

# **Marine Finfish Aquaculture Mass Mortality Events and Aquaculture Occupational Health and Safety: Assessing Hazards and Risk**

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Program

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I have no conflicts to declare



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# Presentation Overview

- Global Expansion of Aquaculture and Complexity of the Sector
- Mass Mortality Events – introduction
- Aquaculture OHS
- The research problem and methods for the MME hazards and risk assessment exercise more generally and methods for the OHS piece of that exercise
- Some key findings
- Conclusions and recommendations

## THE STATE OF WORLD FISHERIES AND AQUACULTURE 2022

### PART 1 WORLD REVIEW

Global fisheries and aquaculture at a glance

Total fisheries and aquaculture production

Capture fisheries production

**Aquaculture production**

The status of fishery resources

Fishing fleet

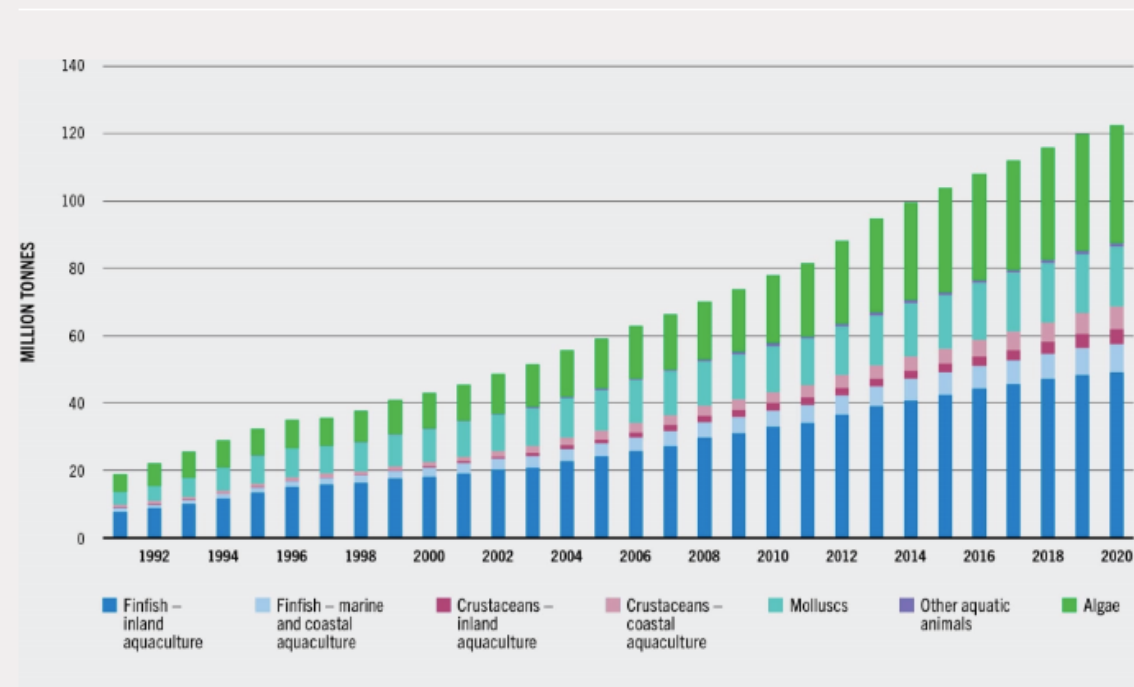
Employment in fisheries and aquaculture

Utilization and processing of fisheries and aquaculture production

Consumption of aquatic foods

Trade of fisheries and aquaculture products

**FIGURE 13** WORLD AQUACULTURE PRODUCTION, 1991–2020



NOTES: Data exclude shells and pearls. Data expressed in live weight equivalent.

SOURCE: FAO.

## Mass Mortality Events (MMEs)

MMEs = events where large numbers of organisms (thousands to millions) die in a short period of time (Fey et al., 2015; Munasinghe et al., 2008; Koopmans et al., 2004)

- E.g. outbreaks of avian influenza (also called “bird flu”) = devastation in animal populations, including poultry, wild birds, and some mammals; harm farmers’ livelihoods and the food trade. Although largely affecting animals, these outbreaks pose ongoing risks to humans. (WHO 2023)

Fish mortality always a concern in farmed salmon production, MMEs of particular concern (scale and rapidity of loss, and associated effects on communities dependent on aquaculture). (Singh, G. G., Sajid, Z., & Mather, C., 2024)

MME risk and consequences are under-researched in aquaculture

Agents responsible for MMEs in salmon aquaculture are not infectious for humans but MMEs can entail risks to worker health (our focus here)

# MMEs in finfish aquaculture: a widespread and growing concern

ENVIRONMENT

**Salmon 'die-off' incident raises concerns about the state's future in large-scale aquaculture**

May 28, 2019

Norway loses millions of farmed salmon to algae bloom



Photo credit: Ballangen Fish Farm

RADIO CANADA INTERNATIONAL

**Fish farming controversy over massive salmon die-off**

MARC MONTGOMERY

**Mowi experiences more salmon die-offs in Canada, Ireland**

**Marine Harvest reports massive smolt die-off in Norway**

**Mass Die-Off of Farmed Salmon Linked to Climate Change**

**Chilean salmon farmer reports massive 1 million salmon die-off; cause unknown**

**Deadly algae kill 4,200 tonnes of Chilean salmon**

ENVIRONMENT

**DEP finds no permit violations associated with recent 'die-off' incident at salmon farm off MDI**

## Aquaculture is a hazardous sector

- Diverse and variable safety, physical, chemical, biological, ergonomic and psychosocial hazards (Ngajilo and Jeebhay 2019)
- Documented aquaculture injury rates exceed average national/state/provincial rates (Holmen and Thorvaldsen 2018; Mitchell and Lystad, 2019; Ochs et al. 2021; Fry et al. 2019).
- Limited knowledge of occupational exposures, risk factors and associated adverse health outcomes, especially in low and middle - income countries (Ngajilo and Jeebhay 2019)
- Major data gaps around the adoption and implementation of regulatory standards, industry practices, and their health and safety management systems (Watterson et al. 2019)

## OHS risk in marine aquaculture

- Aquaculture accident causality is often complex and associated with a range of contributing factors (Thorvaldsen et al., 2015).
- Involves rearing live animals affecting the risk profile of the sector (Holen et al. 2019; Yang et al. 2019)
- Monitoring and penalties for certain kinds of events affecting fish health or the environment can lead workers to focus on these issues versus OHS (Storkerson 2012)
- MMEs can be thought of as a type of major accident but, unlike the oil and gas and chemical sectors, attempts to develop holistic risk management systems for aquaculture are in their infancy (Holen et al. 2019).



