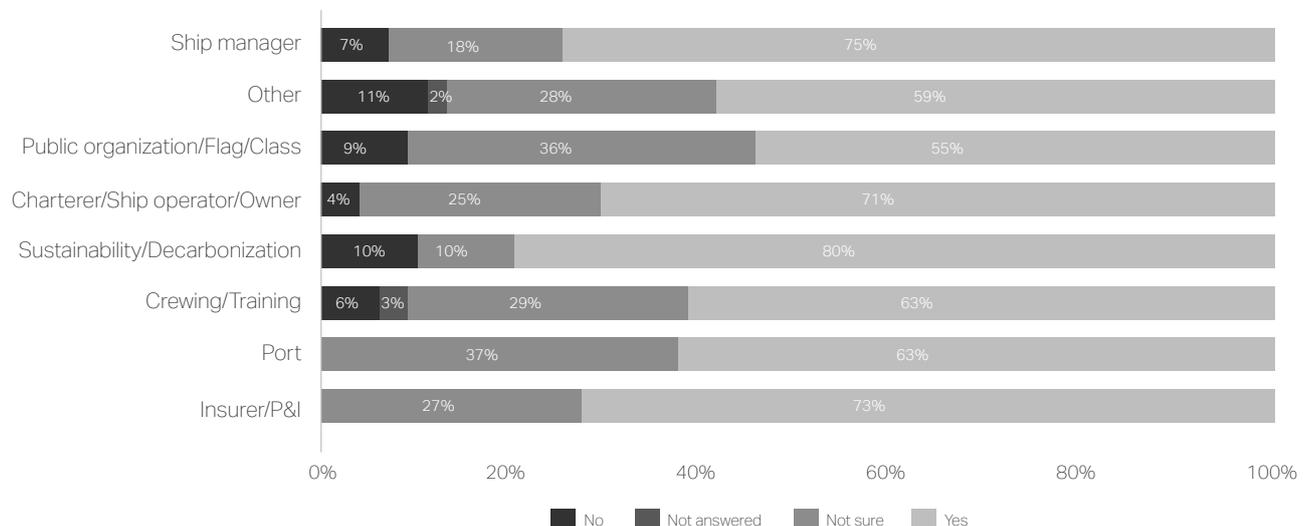


Figure 12: Summary of ashore respondents' responses regarding whether they would accept working with ammonia as a marine fuel (results broken down by respondent position, 'N/A' responses excluded). P&I = protection and indemnity.

Do you accept to work with ammonia-fueled vessel?



Selected comments from ashore respondents on willingness to sail with ammonia

'There are a lot of misconceptions [about ammonia]. When methanol, LPG [liquefied petroleum gas], and LNG do not leak in the engine room, then why will ammonia leak? Similarly, LNG and LPG are bunkered at much lower temperatures and, to date, there have been no incidents of leaks during transfer or bunkering. Then why will it happen with ammonia?'



Comment from a ship manager/superintendent

'I am not sure we would agree to manage an ammonia-fueled cruise ship in the near future.'



Comment from a ship manager/superintendent

It is also interesting to compare the ashore respondents' perception of seafarers' attitudes towards ammonia-fueled vessels with the data collected from seafarers in our survey (Section 4.1).

An average of 67.5% of ashore respondents agreed that they "would consider crew reluctance as a barrier to ammonia implementation on board vessels".* Respondents from ports, public organizations/flag states/class societies, and charterers/operators/shipowners were especially likely to answer 'yes' to this question (Figure 13). This stands in contrast to the results shown in section 4.1.

For additional insight into this aspect of the results, we can turn to the ashore respondents' comments in their own words. We collated 69 unique entries in the free response field associated with this question. The respondents express a range of views on seafarer reluctance, adding some nuance to the multiple-choice data. A selection of representative comments is reproduced below.

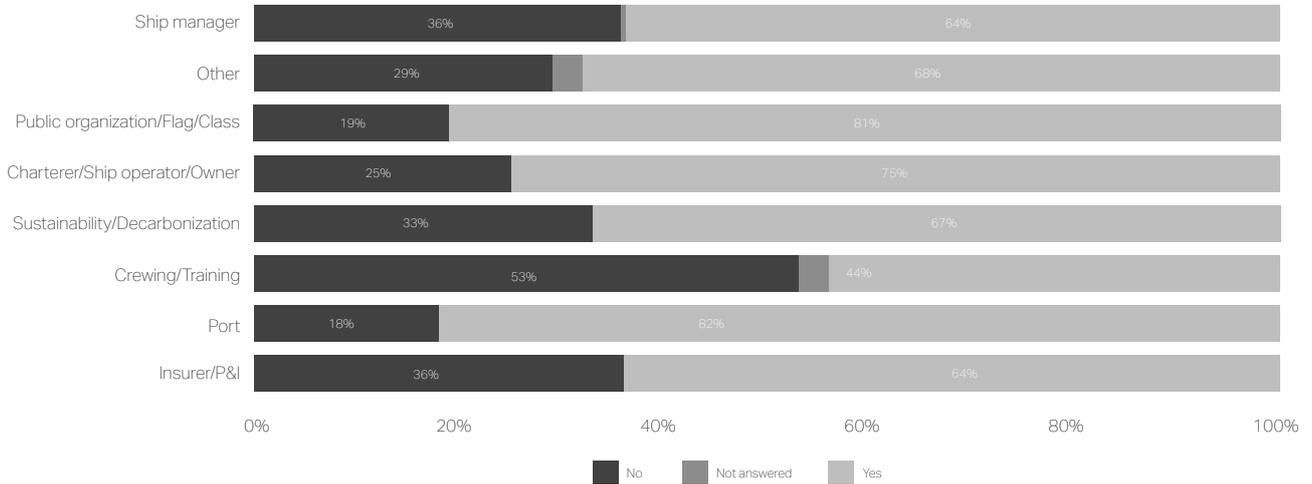


*This question was not included in the 'seafarer' version of the questionnaire.



Figure 13: Summary of ashore respondents' perception of crew attitudes to ammonia as a marine fuel. Respondents were asked whether they would consider crew reluctance as a barrier to ammonia implementation on board vessels. P&I = protection and indemnity

Would you consider crew's reluctance as a barrier for ammonia implementation onboard?



Selected comments from ashore respondents on crew reluctance**

'Yes, such reluctance would be well founded.'

 Comment from a fleet manager/superintendent (yes)

'Yes, but only at the beginning. With an increasing number of ammonia-powered vessels, the reluctance will swiftly disappear.'

 Comment from a sustainability department respondent (yes)

'I am sure that crew handling the ammonia on board will be trained and experienced in such operations (loading/discharging operations, LNG/NH₃) and sourced from our existing gas (LPG) fleet today.'

