November 14th, 2024 (Peer Review Meeting)

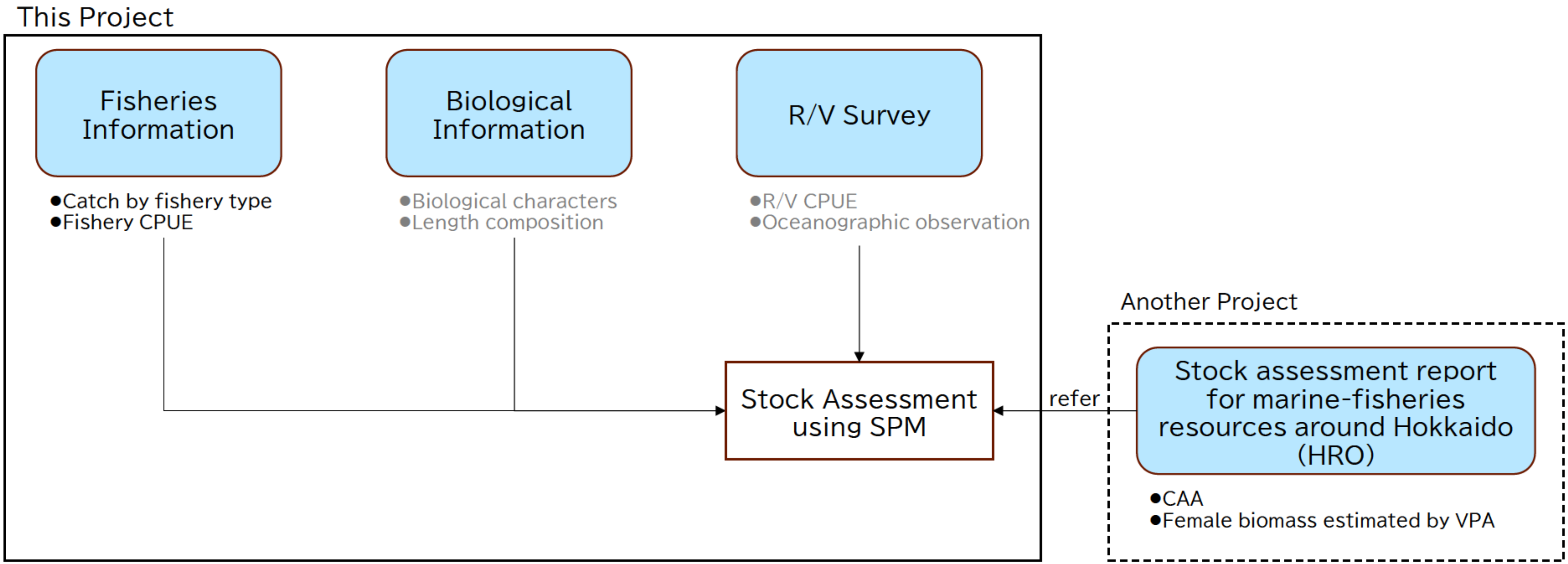
Stock Assessment for Northern Hokkaido Stock of Pointhead Flounder (Fiscal Year 2023)

Fisheries Stock Assessment Center, Fisheries Resources Institute, Japan Fisheries Research and Education Agency (FRA)

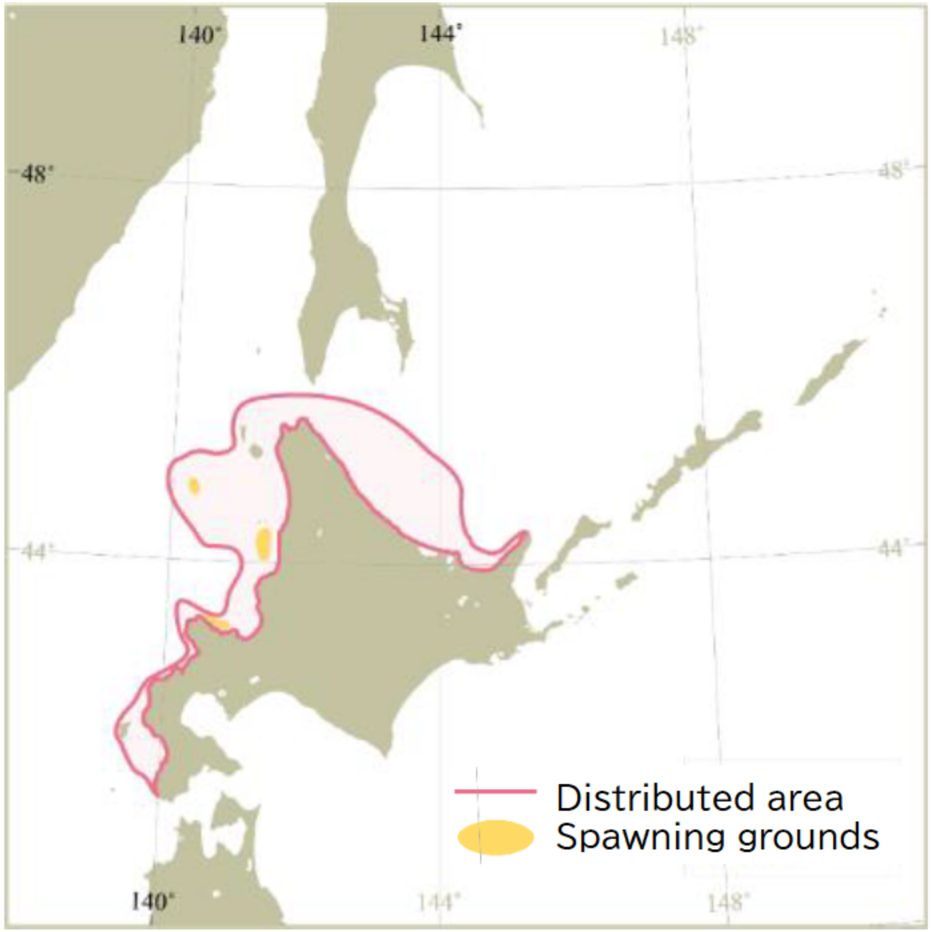
Participating Organizations: Hokkaido Research Organization (HRO) and Marine Ecology Research Institute (MERI)

Contents

Flow of Stock Assessment



Ecology of Pointhead flounder (PF)



Distribution / Migration

- Distributed along coasts of the Sea of Okhotsk and the Sea of Japan
- Composed of two groups
  - Spawned in the Sea of Japan and live in there
  - transported to the Sea of Okhotsk as eggs and larvae, which migrates to the Sea of Japan for spawning as mature fish

Maturation / Spawning

- 50% maturity is age 3 for females and age 2 for males
- Spawning season is from May to September, peaks in July
- Spawning grounds are offshore waters of north Sea of Japan, depth of 50 to 80 m

Predator-Prey Relationship

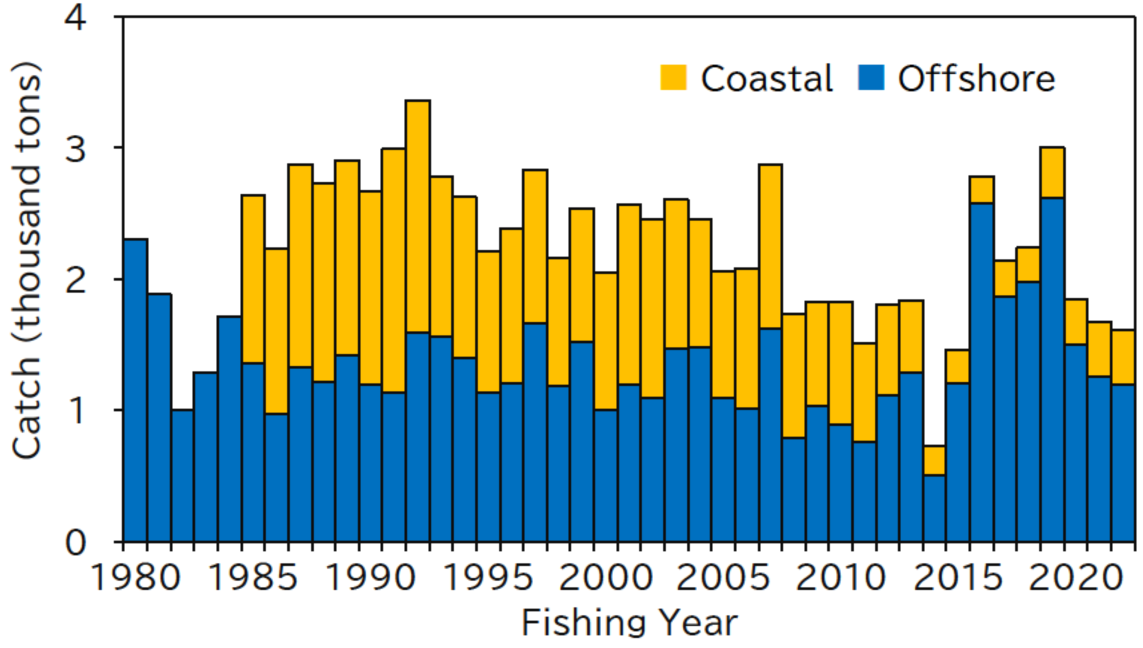
- Prey: small fishes, krill, brittle stars, polychaetes, squids, shrimps, bivalves
- Predator: marine mammals

