Food Safety Culture in the South African deep-sea hake trawling industry: a comparative analysis between two different organizational structures

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ABSTRACT

Food safety regulatory bodies increasingly recognise food safety culture (FSC) as a critical determinant of compliance with good manufacturing practice, yet FSC research within the fishing sector — and particularly the South African deep-sea hake trawling industry — remains scarce. This study explored differences in FSC between two deep-sea hake trawling vessels representing distinct organisational structures (a family-owned operation and a conglomerate-owned operation), using a 20-item questionnaire covering eight recognised FSC dimensions, administered over three consecutive years (2023–2025). Chi-square, Fisher's exact and stratified Cochran–Mantel–Haenszel analyses indicated vessel associations for six of the eight FSC dimensions: *risk perceptions and knowledge, business ownership of food safety, competence, learning and training, employee engagement, and communication and trust*). No significant association was found for *confidence in food hygiene requirements* or *leadership on food hygiene*.

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Because only two vessels were included in this research, the results are exploratory and do not establish causality or support generalisation to the wider fleet. The results may inform future research and discussion of food safety culture in seafood supply chains. The potential use of FSC indicators in supplier audits is a practical implication requiring further evaluation. Studies involving more vessels and validated instruments are recommended.

Keywords: Food Safety Culture (FSC), deep-sea trawling, organisational structure, seafood supply chain, South Africa

1. INTRODUCTION

Annually, approximately 600 million cases and over 400 thousand deaths are caused by foodborne diseases globally, with children accounting for almost a third of these deaths (World Health Organization [WHO] 2025). Africa has the highest incidence of food-borne illness of any continent, with an estimated 91 million cases and 137,000 deaths annually (McDonnell 2019; Shonhiwa et al. 2019). South Africa, like other developing countries, has higher reported rates of foodborne diseases due to many factors, including the use of unsafe water for food cleaning and processing (WHO 2015). At the same time, globalisation poses great risks by extending the consequences of foodborne outbreaks in developed countries by expanding cross-border trade in food products. Many facilities are not adequately equipped to manufacture for the global market whilst maintaining appropriate handling and sanitation practices (WHO 2015; King 2025).

Considering the increasing risks of food-borne illnesses, food safety regulatory bodies advise the industry to follow good manufacturing practices (Jaleel & Grewal, 2017). The *Codex Alimentarius* is a collection of internationally adopted food standards and related texts, uniformly presented by the Codex Alimentarius Commission (CAC), an intergovernmental body established in 1963 jointly by the Food and Agriculture Organization (FAO) and the WHO (Matlala 2023). These food standards and related texts aim at protecting consumers' health and ensuring fair and safe practices in the food trade industry by addressing hygiene, contaminants, labelling, methods of analysis, and inspection procedures. National regulatory frameworks, including South Africa's National Regulator for Compulsory Specifications (NRCS) and the associated South African National Standards (SANS), adapt these provisions domestically, frequently in conjunction with the Global Food Safety Initiative (GFSI).

Beyond formal regulatory compliance, the GFSI has emphasised that food safety must be embedded in organisational culture (GFSI 2018). This behavioural dimension of food safety, commonly termed food safety culture (FSC), is defined as the shared values, beliefs and norms that shape how an organisation prioritises and implements food safety practices (GFSI 2018).

Food safety culture is defined as 'an organizational atmosphere where safety and health are understood to be, and accepted as, the number one priority' (Griffith et al. 2010a; Sterling Crew 2019). It is more than just following rules; it's about creating an environment where everyone understands and embraces the importance of producing safe food. A strong FSC ensures consistent, safe food production and minimizes the risk of foodborne illnesses (Guevara 2024; Griffith et al. 2010b).

The fishing industry presents a distinctive organisational context for FSC research. Fishers often work in confined quarters, removed from society, for extended periods and often in dangerous conditions, with survival and meeting fishing demands frequently taking precedence over food safety compliance (Jaleel & Grewal 2017). South Africa's

linguistic, cultural and racial diversity – with twelve official languages (Stats SA, 2025) adds a further layer of complexity to workplace communication and shared understanding of food safety norms.

Despite the recognised importance of FSC, no known published research has examined FSC within the South African seafood sector specifically. This study addresses that gap by comparing FSC across two deep-sea hake trawling vessels operating under different organisational structures, and by considering the implication of these differences for downstream seafood retailing and supply-chain governance.

2. LITERATURE REVIEW

2.1 FOOD SAFETY CULTURE AS A BEHAVIOURAL CONSTRUCT

Traditional food safety management has relied heavily on documented, process-based systems such as Hazard Analysis and Critical Control Points (HACCP), which focus on hazards and critical control limits (FAO, nd). However, despite substantial global investment in food safety training and regulatory inspection, foodborne illness rates have not declined proportionately (Yiannas 2010; De Boeck et al. 2015). This has prompted growing recognition that human behaviour – rather than technical knowledge alone – is a principal determinant of food safety outcomes (Redmond & Griffith 2009; Yiannas 2010).

The eight interrelated dimensions of FSC include *communication, business priorities, risk perceptions, perception of safety procedures, competence, leadership, employee involvement* and *ownership of safety* (Griffith et al. 2010a; Yiannas 2010; Ball, Wilcock, & Colwell 2010; Taylor 2011; Wright et al. 2012; De Boeck et al. 2015; Nyarugwa et al. 2016). Each dimension provides a distinct facet of how an organisation embeds food safety into daily operational decision-making. Collectively, these dimensions have been linked to measurable food safety outcomes (Ijabadeniyi 2013; Ungku Fatima, Strohmehn & Arendt 2014; Powell, Jacob & Chapman 2011)

2.2 FSC WITHIN HIGH-RISK OCCUPATIONAL SETTINGS

The fishing industry is considered among the most hazardous occupations globally (Belja, van Anrooy & Kalikoski 2022), with South Africa recording 162 fishing-related fatalities per year (Jaleel & Grewal 2017). Fishing vessels combine physical isolation, confined working environments, multicultural crews, and economic pressure to meet catch targets. These conditions may compromise food safety prioritisation (Jaleel & Grewal 2017).

Organisational hierarchy further shapes how food safety information and expectations are communicated between departments (e.g., engineering and HACCP functions) and across ranks (Posthumus 2026, personal communication). No peer-reviewed literature currently examines how differing organisational structures within the South African hake trawling sector relate to FSC outcomes, representing a clear knowledge gap that this study addresses.

2.3 ORGANISATIONAL STRUCTURE AND CULTURE

Organisational culture theory suggests that hierarchical complexity, communication channels, and leadership visibility influence how consistently policies are implemented across an organisation (Clayton & Griffith 2008). Flatter organisational structures, such as smaller family-owned enterprises, may enable more direct communication and feedback between crew and leadership, whereas larger, multi-tiered organisations may experience longer feedback loops and more standardised, less personalised communication (Posthumus 2026, personal communication). While this theoretical association is well established in general organisational behaviour literature, it has not previously been empirically examined within the FSC context of South African deep-sea trawling.

3. PURPOSE AND OBJECTIVES

The objectives of this study were to:

- determine the current FSC profile of two deep-sea hake trawling vessels representing distinct organisational structures within the South African fishing industry;
- compare FSC survey responses between the two vessels across the eight recognised FSC dimensions over a three-year period (2023-2025); and
- explore the association between the organisational structure and observed differences in FSC responses and consider the implications of these differences for seafood retail supply-chain governance.

It is important to note that, given the two-vessel case-comparison design, this study is exploratory. It is intended to identify associations and generate hypotheses for future research, rather than to establish causal relationships between organisational structure and FSC.

4. RESEARCH DESIGN AND METHODOLOGY

4.1 STUDY DESIGN

This study employed a quantitative, exploratory comparative case design, examining FSC in two purposively selected deep-sea hake trawling vessels representing contrasting organisational structures (Figure 1). Given the small number of organisational units under comparison, the design should be understood as a case comparison rather than a representative sample survey. Findings, therefore, described associations between organisational context and FSC responses rather than causal effects.

