Abundance index of young Pacific bluefin tuna (*Thunnus orientalis*) estimated from the Japanese set net fishery's data

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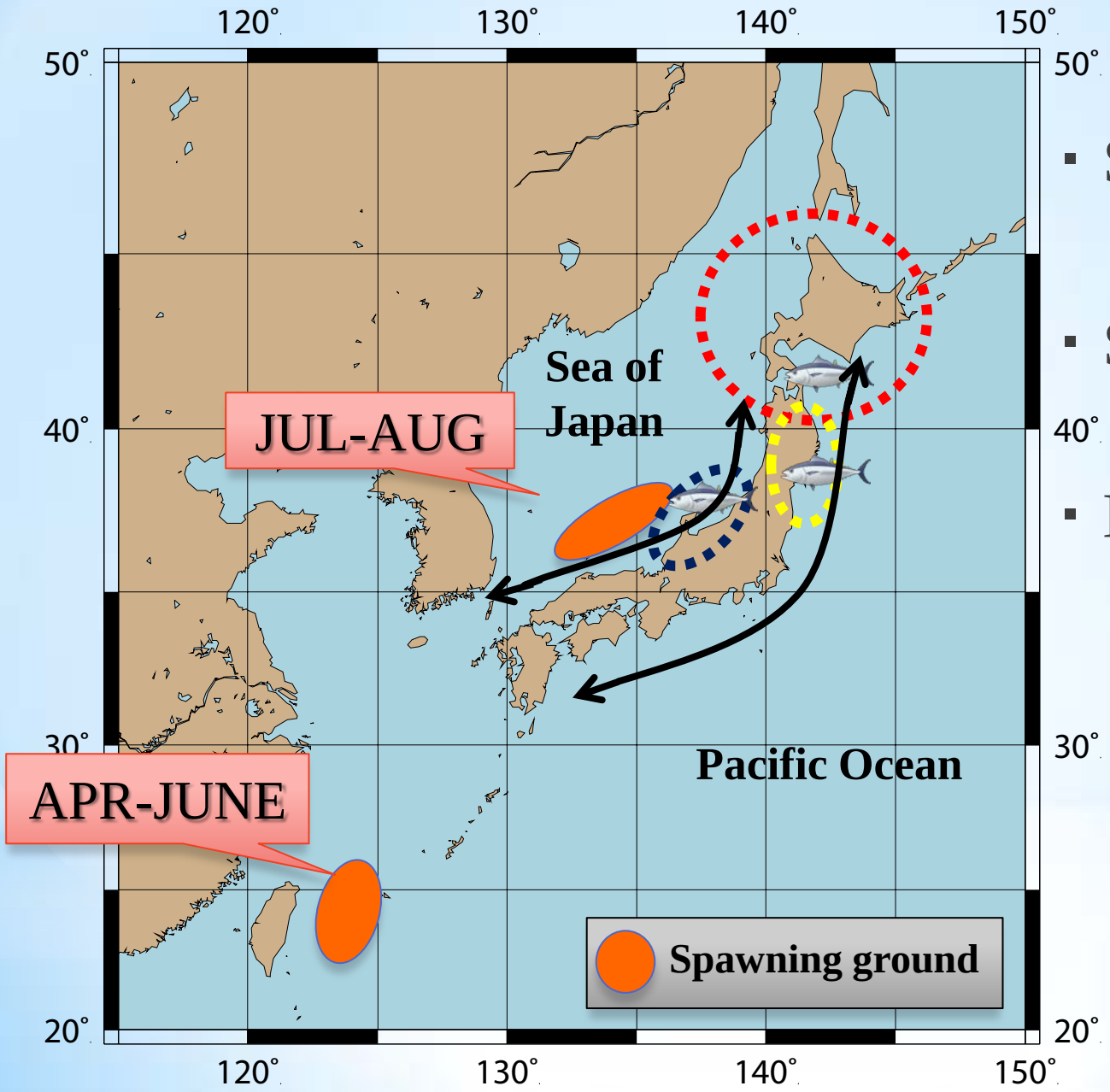
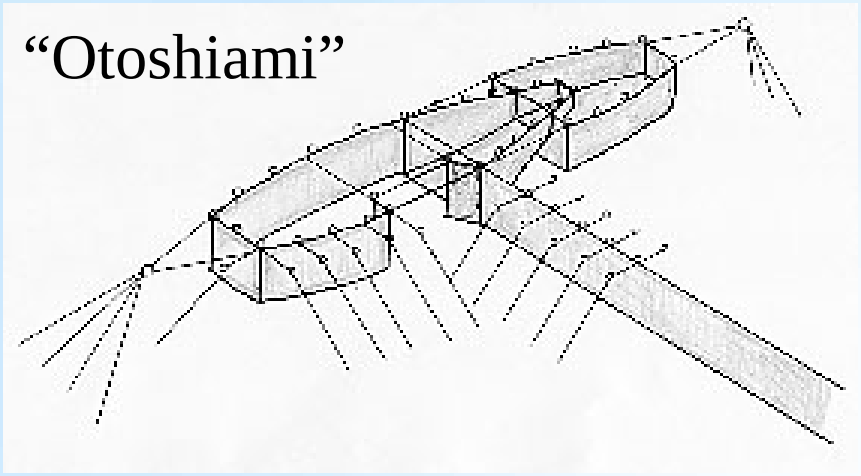
Background-1

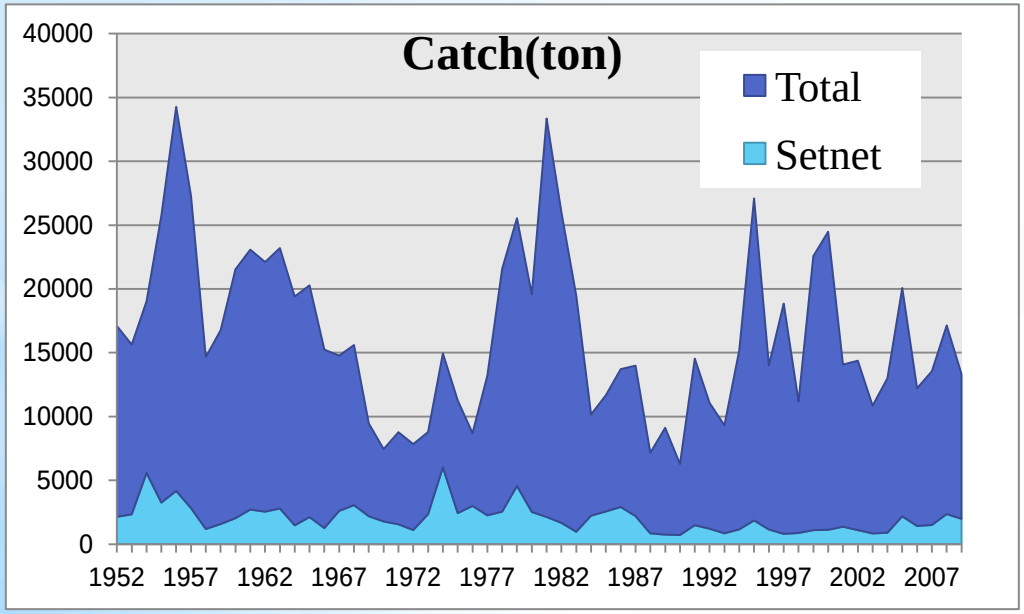


- Spawning ground
- Seasonal migration
- Main fishing areas

Background-2



Ref.;Japan set-net fishery association



- Passive gear
- Bycatch
- Whole year operation
- 5 year license system
- Main catch is young fish(<100cm)
- 4-28 % catch to the total catch in Japan

- Set net is one of the important fishing gears to know the abundance of young PBF

Background-3

- Stock assessment of PBF have been conducted by stock synthesis (SS).