Other

- The female is larger than the male

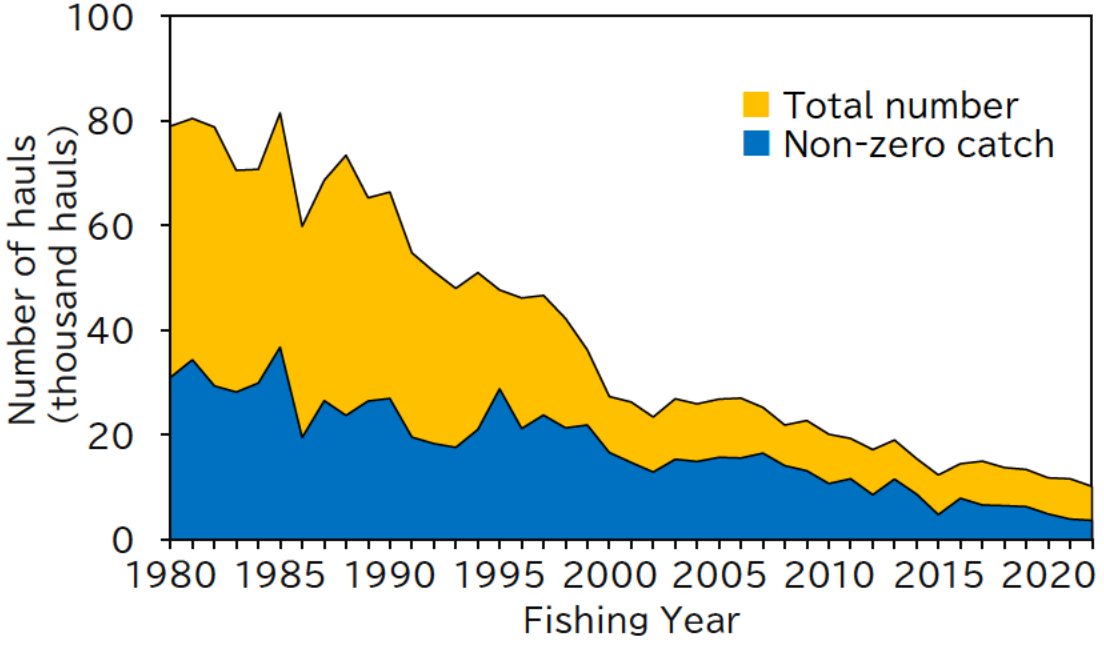
Fishery Status (Fishing year: from August to July of the following year)

Catch



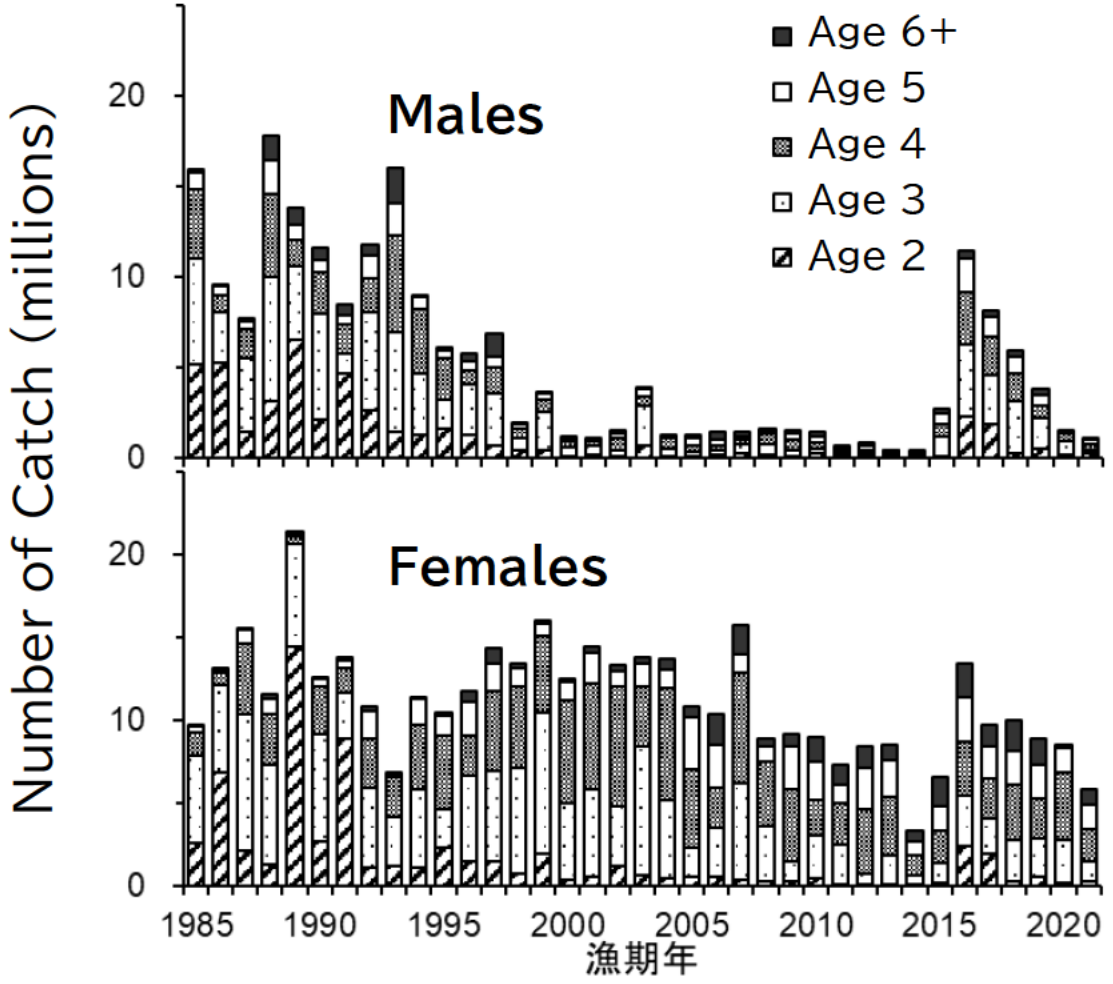
- Offshore bottom trawl mainly catches foraging groups (from Sep. to Apr.)
- Coastal gill net mainly catches spawning groups (from Apr. to July)
- Proportion caught by offshore increased to exceed 70% of catches in the 2022 Fishing Year (FY)
- Catches in the Sea of Okhotsk are extremely small
- Total catch was 1,612 tons in the 2022 FY
- Unreported catch might be existed because it is a bycatch species

Fishing effort



- Fishing effort was based on the total number of hauls by all operations of offshore bottom trawl fishery with Danish seine, which is the primary method of catch
- Fishing effort has continued to decline
- Proportion of non-zero catches is higher since the 2000s than in the 1980s
- Details about the fishing effort of coastal operations are not known

Catch in number at age by sex (estimated by HRO)



- Up to the early 1990s, catch in number of males was equal to females, but few males have been caught since the late 1990s
- Up to the 1991 FY, females age 2 comprised the majority of catches, but few females age 2 have been caught since the 1992 FY, and since then the majority of catches have been females age 3 to 4