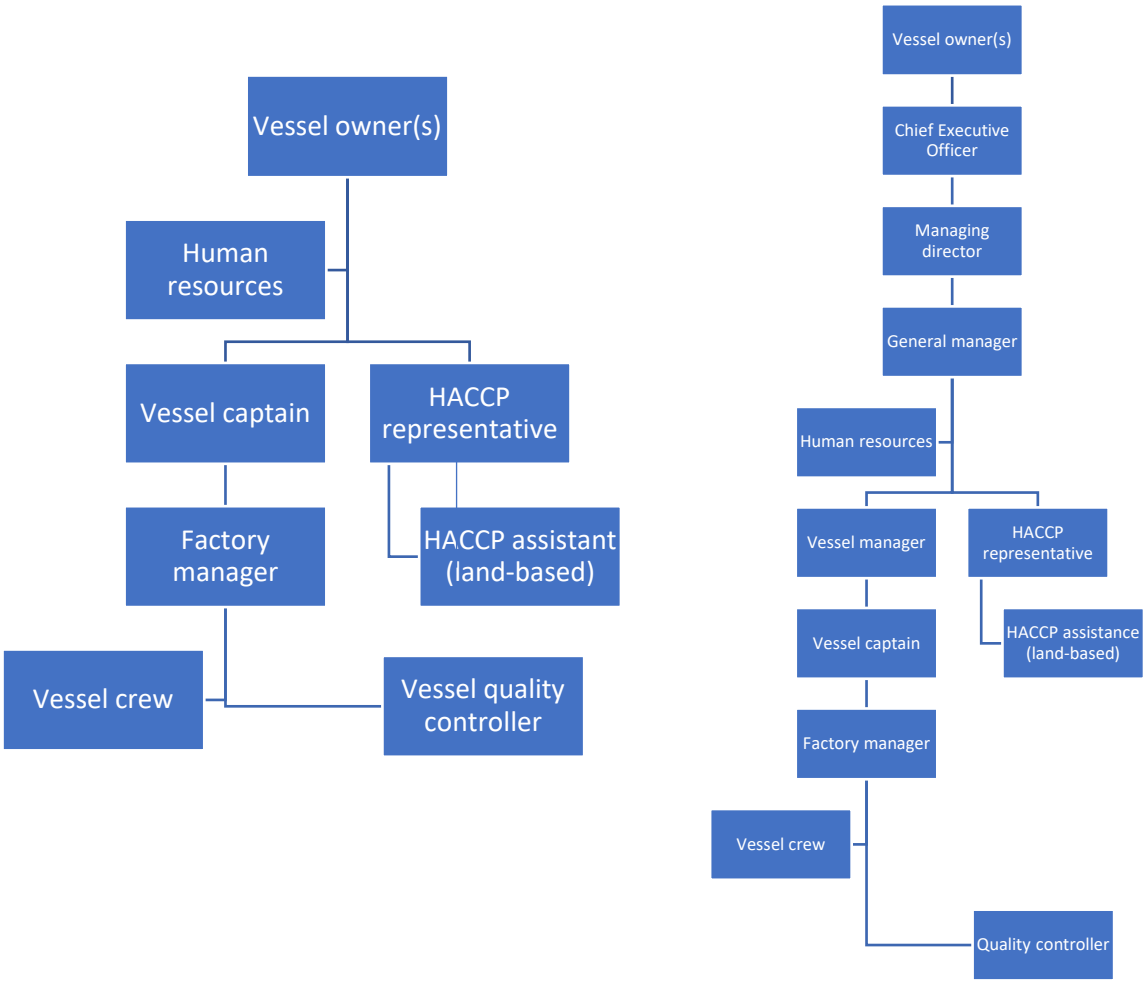

FIGURE 1: ORGANOGRAM DEPICTION OF ORGANIZATIONAL HIERARCHY USED IN THIS STUDY (LEFT: FAMILY-OWNED VESSEL; RIGHT: CONGLOMERATE-OWNED VESSEL)

4.2 STUDY SETTING

South Africa's deep-sea hake trawl fishery is highly regulated under the *Marine Living Resources Act No 18 of 1998* (South Africa 1998), with long-term commercial fishing rights allocated by the South African Department of Forestry, Fisheries and the Environment (DFFE).

Currently, all 37 right-holders in the hake deep-sea trawl fishery are members of the South African Deep-Sea Trawling Industry Association (SADSTIA). While membership in SADSTIA is not a legal requirement, it effectively reflects who holds the legal rights to operate. Among the 37 rights holders, only 54 deep-sea hake fishing vessels are currently registered with SADSTIA. Due to minor discrepancies in the reported numbers, the SADSTIA-Marine Stewardship Council (MSC) List of Vessels & Companies in the Unit of Certification (version 11, August 2025) was used.

Each vessel registered with SADSTIA is a deep-sea hake fish trawler. The main fish species targeted by these vessels is hake *(Merluccius* spp.*),* with other fish caught considered bycatch. Most of the SADSTIA-registered vessels operate from the Cape Town Harbour.

4.3 STUDY UNITS AND SAMPLING

Two organisational sampling units – hereafter Vessel A and Vessel B – were purposively selected from the 54 SADSTIA-registered deep-sea hake trawling vessels based on the following criteria: SADSTIA registration; a crew complement of fewer than 50 members; docking at Cape Town Harbour; completion of the FSC questionnaire in each of 2023, 2024 and 2025; and voluntary, written company consent to participate.

It is important to distinguish between two levels of sampling in this study:

- Organisational sampling unit: the vessel (Vessel A, family owned; Vessel B, conglomerate-owned), representing two contrasting organisational structures.
- Respondent unit: individual crew members (approximately 25-30 per vessel per year), who completed the anonymous questionnaire.

Given the absence of comparable South African FSC research in the seafood industry, this study is presented as a purposive, exploratory two-case comparison, intended to generate foundational, hypothesis-generating findings rather than population-representative conclusions. No claim of statistical generalisability to the wider 54-vessel population is made.

4.4 QUESTIONNAIRE DEVELOPMENT

The questionnaire was designed based on various FSC questionnaires suggested by recognised FSC experts in the field (Dr. Joanne Taylor, Culture Excellence in the UK; personal communication; Frank Yiannes, formerly Deputy Commissioner, Food Policy & Response, US FDA), and consolidated by a food science professional with over 30 years of HACCP consultancy experience. The industry-generic instrument was shortened and reworded to improve accessibility for the fishing crew respondent group, considering literacy levels, question format, and questionnaire length.

During the feasibility parameter checks for this study, the questionnaire was examined by food safety culture specialist Professor Ryk Lues (Central University of Technology) and two lecturers and researchers from the University of the Free State to determine whether it would yield feasible and potentially statistically valid results and/or observations. No amendments were recommended during this parameter check.

The final FSC questionnaire consisted of 20 questions across the eight FSC dimensions defined in Section 2.1: *business priorities and attitudes; food safety (HACCP) risk perceptions and knowledge; confidence in food hygiene and safety requirements; business ownership of food safety (HACCP) and hygiene; competence, learning, training and knowledge; leadership on food hygiene; employee engagement in the review and development of food hygiene practices*; *and communication and trust to engage in food hygiene and report issues.*

The questionnaire contained 20 items informed by existing food safety culture instruments and reviewed by subject-matter experts. For the dimension-specific results, the manuscript reports selected items judged to be directly relevant to the study objectives and sufficiently comparable across the three survey years. This item-level approach is exploratory: individual questions are treated as indicators of specific aspects of a dimension, not as validated measures of the entire latent construct.

