Pinbone measurements in fish fillets using CT

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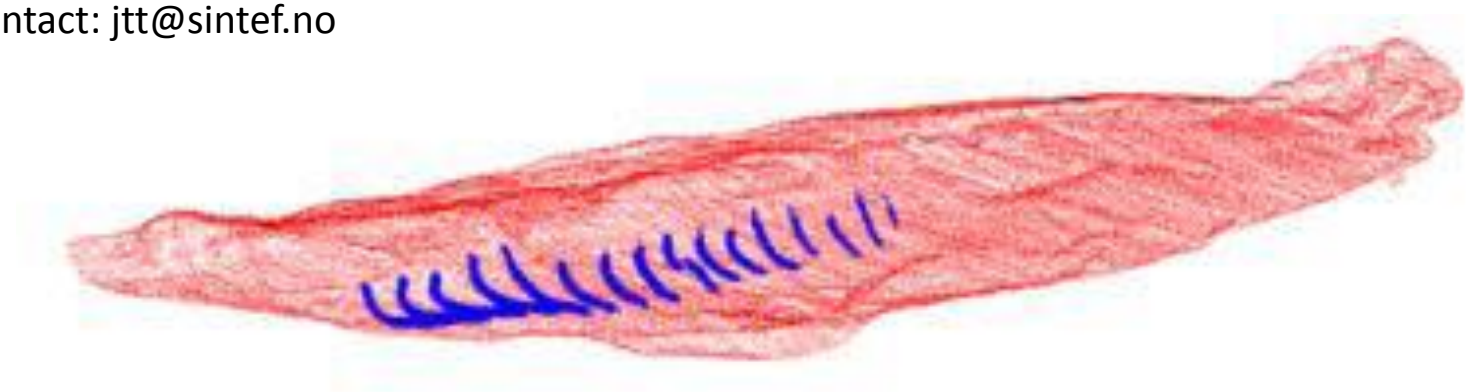


Gardermoen 27.11.2013

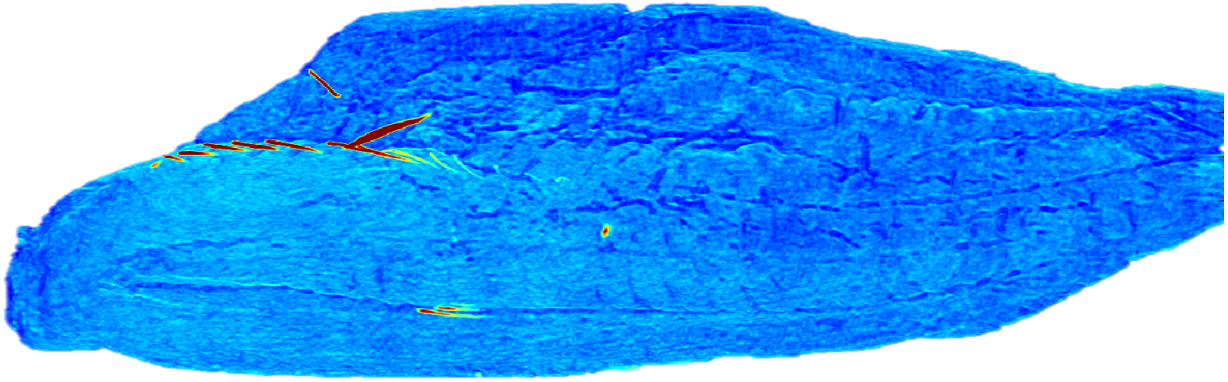
Agenda

- Background & objective
- Experiment design
- Processing of raw data
  - Low level
  - Higher level
- Results
- Conclusion and summary

Background & project objective

- Marel, Norway Seafoods and SINTEF IKT develops X-ray pinbone removal machine (APRICOT)
- How to enable cost-efficient testing of various designs?

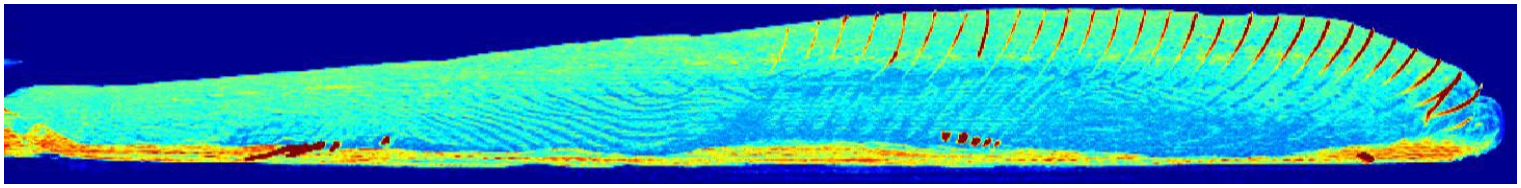
- Objective FHF project:
- Provide detailed information about the size, orientation and location of pin bones in selected species of *filleted* fish.