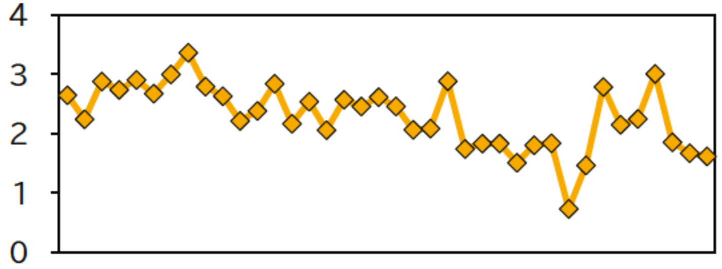
→**Catch size restrictions based on stock management agreements between fishery stakeholders**

- However, catch of males increased in the 2016 to 2017 fishing seasons, and the catch in number of males was equal to females and catch of female age 2 also increased

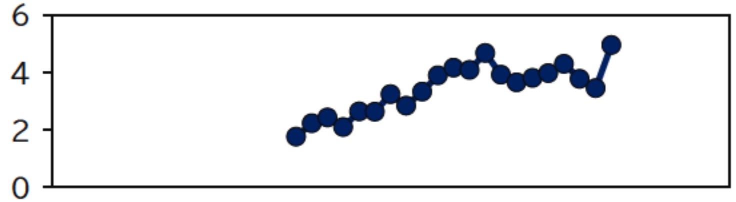
→**Higher catch by offshore bottom trawl of small individuals following the introduction of a new commercial size category (“bara”: unsorted)**

Stock status: Methods

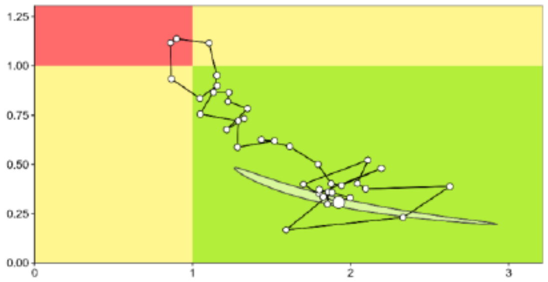
Catch data
Coastal and offshore landings



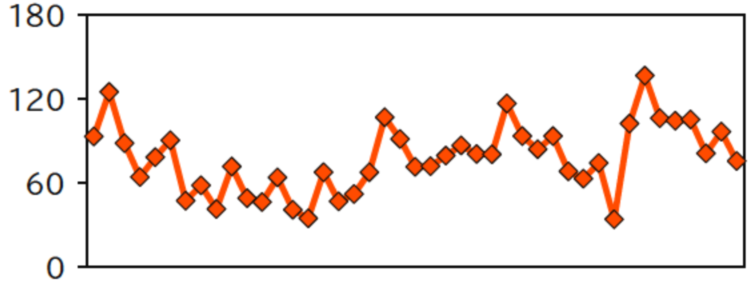
Abundance index 1
Total surviving biomass calculated from the female biomass as estimated using VPA by HRO



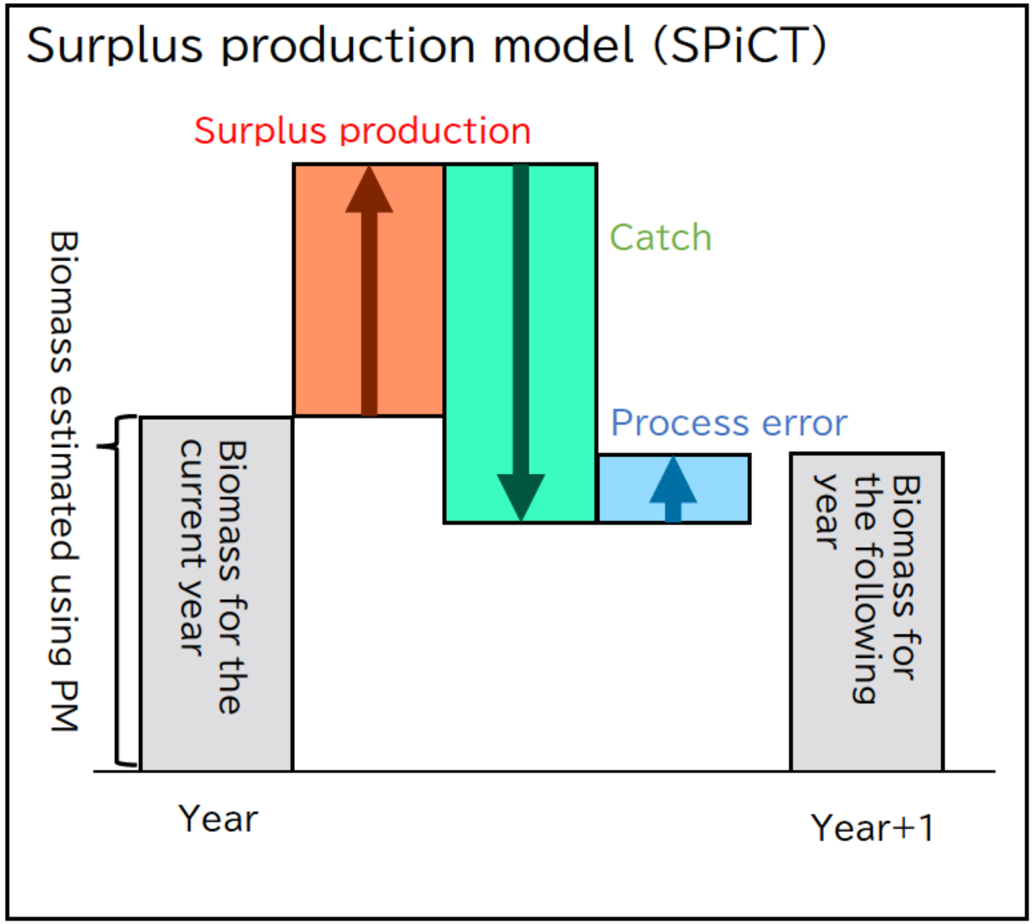
SPiCT
Pella-Tomlinson state-space surplus production model

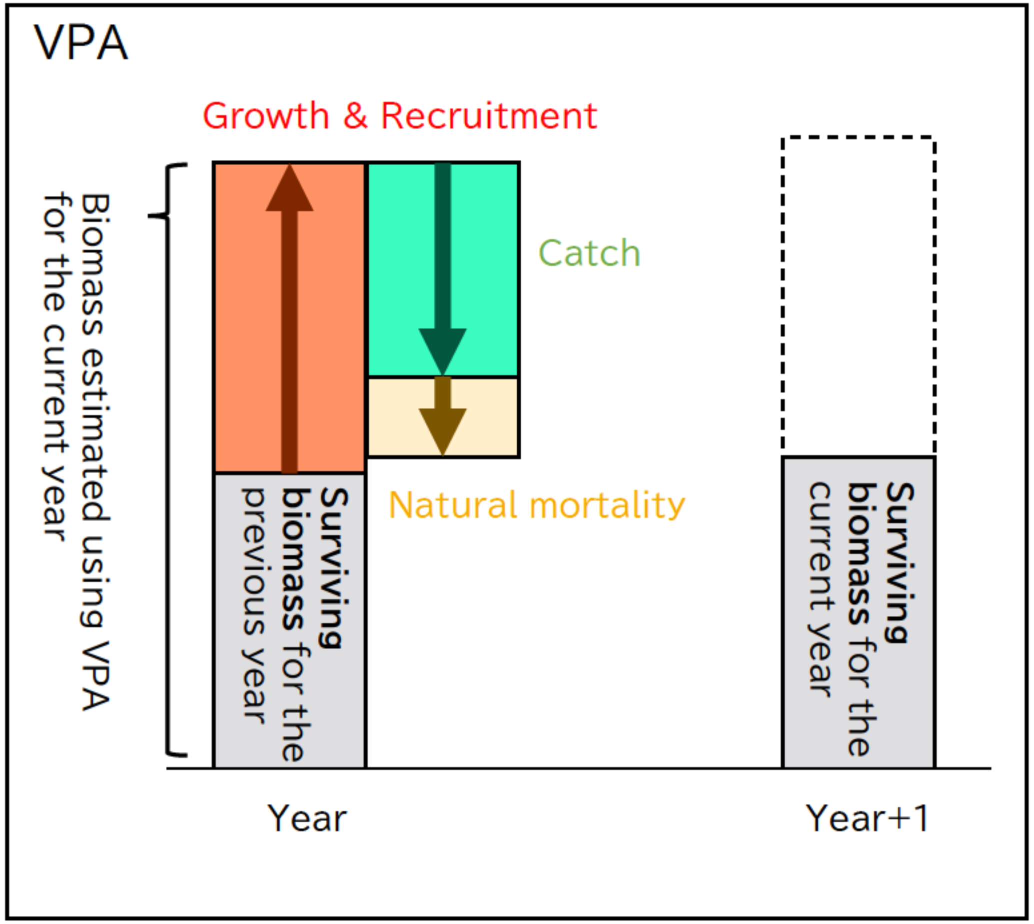


Abundance index 2
Standardized CPUE of offshore bottom trawl



Biomass conversion for the surviving biomass (D)