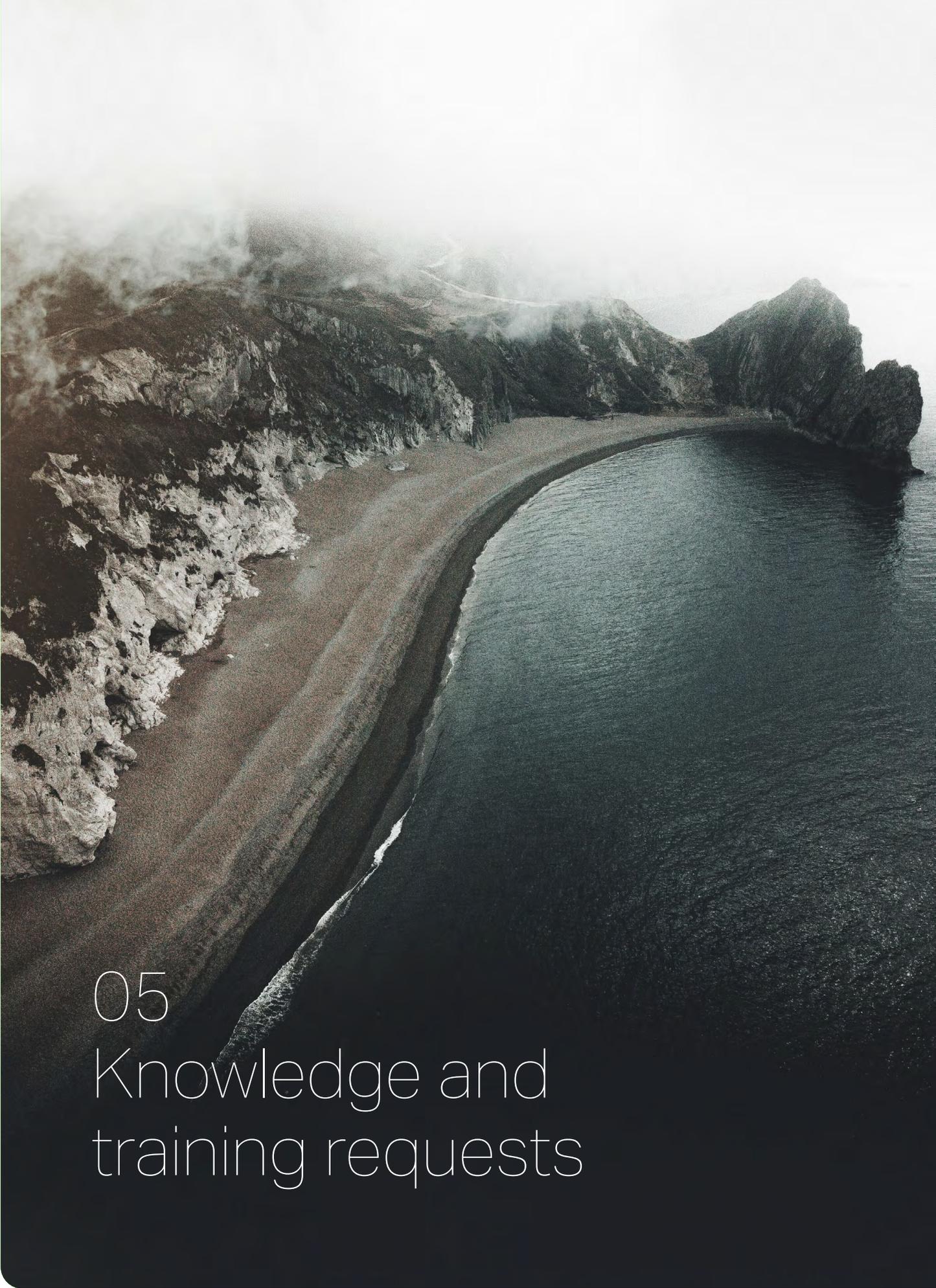
 Comment from a shipowner/ship manager (no)

'If they are reluctant, I trust that it can be overcome by training and information.'

 Comment from an insurer/P&I club (comment only)

** Words in parentheses show respondents' answers, if applicable, to the multiple-choice question 'Would you consider crew reluctance as a barrier for ammonia implementation on board?'





05
Knowledge and
training requests



Key takeaway 2: Acceptance of ammonia as a marine fuel is conditional on a comprehensive level of training and certification.

The open-field comments collected throughout our survey show that comprehensive training is the main request from the maritime community regarding ammonia as a marine fuel. A failure to conduct adequate training at the requested level is therefore a key barrier to the implementation of ammonia as an alternative shipping fuel.

Selected comments from respondents highlighting training

'Would love to sail on a ship with such a system onboard, but prior to that – to obtain a proper training.'



Comment from a seafarer

'The industry (concerned IGF vessel crew and owner/manager) needs proper and mandatory (certified) training on how to safely handle ammonia before ammonia goes live as fuel. It is not rocket science and is manageable — however, an ignorant approach will kill seafarers. There is a very good reason why engine makers currently put the highest safety standards on their ammonia-fueled engine testbeds.'



Comment from a ship manager/superintendent

'It would have to be of no impact to my health. Obtain suitable training on how to manage and maintain equipment handling ammonia.'



Comment from a seafarer

'For me all depends on the type of ship and crew. I would have less concerns with gas/chemical tanker crew. Safety culture still varies a lot across different ship types, I'd be worried with your average bulk carrier crew... Deep understanding of the topic and training would be required for safe handling, along with a well-implemented behavioral safety program.'



Comment from a ship manager/superintendent

'I would need to learn more about it. I'd rather have onboard training with ship-specific systems. NOT classroom training!'



Comment from a seafarer



'Ammonia is a highly toxic liquid and can cause breathing difficulty or even suffocation at high levels of ammonia concentration. Therefore, it should be handled with great care including maintenance/conditioning during storage. When used on board as a fuel, suggest that all personnel should have basic knowledge of ammonia handling. Training is needed for safe handling of such a toxic liquid and a good tool for everyone to acquire knowledge in handling, conditioning, and later use as a fuel.'