Cod

Experiment design

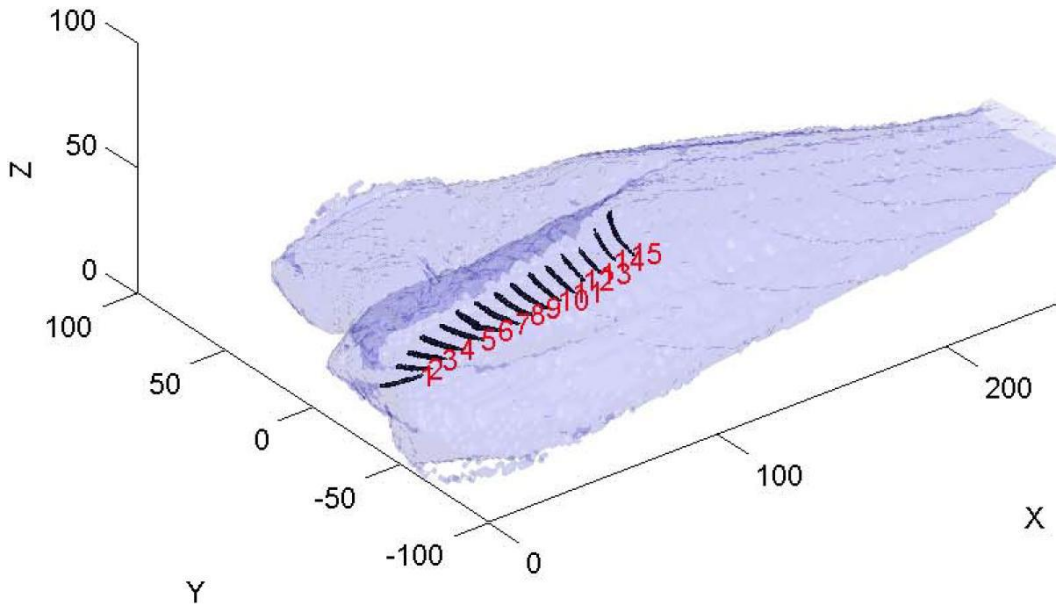
- Species: Cod, Haddock, Saithe, Salmon
- 64 fish scanned, 16 of each species
- CT machine: Toshiba Aquilion One CT
  - 0.5 mm slice thickness (X)
  - 0.24-0.52 mm resolution (Y,Z) – depends on size of fish
- Result: 3D cube with information about specific absorption per voxel



