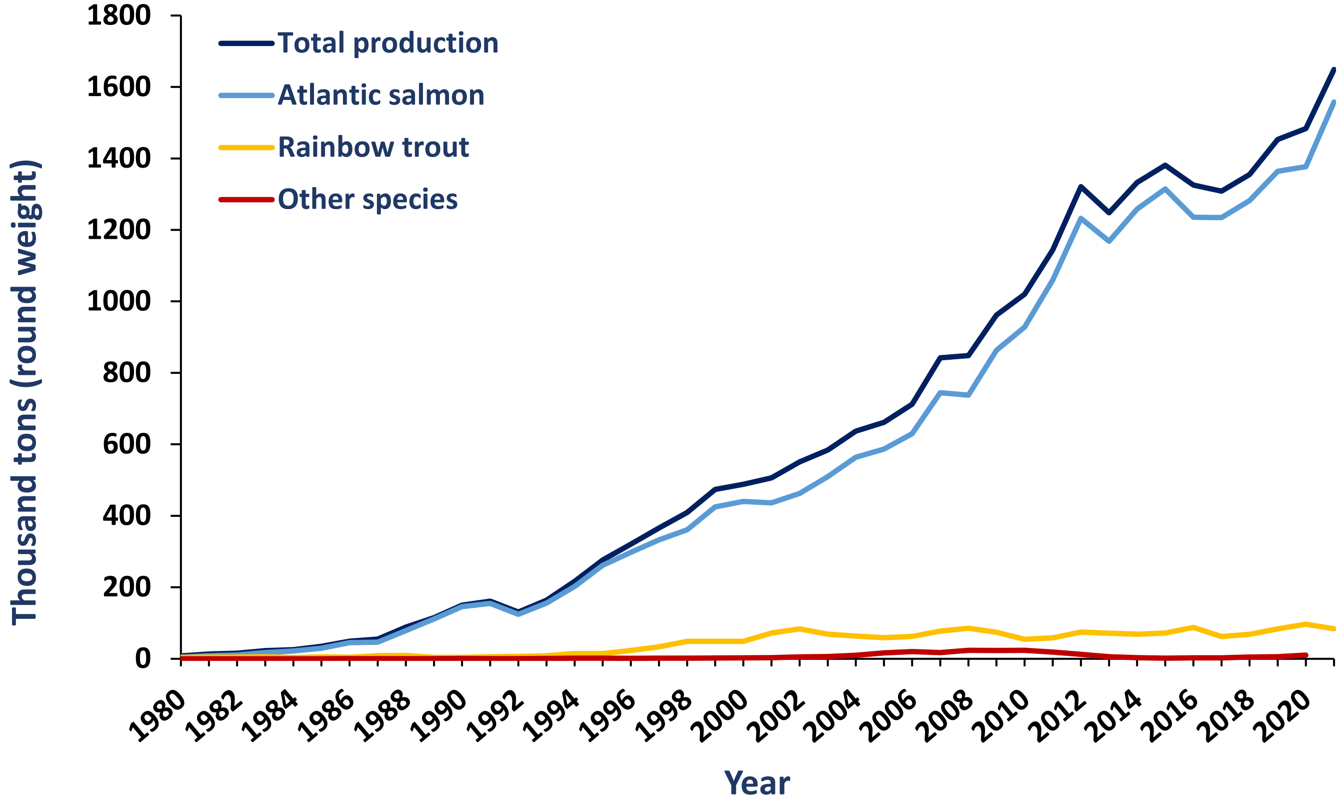
Method for Risk Assessment of Animal Welfare and Environmental Impacts

