Reporting of hazardous events in aquaculture operations – the significance of safety climate

Abstract

Objectives: In Norwegian aquaculture, safer technology and better safety management systems have been developed during the last decade. Safety commitment and safe behavior is still vital to ensure a safe working environment. The objective of this paper is to explore what factors might influence the reporting of hazardous situations in aquaculture. The significance of factors on both the individual (work experience, position) and company/organizational level (company size, safety climate) were studied. It was hypothesized that reporting of hazardous situations was positively predicted by work experience, having the position as operational manager, company size and safety climate.

Methods: The study is based on a quantitative questionnaire study, involving 428 fish farmers, operational managers and service vessels employees in the Norwegian aquaculture industry, interviewed by telephone. A purposive sampling procedure was employed. Correlation and hierarchical regression analysis were applied. The data quality was considered satisfactory.

Results: Individual factors had no significant relationship with the reporting of hazardous situations. Company size and safety climate factors had positive associations with reporting. Larger companies might have more resources for safety management and the development of practical reporting solutions. A positive safety climate might increase the motivation for reporting.

Conclusion: Efforts by management to improve the safety climate can contribute to the reporting of hazardous events, continuous improvement of safety management and improvement of the safety level.

Keywords: Aquaculture, safety, safety climate

1. Introduction

The Norwegian aquaculture industry is a leading global exporter of Atlantic salmon that provided close to 68 billion Norwegian Kroner to the gross domestic product in 2018. Since the beginning in the 1970s, the industry has grown considerably [1].

Compared to other industries in Norway, working in aquaculture involves high risk. Fish farmers have high fatality rates compared to other industries [2, 3]. The most common modes of injuries include falls, blows from objects, entanglement/crush injuries and cuts [4].

In recent years, attention to worker safety has increased by both industry and regulatory authorities. Technology development and safe design are important strategies to improve personnel safety at fish farms [5]. For Norwegian salmon aquaculture, sea-based fish farms consisting of several circular net cages are the most common production concept [6].

Studies indicate that safety management systems in the Norwegian fish farming industry have been strengthened during the last decade, involving for example the development of procedures and rules for safe working practices, systems for safety training and competence requirements [7, 8, 9]. Improvements in technology and safety management will still not be fully effective without the actual safety commitment from the workers and the organization as a whole [10]. New technological solutions might fail, and safety management systems must be suitable for the work as performed.

Workplace safety management systems must also be perceived by the workers as reasonable in scale and content and adapted to the aquaculture industry [8]. In addition, technology and systems do not eliminate production and efficiency demands, and possible trade-offs to safety. Even if suitable safety management systems and technology are in place in aquaculture, the human element will still be of great importance. For example, the ability to speak up and report conditions that might increase the risk for accidents will always be vital. Reporting is a central part of experience feedback, which is a basic mechanism for continuous improvements to safety management and the safety level [11]. Reporting of hazardous events, so that corrective actions can be taken before incidents happen, is evidently a valuable type of proactive safety behavior. Such reporting signals a mindful approach to safety that includes an awareness of details that can build up to serious accidents and a sensitivity to operations [12].

Organizational aspects influence the conditions of aquaculture employees [13].Organizational challenges such as prioritizing production at the expense of safety, long work hours and lack of rest during large operations, lack of training, inadequate maintenance and insufficient manning are some relevant examples that illustrate this [8, 13, 14, 15, 16, 17, 18]. Previous analyses also showed that

31% of 258 fish farmers agreed that it is uncomfortable to point out a lack of compliance with safety rules and procedures [13] and that near accidents are frequent among workers at the fish farms [17].

1.1 Objectives and hypotheses

The objective of this article is to explore which factors might influence the reporting of hazardous events in aquaculture production. We investigate the significance of factors on the individual level (work experience, position), the company level (company size) and the organizational level (safety climate). The safety climate is of particular interest, as it involves some of the informal aspects of a work community and may provide a glimpse into the safety culture [19]. In this research, safety climate is defined as the shared perceptions regarding safety policies, procedures and practices, and regarding how safety is managed and valued [20, 21, 22]. Empirically, the study is based on a quantitative questionnaire study, involving 428 sharp end workers in the Norwegian fish farming industry.

