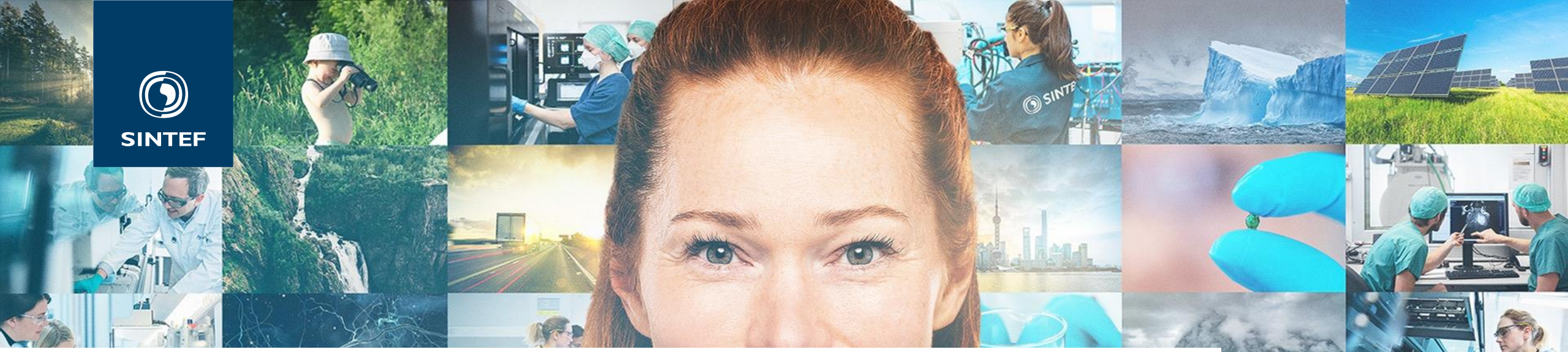


Towards Automated Welfare Assessment in Aquaculture Using AI and Computer Vision

Fremtidens smoltproduksjon, Sunndalsøra, 15 Oct 2026

Dr. Christian Schellewald, senior researcher
SINTEF Ocean



Outline: Measuring Fish Welfare with Computer Vision Technology

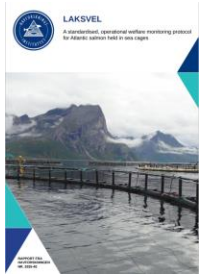
- Can we measure fish welfare with computer vision?
- From camera images to welfare information
  - Camera/video → Fish-level measurements → Welfare indicators → Decision support
- Focus Today:
  - Scale loss · Respiration · Movement · Individual monitoring

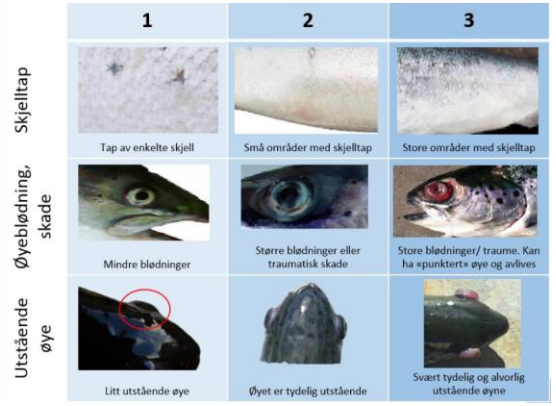
Can we measure welfare with Computer Vision?

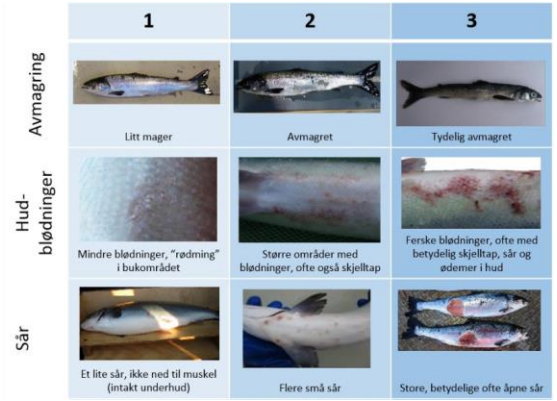
- Fish perspective:
  - **Animal welfare = the quality of life as perceived by the animal itself (**Stien et al., 2013**)**
    => see “Welfare indicators for farmed Atlantic salmon” (**FISHWELL/LAKSVEL**)

  - We **cannot measure** the **salmon’s experience directly**, but we can measure: Respiration, Swimming behaviour. Wounds/Scale loss, distribution, etc.









=> Our aim/approach:
Automate and objectively measure **visual operational welfare indicators (OWI).**

Computer Vision: Challenges in Underwater

Underwater recordings belong to the most challenging image sequences for analysis with Computer Vision:

Why is this difficult?