Conversion equation→ $D_y = \left(B_{y-1} \cdot e^{\left(-\frac{M}{2}\right)} - C_{y-1}\right) e^{\left(-\frac{M}{2}\right)}$

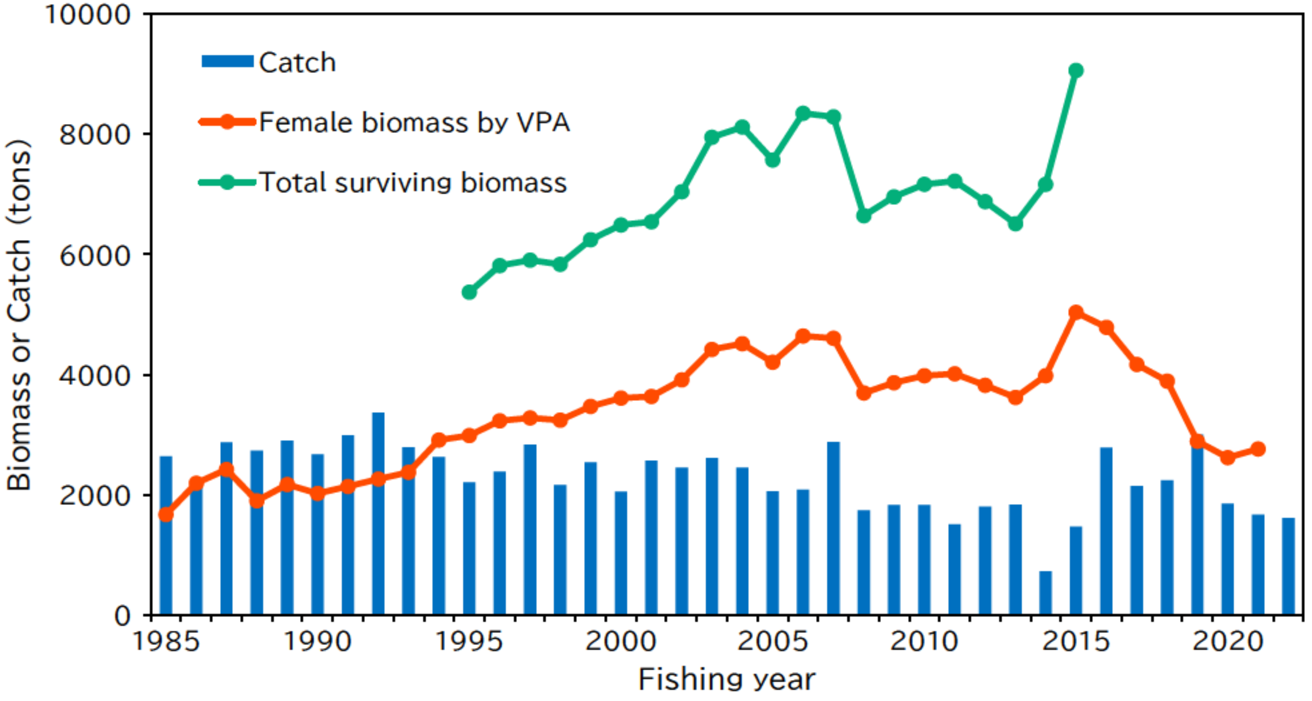
By = Biomass in year y as estimated based on VPA
Cy = Catch in year y
M = Natural mortality

Abundance index 1—Surviving Biomass (D)

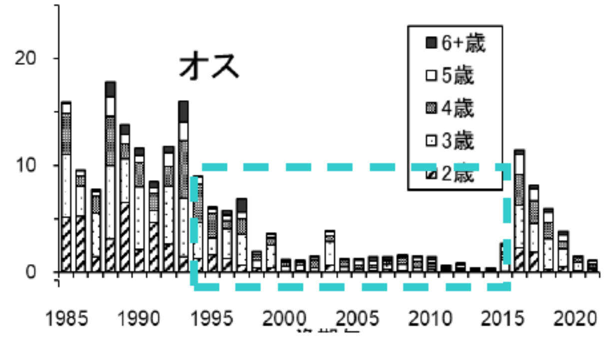
Conversion equation in this stock → $D_y = \left(B_{y-1} \cdot 1.8 \cdot e^{\left(-\frac{M}{2}\right)} - C_{y-1}\right) e^{\left(-\frac{M}{2}\right)}$

Biomass of females in this stock is estimated using the VPA, it is necessary to add the biomass of males to *By*.

Assumption:
Sex ratio (F:M) = 1:1
Body weight ratio (F:M)= 1:0.8
M = 0.25 (using in VPA)



CAA of males



Only data from the period when the number of males caught was small and stable compared to the number of females caught were used.

Abundance index 2—Standardized CPUE of offshore bottom trawl

Data

Logbook: Catch reports of Danish seine (by month / fishing area / ship)

*One representative fishing area is reported, even if the fishery operates in more than one area in a day.

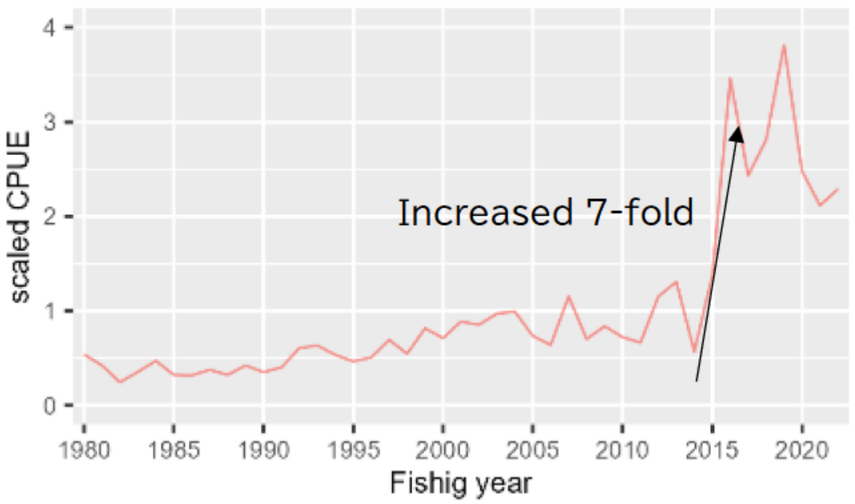
(Example)

Year	Month	Ship	Area	# of hauls	Walleye pollock	Arabesque greenling	Pacific cod	Pointhead flounder
1999	5	12	56	5	50	200	100	200
1999	5	10	45	3	1000	100	50	10
1999	6	11	55	10	100	50	100	500

Data available period

1980～2022 Fishing year (August～July of the following year)

