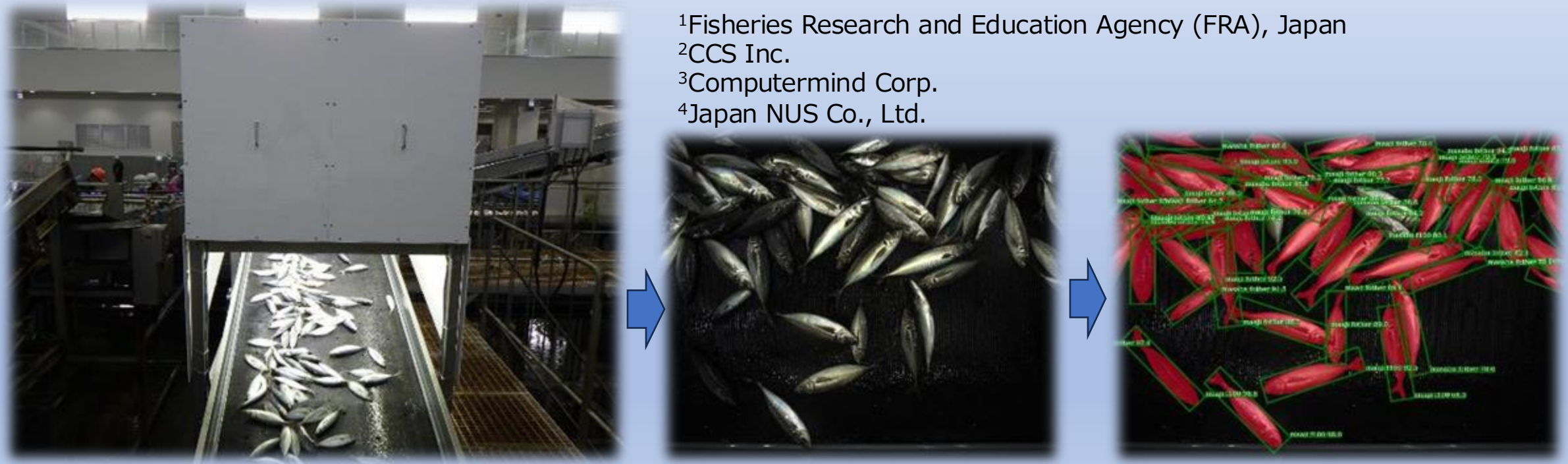
Estimation of length composition by species from images of catches obtained using a fish image analysis system using deep learning (FIAS-Deep)

Yasutoki Shibata[1], Yuka Iwahara[1], Masahiro Manano[1], Daiki Suzuki[2], Tomoya Nishino[3], Yuka Murayama[4], Toru Kitamura[4]

[1]Fisheries Research and Education Agency (FRA), Japan
[2]CCS Inc.
[3]Computermind Corp.
[4]Japan NUS Co., Ltd.

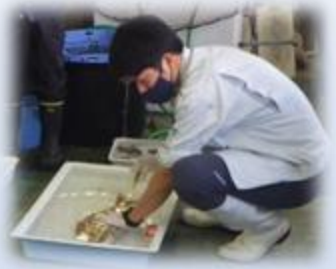


PICES-2024 Annual Meeting, Session 3, October 30th, Honolulu, USA

Previous studies and limitation of Japanese case

【Stock assessment】

To scientifically evaluate whether the current catch of a target fish is sustainable for its stock status.



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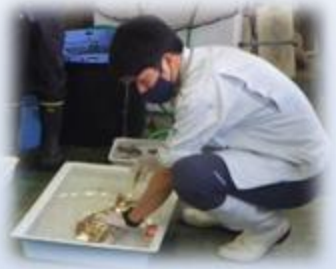

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Vessel-mounted electronic monitoring (EM) cameras

https://www.afma.gov.au/afma-leading-way-fisheries-technology

Modified and reproduced from Tseng and Kuo (2020)

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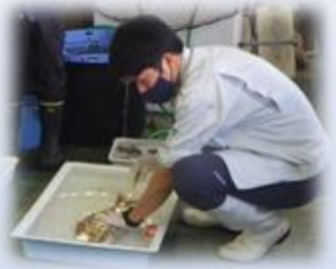

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Country	Fishermen (persons)	Fishing vessels (units)	Ratio of vessels under 25 tons
Iceland	6,300	826	0.63
Norway	22,916	8,664	0.89
Denmark	4,792	4,285	0.86
United Kingdo	19,044	9,562	0.82
France	26,113	6,586	0.78
Canada	84,775	18,280	0.74
New Zealand	2,227	1,375	0.74
Spain	75,434	15,243	0.76
United States	290,000	27,200	0.53
South Korea	180,649	50,398	0.90
Japan	278,200	219,466	0.98
Australia	13,500	5,000	N.A.

The data is based on calculations from FAO (1999), as referenced in *Institutional Analysis of Japan's Fisheries: Fisheries Management and Ecosystem Conservation* (2013) by Mitsutaku Makino.

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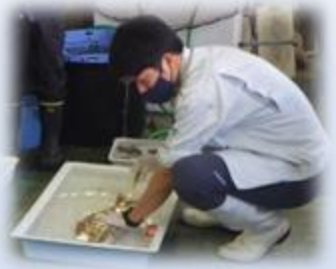

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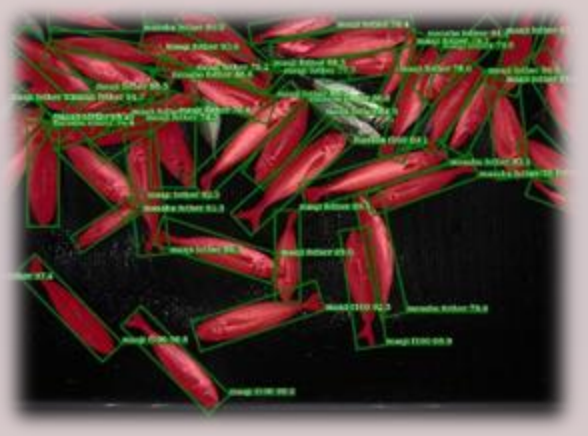
A fish image analysis system using deep learning (FIAS-Deep)

FIAS-Deep

1. Image capture subsystem

・This subsystem that acquires images from cameras installed on such as conveyors in a port.



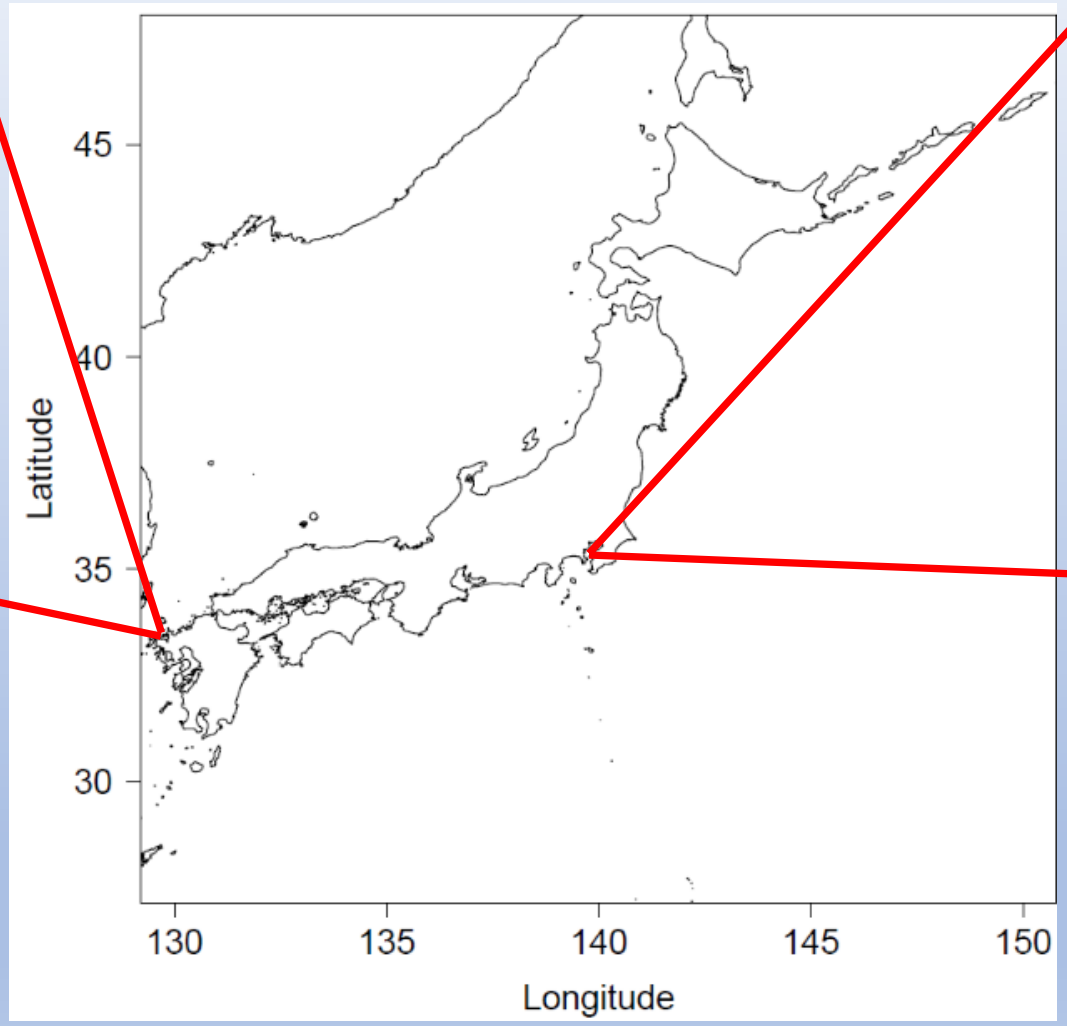
2. Training and inference subsystem

・This subsystem capable of executing learning using deep learning and inference with newly provided images.

FIAS-Deep's installation location

The image capture subsystem@Matsuura

The largest catch of Japanese jack mackerel *Trachurus japonicus*!



The training and inference subsystem @Yokohama, FRA

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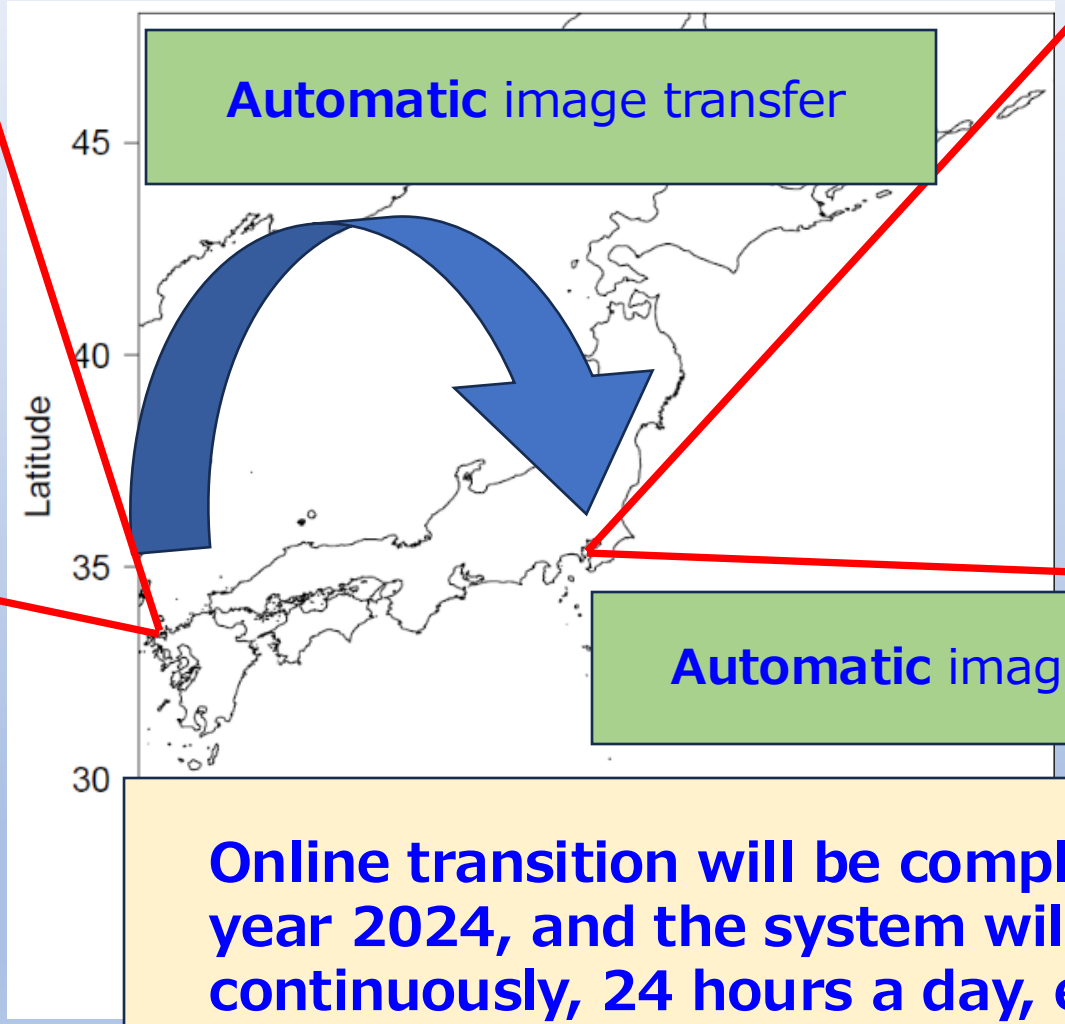

Automatic image transfer

The training and inference subsystem @Yokohama, FRA

Automatic image analysis

Online transition will be completed during fiscal year 2024, and the system will be running continuously, 24 hours a day, every day of the year.

