


ORIGINAL ARTICLE

# Occupational health and safety in aquaculture: Organisation of work and employment in small seaweed farms in North West Europe

Eva Makri<sup>1</sup>, David Walters<sup>2</sup>, Emma Wadsworth<sup>1</sup>, Helen Devereux<sup>1</sup> and Sander W. K. van den Burg<sup>3</sup>

<sup>1</sup>Solent University, Southampton SO14 0YN, UK, <sup>2</sup>Cardiff University, Southampton, UK and <sup>3</sup>Wageningen University and Research, Wageningen, Netherlands

**Corresponding author:** Eva Makri; Email: [eva.makri@solent.ac.uk](mailto:eva.makri@solent.ac.uk)

(Received 8 January 2024; revised 8 February 2024; accepted 9 February 2024; first published online 11 March 2024)

## Abstract

There is evidence that seaweed production can involve a variety of physical risks, but there has been little study of how wider contextual factors – such as enterprise size, economic and business relations, and forms of employment arrangements – may affect workers' safety. This study explores the impact of such aspects on workers' experiences of occupational safety and health (OSH) risks and their management in the developing seaweed industry, in North West Europe. Based on qualitative findings from a survey and discussions with owners/managers, workers and stakeholders in the industry, the study identified a number of issues relating to OSH in seaweed production. These include the predominance of micro small enterprises, the presence of significant risks to health and safety and limitations in the capacity of owners/managers to address them, as well as structural and economic factors in the sector that promote precarious work, and the low visibility and inaccessibility of micro and small enterprises (MSEs) to both public and private regulations. The paper discusses experiences of these issues in the emergent industry and relates them to the wider literature about work health and safety in micro and small firms and precarious and non-standard forms of work, typically found in agriculture and food production. Findings point to the need for better orchestration of public and private regulatory influences and further research to determine if strategies that are seen as successful in other sectors could be transferred to the emergent European seaweed industry.

**Keywords:** Europe; micro and small enterprises; occupational safety and health; precarious employment; seaweed

## Introduction

Micro and small enterprises (MSEs) account for 99% of businesses within the European Union, contributing to the economy and creating employment opportunities (EU-OSHA 2018). It is also recognised though, that many follow a low road strategy in relation to safety at work practices, due to a lack of resources or knowledge on how to protect workers. Worker vulnerability is exacerbated by the prevalence of precarious and informal employment and the invisibility of those businesses to labour inspectors (EU-OSHA 2018). The present paper presents the findings of a study carried out to understand the

organisation of work in small seaweed farms within North West Europe, and how it influences experiences of occupational safety and health (OSH) risks and arrangements for their management.

The following sections first provide a brief account of the methods used in the study, before presenting an analysis of relevant findings from the qualitative fieldwork, that focuses on contexts in which owners and managers seek to assess and manage the risks of the work for which they are responsible in the seaweed production sector. This is followed by a discussion in relation to the wider literature, especially that addressing work health and safety in micro and small firms and precarious and non-standard forms of work, typical of those found widely in agriculture and food production. Arising from this, the paper ends with some reflections on what may be required of approaches to supporting health and safety and compliance with regulatory standards in the emergent work activity represented by seaweed production in European economies. Drawing on the lessons of the wider literature, it considers how such support might be provided from within the sector and its business relations as well as the implications for public and private regulatory influences.

### **The industry**

Seaweed has a variety of uses, such as in food, feed for livestock, in pharmaceuticals and cosmetics or as biostimulant (van den Burg *et al.* 2021b). The production of seaweed is a sector that is growing globally, but is a relatively new activity in Europe, accounting for less than 1% of world seaweed production (Araújo *et al.* 2021, FAO 2022). Although European producers aim to strengthen their position in the global supply chain, production is still marginal compared to the established, low-cost/high-yield growers in South-East Asia (China and Indonesia being the largest suppliers), mainly because of technological, licensing, and market-related issues (Selnes *et al.* 2021; van den Burg *et al.* 2021a, 2021b). The cost of production and lack of competitiveness on price create some uncertainty on the future position of European seaweed into the existing global value chain (van den Burg *et al.* 2021b). European producers are currently supplying their seaweed to wholesalers or as final product (e.g., seaweed flakes). It is suggested though that they should be aiming for high-value products in order to target higher value activities and market segments (van den Burg *et al.* 2021a; van den Burg *et al.* 2021b; Albrecht 2023).

Exact figures and demographics of workers in the industry are sparse, but in 2022 it was estimated that 1,161 workers were employed in algae-related activities, with France (478) and Spain (285) employing the largest number (Vazquez and Sanchez 2022). Nearly, all are employed in the production and processing of seaweed rather than other forms of algae. Although production is mostly based on wild harvesting (68% of seaweed in Europe is wild-harvested), recent increase in demand has stimulated the creation of small-scale seaweed farms producing cultivated seaweed (Stanley *et al.* 2019; Vazquez and Sanchez 2022). A report from Phyconomy (2022) indicates that production at the lower end (less than 100 tonnes) is mainly generated by these small-scale farms or harvesters, co-ops, or family-run businesses, while the Secretariat of Seaweed for Europe (2021) reports that 58% of the 223 companies it surveyed employed less than 10 people and that the European seaweed industry is mostly comprised of small local businesses. Vazquez and Sanchez (2022) also report that 87% of the 156 companies that are focused on algae cultivation activities in France, Spain, and Portugal are micro-enterprises with fewer than five employees.

The turnover of European seaweed (which also includes wild harvesting) is estimated at around EUR 129.5 million but, due to a recent drive to accelerate production, the largest number of investment opportunities and start-up companies are currently found in Europe (Kuech *et al.* 2023).

In Europe, seaweed production is primarily concentrated on the Atlantic region and mostly takes place in the intertidal zone or offshore (by boat), in structures such as ropes or rafts (Araújo et al 2019; Araújo et al 2021). Production stages include seeding, monitoring, harvesting, and processing of the seaweed. Cultivation methods depend on the type of algae grown, but sea-based production results in variability of the quality and yield as well as vulnerability due to environmental conditions and diseases (Araújo et al 2021). In seaweed cultivation, much of the production process is carried out by hand and it is labour-intensive (Msuya cited in Gegg and Wells 2017). Often aquaculture and seaweed operations occur in remote environments, making access to health services challenging (Cavalli et al 2019). Although literature on hazards in seaweed production are scarce and focused on studies carried out in the largest producing regions (see e.g., Said et al 2018; Ngajilo and Jeebhay 2019; Thamrin et al 2019; Thamrin et al 2020; Ngajilo et al 2023; Valderrama et al 2013), it is agreed that cultivation can entail biological (Cavalli et al 2019), ergonomic (Hussin and Khoso 2021; Shimada et al 1990; Thamrin et al 2020), and physical hazards (Hussin and Khoso 2021; Thamrin et al 2019). Thamrin et al (2020), also found that two-thirds (67%) of seaweed workers surveyed suffered from fatigue, especially during busy periods, suggesting that work organisation may also give rise to significant risks. Those risks are not dissimilar to hazards found in aquaculture and fishing in general, although they can vary depending on the species, and the operating area's climate and environmental conditions (see e.g., Myers and Durborow 2012; Fry et al 2019; de Oliveira et al 2017; Windle et al 2008; Phu et al 2015; Tatar 2019). Additionally, globally, there is evidence of informal and seasonal employment, as well as employment of vulnerable workers such as migrants and children (Fröcklin et al 2012; Cai et al 2021; Hussin and Khoso 2021; Ngajilo et al 2023; Valderrama et al 2013). Specifically, in Europe, most jobs in the sector are seasonal and many seaweed workers are registered as 'fishers' or are self-employed (Gegg and Wells 2017).