- Length based model
- 10 fishery
- Input data: Length composition, cpue, catch

The quality of the data is very important

Sampling bias is a issue of the length composition data

The methods to reduce the effects of the sampling bias

1) Calculation of effective sample size

2) Weighting of measurement data by catch

Objectives

1) Estimation of catch in number at size

2) Estimation of effective sample size

3) Estimation of abundance index of young PBF

Data sources

The research on Japanese bluefin tuna (RJB)

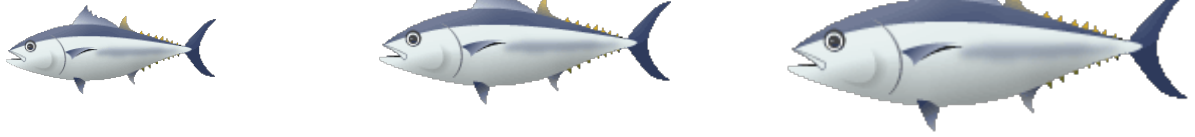
- The purpose is to collect information on PBF landings at local fishing ports in Japan for 1994-2009

Contains size measurement data and catch (sales slip) data

Year, Month, Day, Landing port, Prefecture, gear, size category for auction, processing status of fish…

Size category for auction

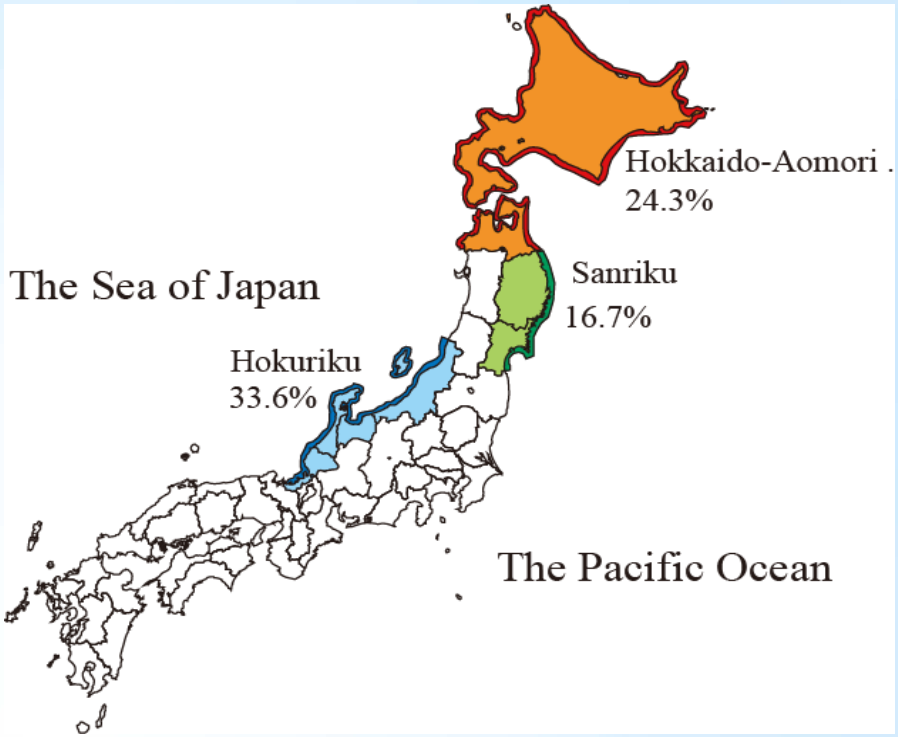
- A variety of names in each local market
- Useful information to determine rough size class



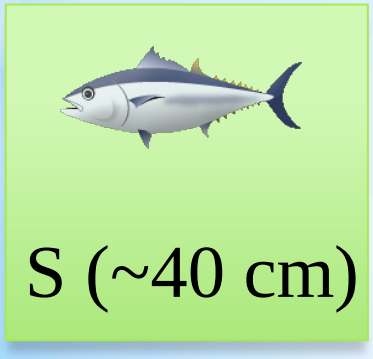
Small tuna Middle tuna Large tuna

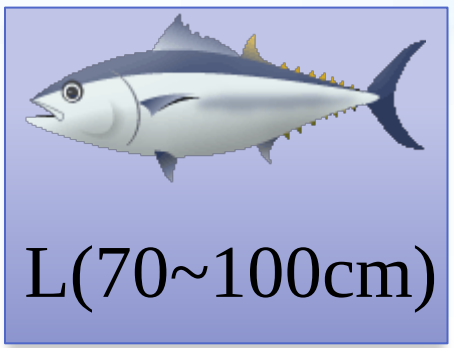
Stratification of the data

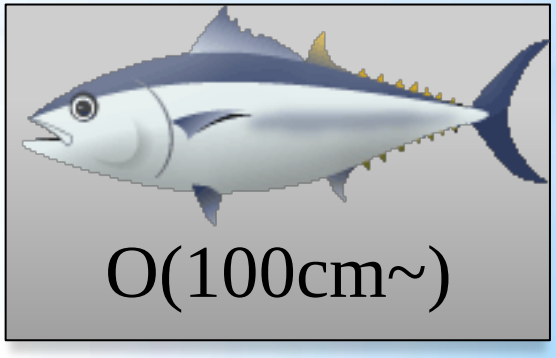
Catch and size measurement data are stratified by the year, month, and four main fishing areas



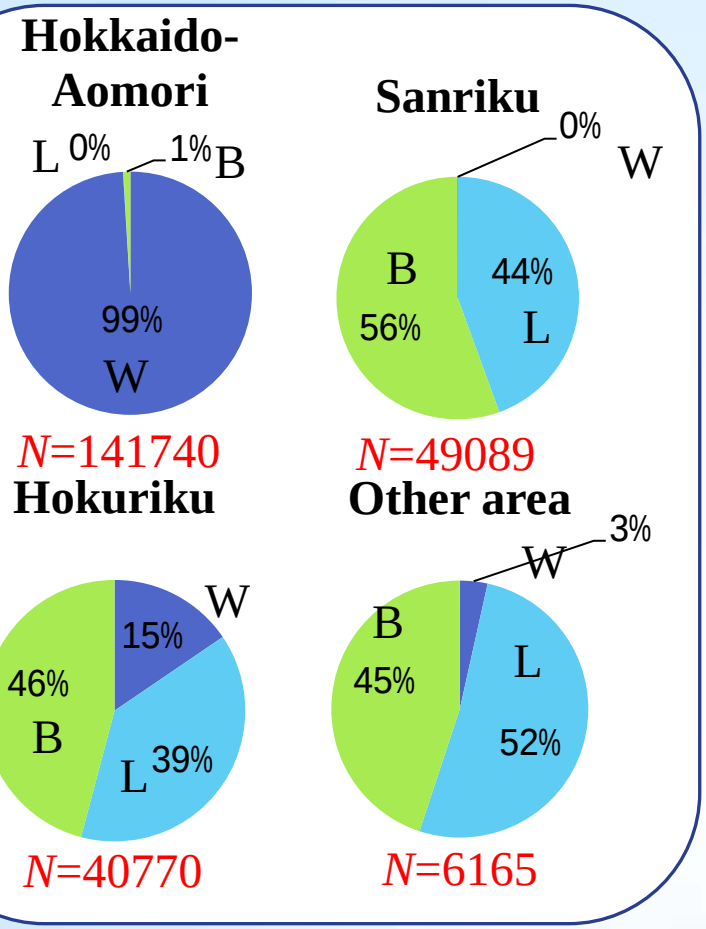
- Aggregate the size class for auction into 4 groups



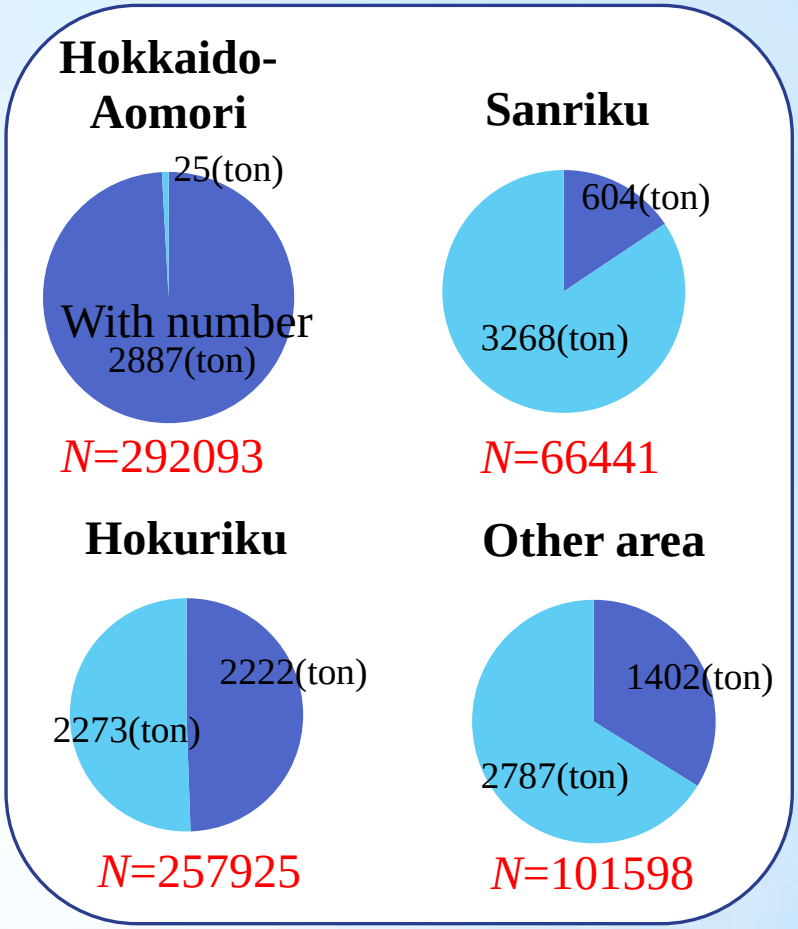




Size measurement data



Catch (sales slips) data



Most of the size measurement data in H-A is weight alone

Catch with number occupies high proportions in H-A

H-A: Estimate the weight composition instead of length comp.