Purpose of this study

This study aims to evaluate length composition by species estimated using a fish image analysis system (FIAS-Deep) which is designed to capture images of fish catches onshore.

Example images

November 9, 2023

November 10, 2023

April 24, 2024

Two types of sampling

Matsuura fish market, Nagasaki prefecture

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I. Punching manually

I. Total length was recorded manually using a punching sheet nine times between Oct. 5, 2023 and Apr. 24, 2024.

Two types of sampling

Matsuura fish market, Nagasaki prefecture

I. Punching manually

II. Image capture subsystem

I. Total length was recorded manually using a punching sheet nine times between Oct. 5, 2023 and Apr. 24, 2024.

II. Images were obtained semi-automatically (powering on is done manually) using the subsystem 10 times between the same period.

Summary of sampled and annotated data (instance segmentation)

			I (Punching sheet)		II (The subsystem of FIAS-Deep)			
Year	Month	Day	*Trachurus japonicus*	**Scomber*	Total # of obtained images	Anottated # of images	Annotated *Trachurus japonicus*	Annotated **Scomber*
2023	Oct.	5	112		935	32	1,014	30
	Nov.	9	1,123	1,191	9,476	19	135	1,000
	Nov.	10		1,055	4,046	68	244	1,006
	Dec.	20		1,054, 1,078	10,231	17		501
	Dec.	21		1,101	5,333	10		500
	Dec.	22			3,633	14		510
2024	Jan.	17			3,226	15	2	505
	Jan.	18			7,395	29		541
	Jan.	19	1,077		4,785	29	418	502
	Apr.	24		191	6,024	12	518	90
			2,312	5,670	55,084	245	2,331	5,185

**Scomber* includes both *scomber japonicus* and *scomber australasicus*.

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	Dec.	21		1,101	5,333	10		500
	Dec.	22		Used for prediction except images that were used for learning	3,633	14		510
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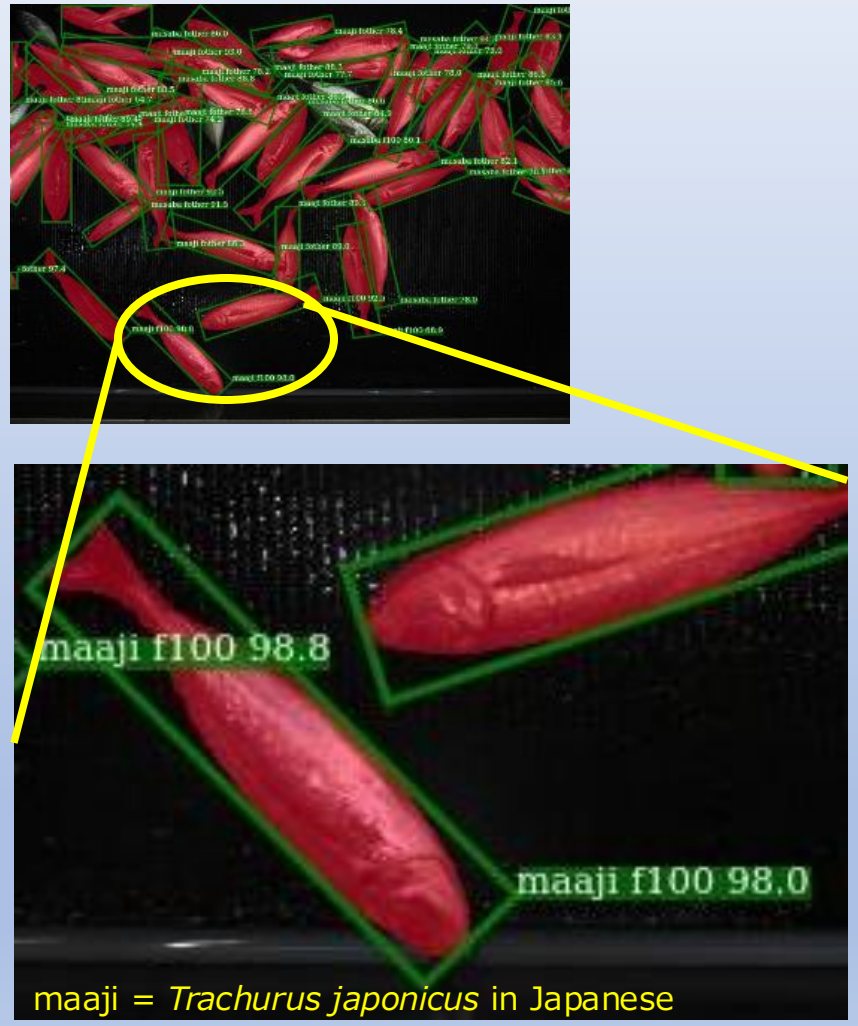
Detection process combined with two AI models and scores



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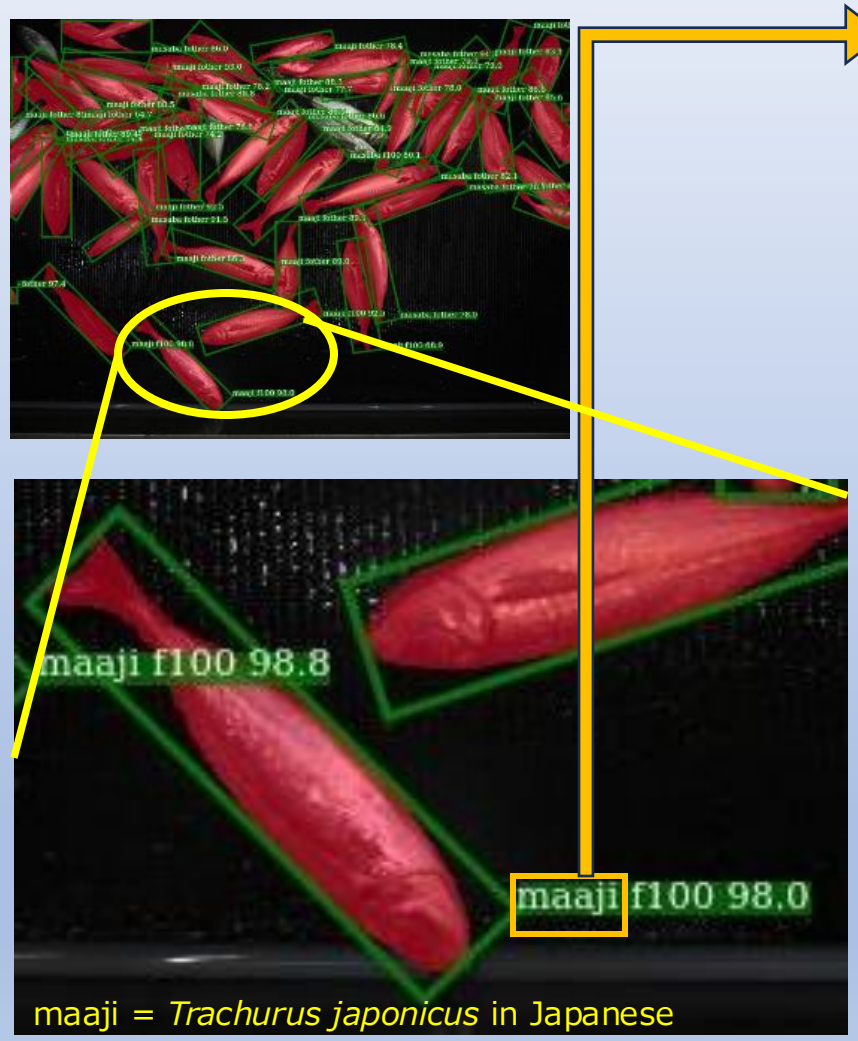
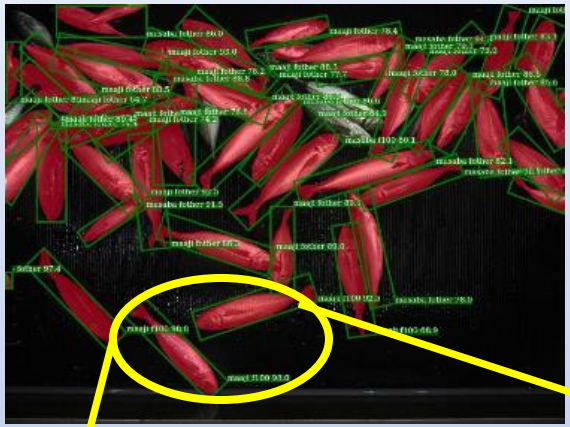
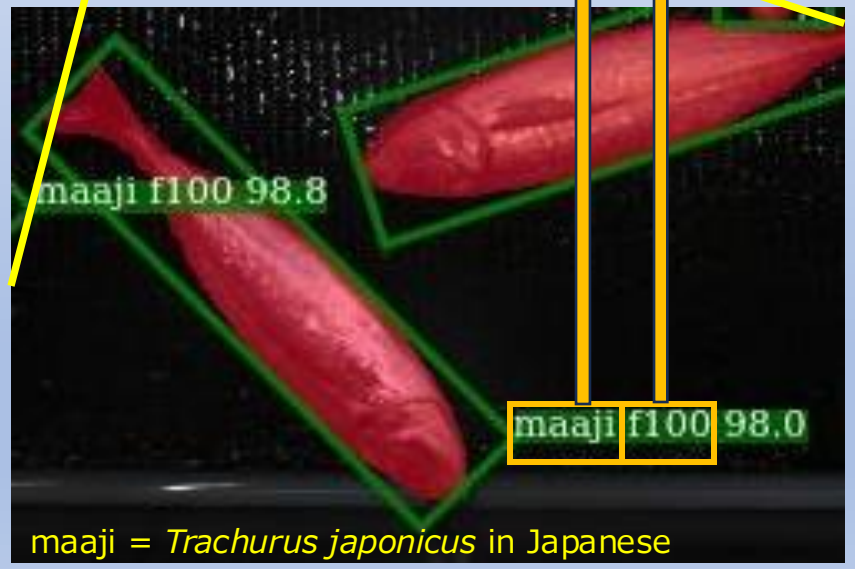