It should be noted that formal psychometric validation (e.g., confirmatory factor analysis, reliability coefficients) was not conducted on this adapted instrument. This represents an acknowledged limitation, and the questionnaire is more accurately described as an expert-reviewed, adapted instrument rather than a fully validated psychometric tool. The questionnaire is available on request from the main author.

4.5 DATA COLLECTION PROCEDURE

The FSC questionnaires were distributed to all the crew members of both vessels. The questionnaire had the name of the relevant vessel printed in the header, as is consistent with standard HACCP documentation practice. To promote honesty in completing the FSC questionnaire, it was completed anonymously, requiring no form of identification, e.g., name, surname, or ID number. Crew members had the duration of the fishing trip to complete the questionnaire in their own time (25-30 days). Once the vessel had docked, the researcher collected the completed questionnaires.

Because responses were anonymous, individual crew members could not be tracked longitudinally across the three years. Given self-reported low staff turnover (fewer than four new crew members per vessel per year, on average), it is likely that a substantial proportion of respondents participated in more than one annual survey round; however, this cannot be confirmed. Consequently, the three annual datasets for each vessel are treated as repeated cross-sectional vessel-level samples, rather than a matched longitudinal panel, and year is included as a stratification variable in the analysis, rather than as a repeated-measures factor.

4.6 DATA ANALYSIS

The results of the questionnaires were captured in Microsoft Excel and analysed using descriptive statistics (frequencies and percentages) for each item. Inferential analysis comprised:

- Chi-square tests were used to determine whether there was a significant association between categorical variables (vessel and response category);
- Fisher’s exact tests were used to verify chi-square results where smaller data sets were expected.
- Cochran-Mantel-Haenszel (CMH) tests were used to evaluate associations, and significance thereof, between vessel and response category while stratifying by year (2023-2025), thereby controlling temporal variation.
- Cramer’s V is a measure of effect size for the Chi-Square test of independence, used to determine the strength of association between two categorical variables.

These four tests were selected specifically for their suitability to categorical, stratified survey data. The software used for the statistical analysis, is R Core Team (2025). Statistical significance was set at $\alpha = 0.05$.

The hypothesis tests conducted are tests of independence. The null hypothesis is that the response patterns are independent of the vessel. A small p-value might indicate an association between vessel and response. For the CMH test, the null hypothesis was that vessel and response were independent, conditional on year.

4.7 ETHICAL CONSIDERATIONS

Ethical approval was granted by both the General/Human Research Ethics Committee (GHREC) and the Environmental and Biosafety Research Ethics Committee (EBREC). The ethical clearance numbers were UFS-

HSD2025/0056 and UFS-ESD2025/0040, respectively. Ethical clearance was granted on secondary use of collected data on merit that the researcher had collected, stored and protected the anonymous responses as part of her working duties.

Recruitment letters were electronically sent to SADSTIA-registered deep-sea harvest companies that met the inclusion criteria to ask permission to use the data generated from this data collection tool. Two companies signed the information leaflet and the written consent form. Participation was voluntary, and participants could withdraw from the study at any time without negative consequences, regardless of the reason for withdrawal. No participant was financially remunerated nor charged to participate in the research study. Participation in the study did not prevent participants from attending to their daily work tasks; therefore, it did not result in a loss of wages.

5. RESULTS AND DISCUSSION

5.1 RESPONSE RATES TO QUESTIONNAIRE

The distribution and completion of the questionnaire are summarised in Table 1. Across the three-year period, 90 questionnaires were distributed per vessel (30 per year). For Vessel A, 85 were returned and 84 were usable (return rate: 94.4%; usable response rate: 93.3% of distributed and 98.8% of returned). For Vessel B, 66 were returned and 60 were usable (return rate: 73.3%; usable response rate: 66.7% of distributed, 90.9% of returned).

TABLE 1: QUESTIONNAIRE DISTRIBUTION, RETURN AND USABLE RESPONSE RATES (2023-2025)

Year	Vessel	Number of questionnaires returned	Number of questionnaires usable
2025	Vessel A	30	30
	Vessel B	30	29
2024	Vessel A	30	30
	Vessel B	18	13
2023	Vessel A	25	24
	Vessel B	18	18
Total	**Vessel A**	**85**	**84**
	Vessel B	**66**	**60**

5.2 DIMENSION 1: BUSINESS PRIORITIES AND ATTITUDES

When respondents were asked to indicate what they regard as most important in their company, the CMH test indicated a significant association ($p < 0.001$) between vessel and response category after stratification by year (Fig. 2). The options that the respondents could choose were *cost, waste, people, quality of the end product* and *food safety (HACCP)*.

In 2023, on Vessel A, most respondents (87.5%) indicated that *the quality of the end product* was the most important, whereas respondents from Vessel B indicated that *people, the quality of the end product*, and *food safety (HACCP)* were almost equally important (22.22%, 44.44% and 33.33%, respectively).

By 2025, Vessel A's respondents shifted toward *people* as the largest proportion (43.33%), with the *quality of the end product* (20.00%) and *food safety* (30.00%) as the second- and third-largest proportions. *Quality of the end product* was significantly lower than in 2023, while *waste* (6.67%) was considered the most important to the company. This vessel was the only one that indicated that *waste* was important.

By 2025, Vessel B's respondents indicated that *food safety* (82.76%) was the most important to the company, with a small proportion indicating that *people* (6.9%) and *quality of the end product* (6.9%) were equally important. A very small proportion indicated that *cost* was important (3.45%).

The observed changes in proportional responses for Vessel A may be attributable to a change in vessel captaincy in 2025. Differences in leadership style and managerial priorities between the current and previous captains may have influenced crew perceptions of organisational priorities. This interpretation is supported by an examination of the response categories selected across the study period. While only *people*, *quality of the end product*, and *food safety* were identified as key business priorities in 2023 and 2024, *waste* emerged as an additional priority in 2025. The inclusion of this category may reflect a shift in operational focus under the new leadership.

Similarly, the changes in proportional responses observed for Vessel B may be associated with a change in vessel captaincy in 2025. As with Vessel A, differences in management style and emphasised priorities may reasonably account for shifts in crew responses. This explanation is supported by the response patterns, whereby only *people*, *quality of the end product*, and *food safety* were selected in 2023 and 2024, while *cost* was additionally identified as a business priority in 2025. Although a change in the general manager role also occurred in 2023, the most notable variations in responses appeared to involve changes in the proportion of responses rather than the types of priorities identified between 2023 and 2024. Consequently, the change in captaincy may represent a more plausible explanation for the emergence of *cost* as an identified priority in 2025.

Food safety was the only business-priority category that demonstrated a consistent increase in response frequency across both vessels throughout the study period. This trend may reflect the training facilitator's increasing emphasis on food safety during annual training sessions, particularly in relation to year-on-year food safety recalls, or the HACCP representative's greater attention to food safety during operational meetings, prompted by recurring safety-related recalls. Other plausible explanations include an increase in customer complaints, HACCP-related non-conformances, or other food safety incidents not accessible to the researcher, which may have prompted management and HACCP personnel to place greater emphasis on food safety communication and compliance.