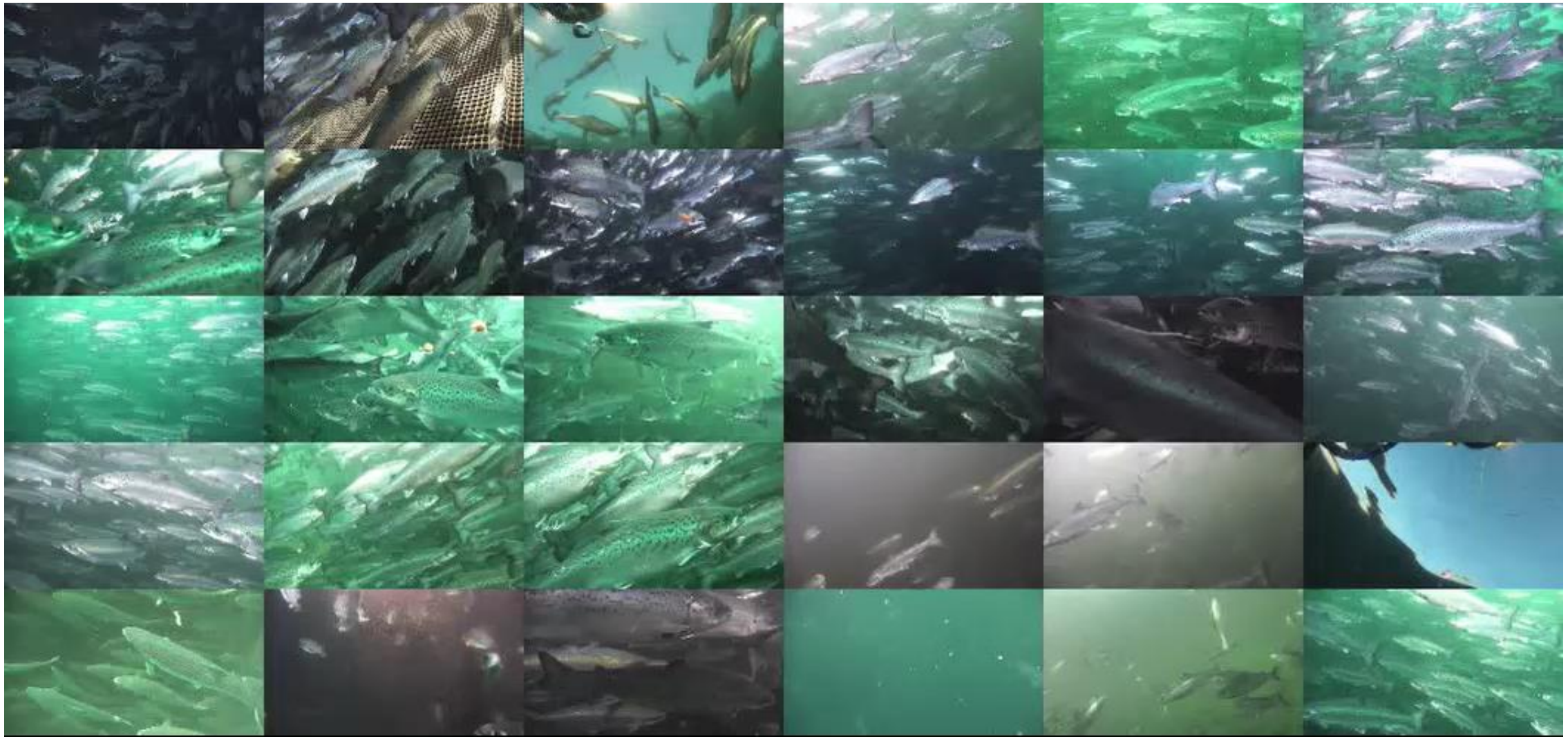
- Poor visibility
- Changing light
- Moving camera
- Fish overlap
- Deforming animals



→ Good image quality is an advantage (HD+)

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Robustness is an important "Key to Success"



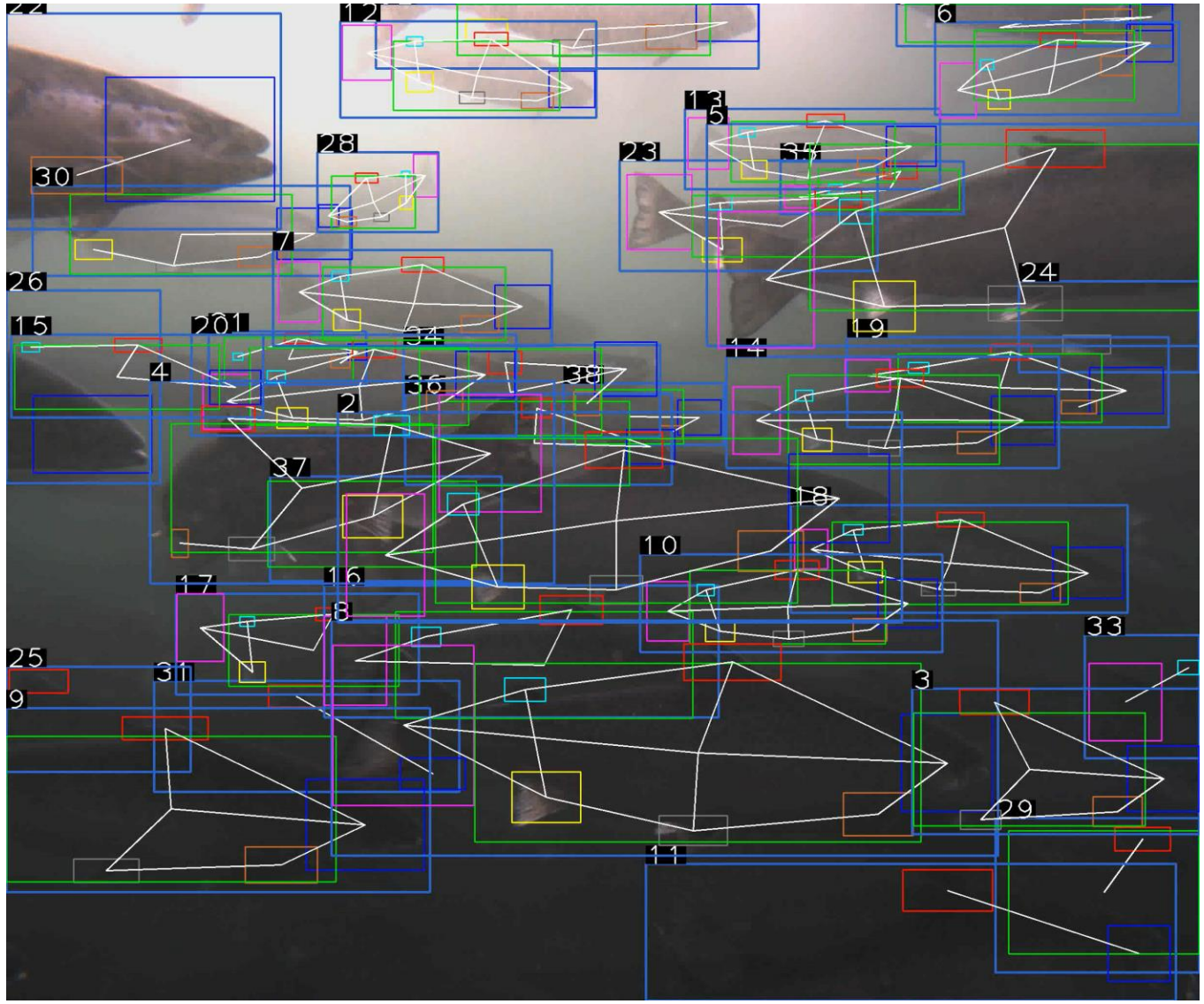
Large scene variations: Same salmon cage, same camera!