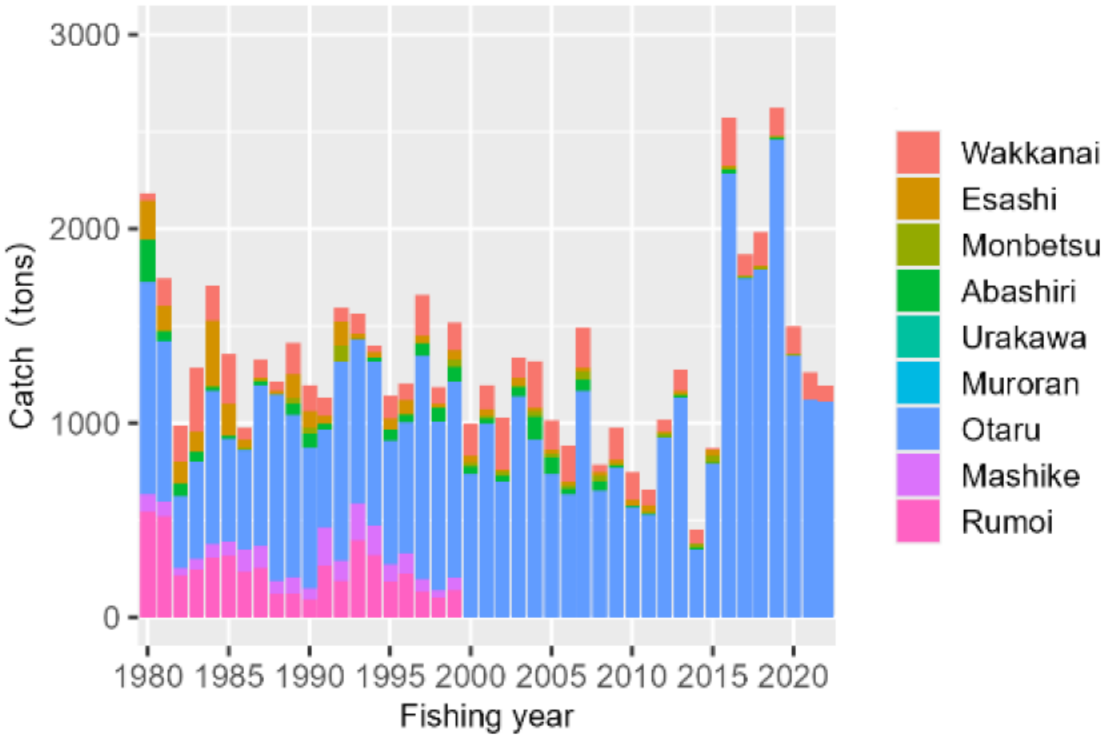
Annual trends of nominal CPUE



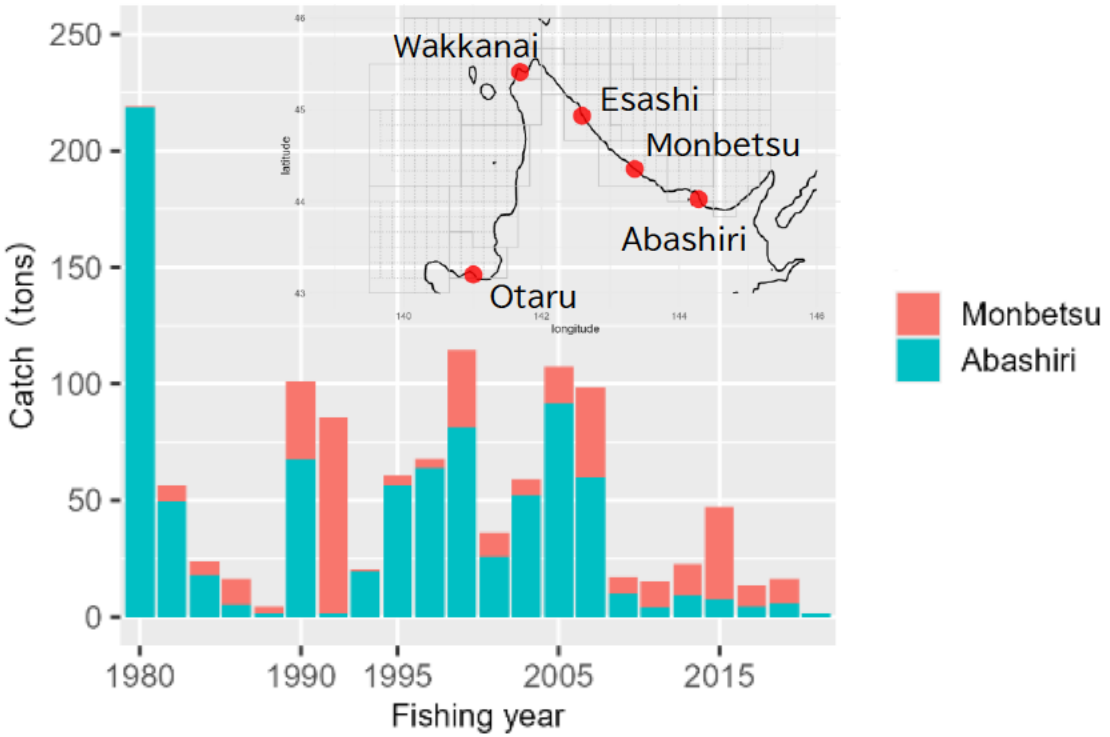
The CPUE increases 7-fold from 2014 to 2016, but there is a discrepancy with the fishermen's perception.

Data filtering by base port of operations

Catch by Base port



Monbetsu & Abashiri

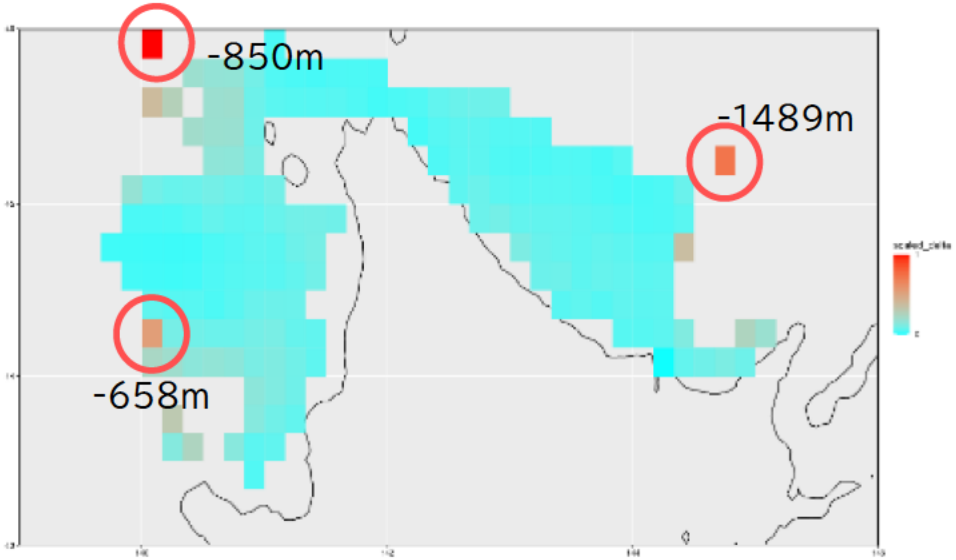


- The base ports still in operation today are Wakkanai, Esashi, Monbetsu, Abashiri, and Otaru
- In some years, catches were extremely low in Monbetsu & Abashiri, and it is thought that PF were dumped or landed as “Others”

