A spectrum of life history information: Spectroscopy approaches expand data collection capabilities for fisheries research and management

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Western Groundfish Conference
April 2023

Sea Grant Alaska

NOAA FISHERIES | ALASKA FISHERIES SCIENCE CENTER
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

Outline

1. **Introduction:** Broad view of why we are doing this work
2. **Project design**: Introduce approach & methods
3. **Preliminary findings**: Progress & results
4. **Conclusions:** Next steps & goals

Rationale: Life history data needs for fisheries management

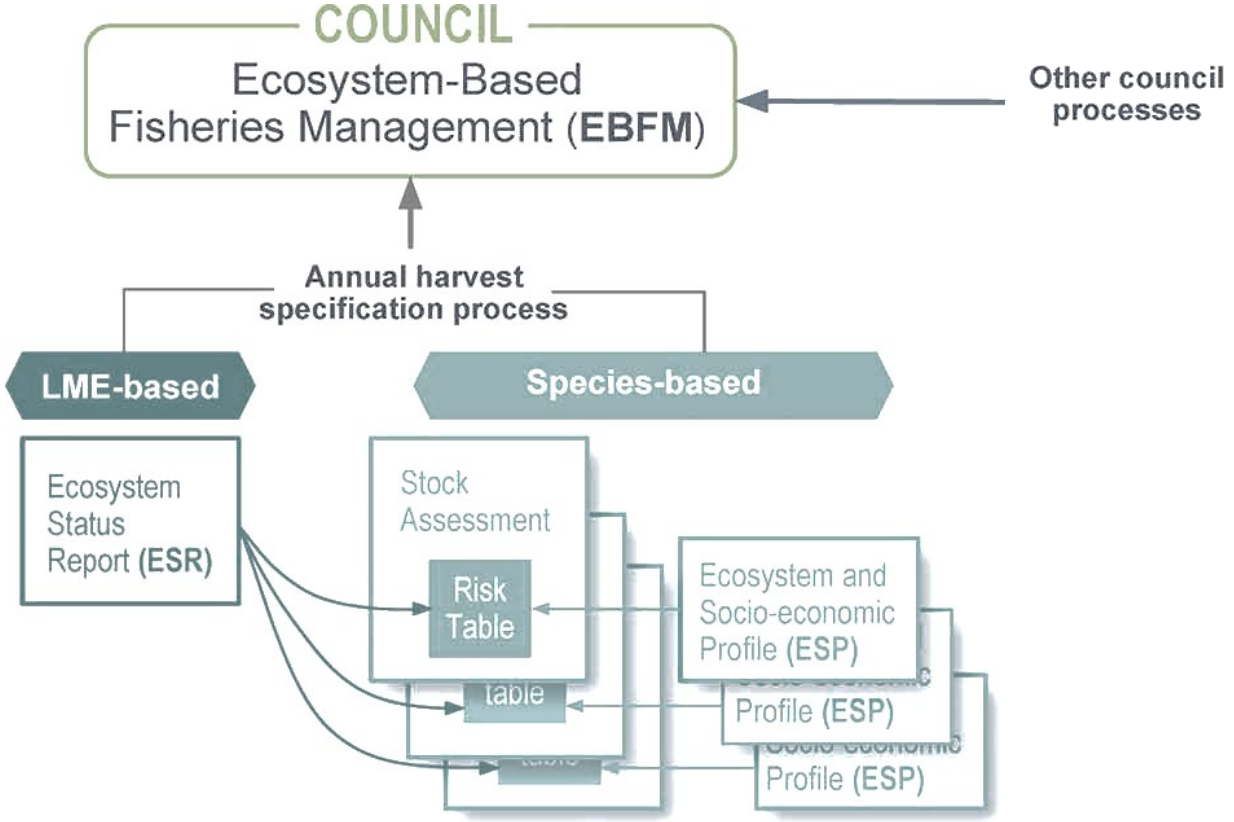
Stock assessment

- Age class composition
- Maturity

Ecosystem-Based Fisheries Management

- Daily age/growth:
  recruitment, survival, phenology
- Body condition:
  survival, energetic investment

→ Environmentally-driven changes

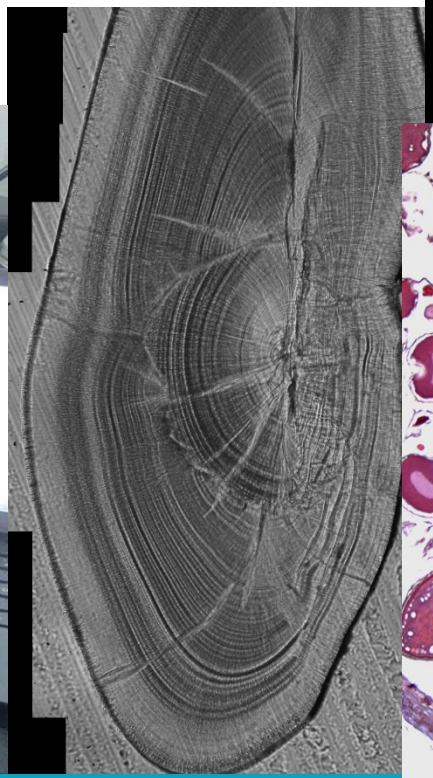


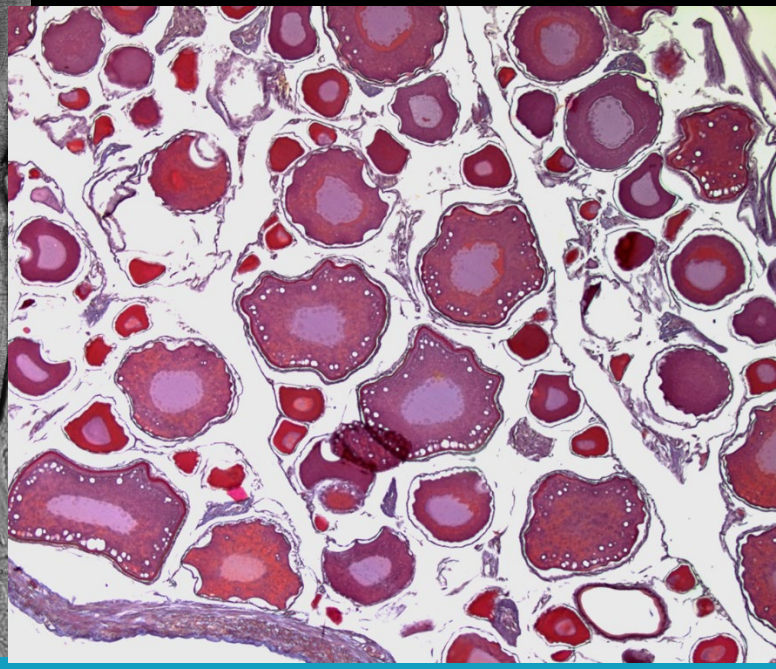
adapted from Dorn and Zador 2020

Why develop new methods?

Traditional analyses are labor intensive

- Age - 40,000+ annual ages/year. No regular daily ageing
- Maturity - histological processing & interpretation
- Body condition - laboratory analysis for most informative indices





Why develop new methods?

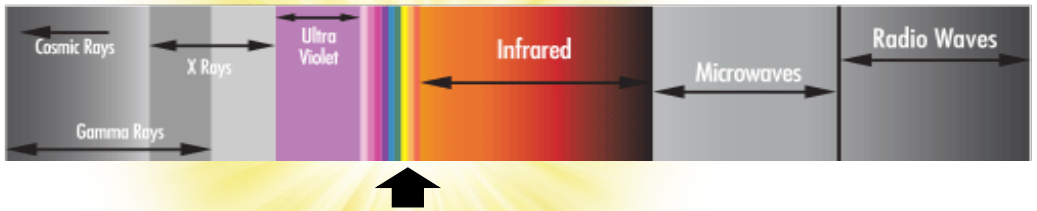
Meet data needs, potential to expand data capabilities & improve efficiency using Fourier transform near-infrared spectroscopy (FT-NIRS)

- Measure multiple indices
- Portable
- No chemicals
- Non-destructive
- Rapid

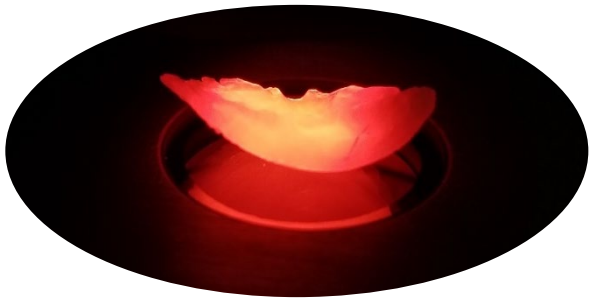
Photo credit: D. Anderl

How does FT-NIRS work?

Shine near-infrared light at a material



NIR 12500-2000 cm^{-1}



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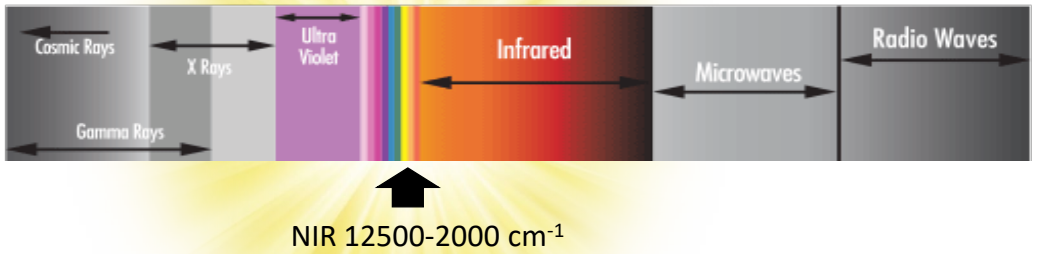
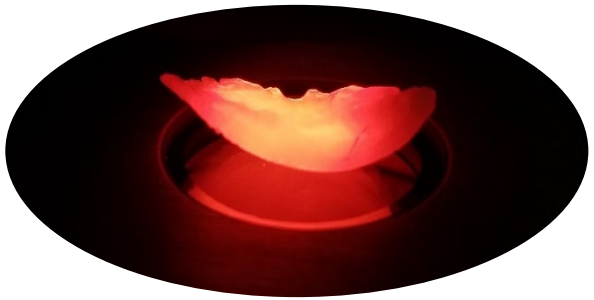
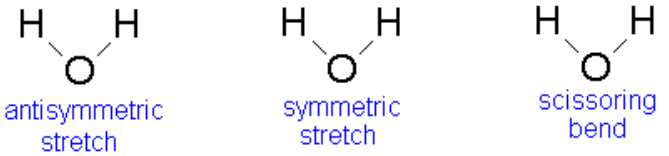




Absorption of light causes bond vibrations & different bonds absorb different wavelengths



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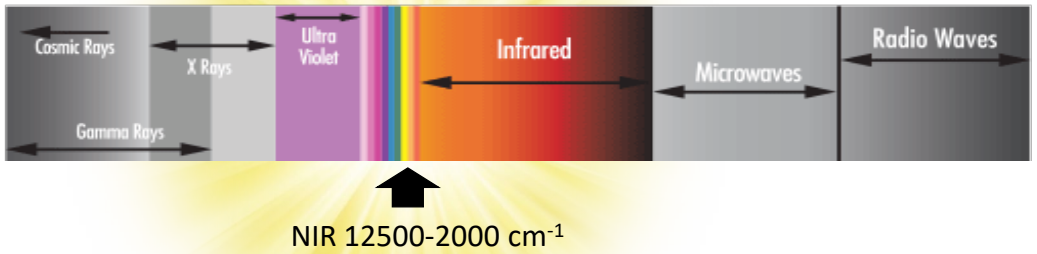

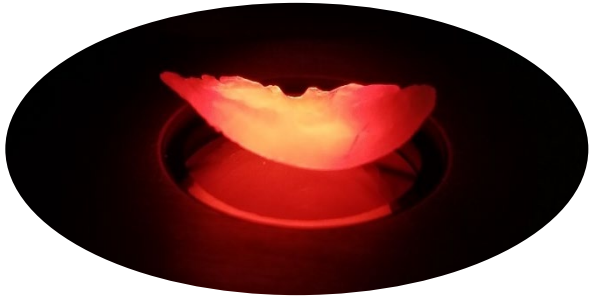

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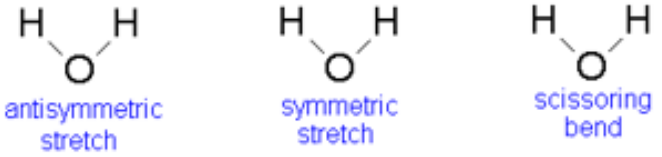

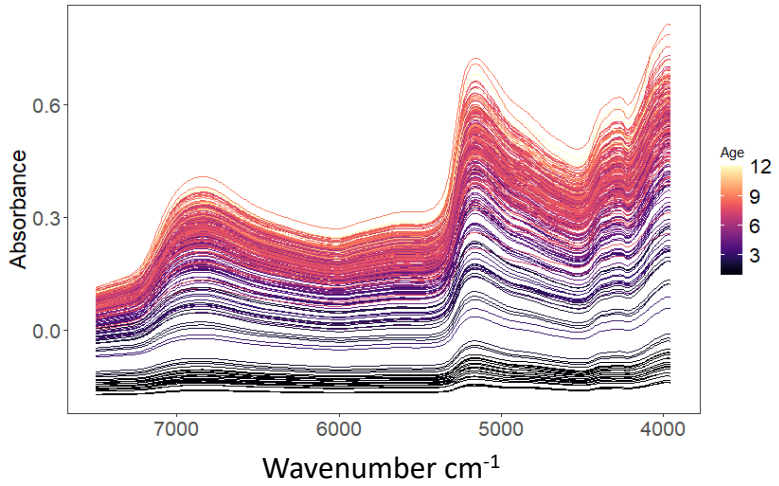

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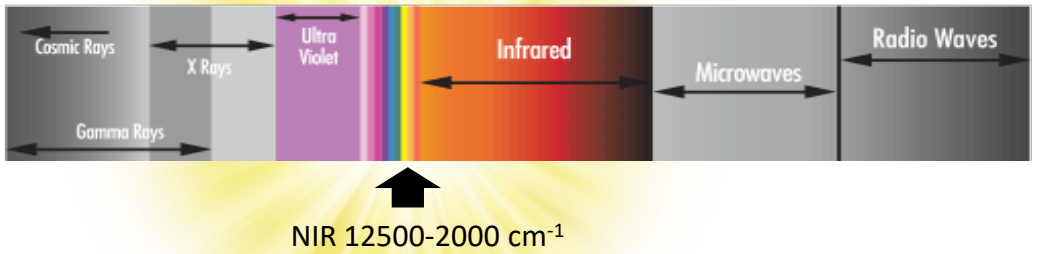