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Salmon Tracking

- Use of AI methods to track the fish + fish parts
- track in difficult conditions
  - Lighting/turbidity
  - Turning salmon
  - Occlusion of fish

=> Reliable tracking enables more detailed analysis!

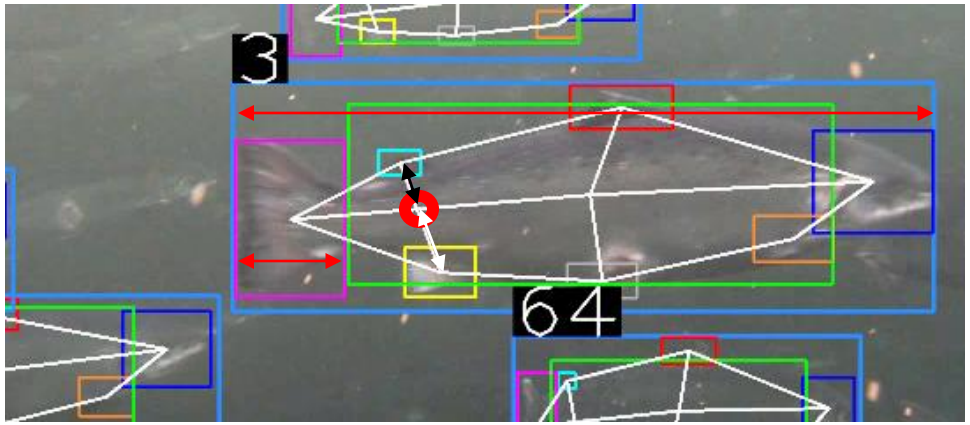


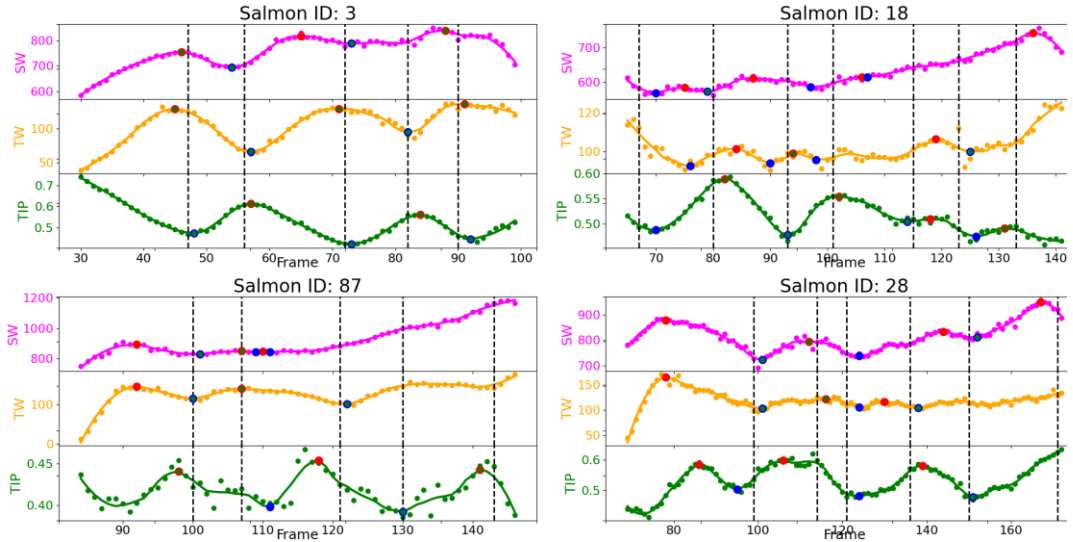
E. U. Høgstedt, C. Schellewald, A. Stahl, and R. Mester, "A Multi-purpose Tracking Framework for Salmon Welfare Monitoring in Challenging Environments," in *Proc. ICCV 2025 Joint Workshop on Marine Vision (CVAUI & AAMVEM)*, 2025.

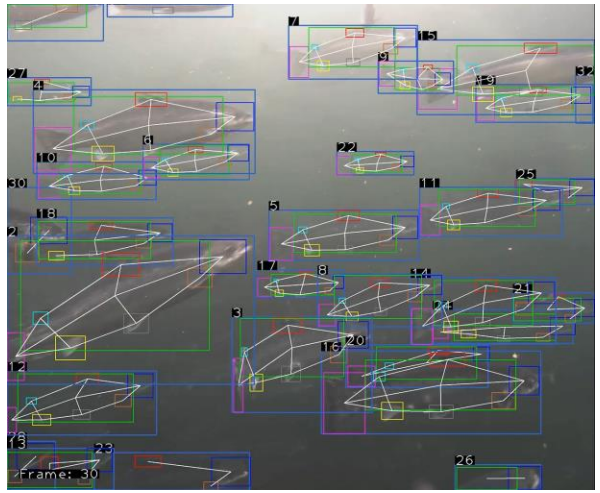
Tail beat analysis as a potential welfare indicator