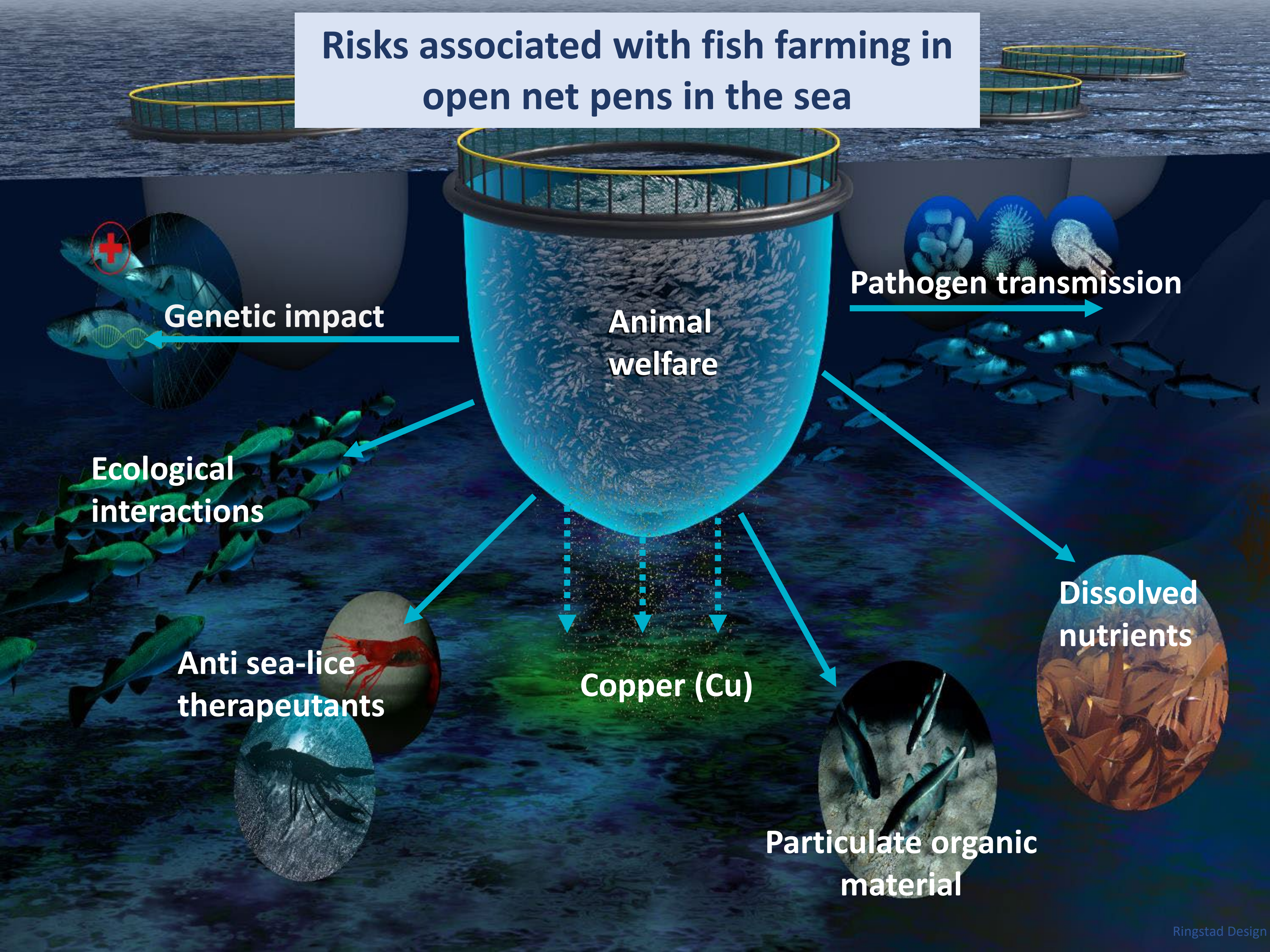
Ellen Sofie Grefsrud

Institute of Marine Research

Norwegian aquaculture production



- > 1.65 million tons in total (preliminary figures 2021)
- 94% Atlantic salmon
- > 400 million fish at any time, makes salmonid farming the most extensive production of farmed animals in Norway



Risks associated with fish farming in open net pens in the sea
Pathogen transmission
Genetic impact
Animal welfare
Ecological interactions
Dissolved nutrients
Anti sea-lice therapeutants
Copper (Cu)
Particulate organic material
Ringstad Design

Risk report Norwegian fish farming

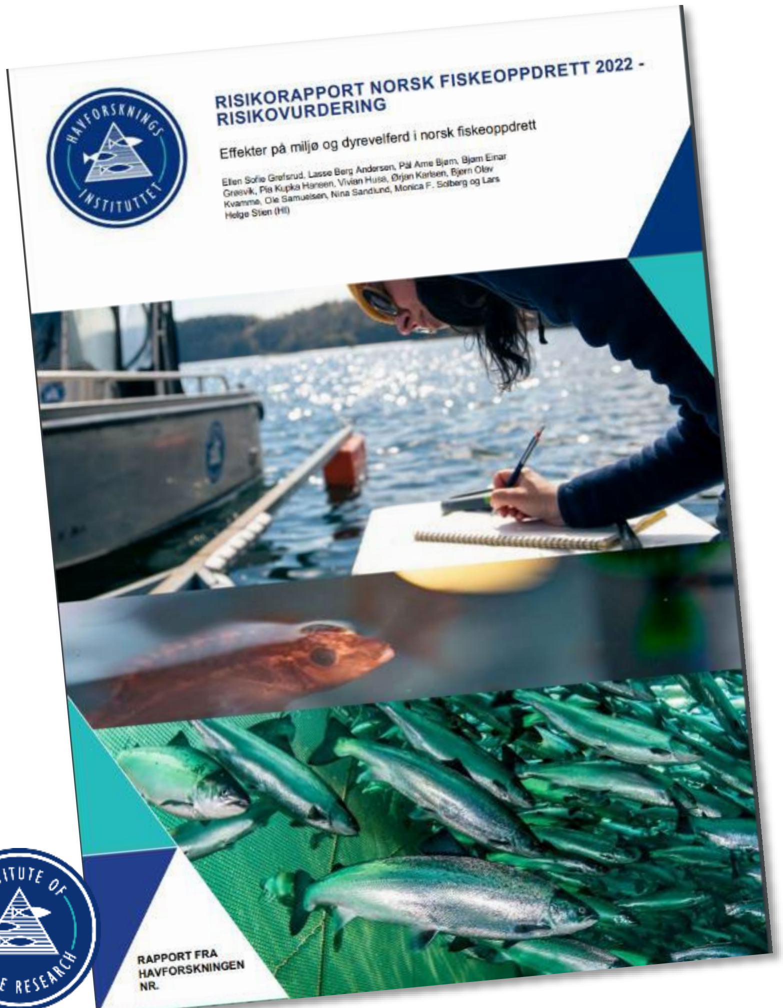
The Institute of Marine Research has provided management and decision makers with annual risk assessments on fish welfare and environmental impact of Norwegian fish farming since 2010