## The Larger Project

*Problem:* MMEs seem to be increasing in salmon aquaculture and can have different causes. Design a risk assessment exercise to assess causes and consequences of MMEs

Methodology:

- a) Develop a database of salmon aquaculture MMEs and document trends (Singh et al. 2024)
- b) Assemble a large, multidisciplinary team of salmon aquaculture experts with expertise on diverse potential risk factors related to causes and consequences of MMEs.
- c) Ask teams to develop risk assessments based on their expertise (i.e. water temperature, fish nutrition, disease, harmful algae blooms, occupational health and safety, community impacts).
- d) Expert elicitation process involving leaders of all teams to discuss preliminary risk assessments and to build a pathway model based on each of the separate, potentially intersecting pieces (Sajid et al. 2024).

# MME OHS Hazard and Risk Assessment

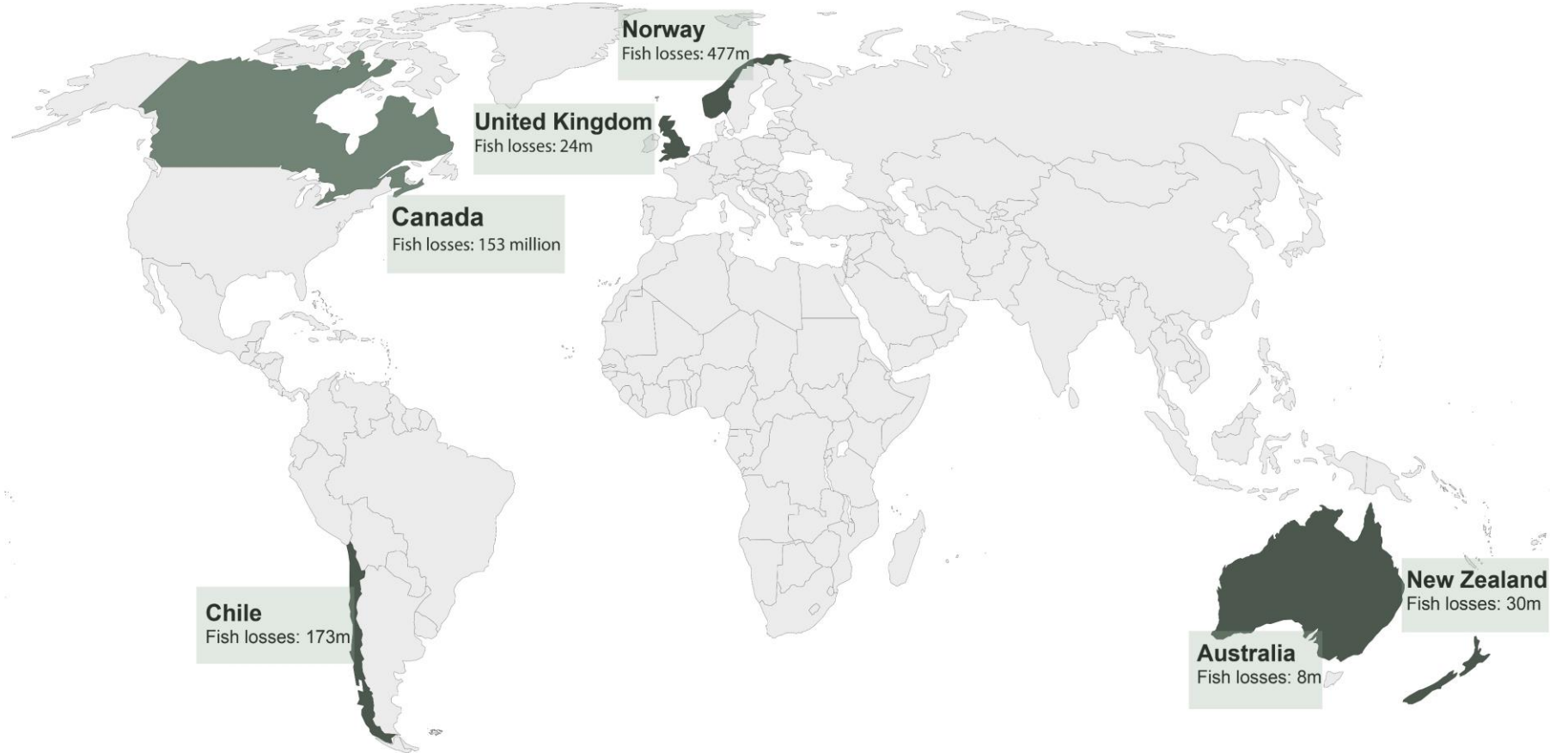
## *OHS Subproject Methods:*

Multi-national desktop exercise by AOHS researchers from 5 countries using:

- ✓ information on definitions of MMEs
  - ✓ incident reports
  - ✓ legal and regulatory guidance and documentation
  - ✓ media coverage
- Develop 5 country profiles
  - Profile synthesis
  - Participate in a multi-disciplinary, expert elicitation risk assessment process encompassing potential causes and consequences of MMEs
  - Refine AOHS risk assessment including pathway analysis

# Total number of fish mortalities reported by country\*

\* Not just MMEs



Source: G. Singh, Z. Sajid, Charles Mather, 2024.