→Only data with Wakkanai, Esashi, and Otaru as the base port were used

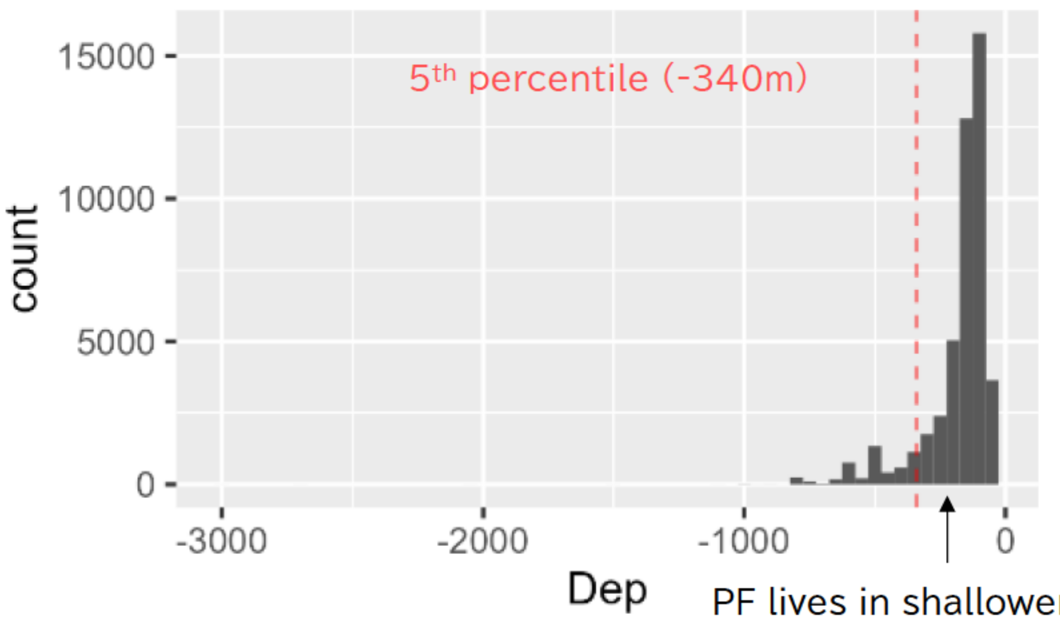
Data filtering by water depth

Geographical distribution of previous standardized CPUE



CPUEs are scaled with the maximum value set to 1

Histogram of none-zero catch operation depth

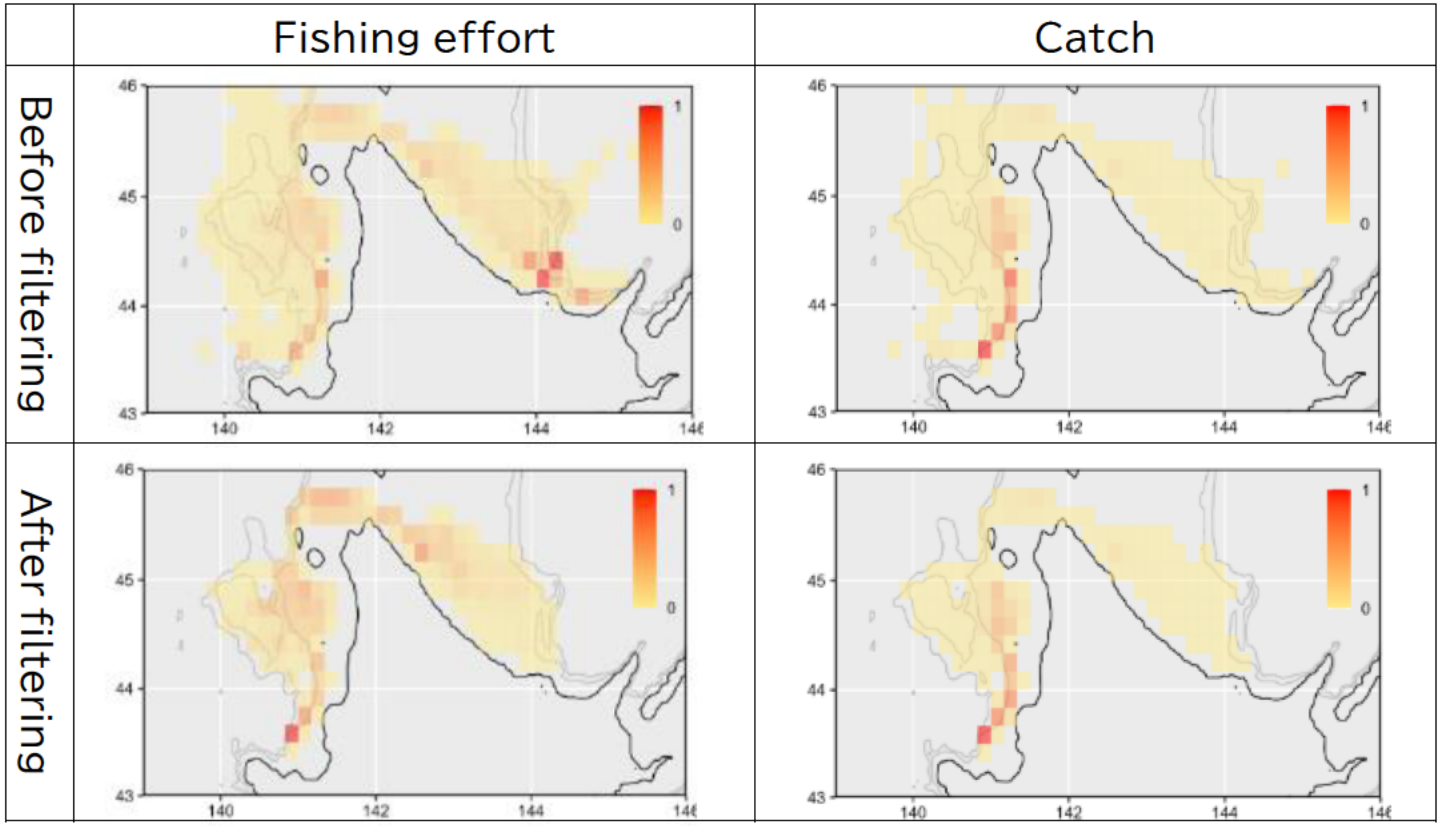


- Representative fishing area where target species such as pollock and greenling were caught is reported
- Fishing areas far from where the PF was actually caught are sometimes reported

→Data below the 5th percentile value of water depth (<-340m) are excluded

Before and After data filtering

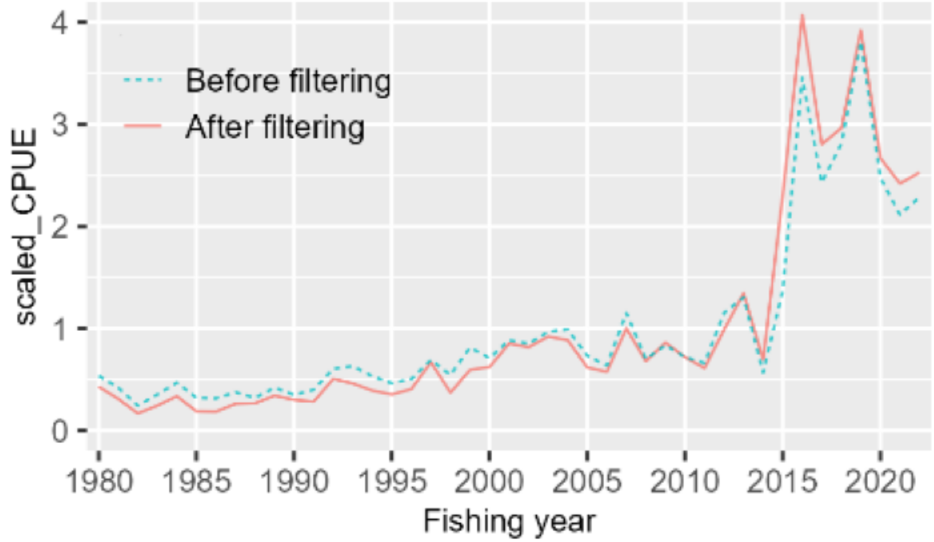
Geographical distribution of catch and fishing effort



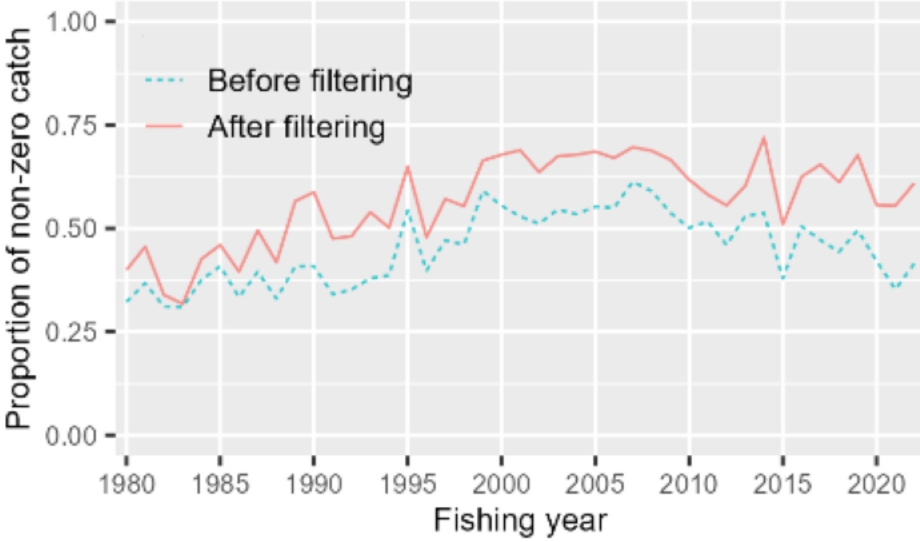
※ Isobaths 200m & 400m. Data are scaled with the maximum value set to 1.