Risk report Norwegian fish farming 2022

The risk report consists of two parts:

- **Risk assessment**
- **Knowledge status**

Risk report Norwegian fish farming 2022



Risk assessment of environmental impact of fin fish production:

- Effects of salmon farming on wild salmon populations
- Effects of emissions from salmon farming
- Use of wild caught wrasse in salmon farming
- Animal welfare (farmed salmon and cod)
- Effects of cod farming on wild coastal cod populations

Risk report Norwegian fish farming 2022

- **Knowledge status** gives a thorough overview of the background knowledge for the risk assessment
- Updated numbers
- Scientific references

Aim of the risk assessment

- Create risk understanding and acknowledgement across stakeholders with different value perceptions
- Provide a quick overview and be intuitive to understand
- Add structure to discussions on risk
- Starting point for management priorities and measures

Risk assessment methodology

The methodology has been developed by the Institute of Marine Research and published in Andersen et al. (2022)

ICES Journal of Marine Science, 2022, 0, 1–10
DOI: 10.1093/icesjms/fsac028
Food for Thought

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

Risk understanding and risk acknowledgement: a new approach to environmental risk assessment in marine aquaculture

Lasse Berg Andersen[1,2,*], Ellen Sofie Grefsrud[1], Terje Svåsand[1] and Nina Sandlund[1]

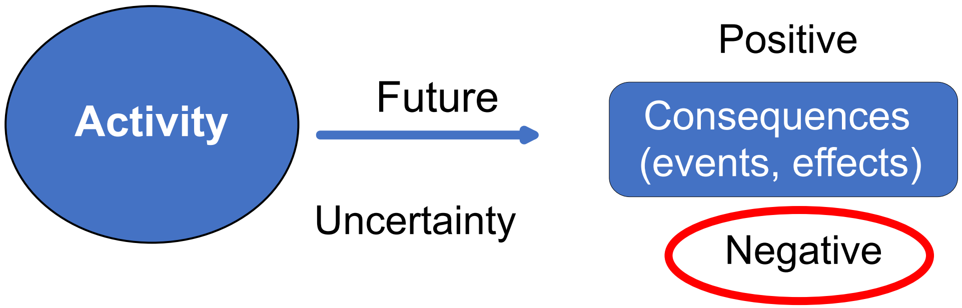
[1]Institute of Marine Research, P.O. Box 1870, Nordnes, N-5817 Bergen, Norway
[2]University of Stavanger, Kjell Arholmsgate 41, 4021 Stavanger, Norway
[*]*Corresponding author: tel: +4790957311;* e-mail: lasse.berg.andersen@hi.no.

A better understanding of the potential cumulative impacts of large-scale fish farming, could help marine aquaculture to become more environmentally sustainable. Risk assessment plays an important role in this process by elucidating the main challenges and associated risk factors. An appropriate aquaculture risk assessment should contribute to mutual risk understanding and risk acknowledgement among stakeholders, and thus common perspectives on measures and governance. In this paper, we describe an approach to risk assessment in marine aquaculture that aims to promote fruitful discussions about risk and risk-influencing factors across stakeholders with different value perceptions. We elaborate on the concept of risk and risk terminology and conclude that new aquaculture risk assessment methodology should be guided by risk science. The suggested methodology is based on the latest thinking in risk science and has been tested in a thorough study of environmental risk related to Norwegian aquaculture. The study shows that the new methodical approach has an immanent pedagogical potential and contributes to strengthening risk understanding and risk acknowledgement among stakeholders. In conclusion, the suggested risk assessment methodology has proved a valuable tool for marine scientists in analyzing, evaluating, and communicating environmental risk.

Keywords: environmental risk management, marine aquaculture, risk assessment methodology, risk communication, risk-informed decisions, risk science, risk understanding.