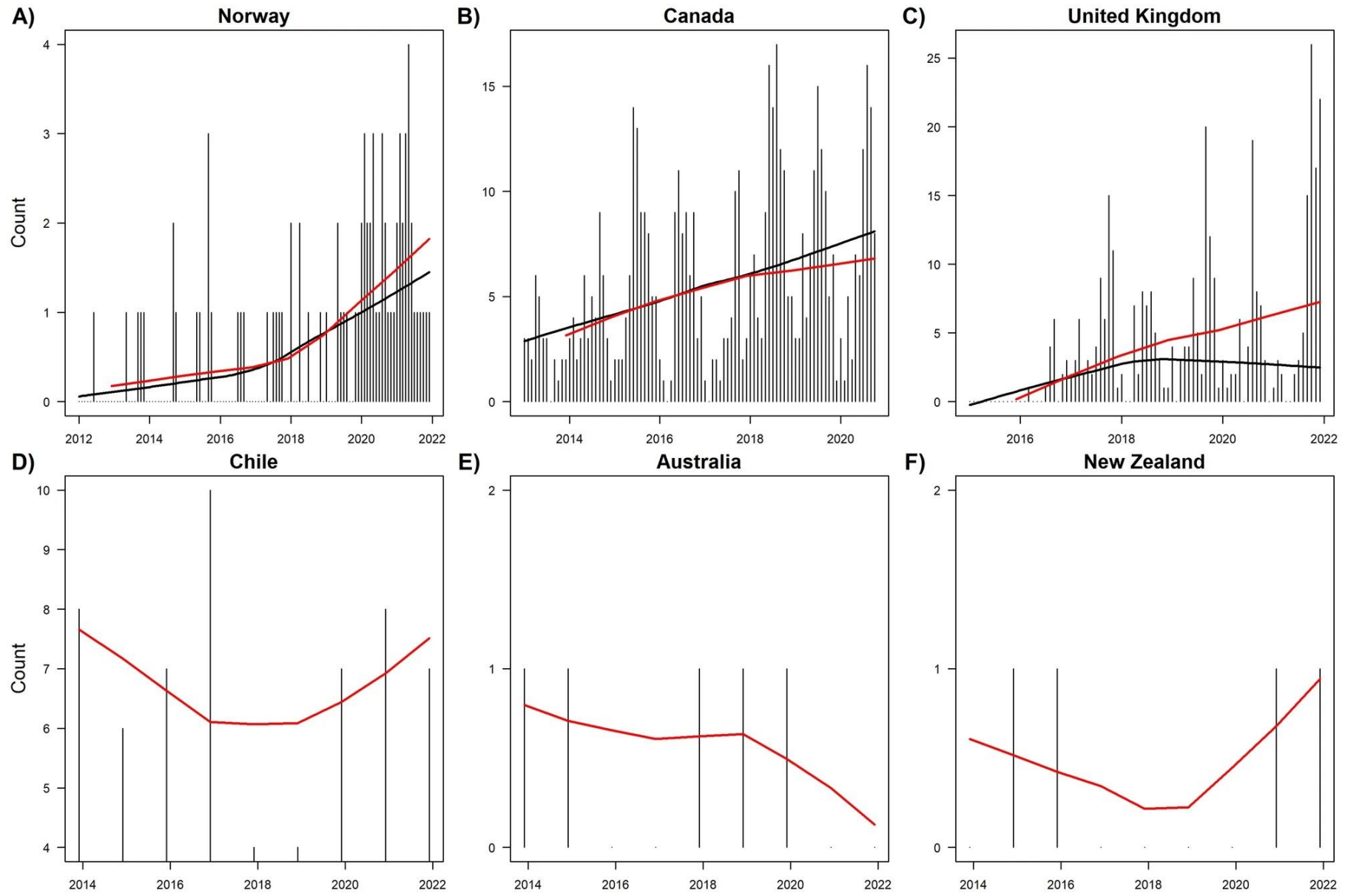
Used with permission.

# MMEs by country 2012-2022

Events include the top 10% of events as measured by the number of fish lost within each country. For the top three countries, the number of fish lost in the top 10% of MMEs is on the rise.

There are problems with the data from Chile, Australia and New Zealand that make it difficult to compare.

Source: Singh et al. 2024. Used with permission.



# MMEs in Aquaculture

The sudden death of thousands to millions of fish in finfish aquaculture.



Significant asset losses; compliance threats to environmental, animal health and occupational health and safety obligations; can undermine social license to operate.



Trigger rapid mobilization of workers, vessels and other supports to identify the extent and cause of the event, plan and undertake operations for removal, transport, and disposal of dead finfish and can lead to changes in fish production and location

## Activities and Hazards Associated with MMEs

- Travel to and from cages (marine shipping and transport capacity)
- Work on and under cages (Mort removal; diving/pumping)
- Mort transport (fish/slurry)
- Mort rendering/processing
- Net removal & cleaning
- Post-event cage repositioning (diving, work on cages and vessels, cranes)
- Vessel and weather-related hazards
- Diving/chemical/biological hazards in the water and on vessels
- Confined space working
- Net lifting, anchoring, manual materials handling
- Fast-paced work/long hours/stress/fatigue

## Diving and MME mort removal in Newfoundland (NL) 2019

Media coverage for the MME reported a diver had to be transported several hundred km from the site to St. John's for hyperbaric treatment due to decompression illness, other stories suggested chaotic approach to accessing divers...