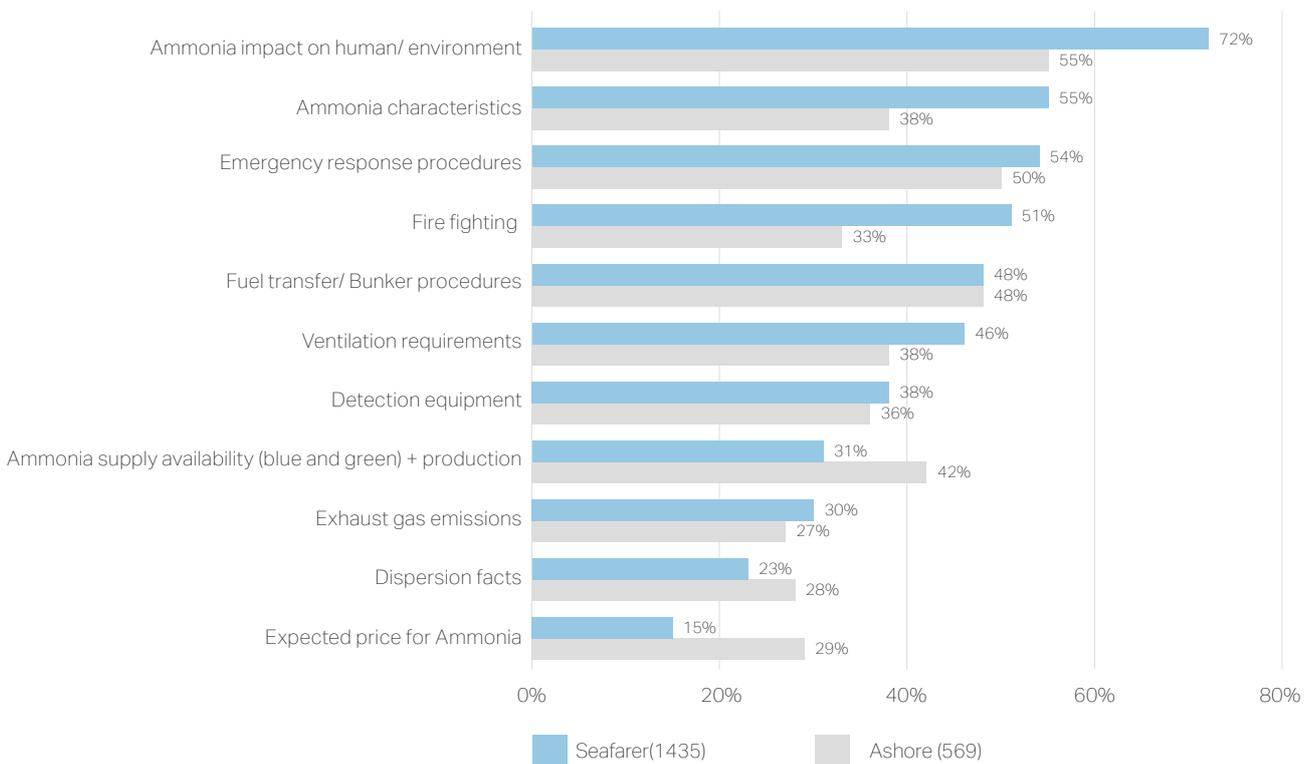
Comment from a ship manager

To gather more specific insights into training needs and priorities, we also directly asked respondents what knowledge they needed about ammonia as a marine fuel, with a list of possible answers to select from (see Figure 14). In the responses to this question, information relating to ammonia's impacts on humans and the environment was the most requested category for both seafarers and ashore respondents (Figure 14). Knowledge about emergency response procedures was also highly requested by both groups (Figure 14).

The responses suggest that the maritime community may need to gain more competence regarding certain operational and technical aspects of ammonia as a fuel. For example, an understanding of how ammonia gas disperses is critical safety knowledge – yet, a relatively small number of respondents selected 'dispersion facts' as an area that they needed knowledge in.

Figure 14: Summary of topics on which survey respondents reported that they needed knowledge about ammonia as a marine fuel. Respondents could select multiple options, results are presented in percentages, with fraction of respondents in parentheses next to the legend.

What knowledge do you need about ammonia as a marine fuel?



In the next question, we asked respondents to select desired options from a list of focus areas for training (see Figure 15). This question was phrased slightly differently depending on the respondent group, asking respondents either what they would like to be trained on (seafarers, ship managers, and port operators), what they or the people they represent would like to be trained on (seafarer representatives or unions, flag states), or what seafarers should be trained on (insurers/ P&I, charterers/ship operators).

Ammonia leakage was clearly highlighted as a major hazard that seafarers need guidance on and was also the most popular response among ashore respondents (Figure 15). Alongside emergency response and firefighting, day-to-day operations such as maintenance and bunkering were also identified as important training topics (Figure 15). Among the seafarer respondents, 605 (605/1465=42%) selected 'regulation' as an area in which they would need training, as did a similar proportion (252, or 44%) of ashore respondents (Figure 15). Some comments in the survey also expressed concerns about regulatory readiness and effectiveness of training.

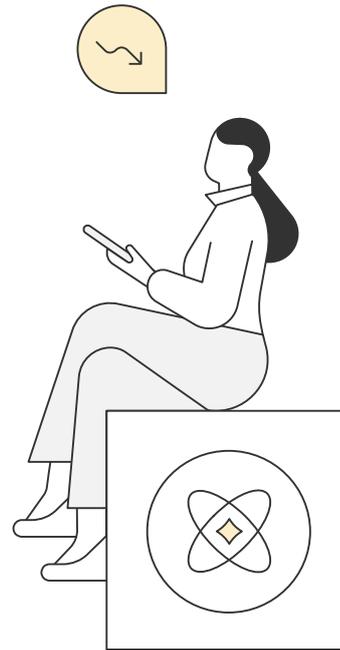
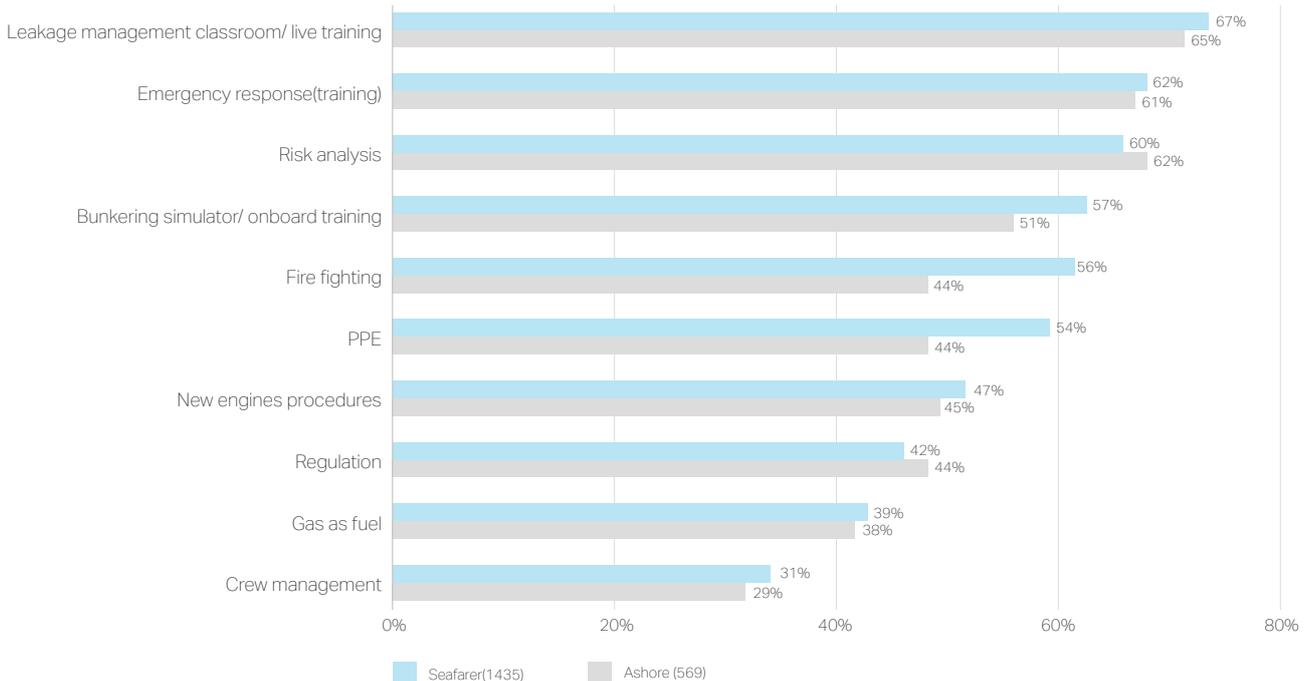


Figure 15: Summary of topics on which survey respondents reported that they (or seafarers) needed training regarding ammonia as a marine fuel. Respondents could select multiple options. Results are presented in percentages, with number of respondents in parentheses next to the legend. PPE = personal protective equipment

What training would you need?



Selected comments from respondents on regulation and training

'For me, the biggest hesitation on this issue will be crew training. How realistic the certificates to be issued in this regard will be is a matter of great debate. Training and certification on this subject should be provided by international organizations and not left to the authority of states.'



Comment from a seafarer

'STCW curriculum updates will have to be introduced very quickly and ratified to ensure seafarers are properly trained before ammonia is seen as a mainstream marine fuel.'



