

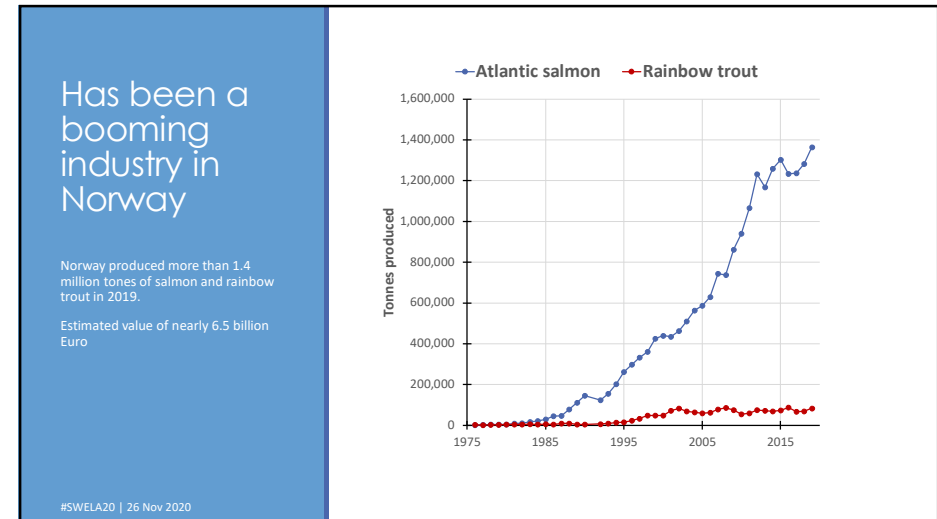


Operational Welfare Indicators for Salmon

Dr Lars Helge Stien
Institute of Marine Research, Norway



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Based on open sea cages

Salmon farms are scattered along the Norwegian coastline from south to north.




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Low level of control

Feed particles, feces and other metabolites emanating from the fish are removed by the natural water current at the location, which also replenishes the cage with new fresh oxygen saturated water.

But outside pathogens have also free access to the sea cage.

Pictures shows salmon being attacked by sea lice (*Caligus elongatus*)



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Can be very difficult to assess fish welfare in a sea cage

Welfare indicators are measurements and observations that say something about the welfare status of the fish.

Fish welfare?

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The FISHWELL handbooks for Atlantic salmon and Rainbow trout

Welfare Indicators for farmed Atlantic salmon: tools for assessing fish welfare

Welfare Indicators for farmed rainbow trout: tools for assessing fish welfare

Can be downloaded from <https://nofima.no/en/fishwell/>

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Operational Welfare Indicators

Results from projects: FISHWELL (FHF: 901157), LAKSVEL (FHF: 901554), CROWDMONITOR (FHF: 901595), AND TRIPVEL.

Collaborations with Nofima, Norwegian Veterinary Institute, Nord University, University of Stirling, Norway Royal Salmon, Marin Helse AS

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Welfare indicators

Input WIs → The fish → Outcome WIs

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Welfare indicators

Operational WIs (OWIs)



Lab based WIs (LABWIs)



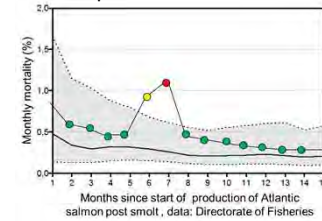
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Outcome OWIs

Group OWI



Individual OWI



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Example of a group-based outcome OWI

Abnormal behaviour: The populations aggregate in the surface, standing against the current.



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Example of a group-based outcome OWI

Illustration of different levels of crowding intensity during surface monitoring of behaviour according to the RSPCA and Mejdell et al.



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Different interests

- Fish farmers want to have a welfare assessment system that is easy and fast to use.
- Fish health personnel want a system that gives detailed information that they can use to diagnose the fish.
- All want a system that can identify deteriorating welfare conditions before they become detrimental to the fish, and there still is time to perform mitigating measures.

A photograph showing a large, dark fishing net being pulled up from the water. The net is filled with many small, silvery fish. The net is attached to a dark, cylindrical structure, possibly part of a boat or a large container. The water is dark and choppy.

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Framework for Welfare Monitoring

Framework for utilizing different Operational Welfare Indicators (OWIs) and Laboratory-based Welfare Indicators (LABWIs) in an on-farm welfare assessment.

```
graph TD
    subgraph Level1 [Level 1  
Daily management]
        direction LR
        IOW1[Input OWIs  
Basic observations of feeding and rearing environment]
        OOW1[Outcome OWIs  
Basic observations of fish behaviour, appearance and mortality]
        IOW1 --> OOW1
    end

    subgraph Level2 [Level 2  
When level 1 outcome OWIs are compromised]
        direction LR
        IOW2[Input OWIs  
Detailed assessment of water environment, rearing practices etc.]
        OOW2[Outcome OWIs  
Detailed assessment of compromised fish and blood and faecal samples (LABWIs)]
        IOW2 --> OOW2
    end

    subgraph Level3 [Level 3  
When level 2 outcome OWIs are compromised  
Expert personnel needed]
        direction LR
        IOW3[Input WIs  
Technical analysis of the rearing system, identifying pathogens in system (LABWIs)]
        OOW3[Outcome WIs  
Fish health diagnosis, blood and tissue samples (LABWIs)]
        IOW3 --> OOW3
    end

    OOW1 -- "Not enough information" --> IOW2
    OOW2 -- "Not enough information" --> IOW3
```