Report on the MME:

“During the mort removal process diver safety was a major concern. Diving practices were inspected by outside agencies to ensure safety. Initially, Barry's was advised that the divers were not allowed to be in the netpen while they were pumping out the fish due to diver safety. However, there was no way to determine where the fish were in the netpen and pumping was going very slow (*sic*). Eventually a Diver Safety SOP was implemented ...” (Fisheries and Marine Institute 2020, p. 24)

## Diving and MME mort removal NL

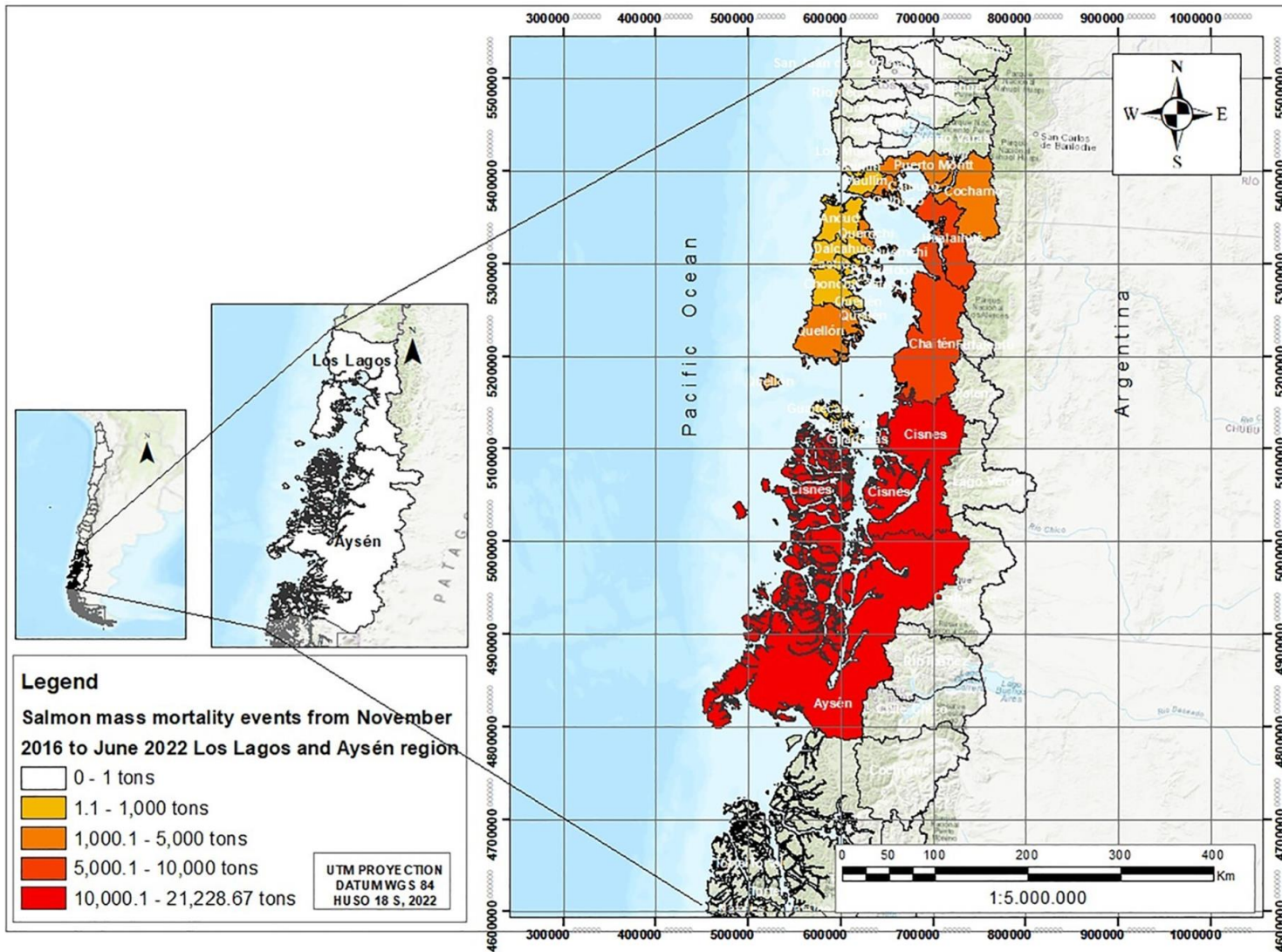
“[the company] did not have a contingency plan to have additional divers on call beyond their normal needs...Eventually 20 divers were brought in from five dive companies and three provinces...Most divers had never dived in a fish pen and required training before doing a dive ... There were also some issues with communication between the divers, pump operators and the deck. Some divers had very good communication gear, while others had limited to no communication gear.”  
(Fisheries and Marine Institute 2020, p. 24)



## Diving and MME mort removal NL

- “On some sites, nets were weighed down by dead fish to depths well below 15 m that would require decompression dives to clean up. A component of the diver safety SOP that was implemented *ad hoc* during the clean-up included an assessment of each net pen to determine if the diver could do the dive safely based on the depth of the dead fish mass...Each diver averaged about 6 hours per day in the water...There is no question that this is an arduous dive schedule day in and day out.” (Fisheries and Marine Institute 2020, p. 24)

