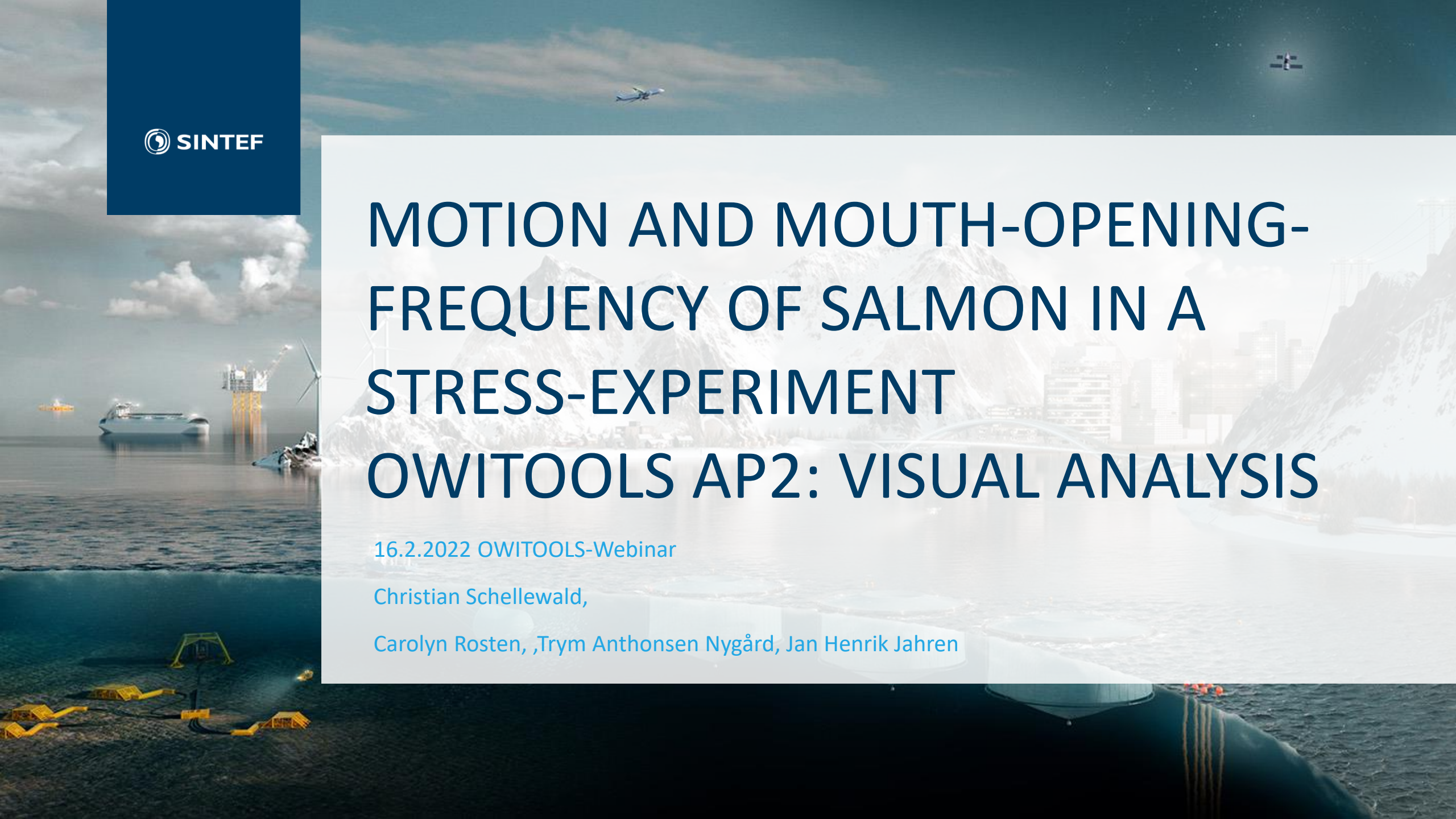


MOTION AND MOUTH-OPENING-FREQUENCY OF SALMON IN A STRESS-EXPERIMENT OWITOOLS AP2: VISUAL ANALYSIS

16.2.2022 OWITOOLS-Webinar

Christian Schellewald,

Carolyn Rosten, ,Trym Anthonsen Nygård, Jan Henrik Jahren

Overview

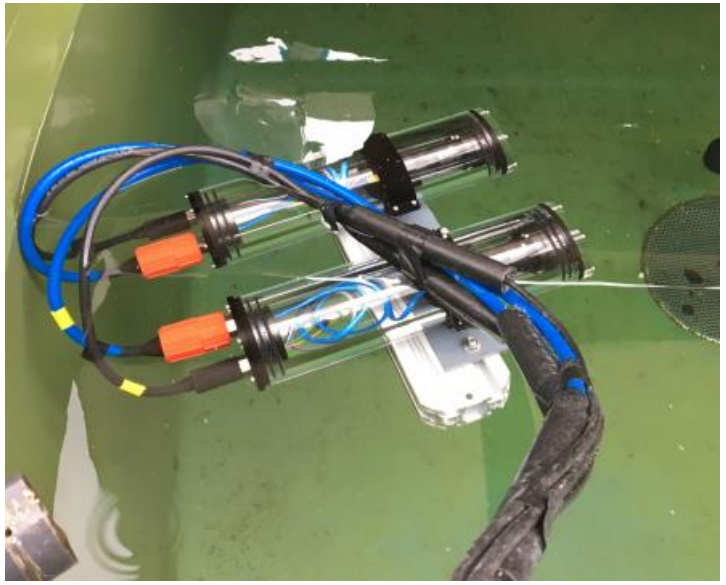
- Aim / Background
  - IMS CO2 Experiment
- Visual Analysis
  - Stereo Image Processing / 3D reconstruction
  - Trajectory extraction of the Salmon
  - Mouth-Opening-Frequency
- Results
  - Trajectory Motion-Measure
  - Mouth-Opening-Frequency

Aim

The main aim within this OWITOOLS subtask is to investigate/verify that selected **non-invasive visual measurements** from salmon videos are suitable to extract information that can be linked to the welfare of the fish.
Focus is on the **mouth-opening-frequency** (breathing) and the fish **motion**.

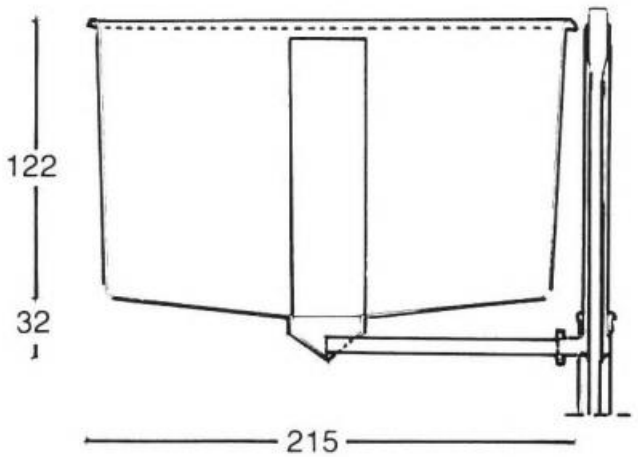
Background: IMS Experiment (Stereo-camera)