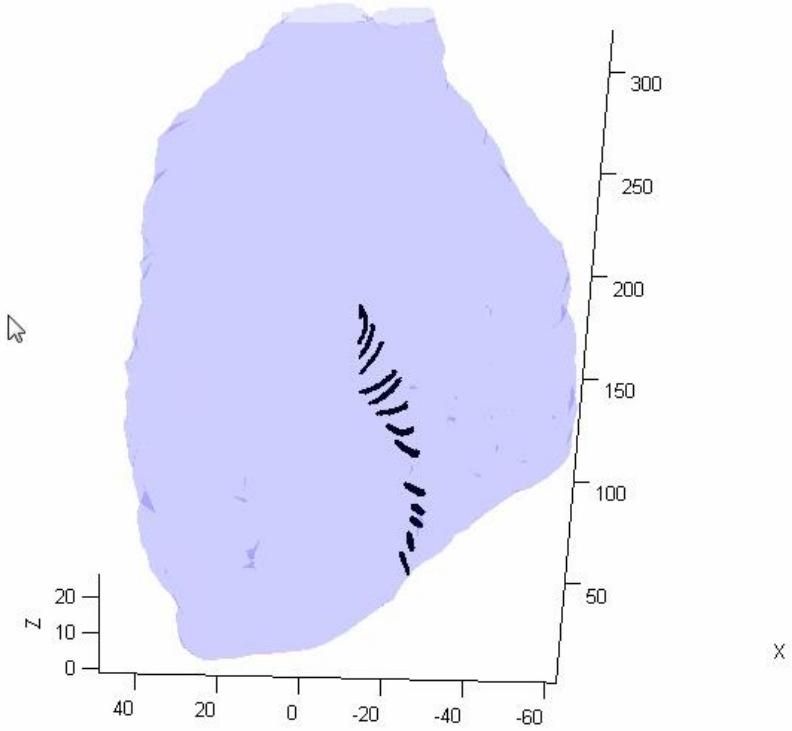
Salmon

Processing of CT data - segmentation

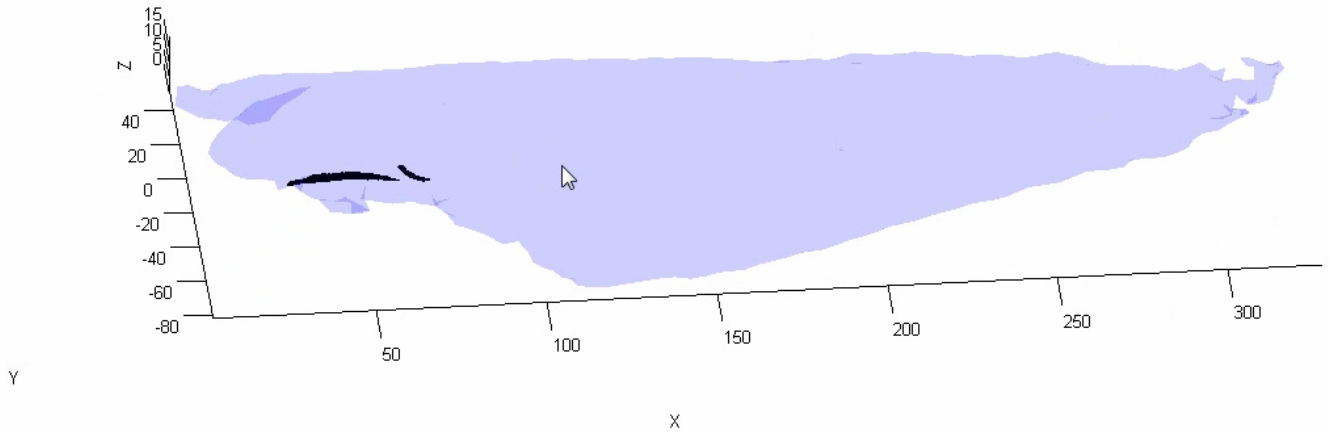
- Segmented raw data into bones, meat, air
- Each individual bone has its unique ID
- Rotated each fish such that
  - X: length axis of fish
  - Y: width axis of fish
  - Z: height axis of fish