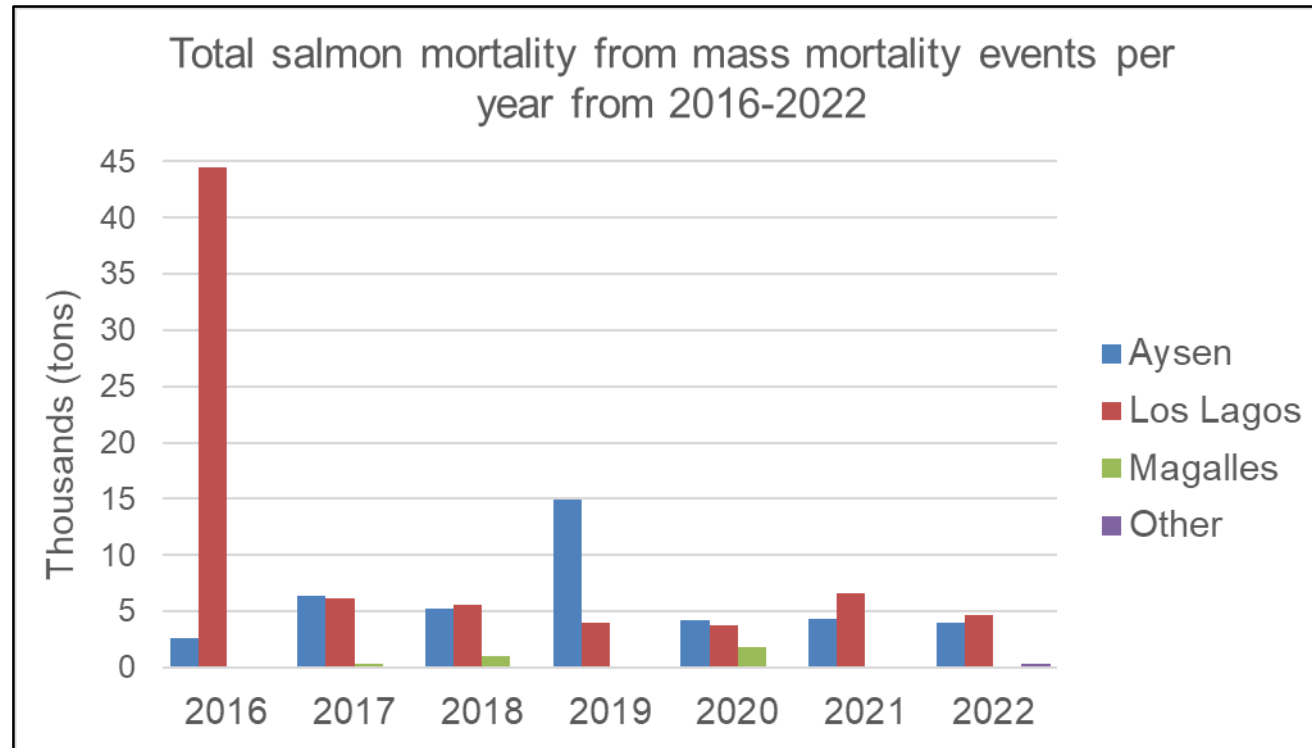
Also: No requirement in place for companies to contact NL OHS Branch in response to the event and prior to implementation of diving



Chilean salmon aquaculture with cumulative MME mortalities by region, November 2016 to June 2022 in tons.

Source: Cavalli et al. 2023

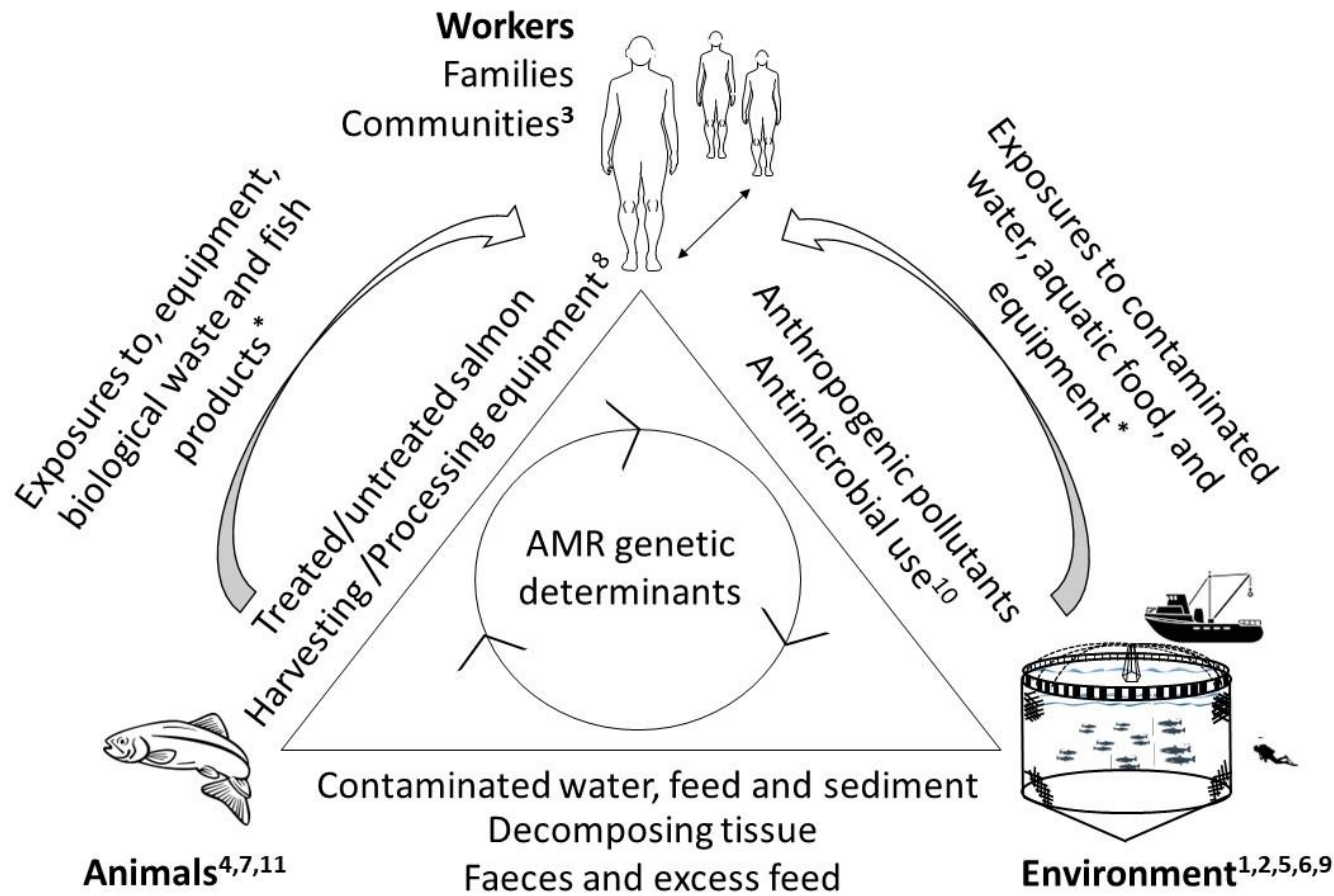
## Chile reported MME mortalities 2016-2022



## Chile and MMEs (Cavalli et al. 2023)

Chile MME case study highlights risks related to transport of dead fish for disposal

1. High reliance on fishing and other vessels for transporting MME morts
2. Vessel crews with limited training/knowledge OHS hazards- risk of injuries, falls overboard, capsizing, potential exposures to deadly H<sub>2</sub>S gas and potentially to antimicrobials, AMR bacteria, etc.
3. Potential exposures to algae via harmful algae blooms may pose OHS risk (discussed in Neis et al. 2023)
4. Based on exposure to H<sub>2</sub>S in 2016, Chile implemented guidelines for safe removal waste from MMEs.