Data was filtered down to 818,751 operations according to what is considered to be relevant for trends in PF stock in this area.

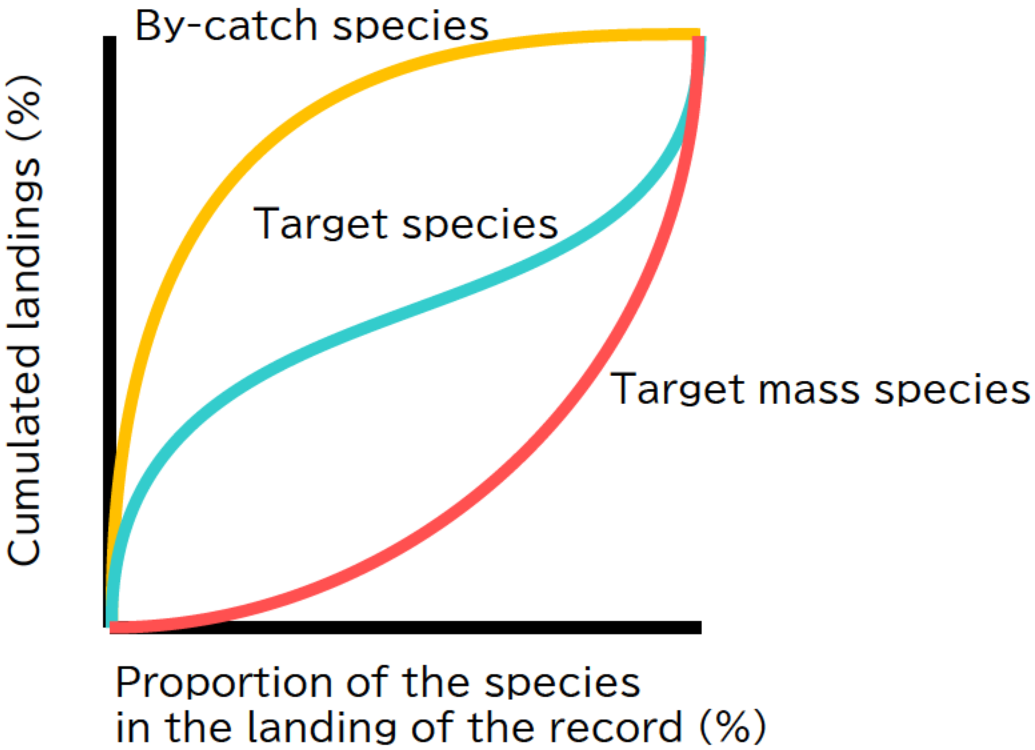
Nominal CPUE



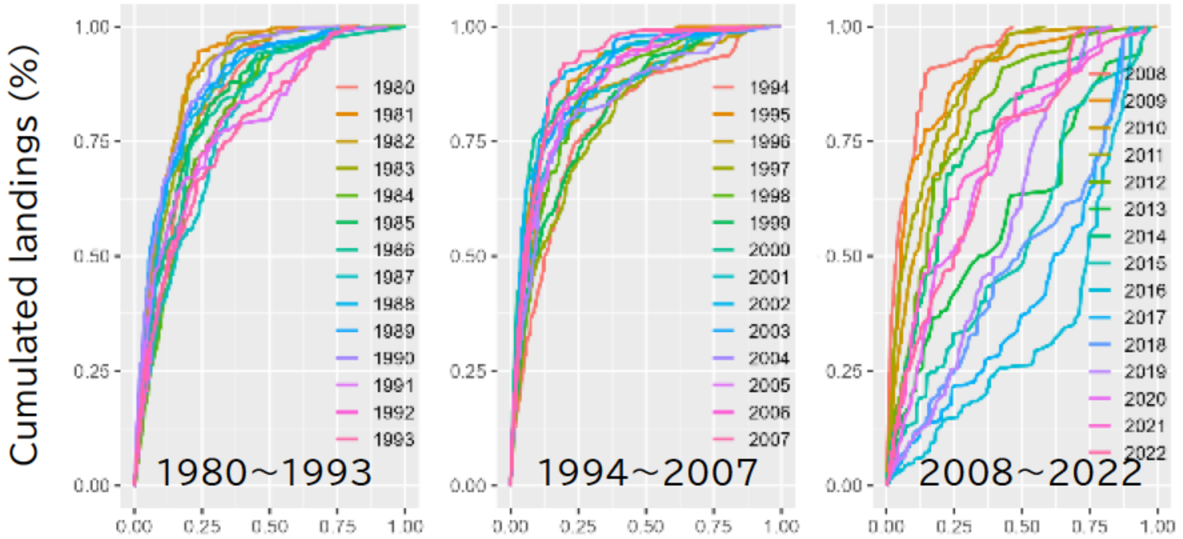
Proportion of none-zero catch



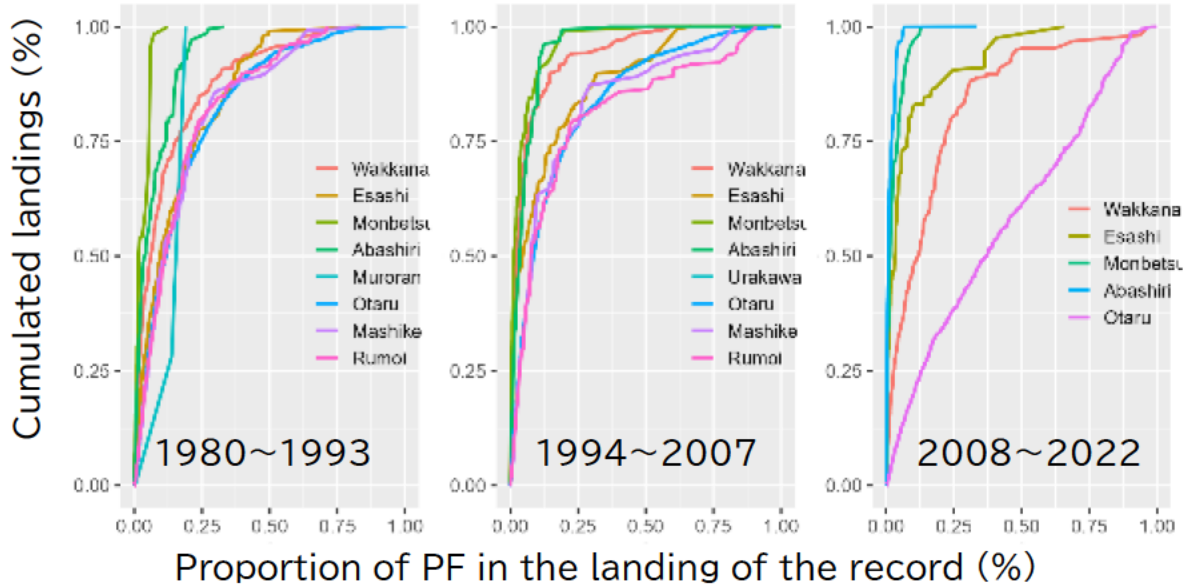
The cumulative relative landings curves (Biseau 1998)