1. Species identification model (Mask R-CNN)

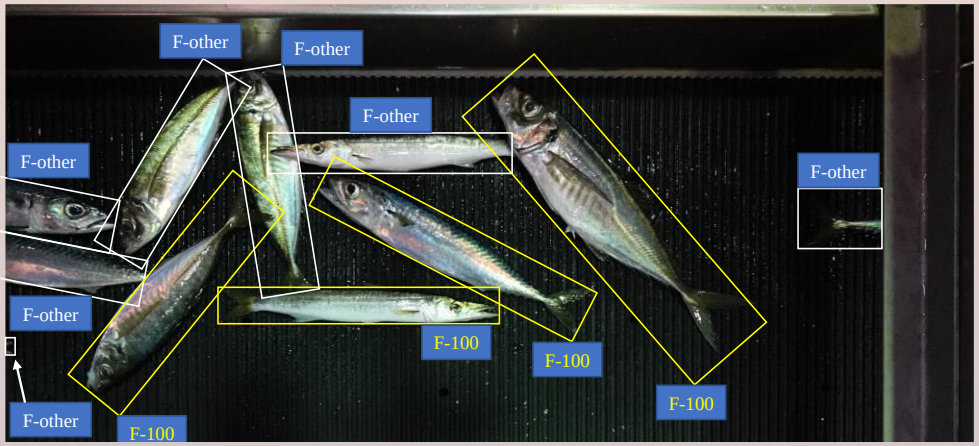
Detection process combined with two AI models and scores





1. Species identification model (Mask R-CNN)
2. F-100 or F-other model (Mask R-CNN)

(Shibata et al., 2024)



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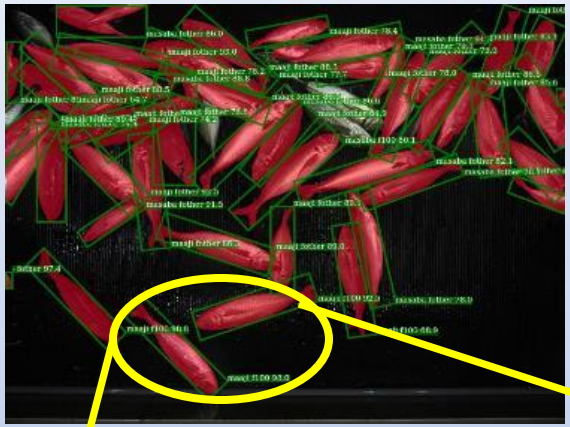

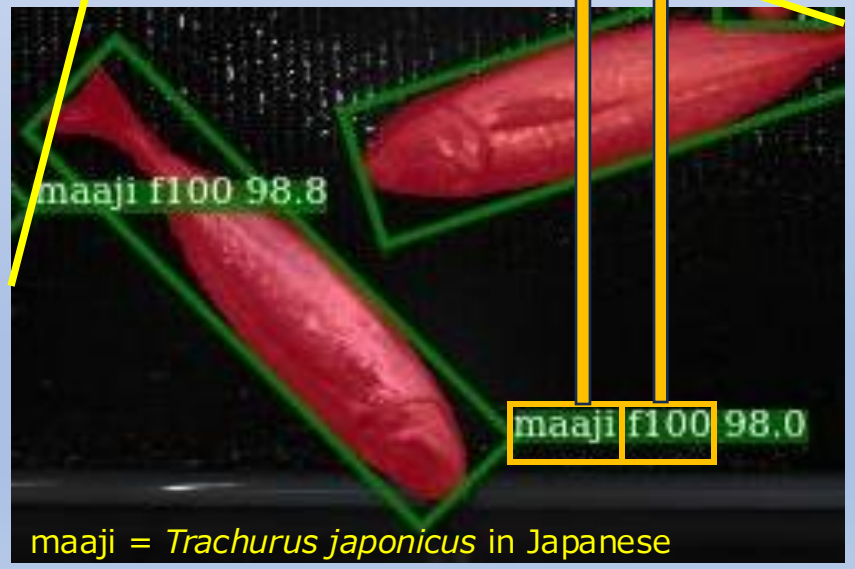

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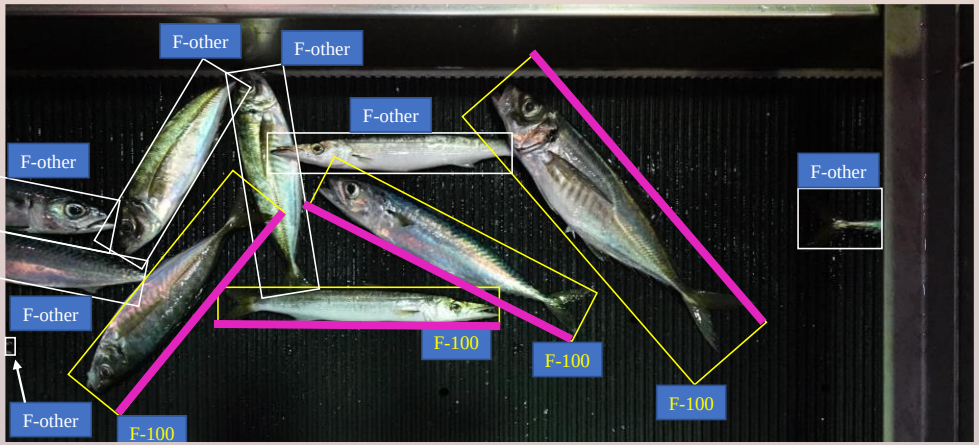
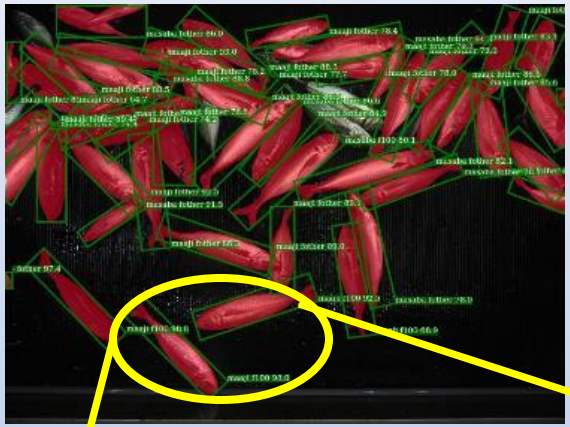
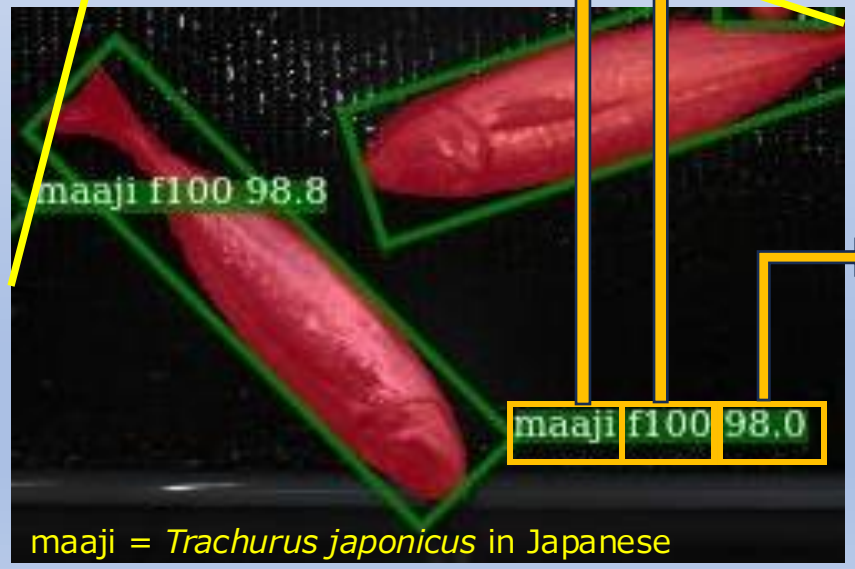


The longer side of the rectangle was used as the **total length (TL)**

Detection process combined with two AI models and scores





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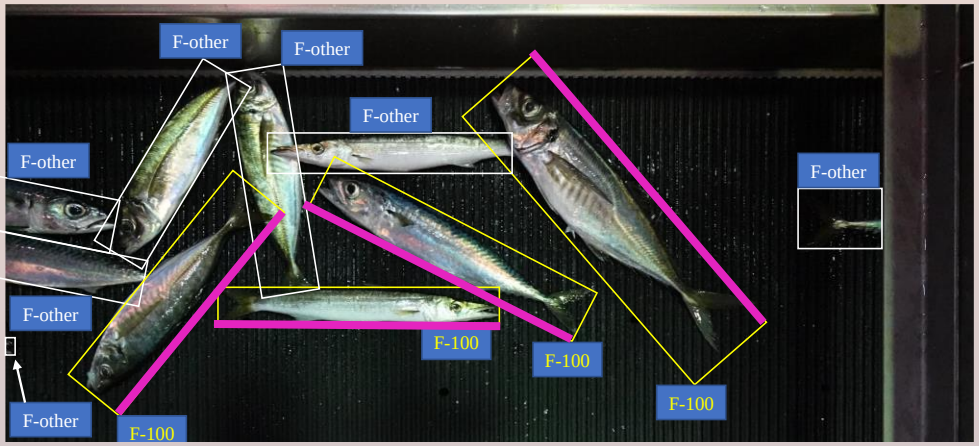

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3. If the scores from both Model 1 and Model 2 exceed 95.0, the fish is detected

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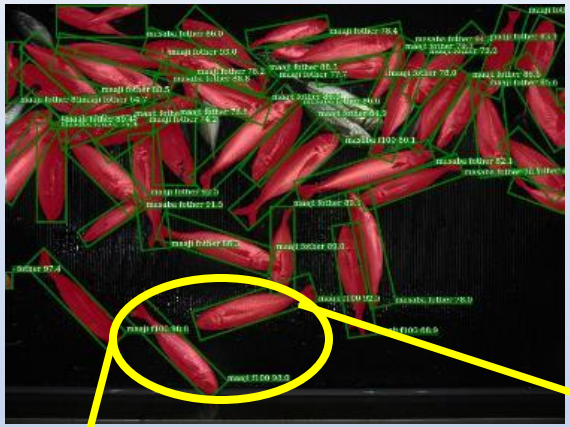

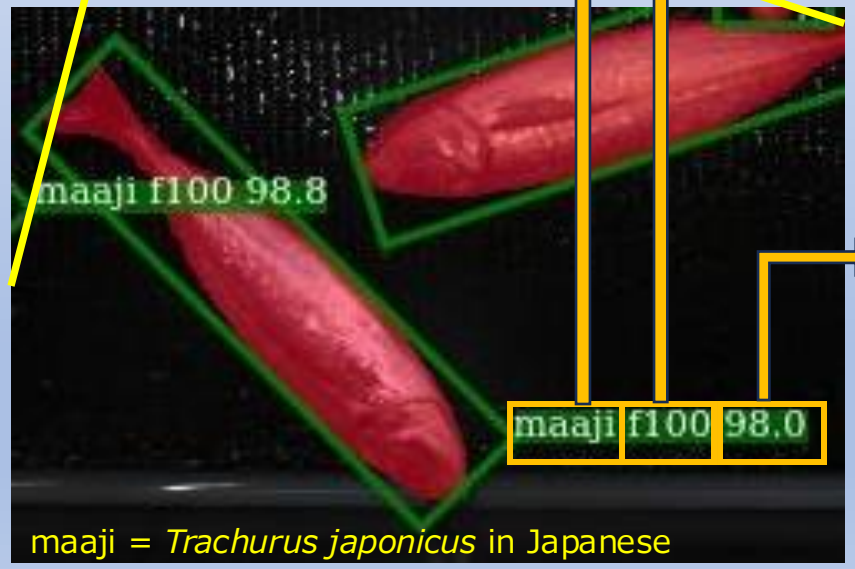

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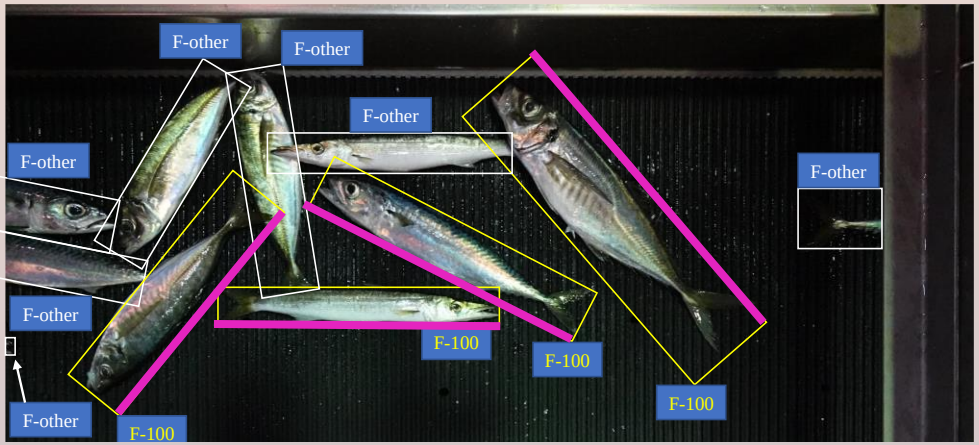