Individual factors

We explore if work experience from fish farming positively influence the reporting of dangerous situations. Workers that have longer experience in the industry might be better at recognizing situations that involve hazards, feel confident in their own evaluations and role in the company, and thus be more inclined to report dangerous situations. Further, we will investigate if operational managers are more inclined to report than fish farmers. Operational managers have a special safety responsibility for the personnel at the fish farms. The following hypothesis will be explored:

Hypothesis 1: Reporting of dangerous situations is positively predicted by work experience in the aquaculture industry, and by having a position as operational manager.

Company factor

The second hypothesis relates to company size. Over the years, there has been a consolidation of the industry, where some major companies have evolved through acquisitions and mergers with smaller, partly family owned companies. Still, there is a variation in company size, and there is substantial share of smaller companies [23]. We will explore if workers in larger companies are more inclined to report than workers in smaller companies. As larger companies have more resources available in terms of personnel and competence, they might be in a better position to prioritize safety and encourage reporting from workers. We will explore the following hypothesis:

Hypothesis 2: Reporting of dangerous situations is positively predicted by company size.

Safety climate

The third hypothesis relates to safety climate. [21]. The safety climate has mainly been measured by questionnaire surveys. Different aspects of the safety climate that have been measured include management prioritization and commitment to safety, safety competence, work pressure and safety participation [24, 25].

Several studies have supported the assumption that a positive safety climate is associated with good safety behavior and safety results. Related to safety behavior, a positive safety climate has been associated with compliance to safety rules and procedures, participation in safety-related activities, and mindful safety practices [26, 27, 28, 29, 30]. A positive safety climate has also been associated lower accident and injury rates [31, 32, 33, 34]. Based on this, we will explore the following hypothesis:

Hypothesis 3: Reporting of dangerous situations is positively predicted by the safety climate.

2. Methods

2.1 Sample and data collection

The study was a part of a research project on occupational health and safety in Norwegian fish farming financed by the Norwegian Research Council, aiming at generating knowledge for safer operations and workplaces.

According to Statistics Norway [35], 5748 people were working in the fish farming industry in Norway in 2016. Of these, 34% were working in the western region, 27% in the middle region, 38% in the northern region, while 1% were working in other regions of Norway. There were 162 registered companies producing salmon or trout in Norway in 2016 [36].

The empirical material was collected through a telephone survey conducted by a professional polling company during the fall of 2016. A purposive sampling procedure was employed. The target group was active workers from both small and large companies within sea-based fish farming in different areas along the coast. First, 40 fish farming companies were selected based on available information found online and the research group's network in the industry. Emphasis was put on selecting companies of different size and from different regions of Norway. From these companies, a list of 1000 active working employees was collected, and 992 of these were called. Some did not answer, and some interrupted the call before the polling company could explain the purpose of the survey. Out of the 992, 735 were explicitly asked to participate in the anonymous survey. Here, 288 declined

and 447 accepted. There were 19 participants who had jobs outside of fish farms or service vessels and these were excluded from the analyses due to the objective of the paper. Thus, 428 respondents were included in the study, giving a response rate of 43%. Some background information of the respondents is provided in Table 1.

Table 1 Sociodemographic and Employment Profile of Study Participants

Variable		%	N
Position	Fish farmer	60.3	258
	Operational manager	25.7	110
	Service vessel employee	14.0	60
Age (years)	< 25	11.7	50
	25-34	26.6	114
	35-44	24.5	105
	45-54	23.8	102
	> 54	13.3	57
Gender	Men	95,3	408
	Women	4,7	20
Experience of aquaculture (years)	0-2	13.6	58
	3-6	24.5	105
	7-14	23.6	102
	> 15	38.3	164
No. of employees in company	< 50	10.0	40
	50-200	24.1	96
	> 200	65.9	263
Region	West of Norway	40.2	172
	Middle of Norway	41.6	178
	North of Norway	15.7	67
	Other	2,6	11

The survey was approved by the Norwegian Centre for Research data and was performed according to applicable research ethical requirements, including informed consent by all participants, anonymity in the data presentation, and deletion of identifying information in the data material.

