INTERNATIONAL PACIFIC HALIBUT COMMISSION

Using artificial intelligence (AI) for supplementing Pacific halibut age determination from collected otoliths

Agenda item: 4.2.3. Age composition data (both fishery-dependent and fishery-independent)
IPHC-2024-SRB024-INF01
(B. Hutniczak)

Purpose

- To summarize the information available on the use of artificial intelligence (AI) for determining the age of fish from images of collected otoliths
- To provide an update on the exploratory work of implementing an AI-based age determination model for Pacific halibut

Why AI based model?

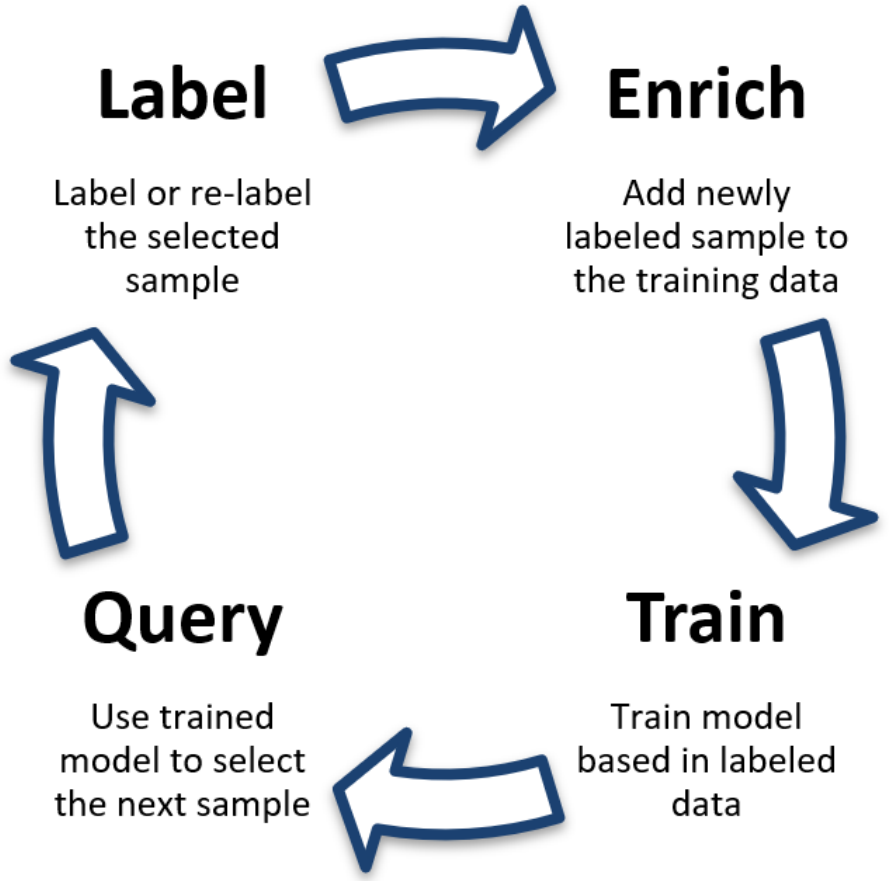
- AI algorithms can be trained on a large dataset of otolith images with known ages to learn the patterns and variations in growth rings. Once trained, the AI model can analyze new otolith images and predict the age of the fish based on the identified patterns in the image.
- Using AI for age determination of Pacific halibut could improve consistency and replicability of age estimates, as well as provide time and cost savings to the organization, providing age data for reliable management advice.

Model framework

- The proposed approach integrates AI-based age determination and traditional ageing methods for maximum accuracy of the estimates.

Climate-readiness:
Training the model with inputs that capture temporal changes

- ➢ increasingly important in the face of changing environmental conditions and climate change