Comment from a ship manager

The training priorities did not differ greatly between ashore and seafaring respondents (Figure 15), nor between seafarers with and without experience with dangerous liquid cargo (Figure 16). Training priorities did appear to differ slightly for seafarer respondents with different levels of willingness to sail on an ammonia-fueled vessel – for example, training on personal protective equipment (PPE) was the fourth-most requested training topic for seafarer respondents who were unwilling to sail on ammonia, but the sixth-most requested for those who were willing or unsure (Figure 17). Overall, the breadth of training topics requested by numerous respondents points to an industry-level awareness that implementation of ammonia as a marine fuel will require extensive and comprehensive training.

Figure 16: Summary of topics on which seafarer survey respondents reported that they needed training regarding ammonia as a marine fuel (comparing seafarers with and without experience with dangerous/gas/liquid cargo – see Figure 6). Respondents could select multiple options. Results are presented in percentages, with number of respondents in parentheses next to the legend. PPE = personal protective equipment

What training would you need? (Seafarer with/ without experience dangerous liquid bulk in cargo)

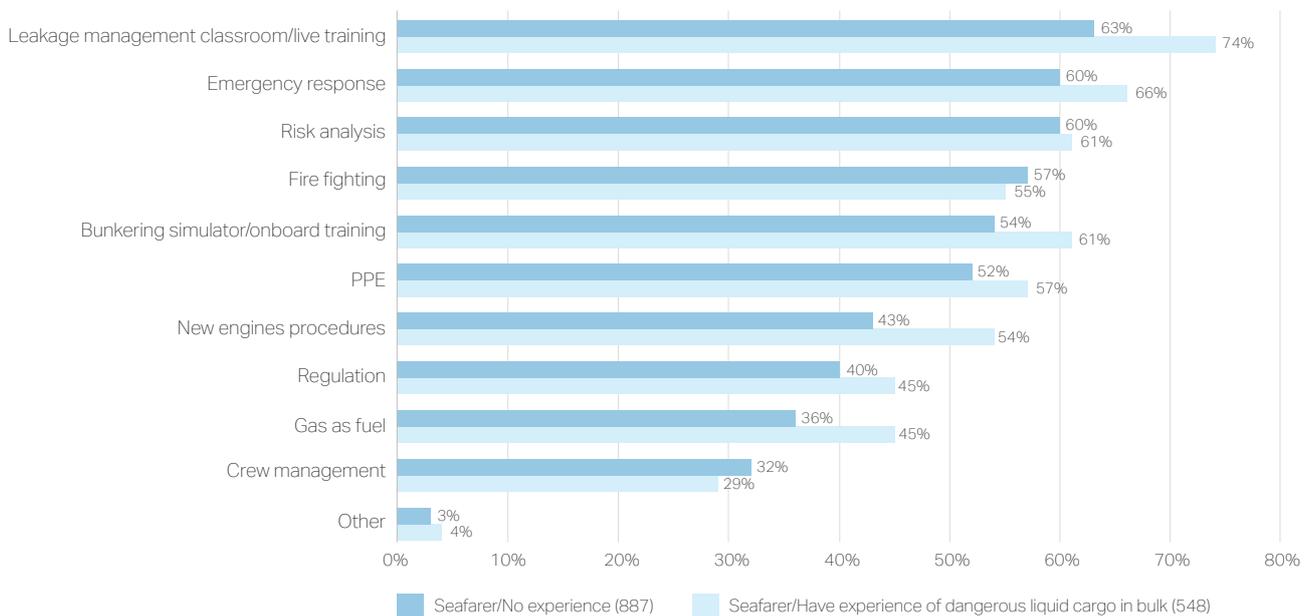
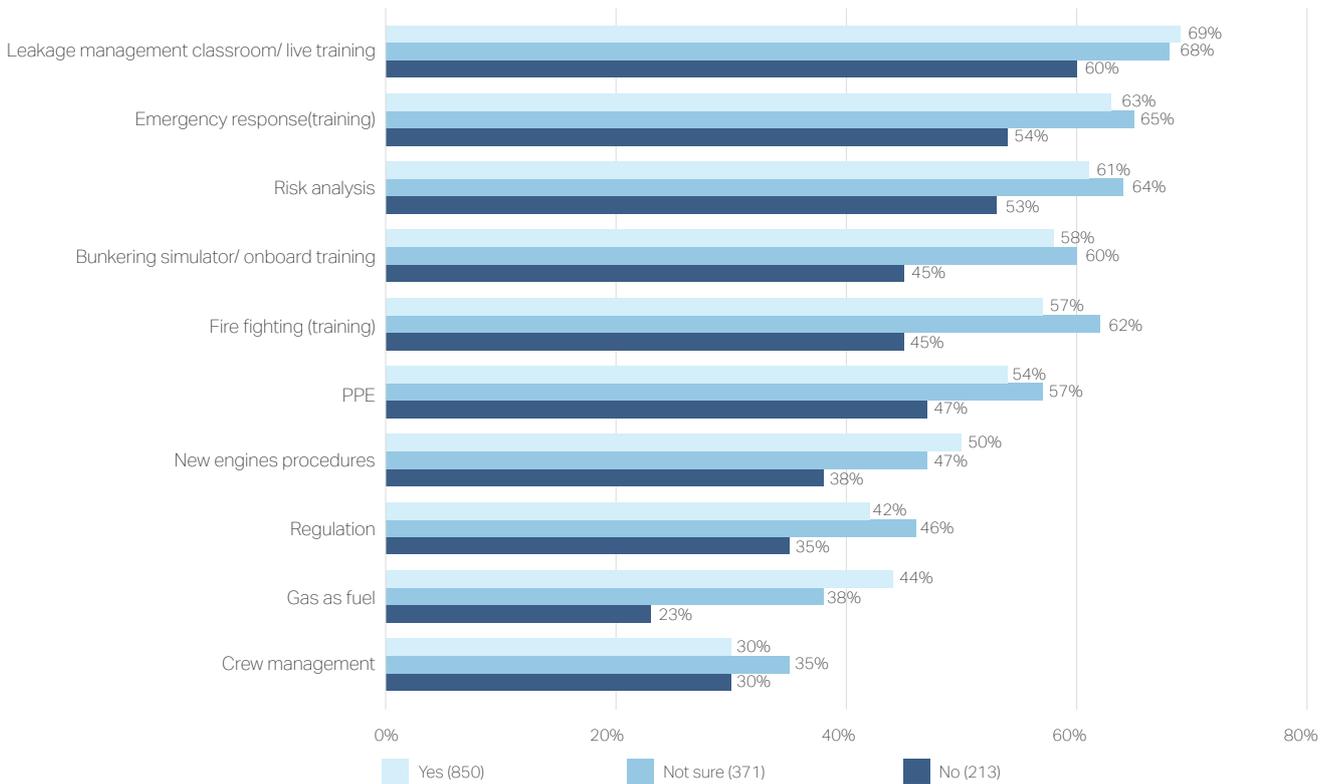


Figure 17: Summary of topics on which seafarer survey respondents reported that they needed training regarding ammonia as a marine fuel (comparing seafarers based on willingness to sail on an ammonia-fueled vessel – see Figure 8). Respondents could select multiple options. Results are presented in percentages, with number of respondents in parentheses next to the legend. PPE = personal protective equipment

Are you willing to sail with ammonia fueled vessels? / What training would you need?