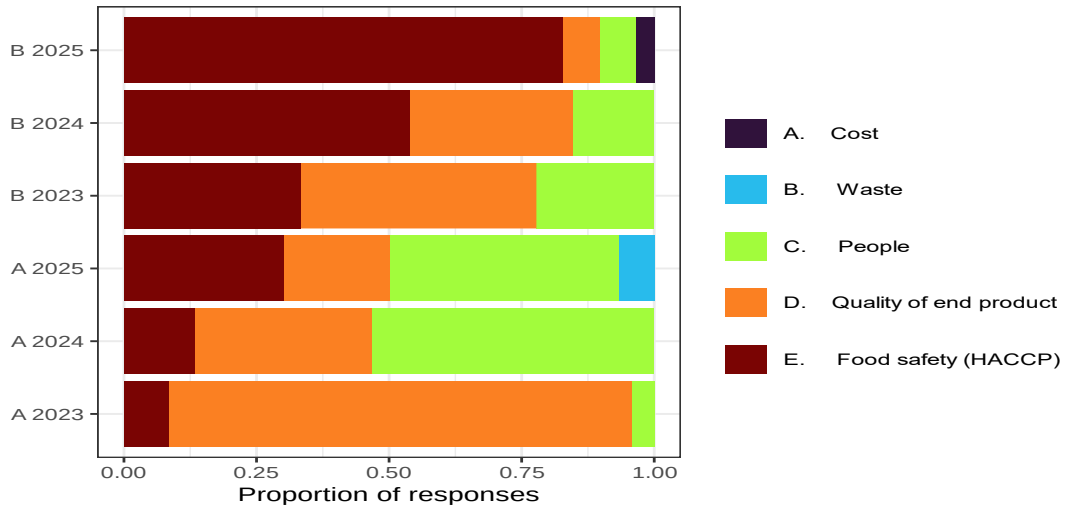

FIGURE 2: THE PROPORTION OF RESPONSES TO WHAT CREW MEMBERS THINK IS THE MAIN PRIORITY FOR THE COMPANY (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P < 0.001)

5.3 DIMENSION 2: FOOD SAFETY (HACCP) RISK PERCEPTIONS AND KNOWLEDGE

When respondents were asked whether team members ignore food safety and hygiene (HACCP) rules and procedures, believing it is not their responsibility, the CMH analysis revealed a significant difference between vessels (p = 0.003) and across years (Fig. 3).

Most of the respondents on both vessels indicated that they *disagreed* with the question in 2023 (83.33% and 94.44% for vessel A and B, respectively) and 2025 (100% and 82.76 for vessel A and B, respectively), however, in 2024, there was a significant (p = 0.003) difference between respondents from Vessel A and Vessel B (13.33% and 61.54%, respectively). Most of the respondents from Vessel A now *agreed* with this question (86.67%), while Vessel B's respondents still *disagreed* (61.54%), but there was an almost equal number of responses indicating that they *agree* or are *not sure* (23.08% and 15.38%, respectively).

The observed changes in proportional responses for Vessel A may be associated with the appointment of a new vessel captain in 2025. Differences in leadership practices and operational priorities, including a stronger focus on food safety, accountability, and responsibility, may have affected crew perceptions and responses. As such, the change in captaincy represents a potential explanatory factor for the variations observed between survey periods.

The observed changes in responses for Vessel B cannot be readily explained based on the available data. Although a change in vessel captaincy occurred during the study period, the timing of this management transition did not correspond with the period in which the response patterns changed. Consequently, no clear explanatory factor can be identified from the quantitative findings alone. Further qualitative investigation is therefore recommended to explore the underlying reasons for these changes and to provide contextual insight into the observed response patterns.

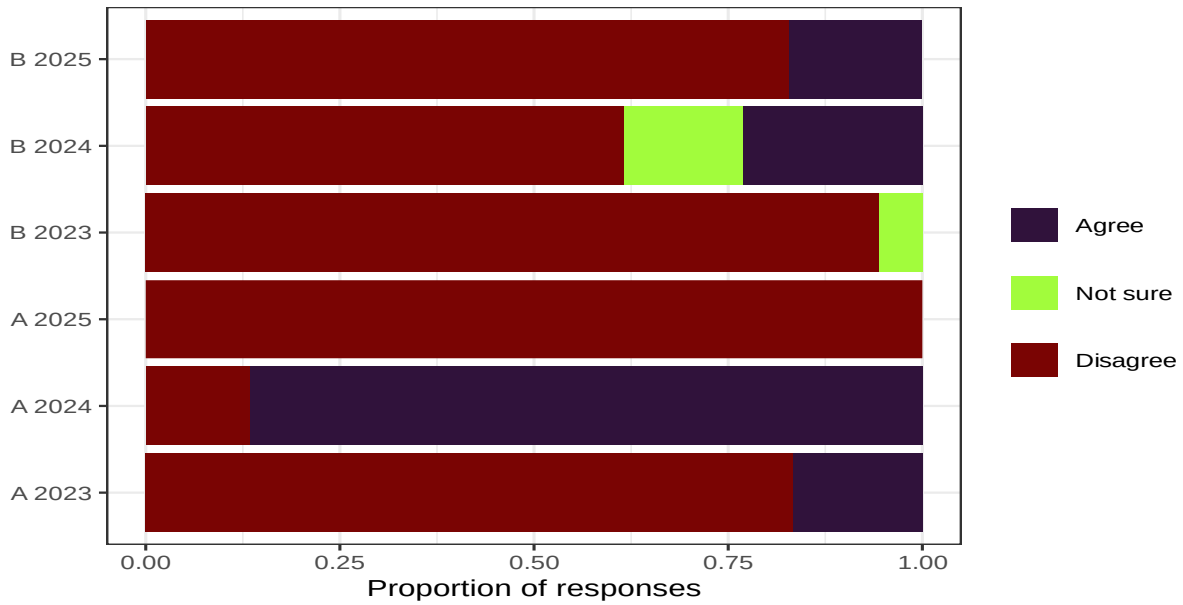

FIGURE 3: THE PROPORTION OF RESPONSES TO WHETHER CREW MEMBERS IGNORE FOOD SAFETY AND HYGIENE (HACCP) RULES AND PROCEDURES, BELIEVING THAT IT IS NOT THEIR RESPONSIBILITY (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P = 0.003)

5.4 DIMENSION 3: CONFIDENCE IN FOOD HYGIENE AND SAFETY REQUIREMENTS

When respondents were asked how food safety (HACCP) rules and procedures affect their daily routine, the CMH test indicated no significant difference (p = 0.277) between the interaction of vessel and year, with most of the respondents indicating that the food safety rules and procedures do not affect their daily routine since it is essential (Fig. 4). Since no significant differences were observed between vessel and year, this dimension will not be discussed further.

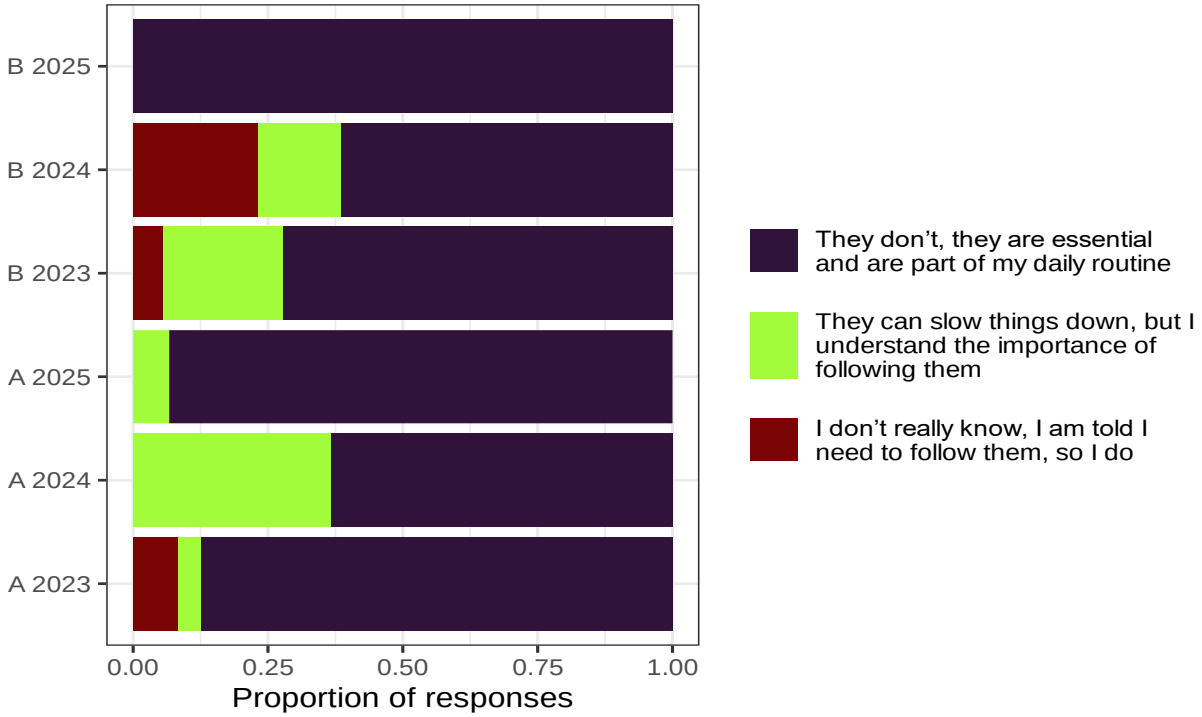

FIGURE 4: THE PROPORTION OF RESPONSES TO HOW FOOD SAFETY (HACCP) RULES AND PROCEDURES AFFECT THE CREW MEMBERS' DAILY ROUTINE (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P = 0.277)