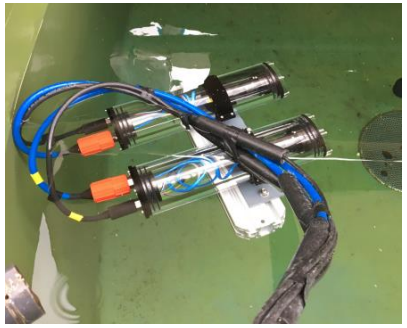
- Stereo-Camera placed in a Tank at IMS (19.5.2021-13.7.2021)
  - Stress Experiment: Increased CO2 concentration 10:20 (for ~6 hours)
  - Recordings scheduled every 15 minutes for 5 minutes
    - Night recordings are too dark/ Variing framerate of the recordings /Bandwidth required an image "cropping" …

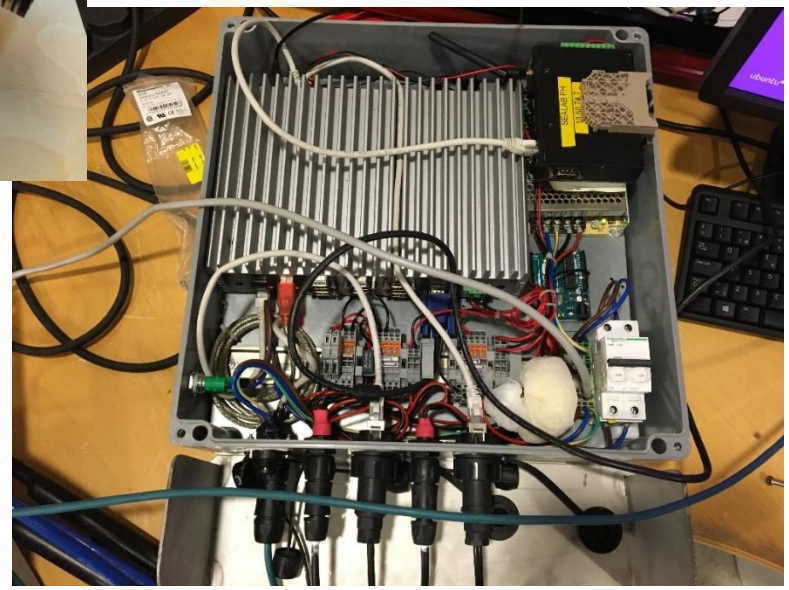


Stereo-Camera within the Tank

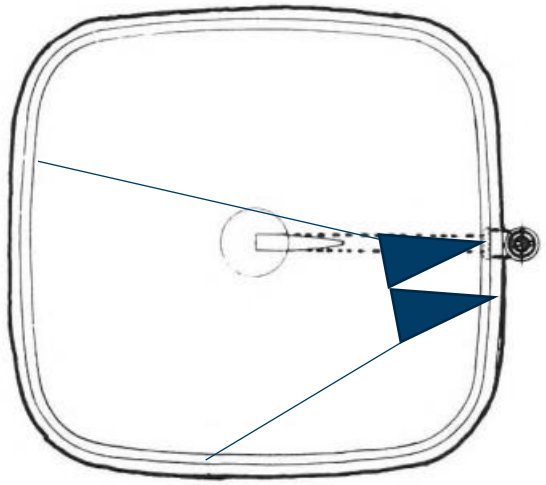
- GSM-Modem, Computer, Microcontroller, Cameras







Stereo-Camera: Ingredients



We were "lucky" with the camera orientation!

NINA Research Station (Ims, close to Stavanger)

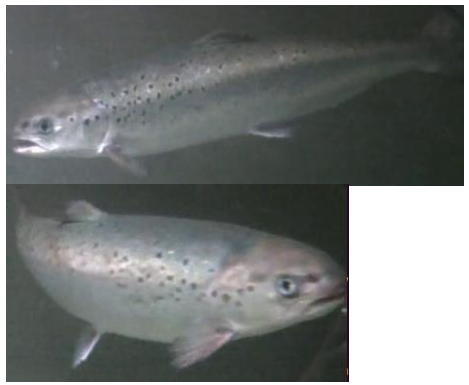
SINTEF

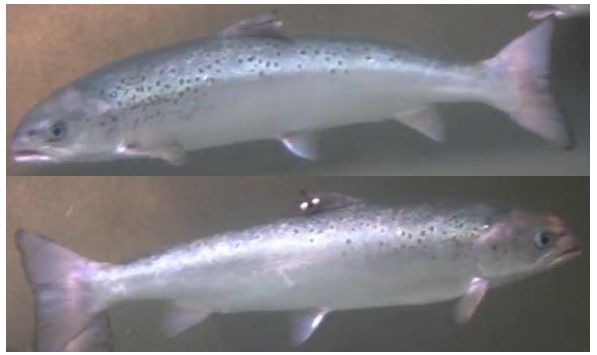
Videorecordings

- Hardware:
  - 2 Industry-cameras: Blackfly BFLY-PGE-13E4C
  - Lens: View angle 51 degrees (underwater)
  - Internal harddrives (2x each with 1 Terrabyte) + External Backup-Hard-discs
    → We recorded 690 Gb with video data (~12.5 Gb per day, incl. dark recordings)
  - Video image size: **1280x1024** pixel 24bit (RGB-color)
  - Remote access
- Recordings
  - In day light approx. **~5min recordings** (7500 frames)
  - Every quarter of an hour (dark/night videos were removed)
- Videos quality
  - Mostly of good quality (occasionally turbidity + low light)
  - Frame-rates: 18-25 images/s (mostly ~24 images/s)

Visual Analysis

- Data collected with a stereo camera at IMS in a Tank with 6 fish.
- Focus on CO2 stress experiment 8.6.2021
- Visual features:
  - **Mouth-Opening-Frequency**
  - **Motion-Trajectory**