Effective management of workers' exposure to risks in the industry needs to take some account of the effects of enterprise size, its economic and business relations, forms of employment arrangements, including pay and contract length, and the visibility of enterprises to agencies of public (and private) regulation (EU-OSHA 2021). It was to explore these influences on seaweed workers' experiences of work safety and health in this developing sector of economic activity in Europe that the present study was undertaken.

As outlined above, the European seaweed industry mostly comprises micro and small enterprises (MSEs). There is a substantial literature that finds health and safety management in MSEs to be problematic (see EU-OSHA 2018 for a review). There is further evidence suggesting a likelihood of undeclared, informal and non-standard work taking place in micro and small firms involved with seasonal work in sectors such as food and agriculture (EU-OSHA 2018). Although there is only limited empirical evidence, such that there is, indicates that in terms of employment type, subcontracting and informal employment has grown in aquaculture (Cavalli et al 2019) and is common in seaweed cultivation, with many workers being occasional staff (Cai et al 2021). Such forms of precarious employment have been long associated with negative OSH outcomes (Quinlan et al 2001; Quinlan and Bohle 2009). Hiring temporary personnel who have no training or knowledge of how to identify and protect themselves from OSH hazards can put both them and other unskilled and skilled workers at risk (Moreau and Neis 2009). Temporary workers are also likely to be less familiar with OSH systems at the work site, are less likely to be unionised, are less aware of their work rights, and are less likely to challenge OSH practices because of fear of loss of employment than are permanent employees (Quinlan et al 2001).

There is little empirical evidence on any of these factors in the emergent European seaweed industry. To address this gap and to better understand the impact of the structure and organisation of work and employment on workers' experiences of OSH risks and their management in this developing industry in North West Europe, this paper draws on the

findings of a wider project undertaken to explore possible protocols supporting the seaweed sector in monitoring and assessing food safety, environmental safety, and work health and safety (carried out between January 2021 and December 2022). Using reference to qualitative findings obtained in the fieldwork, it explores the health and safety arrangements and outcomes as experienced by owners/managers, workers, and other stakeholders in the sector. It situates these experiences in relation to the wider literature on work health and safety, both in seaweed production and in micro and small firms in agriculture and food production, with which it argues, the emergent seaweed cultivation industry in Europe shares features in common.

## Materials and methods

As outlined above, this study was part of a wider project focused on food safety, environmental safety, and work health and safety. The present paper, and the methods and findings described below, relate only to the OSH part of the research.

Initially, a literature review was carried out to gain an understanding of OSH-related concerns in seaweed production. There was a scarcity of information in the literature on OSH within the seaweed sector, therefore, papers related to OSH in aquaculture in general were also included. The search strategy was based on keywords and phrases identified in relation to the objectives of the research and included both truncated variations and combinations of terms. Searches were carried out in the Google Scholar and Scopus databases and were limited to the period 2011 and 2021 and articles written in English. Also reviewed were online resources, official statistics, or reports published from governmental agencies, professional associations, universities, national or international organisations, institutions, and bodies. These were related to OSH, aquaculture, and/or seaweed cultivation. Despite the limited research to date, there was some evidence of similar concerns with sectors that share characteristics of work and employment.

Next, exploratory interviews with seaweed companies were carried out to better clarify some of the key insights of the literature review and gather more information in seaweed production methods and risks associated with it. Twelve interviews were conducted with owners/managers of seaweed companies based in Europe, Asia, and North America. Seven of the companies gave their number of employees and 10 provided their yield. Comments relating to OSH from companies operating in areas where seaweed production is still developing, with fewer than 50 employees and/or low yields were identified and separated for further analysis. Interviews gave an initial overview of production, hazards to environmental, food, and OSH and how these hazards are managed.

A small questionnaire-based survey followed, to better specify risks associated with seaweed production – as identified by the exploratory interview and the literature review – looking to understand measures taken to manage those risks and further information on OSH in the supply chain. The questionnaire was designed in Microsoft Forms and administered through professional networks in the industry, social media, and the Safe Seaweed Coalition. It began with a brief introduction to the study and included sections on each of the project's three disciplines – environment, food, and OSH. There were 36 responses to the survey overall. Responses relating to OSH were separated, and open-ended comments were further analysed. Only the analysis of the qualitative comments is included in this study as the sample size was too small to present any quantitative results.

Following analysis of the survey results, further in-depth interviews were conducted with seaweed companies in Western Europe, focusing on start-ups and micro and small-sized companies, reflecting the make-up of the sector as identified by previous research stages. The aim was to understand better, the experiences of owners/managers and

Method (n)	Participants (n)	Topics
Exploratory interviews (9)	Owner/manager of a company with 1-10 employees (2) Owner/manager of a company with 11-50 employees (2) Owner/manager of a company producing <100 tonnes (5)	Company background Enterprise size and employment type Tasks and risks associated with seaweed production How they manage OSH Support needed to manage OSH
Survey (25)	Seaweed worker (6) Seaweed company owner/manager (6) An academic/ researcher (4) Owner of a company that processes seaweed (1) Owner of a company that buys/sells seaweed (1) Other (7)	Hazards to health, safety and wellbeing Incidents resulting to injury and/or poor health
Further In-depth interviews (8) and informal email discussions (12)	Company owner (8) Worker (1) Stakeholder in the industry (11)	Company size and trading years Employment type Tasks and hazards associated with seaweed production Working conditions OSH management systems in place Incident recording Training and PPE Supply chain influence
Workshop (6)	Company owner/worker (3) Stakeholder in the industry (2) Academic (1)	Feedback on research findings and recommendations

Figure 1. Participants and topics discussed

workers in the seaweed industry, in particular the structure and organisation of work and employment, how health and safety is managed, and what influences this. These allowed a more detailed exploration of the topics by talking to workers directly, talking to managers specifically involved with OHS as well as representatives of bodies representing workers and employers. Five companies agreed to an interview and three agreed to an informal email discussion, where research participants unable to take part in an interview, answered the interview questions in an email, and provided further information or clarification on follow-up emails. These were based in the UK (5), Republic of Ireland (1), the Netherlands (1), and Norway (1). All the companies that participated in the interviews/email discussions were MSEs and/or start-ups. Seaweed, aquaculture and fishing associations and groups, certification scheme organisations, public bodies, government agencies and unions were also contacted and asked to participate in the study. Two stakeholders agreed to an interview and nine agreed to an informal email discussion.

Three different discussion guides were formed with questions for managers/owners of seaweed companies, workers, and stakeholders. These were formulated taking into account the themes emerging from the literature review and results of the exploratory interviews and the survey. The discussion guides were emailed in advance to the interviewees with a document that provided information about the study and the planned use of data and a consent form.

Evidence from both set of interviews, email discussions, and survey qualitative comments were integrated and analysed thematically (Braun and Clarke 2006) and used to inform a set of recommendations. A hybrid workshop was organised to present findings of the research and recommendations and seek feedback. Stakeholders from the industry were invited via email or social media to the event; six took part in the discussion on the day. Comments related to OSH were transcribed, further analysed, and included in the research findings as outlined below.

Figure 1 shows the total number of participants in each stage of the research process and topics discussed.

## Findings

This study identified a number of issues relating to OSH in the seaweed industry. These included the acknowledgement of the presence of significant risks to health and safety, concerns over resourcing in a newly developing sector in which start-ups and MSEs predominated, and resource constraints, as well as low unionisation rates, precarious, temporary and informal work and workers were all in evidence. The following paragraphs summarise qualitative findings across the range of these issues, and where pertinent, further illustrate them with quotes from study participants.