5.5 DIMENSION 4: BUSINESS OWNERSHIP OF FOOD SAFETY (HACCP) AND HYGIENE

When respondents were asked about their company's commitment to food safety (HACCP), the stratified CMH test indicated a significant (p < 0.001) association between vessel and response category after controlling for year (Fig. 5).

On Vessel A, most respondents in 2023 indicated that the company is *committed* to food safety because supervisors regularly discuss it (83.33%). In 2024, the proportion of responses shifted toward the company being *very committed* (73.33%) because it often communicates it to all staff. This trend continued into 2025, with numbers of *committed* (36.67%) and *very committed* (56.67%). A small proportion of responses, however, indicated that the company only talks about food safety when things go wrong (6.67%).

On Vessel B, most responses in 2023 indicated that the company was *very committed* (83.33%), while a small proportion indicated that it was *committed* (16.67%). This trend continued into 2024; however, a small proportion of responses now indicated that the company was *somewhat committed* (15.38%), as they mentioned it at times during meetings, inspections, or audits. In 2025, this vessel's respondents indicated numbers between *very committed* and *somewhat committed* (55.17% and 41.38%, respectively).

Vessel A revealed mixed results, with a concerning factor, *talking about food safety when things go wrong,* may be attributed to increased emphasis on food safety by the captain as well as by the HACCP representative in response to increased food recall trends globally. Other plausible explanations include an increase in customer complaints, HACCP-related non-conformances, or other food safety incidents not accessible to the researcher, which may have prompted management and HACCP personnel to place greater emphasis on food safety compliance and responsibility. Despite this, a positive trend is evident, indicating a positive perception of management's commitment among crew members.

The contrasting results for Vessel B, with a steady downward trend in crew members' perception of management's commitment, do not align with the other trends observed in this study. Differences in leadership style and managerial priorities between the current and previous captains may have influenced crew perceptions of management's commitment to food safety, but this is unlikely based on previously stated results. Further qualitative investigation is therefore recommended to explore the underlying reasons for these changes and to provide contextual insight into the observed response patterns.

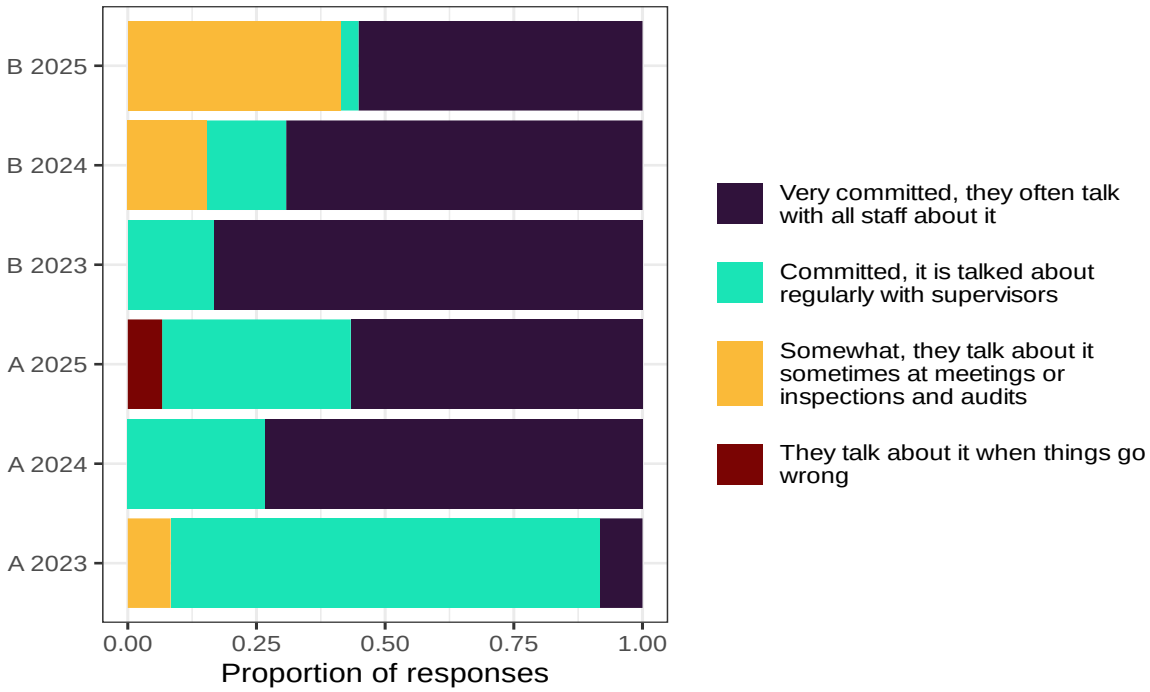

FIGURE 5: THE PROPORTION OF RESPONSES ABOUT THE COMMITMENT OF THEIR COMPANY TO FOOD SAFETY (HACCP) (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P < 0.001)

5.6 DIMENSION 5: COMPETENCE, LEARNING AND KNOWLEDGE

In this dimension, the respondents were asked to rate the quality of food safety-related training received over a 12-month cycle. The stratified Cochran–Mantel–Haenszel test yielded a significant association ($p < 0.001$) between the vessel and response category, after controlling for year. This test alone does not establish a vessel-by-year interaction or demonstrate a statistically significant change within either vessel over time.

On Vessel A, most respondents in 2023 rated the quality of food safety training as *good* (79.17%) (Fig. 6). By 2024, nearly the same number of respondents indicated *good, very good*, or *excellent* training (30.00%, 26.67% and 43.33%, respectively). In 2025, most respondents indicated that the training was *excellent* (60%).

On Vessel B in 2023, respondent numbers indicated either *good* or *excellent* (50% and 38.89%, respectively). In 2024, the small number of respondents who indicated in 2023 that the training was *very good* has now increased to match the number of *excellent* responses (38.46%). By 2025, nearly the entire crew on Vessel B rated the training as *excellent* (93.10%).

Vessel A demonstrated an overall positive trend in perceptions of the quality of training received over the preceding 12-month period, despite a barely adequate rating emerging in 2025. As the same facilitator and training materials were used throughout the study period, this trend may reflect improvements in training delivery and facilitator effectiveness rather than changes within the crew itself. Notably, the proportion of respondents rating the training as *excellent* or *very good* continued to increase despite the isolated negative rating. This response may be attributable to the inclusion of new crew members and the administration of the FSC questionnaire prior to training in 2025. Improved perceptions of training quality may have indirectly contributed to the positive changes observed in food safety attitudes, perceptions, and compliance with food safety requirements over the study period.