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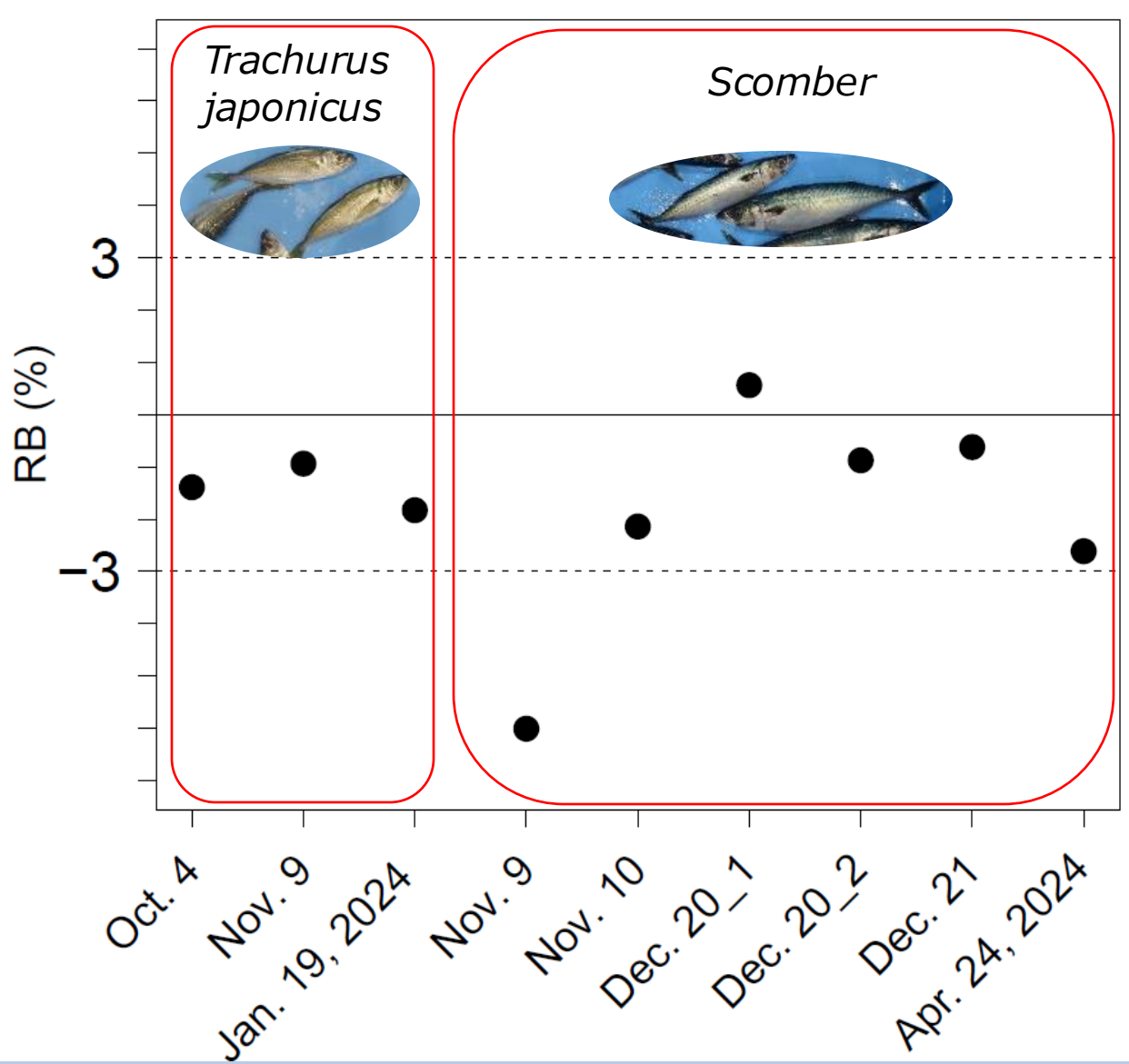
$$RB_{i,j} = \left(\hat{\mu}_{i,j} - \mu_{i,j}\right)/\mu_{i,j} \times 100$$

i: *Trachurus japonicus* or *scomber*
j: *date* μ: *Mean TL*

Result



Except for the RB value of Scomber on November 9, all RB values were within ±3%

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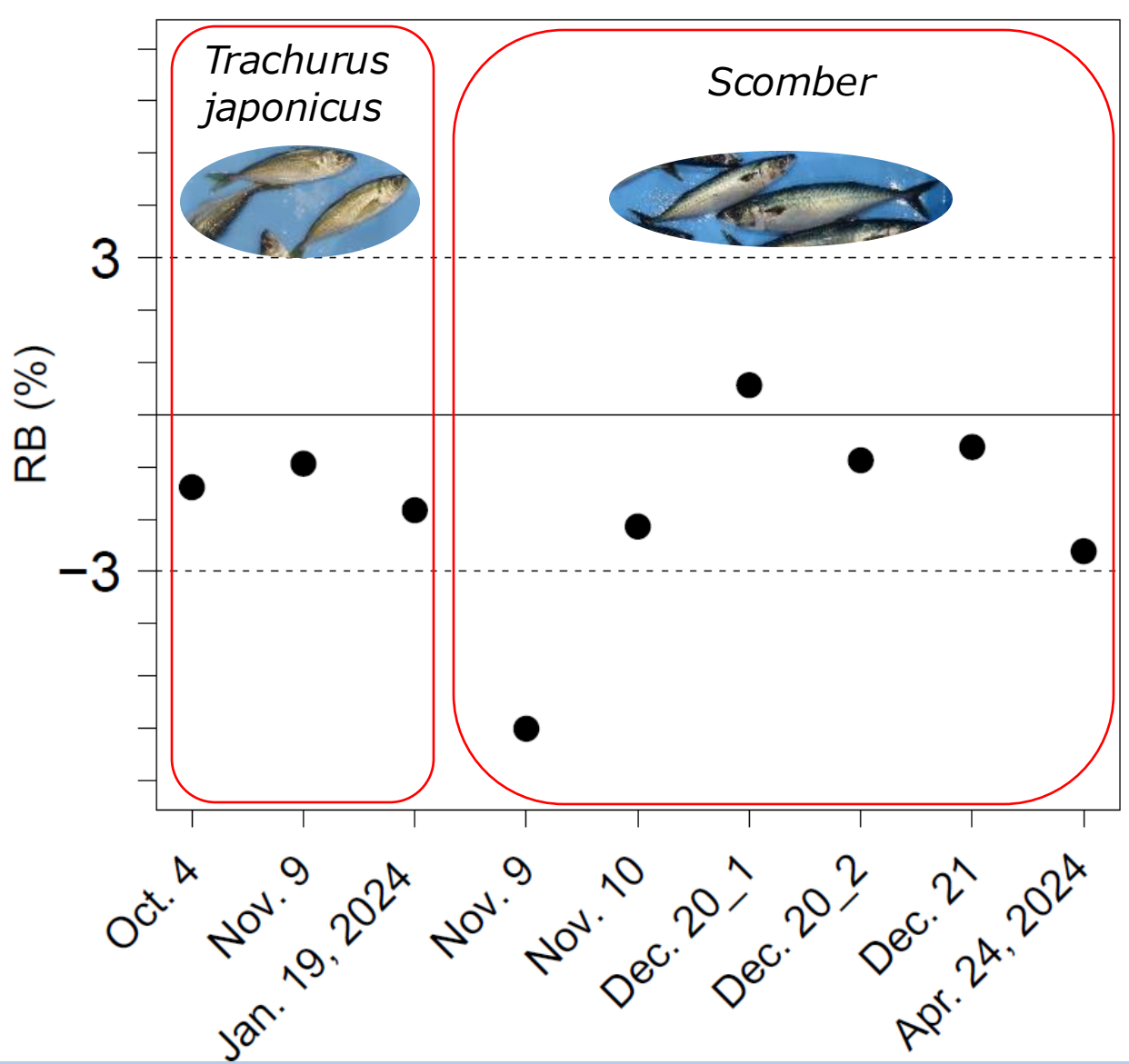

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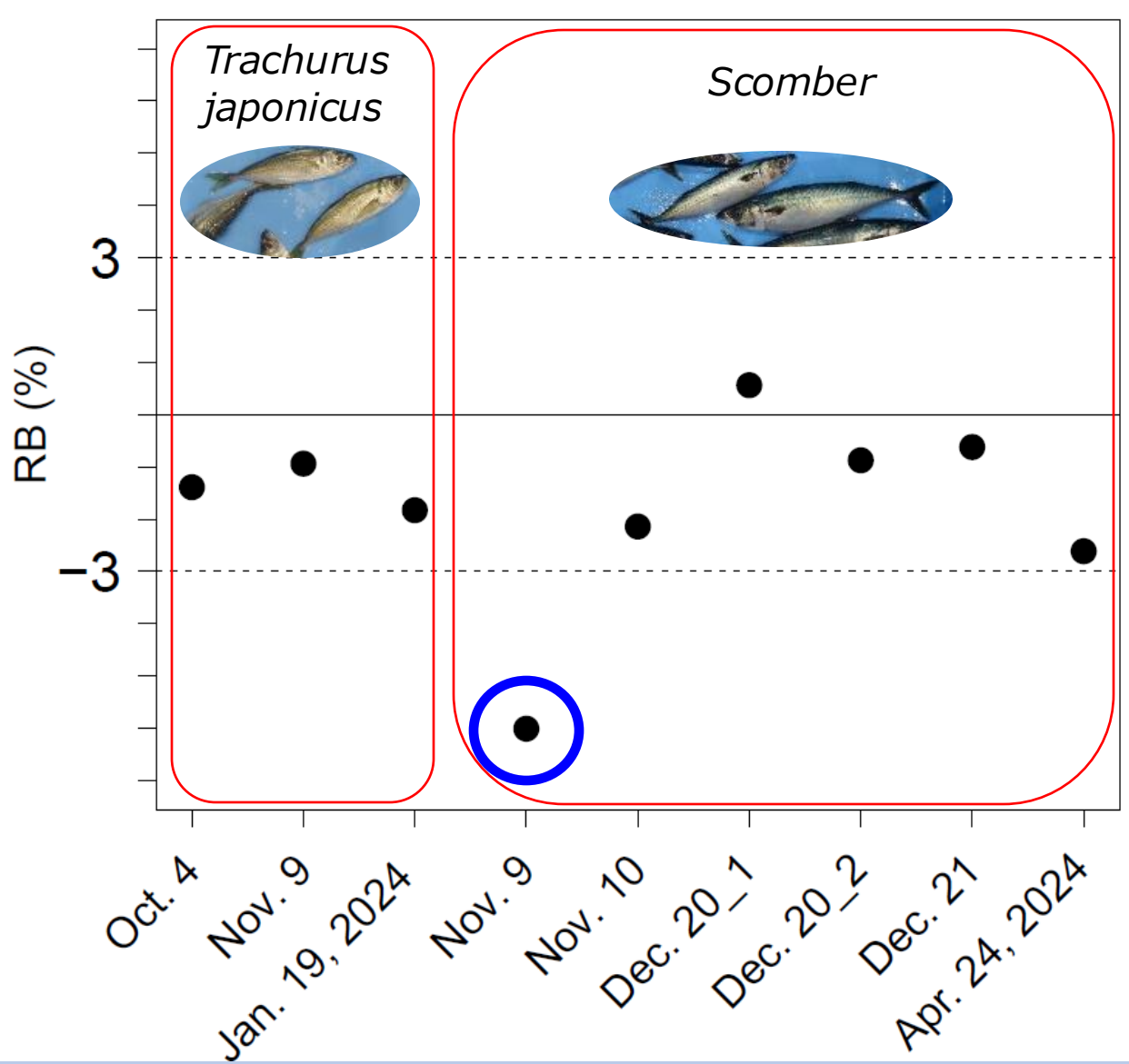