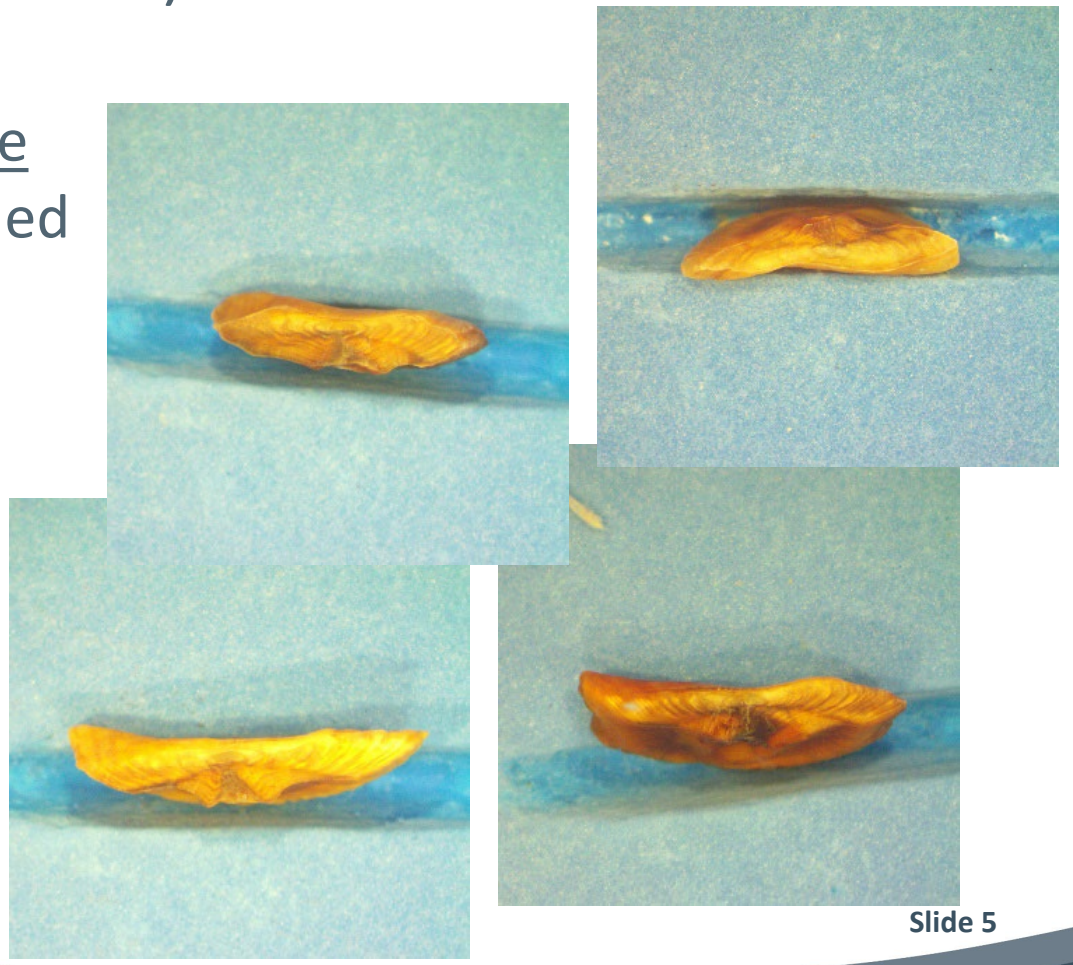


Modeling approach

- Application of convolutional neural network (CNN) model, a type of deep learning approach
  - In CNNs, the layers are structured as stacks of filters, each recognizing increasingly abstract features in the data.
- Application of image regression - predicting a continuous variable from an image
  - Pacific halibut is a long-living species - oldest Pacific halibut on record were aged at 55 years
- Implementation - TensorFlow and Keras libraries, repurposing Inception V3 model from Google:
  - Input → InceptionV3 (feature extractor) → Regressor → Output
  - Initial modeling framework modeled on Deep Otolith project (http://otoliths.ath.hcmr.gr/) applied previously to Greenland halibut, red mullet and salmon (scales)

Database

- Since 1925, over 1.5 million otoliths have been aged and stored for potential future use. ← **unique resource for AI training**
- Aged otoliths are sectioned (broken in half) and baked to enhance the contrast between the growth rings.
- Taking pictures can be incorporated into the ageing process at relatively minor time added
- Pictures are taken with AmScope 8.5MP eyepiece cameras