Vessel B demonstrated a consistent positive trend in perceptions of the quality of training received over the preceding 12-month period. Given that the same training facilitator and course materials were utilised throughout all three years of the study, this finding may reflect improvements in the effectiveness of training delivery, facilitator competency, and/or the refinement of training content over time, rather than a direct change in the characteristics of the vessel crew. While these improvements are not indicative of a direct behavioural change among employees, they may have exerted an indirect influence on food safety culture by enhancing employees' understanding of food safety principles and the rationale underpinning HACCP requirements. Consequently, the observed improvement in training perceptions may have contributed to the positive changes in food safety-related attitudes, perceptions, and compliance with food safety rules and procedures observed among crew members over the study period.

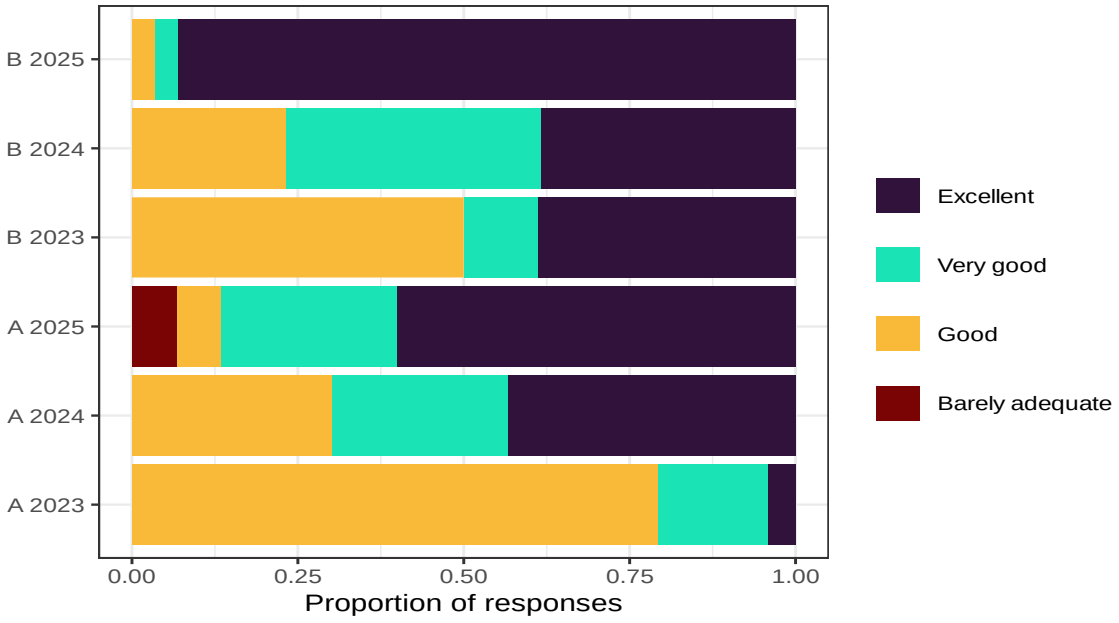

FIGURE 6: THE PROPORTION OF RESPONSES TO RATE THE QUALITY OF FOOD SAFETY-RELATED TRAINING RECEIVED WITHIN A 12-MONTH CYCLE (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P < 0.001)

5.7 DIMENSION 6: LEADERSHIP ON FOOD HYGIENE

Regarding how the management team encourages good hygiene practices, the crew members' responses indicated a non-significant difference in the stratified CMH test (p = 0.209) (Fig. 7). This was well above the 0.05 threshold. The data therefore do not provide evidence of an association between vessel and response category after controlling for year and will therefore not be discussed.

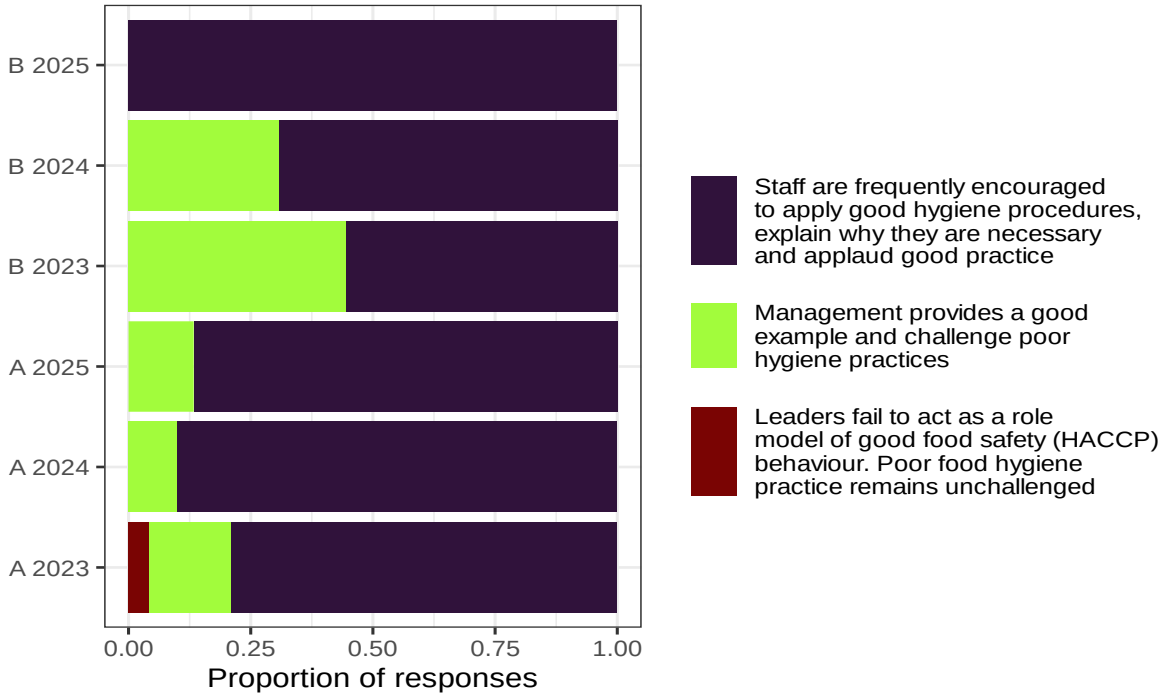

FIGURE 7: THE PROPORTION OF RESPONSES HOW THE MANAGEMENT TEAM ENCOURAGE GOOD HYGIENE PRACTICES (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P = 0.209)

5.8 DIMENSION 7: EMPLOYEE ENGAGEMENT IN REVIEW AND DEVELOPMENT OF FOOD HYGIENE PRACTICES

When asked about how involved the crew members are in reviewing and developing hygiene practices, the stratified CMH test indicated a significant (p < 0.001) association between vessel and response category after controlling for year.

Most respondents on Vessel A in 2023 indicated that *employee suggestions/input are not considered by management* (54.17%) (Fig. 8). However, in 2024 and by 2025, most respondents indicated that management actively seeks their views on how to improve hygiene (66.67% and 36.67%, respectively), or that employee engagement is accepted to help comply with regulations (30.00% and 63.33%, respectively).

For Vessel B in 2023, most respondents indicated that *management actively seeks their views* (88.89%), or *employee engagement is accepted to help comply with regulations* (5.56%). During 2024, a noticeable drop in reviewing engagement was seen with 53.85% now stating that *management actively seeks their views* and 46.15% indicated that *employee engagement is accepted to help comply with regulations*. By 2025, almost equal numbers of

respondents indicated that *management actively seeks their views on how to improve hygiene* (48.28%) or that *employee engagement is accepted to help comply with regulations* (51.72%).

Although a change in vessel captaincy occurred during the study period, the timing of this management transition did not correspond with the period in which the response patterns changed. Other plausible explanations include an increase in HACCP-related non-conformances or other food safety incidents not accessible to the researcher, which may have prompted HACCP personnel to engage more actively with the crew on ways to improve hygiene practices. Consequently, no clear explanatory factor can be identified from the quantitative findings alone. Further qualitative investigation is therefore recommended to explore the underlying reasons for these changes and to provide contextual insight into the observed response patterns.