Flowchart of the estimation of the length (weight) composition in number by year, month, area and four size groups

Catch data (Sales slip) has catch in number

YES

Catch in weight with catch in number

100% coverage of size data

YES

Observed weight/length composition in number

NO

Divided catch in weight by number (Average weight)

Area is Hokkaido-Aomori

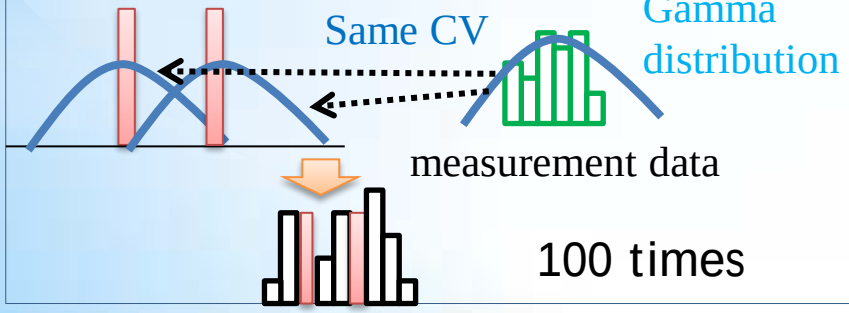
YES

Weight composition in number

NO

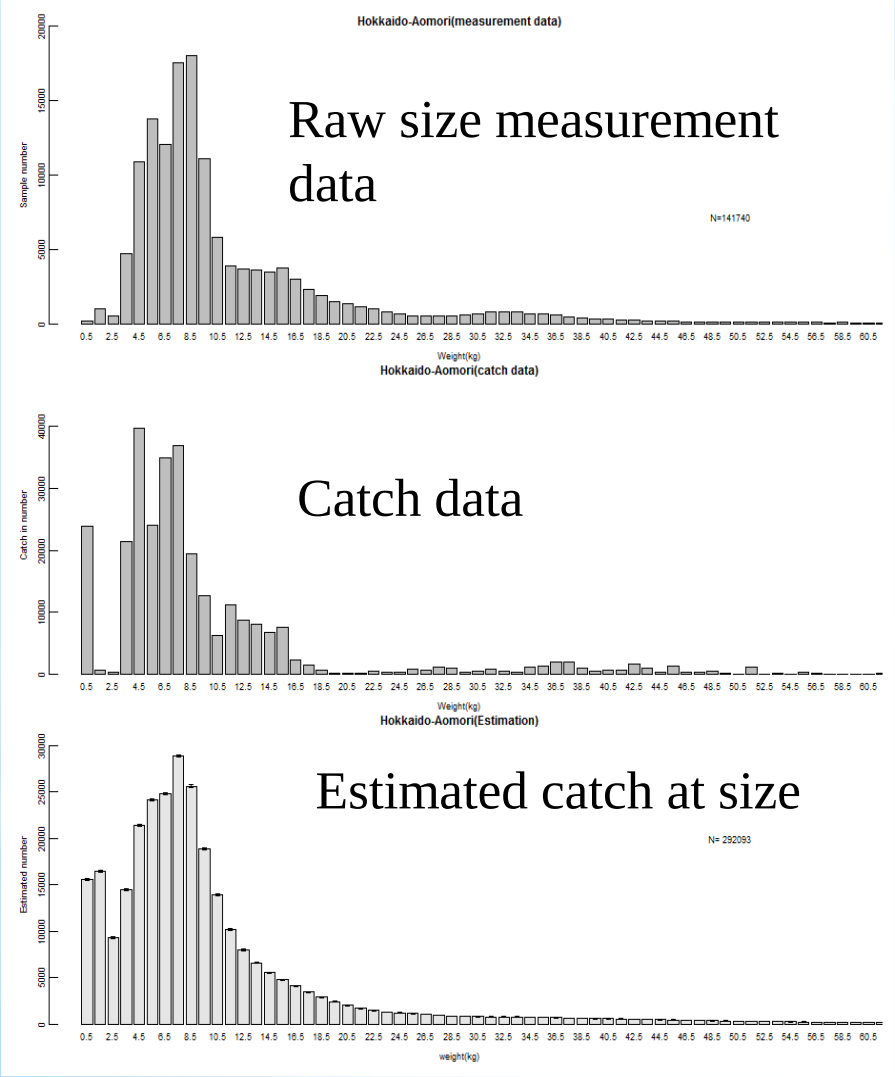
Length composition in number is made using W-L relationships