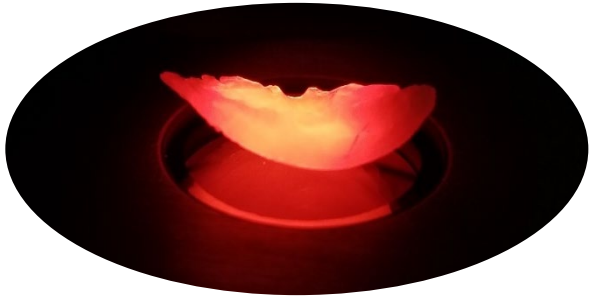

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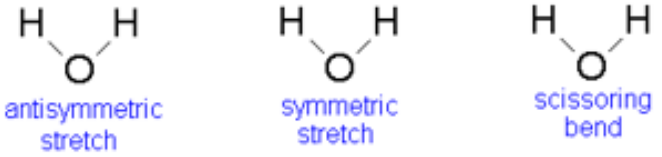
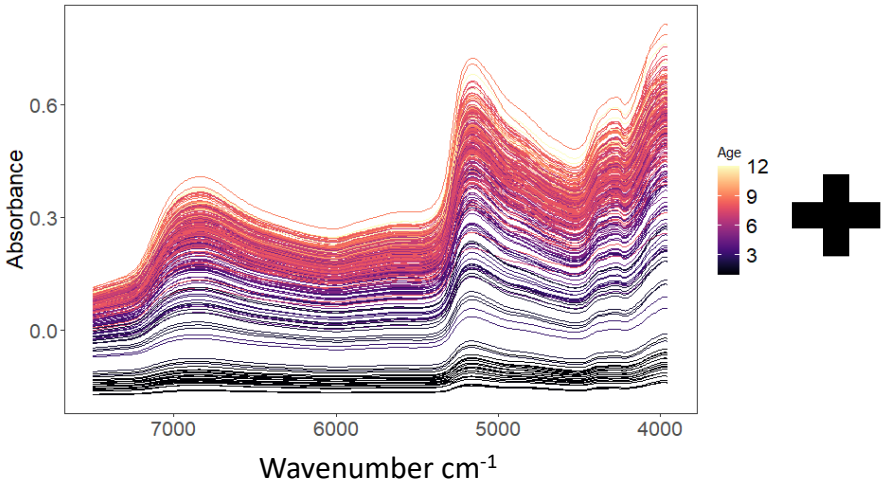
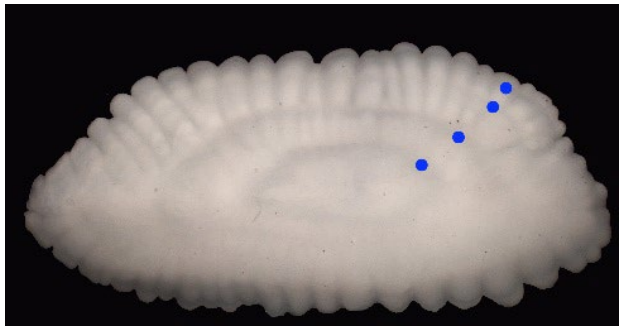


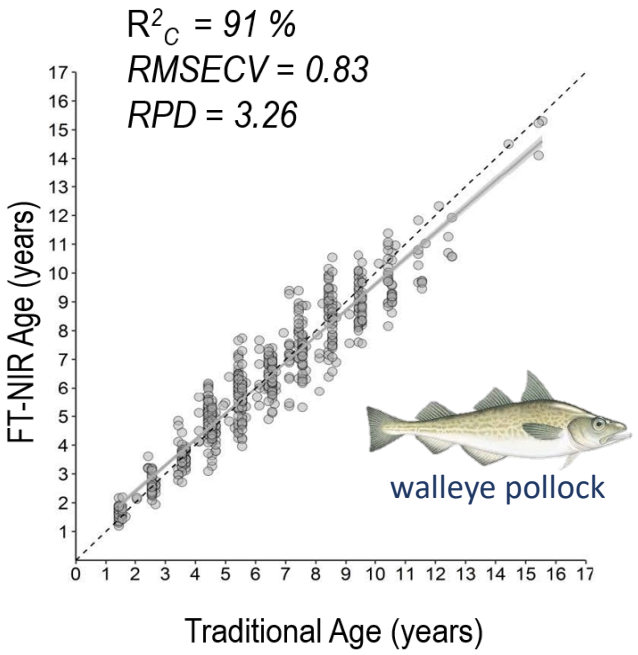




Secondary approach: calibration models relate spectra to reference information for prediction

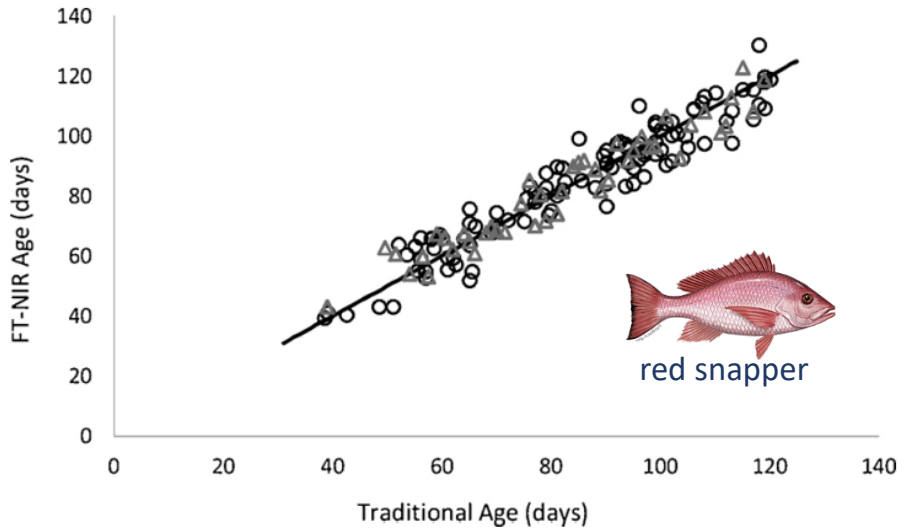
Proof of concept: life history characteristics

Annual age



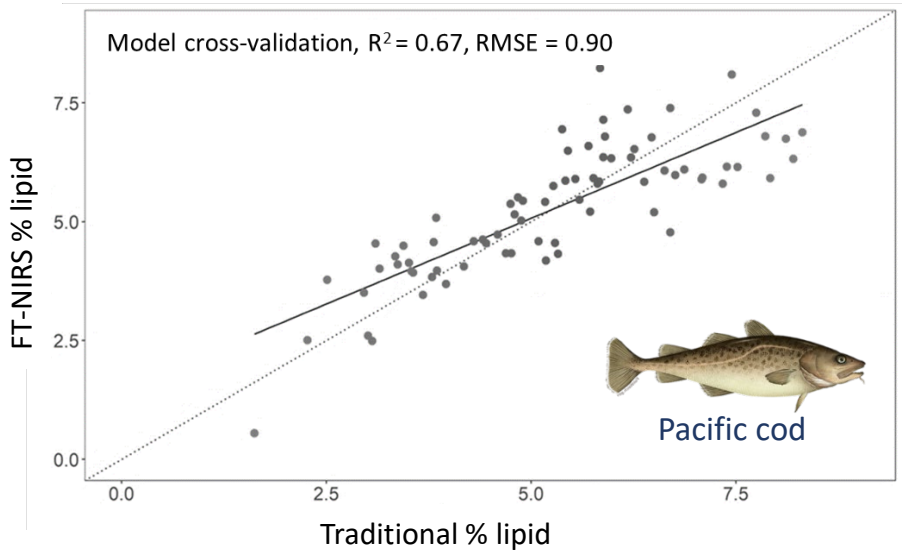
Helser et al. 2019

Daily age



Passerotti et al. 2020

Condition (% lipid)



Goldstein et al. 2021

What do we need to operationalize these new tools?

Foundational comprehensive dataset throughout the year & ontogeny

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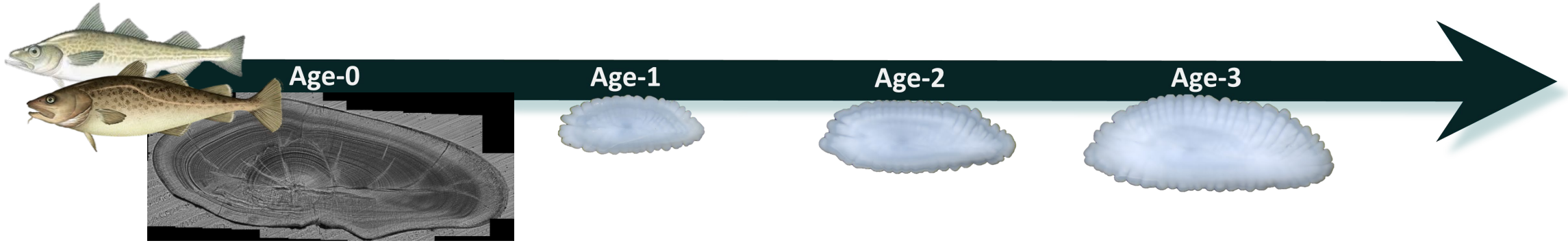
Longitudinal project design with sequential sampling

What do we need to operationalize these new tools?

Foundational comprehensive dataset throughout the year & ontogeny



- **Daily & annual ages**
  - High temporal sampling resolution
  - Known age

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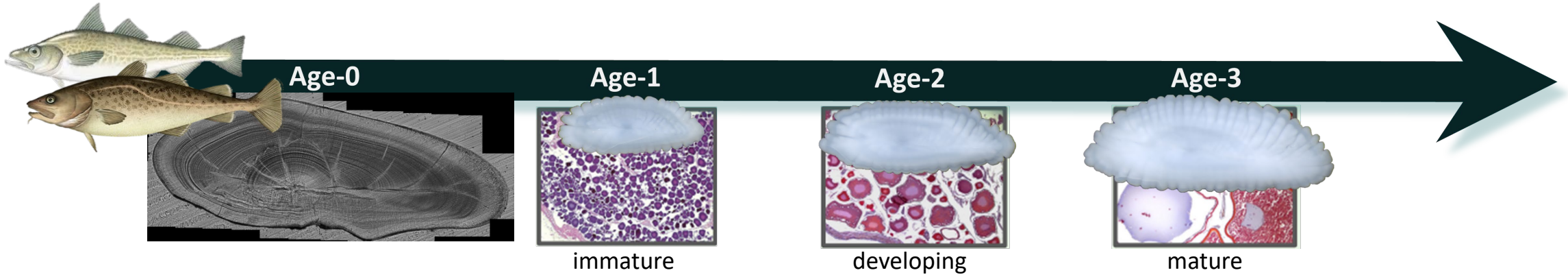

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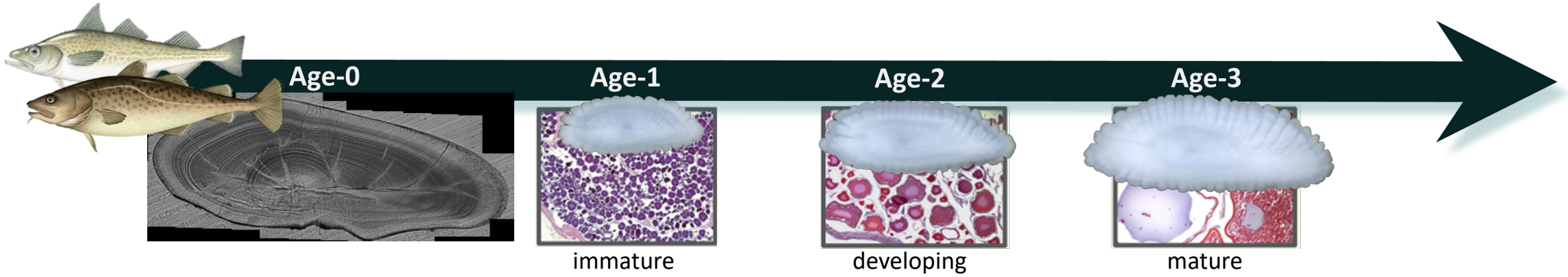

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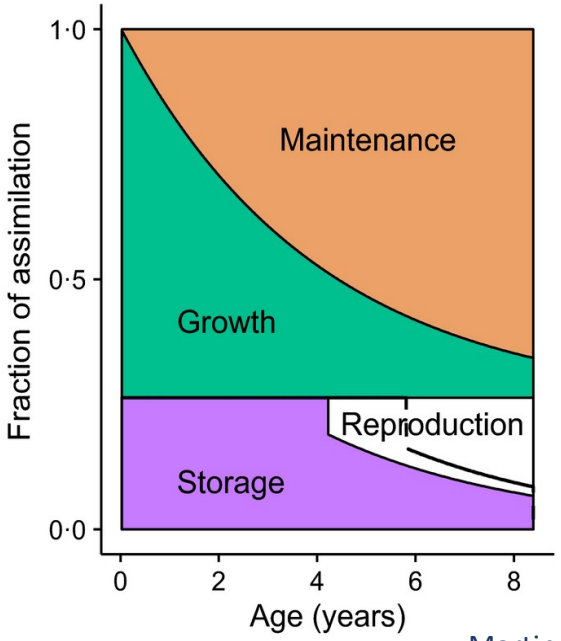
  - Ontogenetic shifts



Martin et al. 2017

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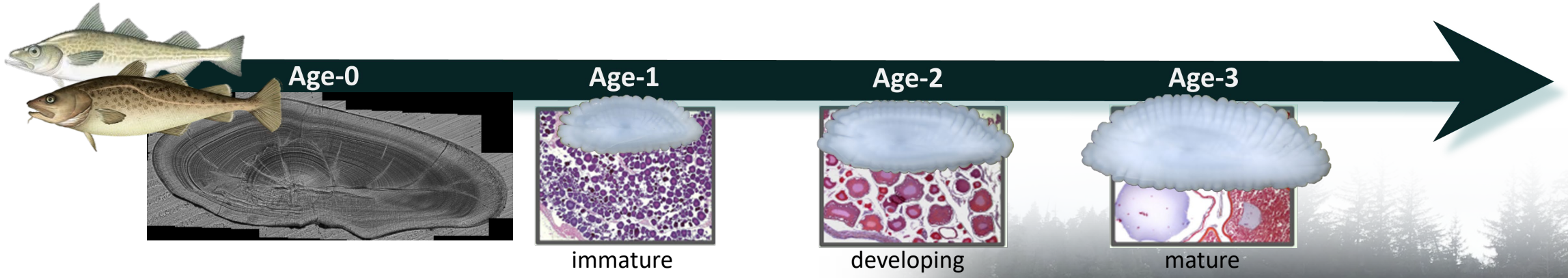

