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Report

Occupational health and safety in Norwegian aquaculture

National profile for a FAO report on global aquaculture OHS

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ABSTRACT

The Food and Agriculture Organization (FAO) are gathering an overview of the global, regional and national terrain of aquaculture/fish farming occupational health and safety and related social and welfare impacts. This report is Norway's national profile and presents the status of occupational health, safety management and challenges in the Norwegian aquaculture industry. Farmed Atlantic salmon and trout amount to 99.6 percent of the total aquaculture production. Being a fish farmer is the 2nd most risk exposed occupation in Norway. Occupational injuries as well as musculoskeletal problems are the most common reasons for both sick leave and worry amongst employees. Working life in the Norwegian aquaculture industry is regulated by the Working Environment Act. The "Norwegian model" is based on the idea that we can unite value creation and competitive power with social equality and welfare. Safety work has improved considerably since the 1990's. Future research may include a thorough evaluation of preventive measures for the improvements of OHS in the Norwegian aquaculture sector.

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1 Introduction

SINTEF Ocean was contacted by Professor Andrew Watterson in October 2017 with a request to contribute to an on-going project by the Food and Agriculture Organization of the United Nations (FAO). The project aims to scope out the global position on aquaculture/fish farming occupational health and safety (OHS), and will draw on country-specific profiles.

This report provides a country-specific profile for Norway on OHS in the aquaculture industry and is the Norwegian contribution to the global overview by FAO. The information is collected from scientific publications, national research reports and other information sources both in the English and Norwegian language. The reference list provides a collection of relevant previous research studies and key literature on the topic in the Norwegian context.

2 Characteristics of the Norwegian Aquaculture Industry

Since the 1970's, the Norwegian aquaculture industry, in particular fish farming, has become a significant contributor to the national value creation. Norway is the number two major exporter of fish worldwide after China, and is the largest producer of finfish in marine and coastal environments (FAO, 2016). In 2016, the total production in the Norwegian aquaculture industry was 1.3 mill metric tons, and the landed value was 65 billion NOK (Directorate of Fisheries, 2017b). Farmed salmon and trout amount to 99.6 percent of the total aquaculture production. 93 percent of the biomass were Atlantic salmon, thus being the most important farmed species in Norwegian aquaculture.

Table 1 shows key figures of the aquaculture sector in Norway in terms of types of species, licenses, sites, produced quantity and sales value in 2016. The aquaculture sites are located along the entire coastline of Norway, thus covering a large geographical area with different climatic factors.

Table 1 The aquaculture production in Norway in year 2016 (Directorate of Fisheries, 2017b).

Species	No. of licenses	Number of sites in sea water	No. of companies	Production (metric tons)	Sales value (1000 NOK)	Percentage of total production
Atlantic salmon and trout (total)	(1342)	978				
-juvenile	220		117			
-grow-out	990		162	1,321,471	63,803,590	99.6421
-brood-stock	42					
-R&D	90					
Other marine species*	284	69				
-juvenile			41	-	-	
-grow-out			48	2,473	210,631	0.1865
Molluscs, crustaceans and echinoderms	198	150	57	2,213	24,542	0.1669
Sea-ranching	12	-	-	-	-	
Algae	242	-	11	60	917	0.0045
TOTAL				1,326,217	64,039,680	100

*Cod, Arctic char, Atlantic Halibut etc.

Because finfish constitutes more than 99 percent of the produced biomass, the OHS research in Norway mostly focus on the challenges in fish farming (cage aquaculture). However, the knowledge generated is also valid for other types of marine and coastal aquaculture production.

The Norwegian aquaculture production has the potential to increase fivefold within 2050 (Olafsen et al., 2012), and is the most important sector after oil and gas. To be able to grow, and at the same time safeguard fish welfare and environmental issues, the companies are exploring the possibilities for moving the production to sites further from the shore. Production in more exposed areas will increase challenges as a result of extreme weather (Bjelland et al., 2015). Technology is gradually developed to meet these challenges, until recently the strategy has been to upscale boats and net cages. Simultaneously, the industry is facing an increase in production cost per kg, and needs to focus on operational efficiency at today's production sites.

A variety of large and small companies constitute the industry. There are large global fish farming companies, and family-owned fish farms in small communities. Eleven of the 20 largest salmon farmers in the world have their headquarters in Norway (Berge, 2018). The largest company is Norwegian-owned and had a slaughter volume in 2016 of 380,621 metric tons globally. The 19th largest is, comparable, also a Norwegian company, had approximately 25,000 metric tons, all produced in Norway. There are also a growing number of manufacturers and providers of equipment, fish farm constructions and other technology to the aquaculture industry. In addition, several actors assist in aquaculture operations, such as service vessels, divers and well boats. During the last decade, the trend in Norwegian aquaculture enterprises has been to outsource heavy mounting and maintenance operations to specialized service providers (Fenstad et al., 2009). This has changed the organization of the aquaculture sector to resemble the building and construction industry, where several legal entities (sub-contractors) are present at one building site. Altogether 7,825 persons were employed in the aquaculture sector of Norway in 2016, of which 17.5 percent were female (Directorate of Fisheries, 2017b). The number of employees has increased from 4,553 (13.9 percent women) in 2006, thus an increase of 72 percent during the last decade. Key performance figures on the productivity of the Norwegian aquaculture industry can be found in Directorate of Fisheries (2017a).

There are normally six to 12 circular plastic collar net cages in one fish farm (Jensen et al., 2010, Holen et al., 2018a). The number of cages will vary according to the locations and production licenses. A feeding barge for equipment and feed storage, the feeding system, as well as manager offices, meeting rooms and accommodation for the workers are permanently anchored within the fish farm. Work vessels, 8-15 meters l.o.a. and equipped with capstans and/or a crane, are used for inspection and maintenance of the fish cages. The daily inspections are performed in accordance to official regulations on aquaculture operations (Norwegian Ministry of Trade Industry and Fisheries, 2008), making sure the net cages are in order and assessing fish welfare. Aquaculture operators perform tasks such as maintenance, removal of dead fish from the net cages and monitoring the amount of salmon lice on a selection of fish each week. Specialized vessels and crews are hired for the heavier operations, such as mooring operations and delousing. The safety of fish, constructions and personnel is thoroughly regulated by legislator requirements (Holmen et al., 2017a), which are the responsibility of five different regulatory authorities to audit (Holmen et al., 2017b).