Allocation of the mean weight/length to each bin using measurement data

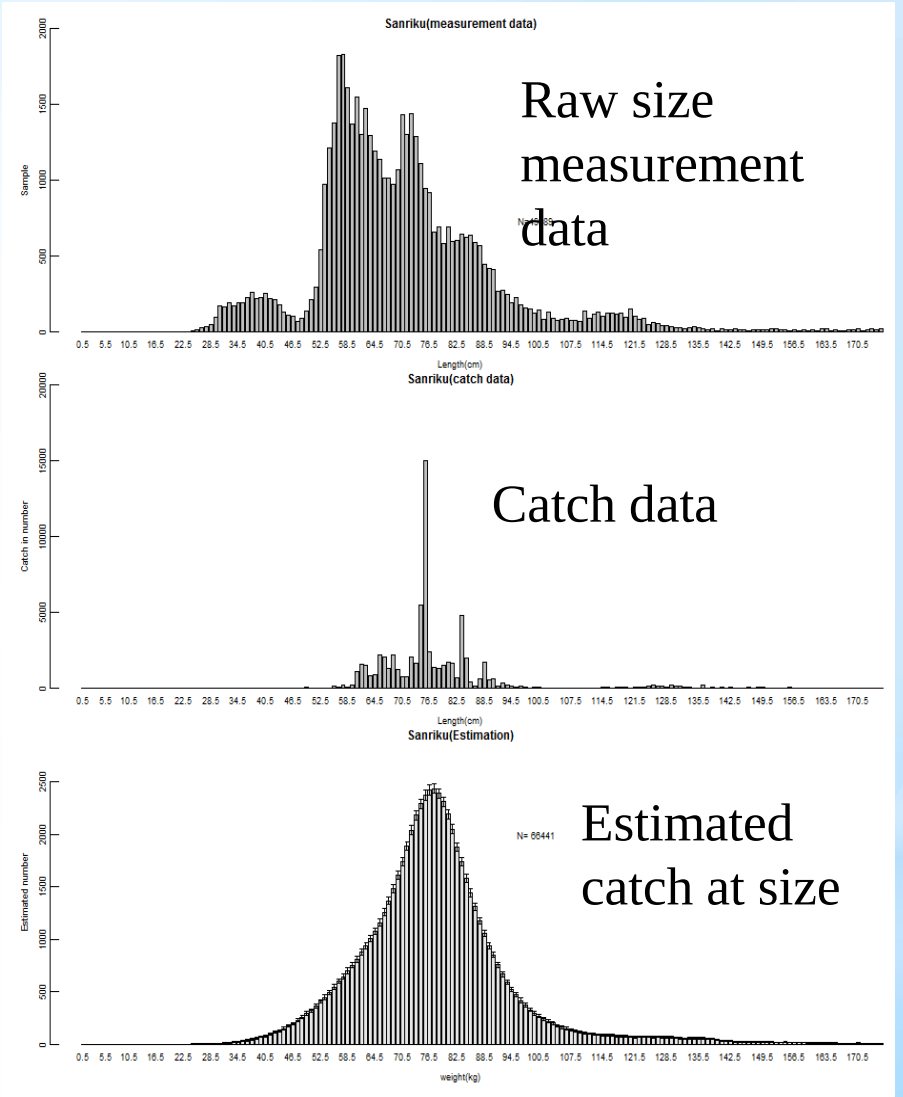


Estimated catch in number at size

Hokkaido-Aomori

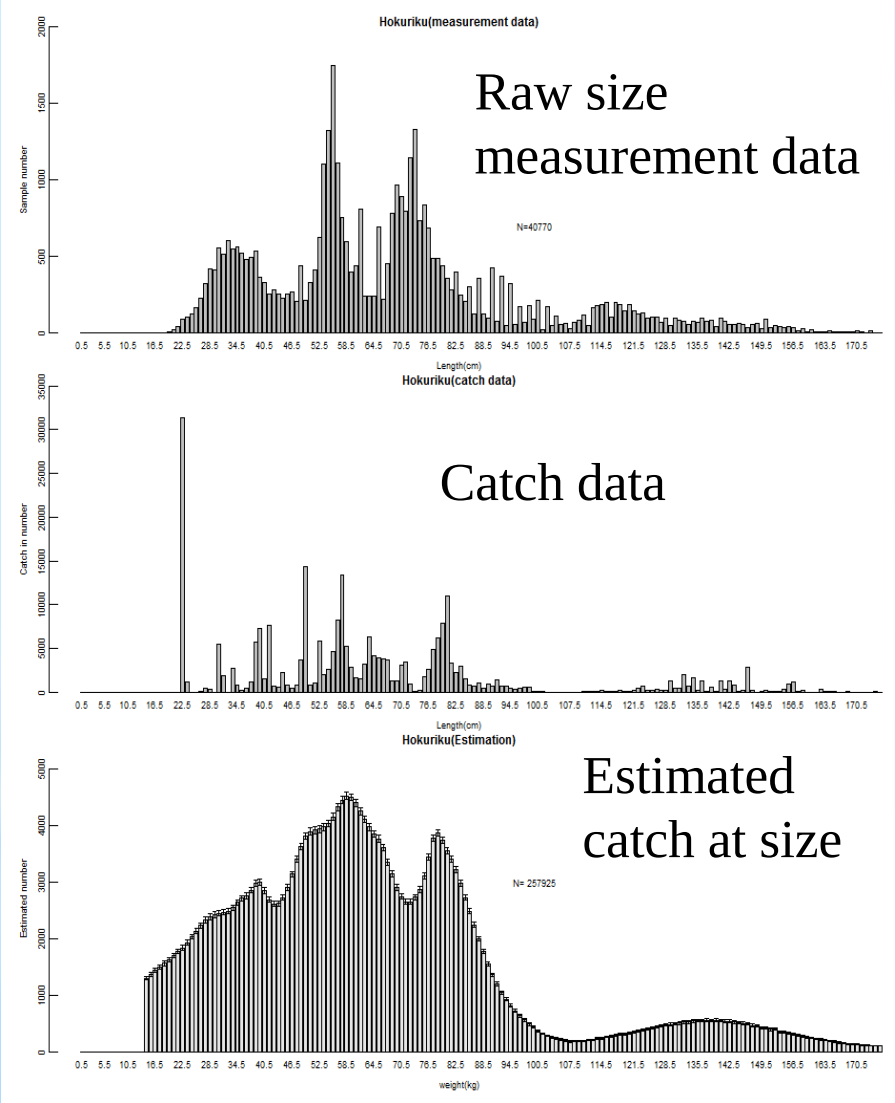


Sanriku

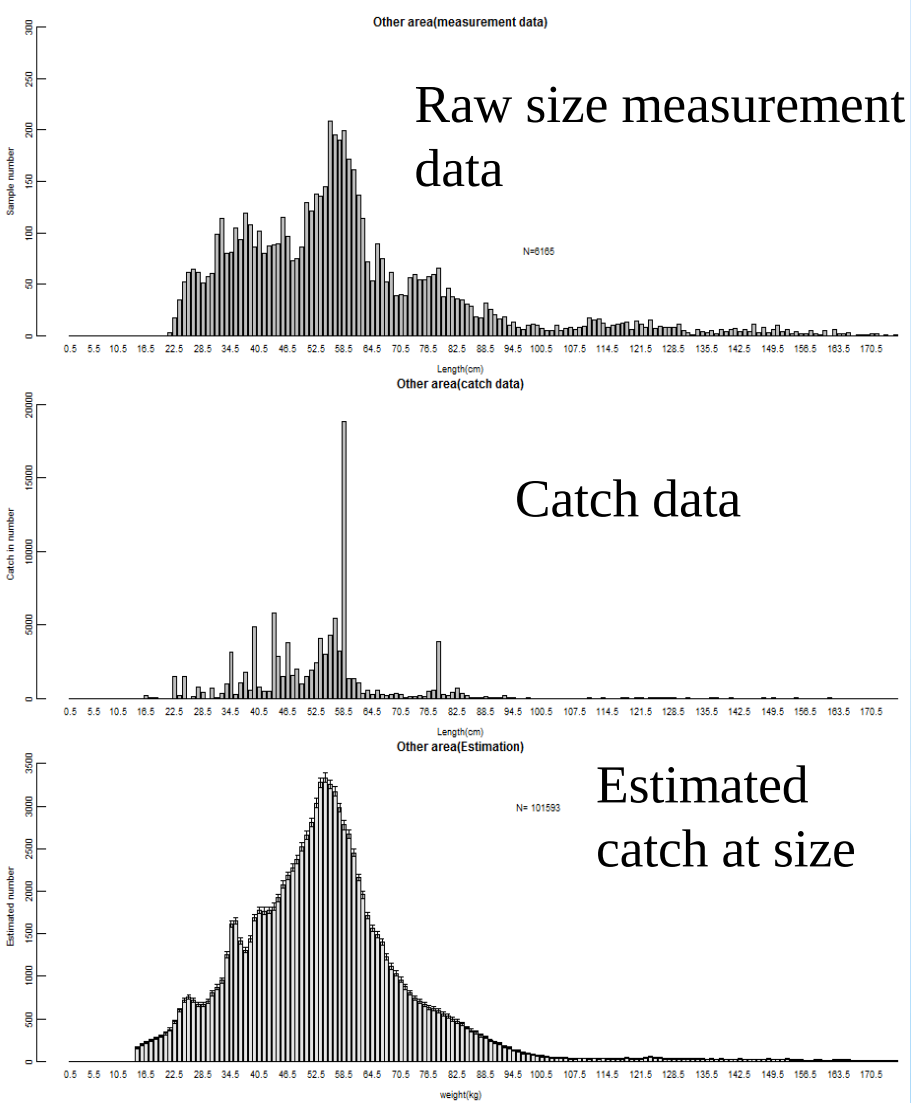


Estimated catch in number at size

Hokuriku



Other area



Flowchart of the estimation of the length (weight) composition in number by year, month, area and four size groups

Catch data (Sales slip) has catch in number

YES

Catch in weight with catch in number

100% coverage of size data

YES

Observed weight/length composition in number

NO

Divided catch in weight by number (Average weight)