Interpretation requires context: Current speed, temperature, oxygen

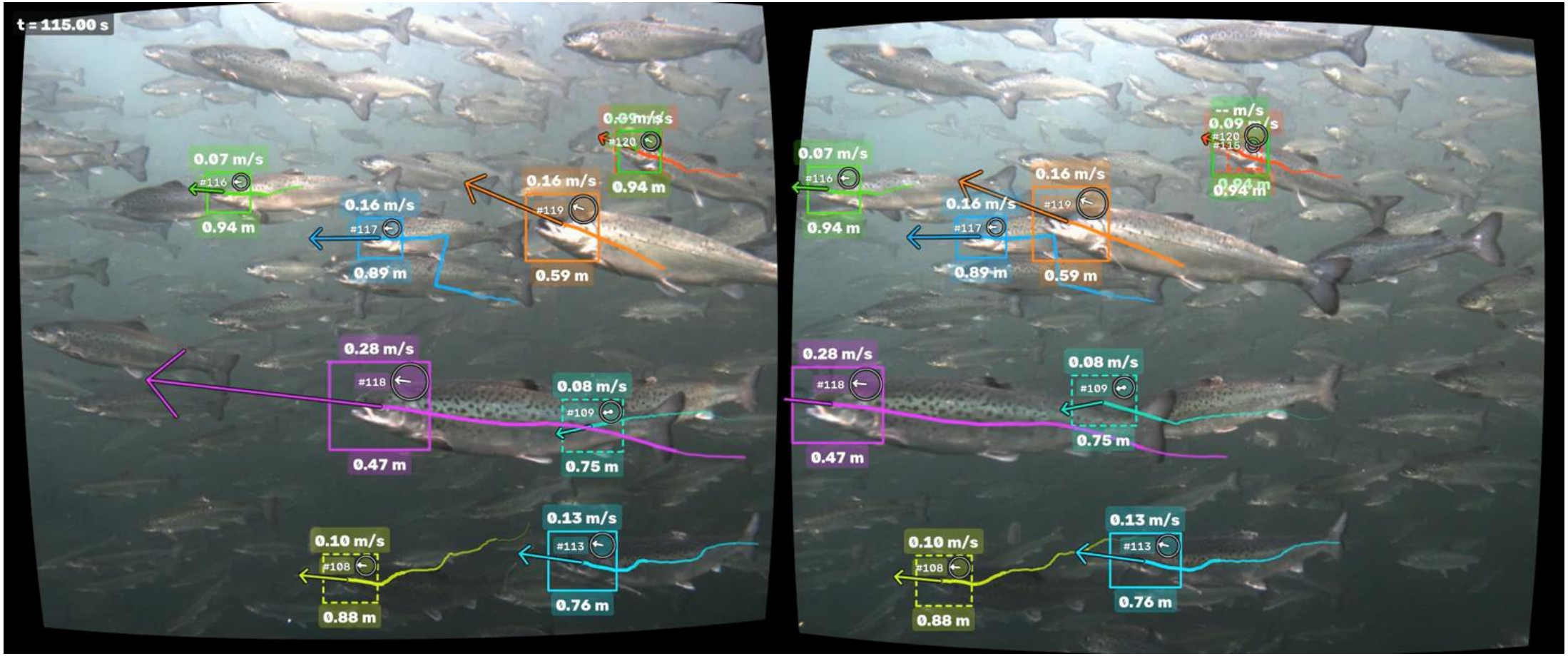
- Dynamic measurements of:
  - Tail fin width
  - Salmon width
  - Tail intersection point
- Frequency analysis: peaks, wavelengths







3D “Swimming speed”



Relative motion of the fish to the camera.

Respiration – Mouth Motion Analysis

"Different options to measure the breathing of salmon"

Interpretation requires context: Current speed, temperature, oxygen

Jaw keypoints: Individual Breathing (in tanks)



Mouth-opening-freq. (in Cage):



A classical "Optical-Flow" approach is used to analyze the mouth motion.

Opening phase

Closing phase

Ground truth

"Measurement"

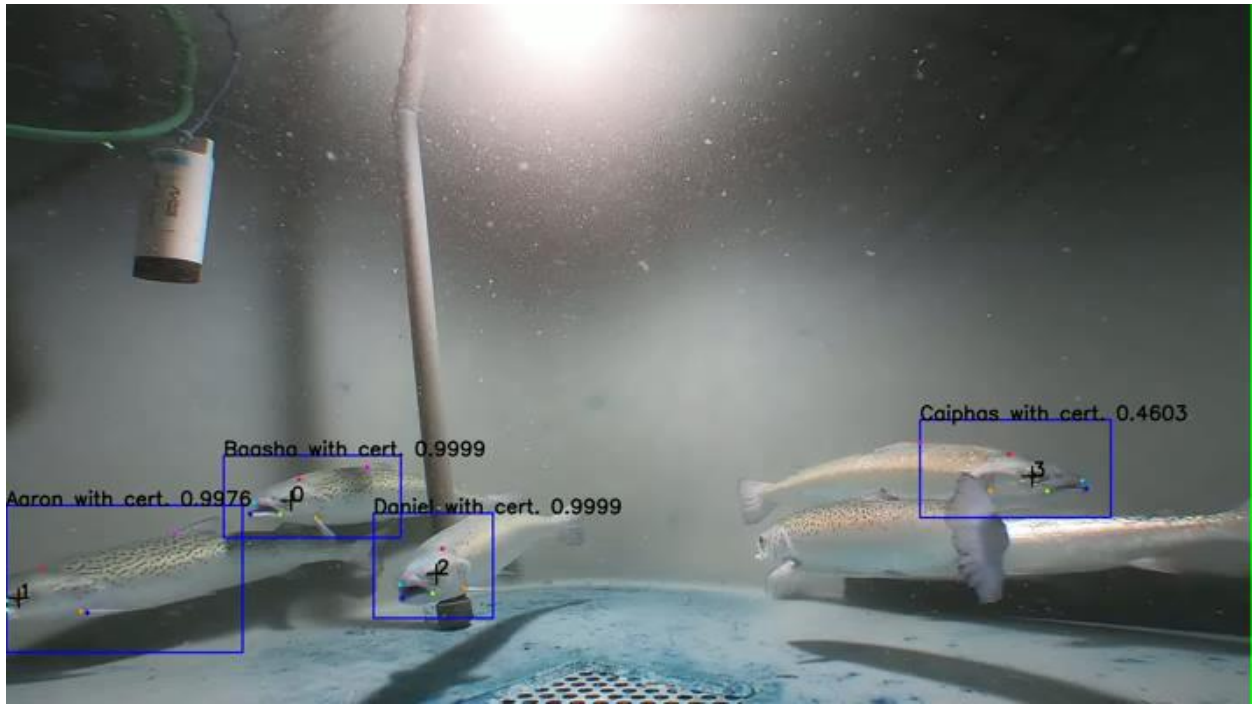
Høgstedt, E. B., Schellewald, C., Mester, R., Stahl, A., "Automated computer vision based individual salmon (Salmo salar) breathing rate estimation (sabre) for improved state observability," Aquaculture, 2024.