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Overcrowding

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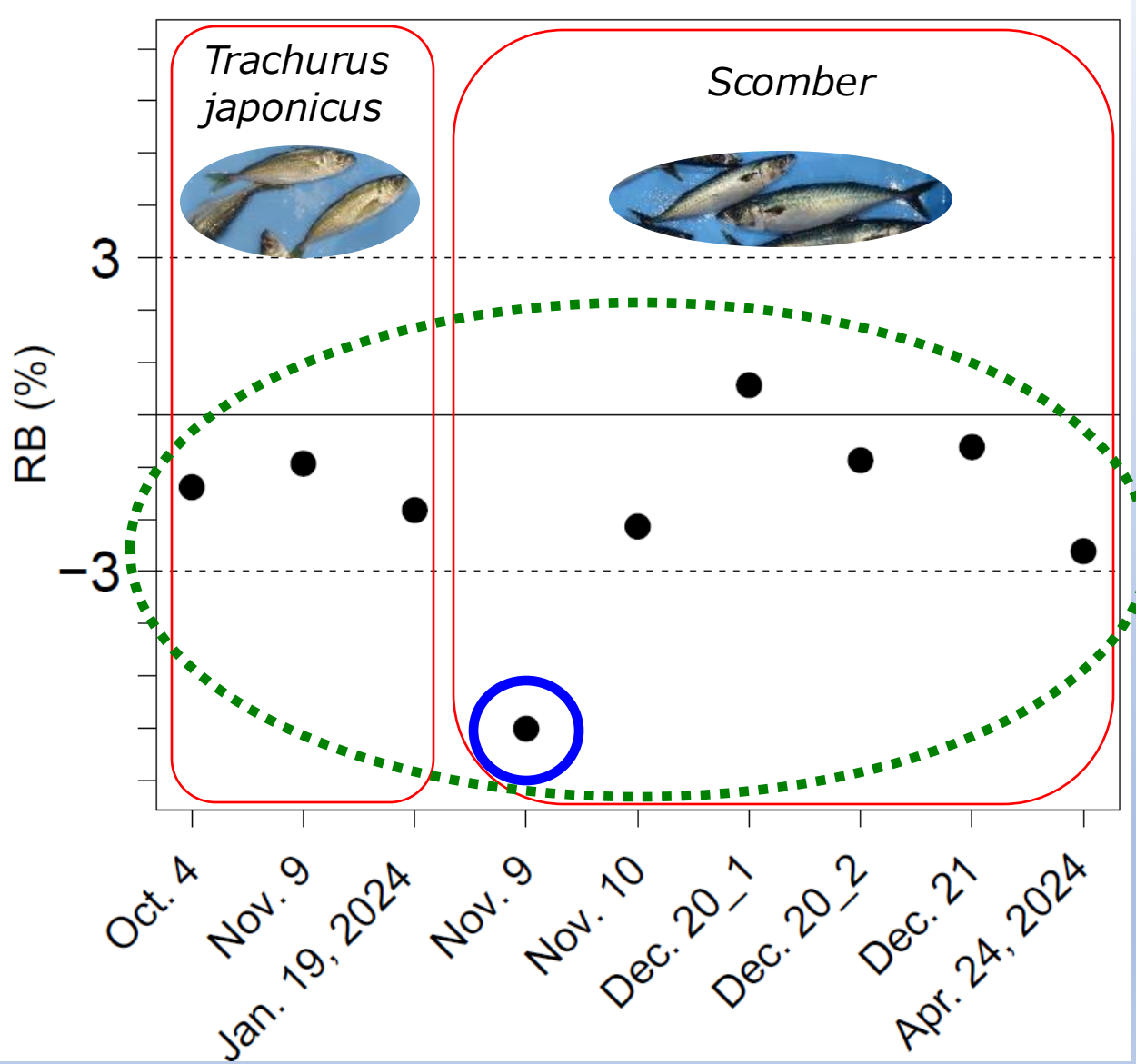

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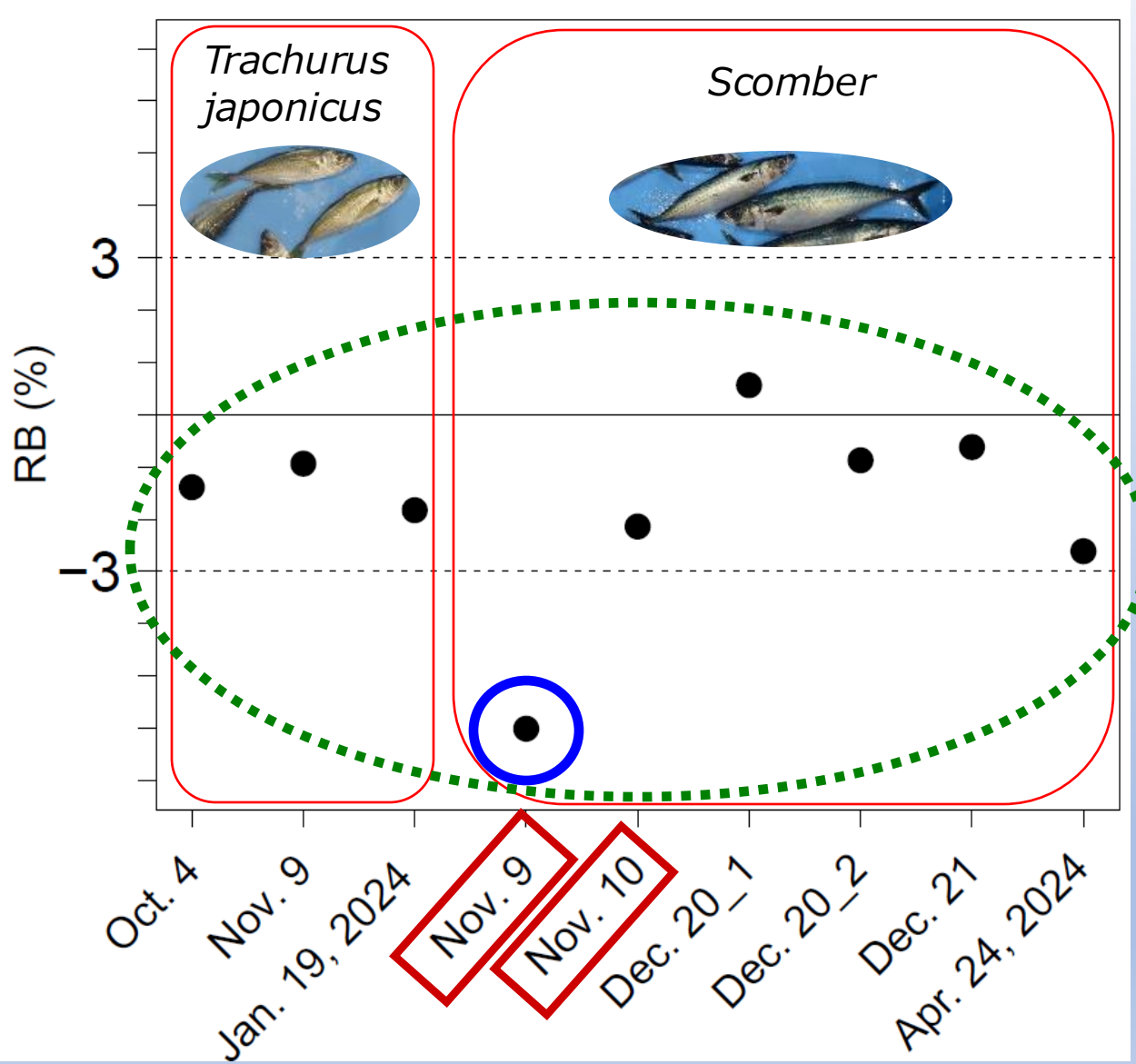

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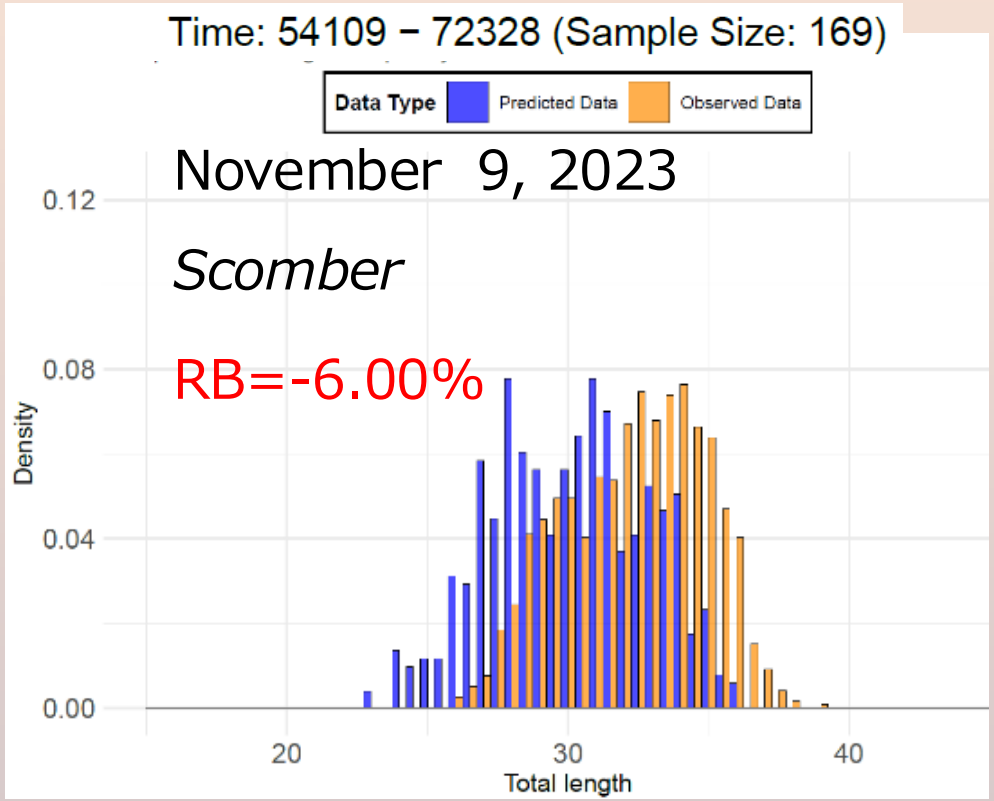
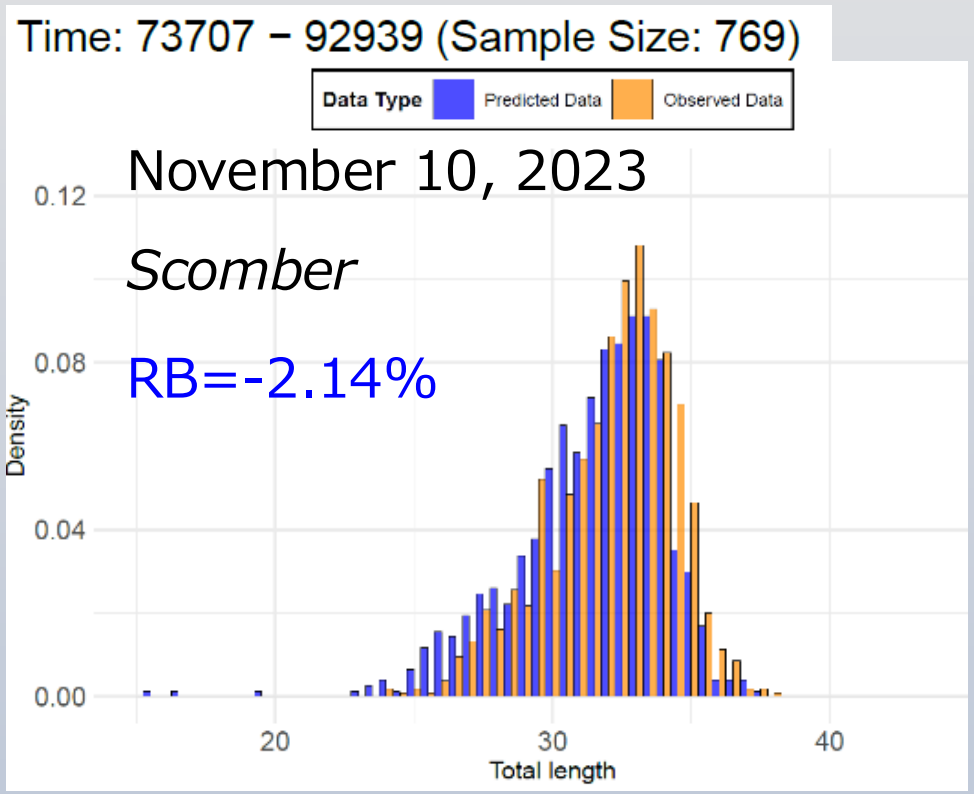
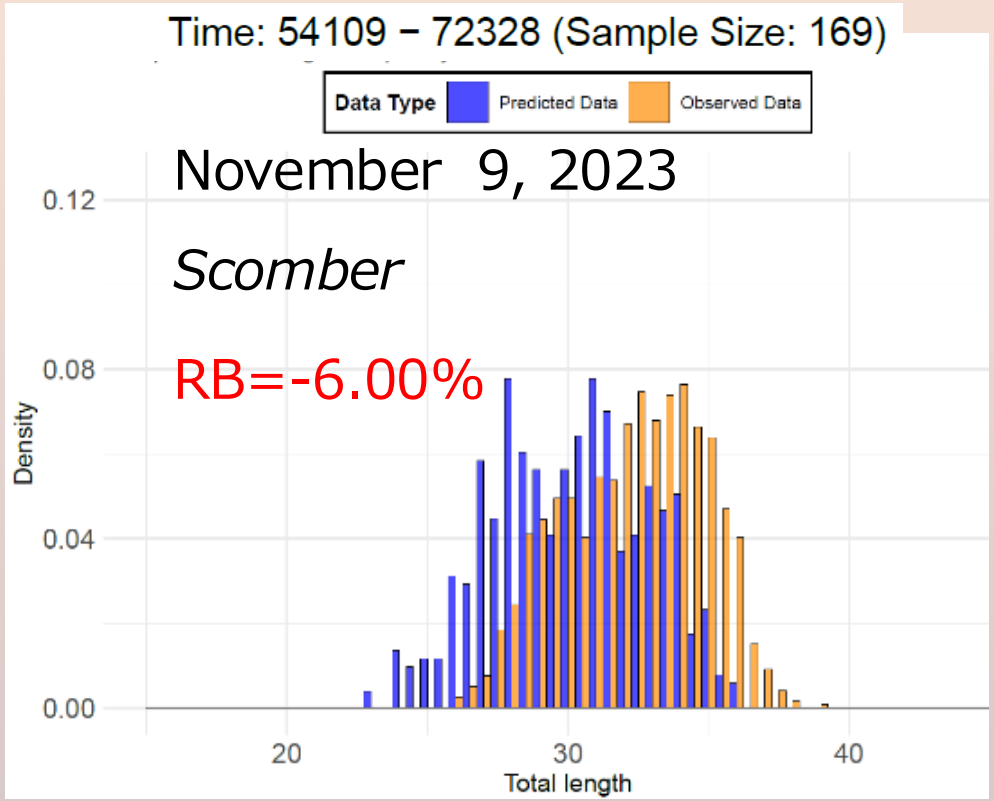