The fish feeding system consist of tubes laid out from the barge, in which the feed storage is located. The system can be remotely controlled from either the feeding barge or an onshore "feeding central". Cameras mounted within each fish cage, at several depths, are used to monitor fish at several locations. The rate and amount of feed is based upon assessment of the fish behaviour. Dedicated and well-trained personnel are capable of continuously adjusting the feed rate so that almost every food pellet is eaten before it sinks to the bottom. The grow-out period in seawater is approximately 18 months before harvesting.

The size of the companies may be relevant for the occupational health and safety (OHS) work. Larger companies usually have onshore offices where dedicated staff works with safety and health for the aquaculture site employees. Smaller companies may have OHS personnel that serve several functions, such as fish welfare and quality management. The operational manager is responsible for both biological production and the personnel's safety at the location. Each fish farm employs about three to six workers (here also referred to as fish farmers) who are responsible for the daily inspections, feeding and maintenance work.

3 Occupational health and safety issues in Norwegian aquaculture

Being a fish farmer is the 2nd most risk exposed occupation in Norway after being a fisherman (Aasjord and Geving, 2009, McGuinness et al., 2013). The three most recent fatal accidents occurred in July, 2013, August 2015 and in November 2017. No detailed information is yet available on the latest accident, but media articles indicate that the consequence of this accident could have been less severe if lifejackets had been used on deck. The previous two fatalities were caused by uncontrolled transfer of high energies from ropes under high tension. The occupational accident statistics for the Norwegian aquaculture industry contains reports of similar incidents involving hits or blows caused by equipment failure or a mistake. Fortunately, the vast majority of incidents do not lead to such fatal accidents, but the potential is alarming: 761 occupational injuries were reported to the Norwegian Labour and Welfare Administration (NAV) from 2001 to 2012 (Holen et al., 2018b), and 34 fatalities have been registered in the period from 1982 to 2015 (Holen et al., 2018a). Although the reported injury rate has decreased since the beginning of this century, there are still many operations at the fish farms dependent on manual labor, bringing the workers in close interaction with heavy equipment and strong forces in the fish cage structures.

Another great safety challenge for the fish farming companies is escape of salmon. Public statistics show that the reported escapes from Norwegian fish farms in earlier years mainly were caused by technological and structural failures (Jensen et al., 2010), but in the later years "human error" or more generally "human factors" have been given as the main reason. However, recent research proves that the accident causality often is complex and with several contributing factors; e.g. a harsh work environment, demanding work operations, variations in worker skills, poorly implemented safety management and suboptimal functionality of solutions and technology. The workers identify the same operations as being critical for personal safety as for fish escape risk (Thorvaldsen et al., 2015).

The physical environment of the fish farmers is a challenge that cannot be avoided. A large part of the aquaculture industry operates in open sea and is exposed to a constant impact from wind, waves and currents, and the northern winters worsen the working conditions due to cold temperatures, darkness and icing on gangways and fish cages. Cold, wet and windy conditions negatively affect work performance, comfort and health. Impairment of physical and mental performance, as well as cold-related health problems are likely to occur more frequently at low ambient temperatures than in thermo-neutral environments. In cold environments, health problems are more evident than in warm environments (Rintamaki, 2007, Sandsund et al., 2001, Sandsund et al., 2007).

Fish farmers, who have started to utilize more exposed locations, report considerable difficulties in maintaining reliable production (Sandberg et al., 2012). Weather conditions are already causing downtime at several sites, especially during the winter months, and this is expected to increase due to climate changes. The weather thus makes the overall management of maintenance and daily operation unpredictable, and also increases the HSE risks at the workplace (Holen et al., 2013).

The work shifts for fish farmers as well as the crews of the service vessels may be long and the workload hard in periods (Thorvaldsen et al., 2015). Lice treatments are to be carried out at all farm sites within a region during a limited period of time. These operations demand extra staff either gathered from other locations or hired. Finding qualified personnel and required vessels and equipment in periods of frequent lice treatments may be a problem, resulting in understaffing and increased pressure on the workers. Lack of qualified personnel raises in itself a safety issue, because inadequate training and experience affect the situational awareness and ability to identify hazards and predict consequences of actions. This might also put extra mental stress on the skilled workers and the operational manager and thus influencing their ability to do the correct actions when required to avoid dangers.

Work stress, shift work, and physical workloads are known to interfere with sleep and contribute to fatigue (Åkerstedt et al., 2002). Fatigue is defined as physical and/or mental exhaustion that can be triggered by stress, medication, overwork, or mental and physical illness or disease. As an example, in the summer of

2015 there was a near-accident when a driver of an aquaculture vessel fell asleep and hit the shore. This time it all went well, however, serious maritime accidents have been caused by skippers falling asleep at the wheel. From offshore fleet studies it is known that accumulated sleep deficit over time causes fatigue, and that long working hours at moving work platform also affect cognitive and physical performance (Hansen et al., 2010). There are several similarities between working on a boat and at a fish farms, thus it is likely that these findings are relevant for fish farmers' performance. Work at sea involves multiple risk factors for fatigue (Jepsen et al., 2015) and these are associated with a higher risk for operational and human errors.

The aquaculture industry is obliged to fulfil requirements set by the laws and regulations controlled by five regulatory authorities (Holmen et al., 2017b). Development of safety management systems that satisfy legal requirements in the Working Environment Act and The Aquaculture Act and in addition achieve coordination of health, safety and environment (HSE) routines among farmers and service providers is challenging. Conduction and documentation of risk assessments and non-compliance reporting are essential parts in the companies' routines to manage risks and maintain acceptable safety levels in the operations.