SINTEF

Recordings from CO2 Stress Experiment Day

- 8.6.2021
- Bright enough: 05:45-21:15
- => ~62x2 Stereo videos
- 6 GB

Video processing => **“Big Data”**

Example Recordings

20.5.2021 18:18

20.6.2021 13:45

13.7.2021 07:00

SINTEF

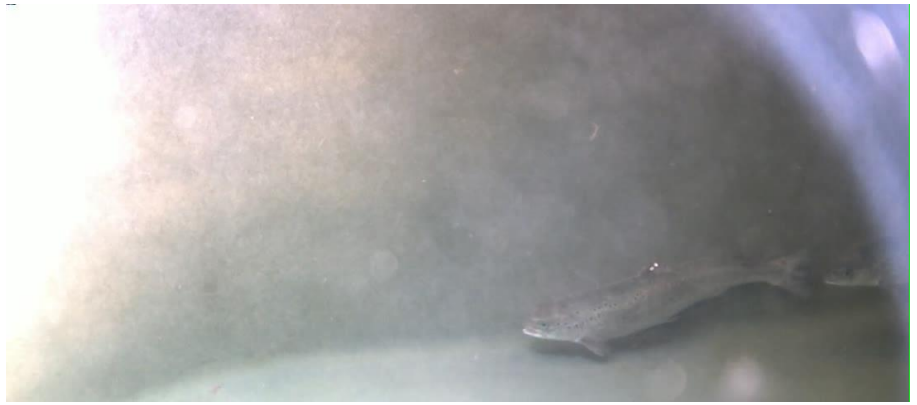
Challenges

22.5.2021 13:45

27.5.2021 21:45

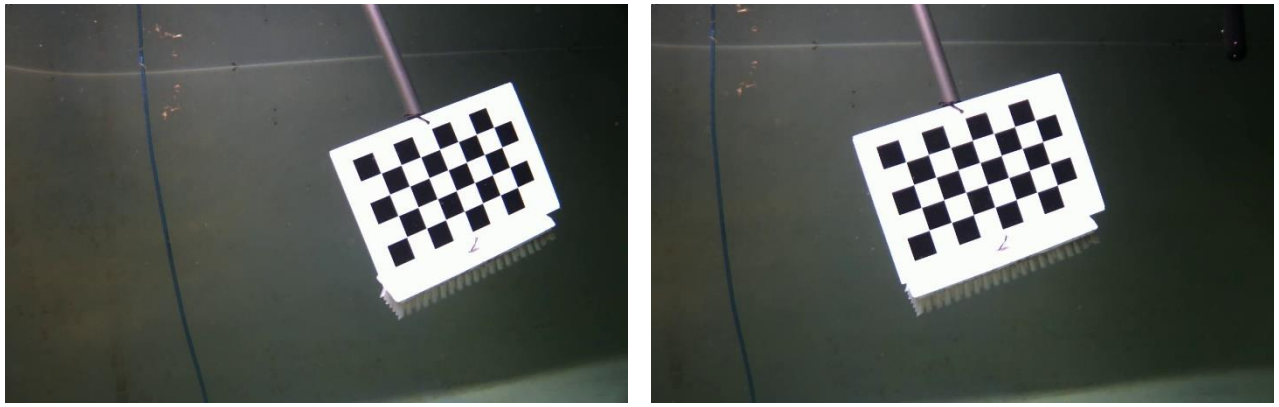
Noise,
Varying lighting conditions,
Occlusion,
Reflections,
Non-rigid objects,
Varying framerates ...

8.6.2021 10:15 + 10:30 + 15:30



Stereo Image Processing

- Calibration of the camera-setup
  - Checkerboard (underwater!)
  - Internal camera parameters
    - focal length/view-angle
  - External camera parameters
    - Baseline/camera distance, relative rotation



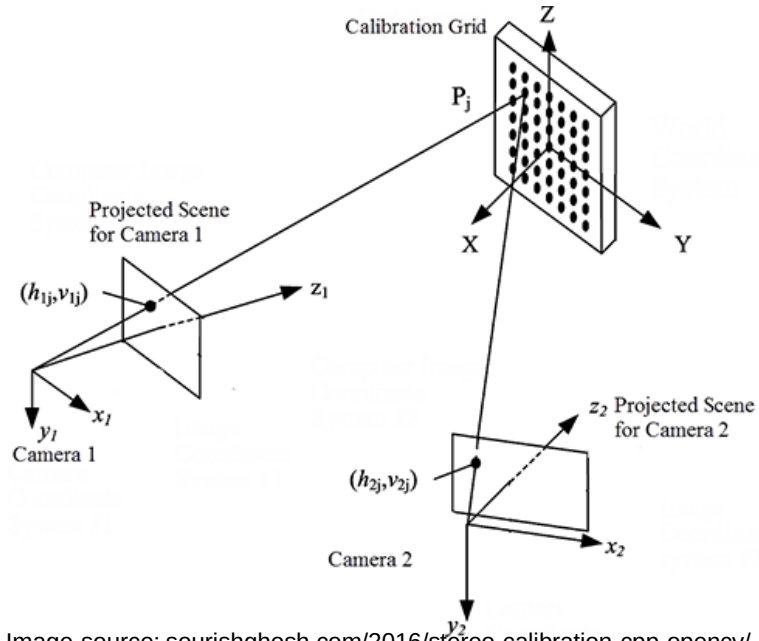


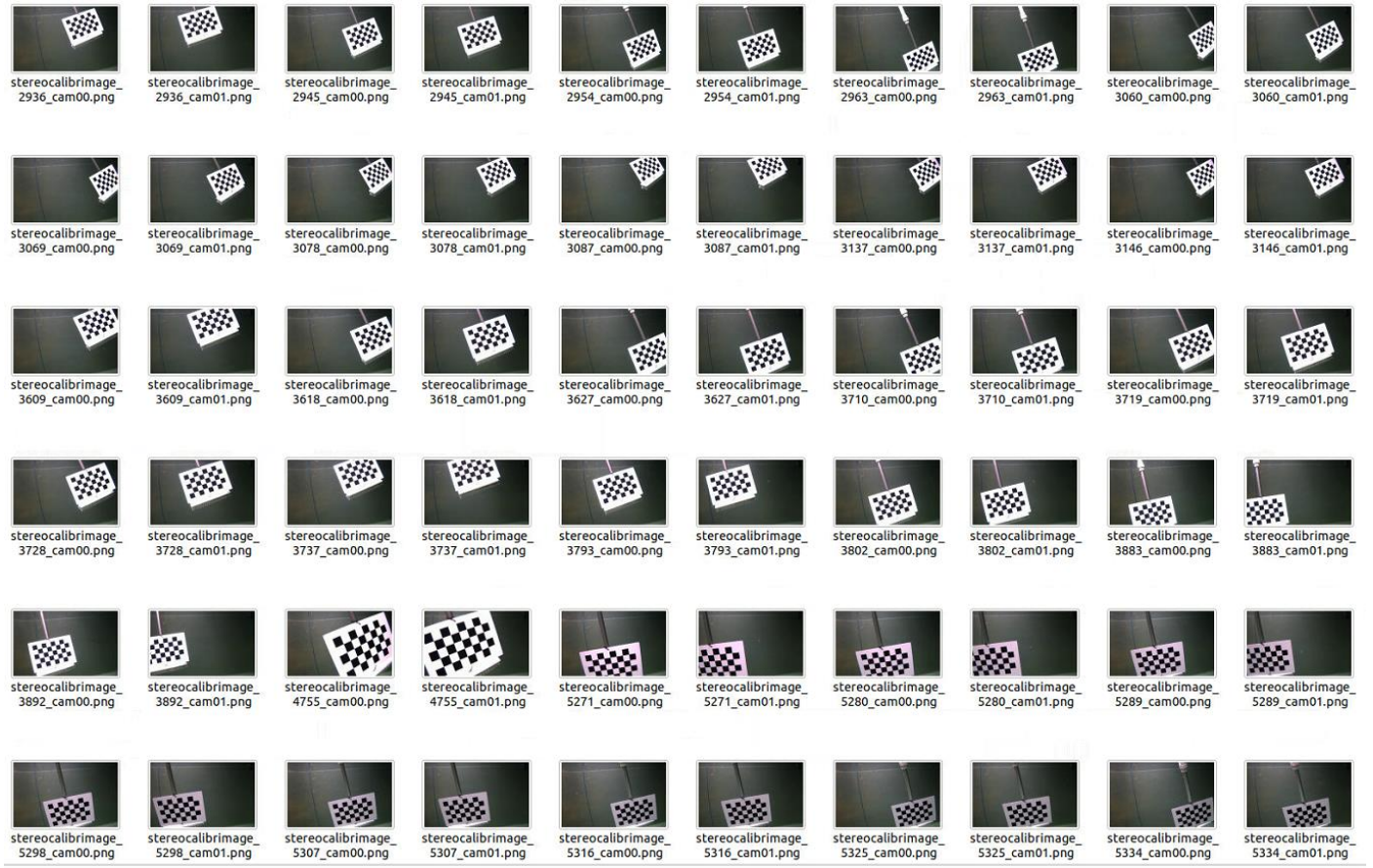
Image-source: sourishghosh.com/2016/stereo-calibration-cpp-opencv/

=> Information about the geometric camera setup:

Field of view: ~51.4 degrees
Baseline: 15.03 cm

SINTEF

Stereo-Camera Calibration



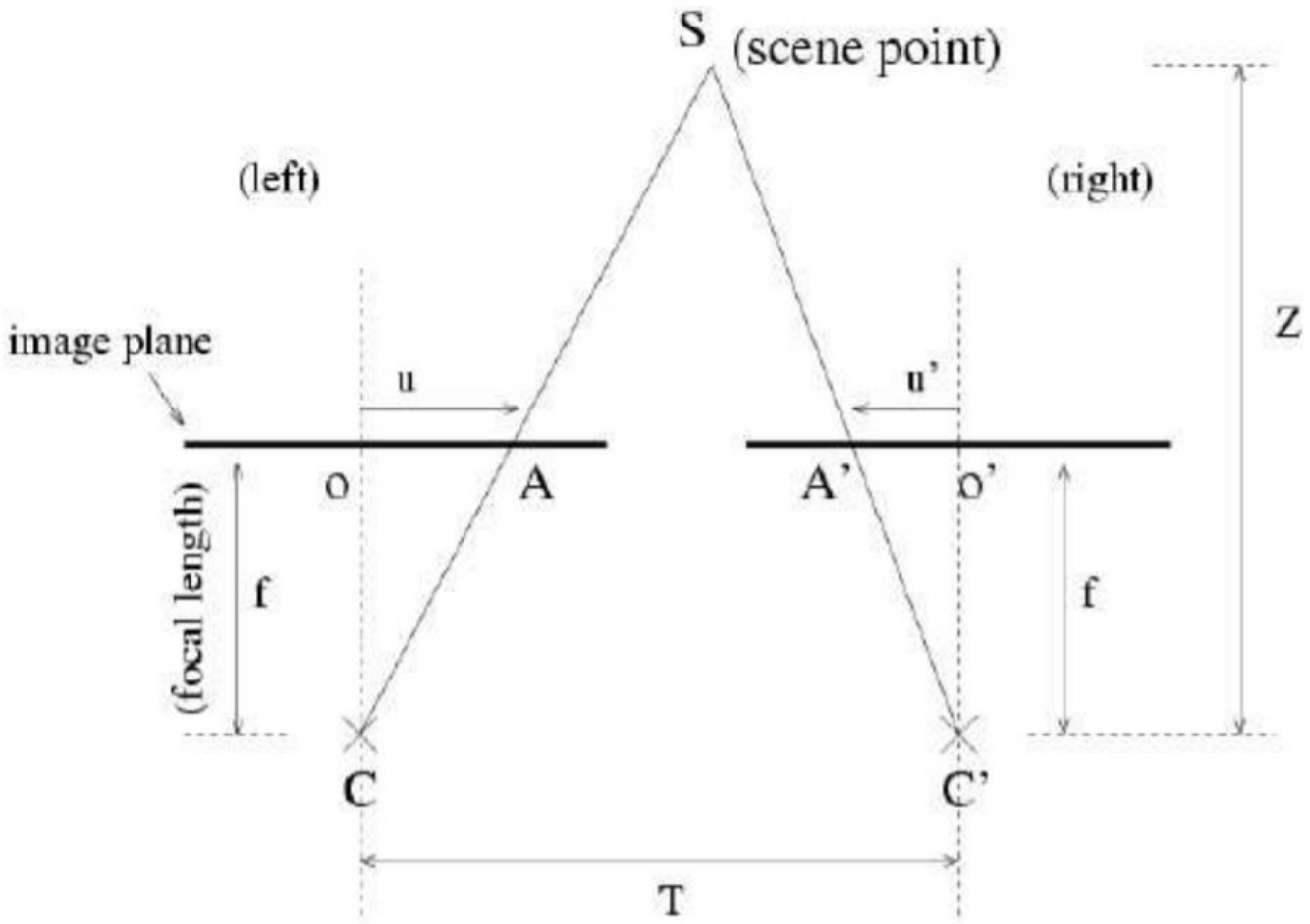
- Calibration pattern of know size: (square 3.11 cm x 3.11 cm)
- Calibrate single cameras
  => internal camera parameters
- Calibrate stereo setup
  => external camera parameters

SINTEF

Rectification

- Knowing the geometric setup (external parameters) and the camera parameters (intrinsic parameters) one can “rectify” the images.
- => This transforms the images into “ideal” stereo-camera setup

Triangulation



T = Baseline

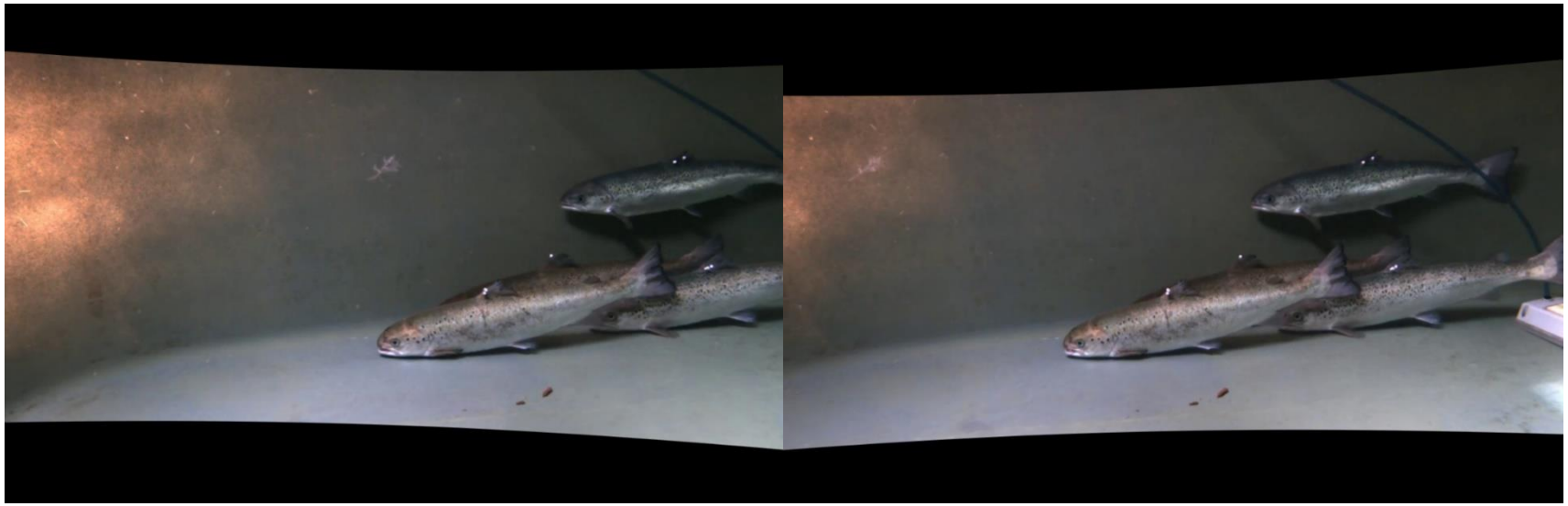
- “ideal” stereo-camera setup
  => parallel cameras

SINTEF

Trajectory extraction of the Salmon

- Method development
  - Stereo-camera allows to extract metric measurements in 3D (i.e. length in meter, cm, mm)
  - Main steps: **Camera calibration, "Rectification", Triangulation**

Calibration "checkerboard"