Time: 54109 – 72328 (Sample Size: 169)
Data Type
Predicted Data
Observed Data
November 9, 2023
Scomber
RB=-6.00%
Density
0.12
0.08
0.04
0.00
20
30
40
Total length

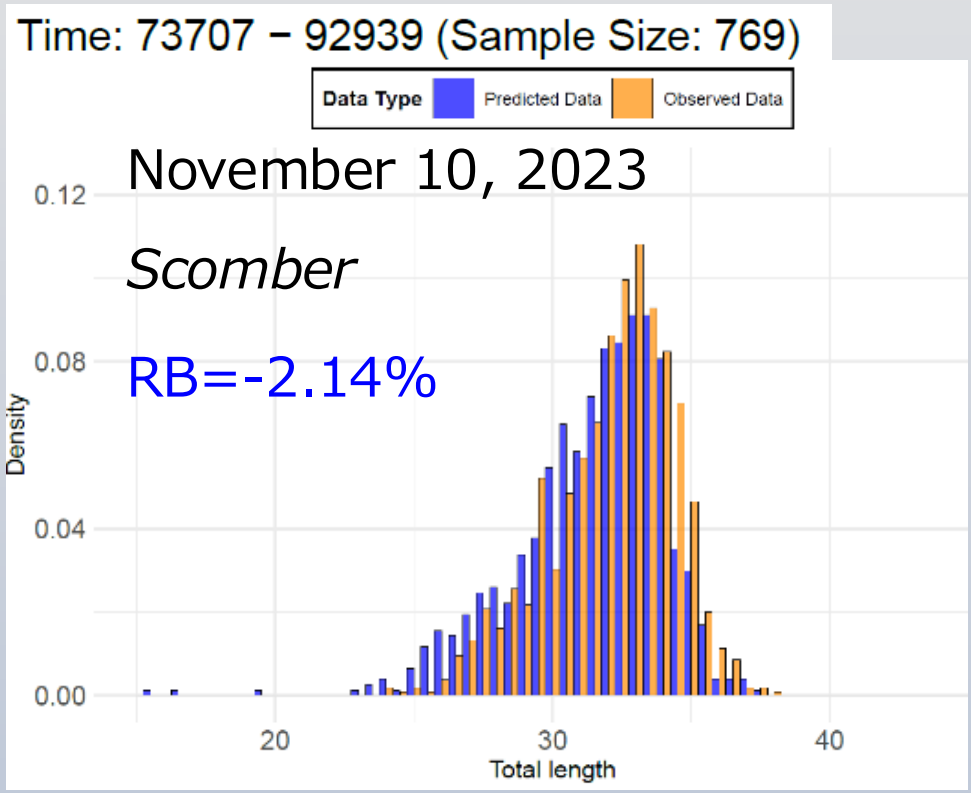

November 9, 2023

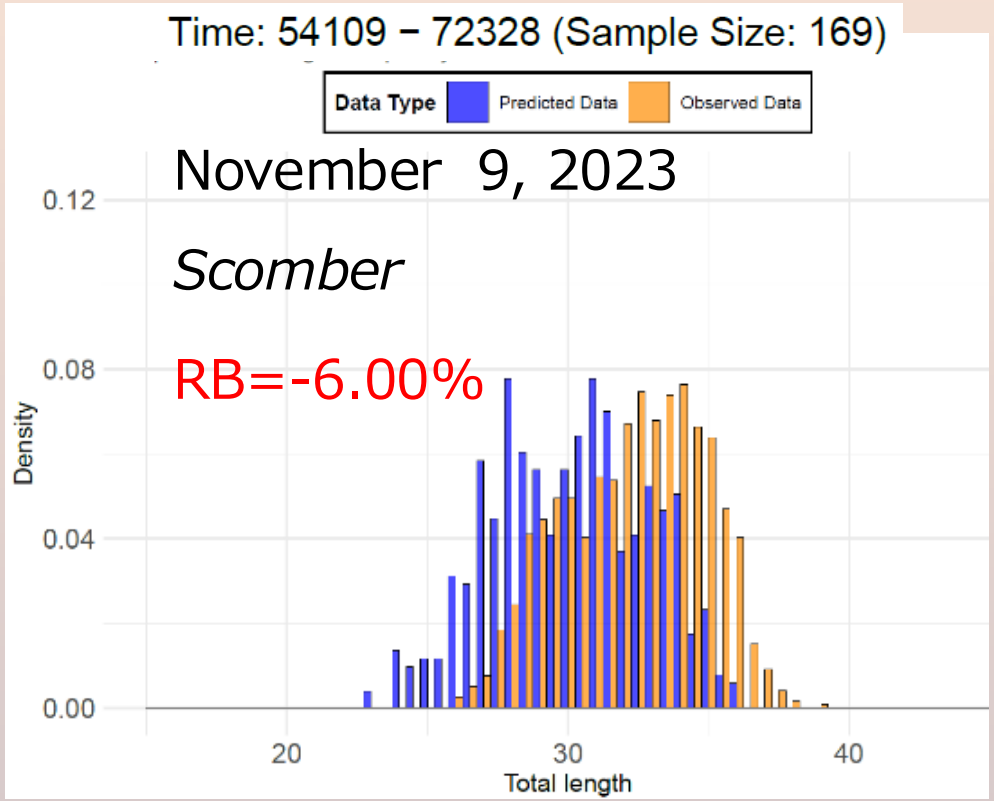

Time: 73707 – 92939 (Sample Size: 769)
Data Type
Predicted Data
Observed Data
November 10, 2023
Scomber
RB=-2.14%
Density
0.12
0.08
0.04
0.00
20
30
40
Total length


November 10 , 2023



Sampling bias: Smaller fish are more likely to be classified as F-100





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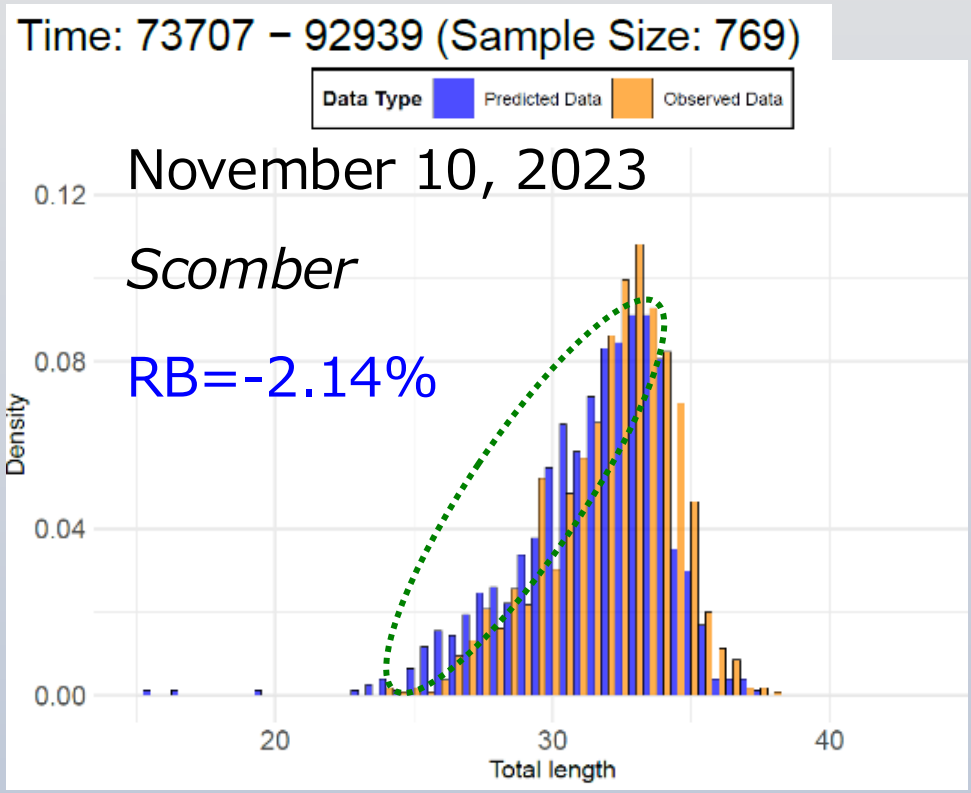
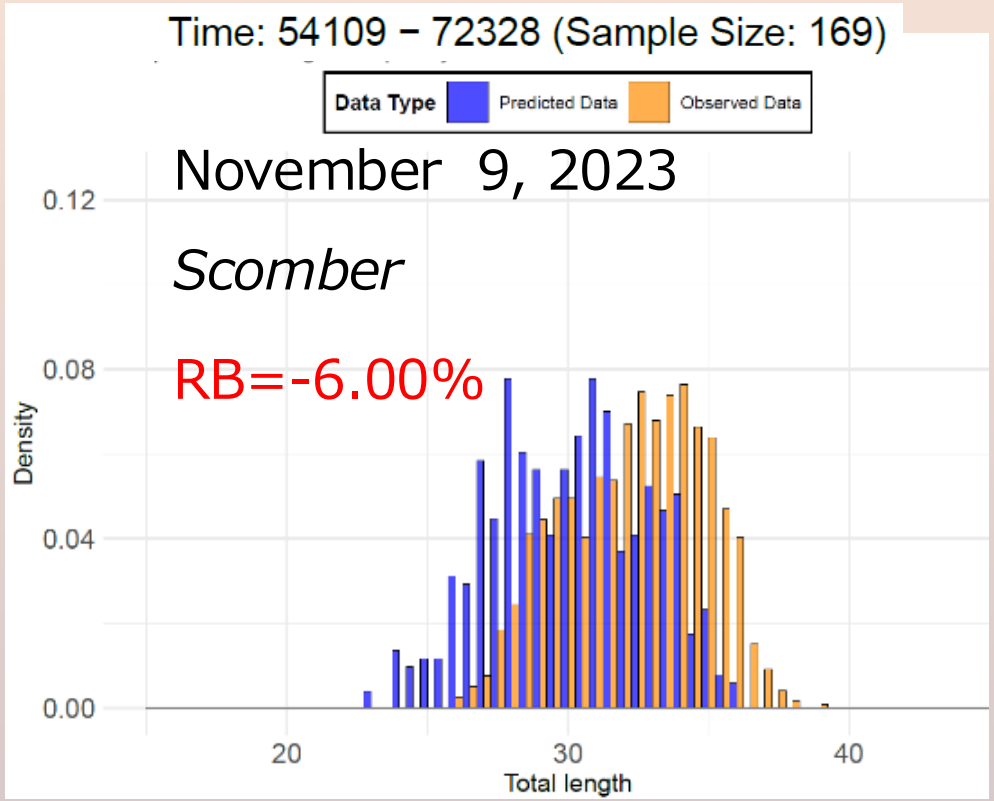