Schellewald, C., Aya, S., Stahl, A., "Mouth opening frequency of salmon from underwater video exploiting computer vision," IFAC-Paper, 2024.

Related Projects: cAlge, BIORELEVANS [FHF901736], OWITOOLS [FHF901594], INDISAL [NFR282423], ReduSår [FHF901835]

Mouth Opening + Individual Identification

Tank 9 (high Temperature)



Tank 5 (lower Temperature)



Observations



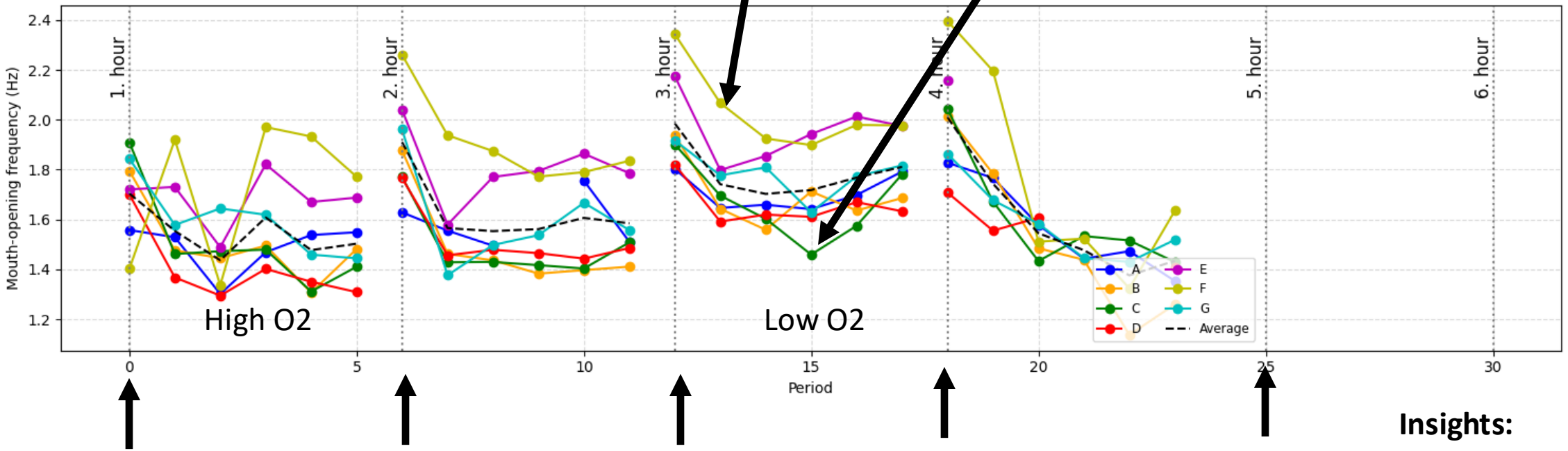


"Fast breather!"

"Slow breather!"

Breathing Measurements for one Tank:

Salmon Mouth Opening Frequency, Tank 8, High Temp, both cams, 28.09.2022



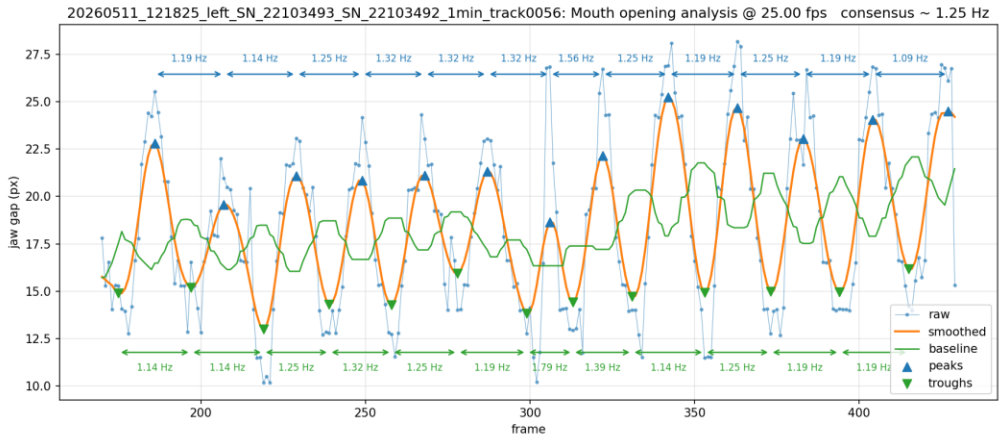
Insertions of the cameras! => Higher breathing frequencies measured!

Insights:
A: "Personality"!!!
B: Increased breathing with camera change!