In the aquaculture industry, there are indications of a challenging safety culture in that fish farmers often neglect their own safety on behalf of actions critical to the production of fish (Størkersen, 2012, Thorvaldsen et al., 2015). Safety culture is now widely recognized as an important construct for safety, although many different definitions and conceptualizations exist (Guldenmund, 2000). Safety management systems and safety culture are two important organizational safety aspects in the industry. The evolution of safety management systems (SMSs) represent a recognition of how companies can organize themselves to reduce risk, by means of establishing policies, information gathering, analysis, risk controlling measures and evaluation of such measures (Hale, 1997). SMSs represent the formal side of organizational safety. Safety culture represents an informal aspect of safety, involving shared values and beliefs that produce safety related behavioural norms among members of an organization (Reason, 1997). Such shared values and norms influence risk through shared work practices. It involves the social aspects of work, and is, as such, a part of "the third age of safety" (Hale and Hovden, 1998), adding to an earlier focus on technological defences and on human/individual factors.

A study of systematic HSE work in the Norwegian aquaculture industry was carried out in 2003 (Allred et al., 2005). The study is based on questionnaires which the operational managers and safety representatives at the fish farms were asked to fill in. The response rate was unfortunately low (26%), however, the study concluded that the safety of the workers to a good extent was taken care of, and that the fish farms had started to implement HSE routines according to the Internal Control Regulation introduced in 1996 (Norwegian Ministry of Labour and Social Affairs, 1996). A later study has focused on the safety perception and precaution at Norwegian fish farms. Organizational conditions of importance to prevent accidents were identified, and the study concluded that due to changes in the aquaculture industry, more systematic safety measures are required (Fenstad et al., 2009). The management rely on operating co-workers (the organizations' 'sharp end') to make all practical safety-decisions during the operation. Furthermore, the fish farming industry in Norway has evolved from a peripheral industry consisting mainly of small family owned businesses to fewer larger centralized organizations administrating several fish farm facilities and outsourcing work operations on e.g. moorings and other specialized services. Smaller organizations have less need for comprehensive safety management systems, as communication between the employees is easier and more transparent. However, a larger organization may also imply that more resources are available for working systematically with safety.

The aquaculture industry is, as described, an exposed and physical work place, highly influenced by operational hazards and environmental factors. From being an underprioritized field of research, the attention to occupational and operational safety in the aquaculture industry has increased during the last decade. In 2016, a study was conducted to analyse the current HSE status at the fish farm workplaces (Thorvaldsen et al., 2017). The aim of this study was to gain updated knowledge on the quality and functioning of safety management systems and the characteristics of safety culture in today's fish farming industry. A questionnaire covering general information on organisation of work and health as well as subjective

perceptions regarding work environment, safety and health was distributed to a selection of fish farmers and managers in the Norwegian aquaculture sector. The respondents were asked about work strain, occupational pains and conditions of their working environment. A selection of results from this study is presented in a later section of the report.

3.1 Occupational hazards

A guide for work environment and safety in the aquaculture industry (Norwegian Labour and Inspection Agency et al., 2011) describes a number of known occupational hazards, which are listed in Table 2. This guide was a result of a tripartite cooperation between the regulatory authority (the Norwegian Labour and Inspection Agency), the trade union Fellesforbundet and the Norwegian Seafood Federation (interest organization for employers within the seafood sector).

Table 2 Occupational hazards in marine and coastal Norwegian aquaculture and examples of mitigating measures (Norwegian Labour and Inspection Agency et al., 2011).

Risk factor/hazard	Possible consequence/accident	Mitigating measure (example)
Diving	Drowning Oxygen poisoning Decompression sickness	Monitoring Check equipment/oxygen Safe diving profile
Chemicals (formalin, anesthetics, vaccines, disinfectants, bases and acids, detergents, technical chemicals)	Respiratory injury Poisoning Skin injury Eye injury	Adequate personal protective equipment Safe work procedures Training/education
Heavy and monotonous work	Musculoskeletal problems	Preventive work Reduce straining work Variation/rotation Time for rest Education and information Sufficient staff Arrangement of workplace
Working alone	No immediate help available Fall from vessel or at the fish farm Drowning and hypothermia Crush injuries Engine breakdown General malaise Stress and psychological strain	Risk assessment to identify acceptable risk and measures Possibilities for communication and assistance Safety radio with alarm

4 Occupational accidents in Norwegian aquaculture

4.1 Fatalities

Figure 1 shows fatal occupational accidents in the period 1982-2017, divided in ten-year periods (except 2012-2017) and categories of operations which were going on when the accident occurred.

Figure 1 shows that the types of accidents have changed over the years. During the first decade, there were many drownings as a result of loss of vessels during transport (shipwreck, collisions), while the last six-year period the majority is fatal accidents during work operations at the fish farm or work boat/service vessel (maintenance and lifting operations). There were no fatal accidents in 2014 or 2016.

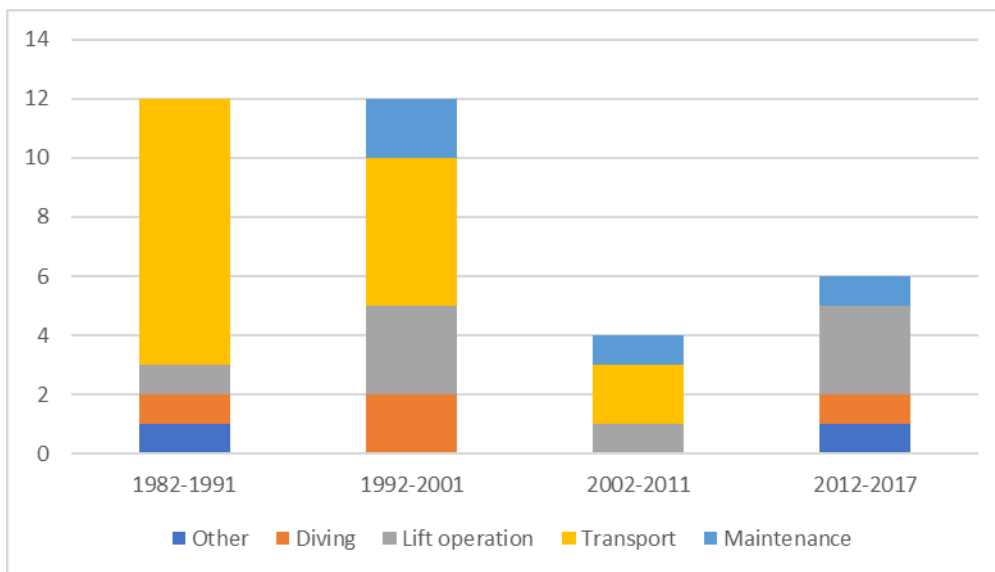


Figure 1 Fatal accidents in Norwegian aquaculture 1982 to 2017 (SINTEF Ocean, 2018). Legend: Yellow - transport (capsize, collision); gray- lift operation (e.g. crane); orange - diving (maintenance/inspection of fish cage, excluding harvesting wild-grown mussels); blue – maintenance operations; dark blue - other (e.g. fall over board).