Prediction error: Factors effect on predicts exist



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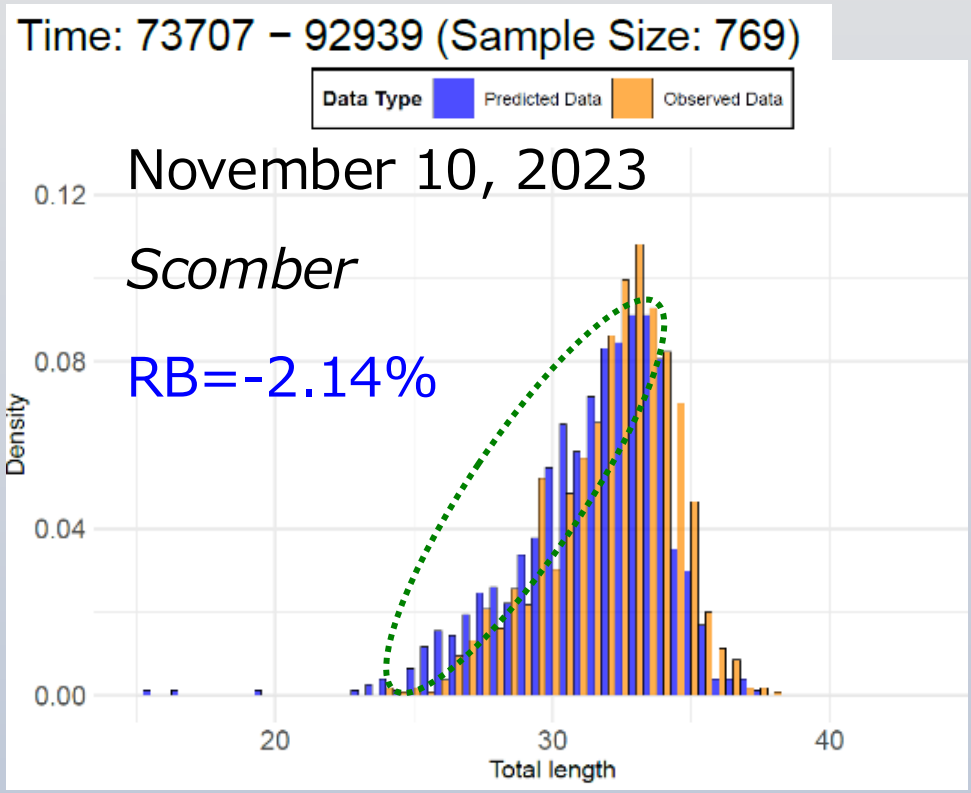
High brightness



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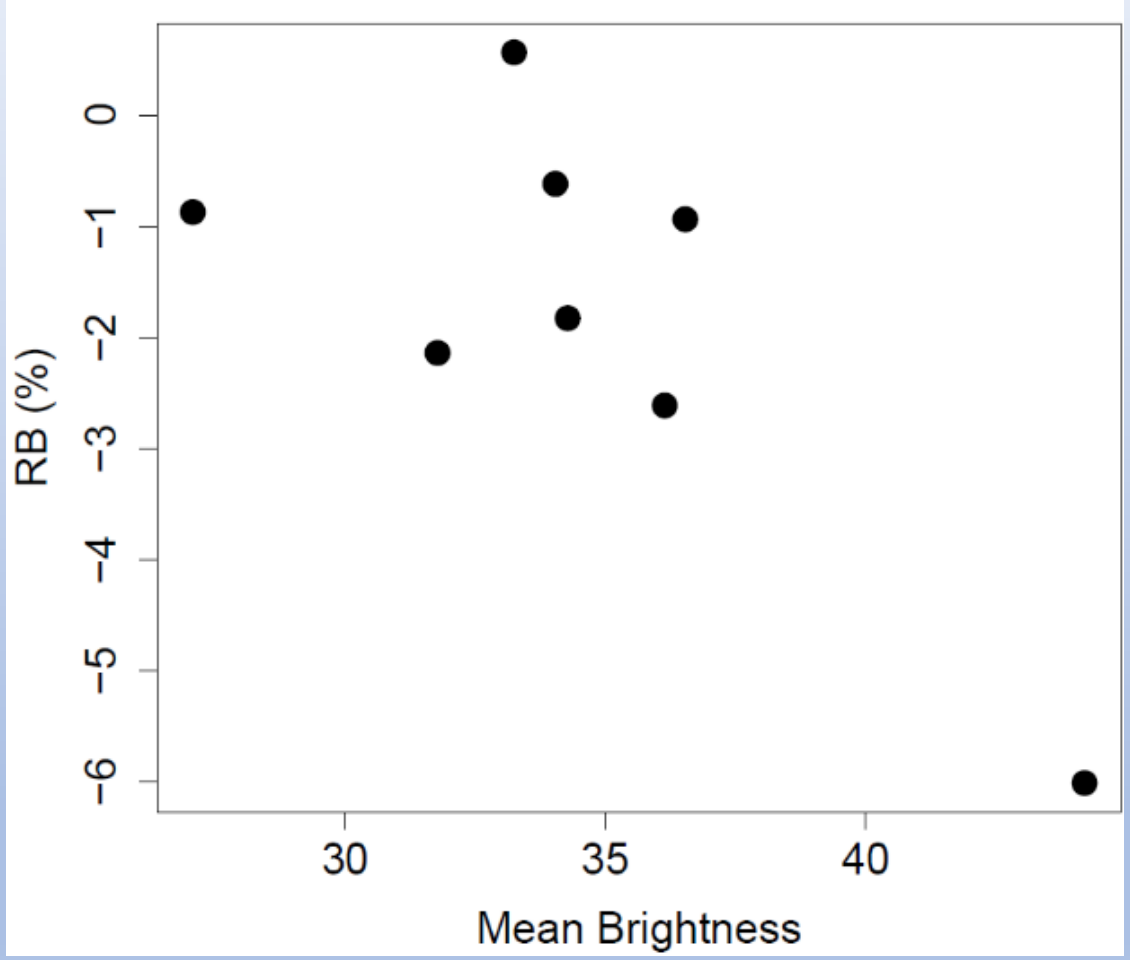
Future approach to eliminating sampling bias



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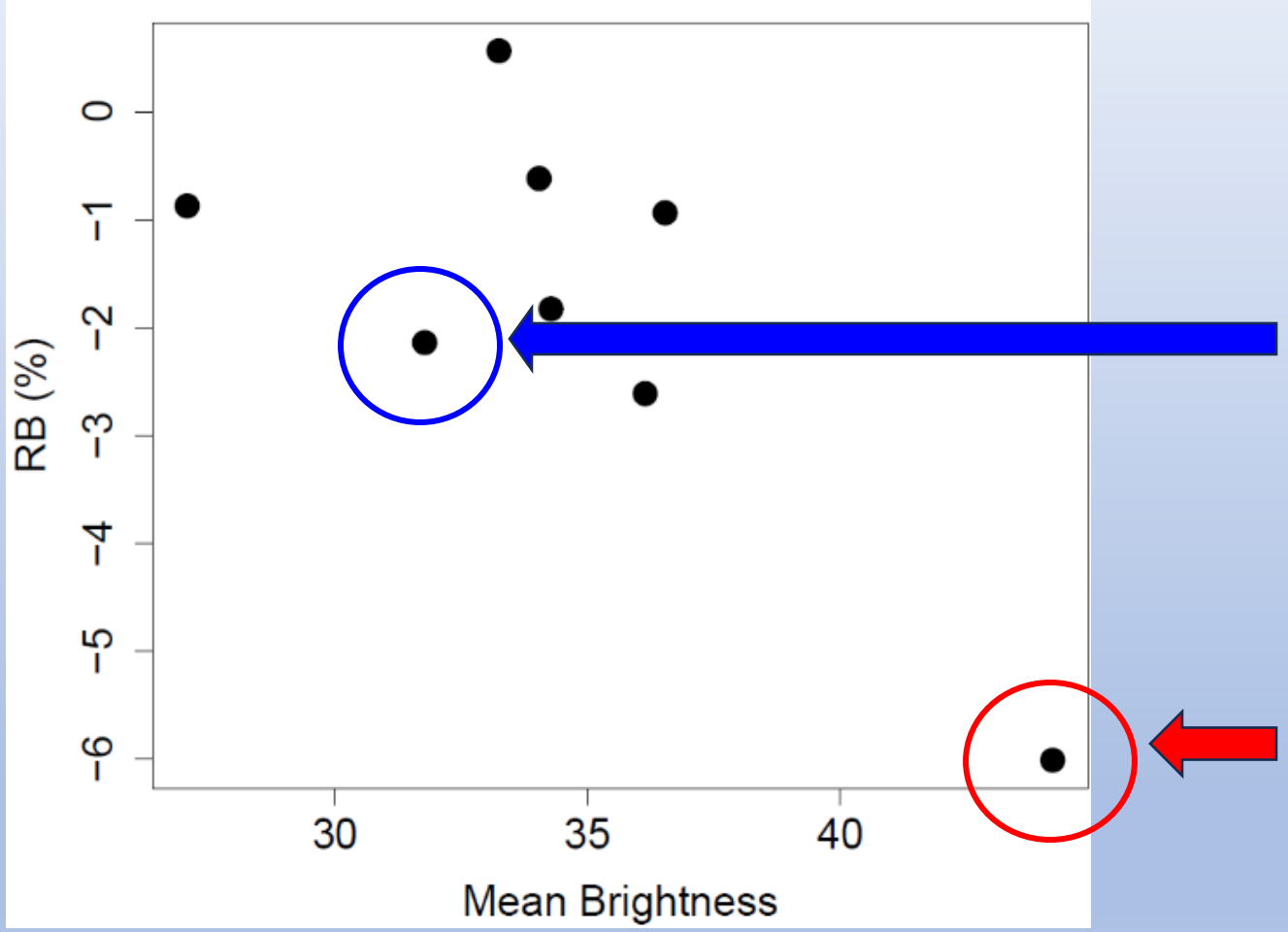