Area is Hokkaido-Aomori

YES

Weight composition in number

NO

Length composition in number is made using W-L relationships

Allocation of the mean weight/length using measurement data

Same CV

Gamma distribution

measurement data

NO

Only catch in weight

Weighting the size composition data by corresponding amount of catch

Area is Hokkaido-Aomori

YES

Raise the weight composition in number using catch data

NO

Raise the length composition in number using catch data

Combine

Kg

cm

Hokkaido-Aomori

Remaining area

Estimated catch in number at size

Size measurement data

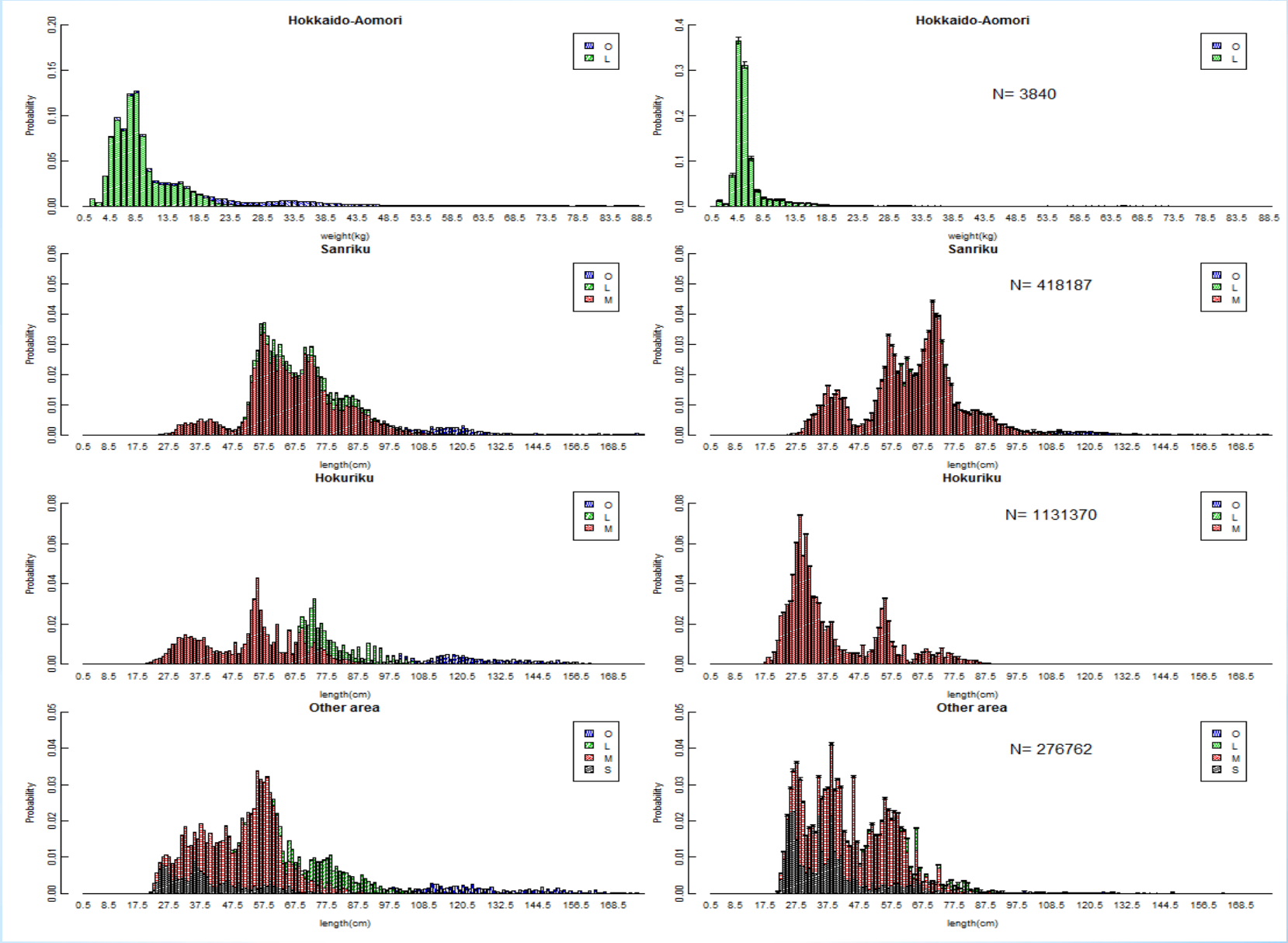
Estimated catch at size

Hokkaido-Aomori

Sanriku

Hokuriku

Other area



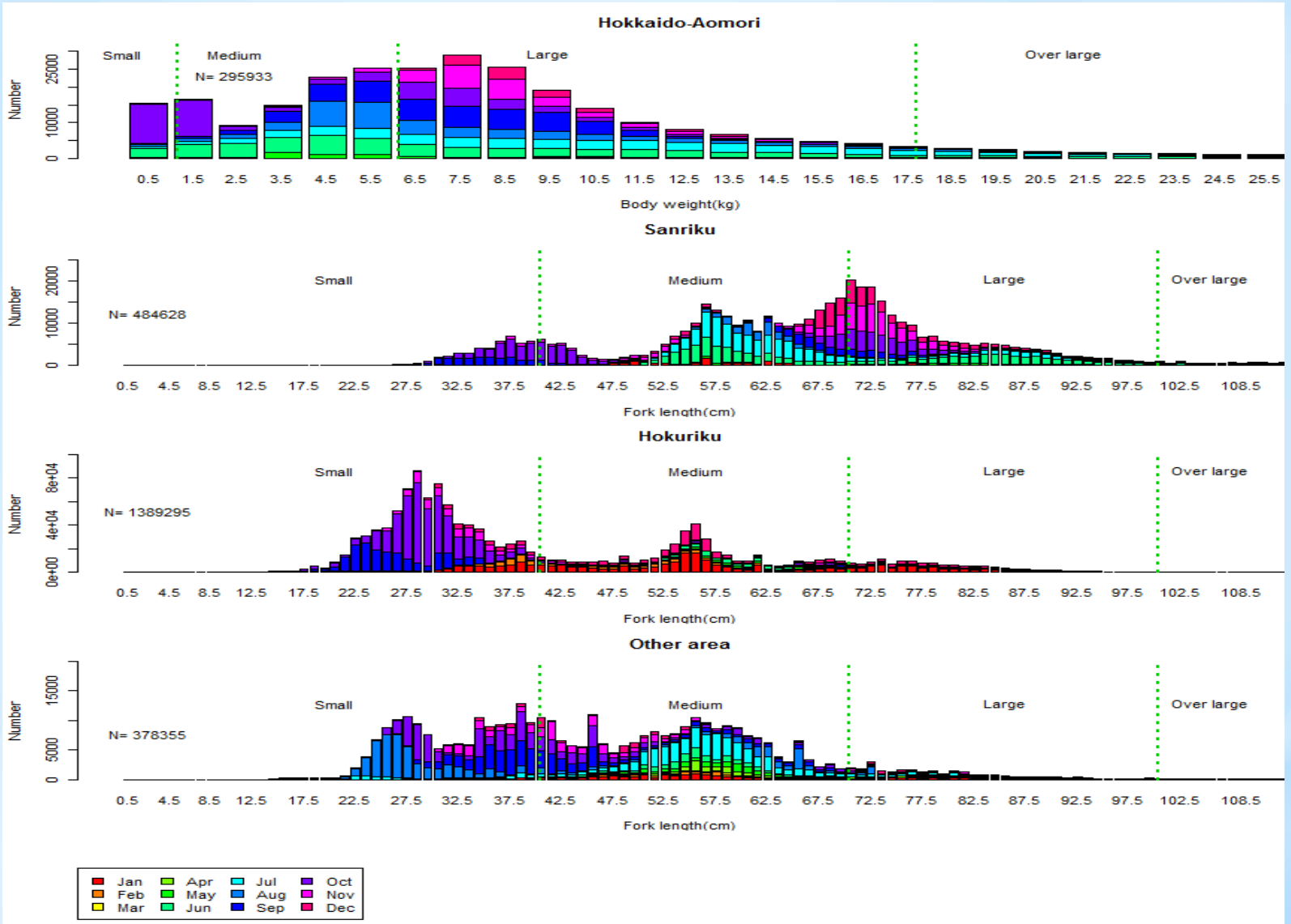
Combined catch in number at size by month and area