Table 3 presents the causes for the accidents during the years 2008-2017. The cause for the fatality in 2017 is not yet identified, as it is currently under investigation by the Norwegian Accident Investigation Bureau. In the meanwhile, this accident is counted as "Other" in the figure.

Table 3 Fatalities in Norwegian aquaculture 2008-2017 (SINTEF Ocean, 2018).

Year	Transport	Lifting operations	Diving	Maintenance	Other	SUM
2008						0
2009						0
2010				1		1
2011						0
2012		2	1			3
2013				1		1
2014						0
2015				1		1
2016						0
2017					1	1
SUM	0	2	1	3	1	7

4.2 Occupational accidents registered by the authorities

4.2.1 Serious occupational injuries

Occupational accidents with serious personal injury shall be reported to the Norwegian Labour Inspection Authority (NLIA). Figure 2 shows serious occupational injuries registered by NLIA over the years 2011-2014. The analyzes of occupational accidents are the result of a collaboration between NTNU and SINTEF, and have been published by Holen et al. (2017a). The red line in the figure shows the accident rate expressed as injuries per 10,000 man-years. The accident rate is at the same level throughout these years. Figure 3 presents the occupational accidents categorized by mode of injury. Injuries caused by blows, crush, fall, electrical shock and chemicals are most frequent.

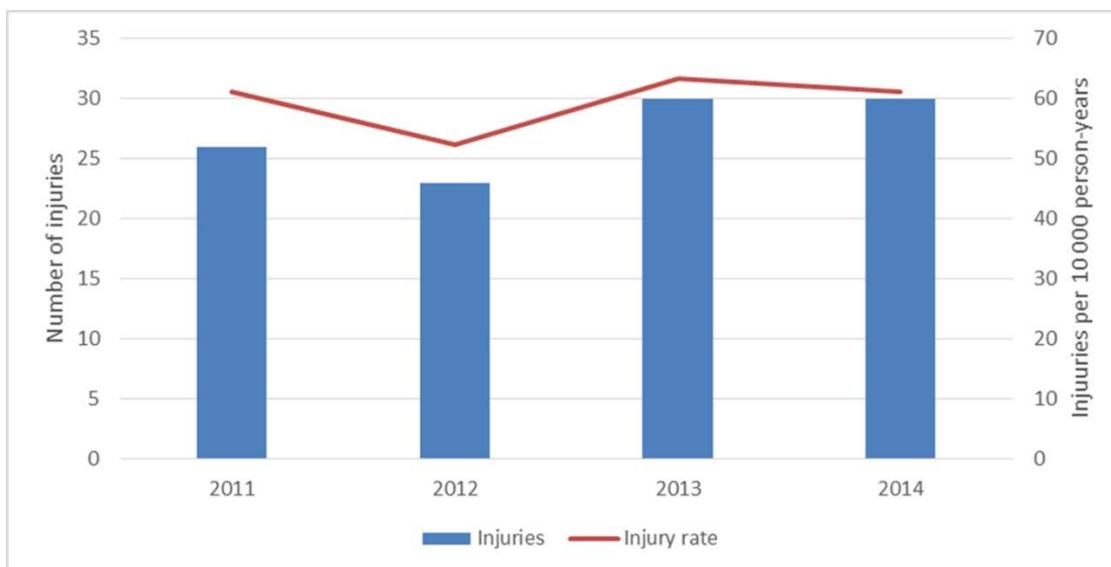


Figure 2 Occupational accidents with serious injury registered by the Norwegian Labour Inspection Agency 2011-2014 (Holen et al., 2018a).

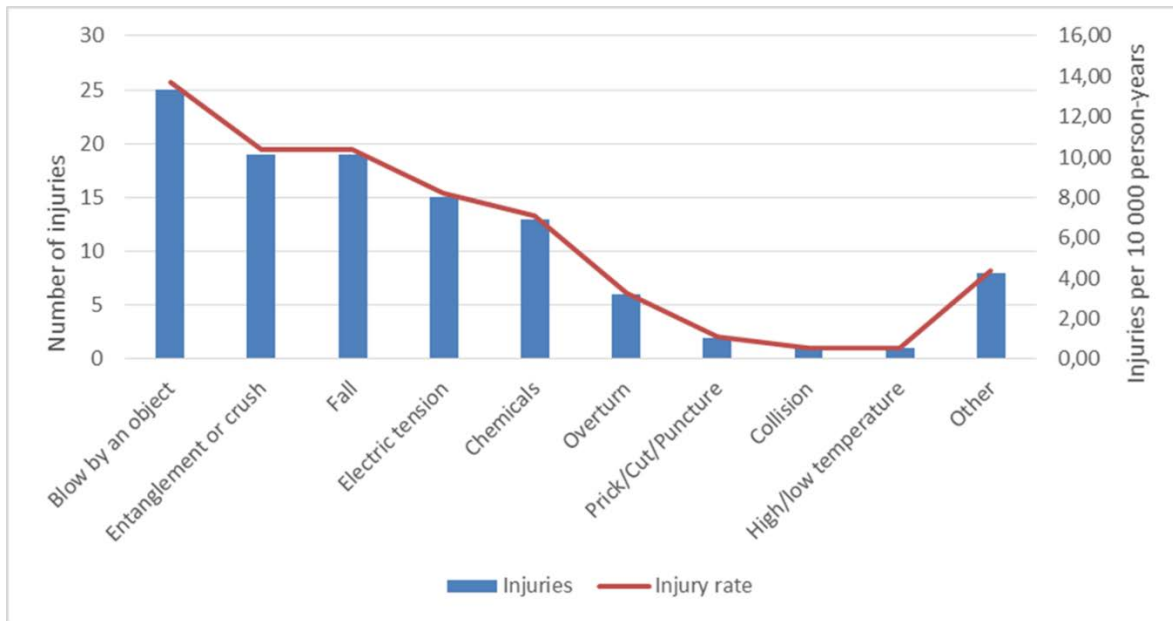


Figure 3 Mode of injury of serious occupational injuries in Norwegian aquaculture 2011-2014 (Holen et al., 2018a).