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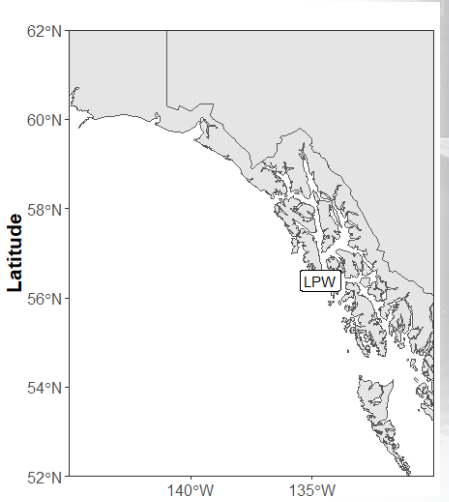
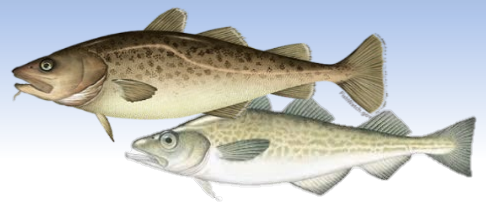
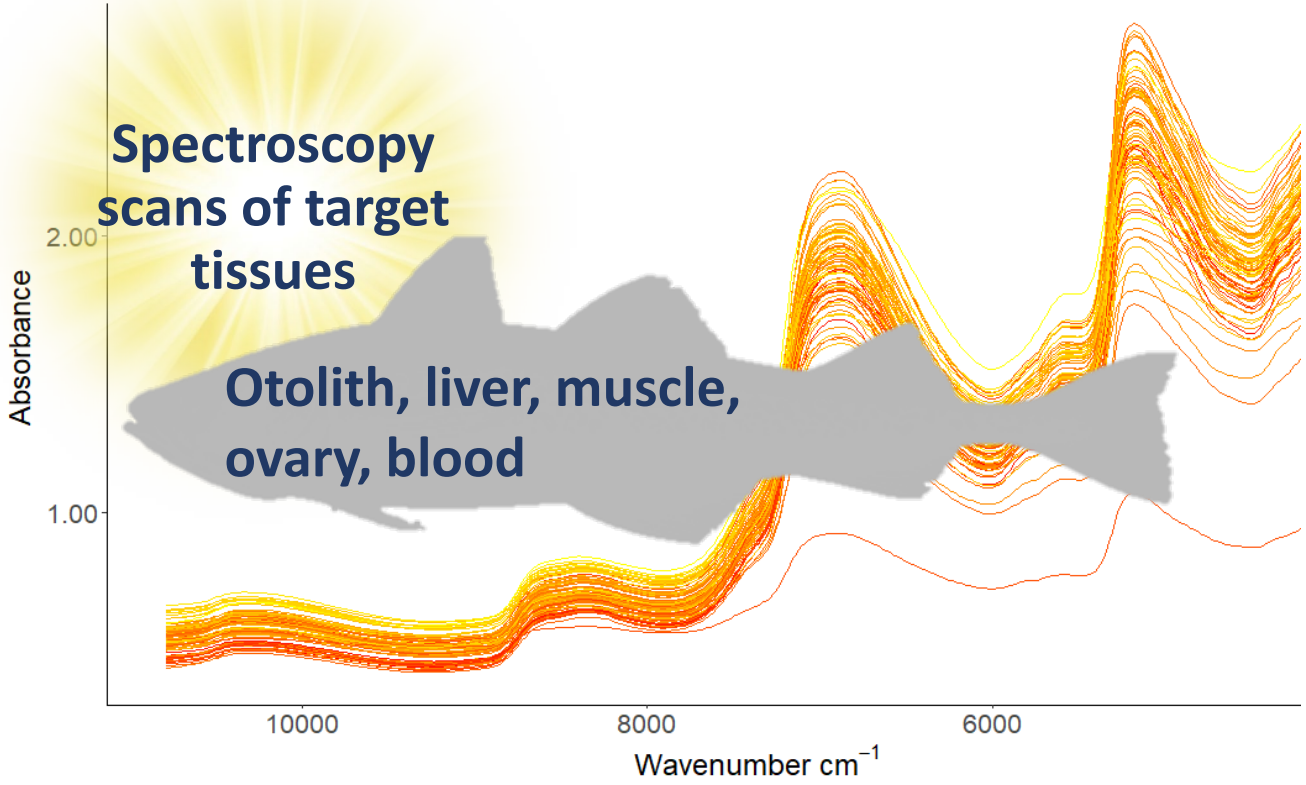




Calibration models

Spectroscopy scans of target tissues

Otolith, liver, muscle, ovary, blood



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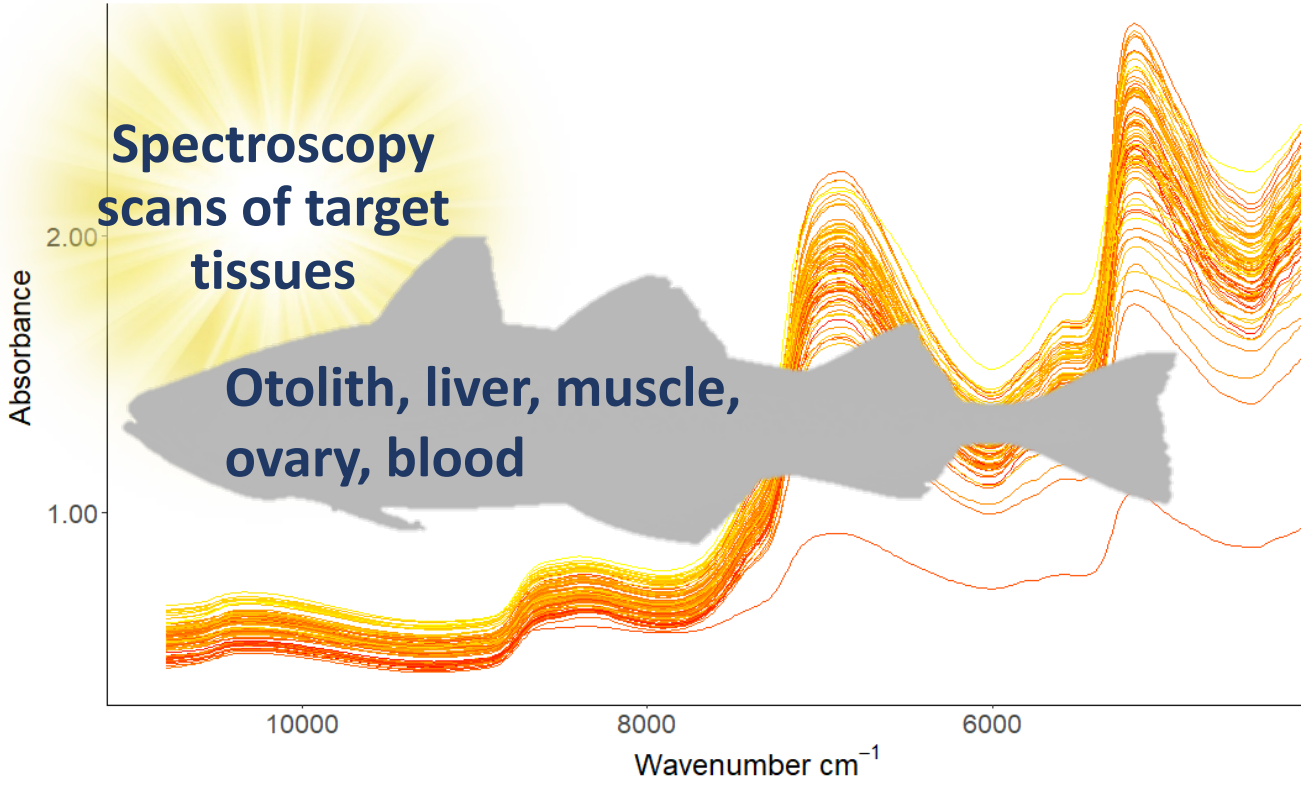
- Age
- Maturation
- Body condition

Objective: Evaluate effectiveness of FT-NIRS as a rapid method to predict daily ages of YOY walleye pollock

Calibration models



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- **Daily age**
- Maturation
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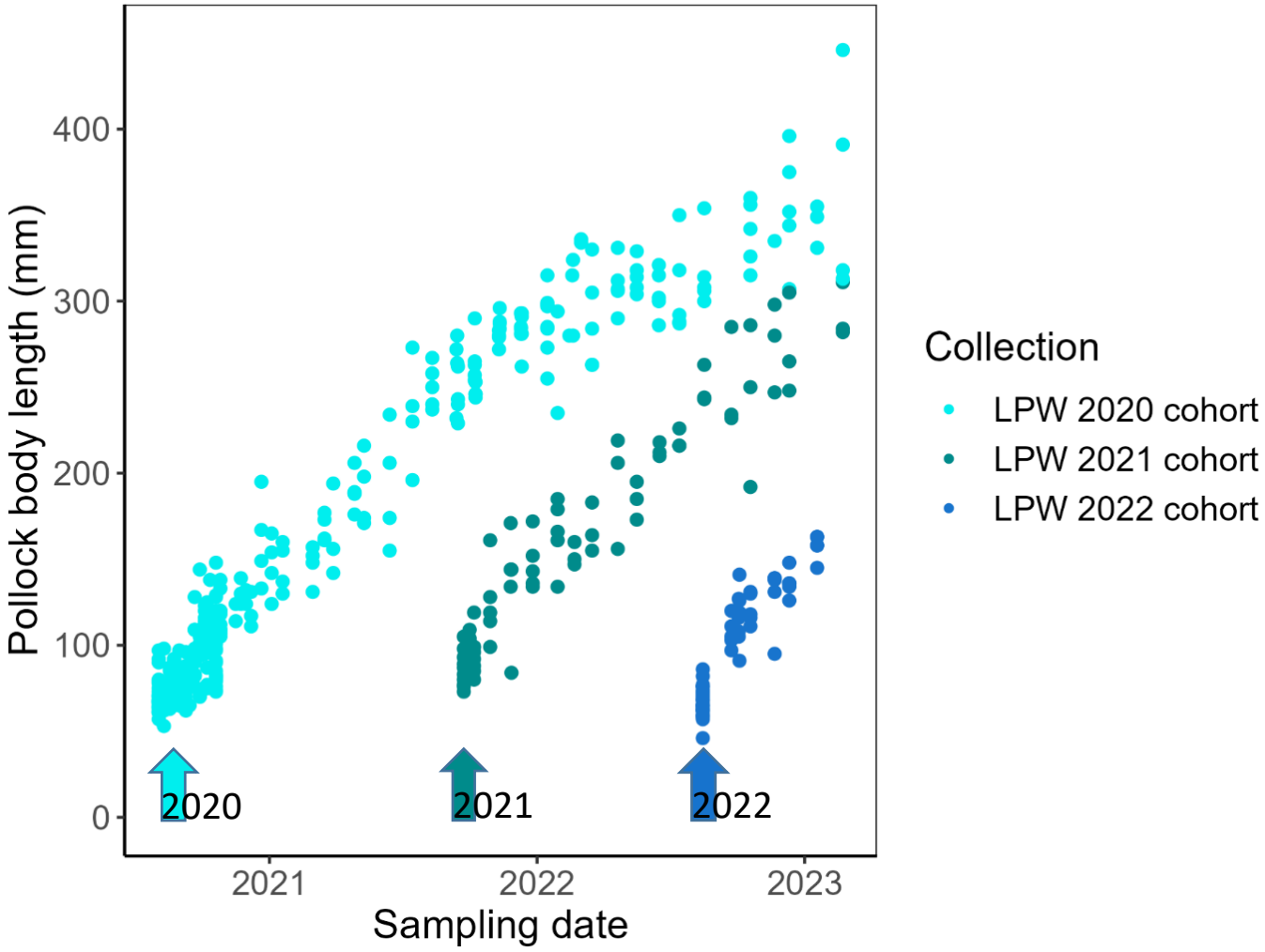
Reared cohorts



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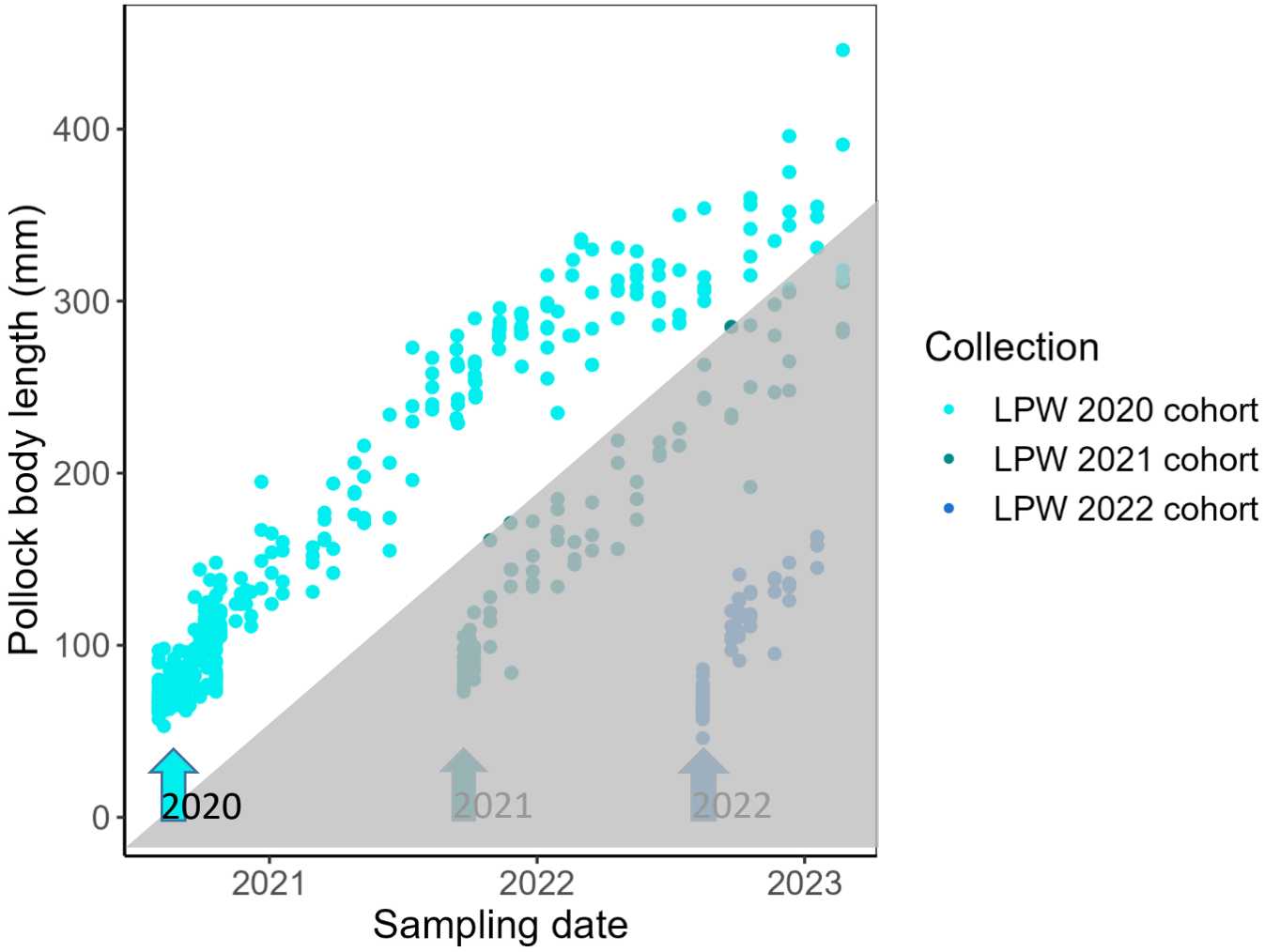

