Science, Service, Stewardship



A revolutionary approach for improving age determination efficiency in fish using Fourier transform near infrared spectroscopy (FT-NIRS)

NOAA Fisheries Strategic Initiative



Ageing fish at the speed of light using Fourier transform near infrared spectroscopy (FT-NIRS)

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https://www.fisheries.noaa.gov/alaska/science-data/age-and-growth-research-alaska

NOAA FISHERIES SERVICE

Science, Service, Stewardship



- Background of FT-NIRS technology and how it works (physics, analytical chemistry, predictive analytics).
- Successful applications of FT-NIRS age estimation (energy density, reproductive status, stock structure)
- Application of AI & deep machine learning (CNN) with FT-NIRS NOAA for age prediction.
- Observation and process errors associated with FT-NIRS
- Operational readiness and integration into production

⁵ NOAA FISHERIES SERVICE

Strategic Initiative work flow



Why walleye Pollock & Pacific cod for FT-NIRS application development





NOAA Tech memo Importance of age data collection for stock assessments: a US national perspective

REPORT FROM THE OTOLITH SAMPLING SIZE WORKING GROUP (OSSWG)

otoliths / FTE / day

Walleye Pollock = 35 - 60 / day Pacific cod = 25 - 50 / day

FT-NIRS = 50-80 / FTE / hour

Unpublished Photo credit: Delsa Anderl

FT-NIRS proven technology in other industries

% fat content



Active ingredient



% protein



Fisheries biology



ARTICLE

A transformative approach to ageing fish otoliths using Fourier transform near infrared spectroscopy: a case study of eastern Bering Sea walleye pollock (Gadus chalcogrammus) Thomas E. Helser, Irina Benson, Jason Erickson, Jordan Healy, Craig Kastelle, and Jonathan A. Short

hydrocarbon



neuroscience



NIR Spectroscopy: measurement of intra-molecular vibrations



How are the molecular motions detected and measured? Fourier transform near infrared spectrometer



Interaction of Light and Matter







Relative Intensities of Infrared Bands



0/2/2024

What is a near infrared spectrum?

Absorbance Units



Different ages have different absorbance profiles

12,000

Wavenumber cm⁻¹





for C-H and N-H						
9000	-	8000	cm ⁻¹			
8000	-	7450	cm ⁻¹			
6900	-	6770	cm ⁻¹			
6770	-	6400	cm ⁻¹			
6400	-	6030	cm -1			
6030	-	5500	cm ⁻¹			
4950	-	4770	cm ⁻¹			
4770	-	4600	cm -1			
4600	-	4500	cm ⁻¹	/////		
4500	-	3850	cm ⁻¹			

for O-H

0550	-	9250	cm ⁻¹	
7100	-	6800	cm -1	
6800	-	6400	cm ⁻¹	/////
6400	-	6030	cm -1	/////
5300	-	4950	cm -1	





SAGE www.sagepublishing.com



Multi-modal convolutional neural network



We used Rectified linear unit (RELU) functions which outputs the input directly if it is positive, for negative input outputs zero.

To implement our models we employed Python using TensorFlow with Keras API and hyperband optimization (HB) for hyperparameter tuning.



Contents lists available at ScienceDirect

Fisheries Research

journal homepage: www.elsevier.com/locate/fishres

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в

Difference Between Traditiona and FT-NIR Ages (years)

Full length article

Fourier transform near infrared spectroscopy of otoliths coupled with deep learning improves age prediction for long-lived northern rockfish

Irina M. Benson^{a,*}, Thomas E. Helser^a, Beverly K. Barnett^b





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Alaska

The future of fish age estimation: deep machine learning coupled with Fourier transform near-infrared spectroscopy of otoliths

Irina M. Benson 🕫, Thomas E. Helser 🗣, Giovanni Marchetti 🗣, and Beverly K. Barnett 🕫







Assessing CNN model performance of future predictions





(Gadus chalcogrammus) Lab rearing study at Little Port Walter (AK)



Quantification of FT-NIRS prediction uncertainty



Eastern Bering Sea walleye

• 2019, 2021, 2022, and 2023

pollock

• n = 552

AFSC Spectroscopy Laboratory



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Observation error (instrument + operator) of FT-NIRS





(Gadus chalcogrammus) Quantification of FT-NIRS prediction uncertainty

Observation error TMA



walleye pollock (*Gadus chalcogrammus*)

^(s) Quantification of FT-NIRS prediction uncertainty

Observation error TMA

Quantifying age-reading error for use in fisheries stock assessments, with application to species in Australia's southern and eastern scalefish and shark fishery

André E. Punt, David C. Smith, Kyne KrusicGolub, and Simon Robertson

nwfscAgeingError R package





walleye pollock (Gadus chalcogrammus)

^{s)} Quantification of FT-NIRS prediction uncertainty