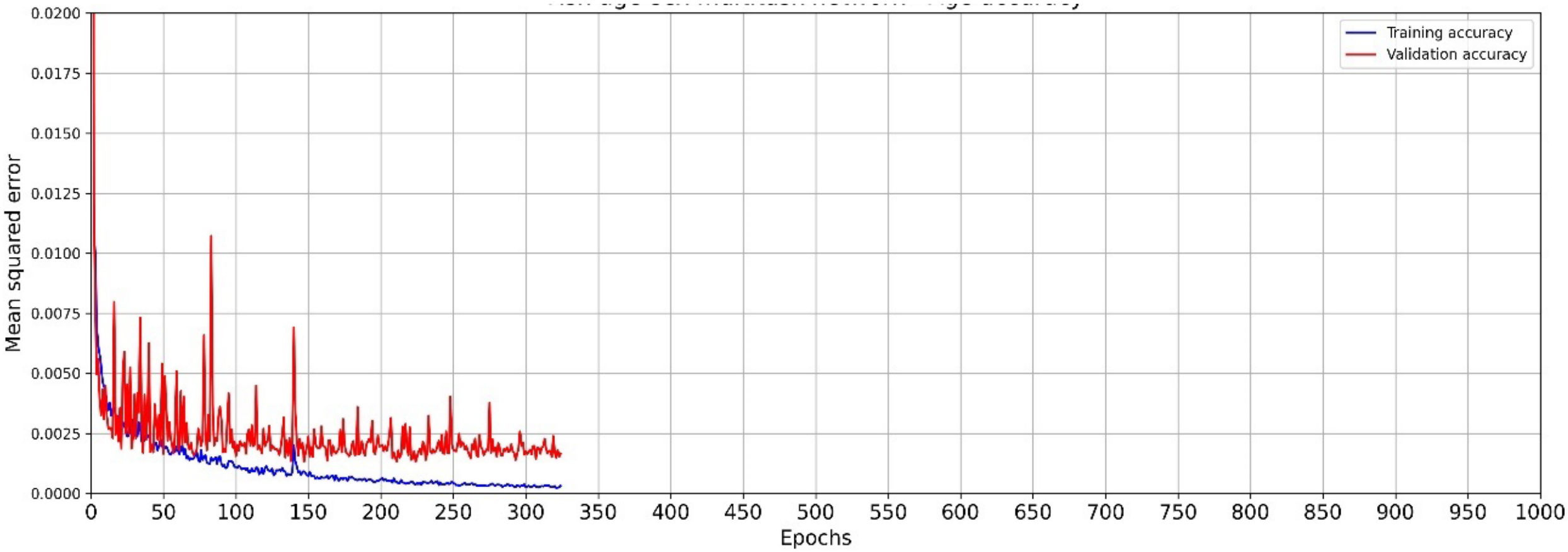


It may not be necessary to image the otoliths at resolutions sufficient for human viewers to resolve, because the CNN may be able to arrive at an age estimate without directly counting bands.

Latest run results (r8)

- 2,286 images (1,360 train, 240 validation, 686 test)
  - Test set is used to assess the performance of the model after training, providing an unbiased evaluation of its generalization capability to new, unseen data.
- Resized to 400x400 pixels, broken otoliths excluded
- Age: 4-41 (normalized)
- Epochs: 1000, patience: 100
- Learning rate: 0.0002, batch size: 16
- Normalized age MSE in training: 0.00032 and 0.00166 in validation, in 324 epochs (224 effective)

Results (1/3)