Structural challenges included the small size of the companies with respondents facing significant financial and operational pressures and a general lack of resources both as start-ups and as enterprises scale up. For these reasons, owners/managers reported that they generally looked after OSH themselves, based on previous experience gained in other industries or with informal advice from friends and others whose OSH knowledge they respected. Most did not have specific OSH management systems in place and did not employ health and safety advisors. While some said they had thought of using an external OSH advisor because they did not have good access to information on how to organise OSH in their business, they regarded the costs of doing so as prohibitive. A stakeholder in the industry stated:

*Most seaweed companies are relatively small businesses with lots of pressures on their time. [...] I don't know any Scottish seaweed companies who employ a specialist Health and Safety Manager. These companies are not big enough (yet) to justify such a role, instead H&S has to be just one of the many responsibilities of the founder or general manager of these businesses. They are all very busy people.*

As with many micro and small firms, efforts described by respondents to manage these risks and protect workers in these structural and organisational contexts were characterised by unsystematic, inconsistent, top-down, and largely behaviour-orientated arrangements. Under such constraints, respondents further felt themselves to lack both guidance and support from regulatory scrutiny. One company owner said:

*So [name removed] will give a briefing just to remind everybody what we're doing, what the expectation is of the day and then we just refresh through all the safety things.*

In a similar vein, referring to workers, a different company owner, when asked if they involve their workers in OSH management, reported that they do not and that they communicate down to them how to avoid risks and follow safety procedures:

*No, we cascade down to them if you like, so I'll assess the risk, how we work, how we operate.*

Related to the limited resources were several indications of the presence of structures of informality in employment in the responses of participants in the study. They spoke of how small seaweed farms relied on staff fulfilling multiple roles. It was not unusual for those involved with cultivation and harvesting to indicate they performed other duties as well, such as handling social media, helping with managing the business, etc., and owners, and on occasion family members, were also involved in cultivation and harvesting. They further recounted how, during busy periods, temporary workers, self-employed individuals (e.g., local fishermen), or volunteers were hired to help, and contracted workboat operators would sometimes provide further help with deployment and harvesting, while an industry stakeholder confirmed that subcontracting in seaweed cultivation was common practice globally. As one company owner reported:

*But it is also a challenging industry because it's so seasonal. It's very difficult to have a large, fixed staff when their main operations are only for two months of the year, so one month with deployment and one month with harvesting. So, there is a need for seasonal workers and that's also going to increase.*

Even with the inclusion of temporary workers, respondents said that small seaweed companies still often lacked enough staff, especially during their busiest seasons. They commented on the work intensity during busy times and what measures – if any – were taken to address this. Some considered extra staff would help mitigate psychosocial risks such as stress and fatigue, but recruitment was challenging because of the seasonality and the nature of the job. A company owner reported:

*Yes, fatigue and stress is a concern because we have very intense seasons. And very short seasons. Especially when we harvest, we have very long working days. The way to mitigate . . . It's very difficult to mitigate because you can't find the rotational staff. It's not possible to get that many people.*

Some respondents were further aware that lack of staff can not only lead to fatigue and psychosocial risks but may also increase the risk of injury due to time pressures. A respondent in the workshop commented on the difficulty of putting into practice OSH measures during busy periods:

*I think there's a big difference between the written theory and then putting it in practice, it all kind of falls apart, especially when you're out seeding and you just need to cope and you're going to go on the boat and do XY&Z, and you've got time limit to get the seaweed seeded or harvested.*

Another company owner commented how they have to work through rough weather conditions to still be able to deliver products to their clients.

*The rough weather conditions and the cold water. Falling in the water is a risk. It is difficult for an entrepreneur to say: the weather conditions are not good enough, so my clients will not get their products today.*

In addition to the hire of temporary workers to help with seaweed cultivation and harvesting, it was clear that it was common practice to do this without the use of formal employment contracts. A stakeholder in the industry further mentioned that some workers in the wider aquaculture sector were migrant workers who were also in precarious employment, and that there was a lack of transparency in the sector concerning these matters. The same lack of transparency was also mentioned by a company owner, when referring to undeclared work and the reluctance of workers to complain about working conditions because of fear of losing their job.

*They would tend to be doing this . . . and this is unofficial . . . I don't know how much I can say but more often than not it's on the black economy. So, it's paid in cash. The people that are wanting it are paying cash because they want as much seaweed biomass to go through as possible ( . . . ) You know that people are afraid to speak up because their livelihood is tied up with it. Now it might be casual labour, but to them . . .*

The employment security of workers might have been enhanced by their belonging to trade unions but generally the unionisation rate in the seaweed industry was agreed to be

<b>Ergonomic</b>	Lifting heavy weights, bending
<b>Biological</b>	Jellyfish stings
<b>Physical</b>	Dangers relating to working at sea (high winds, waves, currents, getting caught by the tide), adverse weather (falling overboard), ropes under high tension, entanglement, slips and falls, electrocution, working with or around moving equipment, trapped limbs, particle inhalation when milling or cutting ropes, climbing ladders in poor
<b>Psychosocial</b>	Fatigue, stress, abusive behaviour, working in isolation. Several respondents also commented on the nature of the work describing it as “tough”, “backbreaking”, “intensive”, “rough” or “hard”. Concerns relating to working at a very fast pace were also raised. Workdays were said to be particularly long, with limited opportunity for breaks for meals or a rest. An owner of a start-up stated that there were no toilet facilities onboard vessels, an issue which was problematic for all workers, but particularly concerning for women.

**Figure 2.** Seaweed production risks

very low and similar to that experienced in the fishing and aquaculture sectors. It was further felt by some respondents that although working conditions in these wider sectors were acknowledged to be poor, they perceived the trade unions organising workers to have little knowledge or resources to help improve them. An industry stakeholder stated:

*So actually, it is terrible, and we are trying now to look at the picture, but the more we're trying to research and get in contact with workers and try to get them connected and unionized, the bigger the problem is appearing. We need much more resources to deal with this.*

In the face of these structures of insecurity and informality within the sector and the perception of a general lack of resources to address OSH more systematically, respondents were nevertheless aware of the nature and variety of risks related to seaweed production. Specifically, they identified risks that they thought depended on the area and type of operations but also age and gender of the workers (Figure 2).

To protect workers from these kinds of risks, most of the seaweed producers interviewed indicated that they carried out risk assessments. But there was inconsistency evident in what they meant by this. For some, risks assessments were included as part of other obligations such as certifications required for the use of particular equipment, for example. Others commented that they would like some advice on *how* to carry out risk assessments properly, whereas one respondent mentioned that there were no formal risk assessments in place and such assessment was done informally. Interviews with seaweed managers and workers also revealed lapses in practice, such as workers not wearing personal protective equipment (PPE) and untidy or poorly designed work environments.

Although respondents felt that relevant training could help prevent accidents and support workers to deal with risky situations, results indicated that not all new workers were provided with OSH training. A number of respondents suggested that there was insufficient guidance available on safe working practices in this new sector, commenting on the absence of requirements regarding safety courses or training specifically designed for the seaweed industry. They suggested that in its absence, some owners/managers did what they could by offering their crew the same training that fishing boat entrants receive, whereas others focused on the safe use of equipment (e.g., cranes).

They further pointed out a need for greater industry research and development, suggesting that because the sector is in its infancy, there is widespread adaptation of



equipment designed for other sectors, a practice which also carries risk. A company manager stated:

*A lot of farmers do a lot of manual operations, they haven't got the cranes and other things they need to fully automate the harvest processes. And I think that is going to be a feature of this industry for a while. Small operations running with not purpose-built equipment, they are adapting something else, whether it is a fishing boat or we are using a dairy plant so we are adapting a dairy plant for our purpose and bringing in additional equipment. So that brings a lot of risk with it because it is not optimal, there is a lot of temporary fixes. That is quite different to the setting where you have purpose-built everything and the operator sits behind the screen and it happens. That is what would worry me the most, some of these temporary fixes going wrong.*

Both owners/managers and stakeholder respondents perceived a lack of clarity or continuity as to who was responsible for OSH in a work environment in which more than one company might operate, and when more than one authority regulated and enforced legislation.