Hokkaido-Aomori

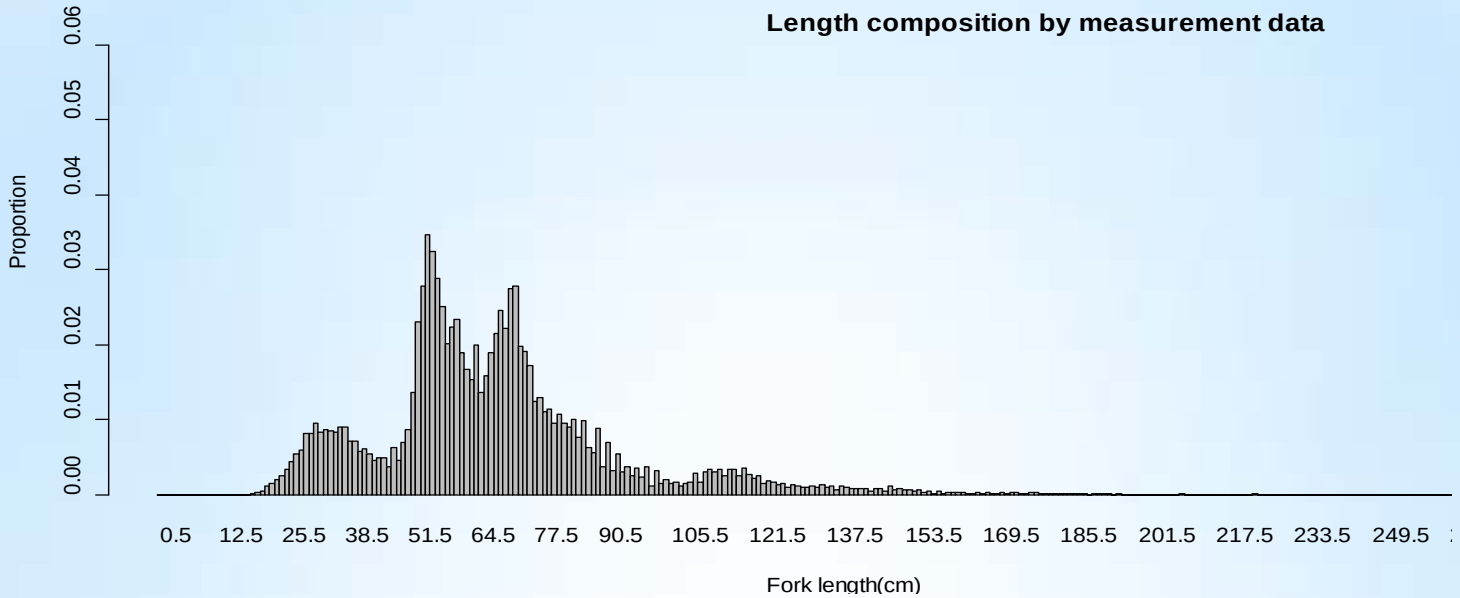
Sanriku

Hokuriku

Other area



Comparison between raw and estimated length composition



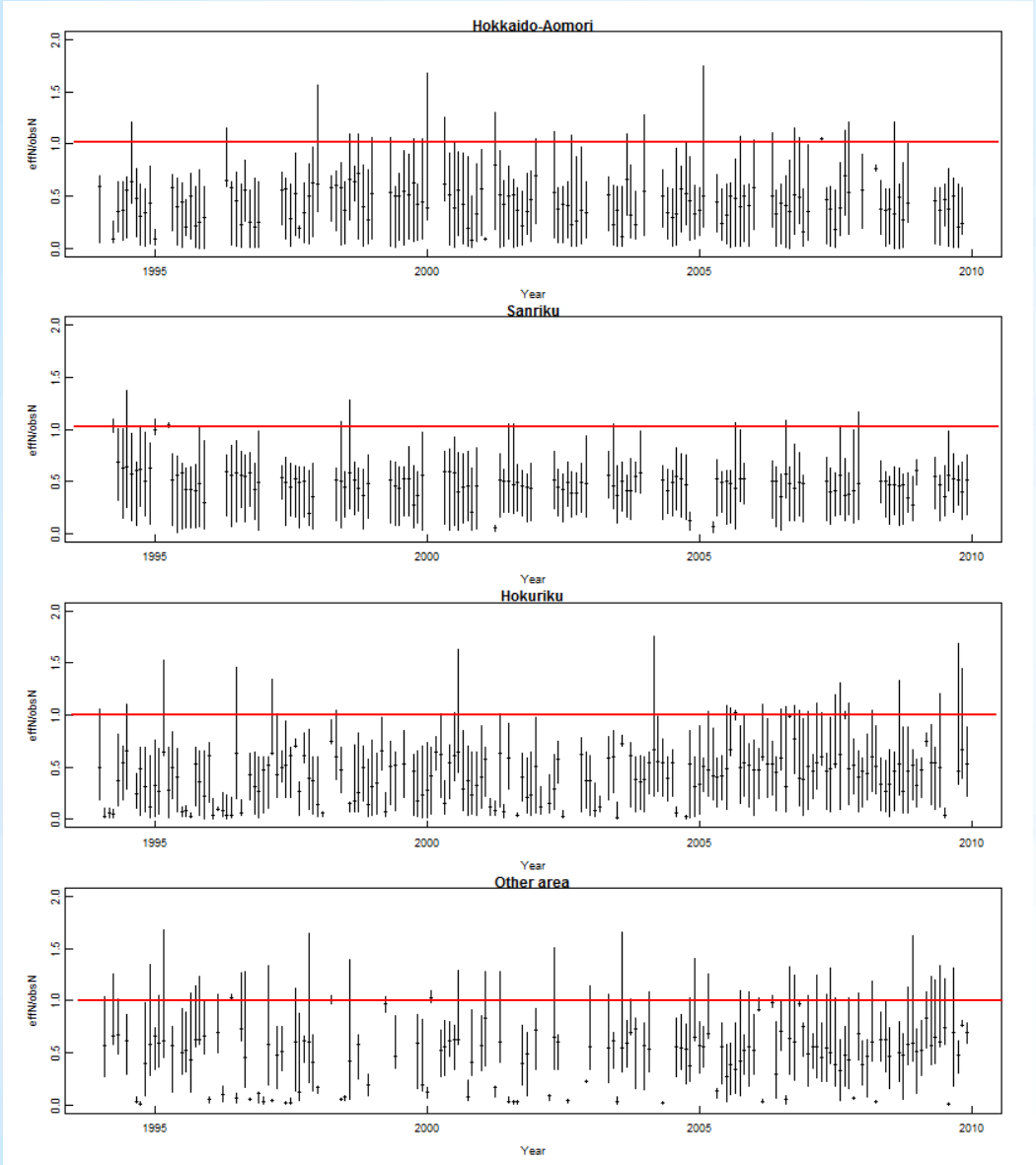
Relative effective sample size (eff*N*/obs*N*) of size measurement data

Hokkaido-Aomori

Sanriku

Hokuriku

Other area



Most of the values were not as large as one

The effective sample size is smaller than actual sample size

Sampling effort can be reduced at all areas

Estimation of abundance index of young PBF

Catch at size ~~⇨~~ Catch at age

Most of the individuals caught by set net fishery are young fish less than 100cm

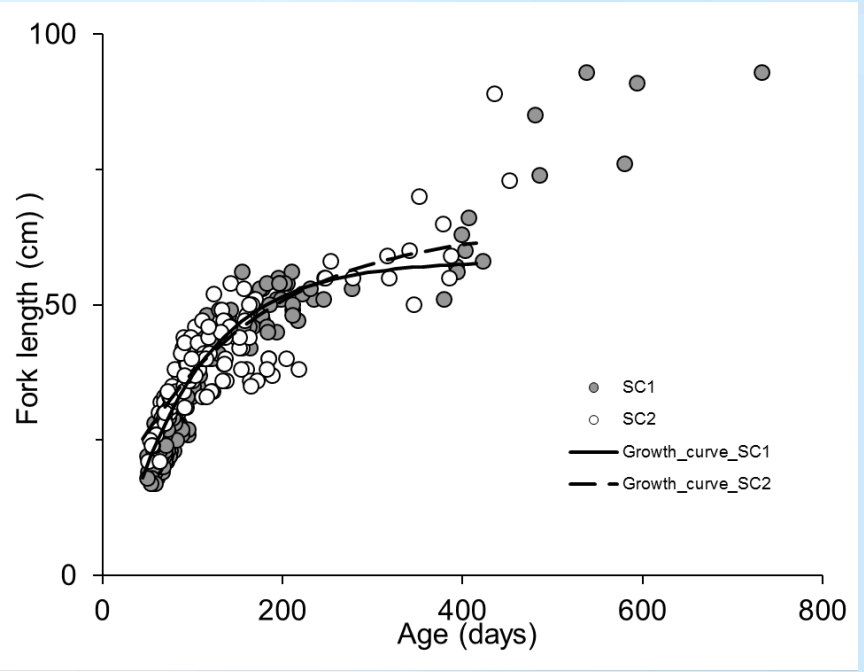
⇩

Both early and later spawned fish are mixed in the catch

Some length composition has a little sample

⇩

The mode is inaccurate



Ito (2009)

Simply separates the catch at size into two groups

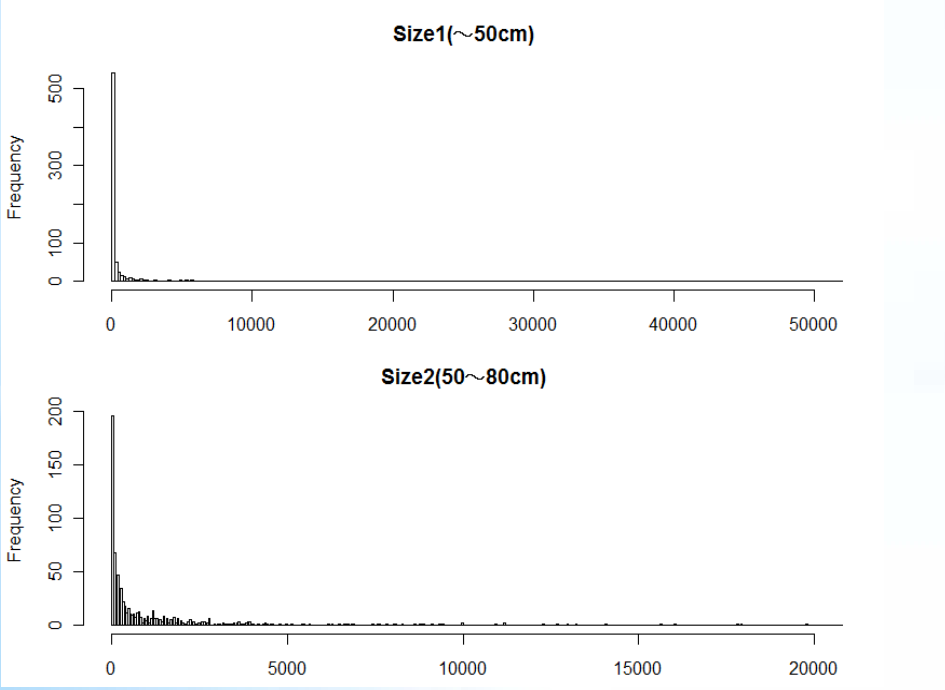
SIZE-1	SIZE-2	Larger size
~50 cm, ~2 kg	50~80cm, 2~9 kg	80cm ~, 9 kg~

Standardization of catch in number

GLM with negative binomial error distribution

$$\log(E(catch)) = intercept + (Year \quad Month + Area)^2$$

Histograms of estimated total catch in number by area, month and year are over-dispersed



Model selection

AIC and BIC
(Bayesian information criterion).