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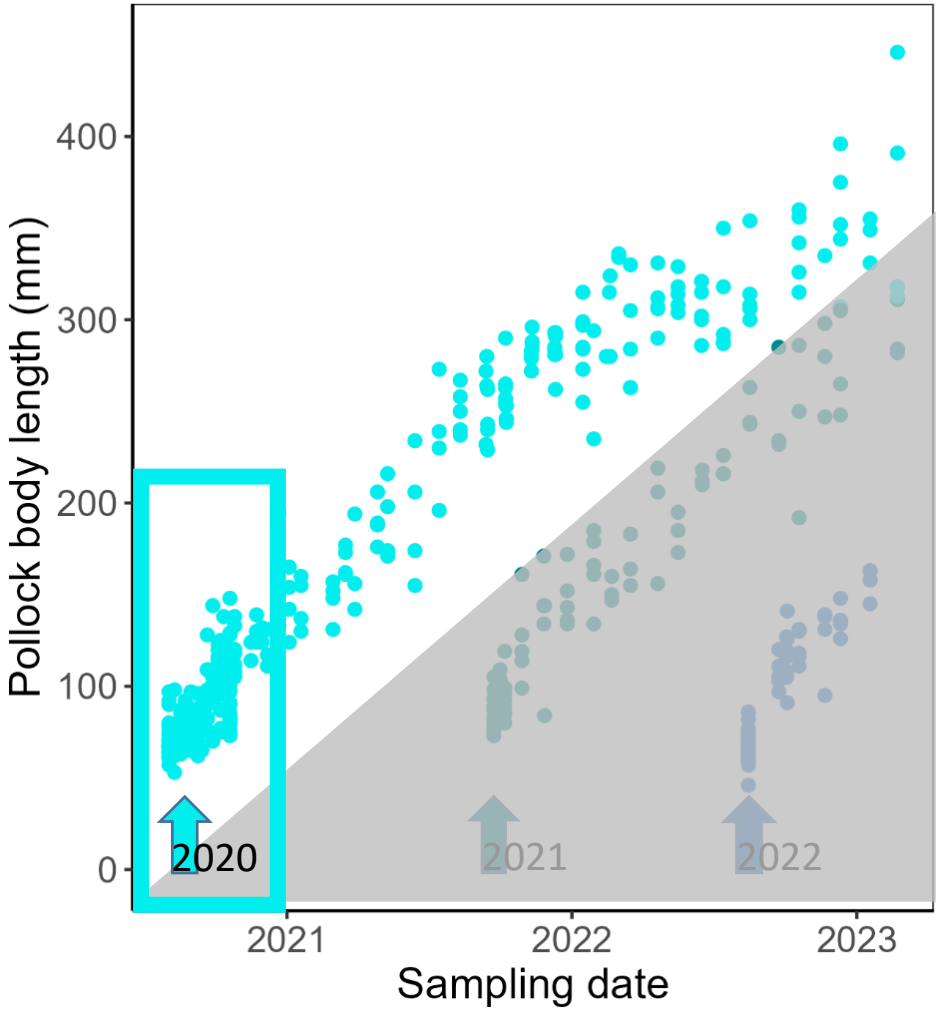
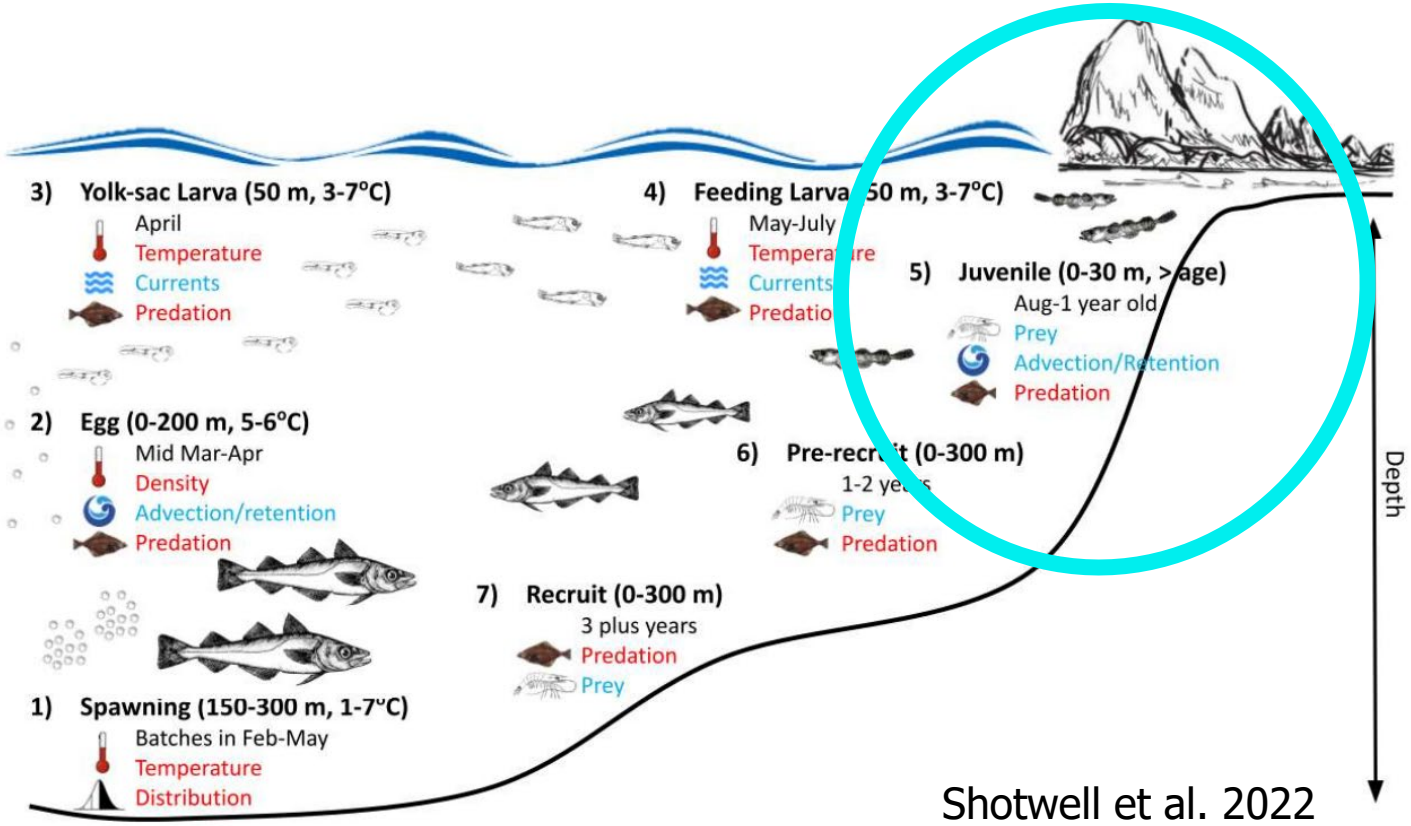
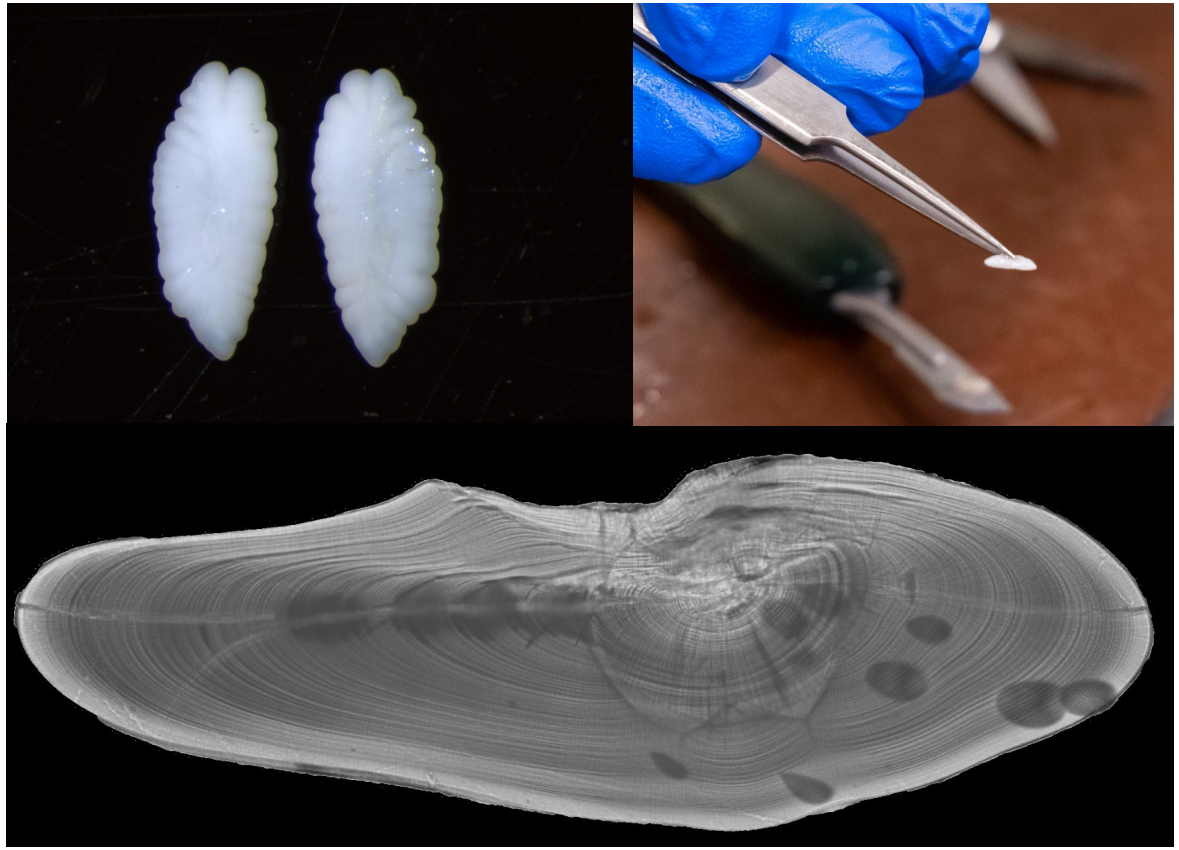




Shotwell et al. 2022

Reference data for models: Traditional (microscopic) age determination

- Aged otoliths (ear stones) by counting daily increments for fish sacrificed < Oct 1
- For unaged fish, age was estimated



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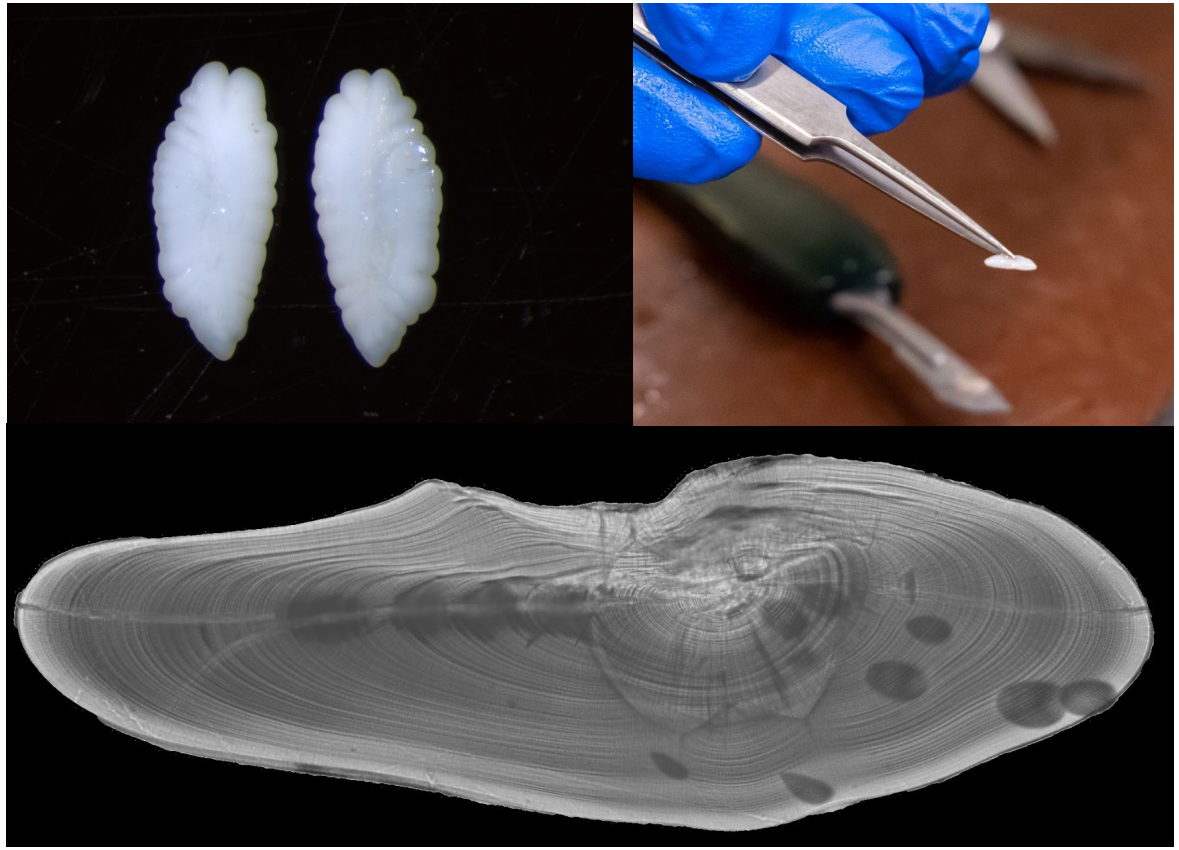

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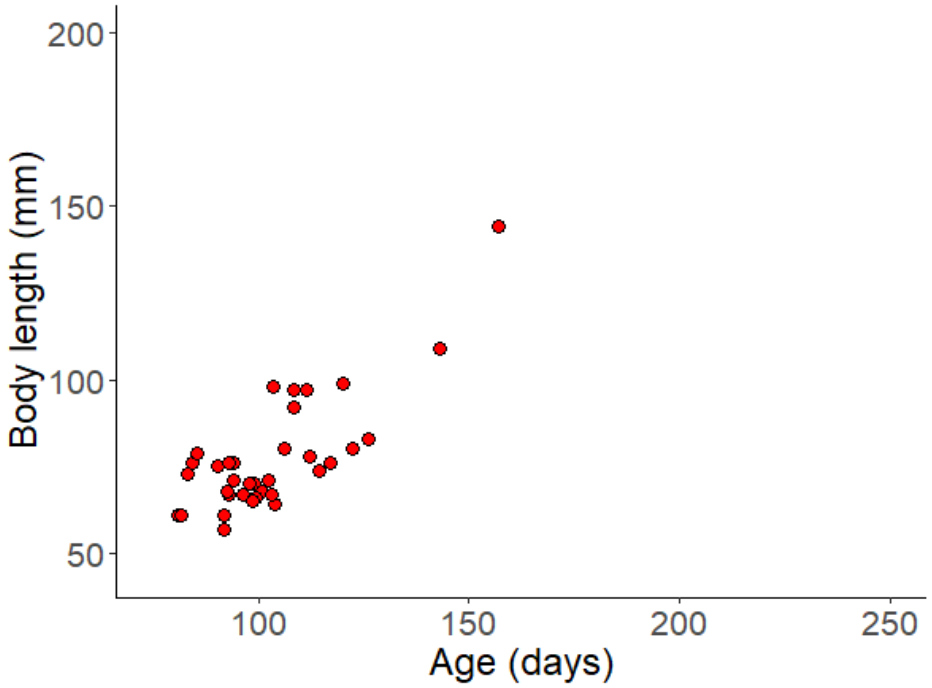