## Discussion

What stands out most from the findings outlined in the previous section are the risks to OSH found in seaweed production and limitations in the capacity of the sector to address them adequately and improve the prevention of harm arising from them for its workers. But neither are especially specific to the sector. Instead, they reflect findings of the wider literature on OSH and micro and small firms more generally and especially those found in other forms of agriculture and food production. This is evident, for example, in the nature of the risks, in the structural and organisational features of work in the sector that help to create them, and which stand in the way of their effective management. It is further seen in the ways that respondents suggest owners/managers 'do what they can' for OSH, without proper resources, knowledge, or support, as well as in their perceptions of limitations of public and private regulatory influences on the achievement of better risk management practices. In the following discussion, we first situate our findings on these elements of OSH practice, and what influences them in seaweed production. We then discuss them in the wider context of findings on OSH arrangements, and what determines them, and their outcomes in micro and small firms in food and agriculture more generally. Then, we pose some questions concerning what is needed to ensure best practice on OSH might be followed more effectively in this emergent sector.

### Risks and seaweed production

The study identified a variety of hazards related to seaweed production in North West Europe. These are also, to a large extent, reflected in the findings of the limited literature on the sector in other parts of the world (see e.g., Thamrin et al 2020; Ngajilo et al 2023). This literature draws attention to further hazards associated with climate change such as exposure to toxic microalgal blooms, the increase of which is attributed to increasing water temperature (Ngajilo et al 2023). Climate change is expected to affect OSH in agriculture in general, with exposure to extreme weather having a direct impact to working conditions and health, safety, and wellbeing (Jones et al 2020).

Although the hazards workers and owners/managers in this emergent sector face in North West Europe have some differences with those in the sector in other parts of the

world, many of the structural and organisational factors that determine the extent of the risk they present are similar, as the following subsections show.

### **Structural and organisational considerations**

Our research findings indicate that small seaweed farms have limited resources and knowledge to devote to the OSH management, with owners and managers following a top-down behavioural approach to OSH. This is a finding typical of many studies on small businesses in the food and agriculture sector (including fishing and aquaculture), where such support is generally found to be poor (Watterson *et al* 2012).

The wider literature suggests that in aquaculture, as elsewhere, company size affects the way OSH is managed. Larger farms are more likely to provide PPE for their workers, keep records of chemical use, sign up for certification schemes that include occupational health and safety and training, and have the resources to hire health and safety consultants (Phu *et al* 2015; Cavalli *et al* 2019). In a review of OSH in agriculture with the European Union, Jones *et al* (2020) noted that larger farms were also more likely to have access to safer technologies and to put structured OSH systems in place.

The same authors further report that the structure of work in agriculture allows for atypical employment and estimate that over 30% of employment in agriculture is temporary or seasonal and that the percentage of migrant workers has increased, a trend they suggest is likely to continue (Jones *et al* 2020). Studies on aquaculture and seaweed production elsewhere in the world further suggest that temporary employment and subcontracting are common in the industry (Cavalli *et al* 2019; Cai *et al* 2021; Valderrama *et al* 2013). Ngajilo *et al* 2023 report that in Tanzanian aquaculture, small-scale farms dominate the sector and work within them is informal or semi-formal in nature, with their workers facing precariousness and poor working conditions. Our research results in North West Europe also showed that limited resources in small seaweed farms result in the employment of temporary workers and informal work practices during busy seasons. There is a substantial literature documenting poor working conditions (including those of OSH) and major challenges for regulation in the informal economy in low- and middle-income countries (LMICs). As we observe above, our findings indicate that informality is not restricted to LMICs but is a feature of the work in seaweed production in North West European countries too.

Jones *et al* (2020) further note that agricultural trade unions are concerned about lack of training and health monitoring of temporary workers – including migrant and family workers who are more likely to carry out dangerous tasks –, especially as they are thought most likely to suffer from accidents (which they are not likely to report) or poor health outcomes due to insufficient training, lack of experience or familiarity with the workplace and – in some cases – absence of provision and use of protective equipment. Again, our findings point to the same concerns being articulated among our respondents in North West Europe.

The International Union of Food and Agricultural Workers reports human rights violations, slavery, human trafficking, and child labour in the wider fishing and aquacultural sectors as well as significant challenges to enforce laws and ensure access to workers (IUF 2014). Together with the International Transport Workers Federation, they advance efforts to unionise workers and improve working conditions. But, as one of our respondents stated, there is little information on the working conditions in the sector and there is a lack of international regulation to protect aquaculture workers, many of whom are self-employed, or have no experience of union organisation. There are efforts to overcome these barriers, by studying work practices and analyse regulations across regions, working with labour inspectors to help them improve practices, create visibility of the sector globally, and put pressure on the supply chain to improve working conditions

and allow workers to organise themselves. Overall, promoting decent labour standards in aquaculture has been recognised (see e.g., FAO 2022; ILO 2021); nevertheless, progress to improve working conditions is slow in an industry that is growing fast.

### **Business relations and OSH**

Pressures on small farms are exacerbated by supply issues and price volatility. The literature suggests that price volatility can be passed down the value chain to small-scale seaweed farmers and that price control and delivery requirements of big brands in global supply chains may lead to exploitation of suppliers in economically vulnerable positions at the ends of such chains. (Aslan et al 2018; Asri et al 2022; Fröcklin et al 2012; Msuya 2013). Despite increasing demand for seaweed, large buyers may reduce the price they pay to small farmers, thus forcing them to cultivate larger areas, which impacts negatively working conditions and OSH outcomes (Rönnback et al 2002; Fröcklin et al 2012; Ngajilo et al 2023). In the emergent sector in NW Europe, we found no evidence of these practices, but this may reflect the newness of the sector rather than any safeguard against their occurrence. As one study on the viability of growing seaweed in the North Sea concluded, ‘there are still many uncertainties about the exact costs of production and the potential revenues’ (van den Burg et al 2016).

Such controls of prices by economically more powerful buyers (such as in food and agriculture and other sectors where low-profit margins may affect the resources a small business can dedicate to managing OSH) are known to encourage owners/managers and workers in small firms to cut corners (see e.g. James and Lloyd 2008 on the power of large retailers to negatively affect OSH practices in the food processing industry). In another study exploring influences and attitudes of small businesses, managers spoke about how they were pressured by customers on their pricing (specifically, larger companies that could choose to use another, cheaper supplier), which resulted in these suppliers making less investment in health and safety measures (Vickers et al 2003). These authors also note that, in some circumstances, customer requirements for health and safety might have positive effects. That is, such requirements could be orientated towards persuading suppliers to adopt *better* health and safety measures in order to win orders and gain business. Either way, it is widely accepted that customer pressure may be a significant influence on how small businesses organise health and safety for their workers. The question remains what determines whether such pressure leads to positive or negative outcomes in terms of such practices.

The authors of a major review of the literature on OSH in micro and small firms acknowledged the heterogeneity of these firms and cautioned against generalisation when discussing their features (EU-OSHA 2016). They nevertheless noted that among these businesses there are a proportion across a range of sectors, that for a host of reasons, pursue ‘low road strategies’ towards their business survival, including undertaking dirty and dangerous manual work for comparatively low profit, and often filling niches in the economy eschewed by other better resourced and more financially successful businesses. Such firms and their workers, because of their business position, are among the more vulnerable to the effects of tightening profit margins – including cutting corners on safety and health as a consequence. It is also among them that resources and capacities to provide appropriate and effective arrangements for safety and health are often at their most limited. The combined effects of these pressures may lead to outcomes in which the more serious forms of poor health and safety outcomes are experienced. This is not to suggest that the micro and small firms involved in the present study were necessarily all pursuing such strategies. Nevertheless qualitative evidence presented in the previous section indicates that – especially in the period of their start-up – such small organisations experienced some of their features; these included including physically demanding,

time-consuming, stressful and hazardous work, a precarious business position and – as many respondents acknowledged – a limited capacity to provide the most effective arrangements for workers' safety and health at the same time as organising an economically viable business.