Risk definition

Risk is defined as *consequences of the activity with associated uncertainties* (Society of Risk Analysis, 2018)



The objective of a risk assessment is always to create clarity and understanding of potential consequences and the associated uncertainty

Approach to environmental risk assessment

- In line with the latest thinking in risk science, we place knowledge characterization and subjective probabilities at the core of the risk assessment
- True Bayesian approach
  - No true/objective probabilities exist
  - We use all available knowledge in our assessments (scientific papers, reports, expert knowledge etc.)
  - Bayesian belief networks are used to visualize cause-effect

Uncertainty (degree of belief)

- Epistemic and related to the outcome of future events
- Knowledge based (not stochastic)
- Measured by subjective probabilities (*P*), evaluation of knowledge strength (*SoK*) and the knowledge (*K*) that forms the basis for the assessment of *P* and *SoK*

Three steps for risk assessment

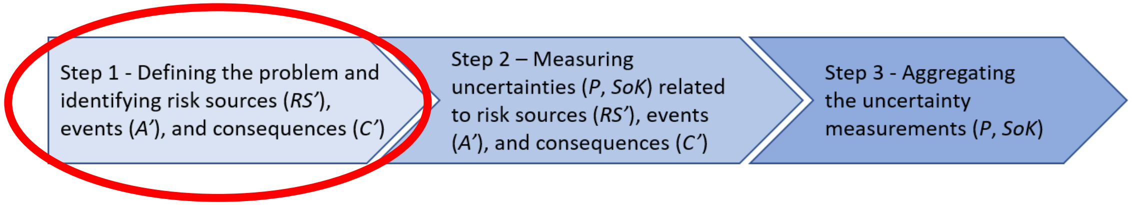
Step 1 - Defining the problem and identifying risk sources (*RS'*), events (*A'*), and consequences (*C'*)

Step 2 – Measuring uncertainties (*P*, *SoK*) related to risk sources (*RS'*), events (*A'*), and consequences (*C'*)

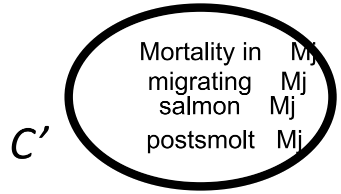
Step 3 - Aggregating the uncertainty measurements (*P*, *SoK*)

- But before you start the risk assessment process:
  - Establish context - who is the main target group? (e.g., government/management)
  - Set up expert groups – ensure to include experts on all aspects

Step 1



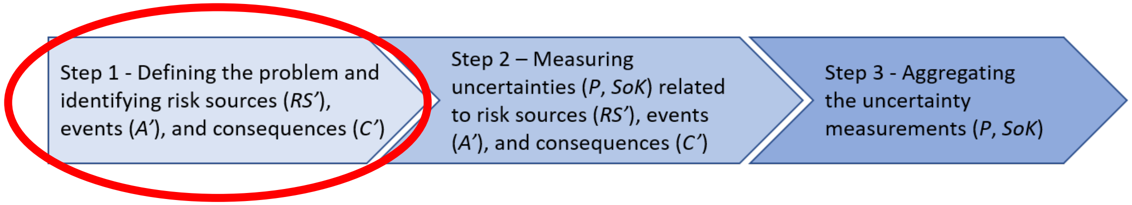
Subject of analysis (problem)



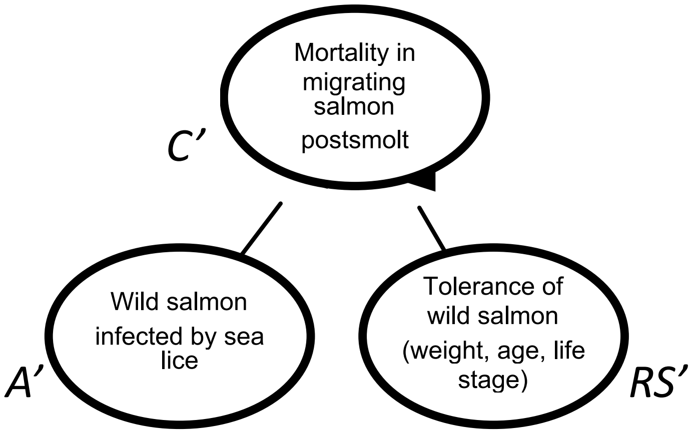
RS’ = risk sources
A’ = events
C’ = spesific consequences

Mortality in migrating salmon postsmolt due to sea lice infection caused by emission of sea lice from salmonid production (in a specific geographical area and production volume)

Step 1

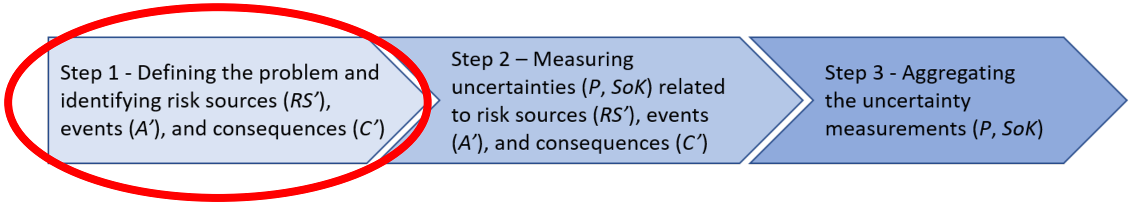


Subject of analysis (problem)