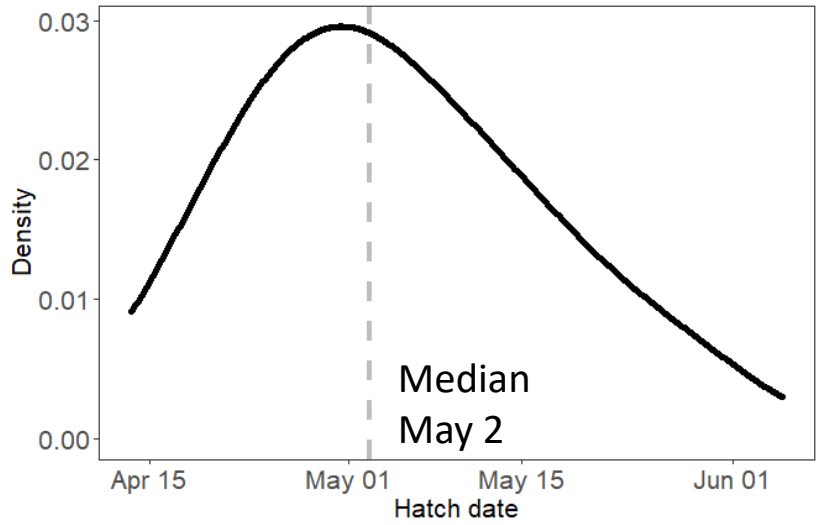

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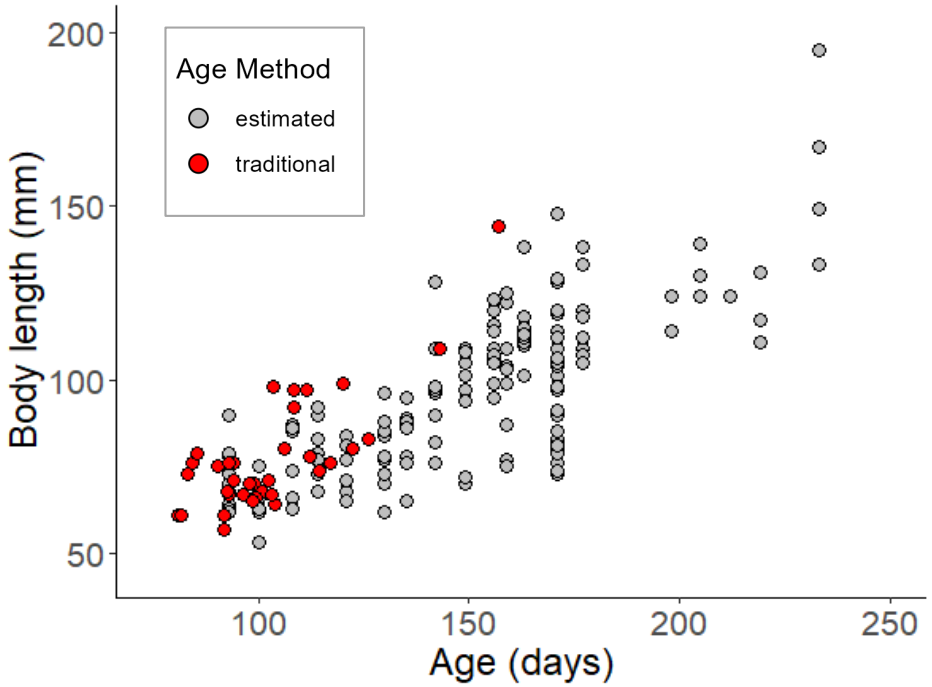

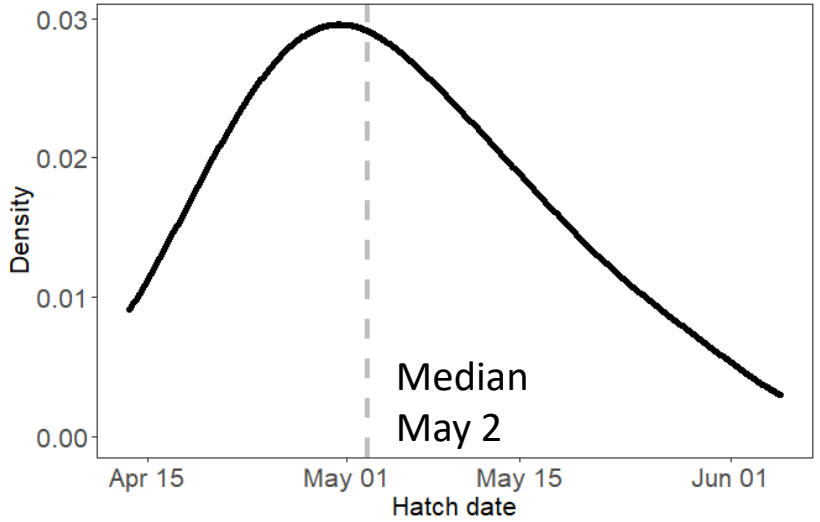

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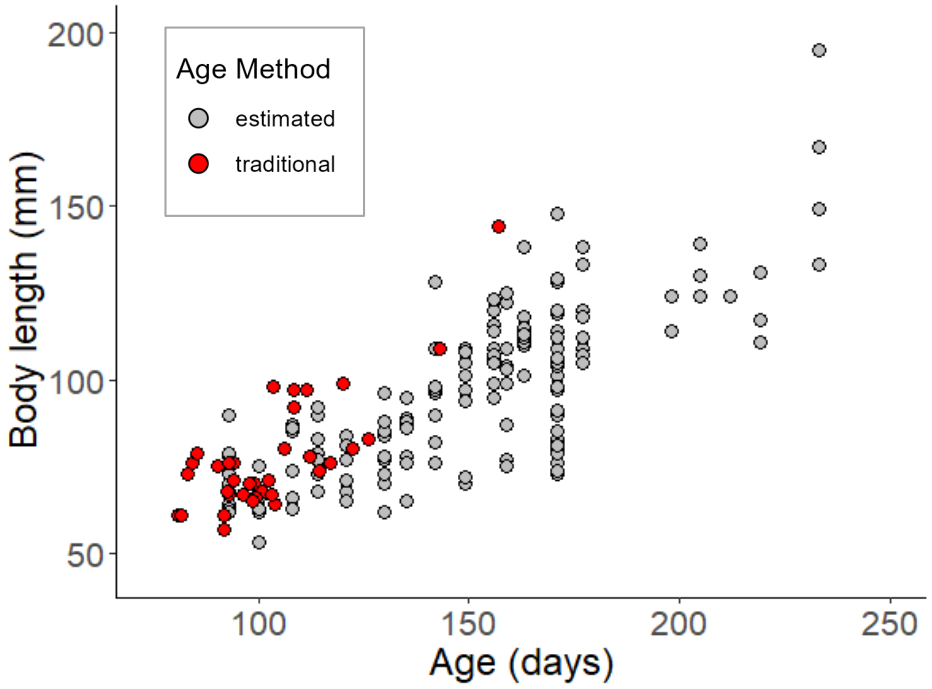
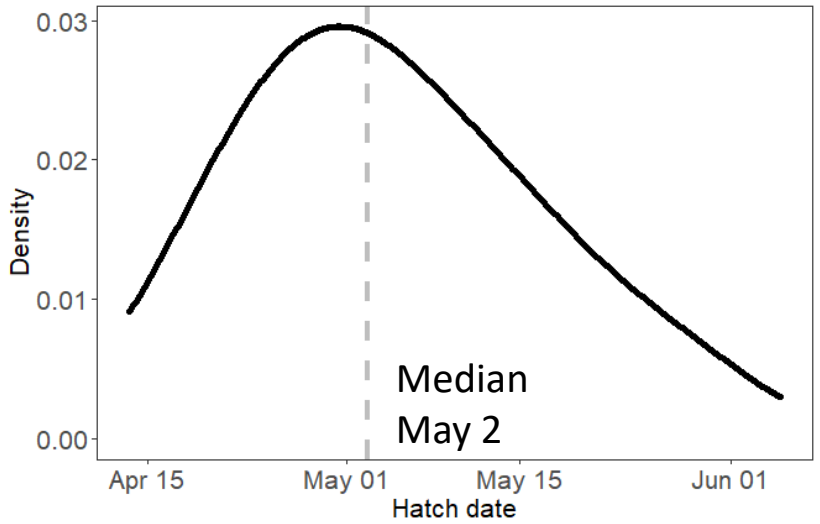
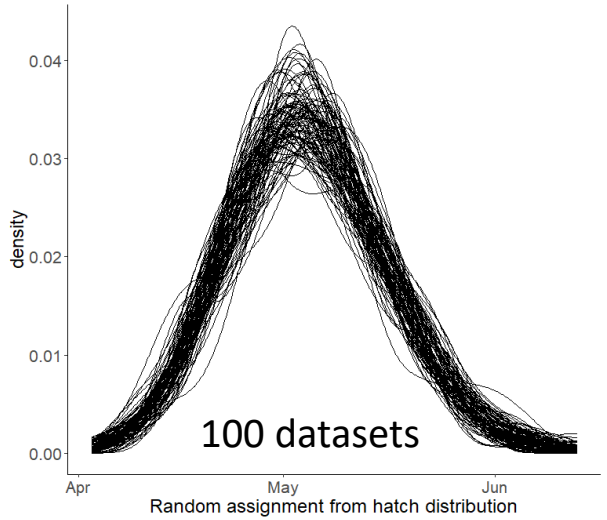


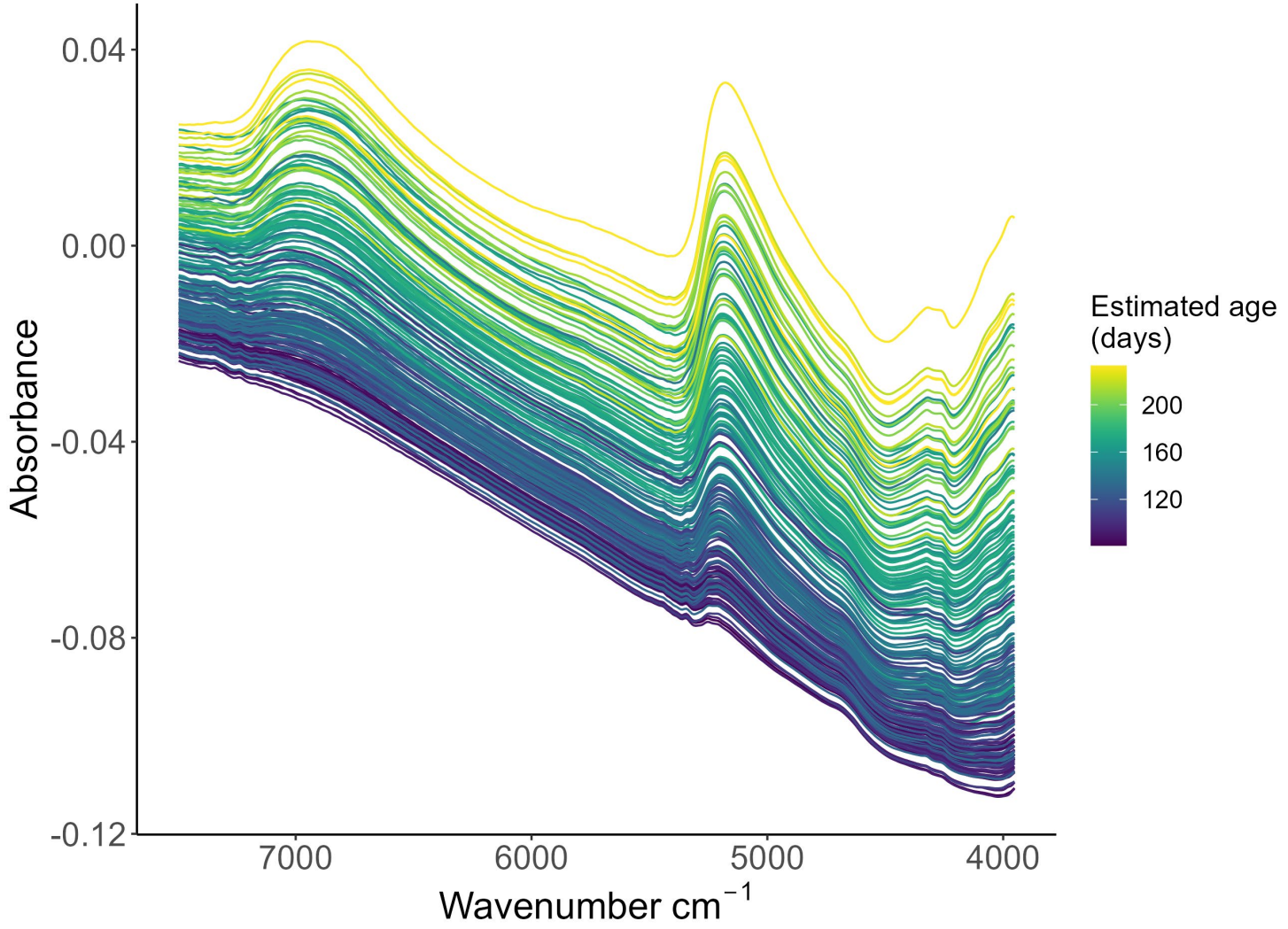




FT-NIRS data collection

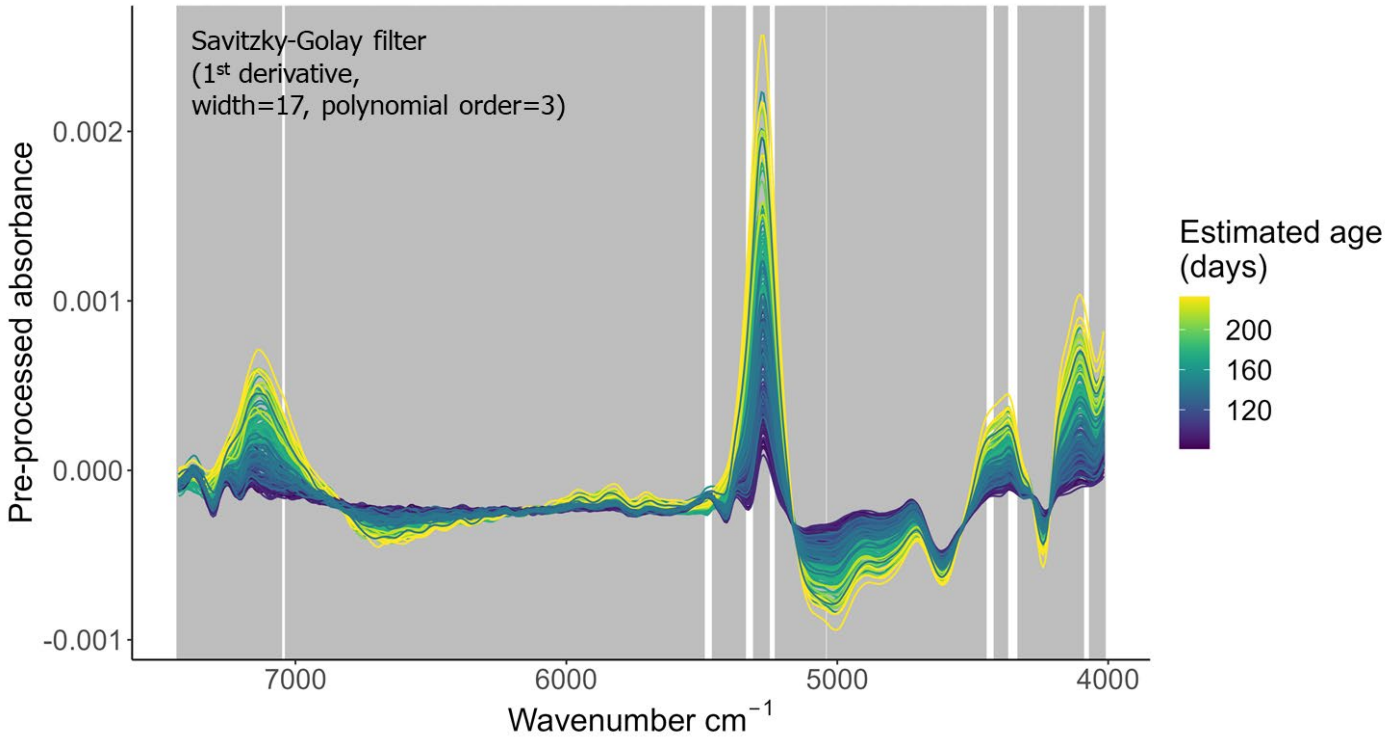
- Scanned all otoliths
- Partial Least Squares Regression (PLSR) models with calibration & test data sets