### **Public and private regulatory influences**

Supply chain pressures to adhere to best practice standards on OSH are a form of private regulation that the wider literature indicates most likely to be effective when applied within a regulatory framework defined by public regulation and in the presence of the means of support for securing compliance with both public and private regulatory standards (see e.g. Walters and James 2011). The empirical findings in the previous section suggest that there was little evidence of awareness among respondents concerning the influence of private regulation such as might be possible through influences of lead firms in supply chains on better practice among suppliers and little pressure from their supply chain relations influencing them to improve OSH. When company owners/managers were asked whether there were any standards that their customers require them to meet, the vast majority replied that there were no requirements for OSH, although some did mention that their customers have requirements for food safety. While there may be standards and certification schemes in food and agriculture that include elements of good practice on occupational health and safety management, farm owners/managers in our study argued that small farms lacked the necessary resources to apply for them and did not find them beneficial in the short term as they were not required by their customers.

In terms of public regulation, Cavalli *et al.* (2019) note that EU Member States and the UK have adopted generic occupational health and safety directives which also cover aquaculture, with Member States being responsible for securing compliance with them from duty holders. It is equally well known that effective compliance with principle and process-based standards requires capacities for competence from duty holders that are seldom in evidence among the persons responsible for OSH in micro and small firms – as has also been well illustrated by our findings in the case of seaweed farming. The wider literature on OSH in MSEs shows that owners/managers in these businesses frequently demand more prescriptive measures from regulators. They want to be told exactly what they must do to meet regulatory requirements and they would, ideally, like further support in doing it. As the previous section makes clear, this is also what was much in evidence in our findings.

Furthermore, aquaculture occupational health and safety is commonly the regulatory responsibility of more than one government agency. Our research findings showed how some seaweed farms owners/managers were unsure about which was the regulatory authority for OSH, and they identified a general lack of clarity and consistency surrounding the OSH regulatory framework. In the UK for example, responsible enforcing authorities for seaweed farming can include the Health and Safety Executive (HSE), the Maritime and Coastguard Agency, the Marine Management Organisation and local authorities, with one company owner reporting that they were unsure which authority to contact for OSH advice. Similarly, in Ireland, the Irish Maritime Administration (IMA) and the Health and Safety Authority (HSA) are the two bodies responsible to enforce legislation related to the health and safety of those working on fishing vessels (Health and Safety Authority 2022). In the Netherlands, responsible for OSH is the Ministry of Social affairs and Employment (Ministerie van Sociale Zaken en Werkgelegenheid) and compliance is monitored by the Inspectorate SZW. Regulations provide a framework of what companies should aim to achieve in terms of OSH but do not define how to achieve it.

Under such circumstances, the uncertainty of some duty holders concerning the identity of regulatory bodies for OSH is perhaps not surprising. It is no doubt compounded

by the likely infrequency of inspection visits (Watterson et al 2019). For example, in the UK, in response to reduced public funding over two decades, the HSE has been progressively reducing the number of its inspections leading to fewer visits to MSEs (EU-OSHA 2017). Overall then, the public regulatory framework within which support and guidance to MSEs achieve better practice and is most likely to be effective was only a shadowy presence in the environment inhabited by our respondents in the sector. As such, it was unable to provide the context in which such support has been shown to work most effectively to address structural, organisational, and capacity-building challenges for better OSH practice in MSEs in other sectors.

### Conclusions and ways forward

This paper has presented a small case study of the challenges that securing effective OSH arrangements present for owners/managers and their workers in MSEs in start-ups in seaweed production – a relatively new form of economic activity in North West Europe. It is acknowledged that it was a small qualitative study with limited collection of field data in which, although the original intention had been to seek balanced participation, the owners/managers of seaweed production enterprises were over-represented. It is also likely these respondents were from companies with a greater than average awareness of and/or concern about OSH in the sector. These caveats notwithstanding, we think that the findings of the study present a realistic snapshot of the challenges for effective management of OSH in the sector and corroborate those already evident in the literature on seaweed production and aquaculture elsewhere, as well as resonating with current understandings concerning the challenges of achieving effective arrangements for OSH in micro and small firms more widely.

The findings identify several serious obstacles to the operation and sustainability of effective arrangements for OSH in a sector that is acknowledged to present serious OSH risks. These include a combination of limited availability of resources and capacities to manage OSH among the many other demands on the time and abilities of owners/managers and workers in MSEs, with structural and economic factors promoting precarious work, including temporary, and informal work. Together with the low visibility and inaccessibility of the sector MSEs to the agents and processes of both public and private regulations, collectively, all these factors contribute to the ‘structures of vulnerability’ inhabited by both owners/managers and their workers in the sector. In turn, these ‘structures of vulnerability’ expose managers and workers to risks of injury and ill health, that are likely to be rather greater than those that might be experienced in larger, better established, and better resourced establishments in the sector and elsewhere (see Nichols 1997, 164-167).

Such findings are congruent with those of the wider literature on the challenges for OSH presented by work in micro and small firms. On the other hand, there is a burgeoning literature on what might be done to help such enterprises to manage the risks they encounter in their production activities more effectively. However, as the EU-OSHA study referred to previously, found that, while there may be a plethora of examples of interventions intended to support MSEs to improve their arrangements for OSH,<sup>1</sup> there are very few that provide effective, transferable, and sustainable solutions in the absence of adequate resourcing, effective surveillance, and access to repositories of relevant knowledge (see EU-OSHA 2016, 2018). The EU-OSHA study noted that key elements of successful initiatives to support such solutions often involved orchestrated constellations of public and private actors and processes. These acted in concert in support of MSEs in ways in which key elements of their self-interest were coordinated in mutually supportive and sustainable strategies (EU-OSHA 2018; see also Hasle et al 2017; Hasle and Vang 2021). Support for the effectiveness of such orchestration is also evident in recent reviews of the

literature on securing compliance on OSH more widely, as well as in studies of ‘what works’ in public/private regulatory mixes to improve safe work at the ends of global supply chains (Abbott *et al* 2015; EU-OSHA 2021; Bluff *et al* 2022; Walters *et al* 2024).

There was little sign of any of these types of interventions in the findings of the present study. Given the small size and recent emergence of the sector, this is not surprising. We would suggest that if seaweed production and harvesting is to expand in Europe as predicted, effective means will be required to ensure that adequate arrangements are made for the health, safety, and wellbeing of the increasing number of workers likely to be involved. There is clearly a potential for better orchestration of existing influences in the sector. For example, we have already mentioned some of the multiple state institutions, including those responsible for surveillance of OSH, that oversee requirements on small businesses in the sector. There are also others that deal with tax, company registration, work permits, and so on in the business environment of these MSEs. Alongside them there are sector organisations representing the interests of owners/managers and workers, agencies of local government that oversee food safety and environmental protection, and so on. The literature gives many examples of how coordinated actions among combinations of such institutions can help provide frameworks for innovative public and private regulatory influences to help support improvement in the capacities of owners/managers in micro and small firms to achieve better OSH standards in their productive activities (see *e.g.*, Hasle *et al* 2017; EU-OSHA 2018; Parker and Nielsen 2017, as well as further examples in the wider literature on ‘smart regulation’ such as Gunningham and Sinclair 2017).

This is not to ignore or diminish the challenge presented by the structure of employment in the sector or the pattern of seasonal work that helps to determine it; nor is it to make light of the serious absence of both material and knowledge-based resources in the sector and in relation to OSH surveillance. It would be both somewhat glib and rather naïve to suggest that such challenges are easily overcome. However, these challenges are not especially unique to the sector. Similar ones are widely reported, especially in relation to MSEs obliged to follow the ‘low road’ business strategies we have referred to previously. A substantial literature already exists on addressing ways of dealing with seasonal work to minimise undocumented work and workers, on strategies to promote the formalisation of employment structures and practices, and on innovative ways to include OSH in support for business start-ups (see *e.g.* Fairman and Yapp 2005; Hasle *et al* 2010; ILO 2020; Fiałkowska and Matuszczyk 2021; Porru and Baldo 2022).