The flowchart illustrates a three-level framework for welfare monitoring. Level 1 (Daily management) involves basic observations of feeding, rearing environment (Input OWIs) and fish behavior, appearance, and mortality (Outcome OWIs). If there is 'Not enough information' from Level 1 Outcome OWIs, the process moves to Level 2. Level 2 (When level 1 outcome OWIs are compromised) involves a detailed assessment of the water environment and rearing practices (Input OWIs) and a detailed assessment of compromised fish and blood/faecal samples (Outcome OWIs, which are LABWIs). If there is 'Not enough information' from Level 2 Outcome OWIs, the process moves to Level 3. Level 3 (When level 2 outcome OWIs are compromised, Expert personnel needed) involves a technical analysis of the rearing system and identifying pathogens (Input WIs, which are LABWIs) and fish health diagnosis, blood, and tissue samples (Outcome WIs, which are LABWIs).

Welfare Indicators for farmed Atlantic salmon
Book for aquaculture fish health

Welfare Indicators for farmed rainbow trout
Book for aquaculture fish health

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[illegible]

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Outcome Welfare schema level 1

- Developed to be used on the fish sampled in connection with the obligatory weekly lice counts at Norwegian salmon farms.
- Easy and fast to use.
- All indicators are scored according to a 0–3 scale: (0) No or very minor damage, (1) minor damage, (2) clear damage, and (3) extreme.

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Scoring rules:

0	=	No or very minor damage / defect
1	=	Minor damage / defect
2	=	Clear damage / defect
3	=	Extreme - reason for culling

OWI – Upper jaw deformation



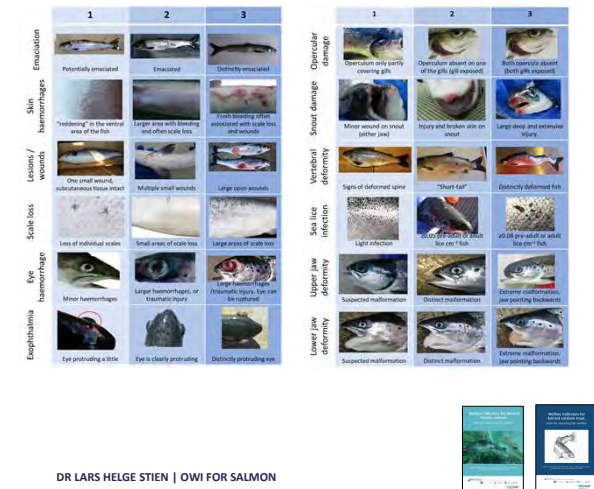
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Outcome OWIs from FISHWELL

- Examples of outcome-based OWIs based on the appearance of individual fish from the FISHWELL-handbooks for Atlantic salmon and Rainbow trout

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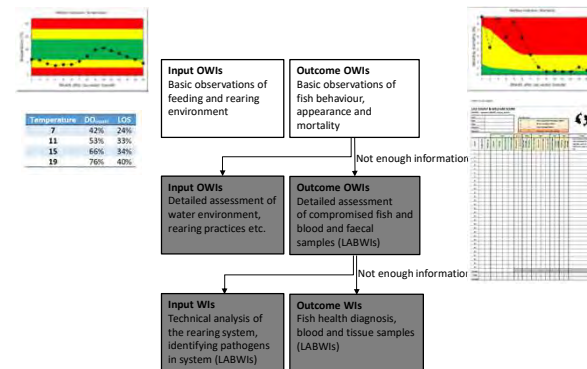
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Framework for Welfare Monitoring Level 1

Daily management: Basic observations

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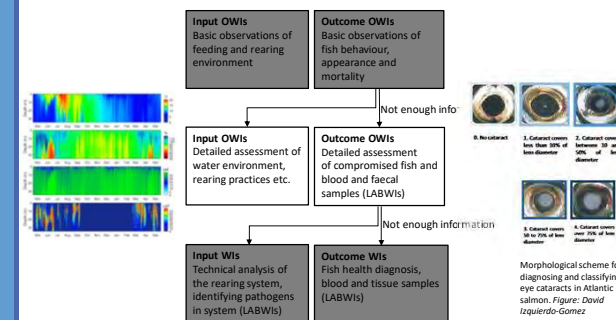
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Framework for Welfare Monitoring Level 2