2.2 The questionnaire

The questionnaire consisted of 90 items, covering different safety, health and working environment issues. It included a safety climate scale of 16 items, as well as one item referring to reporting of dangerous situations. The safety climate scale was based on the work by Flin et al. [25] and their review of safety climate surveys, and Fenstad et al.'s safety climate study [37] in the maritime domain. The items were presented as statements in Norwegian. The respondents stated their level of agreement on a Likert scale, ranging from 1 (totally disagree) to 5 (totally agree).

Table 2 Descriptive statistics for safety climate items and reporting – mean, standard deviation (SD) and number of respondents (n)

Items		Mean	SD	n
Safety climate				
Q1	The company where I work takes safety seriously	4.43	0.89	427
Q2	Manning is sufficient to maintain safety	3.73	1.03	428
Q3	The safety deputies' suggestions are taken seriously by the leaders	3.94	1.02	407
Q4	Information regarding unwanted events is utilized adequately to prevent recurrence	4.11	0.95	427
Q5	My manager appreciates that employees take up safety issues	4.26	0.93	426
Q6	The equipment that I need to work safely is easily accessible	4.07	1.01	428
Q7	In practice, consideration of production is prioritized at the expense of safety	2.43	1.23	427
Q8	Inadequate maintenance has reduced the safety level	2.38	1.19	428
Q9	There are often parallel work operations proceeding that leads to dangerous situations	2.40	1.07	427
Q10	Sometimes I feel a pressure to continue working, although safety can be compromised	2.06	1.10	428
Q11	Due to fish welfare and fish escape considerations, safety procedures cannot always be followed	2.07	1.08	424
Q12	I have the necessary competence to handle my work tasks safely	4.52	0.71	426
Q13	I have received sufficient training to handle critical or dangerous situations	4.11	0.94	425
Q14	I get involved in acquisitions of new equipment	3.42	1.33	427
Q15	I participate in making new procedures	3.08	1.36	426
Q16	I get involved when new procedures are to be introduced	3.54	1.29	427
Reporting				
Q17	If I see dangerous situations at work, I report them	4.45	.92	428

2.3 Statistical analyses

During the telephone interviews, the data was continuously registered in a general format (ascii-file) by the polling company. After completion of the survey the data was exported to the statistical software “Statistical Package for the Social Sciences” (SPSS). A visual inspection of the data file was then performed by the research group. There were 19 participants who had jobs outside of fish farms or vessels and these were excluded from the analyses due to the objective of the paper. Otherwise, none of the respondents were excluded from the data set, as the responses in general were complete.

Exploratory factor analysis

The 16 safety climate variables are challenging to analyse one by one in relation to reporting. We therefore applied exploratory factor analysis (EFA), which is a technique used to identify clusters of

variables that can be combined, and to reduce a dataset to a more manageable number of variables [38]. In the EFA, principal component analysis (PCA) with Varimax rotation was applied, and factors with eigenvalues ≤ 1 were kept for further analysis according to Kaiser's criterion (ibid: 677).

Correlation analysis and regression analysis

The hypotheses involve studying the associations between 'Reporting' on the one hand, and work experience, management responsibilities, company size and safety climate on the other. It was assumed that there was a linear relationship between these variables. It was expected that longer work experience, working as an operational manager, belonging to a larger company and having a more positive safety climate was associated with more reporting. Statistically, this was first explored by bivariate correlation analysis. The statistic Pearson's R is an expression of the strength of the association. The coefficient can vary from -1 to +1. The extreme values indicate a perfect linear relation relationship (negative or positive). Values around +/-0.1 represent a small effect, +/- 0.3 a medium effect, and +/- 0.5 a large effect [38]. The level of significance was set at 0.05.

In order to explore the hypothesis further, hierarchical regression analysis was applied. This analysis allows for determining the controlled ("pure") effects of each independent variable on a dependent variable. In our case, we were interested in exploring what variables that were significantly associated with reporting and the relative strength of these associations expressed by standardized beta-values (β). Hierarchical regression analysis is performed in steps. In the first step, individual variables were entered (work experience and position), followed by company size in the second step, and finally three safety climate components in the third step. Missing values were excluded pairwise. This procedure allowed for comparing the effects of the three models and for investigating the effects of safety climate after controlling for the other variables.