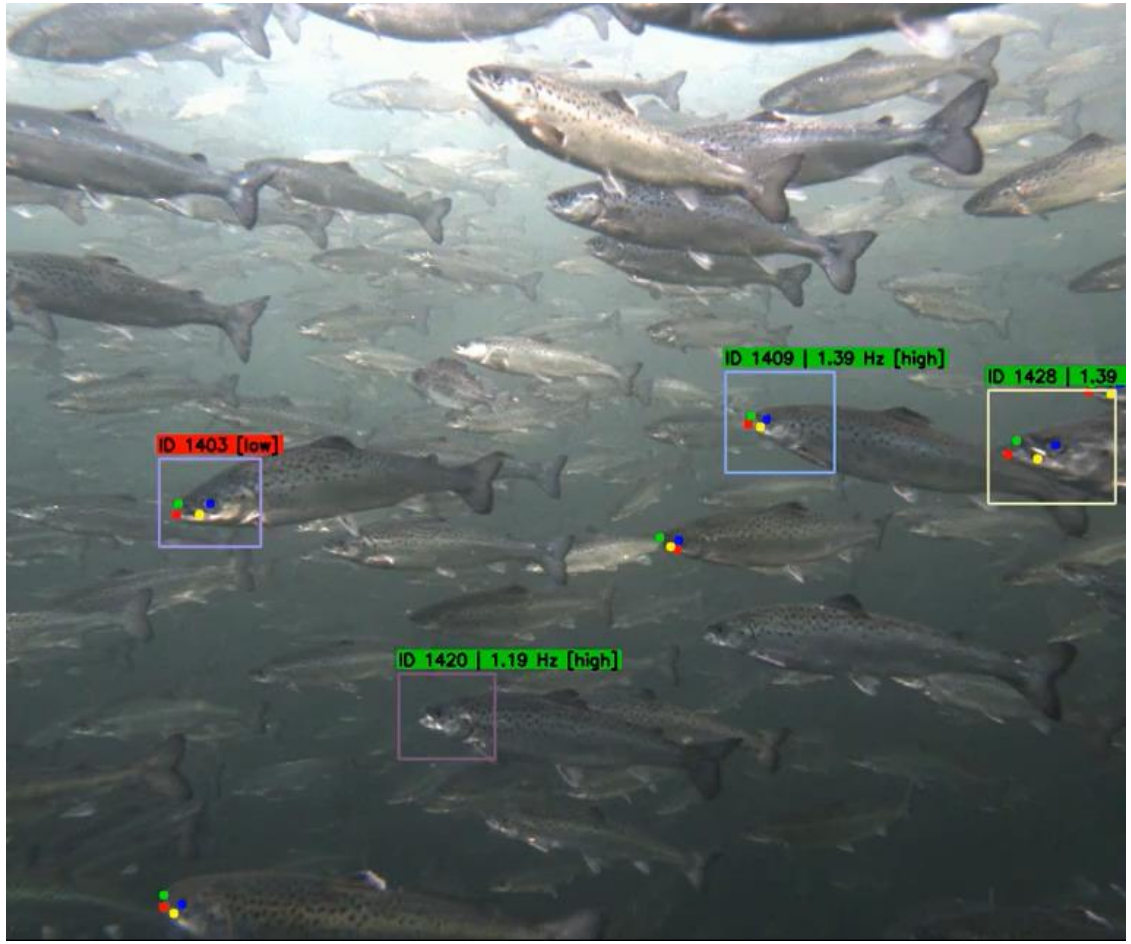
Mouth Opening in cage ….