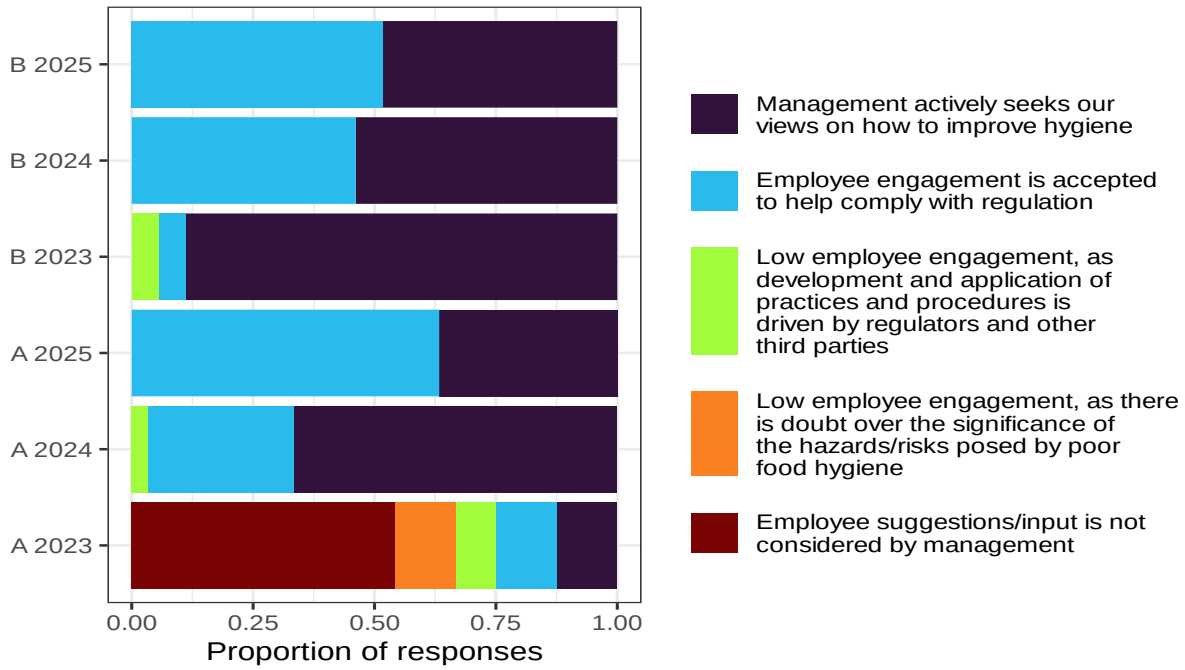

FIGURE 8: THE PROPORTION OF RESPONSES ON HOW INVOLVED THE CREW MEMBERS ARE IN THE REVIEW AND DEVELOPMENT OF HYGIENE PRACTICES (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P < 0.001)

5.9 DIMENSION 8: COMMUNICATION AND TRUST TO ENGAGE IN FOOD HYGIENE AND REPORT ISSUES

For how food safety (HACCP) problems and complaints are addressed, the stratified CMH analysis yielded $p < 0.001$, indicating an association between vessel and response category after controlling for year. This result does not, by itself, establish a vessel-by-year interaction or a significant within-vessel temporal trend.

Although most respondents on both vessels indicated across the three years that the company either *proactively* addressed (55.95% and 75% for vessel A and B, respectively) or *responded strongly* (42.86% and 18.33% for vessel A and B, respectively) to food safety problems or complaints, a small proportion of Vessel B respondents indicated in 2024 that the company *did not respond* (7.70%) or showed a *minimal response* (7.70%) (Fig. 9).

A progressive shift towards a more positive perception of responses to reporting of HACCP-related problems and complaints over the three-year period was seen for Vessel B. The observed changes in proportional responses for Vessel A may be attributable to a change in vessel captaincy in 2025. Differences in leadership style and managerial

priorities between the current and previous captains may have positively influenced the crew's willingness to come forward and report HACCP-related problems or complaints. This interpretation is supported by an examination of the response categories selected across the study period. The mixed observations noted in Vessel B may plausibly be linked to the change in captaincy (2025), for which markedly positive results are observed in said year. Differences in leadership style and an increased emphasis on food safety under the new captains may have contributed to these improved perceptions. Consequently, the observed shifts in crew responses may reflect a stronger managerial commitment to promoting food safety and hygiene practices.

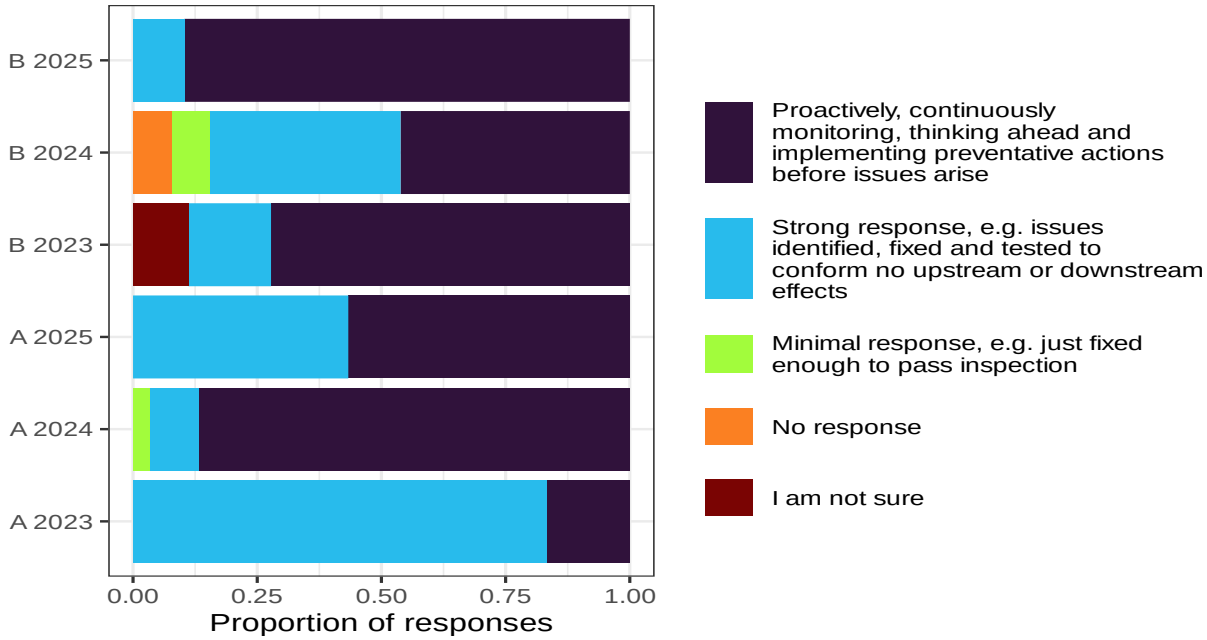

FIGURE 9: THE PROPORTION OF RESPONSES ON THE WAY FOOD SAFETY (HACCP) PROBLEMS AND COMPLAINTS ARE ADDRESSED (2023-2025) USING THE GENERALIZED COCHRAN–MANTEL–HAENSZEL TEST (P < 0.001)

5.10 SUMMARY OF FSC DIMENSIONS RESULTS

The statistical differences between all eight FSC dimensions are summarised in Table 2. Interpreted against conventional thresholds (Cramér's V < 0.10 negligible, 0.10–0.30 small, 0.30–0.50 moderate), the results partition the eight dimensions into three groups. The strongest and most consistent differentials emerged for *risk perceptions and knowledge* (Cramér's V = 0.34; Chi-square $p < 0.001$; stratified CMH $p < 0.001$), *business ownership of food safety* (Cramér's V = 0.31; $p < 0.001$) and *employee engagement* (Cramér's V = 0.30; $p < 0.001$), each attaining statistical significance across all three tests and a moderate effect size. *Competence, learning and training* (Cramér's V = 0.28) and *communication and trust* (Cramér's V = 0.29) showed small-to-moderate associations, though the relatively weaker Fisher's exact result for competence, learning and training ($p = 0.010$) suggests greater sensitivity to analytic approach and should be interpreted with appropriate caution.