The BIC is a consistent information criterion

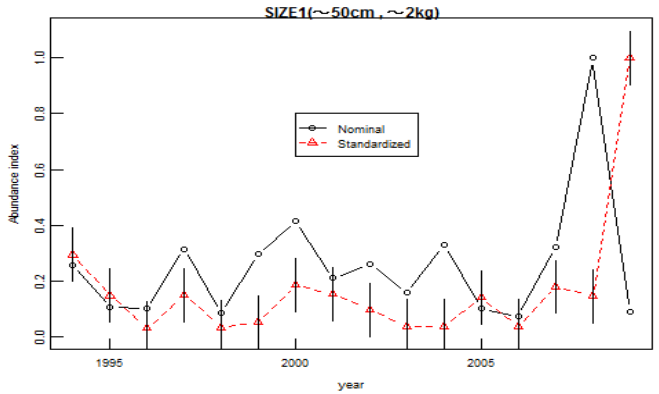
Final model is selected based on the BIC

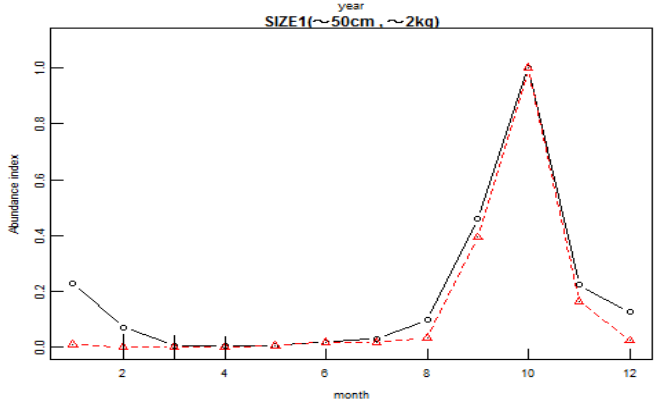
Model selection

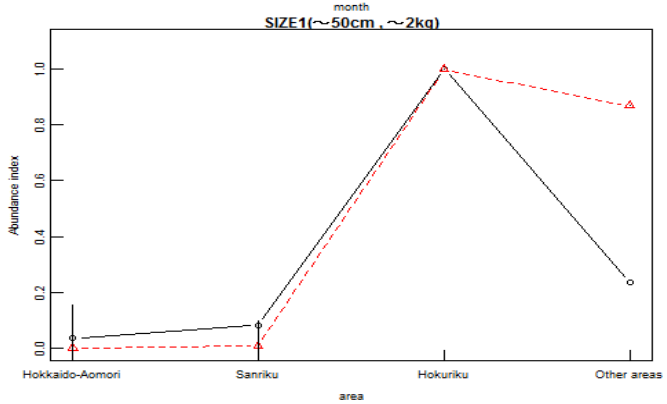
Name	Model	SIZE1		SIZE2	
		AIC	BIC	AIC	BIC
Model-1	Null model	8643	8653	11346	11355
Model-2	Y	8624	8703	11269	11348
Model-3	Y+M	8362	8492	11096	11226
Model-4	Y A	8461	8554	11210	11303
Model-5	Y M A	8150	8294	11038	11182
Model-6	Y M A YM	8159	9069	11134	12044
Model-7	Y M A YA	8096	8449	11044	11397
Model-8	Y M A MA	7807	8104	10412	10709
Model-9	Y M A YM YA	8161	9281	11182	12302
Model-10	Y M A YM MA	7725	8788	10368	11431
Model-11	Y M A YA MA	7736	8482	10409	11082
Model-12	Y M A YM YA MA	7659	8932	10348	11620

Estimated abundance index

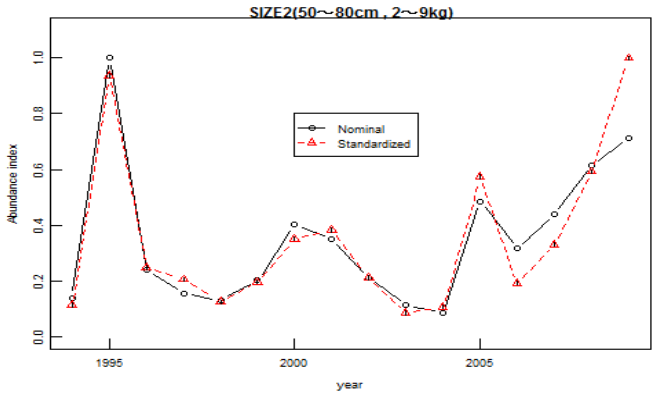
SIZE1(~50cm,~2kg)

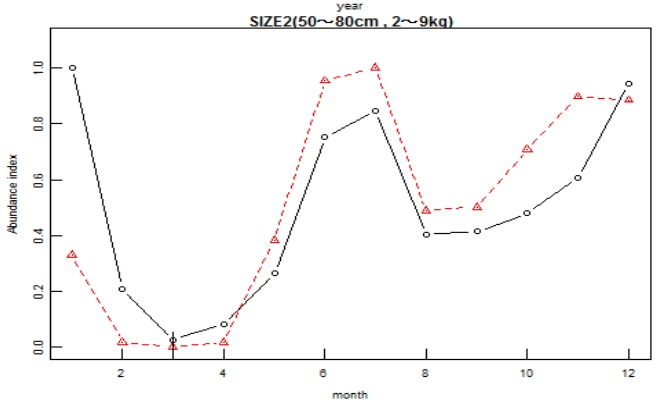


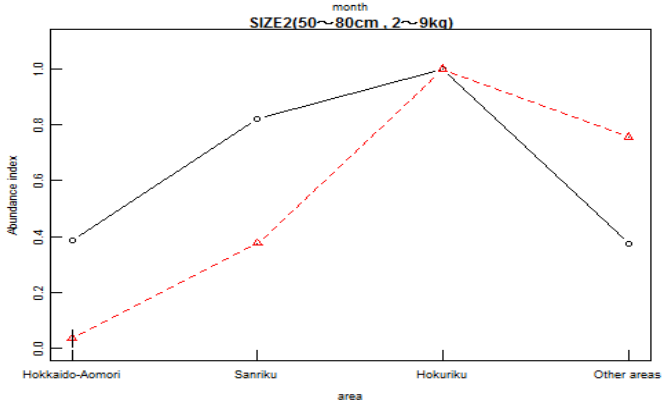




SIZE2(50~80cm,2-9kg)







Year effect

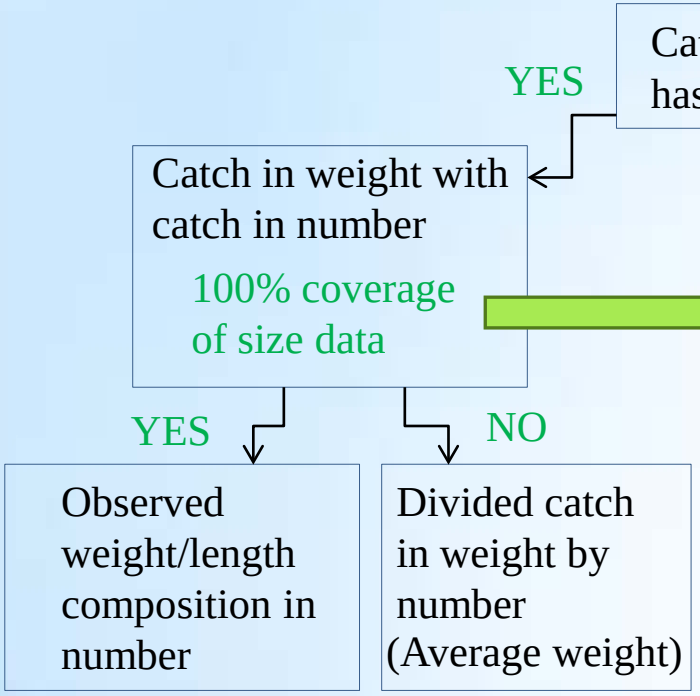
Young PBF has been increasing

Month effect

Area effect

Discussion-1

A part of flowchart of the estimation of the catch at size



If the size measurement data has relatively high coverage (50 or 60),

weighting the size measurement data by corresponded catch in number may be better

Point is to examine the effects of the ratio of the coverage ← Future work

Discussion-2

Best model

$$\log(E(catch)) = intercept + Year + Month + Area + Month*Area$$

Environmental and bycatch effects should be considered

The catch of PBF by set net fishery supposed to be largely influenced by the environmental conditions, such as the course of major currents and sea water temperature

The fish caught by set net contains a variety of fishes such as Mackerels, Squids, Sardines, and Jack mackerel (Suzuki and Kai 2011).