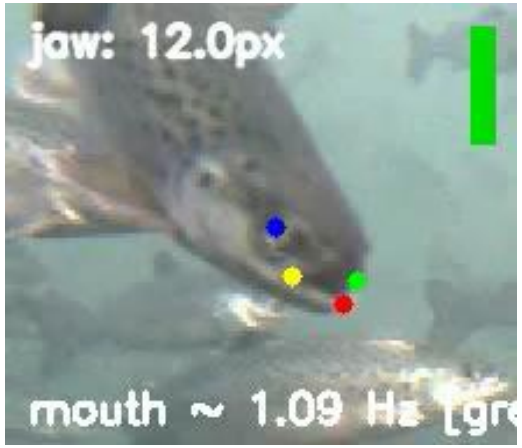


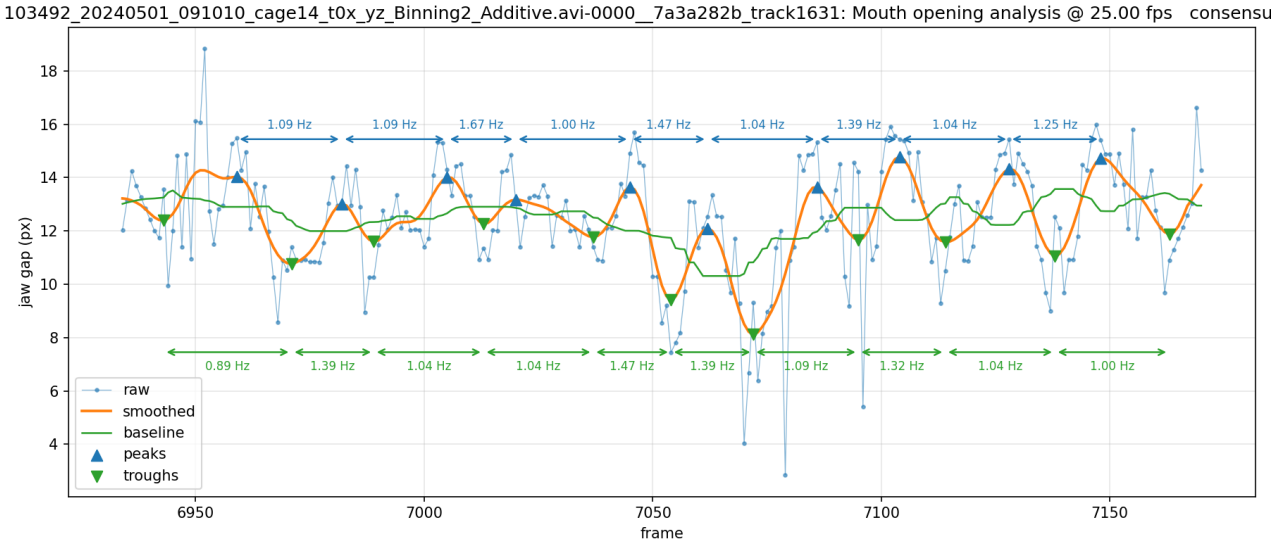




Early Sea phase





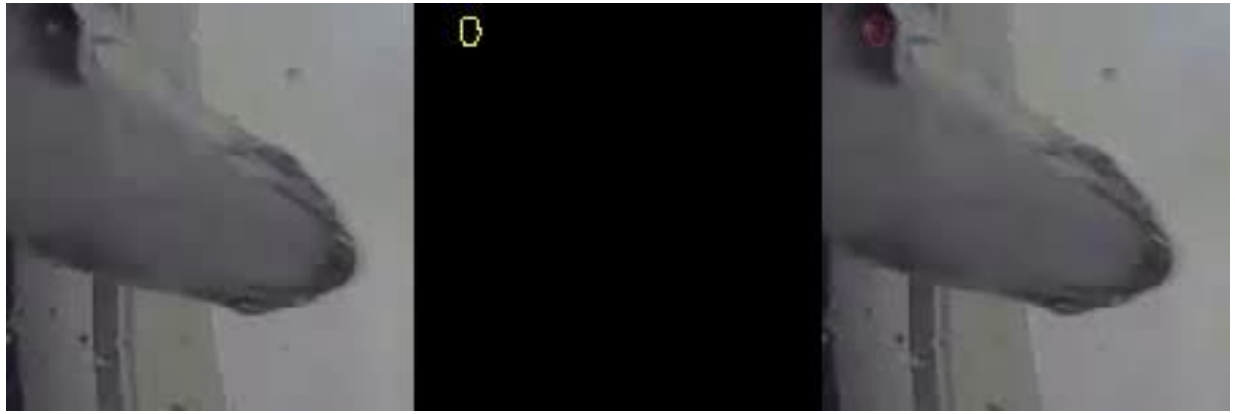


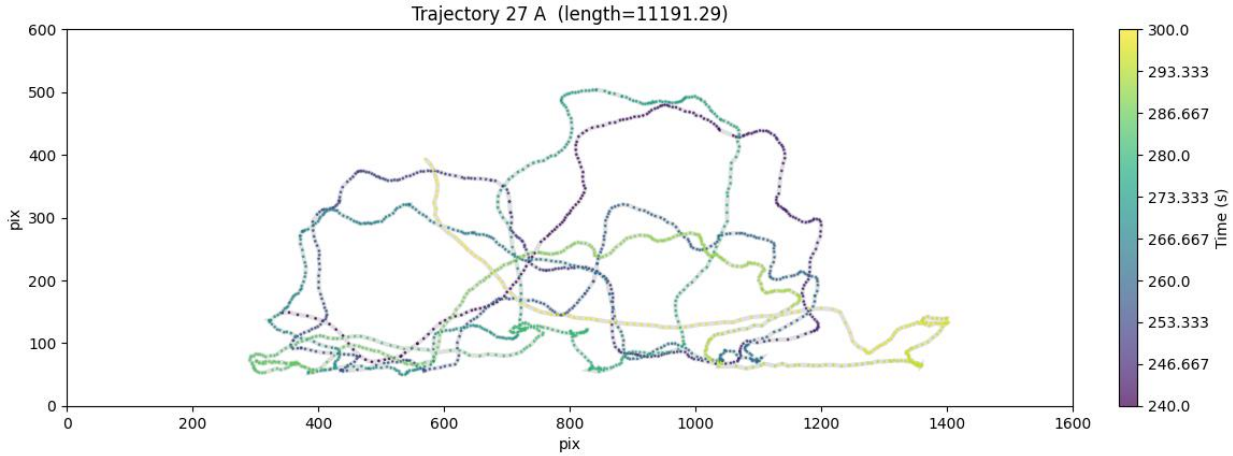
Salmon in more Controlled scenes (Motion)

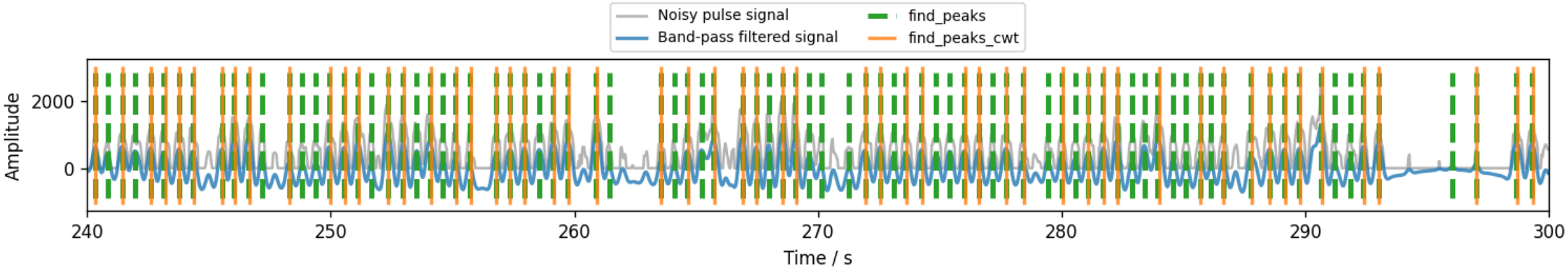
- A filming of the fish from below in a swim-tunnel/aquarium allows for a Bottom-Up view analysis
  - 1. Use Object-Detection methods (i.e. YOLO) to track the fish-head
  - Track/Follow the head
  - Detect and analyse the visible surface of the gill-opening



Salmon in Controlled Scenes (Motion + Breathing)



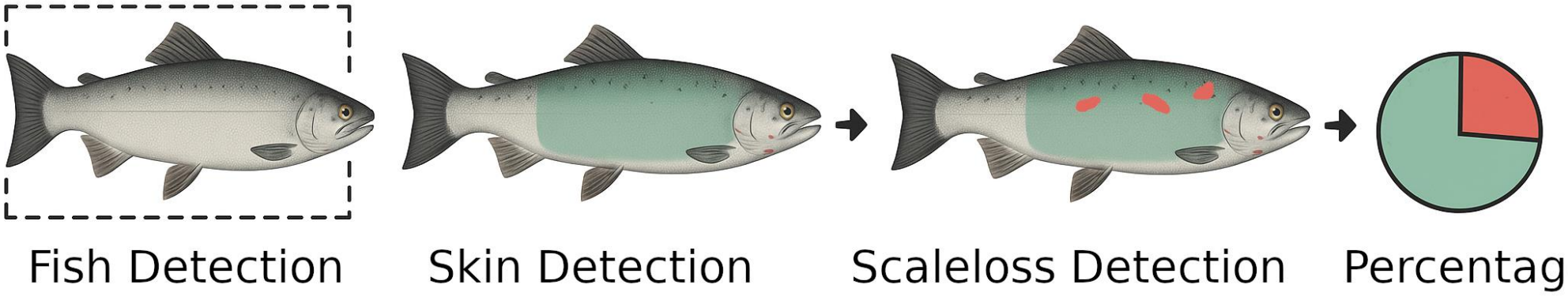




Related Project: Pressure-Chamber experiment to “simulate” pumping: 84 salmon

FHF: OWITOOLS Preliminary observation: High breathing freq. 90+/min [1.5+Hz] in all pressure phases