These findings can be used to inform regulators and the industry in general as they create an effective training scheme for the maritime community working with ammonia as a fuel. Many seafarers will require extensive training on ammonia in the coming years. Therefore, addressing the minimum competence and training standards regarding ammonia fuel is a key collective challenge for the industry. This survey presents a rare opportunity to hear directly from individual seafarers while a new regulatory framework is still being built. These voices, and the ongoing work by multiple organizations to create training guidelines and frameworks,^{11,12,13,14,15} can strengthen the maritime community’s confidence in the implementation of upcoming regulations and training processes.



06

Safety concerns and safer ship designs



Key takeaway 3: Enhanced, reliable, and safe onboard fuel systems and inherently safer ship designs are seen as critical safety elements.

A key objective of this survey was to assess the maritime community’s current perception of ammonia as marine fuel. The results show that a clear majority of respondents have some safety concerns about ammonia (Figure 18). The safety concerns expressed in both the multiple-choice answers and open-field comments illustrate the respondents’ desire to work with safer ship designs and systems, and to have a safe working environment where they feel comfortable at work.

could select multiple options from the list). The responses to this question from both seafarers and ashore personnel were similar overall (see Figures 19 and 20). Based on their answers, the respondents are aware that ammonia is toxic and can be a threat to human health when not handled properly. Leakage and spills are perceived as some of the greatest operational risks and are a large cause of concern. Respondents were also concerned about storage, air pollution, and maintenance.

We also asked respondents to select their primary safety concerns from a list of options (respondents

Figure 18: Summary of survey respondents’ answers to the question, “Do you have primary safety concerns related to ammonia as a marine fuel?”

Do you have any safety concerns regarding ammonia-fueled vessels?

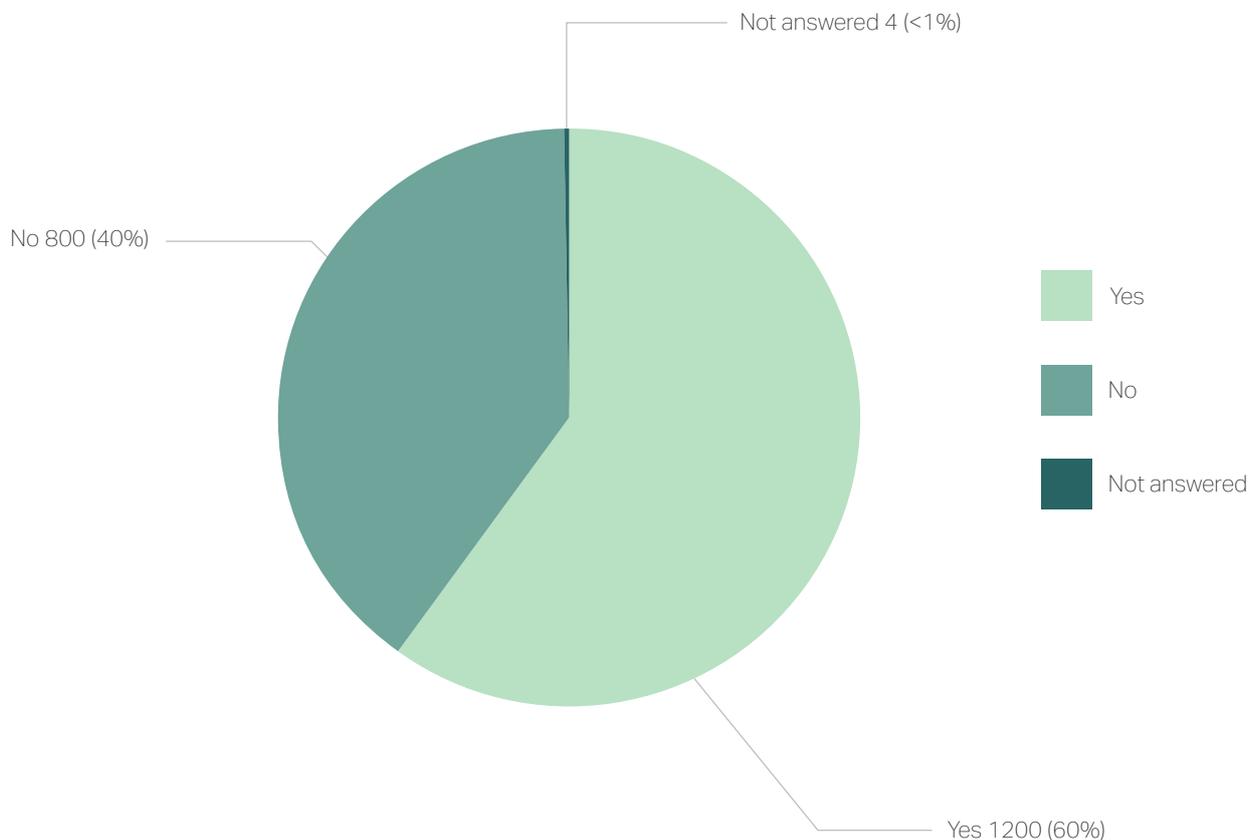


Figure 19: Primary safety concerns of seafarer respondents. Respondents could select multiple options. Numbers on the boxes represent the number of respondents who selected that category as a safety concern.

Seafarer - What are your primary safety concerns around using ammonia as a marine fuel?



Figure 20: Primary safety concerns of ashore respondents. Respondents could select multiple options. Numbers on the boxes represent the number of respondents who selected that category as a safety concern.

Ashore - What are your primary safety concerns around using ammonia as a marine fuel?



Primary safety concerns regarding ammonia as a marine fuel

According to the survey, frequent areas of safety concern for respondents include:

- Toxicity and human health, including specific characteristics of ammonia and the consequences of leakage
- Adequate storage, maintenance, and emergency response
- Pollution of air and, to a lesser extent, water

To assess the respondents' understanding of ammonia-related safety risks, the survey proposed a wide range of answers, from toxicity to cryogenic risks. The results suggest that the respondents have a generally correct perception of the major risks.

The survey's open-field comments can shed further light on respondents' specific safety concerns. As shown here, several comments emphasized the importance of technology and safer vessel and system design in limiting the risks to crew.



Selected comments from respondents on technology, design, and safety

'My main concern is leakage. Actually, I'm working on board an LNG dual-fuel container vessel, and leakages occur regularly. Seafarers must be protected all the time with ammonia.'



Comment from a seafarer

'Although ammonia is not very popular among cruise ship crews, I feel that with proper safety systems the ammonia plant can be quite safe. It is just a matter of design and not dropping the working gloves after stating 'ammonia is unsafe'. LNG was considered unsafe for decades prior to the first LNG-powered ferries.'



Comment from a seafarer

'Need safety mitigation by design for ships, in particular engine room and ammonia engines/equipment maintenance.'



Comment from a charterer

'Additional detection systems for leakages and display in major areas such as bridge, CCR [cargo control room] & ECR [engine control room]. Additional emergency exits from engine room. Portable gas detectors capable of detecting ammonia for all personnel working in the engine room at all times. Additional shore and onboard training requirements for all crew assigned to sail on gas-fueled vessels, especially highlighting all the dangers and the protection measures in place.'



Comment from a seafarer

As mariners on an LNG vessel, we were supposed to not breathe methane once, [but] it has happened already several times. I cannot believe a vessel can be made for ammonia fuel without any leakage or any fatality for crew members. If we can be 100% sure that no leak can arrive during the lifetime of the vessel, I may sail on this vessel.'