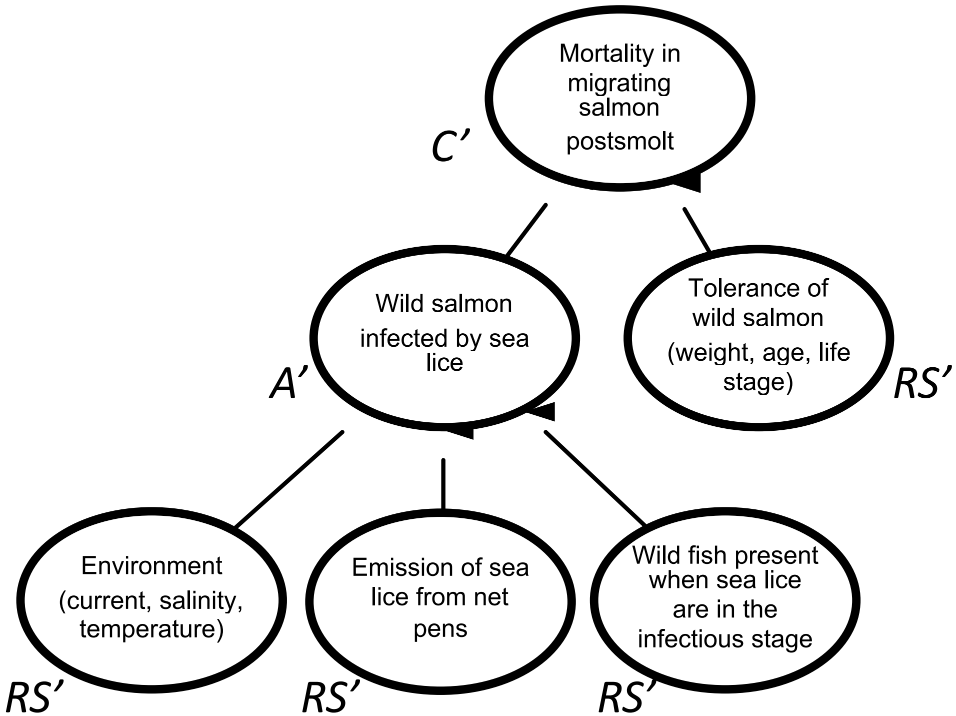


RS' = risk sources
A' = events
C' = spesific consequences

Step 1

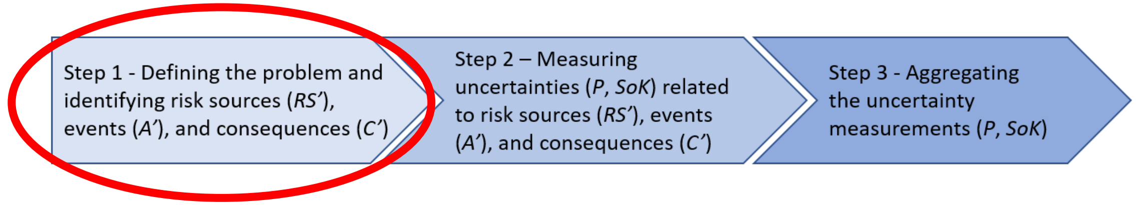


Subject of analysis (problem)