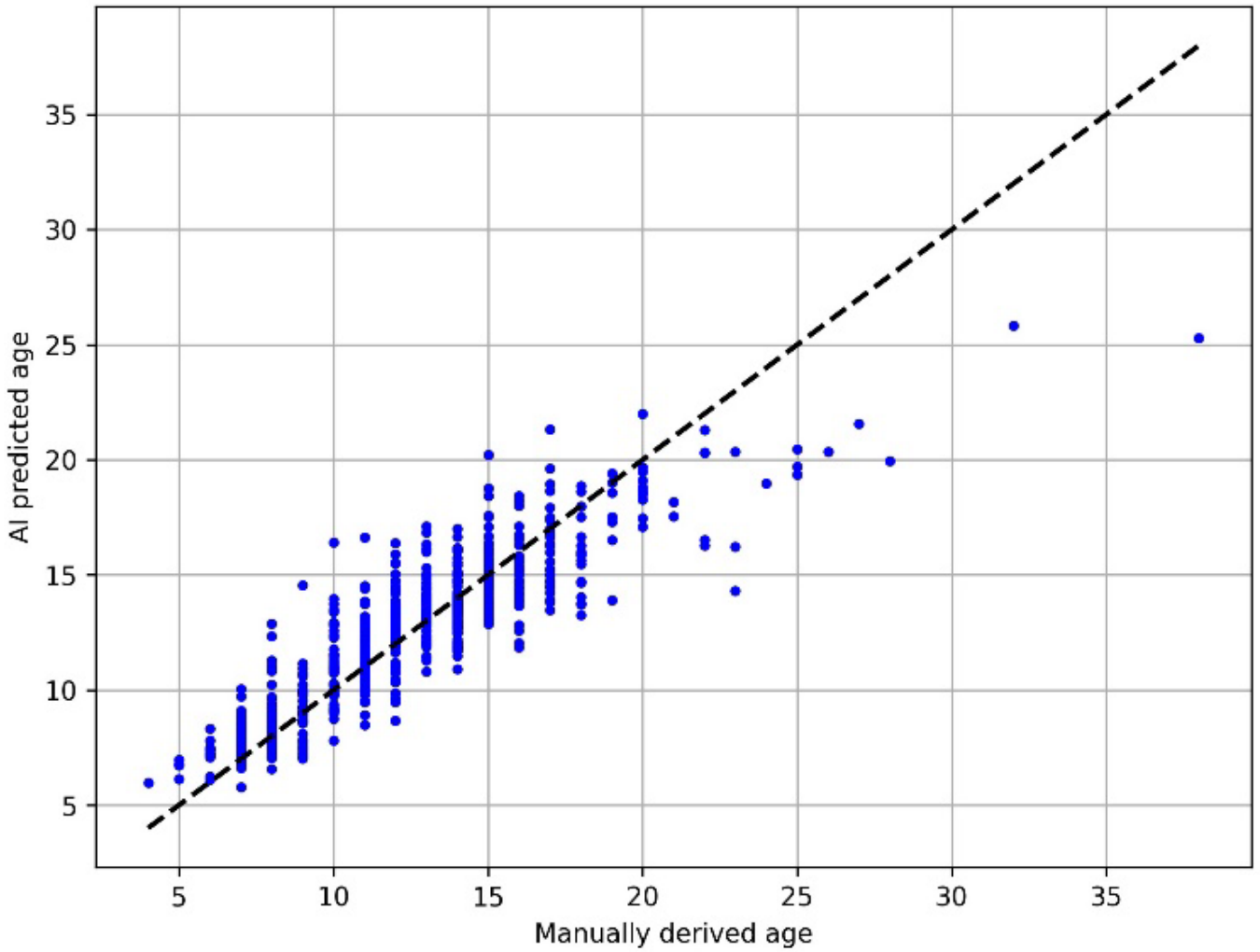


Age accuracy (measured as normalized age MSE) throughout the training process

Results (2/3)