Two dimensions exhibited no statistically reliable association with business ownership: *confidence in food hygiene requirements* (p = 0.259–0.277; Cramér's V = 0.08) and *leadership on food hygiene* (p = 0.209–0.434; Cramér's V = 0.06), both falling within the negligible range. *Business priorities and attitudes* warrant a more nuanced reading: although the unstratified tests returned borderline significance (χ^2 p = 0.034; Fisher's $p = 0.026$), the effect size was small (Cramér's V = 0.19) and the stratified CMH test strengthened markedly ($p < 0.001$), implying that the raw

association is partly confounded by a stratifying variable — plausibly survey round or respondent role — rather than reflecting a strong direct ownership effect.

Taken together, the table indicates that ownership structure is associated with a moderate, statistically robust divergence in FSC on attitudinal and organisational dimensions (risk perception, ownership of food safety, engagement, communication), while core hygiene-compliance constructs — confidence in requirements and perceived leadership — appear invariant to ownership. This distinction carries an important implication: the effect of ownership type operates on the culture and behavioural layer of food safety management rather than on formal compliance expectations, and should be reported alongside effect sizes rather than significance probabilities alone, given the unbalanced group sizes and the risk that significance in the weaker dimensions is driven by sample composition.

TABLE 2: SUMMARY OF STATISTICAL DIFFERENCES ACROSS EIGHT FSC DIMENSIONS

FSC Dimension	N (Vessel A / B)	Chi-square (*p*)	Fisher's Exact (*p*)	Stratified CMH (*p*)	Effect size (Cramér's V)
Business priorities & attitudes	84 / 60	0.034	0.026	<0.001	0.19
Risk perceptions & knowledge	84 / 60	<0.001	<0.001	<0.001	0.34
Confidence in food hygiene requirements	84 / 60	0.259	0.273	0.277	0.08
Business ownership of food safety	84 / 60	<0.001	<0.001	<0.001	0.31
Competence, learning & training	84 / 60	<0.001	0.010	<0.001	0.28
Leadership on food hygiene	84 / 60	0.434	0.415	0.209	0.06
Employee engagement	84 / 60	<0.001	0.001	<0.001	0.30
Communication and trust	84 / 60	<0.001	<0.001	<0.001	0.29

5.11 DISCUSSION ABOUT ORGANIZATIONAL STRUCTURAL DIFFERENCES

Vessel A (family-owned) exhibited a comparatively flat hierarchy, with five organisational ranks between crew and vessel owners (crew, factory manager, captain, human resources, owner), supplemented by a land-based HACCP assistant and representative reporting directly to the owner. Vessel B (conglomerate-owned) exhibited a substantially more complex nine-tier hierarchy (crew, factory manager, captain, vessel manager, human resources, general manager, managing director, CEO, owner), with HACCP personnel reporting to the general manager rather than directly to ownership. This structural contrast (illustrated conceptually in Figure 1) provides a plausible explanatory frame for several of the observed differences discussed below, particularly regarding communication and ownership of safety.

5.12 INTERPRETING THE SIGNIFICANT DIMENSIONS

The significant differences observed in *business priorities, risk perceptions, business ownership, competence, employee engagement*, and *communication* are consistent with organisational behaviour theory, which suggests that hierarchy and communication pathways may shape how safety priorities are communicated and enacted (Clayton & Griffith, 2008). However, the present data cannot establish that a flatter hierarchy produces better food safety culture. Each organisational structure was represented by one vessel, and vessel-specific characteristics may explain some or all of the observed differences.

These findings should be interpreted as associations observed between two specific organisational cases, not as evidence that organisational structure causes differences in food safety culture. Because each organisational structure is represented by only one vessel, unmeasured vessel-specific factors—including leadership, crew composition, operating history and other organisational practices—cannot be separated from the structural differences.

5.13 NON-SIGNIFICANT DIMENSIONS

Confidence in food hygiene requirements and *leadership on food hygiene* showed no significant differences between vessels. This suggests these two dimensions may be less sensitive to organisational hierarchy and more strongly shaped by factors common to both vessels, such as a shared external food safety training provider or shared regulatory requirements. This finding tempers a purely structural explanation of FSC and points to the need for a more nuanced, multi-factor model in future research.

5.14 IMPLICATIONS FOR SEAFOOD RETAILING AND SUPPLY-CHAIN MANAGEMENT

The findings may be relevant to seafood retailers and further processors, as food safety culture is a potential component of upstream supplier risk. However, this two-vessel study did not measure retail outcomes, product safety incidents, recall frequency, or supplier audit performance; therefore, it cannot demonstrate that the observed survey differences resulted in downstream effects.

The findings may provide retailers with a better understanding of the nuances that may impact product safety. Differences in FSC at the vessel and supplier levels may have upstream implications for product safety, consistency, and reputational risk within the retail supply chain. Retailers sourcing from vessels or companies with weaker FSC indicators — particularly in areas such as safety, communication and ownership — may face an elevated risk of non-compliance events reaching the point of sale.

As a practical implication, seafood retailers and further processors could consider complementing conventional HACCP and compliance audits with proportionate food safety culture indicators, such as communication, employee engagement, reporting practices and management commitment. Such indicators may support supplier dialogue and risk-based monitoring, but their value for predicting retail outcomes should be evaluated in larger studies before being treated as validated audit criteria.

6. STUDY LIMITATIONS

This study is subject to several limitations that should be considered when interpreting the findings:

- **Case design**: only one vessel represents each organisational structure; findings reflect observed differences between these two specific cases and cannot be generalised to establish that organisational structure *causes* FSC differences across the broader hake trawling fleet.

- **Repeated cross-sectional data:** responses were anonymous, so individuals could not be linked across years. Crew turnover was reported to be low, making repeated participation plausible, but it could not be verified. The samples should therefore be treated as repeated cross-sections rather than independent samples or a matched longitudinal panel; possible repeated participation may affect the independence assumptions of some tests.

- **Instrument validation and item selection**: the 20-item questionnaire was informed by existing tools and expert review but was not formally psychometrically validated. The results presented for each dimension focus on selected items considered most directly relevant to the research objectives and easiest to interpret consistently across years. Each item was an indicator of a broader food safety culture domain, not a validated stand-alone measure of the full dimension.

- **Response and sparse-cell limitations:** Vessel B had only 13 usable questionnaires in 2024. Percentages for that vessel-year therefore represent small counts and are sensitive to individual responses. Sparse response categories can also make asymptotic chi-square approximations unreliable; exact methods or defensible category consolidation should be considered, with the approach reported transparently.

7. RECOMMENDATIONS AND CONCLUSION

This exploratory comparison identified statistically significant differences between two deep-sea hake trawling vessels of contrasting organisational structure across six of eight FSC dimensions, while confidence in food hygiene requirements and leadership showed no significant difference. These findings suggest that organisational context is associated with meaningful variation in FSC, though causality cannot be established from this two-case design.

Future research should extend this comparison to a larger sample of vessels across multiple organisational structures, incorporate validated FSC instruments, and consider mixed-methods approaches (e.g., qualitative interviews with crew and management) to better explain *why* these associations occur. From a retail perspective, seafood retailers and further processors are encouraged to consider FSC-specific criteria — alongside conventional HACCP certification — when auditing and selecting upstream suppliers, as a means of strengthening supply-chain risk management and consumer protection.

DECLARATION OF GENERATIVE AI USE

Generative AI (Grammarly and Claude Sonnet 5) was used to assist with language editing and reorganisation of manuscript structure. All statistical interpretations, factual content and conclusions were independently verified by the author(s).

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