Comment from a seafarer

'Technology must be proven. If this is achieved – no concerns against ammonia.'



Comment from a seafarer representative/union respondent



07 Closing remarks



The main objective of this survey was to provide an opportunity for the maritime community to raise its voice on safety and acceptance of ammonia, a promising new marine fuel across most segments of shipping. By sharing the concerns, needs, and requests of the stakeholders who will be at the 'front line' of working with this new fuel, these findings can help to shape the future of ammonia as a marine fuel in a collaborative way. Ultimately, the results of this survey can support the industry in creating a safe working environment where people will feel secure and comfortable.

The three key takeaway messages identified from the survey results were:

-
1. The majority of respondents from across the maritime community are willing to sail on or work with ammonia-fueled vessels.

 2. Acceptance of ammonia as a marine fuel is conditional on a comprehensive level of training and certification.

 3. Enhanced, reliable, and safe onboard fuel systems and inherently safer ship designs are seen as critical safety elements.

Important work still remains to enable safe implementation of ammonia on board vessels, especially in terms of training, systems safety, and designs. A failure to adequately address these areas in line with the expectations from the maritime community may create barriers to ammonia as a marine fuel. Developing the right regulations and training requirements, as well as demonstrating safer systems and designs, will facilitate acceptance of ammonia among those who will work with this fuel in the future.



08

The project team and acknowledgements

This report was prepared by the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS) with assistance from our partners. Contributors marked with an asterisk (*) were seconded to the MMMCZCS from their home organization.

Authors: Anaïs Boulay* (Cargill), Shinichi Iwamoto* (NYK Line), Ties Nieuwenhuijs* (Stolt Tankers).

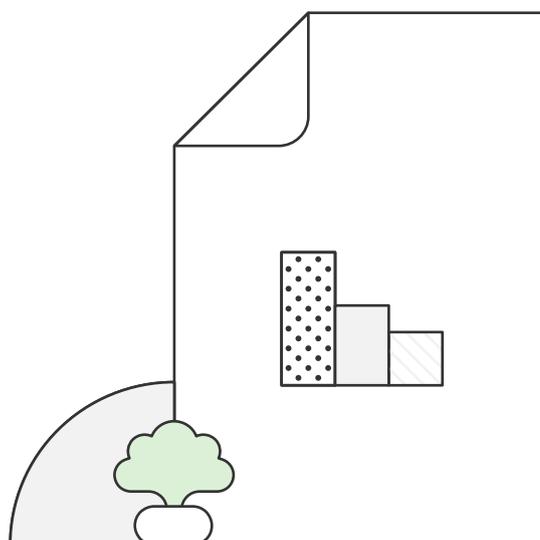
Project manager: Anaïs Boulay* (Cargill).

Steering committee: Estela Vázquez Esmerode (MMMCZCS), Martin Eriksen (MMMCZCS).

Reviewers: Claus Winter Graugaard† (MMMCZCS), Didde Welin (MMMCZCS), Steve Huddart* (bp), Matt Dunlop* (V.Group)

Editor: Matilda Handsley-Davis (MMMCZCS).

Design: SPRING Production.



Abbreviations

DF	Dual-fuel
CCR	Cargo control room
ECR	Engine control room
GHG	Greenhouse gas
IGF Code	International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels
IMO	International Maritime Organization
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas
MMMCZCS	Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping
P&I	Protection and indemnity
PPE	Personal protective equipment
STCW Code	International Convention on Standards of Training, Certification and Watchkeeping for Seafarers



References

- 1 Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping (MMMCZCS), Maritime Decarbonization Strategy 2022. <https://www.zerocarbonshipping.com/publications/maritime-decarbonization-strategy/> (2022).
- 2 MMMCZCS, Concept Design of a 15,000 TEU Ammonia-Fueled Container Vessel. <https://www.zerocarbonshipping.com/publications/concept-design-of-a-15-000-teu-ammonia-fueled-container-vessel/> (2023).
- 3 International Maritime Organization (IMO), International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Code) 1978, Part A, Chapter V, amended 2015. <https://www.imo.org/en/OurWork/HumanElement/Pages/STCW-Convention.aspx> [last accessed September 2024].
- 4 IMO, 2023 IMO Strategy on Reduction of GHG Emissions from Ships. <https://www.imo.org/en/OurWork/Environment/Pages/2023-IMO-Strategy-on-Reduction-of-GHG-Emissions-from-Ships.aspx> (2023).
- 5 International Renewable Energy Agency (IRENA) and Ammonia Energy Association (AEA), Innovation Outlook: Renewable Ammonia. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/May/IRENA_Innovation_Outlook_Ammonia_2022.pdf (2022).
- 6 Alfa Laval, Hafnia, Haldor Topsøe, Vestas, and Siemens Gamesa, Ammonfuel: An industrial view of ammonia as a marine fuel. <https://hafnia.com/wp-content/uploads/2020/08/Ammonfuel-Report-an-industrial-view-of-ammonia-as-a-marine-fuel.pdf> (2020).
- 7 Lloyd's Register and MMMCZCS, Recommendations for Design and Operation of Ammonia-Fueled Vessels Based on Multi-disciplinary Risk Analysis. <https://www.zerocarbonshipping.com/publications/recommendations-for-design-and-operation-of-ammonia-fueled-vessels-based-on-multi-disciplinary-risk-analysis/> (2023).
- 8 Clarksons Research, Shipping Review and Outlook 2024 (2024).
- 9 Hume, D., Ammonia as Maritime Fuel [presentation slides], Pacific Northwest National Laboratory. <https://www.energy.gov/sites/default/files/2021-08/9-nh3-maritime-fuel.pdf> (2021).
- 10 DNV, Insights into Seafarer Training and Skills Needed to Support a Decarbonized Shipping Industry. <https://www.dnv.com/publications/seafarer-training-and-skills-for-decarbonized-shipping-235124/> (2022).
- 11 Lloyd's Register, Human Factors Considerations: Ammonia Fuel End-of-Stage Report. <https://www.lr.org/en/knowledge/research-reports/human-factors-considerations-ammonia-fuel-end-of-stage-report/> (2023).
- 12 DNV and Singapore Maritime Foundation, The Future of Seafarers 2030: A decade of transformation. <https://www.dnv.com/maritime/publications/the-future-of-seafarers-2030-a-decade-of-transformation/> (2023).
- 13 'Safety of Crew in Low/Zero Emission Ships project', Mission Innovation. <https://mission-innovation.net/missions/shipping/safety-crew-low-zero-emission-ships/> (2023) [last accessed September 2024].
- 14 Bartlett, P., 'MAN and Eastern Pacific Shipping team up on ammonia training', SeatradeMaritime News, 5 June 2024. <https://www.seatrade-maritime.com/crewing/man-and-eastern-pacific-shipping-team-up-on-ammonia-training> (2024).
- 15 'About the Just Transition Maritime Task Force', United Nations Global Compact. <https://unglobalcompact.org/take-action/think-labs/just-transition/about> (2022) [last accessed September 2024].