Low brightness, low bias

High brightness, high bias

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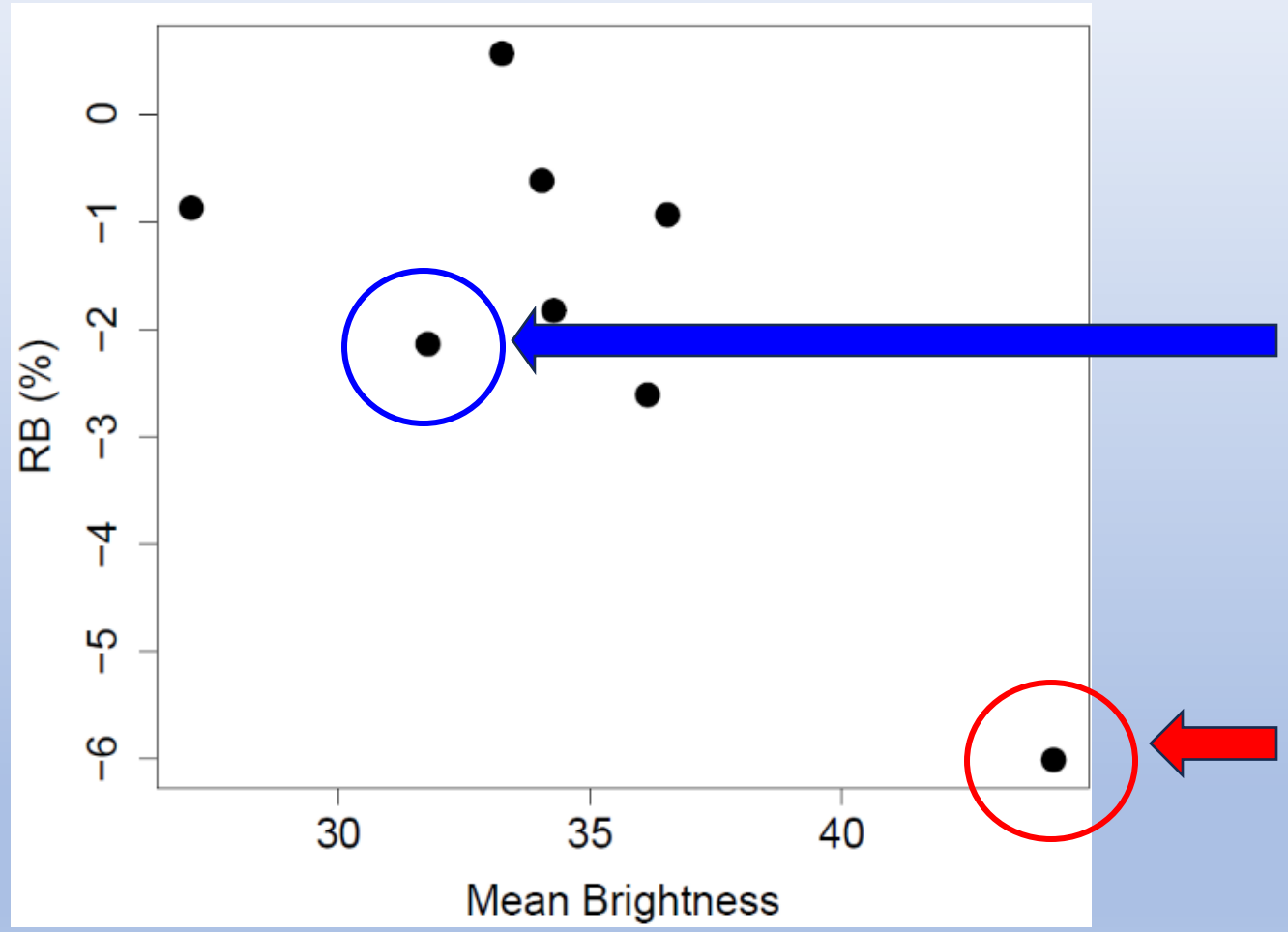
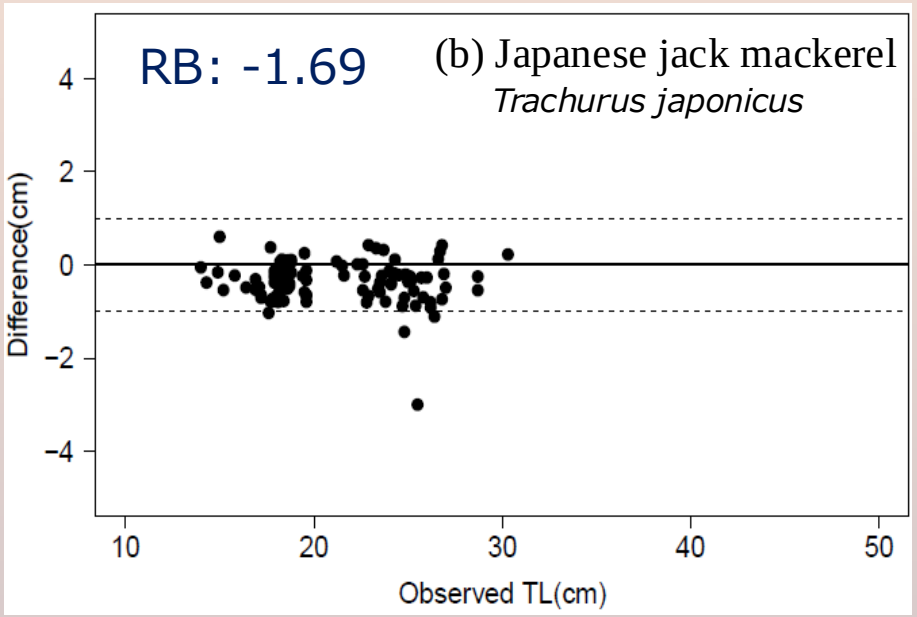


Low brightness, low bias

High brightness, high bias

Sampling bias may be quantified by mean brightness value

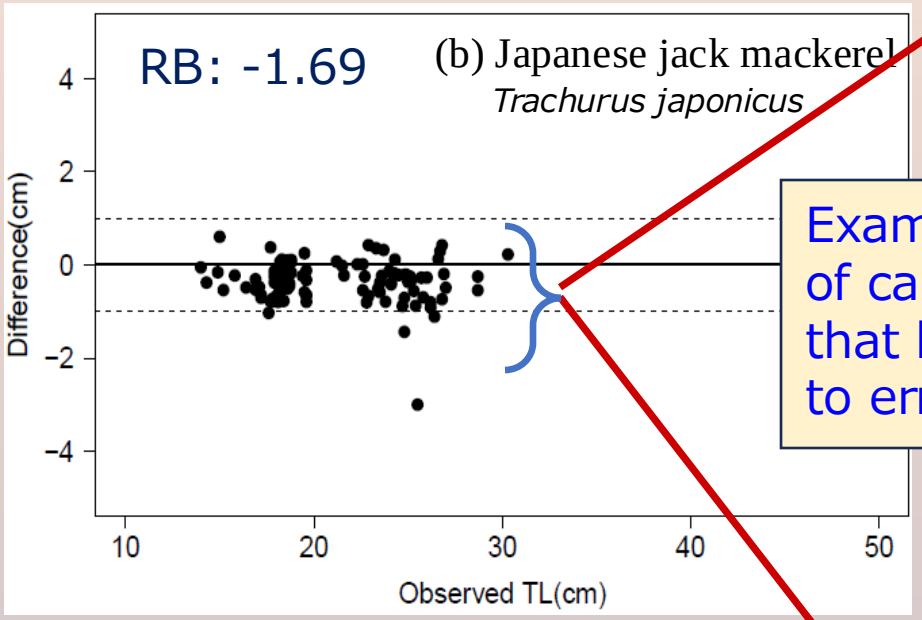
A factor that cause bias: Prediction error



Modified and reproduced from (Shibata et al., 2024)

Difference between predicted TL by AI model and observed TL

A factor that cause bias: Prediction error



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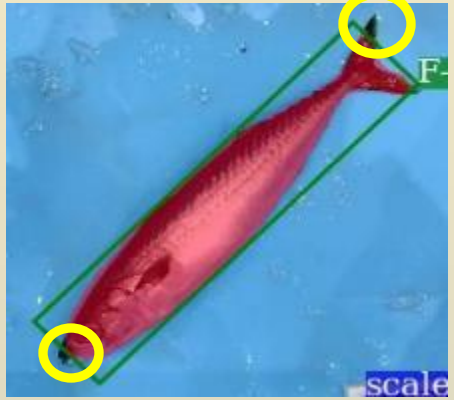
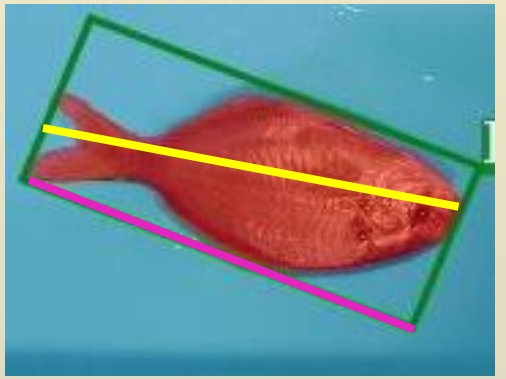
Examples of causes that lead to error

Incomplete prediction of the fish body edges



Blue mackerel
(*Scomber australasicus*)

A rectangle fits diagonally against the centerline of fish body



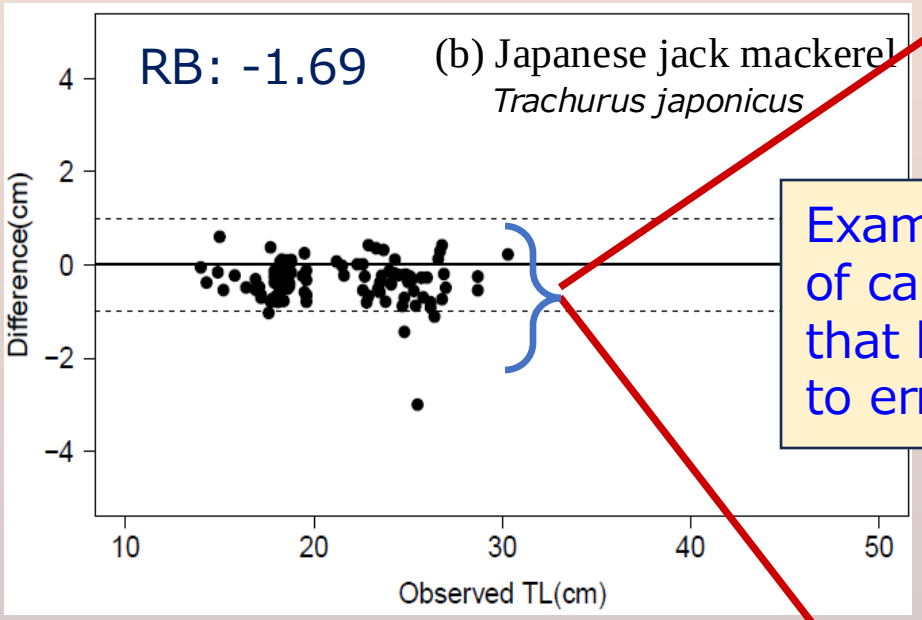
Pacific rudderfish
(*Psenopsis anomala*)

The fish body is curved

Japanese barracuda(*Sphyraena japonica*)

Modified and reproduced from (Shibata et al., 2024 Oral presentation in Autumn meeting of JSFS)

A factor that cause bias: Prediction error



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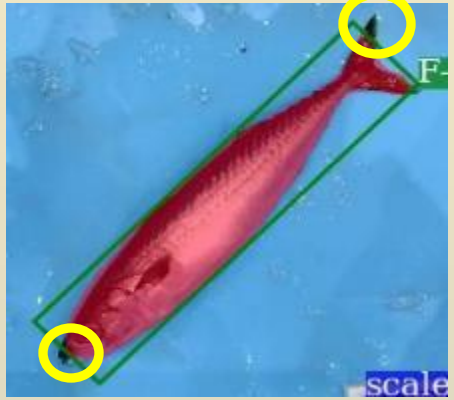

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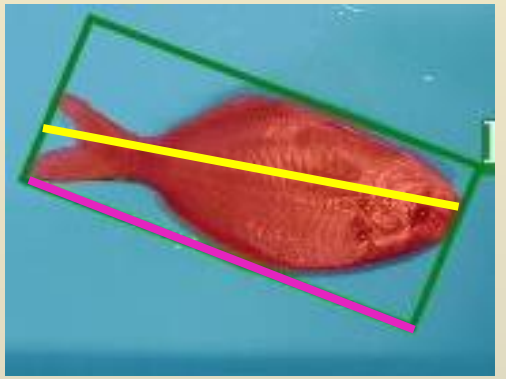

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Prediction error (both bias and variance) can be separated from the sampling bias if observed TL were obtained

Conclusion

FIAS-Deep was developed and installed at Matsuura fish market and Yokohama FRA, Japan. The system will go online during the 2024 fiscal year.

Bias in length composition were within ±3% and those were basically high accuracy.

However, the bias may increase if too many fish are in an image because of sampling bias.

A future work is to correct the bias using such as brightness value and a model that assumes prediction error.