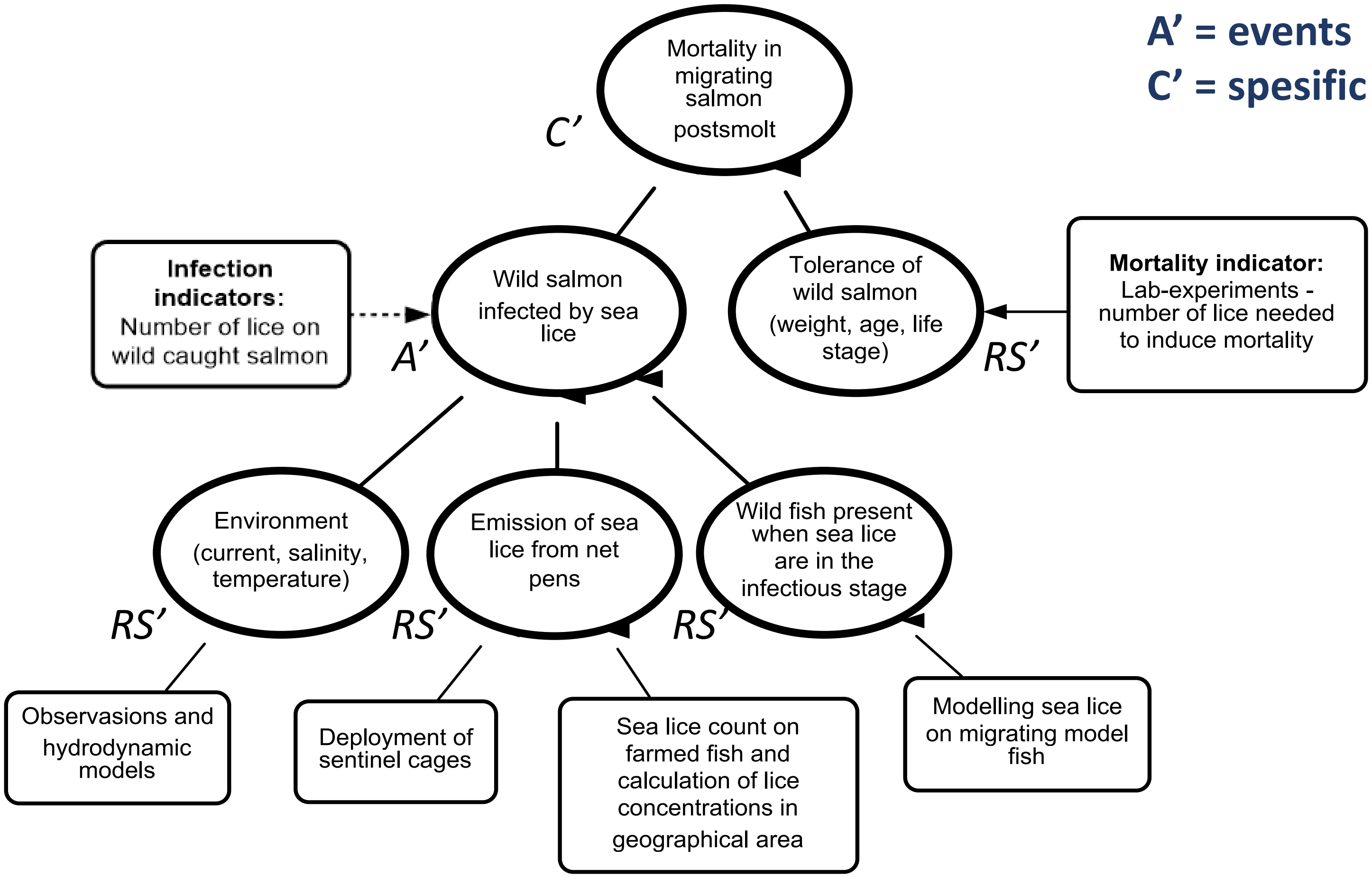


RS' = risk sources
A' = events
C' = spesific consequences

Step 1



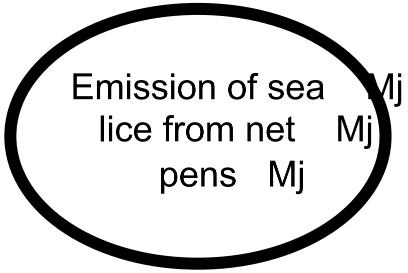
Subject of analysis (problem)



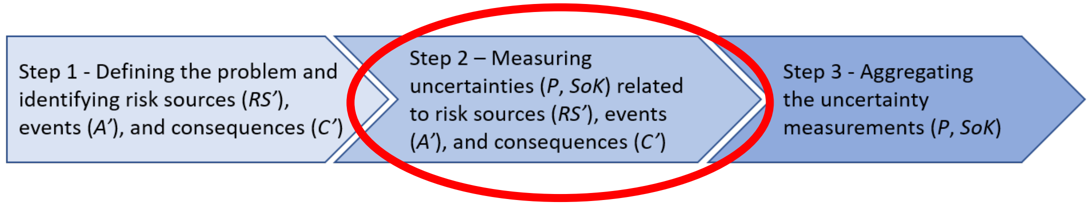
RS′ = risk sources
A′ = events
C′ = spesific consequences