This data set contains occupational accidents that have been reported to and registered by the Norwegian Labor Inspection Authority during the years 2011-2014. The quality of the data is thus entirely dependent on the reporting rate which relates to the severity of the injuries. The police and emergency unit will be present at the accident scene, and they also alert NLIA if relevant.

4.2.2 Accidents at work

Statistics Norway undertook the responsibility for collecting the national occupational accident statistics from year 2014. Statistics Norway's official statistics on occupational accidents in Norway include both fatal and non-fatal occupational accidents (Statistics Norway, 2017a). Statistics on *fatal occupational accidents* are based on information from the regulatory authorities in the different industries/sector, which is the Norwegian Labor Inspectorate Authority for the aquaculture sector.

Accidents at work involving *personal injury* shall be reported from the employer to the Norwegian Labor and Welfare Administration (NAV). NAV has the responsibility for the approval of occupational injuries and occupational injury claims (benefits) in accordance with the National Insurance Regulations for occupational injuries. The system is based on the employer's duty to send an accident report form by mail to NAV if occupational accidents with injury occur. Every month, the reports from NAV are scanned and sent to Statistics Norway for further registration and analysis.

The data is aggregated and published yearly on Statistics Norway's website (Statistics Norway, 2017a). Aquaculture accidents is included in the group named "Agriculture, forestry and fishing". A data extract for the aquaculture industry may be ordered, and Statistics Norway will charge for the work hours spent.

Before 2014, NAV made its own registrations of occupational injuries. Holen et al. (2018a) have analysed 761 injuries reported to NAV from the aquaculture industry in the years 2001-2012 (Figure 4). There was a decline in the reported injuries during this period, and the numbers of employees increased. This results in a sharp decline of the injury rate during the 12 year period. The most common modes of injury were (in this order) fall, blow from an object, entanglement/crush and prick/cut/puncture. Further analyses on mode of

injury, injury types, injured body areas, injuries per age group and number of injuries by month is presented in the article.

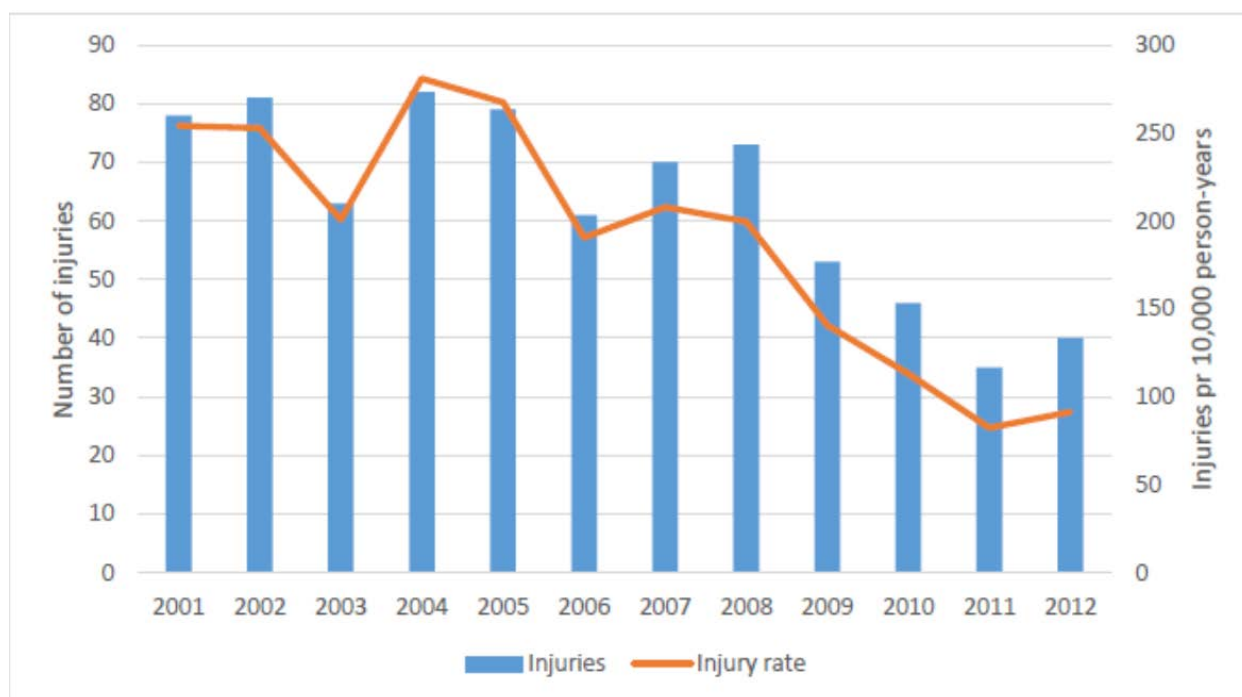


Figure 4 Accidents at work in the Norwegian aquaculture industry 2001-2012 registered by NAV (Holen et al., 2018a).

5 Sickness absence and self-reported health status in Norwegian aquaculture

5.1 Doctor-certified sickness absence

Data on sickness absence adjusted for seasonal and influenza variations (self-certified and doctor-certified) is updated quarterly on the webpage of Statistics Norway (Statistics Norway, 2017b). Aquaculture is included in the group "Agriculture, forestry and fishing" in the publicly available statistics. Doctor-certified sickness absence for the aquaculture industry have been retrieved from Statistics Norway upon inquiry. Table 5 shows data for year 2012-2016.

Table 4 Sickness absence in the aquaculture sector, certified by doctor, 2012-2016. Source: Statistics Norway.