Appendix: Survey questionnaire



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

As briefly outlined in Section 3.1, the first seven questions of the questionnaire are common to all respondents. Thereafter, respondents were presented with slightly different questions depending on their answer to Question 7 ('What is your position?'). For example, some respondent groups were asked what they would like to be trained on, while others were asked what seafarers should be trained on. Specifically, Questions 8-15 were presented to seafarers, 16-24 to seafarer representatives and crew/QHSE managers, 25-33 to ship managers, 34-42 to insurers and P&I clubs, 43-51 to charterers and ship operators, 52-57 to port operators, and 58-66 to flag states, class societies, and port authorities.

Following data collection, the question, 'What would you consider benefits of ammonia as a marine fuel?' (Questions 14, 22, 31, 40, 49, 56, and 64 in the questionnaire) was removed from the analysis due to concerns about possible misinterpretation.



Ammonia Fuel - Safety Acceptance Questionnaire

The International Maritime Organization Greenhouse Gas (GHG) Strategy has three interlinked ambitions. A reduction in carbon intensity of international shipping by at least 40 per cent by 2030 compared to 2008, the uptake of zero or near-zero GHG emission technologies, fuels and/or energy sources to represent at least 5% of the energy used by 2030 and GHG emissions from international shipping to reach net zero by 2050.

The decarbonization of all the ships is critical for reaching the IMO ambitions and will be achieved by using alternative fuels and reducing fuel consumption. Methanol and Bio-fuels as well as ammonia are promising fuels for zero emission ocean transport.

Implementation of ammonia as a marine fuel is going to be technologically feasible by 2025-2026 but it will create some new challenges for the whole maritime community. Thankfully there is already comprehensive industry experience in handling and transporting ammonia as a cargo at sea. Approximately 15 million tons are traded annually through about 160 global ports. The safe use of ammonia as a fuel will draw heavily on this experience.

In order to understand the safety concerns and competence gaps, the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping is launching this survey towards future users of ammonia as a marine fuel. The results will inform future training recommendations and guidelines that will contribute to a modification of the STCW code. The responses will also guide future publications and guidance needed to enable the ammonia fuel pathway.

Thank you in advance for filling in the survey and helping us understand how we best support the decarbonization of shipping going forward.



Your profile introduction

1. What is your age?

- Below 30
 - 30-40
 - 40-50
 - 50-60
 - Over 60
-

2. What type of vessels are you working on or with?

- Cruise ship/ferry
 - Container ship
 - Bulk carrier
 - General cargo
 - RORO
 - LNG gas carrier
 - LPG gas carrier
 - Oil tanker
 - Chemical tanker
 - Product tanker
 - Offshore vessel (crew tender, AHTS, PSV etc)
 - Tugs/pilot boat
 - Other
-

3. Have you ever worked with ammonia as a cargo?

- Yes
 - No
-

4. Have you ever sailed on or worked with gas-fueled vessels?

- Yes
 - No
-

5. What source do you use to stay informed about the shipping industry?

(Please tick all answers that apply to you)

- Flag state publications
 - Class society publications
 - Shipyard/machinery manufacturers' publications
 - P&I Club publication
 - Union reports
 - LinkedIn
 - Lloydlist
 - Other
-

6. Media/news outlets: which do you use to stay informed on shipping/ maritime topics?

(Please tick all answers that apply to you)

- Tradewinds
- Captain
- Safety4sea
- Splash247
- Youtube (if "yes" please mention in Other which channel you look at)
- Social media outlets (if "yes" please mention in Other which channel/ person you follow)
- Other



7. What is your position?

- Seafarer - Officer
 - Seafarer - Engineer
 - Seafarer - Rating
 - Seafarer representative (ILO, ITF or Union)
 - Maritime Organisation
 - Shipowner or Ship manager
 - Fleet Manager/ Superintendent
 - Crew Manager
 - QHSE/ ISM Department
 - Ship Operator
 - Sustainability department
 - Port Operator (Mooring men, Pilots, stevedores, etc.)
 - Port Authority
 - Flag State
 - Class society
 - Charterer
 - Insurer/ P&I Club
 - Other
-

Questions related to the safety perception of ammonia as a marine fuel for seafarers

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

Please make sure you answer these questions within your work time and have sufficient time available to answer the questions.

8. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No

9. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
 - Water pollution
 - Toxicity
 - Intrinsically safe
 - Static electricity risk
 - Storage
 - Cryogenic risk
 - Instability
 - Explosivity
 - Human health
 - Corrosivity
 - Additional workload
 - Flammability
 - Emergency response
 - Maintenance
 - Leakage
 - Other
-

10. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Ship design safety barriers
- Other



11. What would you like to be trained on to feel safer working with ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code.

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other

12. Would you sail on ammonia-fueled vessel?

- Yes
- Not sure
- No

13. What conditions would you have to sail on ammonia-fueled vessels?

OPEN FIELD

14. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced carbon taxation (EU ETS)
- Fuel price benefit
- I don't see any benefit
- Other

15. Please add any additional input you might have here?

OPEN FIELD

Questions related to the safety perception of ammonia as fuel for seafarer representatives, crew/QHSE manager

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

Please make sure you answer these questions within your work time and have sufficient time available to answer the questions.

16. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No



17. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other

18. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other

19. What would you or the people you represent like to be trained on to feel safer working with/on ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code.

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other

20. Would you or the people you represent be willing to sail on ammonia-fueled vessels?

- Yes
- Not sure
- No

21. What conditions would you or the people you represent have to sail on ammonia-fueled vessels?

OPEN FIELD



22. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced carbon taxation (EU ETS)
- Fuel price benefit
- I don't see any benefit
- Other

23. Would you consider crew's reluctance as a barrier for ammonia implementation onboard?

- Yes
- Not sure
- No

24. Please add any additional input you might have here?

OPEN FIELD

Questions related to safety perception of ammonia as a marine fuel for ship managers, shipowners, fleet managers/ superintendents, ship operators, sustainability department

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

Please make sure you answer these questions within your work time and have sufficient time available to answer the questions.

25. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No

26. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other



27. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other

28. What would you like to be trained on to feel safer working with ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code.

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other

29. Would you accept to manage ammonia-fueled vessels?

- Yes
- Not sure
- No

30. What conditions would you have to manage ammonia-fueled vessels?

OPEN FIELD

31. What would you consider benefits of using ammonia as a fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced carbon taxation (EU ETS)
- Fuel price benefit
- I don't see any benefit
- Other

32. Would you consider crew's reluctance as a barrier for ammonia implementation onboard?

- Yes
- No
- Other

33. Please add any additional input you might have here

OPEN FIELD



Questions related to safety perception of ammonia as a marine fuel for insurers and P&I clubs

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

34. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No

35. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other

36. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other

37. What should seafarers be trained on to work safer on ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code.

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other



38. Would you accept to insure ammonia-fueled vessels?

- Yes
 - Not sure
 - No
-

39. What conditions would you have to insure ammonia fueled vessels?

OPEN FIELD

40. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
 - Reducing NO_x
 - Reduced EU ETS
 - Fuel price benefit
 - I don't see any benefit
 - Other
-

41. Would you consider crew's reluctance as a barrier for ammonia implementation onboard?

- Yes
 - No
 - Other
-

42. Please add any additional input you might have here

OPEN FIELD



Questions related to the safety perception of ammonia as marine fuel for charterers

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

43. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
 - No
-

44. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other

45. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other

46. What would you think seafarers should be trained on to work safer on ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code.