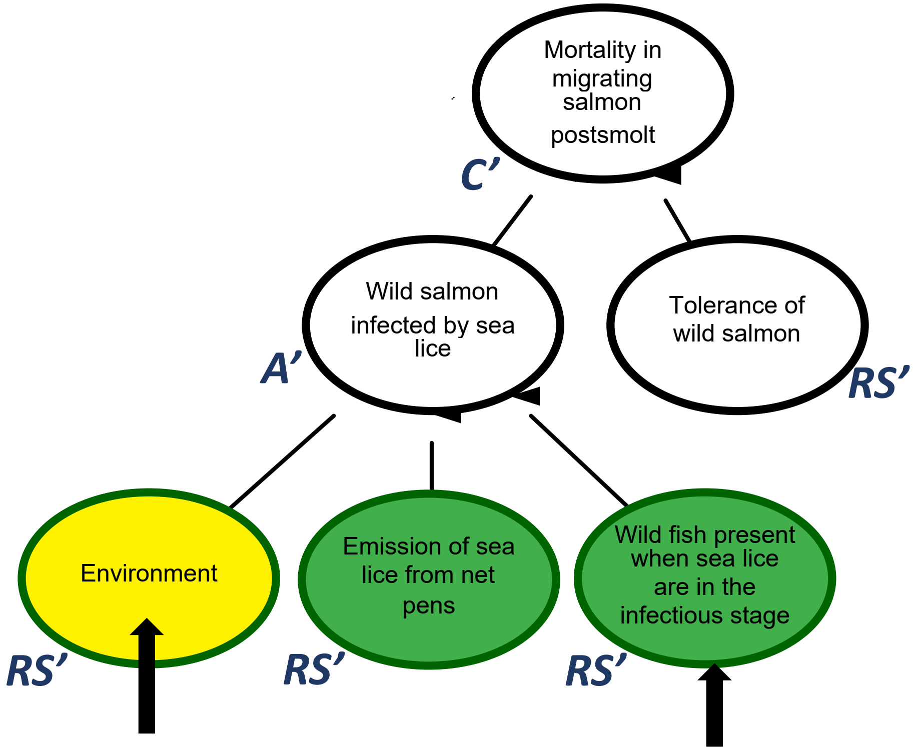
Define the desired state

- Each risk source, event and consequence has a desired state
- A state where the probability for RS’, A’ or C’ to occur is considered low or minor, and in line with accepted threshold values (if such exists)
- Example: *The desired state is low or minor emissions of sea lice from net pens*



Step 2





Arguments related to *P and SoK* values

Miljøforhold. … oltutvandringen. Det er oftest b… de øvre vannlag. Det er oppdrettsanlegg i de fleste fjordene, og smittekartene viser at det år om annet er lakselus i alle delene av PO2 under utvandringsperioden for laks. Miljøforholdene vurderes derfor som moderate for lakselus under utvandringen av postsmolt av laks.

Utslippet av lakselus fra anlegg har økt i perioden 2012–2020, med høyere utslipp under utvandringsperioden for laks de 5 siste årene i forhold til 2012-2015. Den negative trenden gjør at vi vurderer utslippene av lakselus i PO2 som høyt og tilstanden som dårlig.

Overlapp mellom fisk og lus i tid og rom. Utvandringen til laks er kartlagt for enkelte elver, og det antas at utvandringen av laks fra elvene i området hovedsakelig foregår i tidsrommet 24. april-10. juni, mens dato for median utvandring (dato når halvparten av smolten har vandret ut) som snitt for alle elvene i området er satt til 18. mai.

Utvandringsrutene i området varierer fra korte til middels lange for laks. De siste 5 år er det utslipp av lakselus tidligere i sesongen enn i perioden 2012 - 2015. PO2 er vurdert å ha høy grad av overlapp i tid og rom mellom lus og laksesmolt og tilstanden vurderes som dårlig. Kunnskapsstyrken regnes som moderat, da utvandringsrutene og oppholdstiden i fjordene ikke er fullstendig kartlagt.

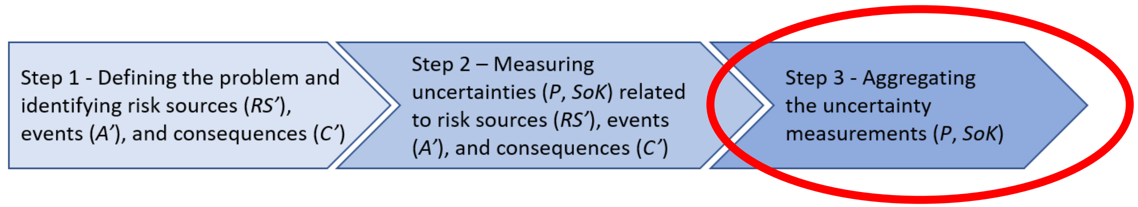
Probability(P)

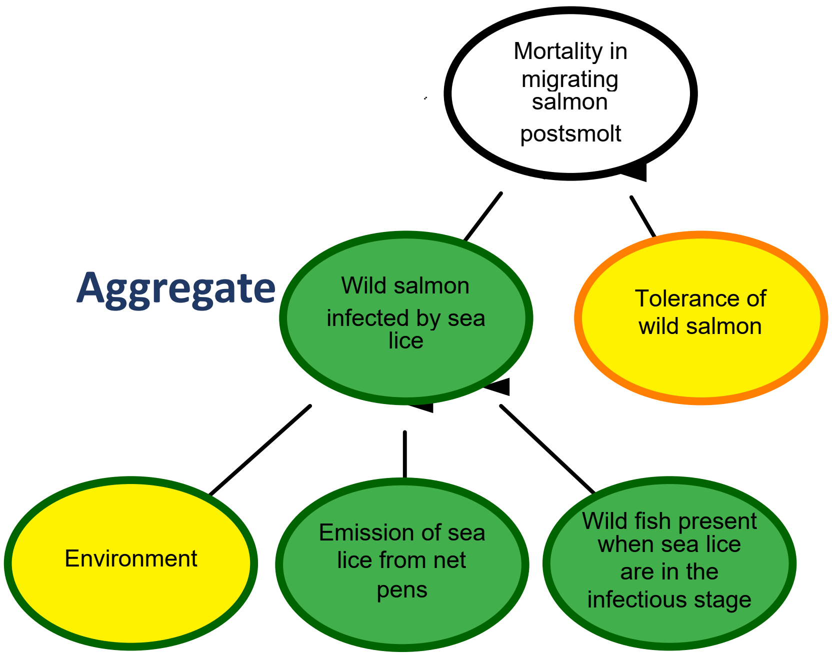
- **Low probability**
- **Moderate probability**
- **High probability**