Rectification: Corresponding features like the eye at same y-coordinate

Length of the calibration board: ~20x30 cm

SINTEF

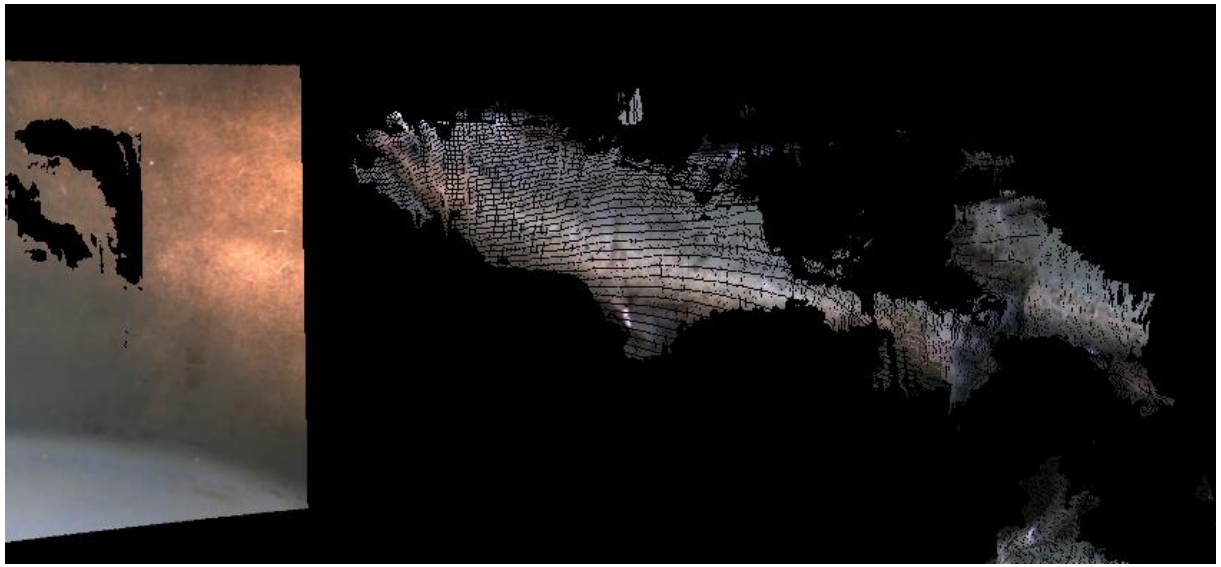
Metric Data Extraction

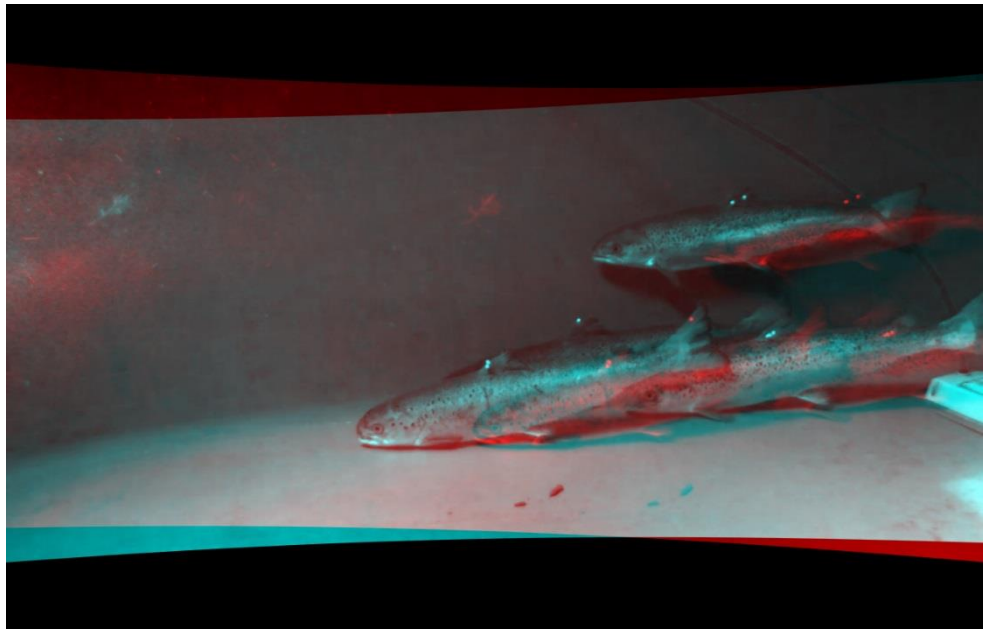
~57 cm

20 cm (20.4 cm measured)

SINTEF

3D representations, Pointcloud, 3D-Glasses ….

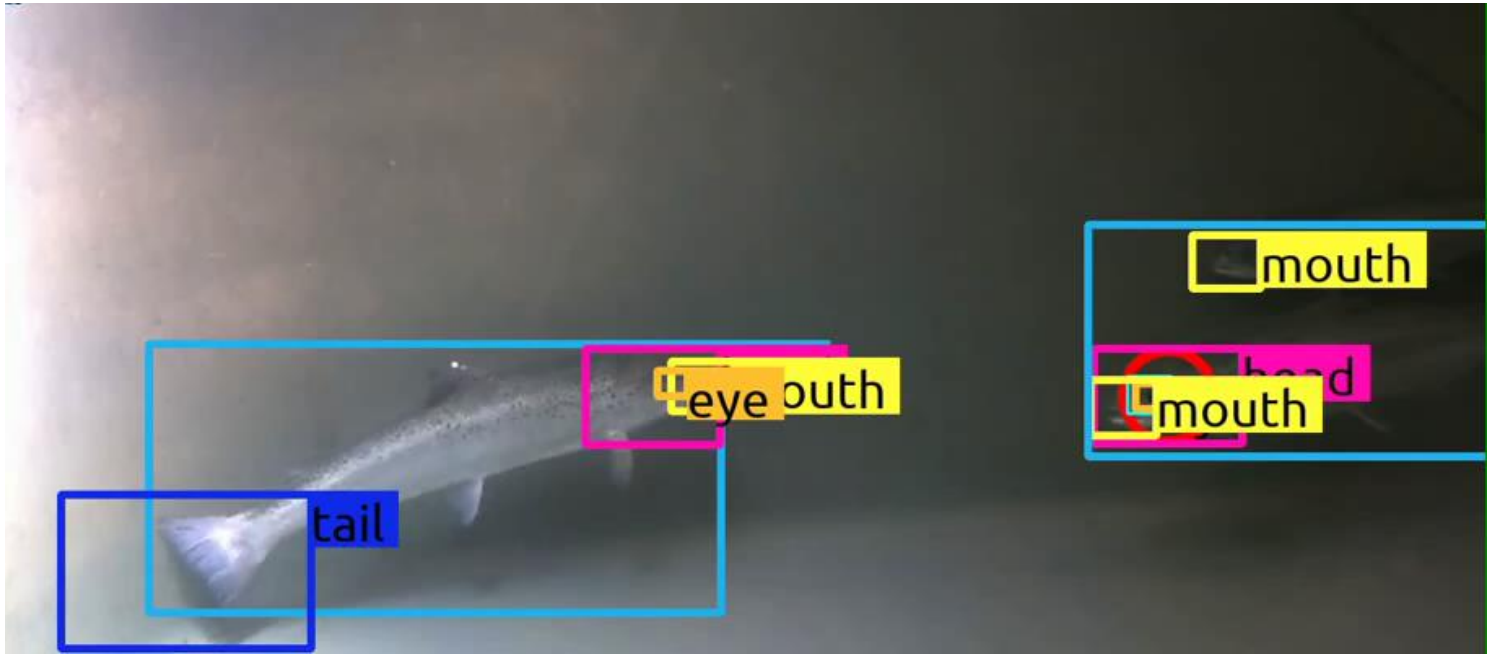




Computing a correct dense pointcloud (reconstruction) is still challenging..