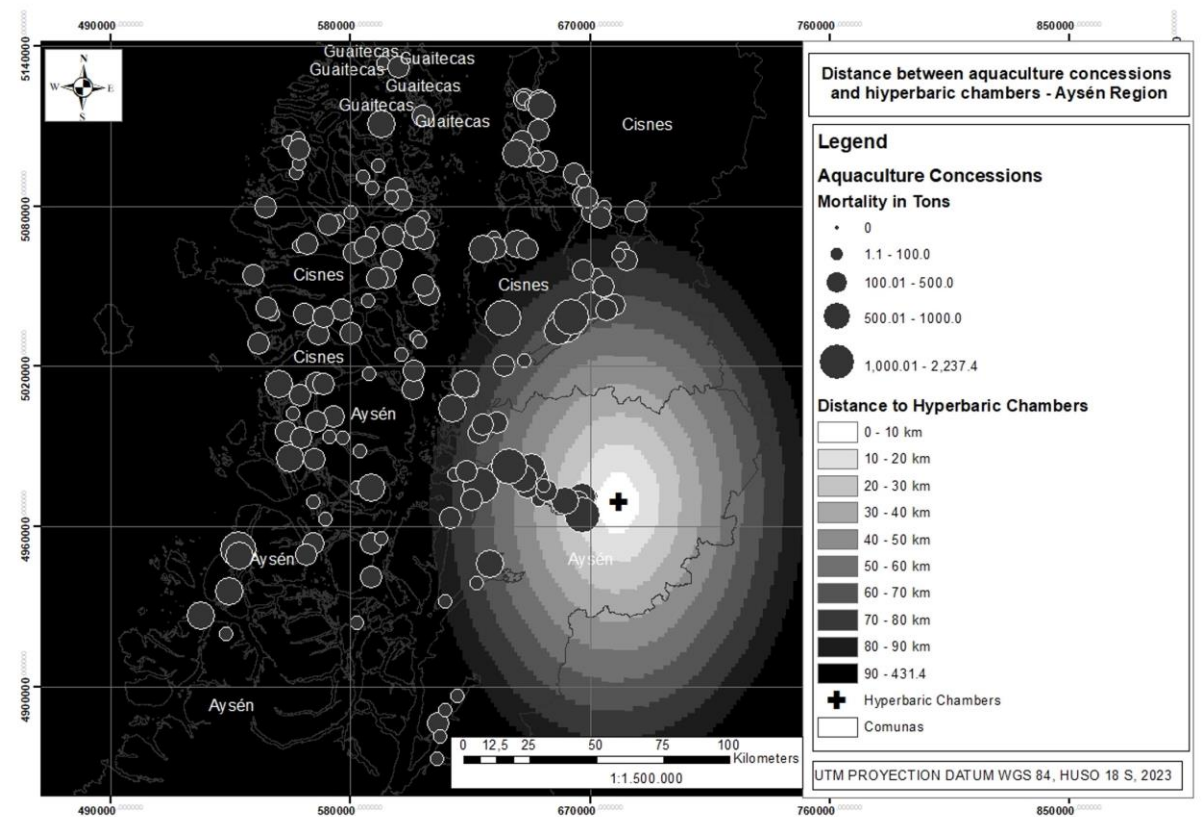
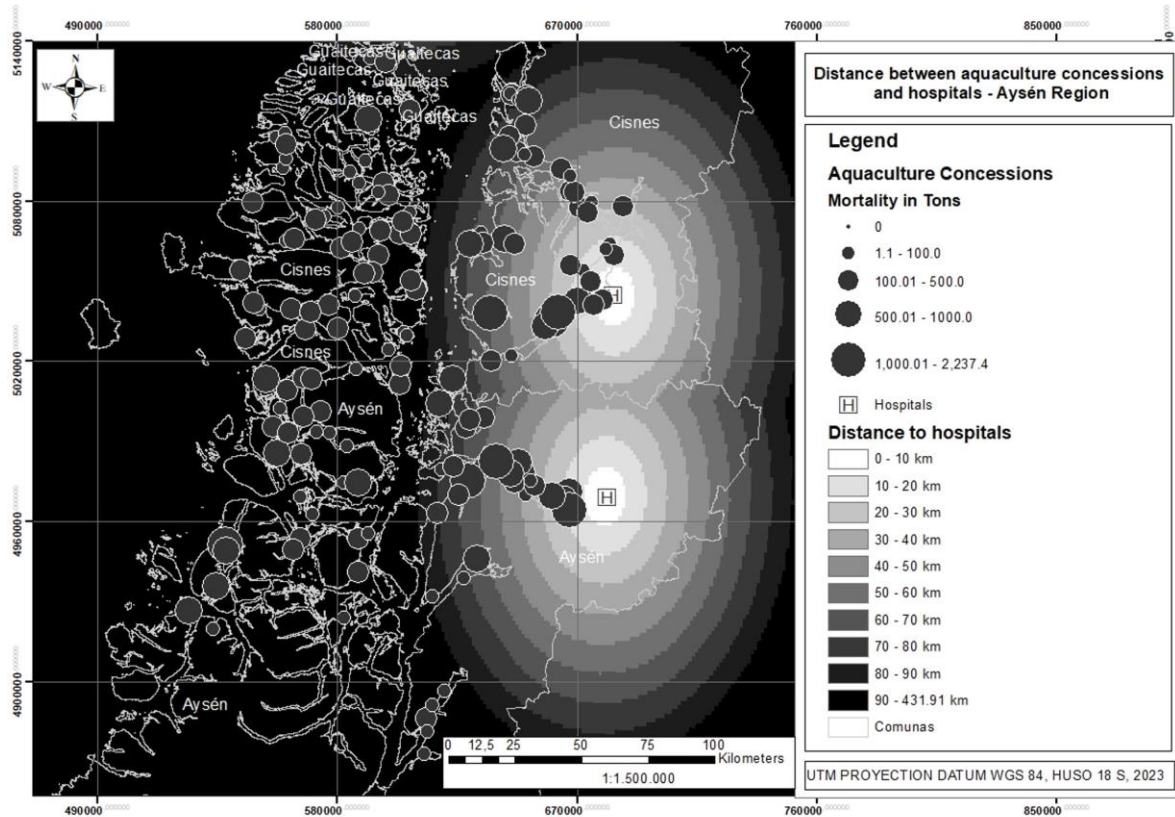
\*An absence of cross-sectional studies hinders risk analyses to evaluate human health risks directly associated with AMR genetic determinants in aquaculture environments, represented by large external arrows, particularly during intensive and high-contact operations required during MMEs