These fishes are prey of the PBF, so that there is high possibility that the PBF follow these schools and enter the net.

Summary

1) Estimated catch in number at size using size measurement and catch data by area, year, month and size groups, which was observed to shift to smaller size

2) Estimated relative effective sample size showed it was on an average smaller than actual sample size

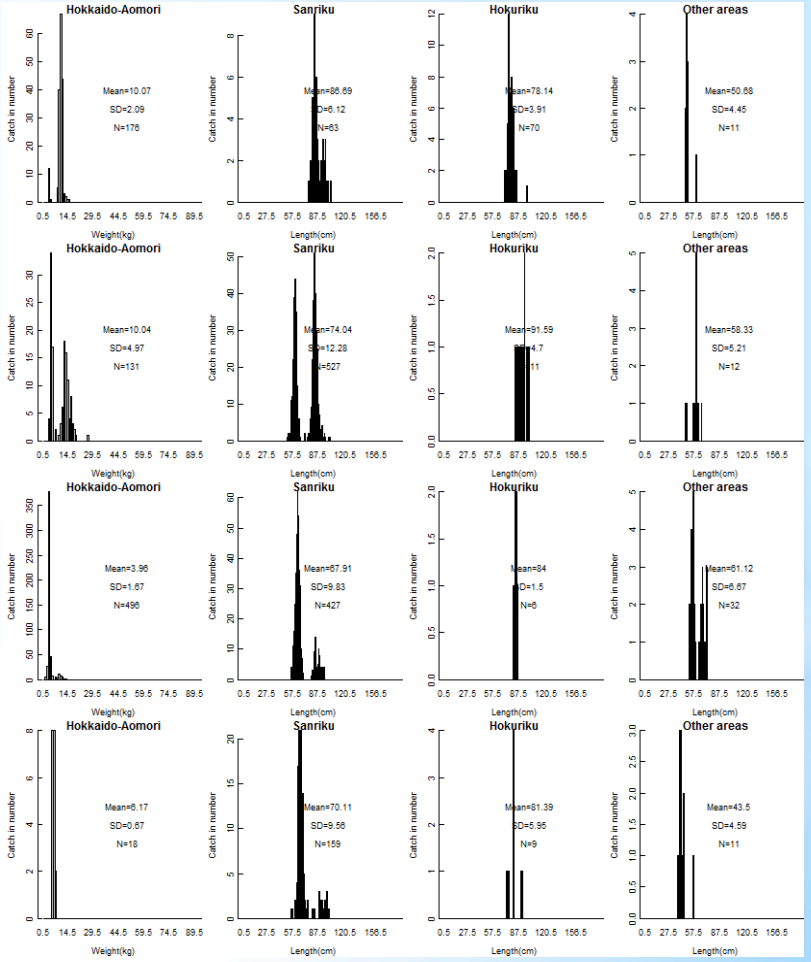
3) Estimated abundance index of young PBF using GLM with negative binomial error distribution suggested it has been increasing in recent years.

Thank you for your attention!

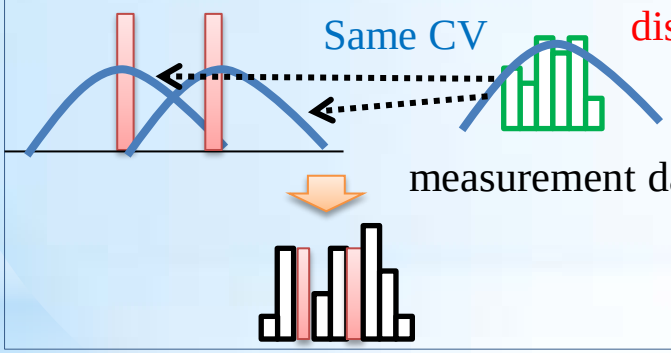
Information criterion of the 3 candidate model

Area	Probability distribution	AIC
Hokkaido-Aomori	Gaussian	999,100
	Log-normal	989,600
	Gamma	802,800
Other three areas	Gaussian	794,200
	Log-normal	797,361
	Gamma	523,639

Some examples of the length compositions in number by area, year, month and size group obtained from size measurement data.

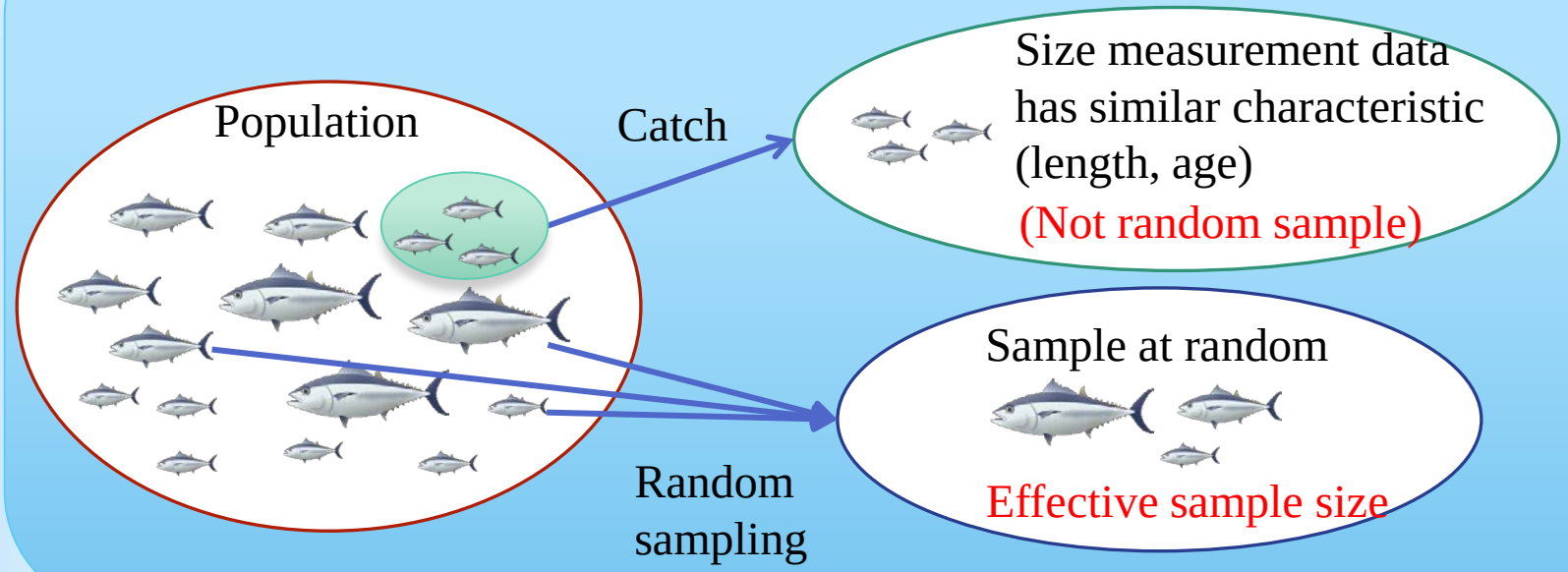


Allocation of the mean weight/length using measurement data



Calculation of relative effective sample size

What is the effective sample size?



$$\text{Relative effective sample size} = \frac{\text{Effective sample size}}{\text{Observed sample size}}$$

$$\therefore R_i = \left(\frac{\sigma_i^{obs} \sigma_i^{boot}}{N_i^{obs} N_i^{boot}} \right)^2$$

Kanaiwa et al (2011)

Each bin of observed and bootstrap data are calculated by original observed data and those obtained by bootstrapping

Two-stage resampling method:

1. Size measurement data collected at the same local market on the same day are grouped and re-sampled with replacements.

2. Weight (length) measurement data in each group are re-sampled with replacements. The trials of bootstrapping are repeated 1000 times.