Motion-Trajectory based on the eye

- Exploitation and development of Computer Vision Methods to detect and track the eye in the left and right video
  - **Motion-Trajectory** can then reconstructed

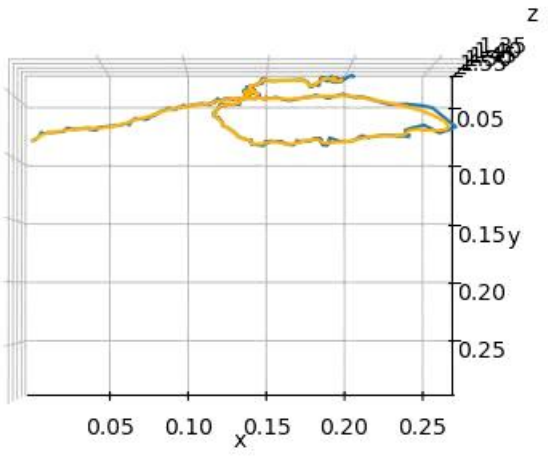


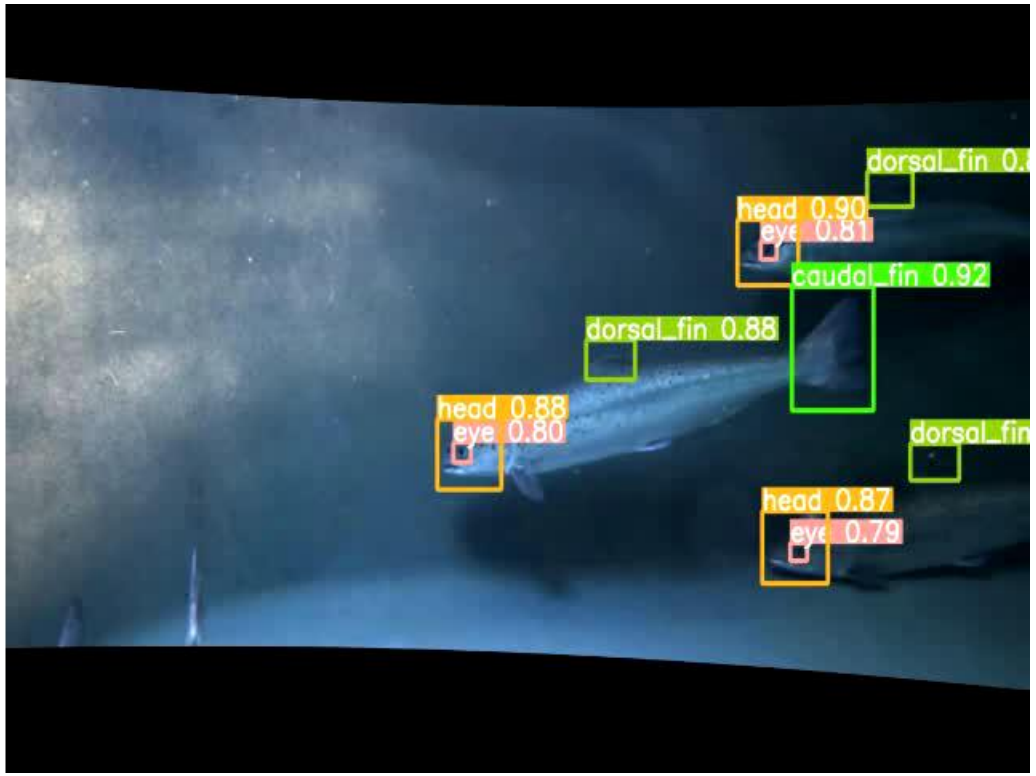
Detections of Salmon parts along with tracking them allows the analysis of motion details of the salmon.

SINTEF

Trajectory extraction of the Salmon

- Following the eye of the salmon in the stereo-image-pair we can compute the trajectory of the eye/fish.
- Requires a robust detection of the eye (Machine Learning exploiting for example Deep Learning)

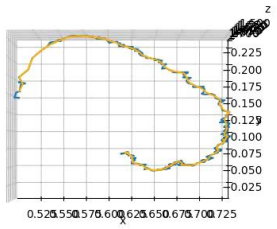


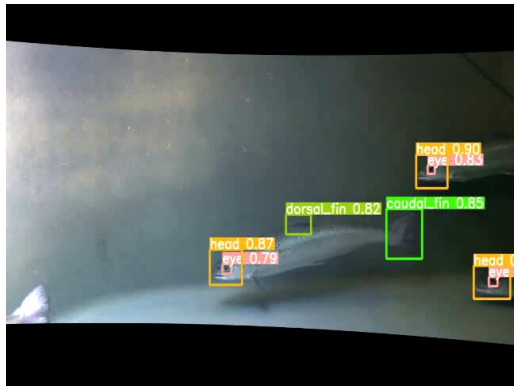


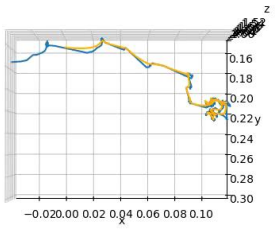
Example of an extracted 3D trajectory of a single salmon (Salmon in the centre)