Raw spectra



- Separation by age
- Pre-process before analysis

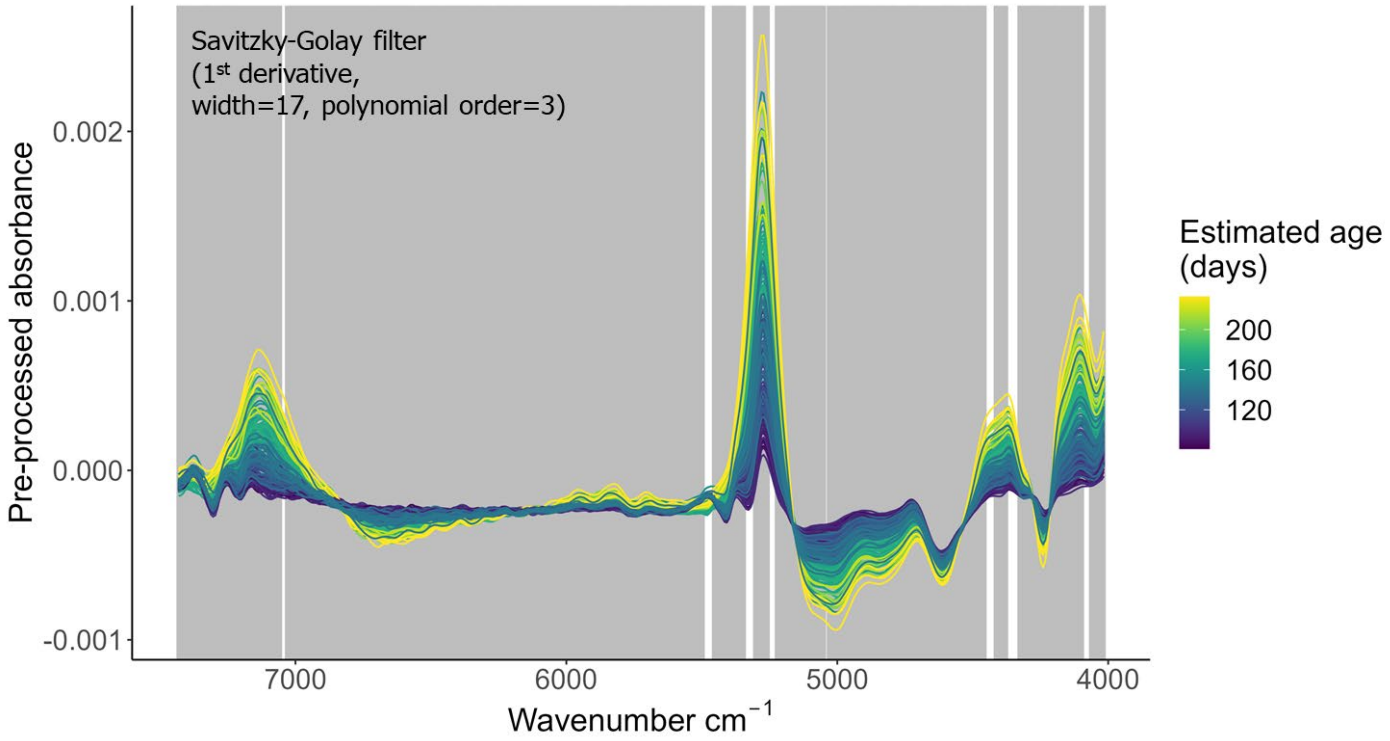
FT-NIRS age predictions



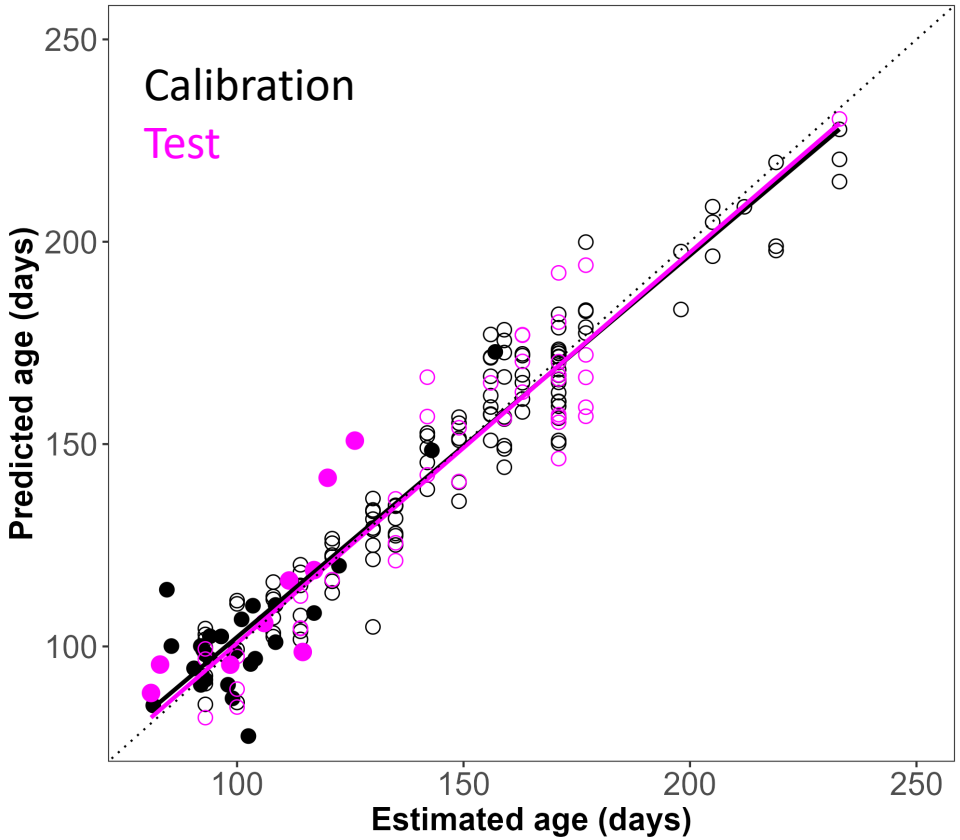
Preliminary findings

FT-NIRS age predictions

- May 2 hatch date assignment

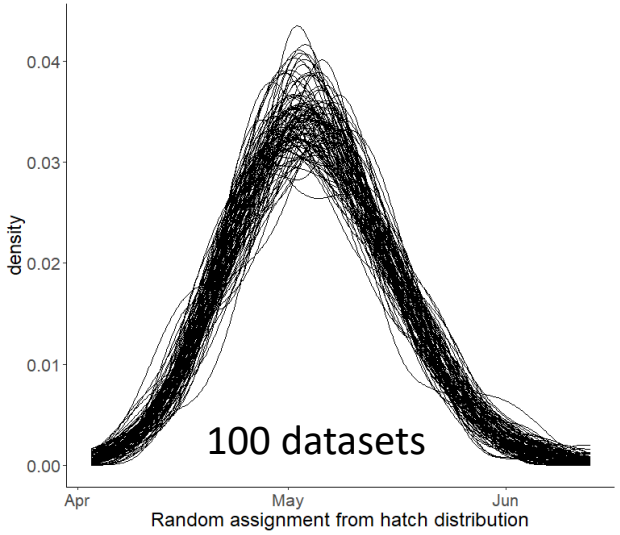


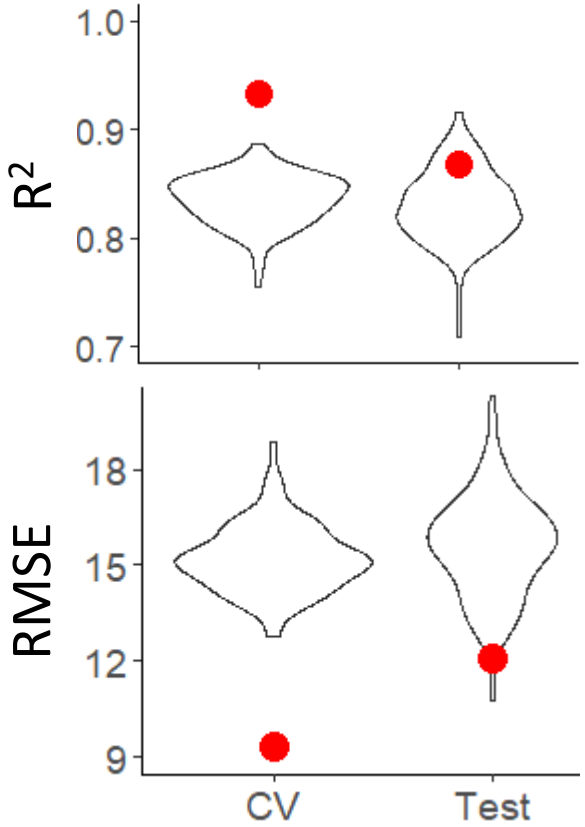
	RMSE	R^2
Cross Validation	9.34	0.93
Test	12.09	0.87



FT-NIRS age predictions

- Random hatch assignment
- Fit models with the same variables & calibration/test





- Reduced model performance

FT-NIRS age predictions

- Random hatch assignment
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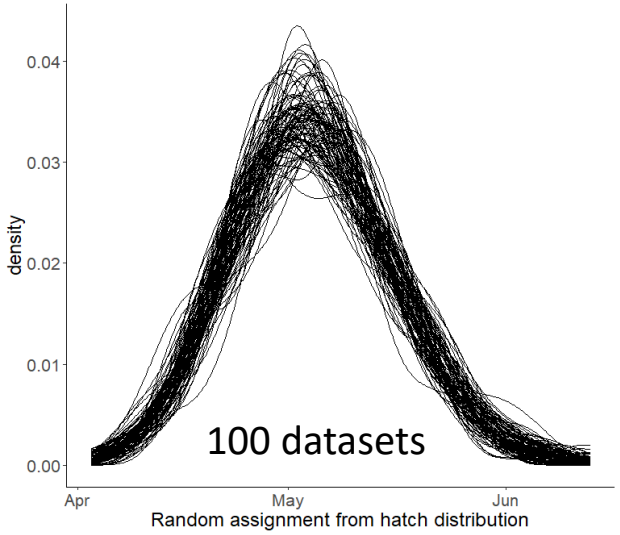
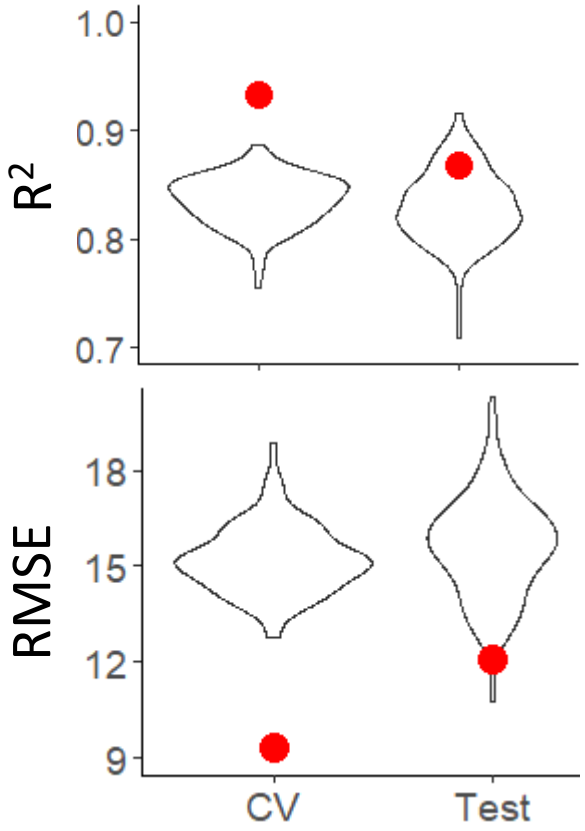
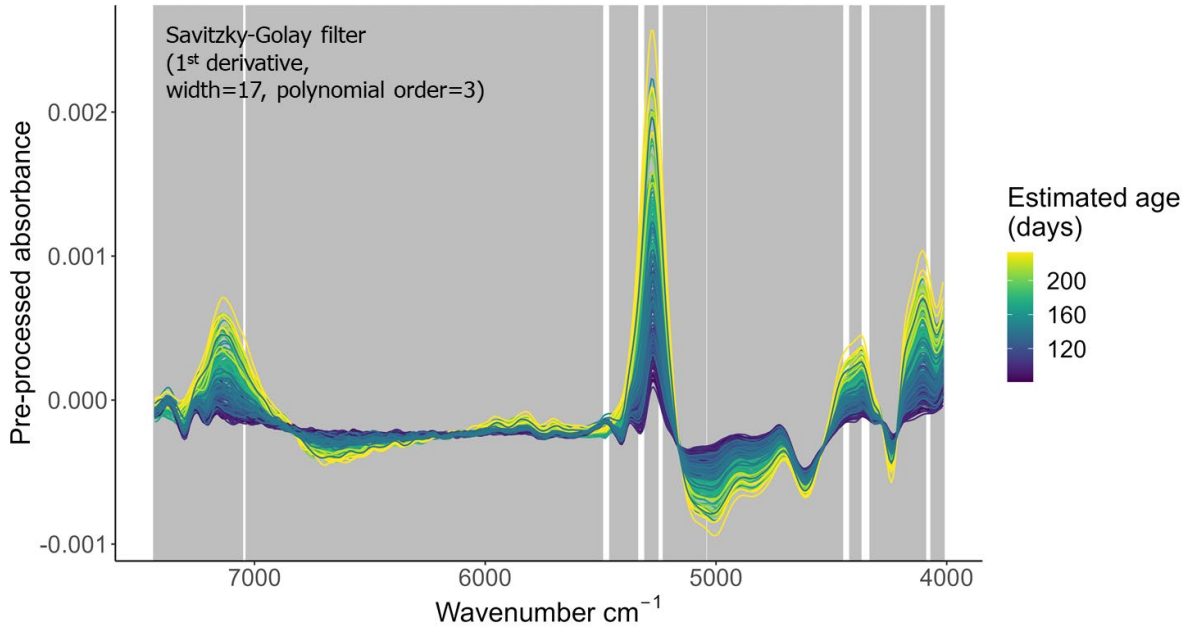