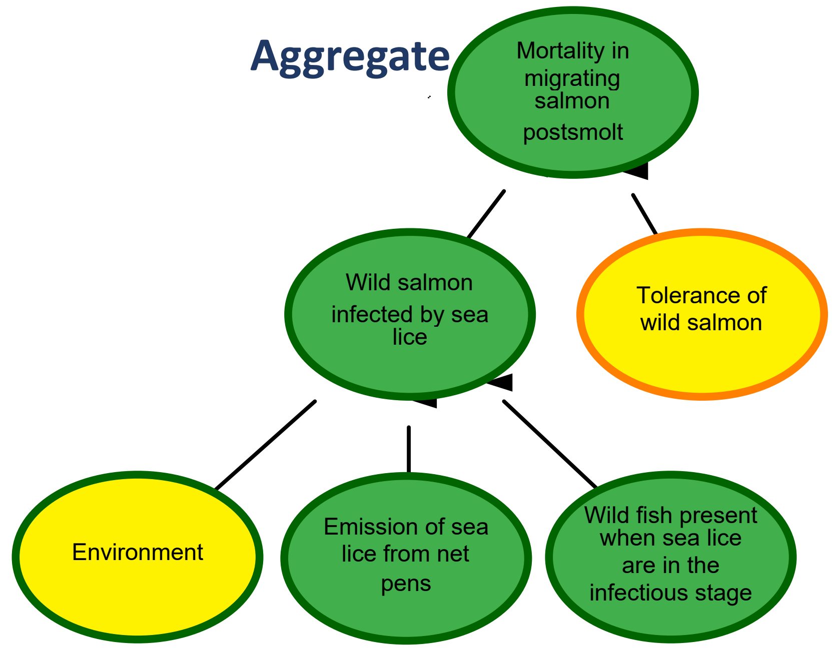
Strength of Knowledge (SoK)

- **Strong background knowledge**
- **Moderate background knowledge**
- **Weak background knowledge**

Step 3







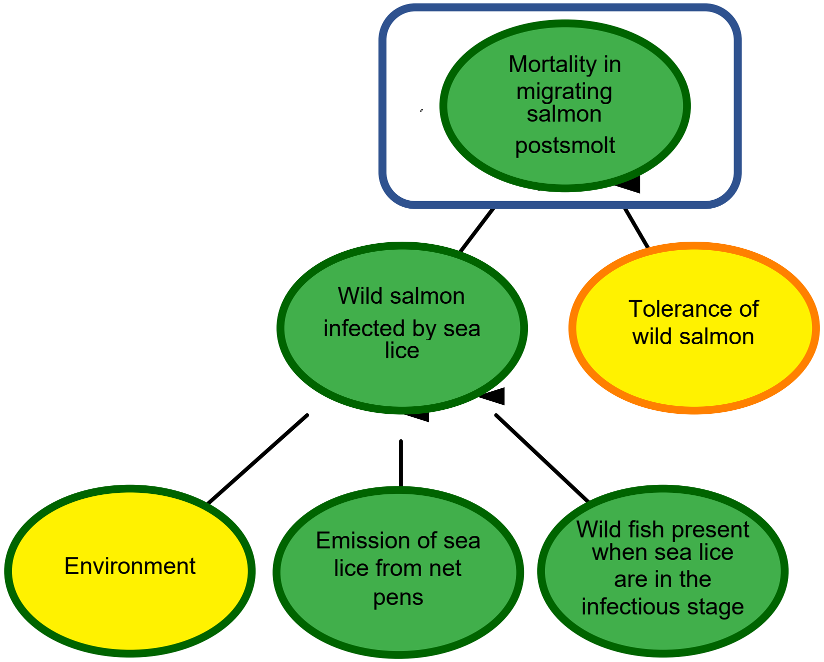
Arguments related to aggregated measurements

Over ... antas at utvar ... dato for median utvandring (dato når halvparten av smolten har vandret ut) som snitt for alle elvene i området er satt til 18. mai.

Utvandringsrutene i området varierer fra korte til middels lange for laks. De siste 5 år er det utslipp av lakselus tidligere i sesongen enn i perioden 2012 - 2015. PO2 er vurdert å ha høy grad av overlapp i tid og rom mellom lus og laksesmolt og tilstanden vurderes som dårlig. Kunnskapsstyrken regnes som moderat, da utvandringsrutene og oppholdstiden i fjordene ikke er fullstendig kartlagt.

Conclusion

In this case the risk of mortality of migrating salmon postsmolt is **low**, which is supported by a **strong** knowledge background



Risk and knowledge-based management

- Risk assessments should be part of the management's decision basis, and contribute to a sustainable development of aquaculture in line with national and international sustainability goals
- A contribution to create a more comprehensive picture of the impacts on marine environment
- Assessing risk is a continuous process and the assessment of influencing factors and the risk associated with these will change in line with increased knowledge

Thank you for listening

Photo: Liv Eva Kirksæther/HI