Year	2012	2013	2014	2015	2016
Sickness absence (%)	4,3	4,5	4,6	4,1	4,1

5.2 Survey on personal health problems and sickness absence

A telephone survey amongst 447 aquaculture employees was conducted during the fall of 2016. The results have been published in a Norwegian research report (Thorvaldsen et al., 2017). The survey focused on employees' perceptions of work and health, exposures, health complaints, reasons for sick leave as well as worries. A telephone survey amongst 447 employees was conducted during the fall of 2016. The results

have been published in a Norwegian report (Thorvaldsen et al., 2017). The survey focused on employees' perceptions of work and health, exposures, health complaints, reasons for sick leave as well as worries.

The respondents were operators at the fish farms (n=258), managers at the fish farms (n=110), service vessel crew members (n=60) or had other positions in the companies (n=19). The results are based on a selection of employees. As there is no register over workers in the industry, the distribution of positions, age and experience are not known. This must be taken into consideration when it comes to the representativeness of the survey data.

Overall, 84.5 percent reported that their health was good or very good. A total of 97 percent were satisfied at work always or most of the time. The main reason for this was a good work environment and good colleagues.

The study identifies musculoskeletal problems as the main work-related health complaint. Pain in the neck, shoulder, arms, back and hands are most common. Employees who reported that they had an ailment/pain often or very often were asked if they thought it was partly or fully related to their work. The answers are given in the table below.

Table 5 Occupational pains in aquaculture, results from a Norwegian survey (Thorvaldsen et al., 2017). Percentage answers to the question: Do you think this ailment is related to your work? (n=number of workers who reported to have the actual pain/ailment often or very often).

	Related to work?		
	Yes	No	I don't know
Ailments (n= answered often/very often)			
Cardiovascular disease (n=10)	10.0	90.0	0
Gastrointestinal disease (n=17)	29.4	70.6	0
Allergic reactions (n=9)	33.3	66.7	0
Respiratory disorders (n=19)	36.8	57.9	5.3
Sleep problems (n=26)	50.0	50.0	0
Ailments of the skin (n=25)	52.0	40.0	8.0
Pain in knees/hips (n=41)	65.9	29.3	4.9
Other (n=6)	66.7	33.3	0
Mental sufferings (n=9)	66.7	33.3	0
Sea sickness (n=10)	70.0	30.0	0
Fatigue (n=34)	76.5	20.6	2.9
Headache (n=29)	79.3	20.7	0
Back pain (n=85)	81.2	16.5	2.4
White fingers (n=11)	81.8	9.1	9.1
Pain in neck/should/arm (n=120)	86.7	10.8	2.5
Pain in hands/wrists (n=51)	92.2	5.9	2.0

All 447 employees were asked the question: Did you during the last 12 months have absence from work due to personal illness or injury?

165 answered "yes" to this question. 16 percent answered that they did have absence due to injuries and 26 percent that they did have absence due to illness.

Out of the 165 respondents, 23.5 percent had reported absence to the physician during this period.

Out of the 165, 52 employees, or 12 percent of all the participants in the survey (447 respondents) did characterize their absence as work-related whereas 106 did not and 7 did not recall or know if it was related to work or not.

Figure 5 shows the main reasons for self-reported sickness absence that the employees related to work. Musculoskeletal problems such as strain and inflammation are the main reason for work-related sick leave, followed by acute injuries such as fractures, crush/blow/cut and other acute injuries.

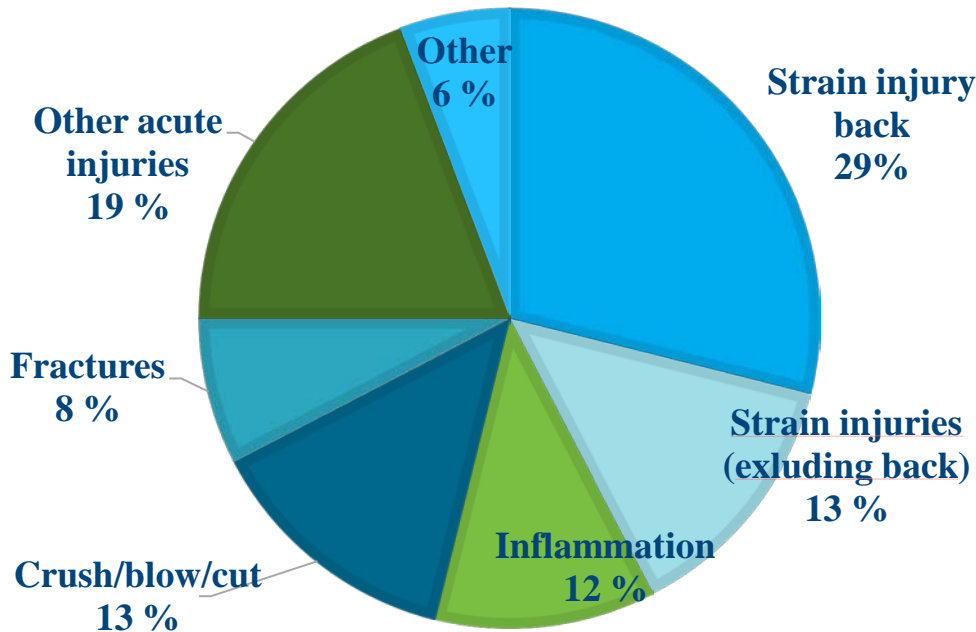


Figure 5 Causes for work-related sickness absence. Numbers show percent of the number of employees who reported work-related sickness absence (n=52).

When employees were asked if they worried that their work may affect their health negatively in the future, 54 percent said yes or sometimes. The employees who did worry primarily related their worries to musculoskeletal problems. Acute injuries were the second most common reason for both sick leave and worry.

Many workers (76 percent) also report that they or their colleagues have experienced near accidents (events that may have caused injuries) during the last two years.

In order to improve employees' health and reduce work-related sick leave the aquaculture industry, including the technology suppliers, must prioritize safety measures aimed at preventing musculoskeletal strain as well as accidents.

6 Regulation of OHS and working life conditions

6.1 The Working Environment Act

The working life in the aquaculture industry is regulated by the Working Environment Act (Norwegian Ministry of Labour and Social Affairs, 2005). This law states work life requirements, and describes the employer's, as well as the employee's, obligation to contribute to a safe and sound working environment.