There is therefore a case for further research to explore how the lessons already learned from examples of successful support elsewhere might be effectively transferred to the sector to better understand structural and organisational constraints to their effectiveness and how they could be overcome. Further research could focus on other European regions and seek more information on the number, profile, and experiences of workers in the seaweed industry as well as those agencies and regulators that could best support OSH when they come in contact in seaweed MSEs. Additionally, research could also assess whether methods to measure and prevent work-related harm in other industries, and toolkits or inspection advice successful in other types of work, could be adapted and transferred to the seaweed sector.

**Acknowledgements.** The authors also wish to acknowledge the support of the stakeholders, seaweed producers, and workers in the seaweed industry who shared their knowledge and experiences to inform the research.

**Author contributions.** Eva Makri is a Research Associate at Solent University. She has carried out public engagement and consultations to inform mental health service reviews. Her research interests broadly focus on research methodologies, mental health and wellbeing interventions, and the work environment and how it affects health and wellbeing. David Walters is an Emeritus Professor at Cardiff University. Until 2019 when he retired, he

was Professor of Work Environment in the School of Social Sciences at Cardiff. He has researched and written widely on social, political, and economic relations of work health and safety, including on challenges posed by micro and small firms. **Emma Wadsworth** is Professor of the Work Environment and Vice Provost Research & Innovation at Solent University (UK). Her research interests include the health, safety and wellbeing of workers, workplace, and regulatory arrangements for their protection, and the wider contexts and environments in which these are situated and with which they interact. **Helen Devereux** is a Research Fellow at Warsash Maritime School, Solent University. Helen is interested in the sociology of work. Her current research interests include the various ways in which the organisation of work and employment impact on the occupational health, safety, and wellbeing of workers. Prior to her academic career Helen worked as an Officer of the Watch onboard chemical tankers. **Sander van den Burg** PhD is senior researcher of aquaculture and mariculture at Wageningen Economic Research, Wageningen, the Netherlands. He is responsible for research and advisory projects on the sustainable development of the aquaculture and mariculture sectors, including analysis of environmental, economic, and social impacts. His research interests lie in the potential of low-trophic aquaculture to combine ecosystem restoration with food production. Sander van den Burg was project leader for Safe Seaweed by Design.

**Funding statement.** This research was supported by Lloyd's Register Foundation under grant reference GA\100395. For more information about the project, see <https://www.wur.nl/en/project/safe-seaweed-by-design.htm#>. The funder had no involvement in preparing the manuscript.

**Competing interests.** The author(s) declare none.

## Note

1 As well as extensively reviewing past examples in the literature, the EU-OSHA SESAME reports explore nearly 150 contemporary interventions ranging from the introduction of low-cost, easy-to-handle tools to support OSH risk management, through to sector specific training, advice, and guidance tailored to the needs of small business and early interventions included in business start-up support packages, innovative approaches to surveillance by both private and public actors, and engagement of intermediaries in the business and social environment of MSEs in the provision of OSH support, and so on.

## References

- Abbott KW, Genschel P, Snidal D and Zangl B (2015) *Orchestration: Global governance through intermediaries*. In Abbott KW, Genschel P, Snidal D and Zangl B (eds), *International Organizations as Orchestrators*. Cambridge: Cambridge University Press, 3–36.
- Albrecht M (2023) A Norwegian seaweed Utopia? Governmental narratives of coastal communities, upscaling, and the industrial conquering of ocean spaces. *Maritime Studies* 22(3), 37. doi:10.1007/s40152-023-00324-2
- Araújo R, Lusser M, Sanchez Lopez J and Avraamides M (2019) *Brief on Algae Biomass Production*. Luxembourg: Publications Office of the European Union.
- Araújo R, Vázquez Calderón F, Sánchez López J, Azevedo IC, Bruhn A, Fluch S, Garcia Tasende M, Ghaderiardakani F, Ilmjärv T, Laurans M, Mac Monagail M, Mangini S, Peteiro C, Rebours C, Stefansson T and Ullmann J (2021) Current status of the algae production industry in Europe: An emerging sector of the blue bioeconomy. *Frontiers in Marine Science* 7, 626389. doi: 10.3389/fmars.2020.626389
- Aslan LOM, Supendy R, Taridala SAA, Hafid H, Sifatu WO, Sailan Z and Niampe L (2018) Income of seaweed farming households: a case study from Lemo of Indonesia. In *IOP Conference Series: Earth and Environmental Science*. IOP Publishing, 175, 012221. doi: 10.1088/1755-1315/175/1/012221
- Asri A, Brodie J, Cottier E, Le Masson V, Matoju I, Montalescot V, Nagabhatla N, Shaxson L, Suyu J (2022) Towards a more inclusive and sustainable red seaweed industry. *Policy Brief* 3 2022. <https://cris.unu.edu/towards-more-inclusive-and-sustainable-red-seaweed-industry> (accessed 19 September, 2023).
- Bluff E, Johnstone R, Walters D, Limborg HJ and Gensby U (2022) Fitness for purpose of occupational safety and health monitoring and enforcement in the European Union. *Comparative Labor Law & Policy Journal* 42, 679.
- Braun V and Clarke V (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology* 3(2), 77–101.
- Cai J, Lovatelli A, Aguilar-Manjarrez J, Cornish L, Dabbadie L, Desrochers A, Diffey S, Garrido Gamarro E, Geehan J, Hurtado A, Lucente D, Mair G, Miao W, Potin P, Przybyla C, Reantaso M, Roubach R, Tauati M and Yuan X (2021) Seaweeds and microalgae: An overview for unlocking their potential in global aquaculture development. FAO Fisheries and Aquaculture Circular No. 1229. doi: 10.4060/cb5670en (accessed 5 November, 2021).