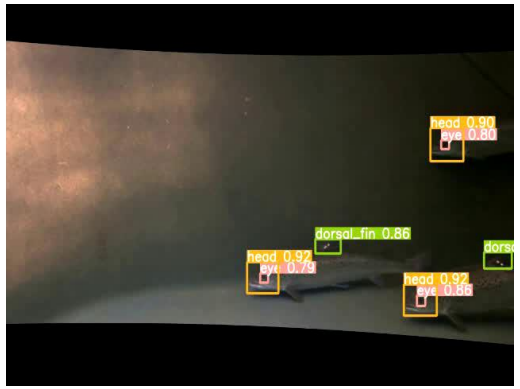
SINTEF

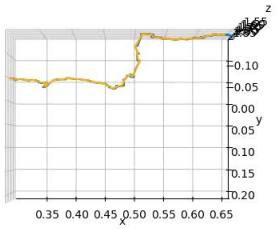
Many Trajectories …

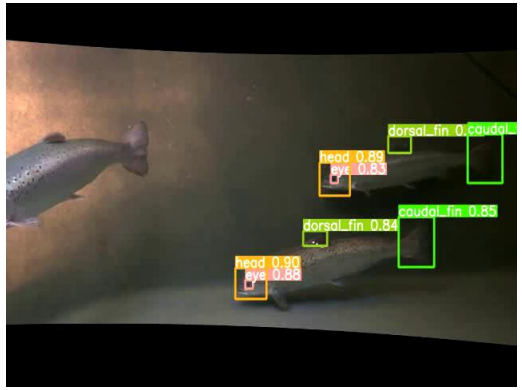


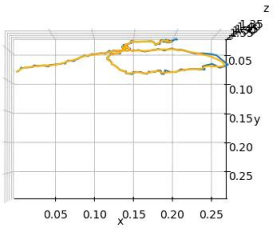


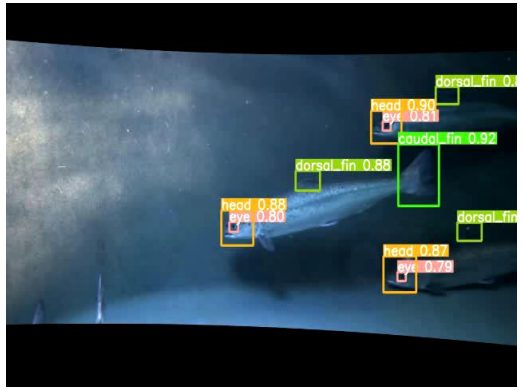


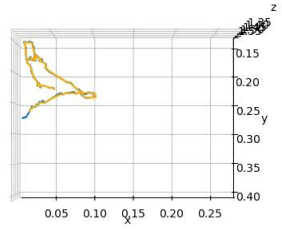


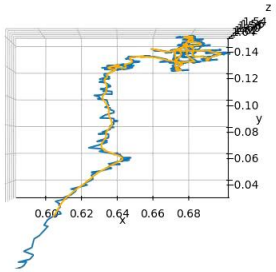


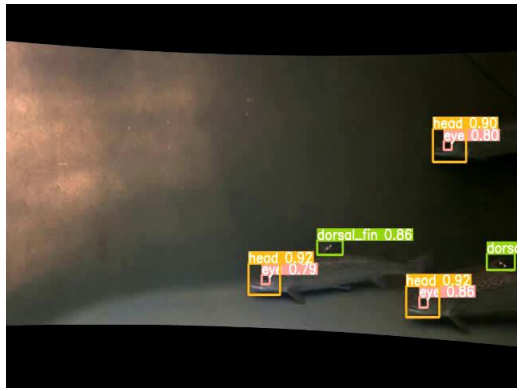








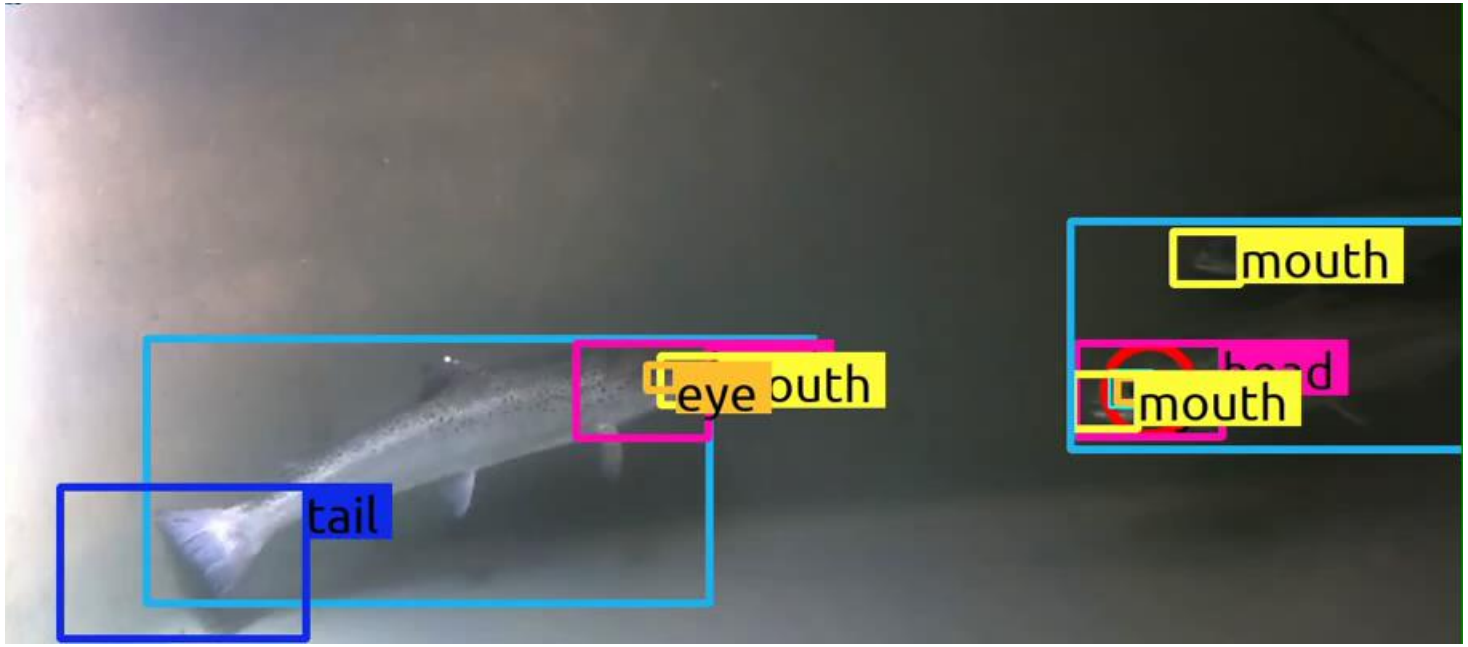




SINTEF

Mouth Motion Analysis

- Exploiting Machine Learning Algorithms and Computer Vision we can track the heads of the salmon for further analysis !



SINTEF

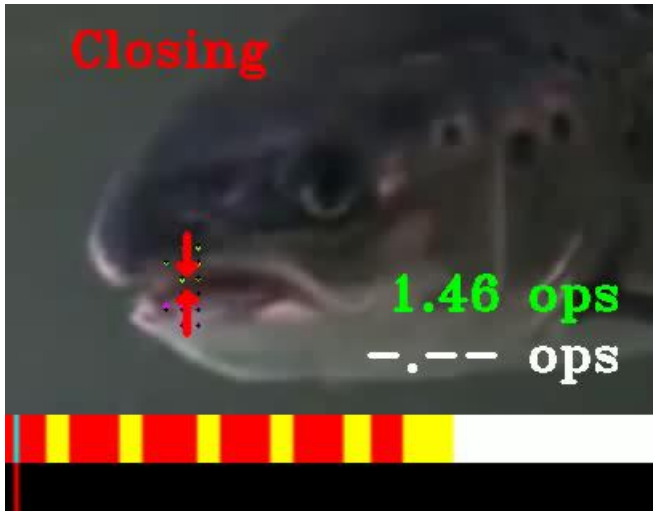
Mouth Motion Analysis

- Good visual conditions allow an automated extraction of the Mouth-Opening-Frequency