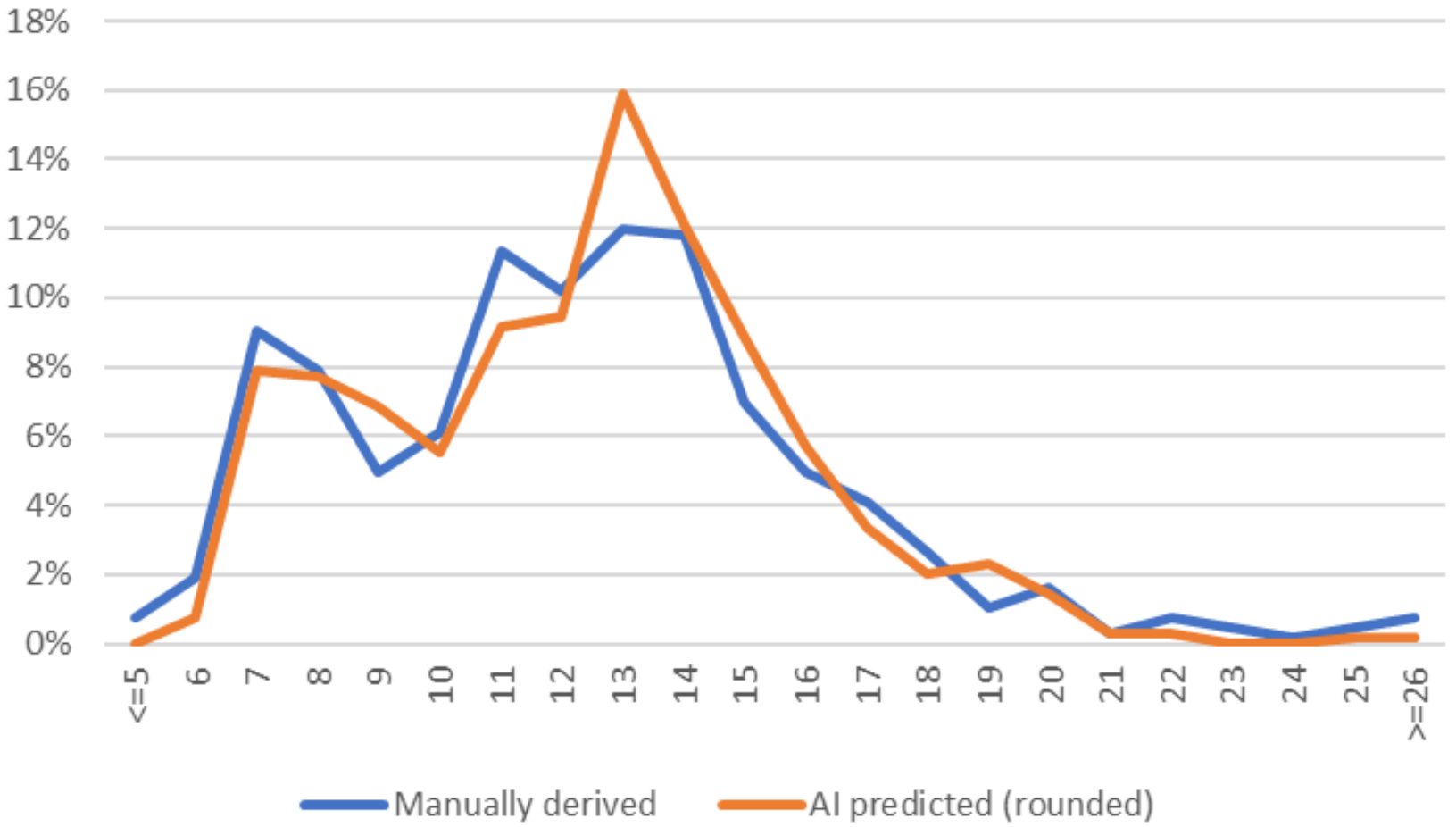
The model achieved RMSE in the test set of 1.82, and 1.84 when calculated for rounded results. Correct age was predicted for 30.0% individuals, with an additional 38.5% being within 1 year of error.

- Previous run: 22% correctly predicted age on 1,311 images (RMSE = 2.11)



Comparison between manually derived age with AI predicted age.

Results (3/3)



Comparison between manually derived age with AI predicted age – age composition.

Conclusions

- The ongoing advancement of AI technologies in the field of marine science offers considerable **potential to enhance the efficiency of age determination** of Pacific halibut using otolith images.
- Preliminary results presented here suggest that AI could serve as a **promising alternative to the current ageing protocol**, which relies entirely on manual age reading.
- **AI is evolving rapidly**, and adapting to new developments may further improve results over time.
- **Adaptive approach** will continue to depend on trained readers for **capturing temporal changes**.

Next steps

- **Increase the size of the training input library** (in progress)
- Create a database comprising labelled images of otoliths both pre- and post-processing and conduct a cost-benefit analysis of processing the otoliths for ageing using AI (summer 2024)
- Use of auxiliary data: The project plans to explore the use of additional spatial covariates for better age prediction.
  - Other available auxiliary data include the year collected, which could be used to account for variation between cohorts and prevalent environmental conditions throughout the aged fish life histories, and the collection date, which provides insights into seasonal variation to the interpretation of the otolith edge.

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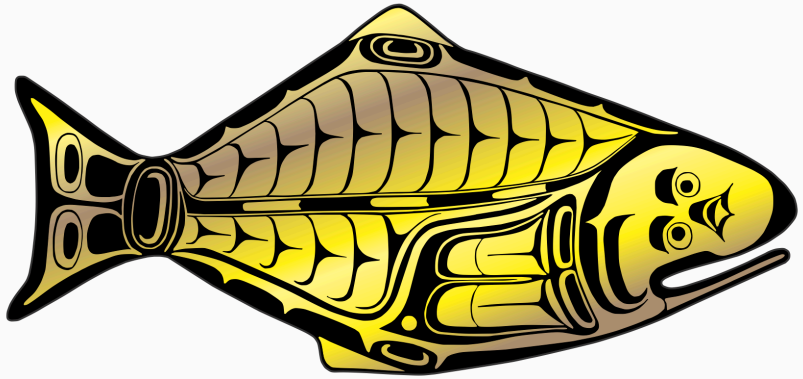

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