- Cavalli LS, Jeebhay MF, Marques FB, Mitchell RJ, Neis B, Ngajilo D and Watterson A (2019) Scoping global aquaculture occupational safety and health. *Journal of Agromedicine* 24, 391–404. doi: [10.1080/1059924X.2019.1655203](https://doi.org/10.1080/1059924X.2019.1655203)
- de Oliveira PK, Cavalli RS, Kunert Filho HC, Carvalho D, Benedetti N, Rotta MA, Peixoto Ramos AS, de Brito KCT, de Brito BG, da Rocha AF and Stech MR, (2017) Occupational health and safety in aquaculture: Insights on Brazilian public policies. *Journal of Agromedicine* 22(2), 148–158. doi: [10.1080/1059924X.2017.1283275](https://doi.org/10.1080/1059924X.2017.1283275)
- EU-OSHA (2016) Contexts and arrangements for occupational safety and health in micro and small enterprises in the EU – SESAME project. Publications Office of the European Union. Available at <https://osha.europa.eu/en/publications/contexts-and-arrangements-occupational-safety-and-health-micro-and-small-enterprises-eu> (accessed 31 March, 2022).
- EU-OSHA (2017) From policy to practice: The design and implementation of OSH policies, strategies, programmes actions and support for micro and small enterprises. Publications Office of the European Union. Available at <https://osha.europa.eu/en/tools-and-publications/publications/policy-practice-policies-strategies-programmes-and-actions/view> (accessed 31 March, 2022).
- EU-OSHA (2018) Safety and health in micro and small enterprises in the EU: Final report from the 3-year SESAME Project. Publications Office of the European Union. Available at <https://osha.europa.eu/en/tools-and-publications/publications/safety-and-health-micro-and-small-enterprises-eu-final-report-3/view> (accessed 31 March, 2022).
- EU-OSHA (2021) Improving compliance with occupational safety and health regulations: An overarching review. Publications Office of the European Union. Available at <https://osha.europa.eu/en/publications/summary-improving-compliance-occupational-safety-and-health-regulations-overarching> (accessed 31 March, 2022).
- Fairman R and Yapp C (2005) *Making an Impact on SME Compliance Behaviour: An Evaluation of the Effect of Interventions upon Compliance with Health and Safety Legislation*. Sudbury: HSE Books
- FAO (2022) Report of the Global Conference on Aquaculture Millennium +20 – Aquaculture for food and sustainable development. Shanghai, China, 22–25 September 2021. FAO Fisheries and Aquaculture Report. No. 1376. Rome: FAO.
- Fialkowska K and Matyszczak K (2021) Safe and fruitful? Structural vulnerabilities in the experience of seasonal migrant workers in agriculture in Germany and Poland. *Safety Science* 139, 105275. doi: [10.1016/j.ssci.2021.105275](https://doi.org/10.1016/j.ssci.2021.105275)
- Fröcklin S, de la Torre-Castro M, Lindström L, Jiddawi N and Msuya F (2012) Seaweed mariculture as a development project in Zanzibar, East Africa: A price too high to pay? *Aquaculture* 356–357, 30–39. doi: [10.1016/j.aquaculture.2012.05.039](https://doi.org/10.1016/j.aquaculture.2012.05.039)
- Fry JP, Ceryes CA, Voorhees JM, Barnes NA, Love DC and Barnes ME (2019) Occupational safety and health in U.S. aquaculture: A review. *Journal of Agromedicine* 24(4), 405–423. doi: [10.1080/1059924X.2019.1639574](https://doi.org/10.1080/1059924X.2019.1639574)
- Gegg P and Wells V (2017) UK Macro-Algae Biofuels: A strategic management review and future research agenda. *Journal of Marine Science and Engineering* 5(3), 32. <http://dx.doi.org/10.3390/jmse5030032>.
- Gunningham N and Sinclair D (2017) Smart regulation. In Drahos P (ed), *Regulatory Theory: Foundations and Applications*. Canberra: ANU Press, 133–148.
- Hasle P, Bager B and Granerud L (2010) Small enterprises–accountants as occupational health and safety intermediaries. *Safety Science* 48(3), 404–409. doi: [10.1016/j.ssci.2009.09.008](https://doi.org/10.1016/j.ssci.2009.09.008)
- Hasle P, Limborg HJ, Grøn S and Refslund B (2017) Orchestration in work environment policy programs. *Nordic Journal of Working Life Studies* 7(3), 43. doi: [10.18291/njwls.v7i3.97092](https://doi.org/10.18291/njwls.v7i3.97092)
- Hasle P and Vang J (2021) Designing better interventions: Insights from research on decent work. *Journal of Supply Chain Management* 57(2), 58–70. doi: [10.1111/jscm.12261](https://doi.org/10.1111/jscm.12261)
- Health and Safety Authority (2022) Fishing landing page. Available at [https://www.hsa.ie/eng/Your\\_Industry/Fishing/Legislation\\_and\\_Enforcement/](https://www.hsa.ie/eng/Your_Industry/Fishing/Legislation_and_Enforcement/) (accessed 10 February, 2022).
- Hussin H and Khoso A (2021) Migrant workers in the seaweed sector in Sabah Malaysia. *SAGE Open* 11(3), 21582440211047586. doi: [10.1177/21582440211047586](https://doi.org/10.1177/21582440211047586).
- ILO (2020) Social Dialogue for the Transition from the Informal to the Formal Economy. Available at [https://www.ilo.org/global/about-the-ilo/how-the-ilo-works/departments-and-offices/governance/dialogue/WCMS\\_750495/lang-en/index.htm](https://www.ilo.org/global/about-the-ilo/how-the-ilo-works/departments-and-offices/governance/dialogue/WCMS_750495/lang-en/index.htm) (accessed 25 January, 2023)
- ILO (2021) Technical meeting on the future of work in aquaculture in the context of the rural economy. Available at [https://www.ilo.org/sector/activities/sectoral-meetings/WCMS\\_815527/lang-en/index.htm#:~:text=aquaculture%20in%20...-](https://www.ilo.org/sector/activities/sectoral-meetings/WCMS_815527/lang-en/index.htm#:~:text=aquaculture%20in%20...-) (accessed 25 January 2023)
- IUF (2014) Executive Committee debates aquaculture and fisheries sector work. Available at <https://www.iuf.org/news/iuf-executive-committee-debates-aquaculture-and-fisheries-sector-work/> (accessed 25 January 2024).
- James S and Lloyd C (2008) Too much pressure? Retailer power and occupational health and safety in the food processing industry. *Work Employment and Society* 22(4), 1–18. doi: [10.1177/0950017008098366](https://doi.org/10.1177/0950017008098366)