Sources:

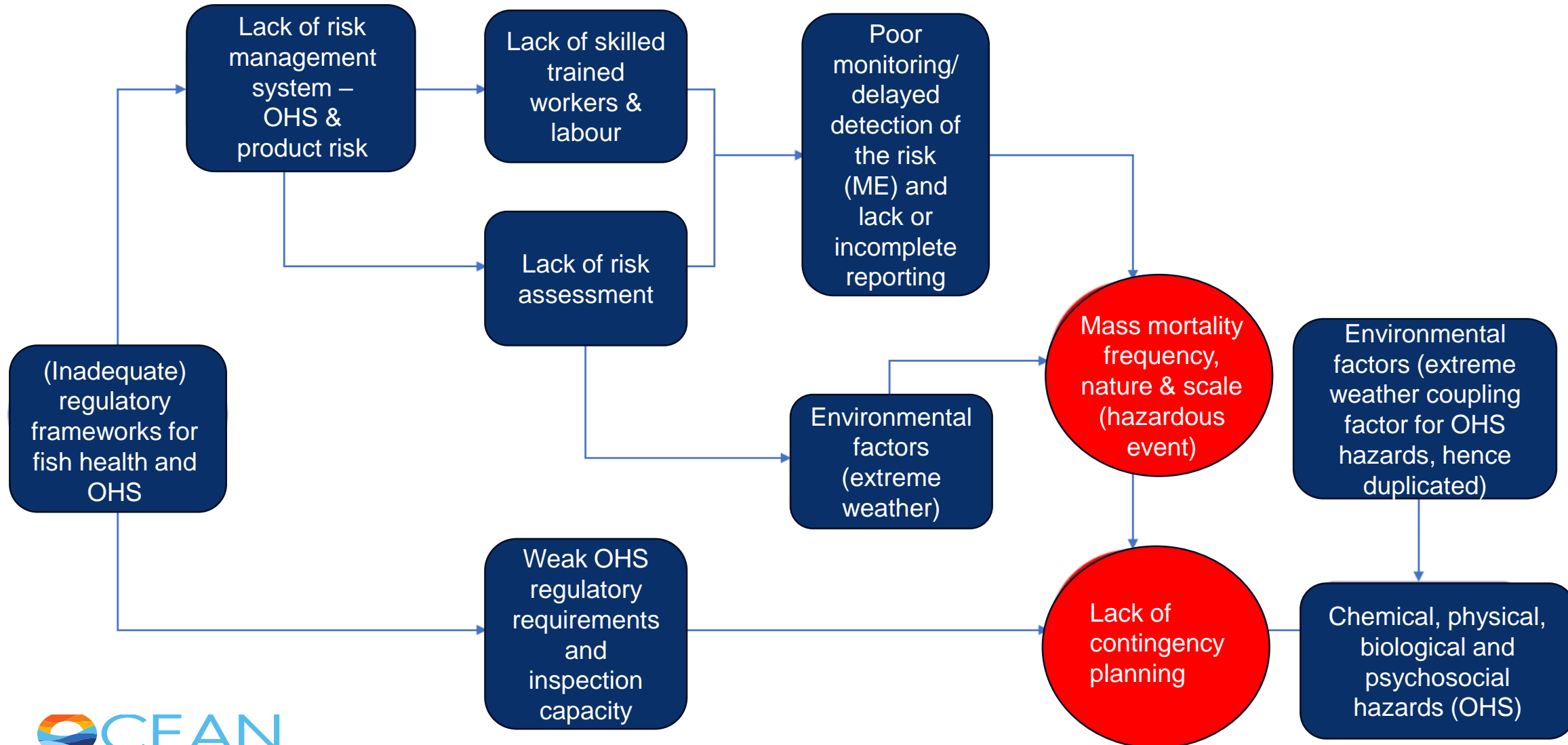
<sup>3</sup>(Tomova et al. 2015); <sup>4, 7, 11</sup>(Higuera-Llantén et al. 2018; Chiesa et al. 2019; Salgado-Caxito et al. 2022); <sup>1,2,5,6,9</sup>(Buschmann et al. 2012; Aedo et al. 2014; Tomova et al. 2018; Domínguez et al. 2019; Ramírez et al. 2022); <sup>8</sup>(Thomassen et al. 2022); <sup>10</sup>(Muziasari et al. 2016; WHO 2022).