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other

47. Would you accept to charter ammonia-fueled vessels?

- Yes
- Not sure
- No

48. What conditions would you have to charter ammonia fueled vessels?

OPEN FIELD

49. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced EU ETS
- Fuel price benefit
- I don't see any benefit
- Other

50. Would you consider crew's reluctance as a barrier for ammonia implementation onboard?

- Yes
- No
- Other

51. Please add any additional input you might have here

OPEN FIELD



Questions related to safety perception for ammonia as a marine fuel for port operators

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

52. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No

53. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other

54. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other

55. What would you like be trained on to feel safer working with ammonia-fueled vessels?

(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other



56. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced EU ETS
- Fuel price benefit
- I don't see any benefit
- Other

57. Please add any additional input you might have here.

OPEN FIELD

Questions related to ammonia as a marine fuel for flag states, class and port authorities

The following questions are related to ammonia as a marine fuel, please answer the questions based on your own views and perceptions.

58. Do you have any safety concerns regarding ammonia-fueled vessels?

- Yes
- No

59. What are your primary safety concerns around using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Air pollution
- Water pollution
- Toxicity
- Intrinsically safe
- Static electricity risk
- Storage
- Cryogenic risk
- Instability
- Explosivity
- Human health
- Corrosivity
- Additional workload
- Flammability
- Emergency response
- Maintenance
- Leakage
- Other

60. Which below topics will increase your knowledge about ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Ammonia characteristics
- Ammonia impact on human/environment
- Ventilation requirements
- Dispersion facts
- Emergency response procedures
- Fire fighting
- Fuel transfer/bunker procedures
- Detection equipment
- Exhaust gas emissions
- Ammonia supply availability (blue and green) + production
- Expected price for ammonia
- Other



61. What would you or the people you represent like to be trained on to feel safer working with ammonia-fueled vessels?

Your answers can be used to build some guidelines to address to IMO to modify the STCW code
(Please tick all answers that apply to you)

- Leakage management classroom/live training
- Bunkering simulator/onboard training
- New engines procedures
- Risk analysis
- Regulation
- Gas as fuel
- Crew management
- PPE
- Emergency response
- Fire fighting
- Other

62. Would you or the people you represent be willing to work on ammonia-fueled vessels?

- Yes
- Not sure
- No

63. What conditions would you or the people you represent have to work on ammonia-fueled vessels?

OPEN FIELD

64. What would you consider benefits of using ammonia as a marine fuel?

(Please tick all answers that apply to you)

- Reducing CO₂ emissions
- Reducing NO_x
- Reduced EU ETS
- Fuel price benefit
- I don't see any benefit
- Other

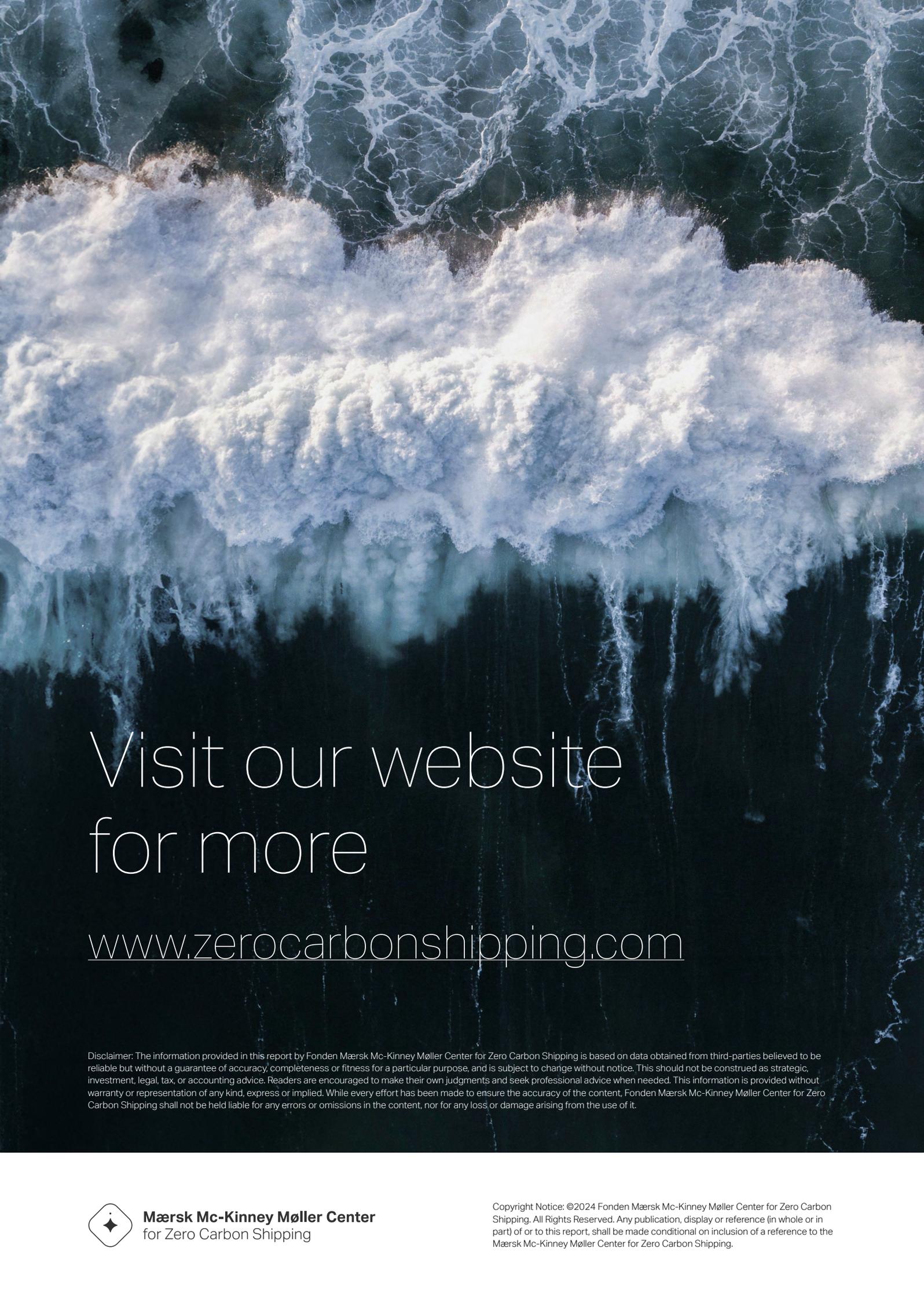
65. Would you consider crew's reluctance as a barrier for ammonia implementation onboard?

- Yes
- No
- Other

66. Please add any additional input you might have here.

OPEN FIELD





Visit our website
for more

www.zeroarbonshipping.com

Disclaimer: The information provided in this report by Fonden Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping is based on data obtained from third-parties believed to be reliable but without a guarantee of accuracy, completeness or fitness for a particular purpose, and is subject to change without notice. This should not be construed as strategic, investment, legal, tax, or accounting advice. Readers are encouraged to make their own judgments and seek professional advice when needed. This information is provided without warranty or representation of any kind, express or implied. While every effort has been made to ensure the accuracy of the content, Fonden Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping shall not be held liable for any errors or omissions in the content, nor for any loss or damage arising from the use of it.



Mærsk Mc-Kinney Møller Center
for Zero Carbon Shipping

Copyright Notice: ©2024 Fonden Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping. All Rights Reserved. Any publication, display or reference (in whole or in part) of or to this report, shall be made conditional on inclusion of a reference to the Mærsk Mc-Kinney Møller Center for Zero Carbon Shipping.