- Jones A, McNamara J and Jakob M (2020) EU-OSHA Review of the future of agriculture and occupational safety and health (OSH)- Foresight on new and emerging risks in OSH. Available at <https://osha.europa.eu/en/publications/future-agriculture-and-forestry-implications-managing-worker-safety-and-health/view> (accessed 5 June 2023).
- Kuech A, Breuer M and Popescu I (2023) Research for PECH Committee – The future of the EU algae sector. Brussels: European Parliament Policy Department for Structural and Cohesion Policies. Available at [https://www.europarl.europa.eu/RegData/etudes/STUD/2023/733114/IPOL\\_STU\(2023\)733114\\_EN.pdf](https://www.europarl.europa.eu/RegData/etudes/STUD/2023/733114/IPOL_STU(2023)733114_EN.pdf) (accessed 22 May 2023)
- Moreau DTR and Neis B (2009) Occupational health and safety hazards in Atlantic Canadian aquaculture: Laying the groundwork for prevention. *Marine Policy* 33(2), 401–411. doi: [10.1016/j.marpol.2008.09.001](https://doi.org/10.1016/j.marpol.2008.09.001)
- Msuya FE (2013) Social and economic dimensions of carrageenan seaweed farming in the United Republic of Tanzania. In Valderrama D, Cai J, Hishamunda N and Ridler N (eds), *Social and Economic Dimensions of Carrageenan Seaweed Farming*. FAO Fisheries and Aquaculture Technical Paper No. 580. Rome: FAO. <https://www.fao.org/publications/card/en/c/8961e0ea-79cc-576c-8578-09eca0587cf6/>
- Myers ML and Durborow RM (2012) Aquacultural safety and health. In Carvalho E, David G and Silva R (eds), *Health and Environment in Aquaculture*. London, England: IntechOpen, 385–400.
- Ngajilo D, Adams S, Kincl L, Guernsey J and Jeebhay MF (2023) Occupational health and safety in Tanzanian aquaculture—emerging issues. *Journal of Agromedicine* 28(2), 321–333. doi: [10.1080/1059924X.2022.2058139](https://doi.org/10.1080/1059924X.2022.2058139)
- Ngajilo D and Jeebhay MF (2019) Occupational injuries and diseases in aquaculture – a review of literature. *Aquaculture* 507, 40–55. doi: [10.1016/j.aquaculture.2019.03.053](https://doi.org/10.1016/j.aquaculture.2019.03.053)
- Nichols T (1997) *The Sociology of Industrial Injury*. London: Mansell.
- Parker C and Nielsen VL (2017) Compliance: 14 questions. In Drahos P (ed), *Regulatory Theory: Foundations and Applications*. Canberra: Australian National University Press, 217–232.
- Phu T, Phuong N, Dung T, Hai D, Son V, Rico A, Clausen J, Madsen H, Murray F and Dalsgaard A (2015) An evaluation of fish health-management practices and occupational health hazards associated with Pangasius catfish (*Pangasianodon hypophthalmus*) aquaculture in the Mekong Delta, Vietnam. *Aquaculture Research* 47(9), 2778–2794. doi: [10.1111/are.12728](https://doi.org/10.1111/are.12728)
- Phyconomy (2022) 2021 seaweed harvest data. Available at <https://phyconomy.net/state-of-the-industry-2022/harvest-data/> (accessed 28 January, 2022).
- Porru S and Baldo M (2022) Occupational health and safety and migrant workers: Has something changed in the last few years? *International Journal of Environmental Research and Public Health* 19(15), 9535. doi: [10.3390/ijerph19159535](https://doi.org/10.3390/ijerph19159535)
- Quinlan M and Bohle P (2009) Overstretched and unreciprocated commitment: Reviewing research on the occupational health and safety effects of downsizing and job insecurity. *International Journal of Health Services: Planning, Administration, Evaluation* 39(1), 1–44. doi: [10.2190/HS.39.1.a](https://doi.org/10.2190/HS.39.1.a)
- Quinlan M, Mayhew C and Bohle P (2001) The global expansion of precarious employment, work disorganization, and consequences for occupational health: A review of recent research. *International Journal of Health Services: Planning, Administration, Evaluation* 31(2), 335–414. doi: [10.2190/607H-TTV0-QCNE-YLT4](https://doi.org/10.2190/607H-TTV0-QCNE-YLT4)
- Rönneck P, Bryceson I and Kautsky N (2002) Coastal aquaculture development in Eastern Africa and the Western Indian Ocean: Prospects and problems for food security and local economies. *Ambio* 31(7–8), 537–542. [http://doi.org/10.1579/0044-7447-31.7.537](https://doi.org/10.1579/0044-7447-31.7.537)
- Said AH, Kyewalyanga MS, Msuya FE, Mmochi AJ, Mwihia EW, Skjerve E, Ngowi H and Lyche JL (2018) Health problems related to algal bloom among seaweed farmers in coastal areas of Tanzania. *Journal of Public Health and Epidemiology* 10(8), 303–312. doi: [10.5897/JPHE2018.1020](https://doi.org/10.5897/JPHE2018.1020)
- Secretariat of Seaweed for Europe (2021) Investor Memo: The case for seaweed investment in Europe. Available at <https://www.seaweedeurope.com/wp-content/uploads/2021/10/S4E-InvestorMemo-MainReport-16OCTOBER2021.pdf> (accessed 28 January, 2022).
- Selnes T, Giesbers E and van den Burg SW (2021) Innovation and collaboration: Opportunities for the European seaweed sector in global value chains. *Journal of Marine Science and Engineering* 9(7), 693. doi: [10.3390/jmse9070693](https://doi.org/10.3390/jmse9070693)
- Shimada T, Takemasa S, Kohbu Y, Ishikawa H and Azuma M (1990) An epidemiological study on low back pain in fishermen working in seaweed farming. *Bulletin of Allied Medical Sciences* 6, 37–41.
- Stanley MS, Kerrison PK, Macleod AM, Rolin C, Farley I, Parker A, Billing SL, Burrows M and Allen C (2019) Seaweed Farming Feasibility Study for Argyll & Bute. A report by SRSL for Argyll & Bute Council. Available at [https://oceanium.world/wp-content/uploads/2021/12/seaweed\\_farming\\_feasibility\\_study\\_for\\_argyll\\_and\\_bute\\_report\\_december\\_2019-1.pdf](https://oceanium.world/wp-content/uploads/2021/12/seaweed_farming_feasibility_study_for_argyll_and_bute_report_december_2019-1.pdf) (accessed 5 November, 2021).
- Tatar V (2019) Evaluation of occupational safety and health in the global fishing sector. *The Online Journal of Science and Technology* 9(2), 156–170.

- Thamrin Y, Muis M, Wahyu A and Hardianti A (2020) Seaweed farmers and work fatigue: A mixed-method approach. *Open Access Macedonian Journal of Medical Sciences* 8(T2), 192–195. doi: [10.3889/oamjms.2020.5226](https://doi.org/10.3889/oamjms.2020.5226).
- Thamrin Y, Wahyu A, Muis M, Russeng SS, Birawida AB, Amqam H and Hardianti A (2019) Determinants of occupational health and safety problems among seaweed workers in Takalar regency. *Indian Journal of Public Health Research and Development* 10(1), 1214–1219. doi: [10.5958/0976-5506.2019.00221.3](https://doi.org/10.5958/0976-5506.2019.00221.3)
- Valderrama D, Cai J, Hishamunda N and Ridler N (eds) (2013) Social and economic Dimensions of Carrageenan Seaweed Farming. FAO Fisheries and Aquaculture Technical Paper No. 580. Rome: FAO. <https://www.fao.org/publications/card/en/c/8961e0ea-79cc-576c-8578-09eca0587cf6/>
- van den Burg S, van Duijn A, Bartelings H, van Krimpen M and Poelman M (2016) The economic feasibility of seaweed production in the North Sea. *Aquaculture Economics & Management* 20(3), 235–252. doi: [10.1080/13657305.2016.1177859](https://doi.org/10.1080/13657305.2016.1177859)
- van den Burg SW, Dagevos H and Helmes RJK (2021a) Towards sustainable European seaweed value chains: A triple P perspective. *ICES Journal of Marine Science* 78(1), 443–450. doi: [10.1093/icesjms/fsz183](https://doi.org/10.1093/icesjms/fsz183)
- van den Burg SW, Selnes T, Alves L, Giesbers E and Daniel A (2021b) Prospects for upgrading by the European kelp sector. *Journal of Applied Phycology* 33(1), 557–566. doi: [10.1007/s10811-020-02320-z](https://doi.org/10.1007/s10811-020-02320-z)
- Vazquez CF and Sanchez LJ (2022) *An Overview of the Algae Industry in Europe*. Luxembourg: Publications Office of the European Union.
- Vickers I, Baldock R, Smallbone D, James P, Ekanem I and Bertotti M (2003) *Cultural Influences on Health and Safety Attitudes and Behaviour in Small Firms*. Health and Safety Executive Research Report No 150. Sudbury: HSE Books.
- Walters D and James P (2011) What motivates employers to establish preventive management arrangements within supply chains. *Safety Science* 49, 988–994. doi: [10.1016/j.ssci.2010.12.004](https://doi.org/10.1016/j.ssci.2010.12.004)
- Walters D, Johnstone R and James P (2024) Regulatory approaches to improving work health and safety in global supply chains: Institutions and evidence of effectiveness. *Journal of Work Health and Safety Regulation*. Advance online publication. doi: [10.57523/jaohlev.oa.22-006](https://doi.org/10.57523/jaohlev.oa.22-006) (accessed 3 January, 2024).
- Watterson A, Jeebhay M, Neis B, Mitchell R and Cavalli L (2019) The neglected millions: The global state of aquaculture workers' occupational safety, health and well-being. *Occupational and Environmental Medicine* 77(1), 15–18. doi: [10.1136/oemed-2019-105753](https://doi.org/10.1136/oemed-2019-105753)
- Watterson A, Little D, Young J, Murray F, Doi L, Boyd K and Azim E (2012) Scoping a public health impact assessment of aquaculture with particular reference to Tilapia in the UK. *International Scholarly Research Notices*. 2012, Article ID: 203796. doi: [10.5402/2012/203796](https://doi.org/10.5402/2012/203796) (accessed 26 February, 2021).
- Windle MJ, Neis B, Bornstein S, Binkley M and Navarro P (2008) Fishing occupational health and safety: A comparison of regulatory regimes and safety outcomes in six countries. *Marine Policy* 32(4), 701–710. doi: [10.1016/j.marpol.2007.12.003](https://doi.org/10.1016/j.marpol.2007.12.003)

---

**Cite this article:** Makri E, Walters D, Wadsworth E, Devereux H, and van den Burg SWK (2024). Occupational health and safety in aquaculture: Organisation of work and employment in small seaweed farms in North West Europe. *The Economic and Labour Relations Review* 35, 27–44. <https://doi.org/10.1017/elr.2024.7>