Ground Truth

Measurement

“Difficult scenes”:
Small motion
Large orientation changes

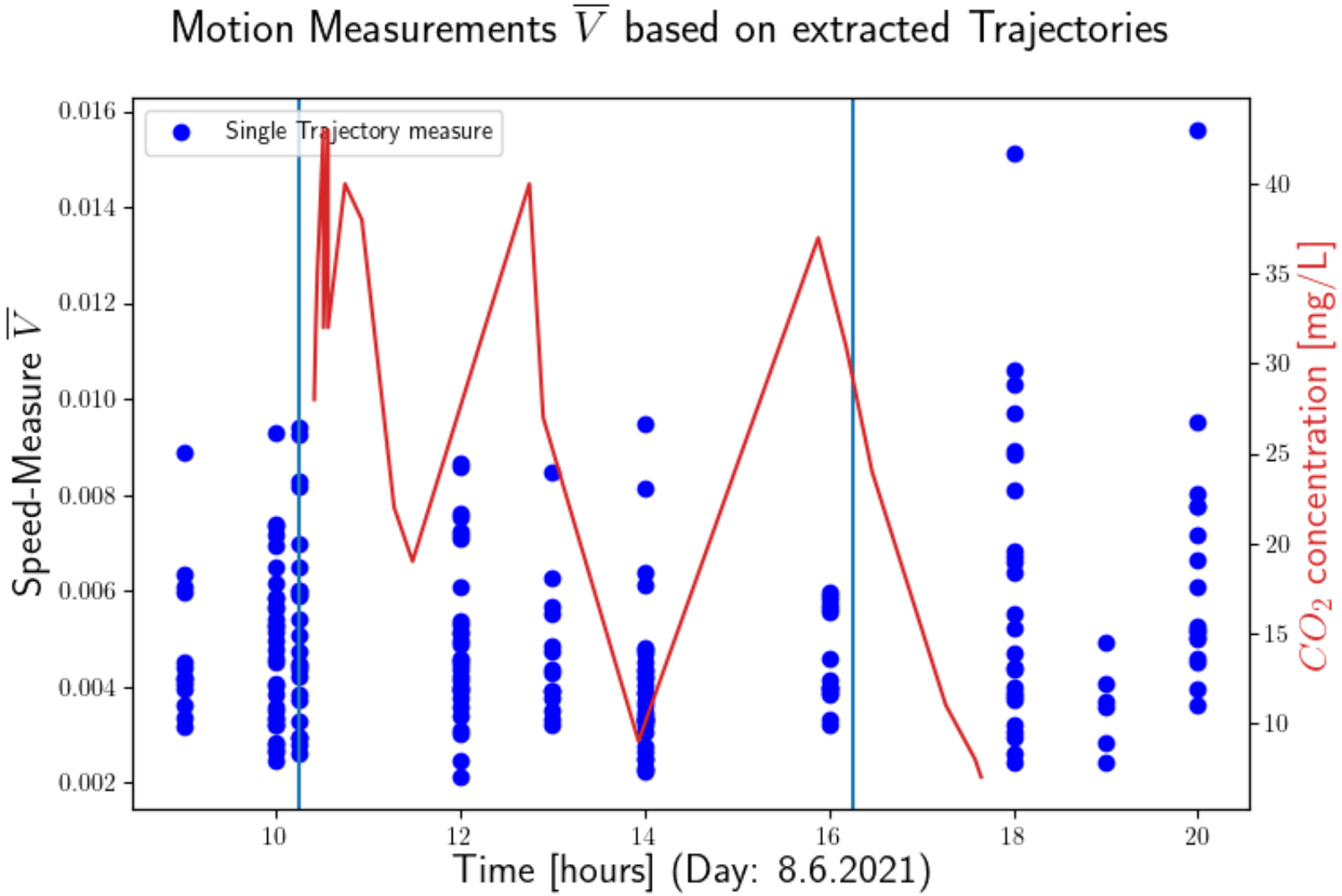


SINTEF

Synergy with NFR project INDISAL (282423)

Results: Trajectory Motion-Measure CO2

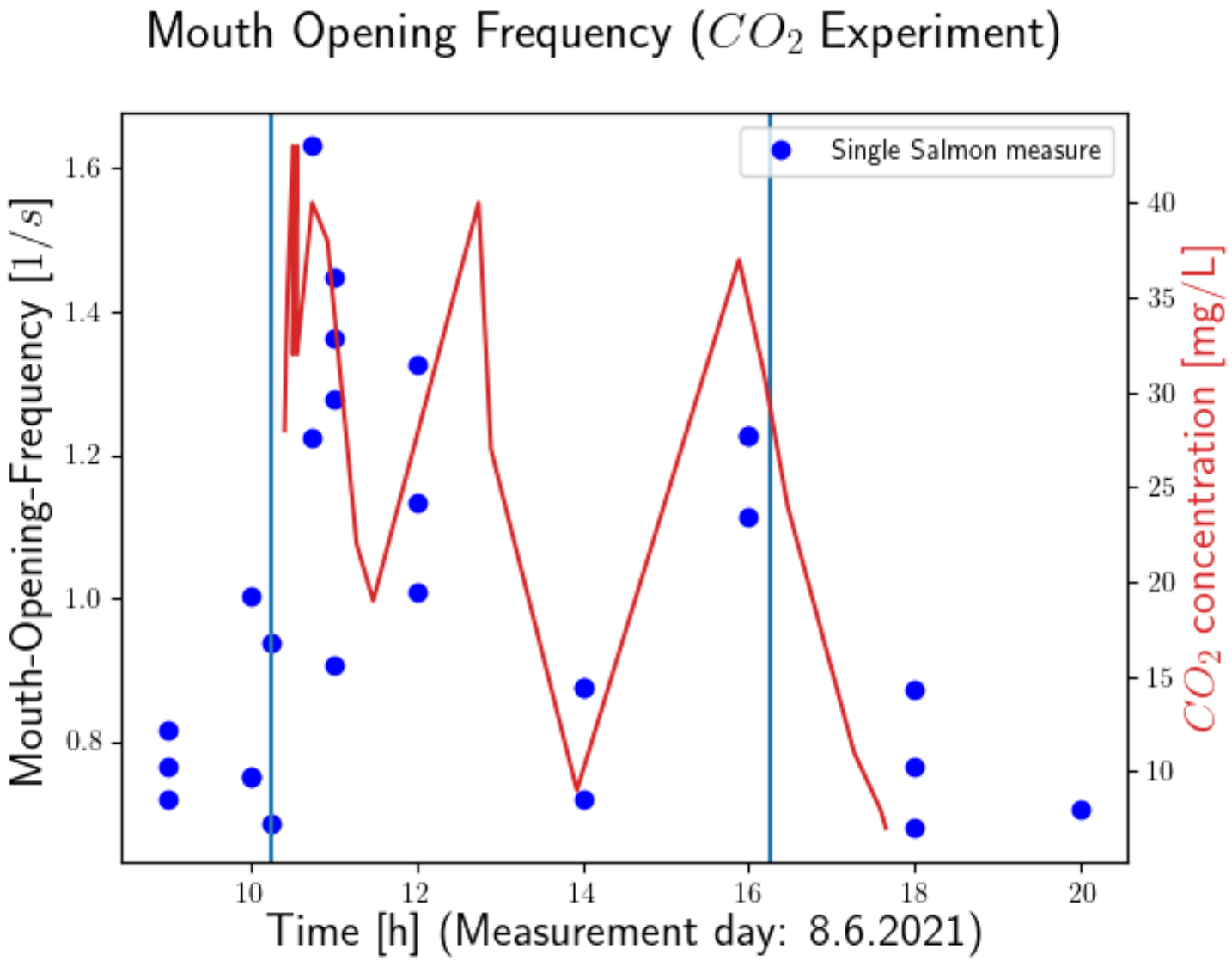
- Observations:
- Current “motion measures” show no strong correlation to the CO2 levels.
- Potential Explanations
  - Bayes towards “stationary” fish-trajectories. (we miss relevant fish trajectories)
  - Accuracy in Z-direction is highly noisy.



SINTEF

Results: Mouth-Opening-Frequency CO2

- Observations:
  - Increased/Decreased Mouth-Opening-Frequency agrees with increased/decreased carbon dioxide levels.
- Highly likely that we can observe the induced stress



We will learn more through a new FHF project BIORELEVANS (901736)

Discussion

- Motion Extraction Approach:
  - Used Approach: Trace the fish eye in stereo videos to get a 3D trajectory and relative speed measurements
  - Trajectory relative to the camera is extracted (speed measurements need water speed too.)
  - Currently inconclusive results regarding CO2 stressor, but the technique allows to determine fish motion (speed and direction).
- Mouth Opening Frequency measurements:
  - Works automated in “ideal” conditions (lighting, opening-motion, distance to camera).
  - The mouth-opening frequency shows a correlation with the CO2 concentration stressor.
  - Measures a biological status variable with meaning for welfare (Needs still a better understanding of all factors that influence the breathing [i.e. Temperature, O2 concentration, Fish-size, etc.])
- More “Visual” Information may be extracted !!!
  - Example: Size measurements and tail motion frequency are promising candidates.

SINTEF

SINTEF

Teknologi for et bedre samfunn