The purpose of the Act is (the following is translated from the Act):

- ✓ to ensure a working environment that provides the basis for a health-promoting and meaningful work situation with full protection against physical and mental harm and with a welfare standard that is always consistent with the technological and social development of the society;
- ✓ to ensure safe employment and equal treatment in working life,
- ✓ to facilitate adaptations in the employment relationship related to the individual employee's assumptions and circumstances,
- ✓ provide grounds for the employer and employees of the enterprises themselves to safeguard and develop their working environment in cooperation with the work life parties and with the necessary guidance and control from the public authority,
- ✓ To contribute to an inclusive working life.

The employer is responsible for complying with the requirements of the Act, and for ensuring that the enterprise maintains a healthy and safe working environment. These responsibilities are explained and reinforced by the regulations relating to internal control (Norwegian Ministry of Labour and Social Affairs, 1996).

6.2 Organisation of work and working hours

Many fish farmers are shift workers. A survey amongst 447 employees in aquaculture showed that 204 out of 258 fish farmers work shift (Thorvaldsen et al., 2017). The same is true for 52 out of 60 crew members on service vessels. In comparison, 13 out of 110 operational managers work shift.

The most common shift in this survey was 12 days at work, and 9 days off or one week at work and one week off. The operational managers work more or less normal hours during the weekdays but are supposed to be available on the phone 24/7, except during holidays when an assistant has the full responsibility.

The Working Environment Act defines working hours as the time when the employee is available to the employer. The time the employee is not available to the employer is referred to as off-duty time. There are limits for how much it is allowed to work per 24-hour day and per week. These limits are laid down in the Working Environment Act but may also be regulated by the employment contract and by any tariff regulation.

The limits laid down by the Working Environment Act for normal working hours are nine hours per 24 hours, and 40 hours per seven days. If the employer works shifts, nights or Sundays, normal working hours are 38 or 36 hours per week. The duration and disposition of the daily and weekly working hours must be stated in the individual employment contract. The employer shall keep an account of the employee's working hours.

6.3 Work-related factors

The survey on self-perceived work environment factors, safety and health conducted in 2016 (see 5.2), also contained questions on occupational pains and possible influencing factors of their working environment (Thorvaldsen et al., 2017). Several factors may affect employees' health negatively, including:

- ✓ Exposure to strong wind
- ✓ Exposure to noise
- ✓ Work in cold environment/feel cold
- ✓ Lifting with upper body twisted or bent
- ✓ Work with hands above shoulder height
- ✓ Heavy lifting
- ✓ Repetitive and monotonous work operations
- ✓ Exposure to chemicals
- ✓ Work stress
- ✓ Lack of involvement
- ✓ Insufficient time for rest
- ✓ The organization of work is demanding/straining

6.4 Safety and risk management

OSH is well-regulated in the Norwegian working life in general, and the same regulations apply in the aquaculture sector. Since 1992, it has been decreed by law that all enterprises under the authority of the Norwegian Labour Inspectorate Agency (LIA) shall work systematically with, and continuously improve the health, safety and environment (HSE) procedures. The Working Environment Act (Norwegian Ministry of Labour and Social Affairs, 2005) and the Internal Control Regulation (Norwegian Ministry of Labour and Social Affairs, 1996) require that all Norwegian enterprises are obliged to implement some kind of performance management systems, to control quality, working health (OHS), safety and/or possible damage to the environment. These areas could be integrated in one system, but the current practice is that operational planning and maintenance records are found in different systems. Software-based management systems have been implemented because it is a rational way of handling and updating all procedures and necessary documentation.

Audits are a central activity in the implementation of "living" management systems. Safety audits are a systematic and planned verification of the safety performance against external and internal requirements. They can be conducted as internal audits, by the regulatory authority or by a third party.

The Internal Control Loop (Figure 6) shows the management cycle mandatory for the aquaculture companies. The NLIA audits enterprises regarding OHS according to this. The status of safety management in Norwegian aquaculture are discussed by Holmen et al. (2017a), as well as a suggestion of how to identify relevant organizational safety indicators in fish farm operations.



Figure 6 The steps of the Internal Control mandatory for the Norwegian aquaculture industry, adapted from (Norwegian Labour Inspection Authority (NLIA), 2017).

Certifications according to international standards is gradually implemented in the aquaculture industry. This is due to a global market and demands from customers to comply with international codes. Standards for e.g. quality management, ISO 9001 (ISO, 2015), are widely used as the basis for certifying enterprises. Accredited certification by an independent third party is a confirmation that the company performs according to the requirements in the standard and has become a quality stamp that several companies obtain. Other standards that are being implemented in an increasing part of the Norwegian aquaculture industry is ISO 14001 (Environmental management), OSHAS 18001, GlobalGAP and ASC (Aquaculture Stewardship Council).

The aquaculture industry in Norway reports to five different regulatory authorities regarding safety management and risk assessments. These are the Directorate of Fisheries, Food Safety Authority, Norwegian Maritime Authority, Norwegian Labour and Inspection Agency and the County Administration, which all perform audits and inspections within the aquaculture enterprises. These bodies have the supervision for fish welfare, food safety, fish farm technical standard, vessel design and equipment, OHS and surrounding environment. Certifications by third parties (Non-Governmental Bodies, NGOs) will result in additional audits, often partly covering the same topics as in the national regulations. The requirements for risk assessments in the Norwegian aquaculture industry are described in detail by Holmen et al. (2017b), as well as the current practice for hazard identification and risk management in the aquaculture companies. HSE personnel and operational managers in the companies report that the certification process improves the general safety work at the workplaces.

7 Labour relations and consultation on OHS

7.1 The Norwegian Model – statutory cooperation between the working life parties

The "Norwegian model" have been described as the idea that value creation and competitive power can be united with social equality and welfare. The Norwegian work life model is based on permanent employment and an organized work life. The majority of employees are member of a trade union. Laws and tariff agreements regulate a tripartite cooperation between employers, employees' representatives and the authorities. Tariff agreements and regulations set the norm for wages and working conditions. At the industry level, the work should be organised in a way that ensures the employees influence their own work conditions. Employee representatives are involved in negotiations on wages and decisions regarding matters concerning the organisation of work and work environment.