Detection of Scale Loss

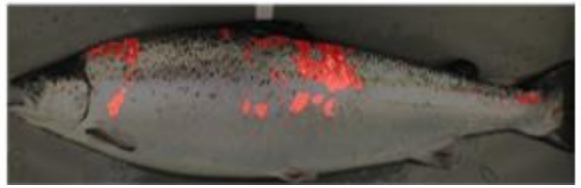


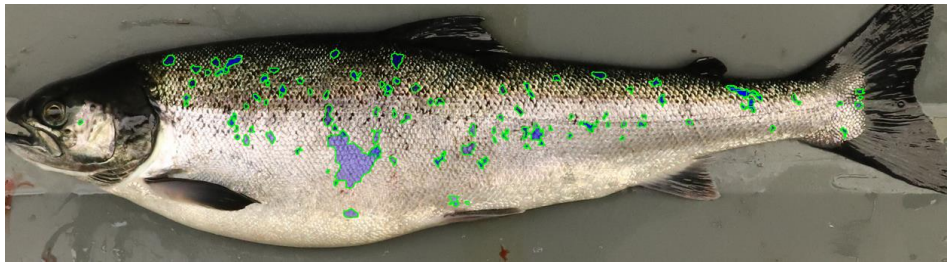
- Objective measurement of Scale loss
  - Multistep: crop fish, skin + scale-loss detection

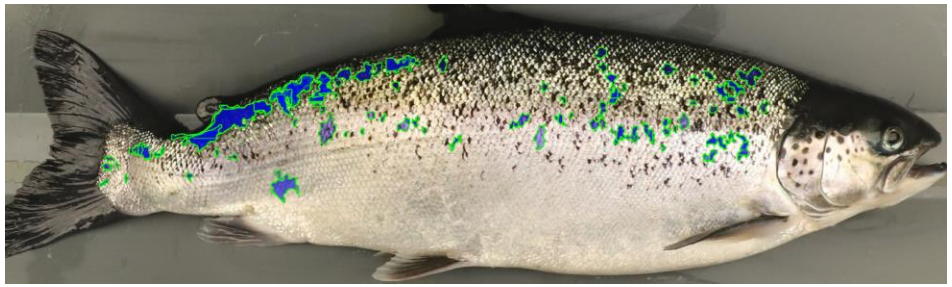




Skin mask







=> F1 score of 76.3% for scale loss segmentation

Fjorden, T., Høgstedt, E. B., Schellewald, C., Mester, R., Remen, M., Nytrø, A. V., Stahl, A., "Image-based quantification of scale loss in fish using machine learning and computer vision," in Proceedings of the 17th International Conference on Machine Vision (ICMV 2024), ICMV, 2024.

cAIge,WP1 [NFR 344022] +ReduSår [FHF901835]

Individual re-identification (ReduSår example)





- PIT tagged
- Valuable data for ID verification.
- Insight

Registration of Photographed Salmon

Automated registration of untagged fish:

- Examples: (May/June BIORELEVANS Experiments)
- Registration = transform images such that corresponding parts match …
- Ease the comparison and detection of scale-loss

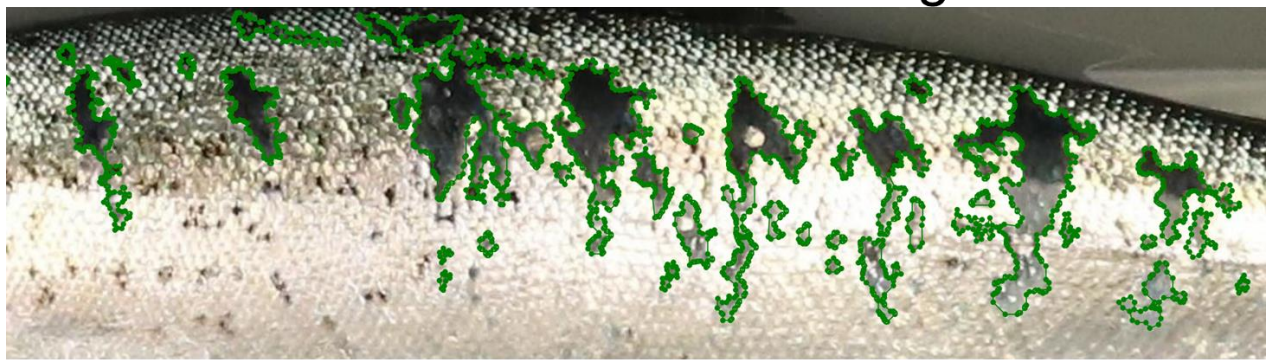


pre- after (three weeks)

Scale loss + Wound detection

- Example for **supervised** scale-loss detection:
  - + good in controlled lighting conditions
  - +Objective quantification
  - **- Requires many labelled training data-examples**

Ground truth - Test image



Prediction



Precision: **89.4%**

Recall: **79.8%**

(Credit: Thomas Fjorden)

Ongoing Research:

From **supervised** to **unsupervised** welfare indicator detection

Fjorden, T., Høgstedt, E. B., Schellewald, C., Mester, R., Remen, M., Nytrø, A. V., Stahl, A., “Image-based quantification of scale loss in fish using machine learning and computer vision,” in Proceedings of the 17th International Conference on Machine Vision (ICMV 2024), ICMV, 2024.

Ongoing Research: Individual Re-Identification

- Small groups: < 10 fish (working)



- Smaller groups: 25-35 fish in a cage (proof of concept)



- Large cage: cross-camera re-identification (proof of concept)





- Open question: How long can we track an individual salmon over time?

Høgstedt, E. U., Schellewald, C., Stahl, A., Mester, R., “Patch ensembles for robust salmon re-identification with weak trajectory labels,” in Proceedings of the IEEE International Conference on Image Processing (ICIP), 2026.

Summary+Conclusion

Computer Vision as a Welfare Sensor for Salmon

Camera + Computer vision → **Computer vision + AI** → **AI + Human**

Indicators we measure:

- Respiration
- Swimming behaviour
- Tail beat
- Wounds
- Scale loss
- Fish distribution

CV + AI enables:

✓ Continuous monitoring
✓ Individual/Group assessment
✓ Objective status information
✓ Early problem detection

Welfare benefit:

✓ Targeted interventions

CV and AI can help to make Better Welfare Decisions!

Computer vision does not measure welfare directly. It transforms visible fish behaviour and condition into objective, continuous welfare information that supports better welfare decisions.

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75 år

75 år med teknologi for et bedre samfunn

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