3. Results

3.1 Factor analysis

The factor analysis (Table 3) revealed four factors that explained 61.5% of the variance. The factors were well aligned with the safety climate literature in content [24, 25], and were named as follows:

- Safety priority: Perceptions on how safety is prioritized in terms of manning, equipment, and how management take care of safety.
- Work pressure: Perceived pressure towards efficiency and high production that can challenge safety.

- Safety competence: Perceptions of own competence and the training received to handle dangerous situations.
- Safety participation: Perceived level of involvement in procedure development and introduction, and in acquisition of new equipment.

Table 3 Exploratory factor analysis: PCA, Varimax with Kaiser normalization

Items		Factor loadings				Communalities
Q1	The company where I work takes safety seriously	0.77				0.63
Q2	Manning is sufficient to maintain safety	0.58				0.48
Q3	The safety deputies' suggestions are taken seriously by the leaders	0.75				0.69
Q4	Information regarding unwanted events is utilized adequately to prevent recurrence	0.76				0.61
Q5	My manager appreciates that employees take up safety issues	0.67				0.58
Q6	The equipment that I need to work safely is easily accessible	0.63				0.54
Q7	In practice, consideration of production is prioritized at the expense of safety		0.56			0.47
Q8	Inadequate maintenance has reduced the safety level		0.67			0.50
Q9	There are often parallel work operations proceeding that leads to dangerous situations		0.75			0.59
Q10	Sometimes I feel a pressure to continue working, although safety can be compromised		0.74			0.61
Q11	Due to fish welfare- and fish escape considerations, safety procedures cannot always be followed		0.71			0.55
Q12	I have the necessary competence to handle my work tasks safely				0.82	0.72
Q13	I have received sufficient training to handle critical or dangerous situations				0.82	0.75
Q14	I get involved in acquisitions of new equipment			0.73		0.65
Q15	I participate in making new procedures			0.88		0.80
Q16	I get involved when new procedures are to be introduced			0.75		0.67
						Sum
Percentage of variance explained		21.26	16.81	13.53	9.85	61.45
Cronbach's alpha		.85	.77	.62	.78	

Bartlett's test of sphericity (approx. chi-square) = 2373.7 ($p < 0.001$). Kaiser-Meyer-Olkin measure of sampling adequacy = 0.888. Factor loadings below 0.40 are suppressed.

Tests indicated that the data were appropriate for factor analysis; Bartlett's Test of Sphericity was significant. The Kaiser-Mayer-Olkin (KMO) measure for adequate sampling exceeded the required 0.5 (see notes to Table 3).

Cronbach's alpha was used to assess internal consistency and reliability [39]. In general, an alpha score above .70 is considered acceptable [38]. Three of the four factors had scores above this level. The lower level of the 'Competence' factor (.62) should be interpreted in light of the small number of items included (2). In total, the internal consistency and reliability were considered acceptable.

3.2 Testing of the hypotheses

In Table 4, the bivariate correlations between reporting of dangerous situations and work experience, position, the number of employees in the company and the safety climate factors are presented.

The correlations between reporting on the one hand and work experience and position on the other were low and not significant, thus not supporting hypothesis 1.

The correlation between reporting and the number of employees was statistically significant ($p <. 05$) and in the expected direction. Hypothesis 2 was thus supported. The result indicated that a higher number of employees in the company is associated with a higher tendency to report dangerous situations, and thus that company size could have a positive effect on such reporting. The correlation was in the lower region.

The four safety climate factors were all significantly correlated with reporting ($p < .01$) and in the expected direction, thus supporting hypothesis 3. Among the four factors, safety competence was most strongly associated with reporting, followed by safety priority, safety involvement and work pressure. Higher levels of reporting of dangerous situations was associated with higher personal safety competence and the training, higher safety prioritising by the company, higher degree of involvement in procedure development/introduction and lower work pressure.