In the aquaculture industry there are two main trade unions, namely Fellesforbundet (Fellesforbundet, 2017) which organizes the employees working on the fish farms, and the Norwegian Seafood Federation (in Norwegian "Sjømat Norge"), which organizes the companies/employers (Norwegian Seafood Federation, 2017).

7.2 Safety representative and safety committee

The Working Environment Act and tariff agreements regulated the labour relations at Norwegian workplaces. The Act states the obligation of all undertakings to elect safety representatives. In companies with less than ten employees, the parties may agree in writing upon a different arrangement, which may involve agreeing that the undertaking shall not have a safety representative. In companies with more than 10 employees, two or more safety representatives may be elected.

The duties of the safety representative(s) are described in detail in the Act. These are summarized in the following:

- ✓ The safety representative shall safeguard the interests of employees in matters related to the working environment. The safety representative shall ensure that the work is performed in such a manner that

the safety, health and welfare of the employees are safeguarded in accordance with the provisions of this Act.

- ✓ The safety representative shall particularly ensure:
 - that employees are not exposed to hazards from machines, technical installations, chemical substances and work processes,
 - that safety devices and personal protective equipment are provided in adequate numbers, that they are readily accessible and in proper condition,
 - that the employees receive the necessary instruction, practice and training,
 - that work is otherwise arranged in such a way that the employees can perform the work in a proper manner with regard to health and safety,
 - that notifications concerning occupational accidents, etc. are made.
- ✓ As soon as a safety representative learns of circumstances that may result in accidents and health hazards, the safety representative shall immediately notify the employees at the location, and if the safety representative is unable to avert the danger himself, he shall bring the matter to the attention of the employer or the employer's representative. When so notified, the employer shall give the safety representative a reply. If no action has been taken within a reasonable space of time, the safety representative shall notify the Labour Inspection Authority or the working environment committee.

The undertakings under the Working Environment Act are also obliged to have company-internal safety committees (usually referred to as "working environment committee"), where both managers and employees are represented.

Safety representatives are entitled to have sufficient time off for training and safety inspections under the Act and Internal Control regulations.

Norway is a member of United Nations and has ratified a number of the ILO conventions regarding international working life.

7.3 Mandatory Occupational Health services

Occupational Health Service (OHS) is an expert and advisory service on prevention of occupational accidents, diseases and pains, both ergonomic, physical and psychological work environment factors. They will assist employers and employees to follow up needed improvements in the work environment. All employers are obliged to associate their business with an approved occupational health service if the business includes operations with certain occupational hazards. Therefore, the Labor Inspectorate may impose any activity on an approved OHS if a risk assessment reveals a special need for monitoring the working environment or controlling the health of the employees in the business.

Some industries have a more hazardous working environment than others, with greater risk of illnesses, injuries and mental strain. All businesses in these industries are required to associate with an approved occupational health service. The aquaculture industry is comprised by this regulation.

8 Concluding remarks

8.1 Analysis of what works, what did not and how improvements can be made

There is, to our knowledge, no thorough evaluation of preventive measures for the improvements of OHS in the Norwegian aquaculture sector. The research referred to in this report show that the safety work has improved considerably since the 1990's. The implementation of safety routines in practical operations, as well as the awareness among top manager on the importance of OHS, seems to have increased during the last decade. A recent study shows that the safety climate among managers, operational managers and fish farmers

is perceived as positive (Kongsvik et al., 2018). This study also showed that there is a high agreement on questions regarding safety procedures and in particular the use of required personal protective equipment.

Risk assessments are the core of risk management. Knowledge about occupational hazards is essential if effective mitigating measures are to be identified and implemented. The regulatory authorities have had special focus on the routines and contents of risk assessments during audits the recent years, as a consequence of high injury rates compared to other industries (Aasjord and Geving, 2009). It seems that this has improved the degree of completed risk assessments throughout the industry (Holmen et al., 2017b). However, the motivation for doing this is still low in parts of the industry, and it is regarded as an "exercise" to comply with regulatory requirements. Hence, it seems to still be a potential for improving the safety work in aquaculture operations.

It is challenging for the authorities to adjust the regulations according to the development in the industry, as the industry grows fast and implement solutions from other marine and offshore industries. Manufacturers previously selling equipment and services to the oil and gas industry have identified aquaculture as a new and promising market, and the push is considerable to transfer knowledge and technology between the sectors.

The main regulatory bodies within aquaculture, the Fisheries Directorate, Norwegian Maritime Authority and the Norwegian Labour and Inspection Agency (NLIA) is continuously working to improve regulatory requirements and their practice for audits according to the changing risk picture of the industry. Recently a regulation for mandatory safety management on vessels below 500 gross tonnage were implemented (Norwegian Ministry of Trade Industry and Fisheries, 2016). This regulation applies for the work boats and service vessels in the aquaculture sector. The occupational accident statistics shows that a majority of the fatal accidents the last decade has happened during operations assisted by such vessels. A new technical regulation for the construction and inspection of smaller cargo vessels came into force January 1st, 2015 (Norwegian Ministry of Trade Industry and Fisheries, 2015), aiming to improve the technical condition of the aquaculture vessels. There have also been capsizes due to lack of competence on the loading capacity and stability of the work boats. The new regulations, when fully implemented, will be significant measures with respect to reducing the risk in marine operations in Norwegian aquaculture.

Several ongoing R&D projects in Norway aim to innovate technology concepts or develop new operational strategies for the aquaculture industry. Still many operations depend on manual workforce. Several of the occupational health and safety risks associated with today's marine operations may be reduced by integrating safety barriers in equipment and procedures, and this should have a stronger focus in technology development projects.

8.2 Summary

This report has summed up the status of occupational health and safety management and challenges in the Norwegian aquaculture industry. Farmed Atlantic salmon and trout amount to 99.6 percent of the total aquaculture production.

Being a fish farmer is the 2nd most risk exposed occupation in Norway. Occupational injuries as well as musculoskeletal problems are the most common reasons for both sick leave and worry amongst employees.

Working life in the Norwegian aquaculture industry is regulated by the Working Environment Act. The "Norwegian model" is based on the idea that we can unite value creation and competitive power with social equality and welfare.

Safety work has improved considerably since the 1990's. Future research may include a thorough evaluation of preventive measures for the improvements of OHS in the Norwegian aquaculture sector.

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