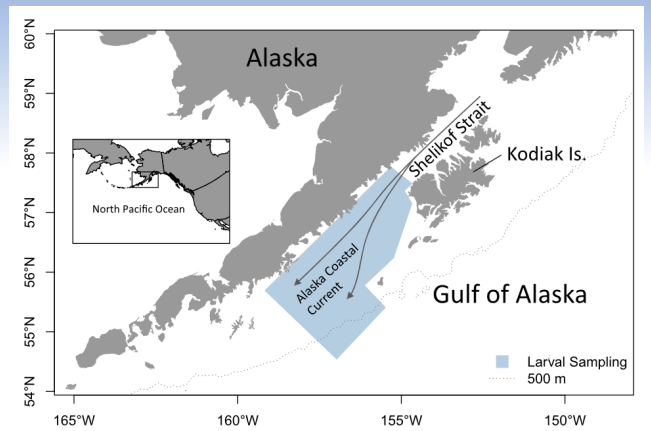


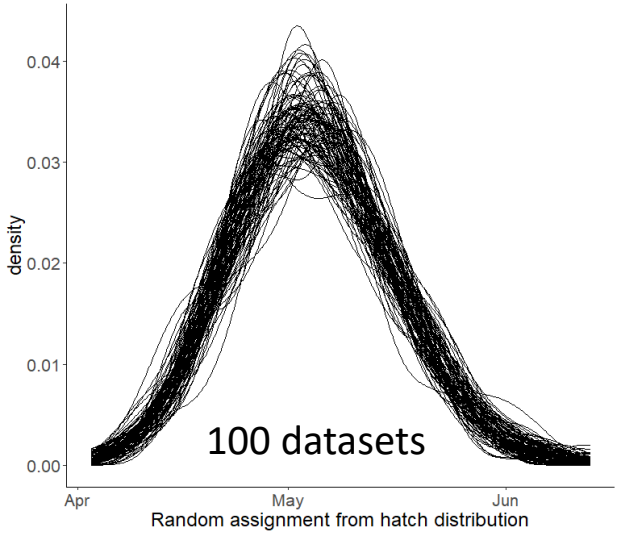
- Reduced model performance
- Stringent variable selection

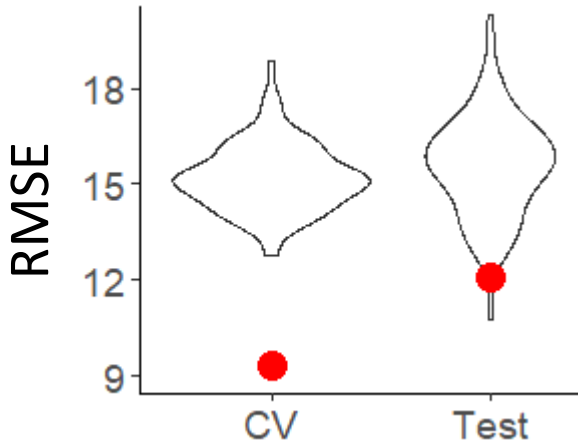


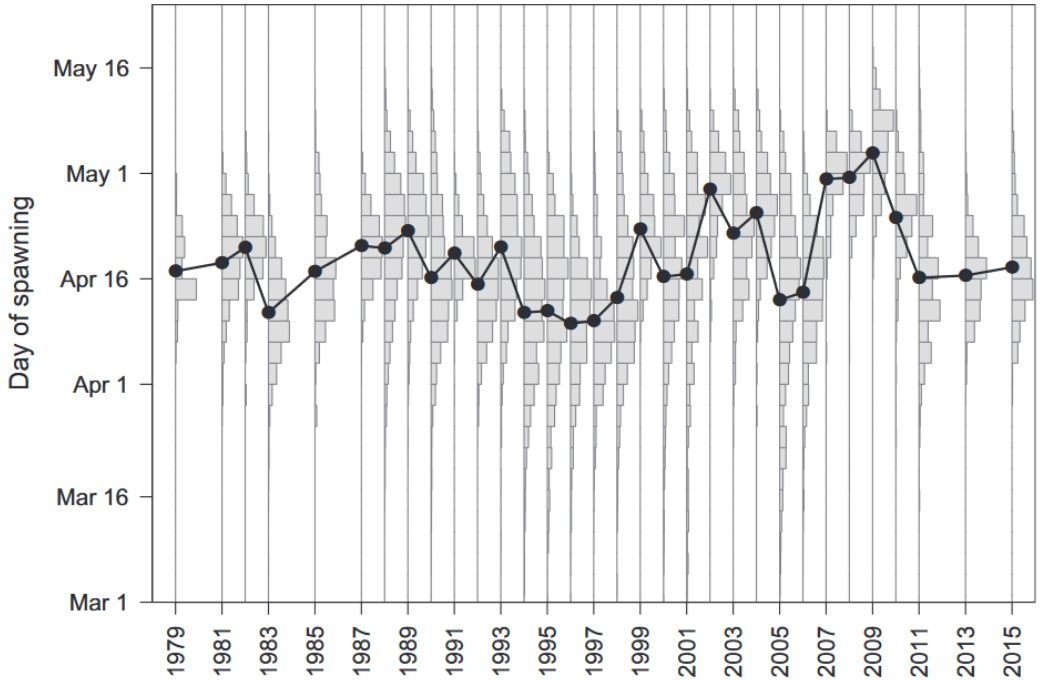
FT-NIRS age predictions

- What could ~10-20 day resolution in daily age prediction tell us?
- Are these informative timescales?





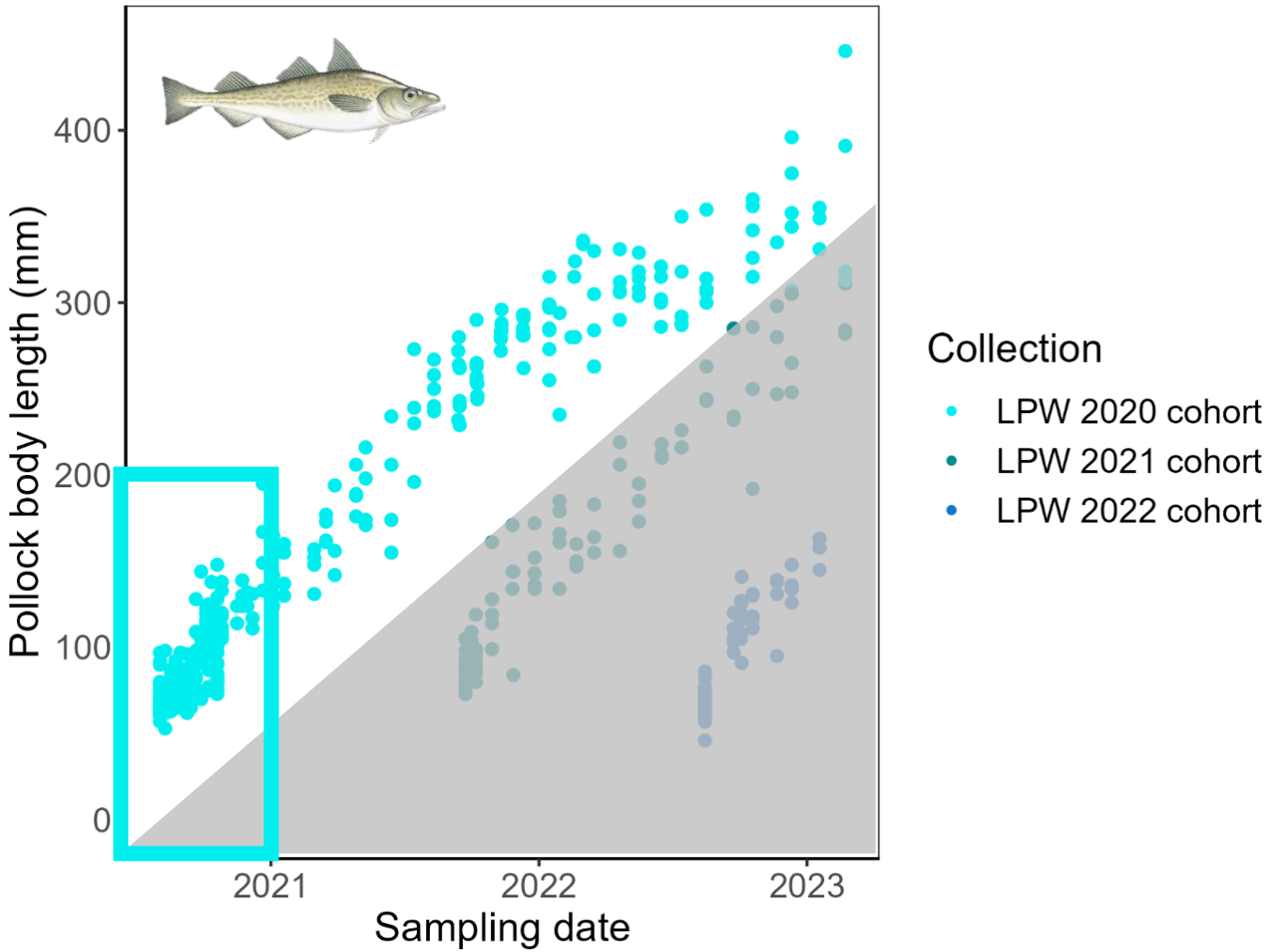




Rogers & Dougherty 2018

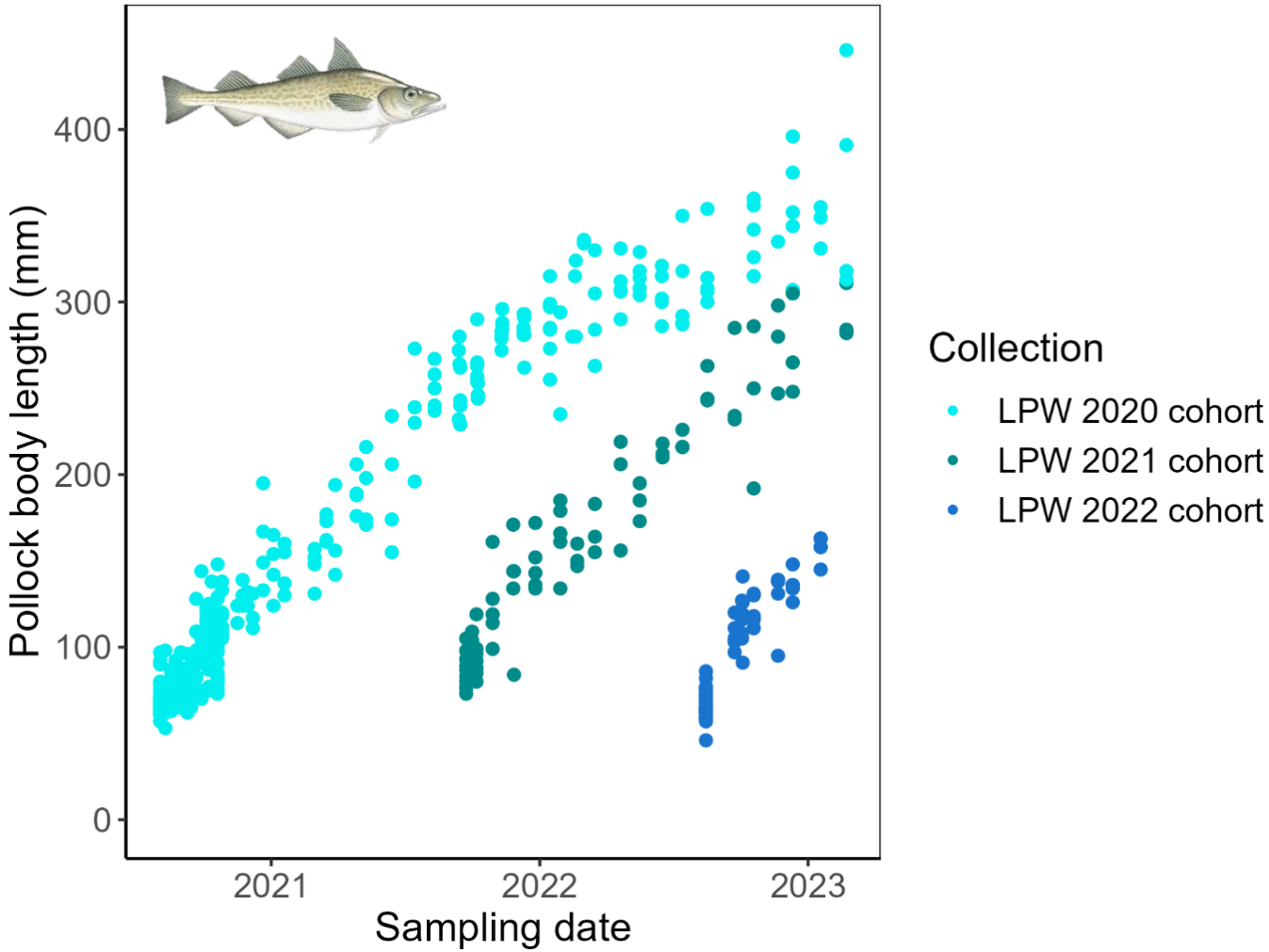
Preliminary findings

Results look promising, what's next?



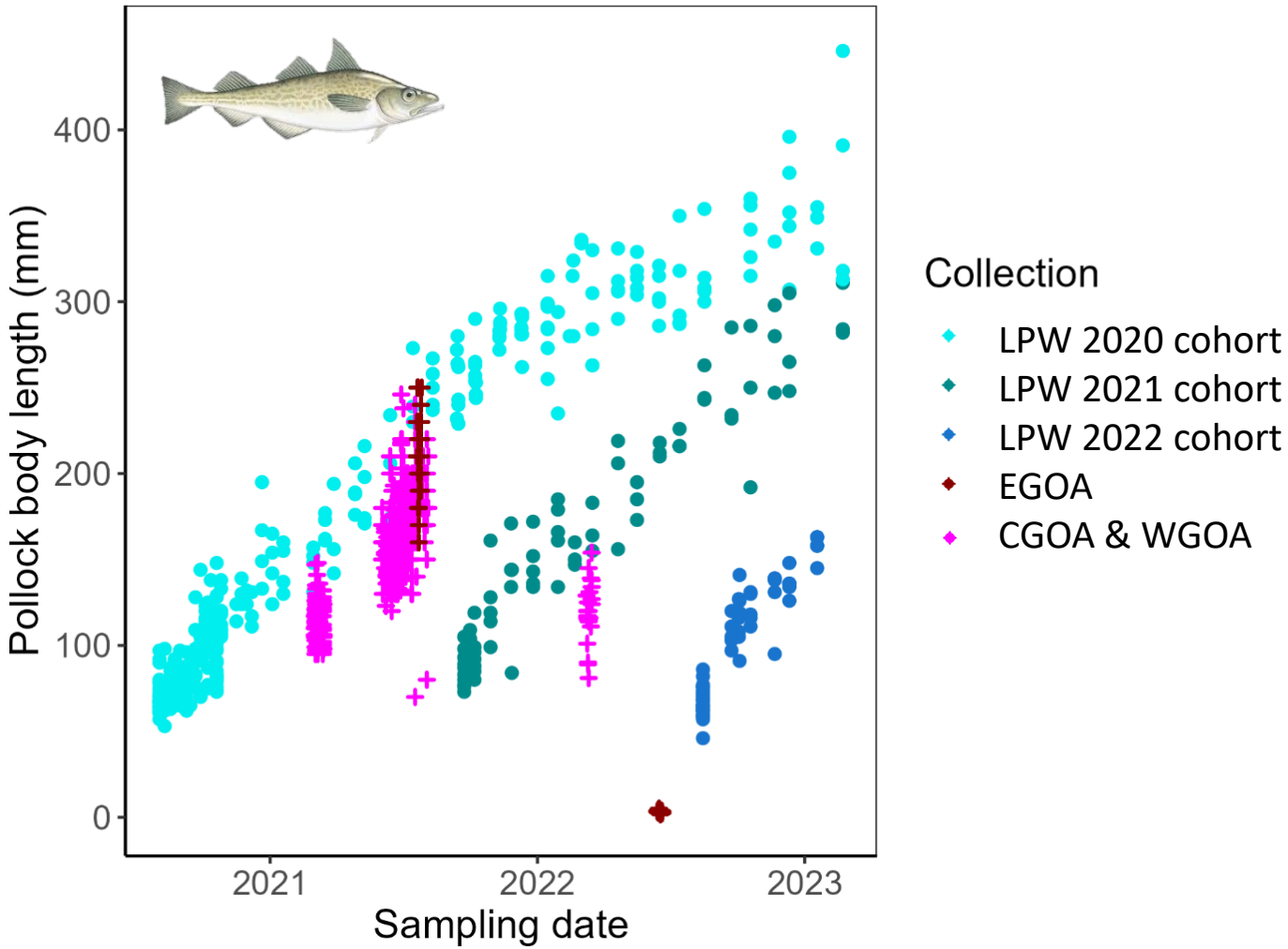
Results look promising, what's next?