Table 4: Pearson's correlations for reporting, background variables and safety climate factors (N in brackets)

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10
1. Reporting	-									
2. Work experience in fish farming	-.02 (428)	-								
3. Operational manager	.06 (428)	.31** (428)	-							
4. Fish farmer	-.08 (428)	-.09* (428)	-.73** (428)	-						
5. Service vessel employee	.03 (428)	-.26** (428)	-.24** (428)	-.50** (428)	-					
6. No. of employees in company	.10* (399)	.09* (399)	.01 (399)	.27** (399)	-.38** (399)	-				
7. Safety priority	.35** (406)	.01 (406)	.05 (406)	-.09 (406)	.07 (406)	-.01 (378)	-			
8. Work pressure	-.26** (422)	.02 (422)	-.04 (422)	-.00 (422)	.05 (422)	-.01 (393)	-.53** (403)	-		
9. Competence	.41** (424)	.11* (424)	.01 (424)	-.00 (424)	-.01 (424)	.09 (395)	.42** (405)	-.31** (418)	-	
10. Safety involvement	.28** (426)	.04 (426)	.19** (426)	-.24** (426)	.10 (426)	-.12* (397)	.51** (404)	-.32** (420)	.24** (423)	-

* p <.05 (one-tailed)

** p <.01 (one-tailed)

In addition, a hierarchical linear regression analysis was performed for reporting of dangerous situations, involving the same independent variables (Table 5). The variables related to the first hypothesis were included in the first step. Work experience and position had no significant relationship with reporting.

In a second step, the number of employees was added, which had a positive and significant relationship with reporting, supporting hypothesis 2.

In a final step, addressing hypothesis 3, the four safety climate factors were added. After controlling for the other variables, safety competence (β = .31, p <. 01), safety prioritization (β = .15, p <. 05) and safety involvement (β = .12, p <. 05) had significant relationships with reporting. The positive relationship with the number of employees was maintained in the final step (β = .10, p <. 05). The independent variables explained 22 % of the variance in reporting of dangerous situations in the final model.

In sum, the bivariate correlation analysis and the hierarchical regression analysis supported that reporting is positively predicted by company size (H2) and by the safety climate (H3)

Table 5 Hierarchical regression analysis, predicting reporting of dangerous situations at work: Beta-values, standard errors (SE B), standardized betas (β) and explained variance (R^2)

Step	Variables entered	B	SE B	β	R^2 change
1.	Constant	4.46	.15		.00
	Work experience in fish farming	-.03	.05	-.03	
	Operational manager	.17	.12	.08	
	Service vessel employee	.10	.14	.04	
2.	Constant	3.95	.25		.02*
	Work experience in fish farming	-.03	.05	-.04	
	Operational manager	.20	.12	.10	
	Service vessel employee	.25	.16	.09	
	No. of employees in company	.19	.08	.14*	
3.	Constant	1.59	.46		.21**
	Work experience in fish farming	-.06	.04	-.07	
	Operational manager	.13	.10	.06	
	Service vessel employee	.14	.14	.05	
	No. of employees in company	.16	.07	.11*	
	Safety priority	.16	.08	.13*	
	Work pressure	-.06	.06	-.06	
	Safety competence	.40	.07	.31**	
	Safety involvement	.10	.05	.12*	
Overall R^2					.24
Overall adjusted R^2					.22

* p < .05.

** p <. 01.

4. Discussion

The study aimed to explore which factors might influence the reporting of hazardous events in aquaculture. Three types of factors were explored: individual factors, company factors and safety climate factors. None of the individual factors were associated with reporting, contrary to the hypothesis. We assumed that workers with longer experience could identify risk better and be more confident in their role, and thus be more inclined to report than workers with shorter experience. One reason that the results did not confirm this might be that attention to safety has increased in recent years, and that new workers are more exposed and receptive to information and knowledge

on safety issues. Several companies have developed structured introduction programs for new workers that include safety topics. This could level out the potential advantages that workers with longer experience might have, related to their competence and confidence. All groups have a high proportion of respondents that state that they report dangerous situations at work.

Also, there was no significant association between having the position of operational manager and reporting. Thus, the hypothesis that their special safety responsibility would lead to higher levels of reporting was not supported. A likely explanation could be that operational managers have different responsibilities that they have to balance. In addition to safety, they also have responsibilities for budget, production, welfare of the fish and general management of the location.