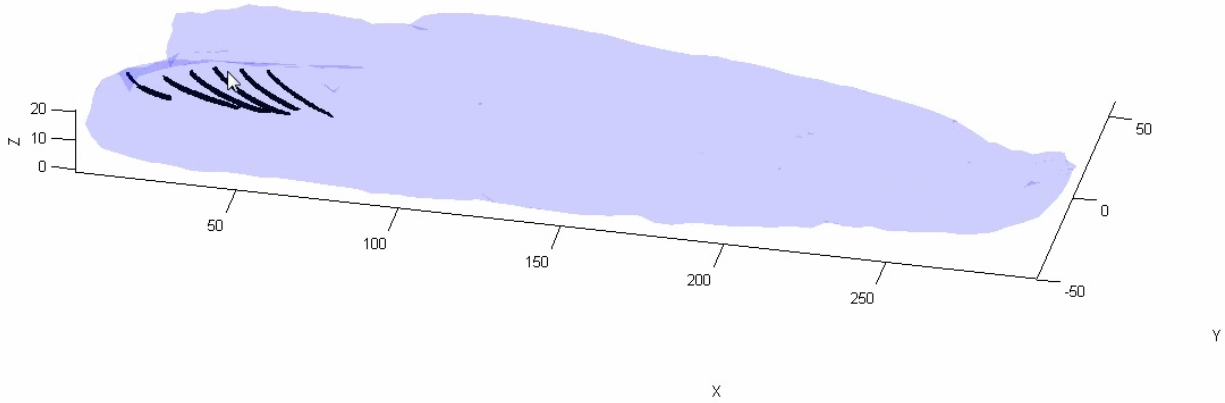
Example cod



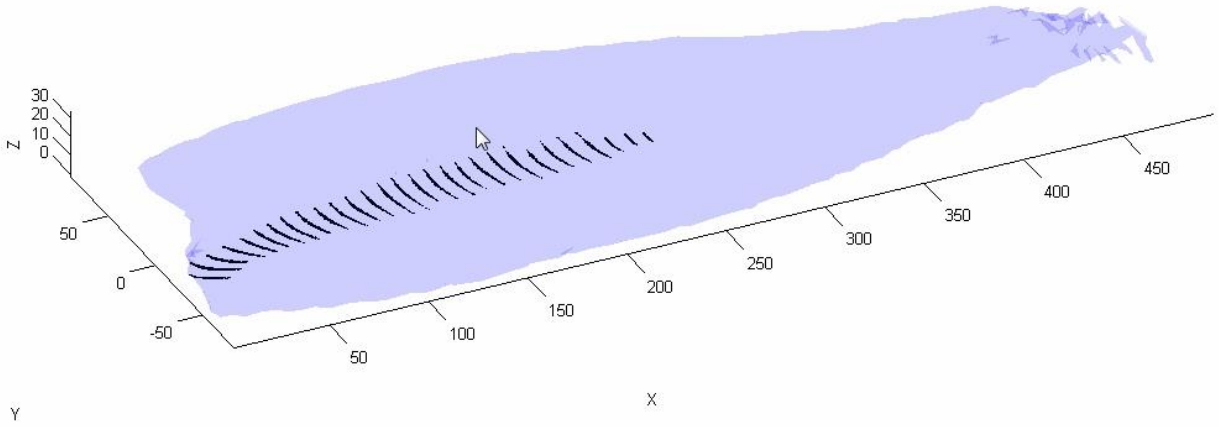
Example haddock



Example saithe



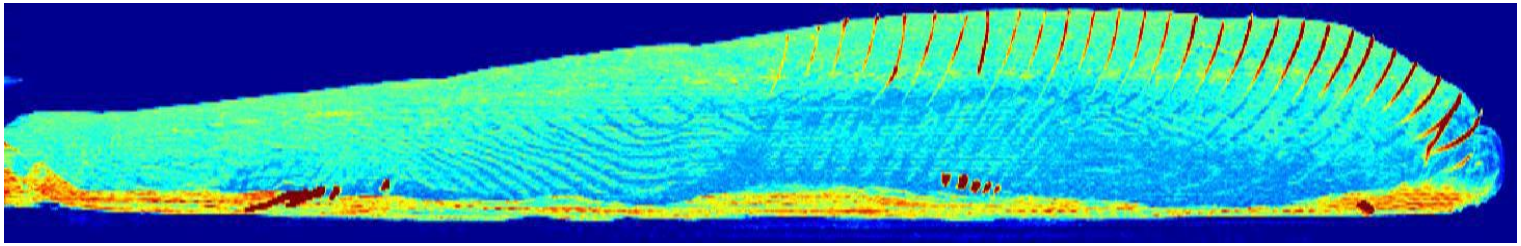
Example salmon



Manually control of CT bone measures

- One fillet of each species manually controlled
- Pinnbones removed and measured
- All manually found pinbones also automatically detected in CT data
- Mean thickness deviation was 0.2 mm
- Mean length deviation was about 5-6 mm for Cod, Haddock and Saithe and 11mm for Salmon
- Length is biased towards too short
- Thickness is biased towards too thick

	Thickness deviation (mm)	Length deviation (mm)
Cod	0,2	4,8
Haddock	0,1	6,4
Saithe	0,2	6,3
Salmon	0,3	11,5



Processing of segmented data - bones

- Measured the number of bones, and for each bone its:
  - Thickness
  - Length
  - Angle relative to major axis
- Lots of data and detailed tables in the report. ☺

Spices	Mean no of bones	Min no of bones	Max no of bones	Mean bone Thickness (mm)	Min bone Thickness (mm)	Max bone Thickness (mm)	Mean bone Length (mm)	Min bone Length (mm)	Max bone Length (mm)
Cod	13	9	17	0.8	0.4	1.4	17	5	38
Haddock	7	2	16	0.8	0.5	2.8	18	6	31
Saithe	7	5	10	0.9	0.5	4.4	22	5	34
Salmon	29	28	31	0.8	0.5	1.9	22	7	37

Results

- CT data is feasible to analyse pinbone size and positions
- In general: Variation within species is too large for any major conclusions
- Possible hints for further studies (too small dataset to say anything decisive):
  - Salmon seems to have a dominating YZ angle of 30±5 degrees
  - Cod seems to have a dominating YZ angle of 25±7 degrees
  - …

- Further analysis done with Marel gives indication of
  - Possible yield gain by using different pinbone removal solutions
  - Possible yield gain by positioning source(s) and detector(s)
  - Conclusions beyond the scope of this project/presentation.
    - We were able to identify some possible good ideas (and some clearly bad ones ☺).

Conclusion and summary

- Quality dataset available on selected species
- 3D cubes with submillimeter precision information about bone and meat location
- High-level information - thickness, angle, length – on various levels:
  - Species
  - Fish
  - Single bone
- *Very suitable for further analysis.* Available in following formats:
  - Solidworks files (.SLDPRT)
  - Matlab files (.mat)
  - STereoLithography files (.stl)
- Can be downloaded for free – just send an email. Contact: jtt@sintef.no.