AMR and MMEs: Literature map of peer-reviewed studies containing empirical evidence of antibiotics, their metabolites, and AMR genetic determinants within open systems salmon aquaculture environments\* (Cavalli et al. 2022)

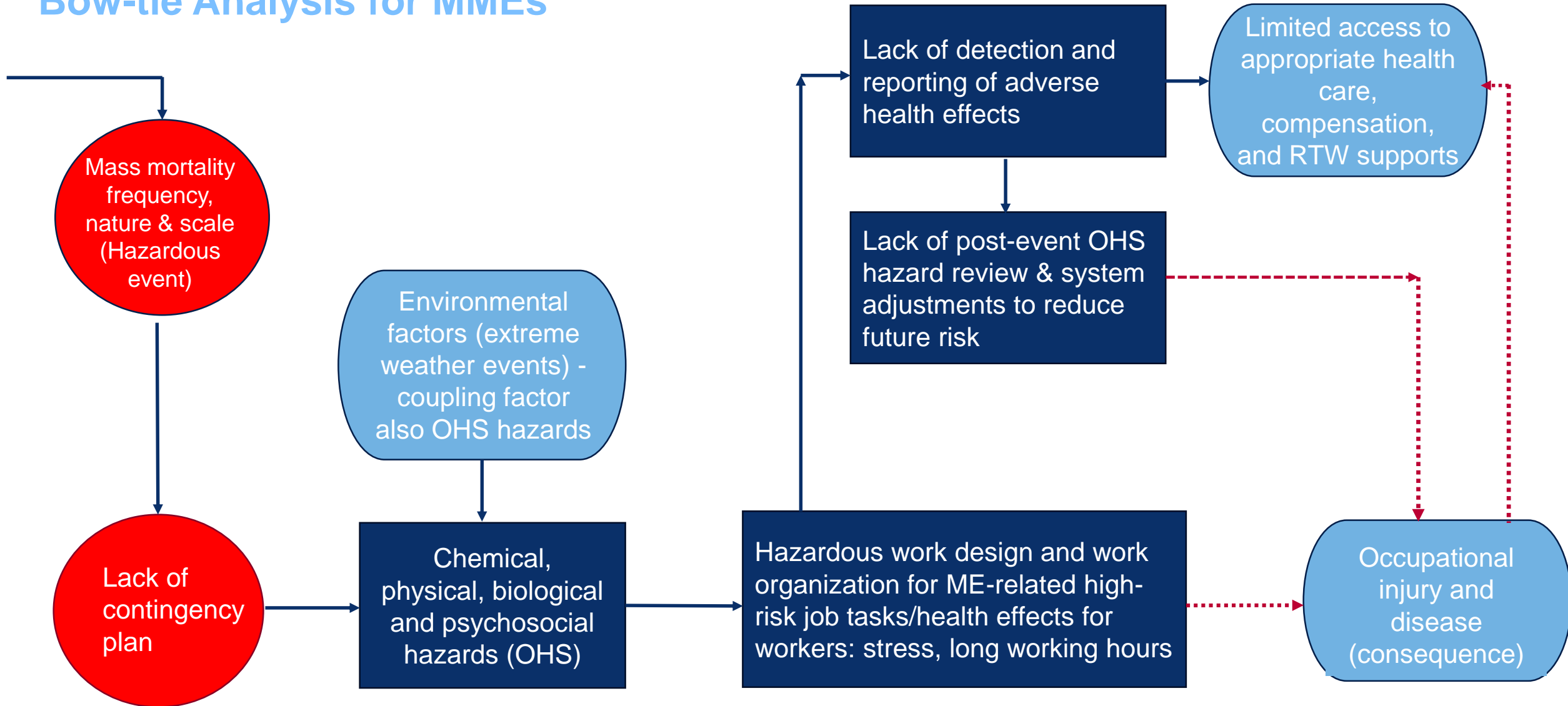
# MMEs and distance to hospitals and hyperbaric chambers in Aysen, Chile



# Bow-tie AOHS Risk Assessment for MMEs



# Bow-tie Analysis for MMEs





## MME Hazard and Risk Assessment Results & Conclusion



Findings indicate variability in MME definitions, requirements for event reporting and MME-related contingency planning encompassing AOHS across countries.



A preliminary bow-tie risk analysis highlights key hazards and potential pathways between MME-prevention planning, monitoring and response and AOHS risks.



AOHS concerns need to be fully and effectively integrated into broader risk assessments on ways to reduce MMEs and their consequences in marine finfish aquaculture.

Photo credits: John Inge Johansen, NRK Norway, Edgar McGuinness, B. Neis

## More generally...

AOSH marginalised and often forgotten in existing aquaculture research/policy

Results:

- Huge global gap in knowledge, resources and systematic monitoring
- Significant opportunities for multi-stakeholder and inter-agency collaboration – producers, workers, government, NGOs, researchers
- Start now by drawing on examples of good practice



# UN commitment to the issue of decent work and aquaculture OSH is ongoing ...

*The aquaculture workforce is exposed to multiple OSH hazards with short- and long-term consequences. The hazards may vary significantly depending on the type and scale of operation.*

*Underdeveloped OSH management systems and weaker regulatory frameworks and enforcement systems, particularly in informal and rural economies, exacerbate the challenge. In recent years, constituents in several leading aquaculture producing countries have taken important steps in establishing a*

*stronger preventive culture and adequate legal frameworks on OSH. Further efforts are needed to ensure occupational safety and health for the aquaculture workforce.*

*(Conclusions of the ILO Technical meeting on the future of work in aquaculture in the context of the rural economy, 2021 a)*

Globally commitment to AOSH should be prioritized at the same level as product quality, biosecurity, food safety and environmental sustainability in the sector.

- develop integrated AOSH actions appropriate for diverse settings, especially in low and middle-income countries
- ensure “greater uptake of international codes, better risk assessment and OSH management, adoption of technological innovations, and effective OSH regulation and enforcement, adequate resources, training and information” (Cavalli et al. 2019).
- For rural areas and vulnerable populations (precariously employed) combine employment standards and OHS inspection capacity

Thank you

Questions and  
Comments



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