When level 1 outcome OWIs are compromised

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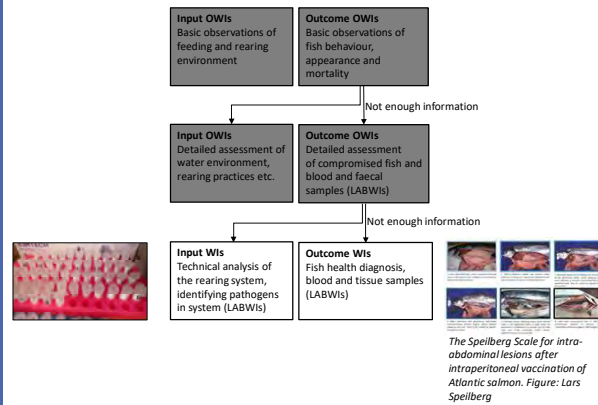
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Framework for Welfare Monitoring Level 3

When level 2 outcome OWIs are compromised Expert personnel needed

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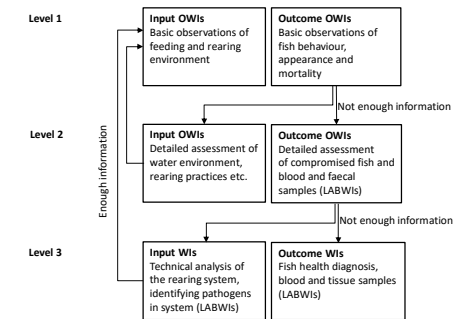


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Framework for Welfare Monitoring

Return to Level 1 when enough information.

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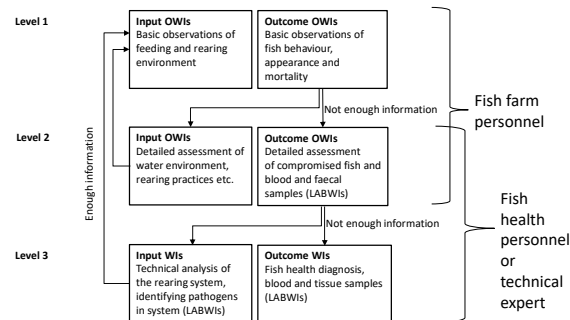


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Framework for Welfare Monitoring

Framework for utilizing different Operational Welfare Indicators (OWIs) and Laboratory-based Welfare Indicators (LABWIs) in an on-farm welfare assessment.

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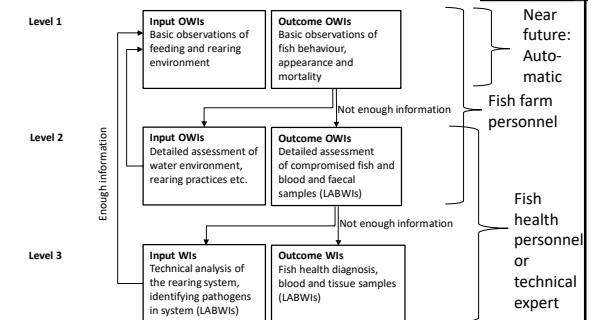
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Framework for utilizing different Operational Welfare Indicators (OWIs) and Laboratory-based Welfare Indicators (LABWIs) in an on-farm welfare assessment.

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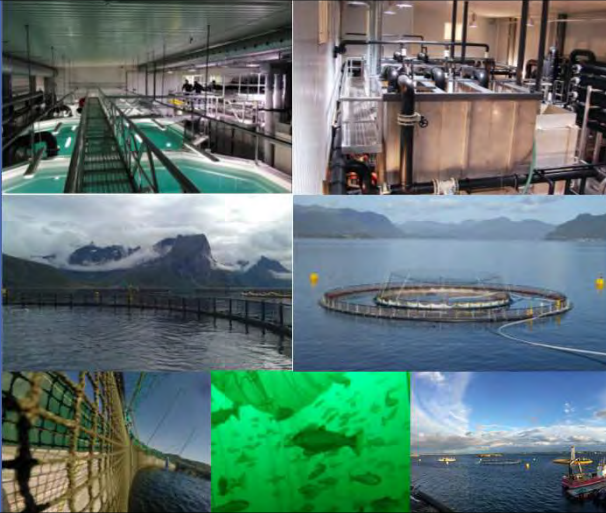


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The FISHWELL handbooks for Atlantic salmon and Rainbow trout

Includes chapters discussing recommended WIs for different rearing systems and operations




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FISHWELL OWIs for salmon in sea cages

Includes chapters discussing recommended WIs for different rearing systems and operations



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Input

Environment based OWIs

- Oxygen
- Temperature
- Salinity
- Water velocity
- Light
- Stocking density
- Total suspended solids
- Turbidity

→

Outcome

Group based OWIs

- Appetite
- Growth
- Mortality
- Deviation from normal behaviour
- Emaciated fish
- Disease/health

→

Outcome


Individual based OWIs

- Emaciation state
- Scale loss and skin condition
- Eye status
- Deformities
- Smoltification state
- Fin damage
- Opercular damage
- Mouth/jaw damage
- HSI
- CSI
- Condition factor
- Gill status
- Sea lice
- Sexual maturation
- Feed in intestine

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Thank you for your attention

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