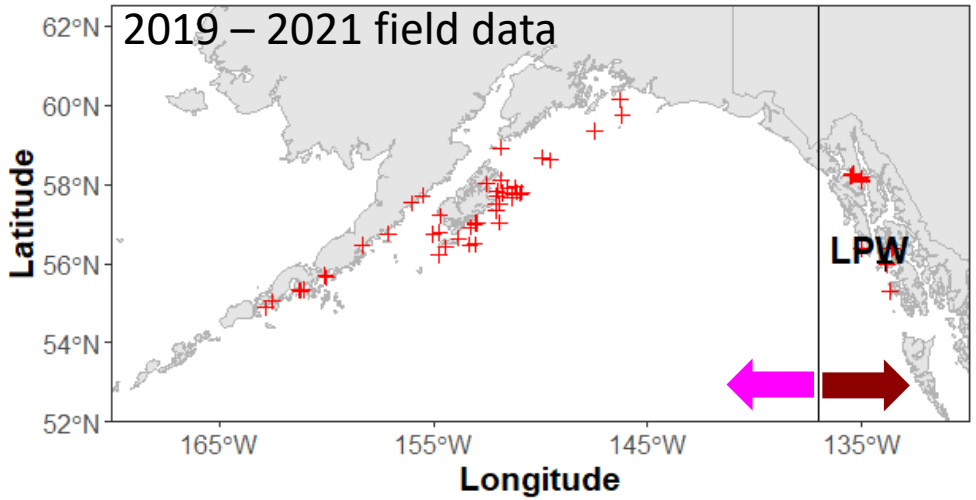
- Other cohorts



Results look promising, what's next?

- Other cohorts
- Wild caught fish





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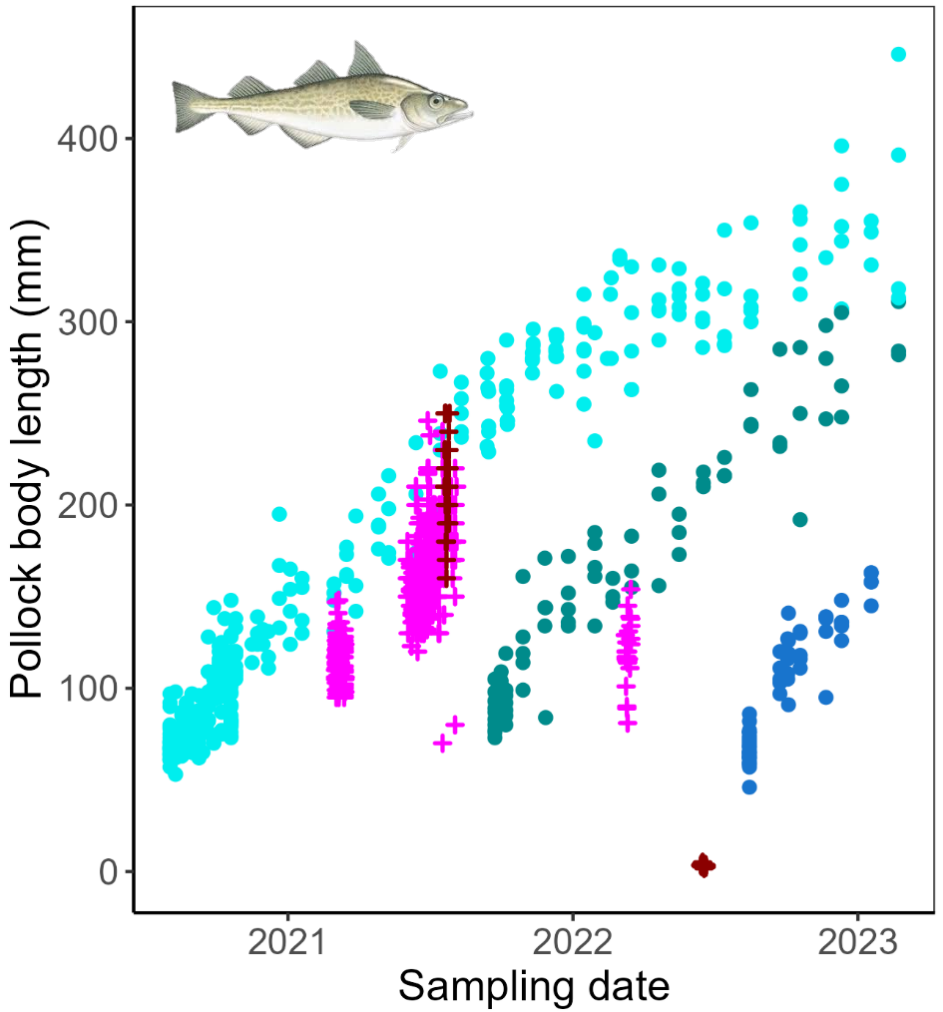
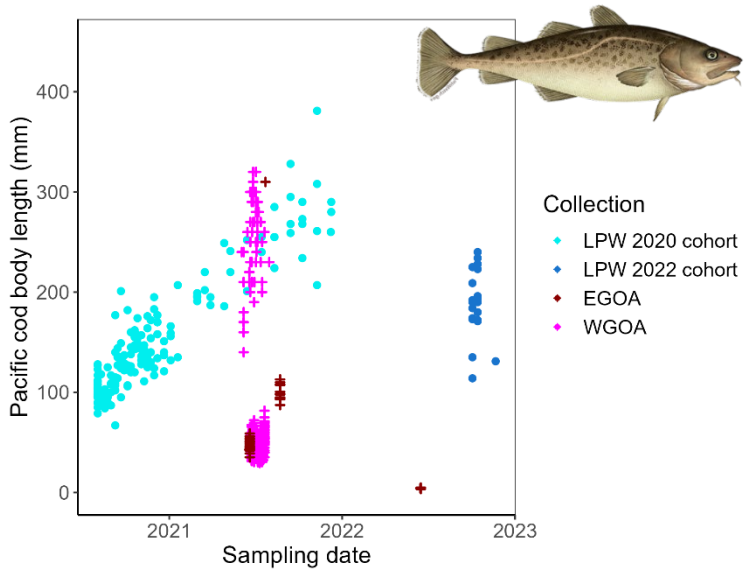


- Other cohorts
- Wild caught fish
- Reference age & model uncertainty
- Other life history metrics
- Pacific cod



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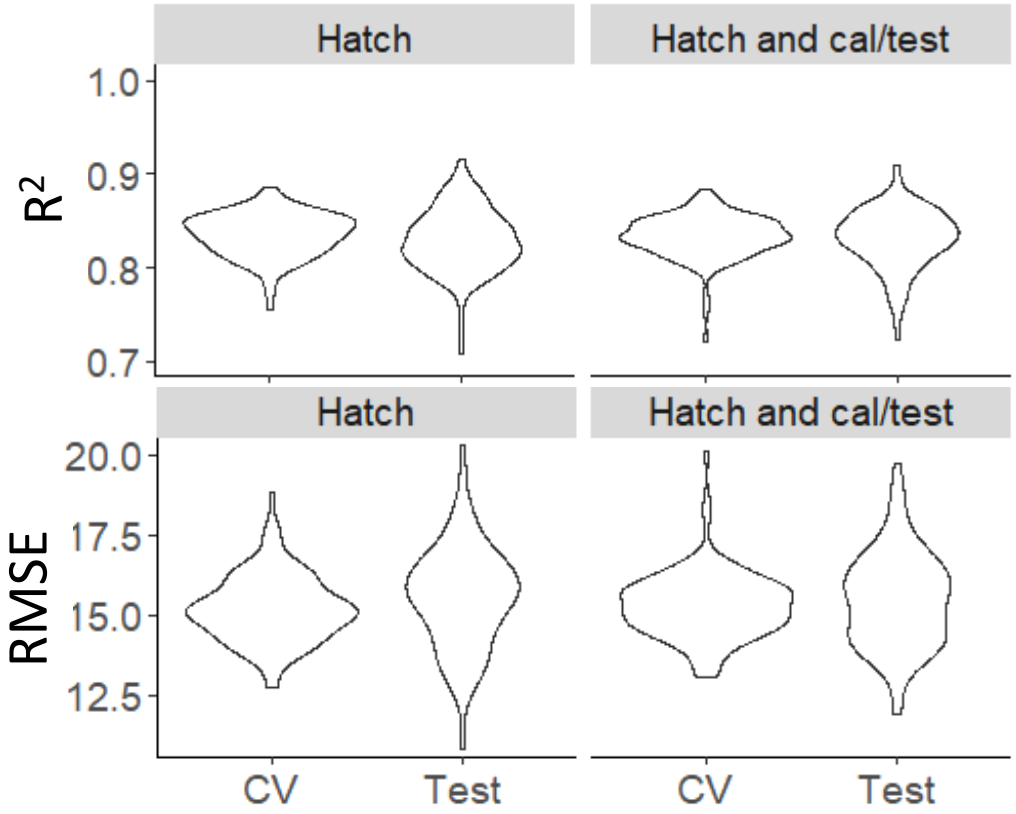
FT-NIRS age predictions

Incorporating error

- Random hatch & calibration & test datasets
- Same variables

9 components	RMSE	R^2
Cross Validation	9.34	0.93
Test	12.09	0.87



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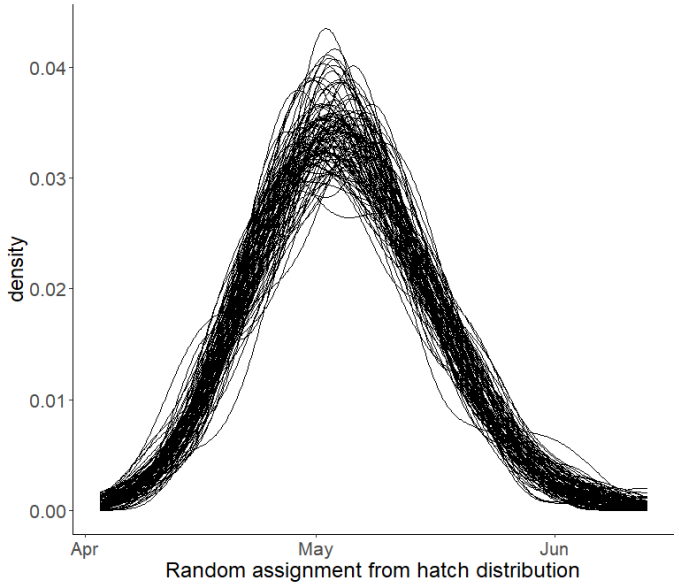

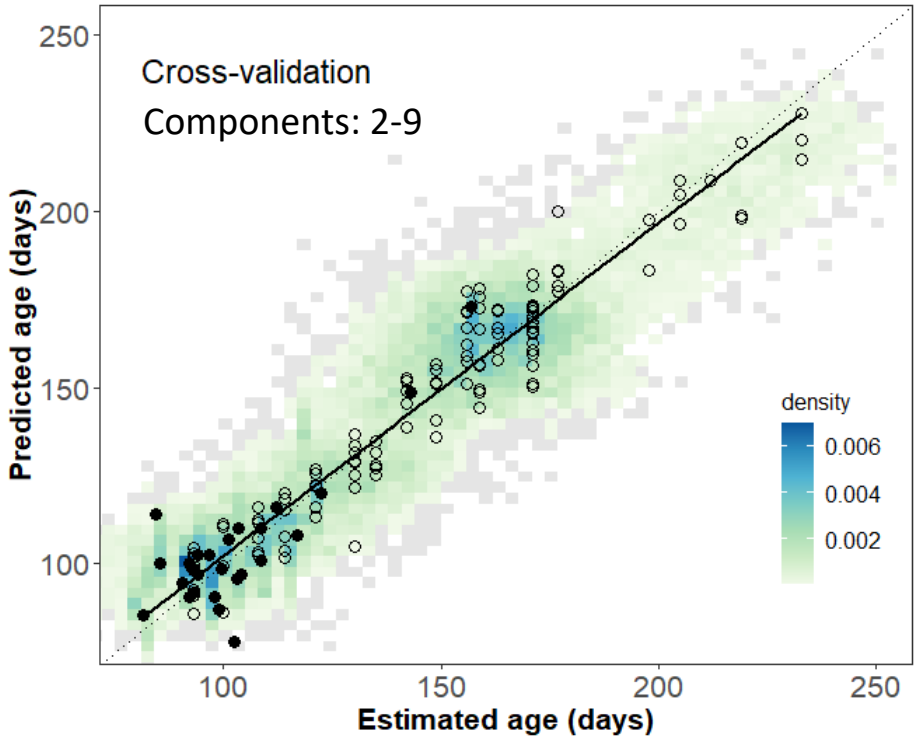

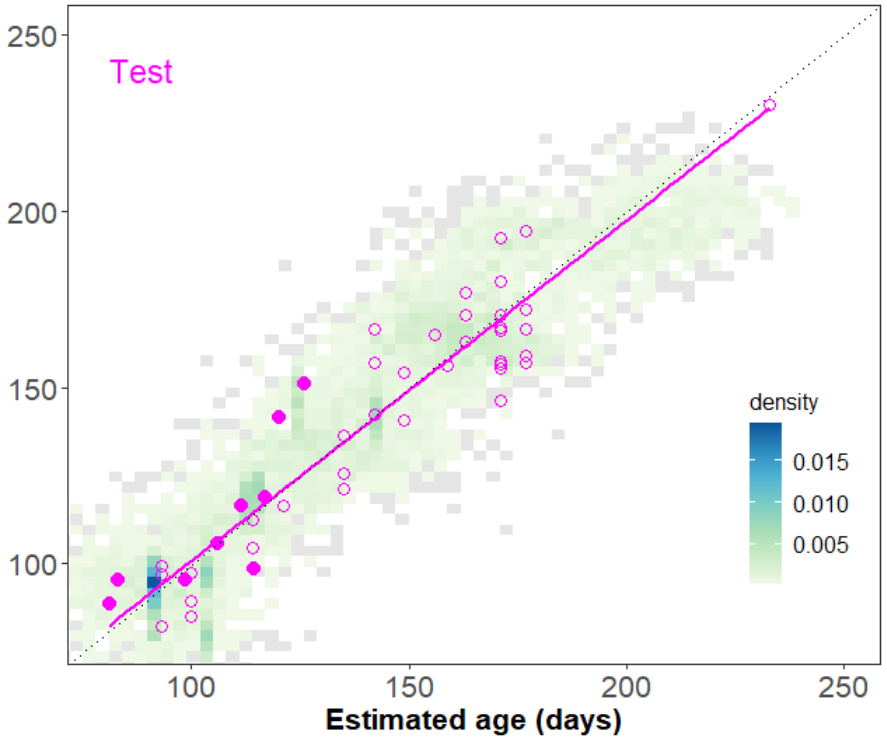

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