Supporting the second hypothesis, company size did positively predict reporting of hazardous events, although the correlation was in the lower region. There was a tendency that respondents from larger companies to a larger extent reported hazardous situations than respondents from smaller companies. The association with company size may relate to the formalized safety management in the different companies, where it is likely that large companies have the resources to prioritize safety for personnel. They may also have digital solutions, like mobile phone apps for internal reporting of unwanted events, and some companies even award fish farms that are good at reporting near accidents or other undesired events.

The safety climate factors correlated in the expected direction with reporting. In the regression analysis, three of the four safety climate factors predicted reporting. There was a tendency that higher perceived safety competence, higher perceived prioritization of safety by the company and higher levels of participation in safety issues were associated with higher levels of hazardous event reporting. Hypothesis 3 was thus supported. This is in line with other studies, indicating that a positive safety climate influences safety behavior, including compliance, and mindful safety practices [26, 27, 28, 29, 30].

Safety competence shows a particularly strong association, which may be an illustration of the importance of training for paying attention to safety, and the importance of understanding why dangerous situations should be reported. Also, competence is likely to make workers more confident in their own assessments.

Safety priority and safety participation might have an influence on motivation to report. Neal et al. [40] explored how safety climate was related to safety behavior and found that motivation was a mediating factor. If safety is perceived as being prioritized by management, and the perceived level of participation and involvement is high, this might increase the motivation to report hazards, which

in turn increases the actual reporting behavior. Such associations might illustrate that there exists an upward spiral for developing safety in the industry. The critical point might be that reporting is actually used for improvements and new measures. When this is the case, it shows that safety is prioritized and that the staff can influence safety issues, again possibly stimulating more reporting. The opposite might also take place. One important barrier to reporting identified by Shaaf and Kanse [41] is when reporting is not acted on by management. Whether reporting is regarded as useful or useless thus depends to a large extent on if and how the reports are used.

There are some limitations related to the validity of the study. The response rate (43%), as well as the purposive sampling procedure might have influenced the representativity of the final sample. If the final sample is not representative, the external validity and generalizability of the study might be compromised. Respondents from the north of Norway seems to be underrepresented, and respondents from the middle of Norway overrepresented. We have no information regarding other population background variables, but with our knowledge of the industry the final sample seems fairly representative regarding position, age, gender and work experience. The survey was conducted by telephone, and there is a possibility that the interview situation might have influenced on the results, providing an incitement for the respondents to give a more positive impression, for example of their own competence and behavior. On the other hand, the method gave a high completion rate of the survey, and the level of missing data was low. Also, the data on the independent variables and the dependent variable were obtained from the same survey, invoking a vulnerability to common method bias [42]. For example, if the respondents in general were motivated to give a positive impression of safety in the industry, this might have influenced all of the results. The associations that we found could then be spurious. Although we have no indications of such threats to validity, future research could explore the possibility of obtaining data from more than one source, for example data on actual reporting frequency or other dependent variables of interest, such as accident or near-miss data.

5. Conclusion

Many companies in the fish farming industry in Norway have strengthened their safety management systems during the last decade. We argue that the human element and the safety commitment among those who work in the industry will still be of vital importance for these improvements to be fully effective.

This study explored the reporting of events and situations that threaten safety. Reporting behavior signals safety commitment and is an important part of a functioning safety management system. The results from this exploratory study indicate that the reporting level is high in the industry in Norway.

Furthermore, the results support that reporting can be influenced by management: by prioritizing safety, by providing sufficient training and competence and by involving the staff in safety-related issues. An implication is that efforts by management to improve the safety climate can contribute to continuous improvement of safety management and the safety level. Also, the results suggest that company size matters for reporting, and that workers in larger companies tend to report more. This may indicate that there is a learning potential on the industry level. Some companies might benefit from insights into how other companies organize and practice safety management.

The aquaculture industry in Norway has a relatively short history, and it has developed rapidly. There is a possibility that some companies might lag behind others when it comes to safety practices. The learning needs and the learning potential on the industry level are potentially important topics to explore in general in future research.

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