By fishing year



By base port of operations



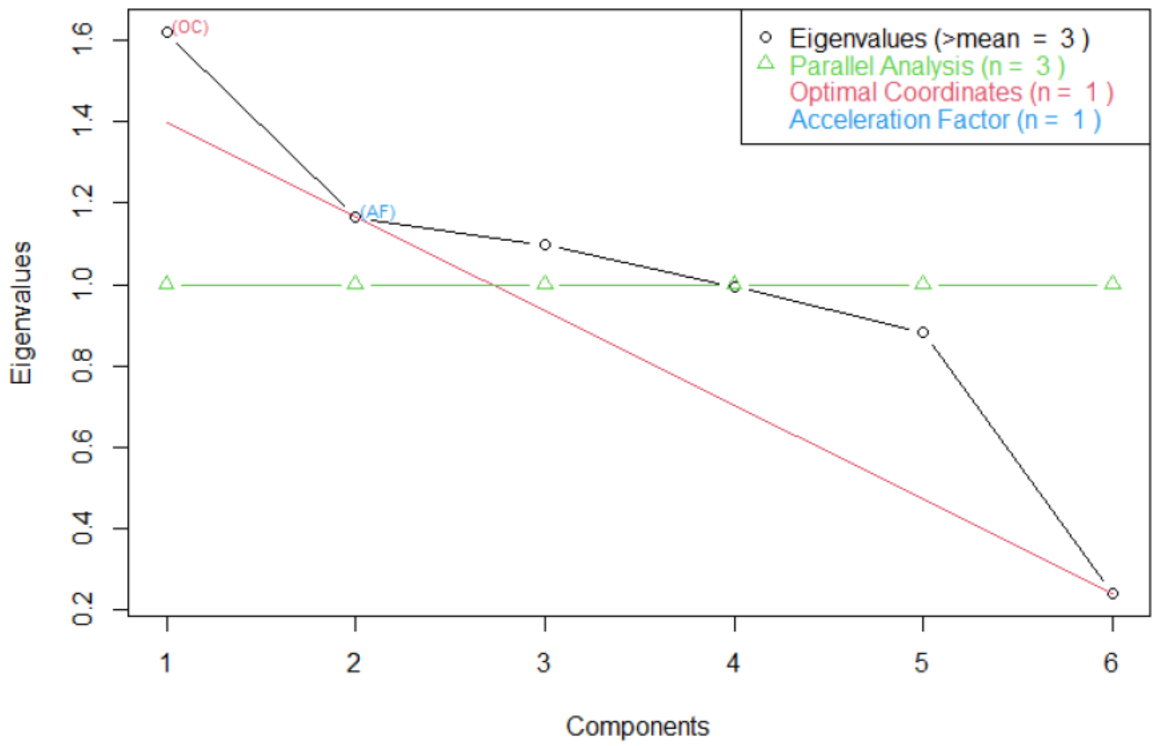
- Operational strategies changed since 2015 FY
- Particularly noticeable in base port of Otaru
- Interviews revealed that PF was targeted in Otaru

→Standardization is needed to take into account **Strategies** and **Base ports** of operations

Direct Principal Component (Winker et al. 2013)

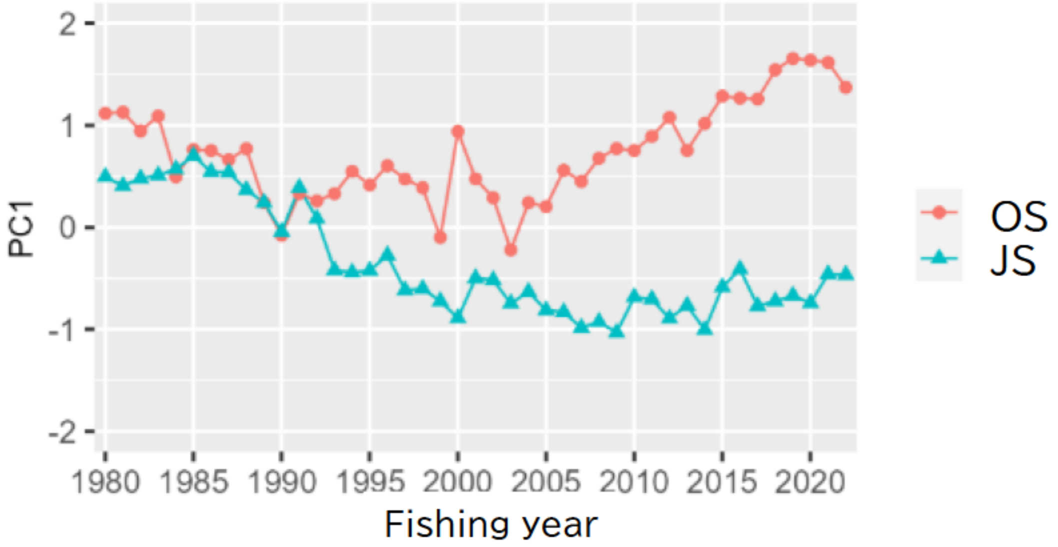
- A method for extracting principal component scores obtained by principal component analysis of catch composition data as explanatory variables for targeting
- Principal component analysis of square root transformed values of the proportion of each fish species in each record

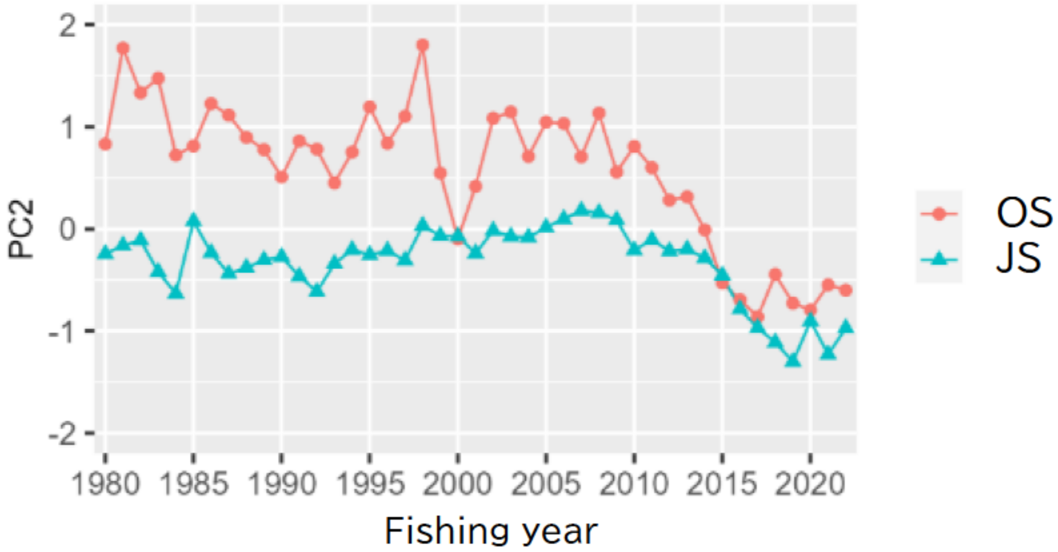
  ex.) Taiwanese Coastal dolphinfish (Chang et al. 2019)、Hawaiian Green job fish (Nadon et al. 2020)、Demersal fishes in American Samoa (Nadon et al. 2023)



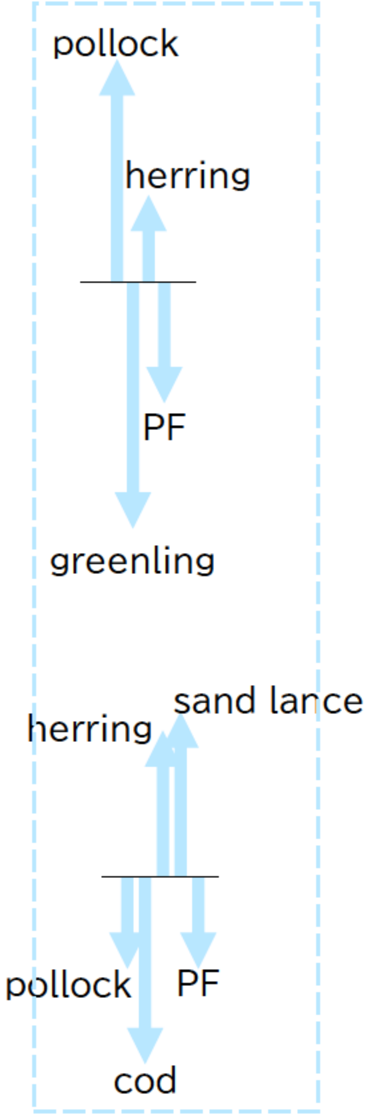
Annual trends of PC scores in Seas of Japan and Okhotsk

Trends of mean PC scores





Factor loadings



In OS, increased since the mid-2000s, reflecting an increase in operations targeting pollock

In JS, the 1992 and 1993 FYs saw large declines, reflecting a decrease in operations targeting pollock

In OS, decreased from 2014 FY, reflecting increased operations targeting pollock and cod

In JS, decreased since the 2015 FY, reflecting voluntary restrictions and poor catches of pollock and greenling, which led to operations targeting cod and PF

Statistical modeling

Data set	Logbook: Catch reports of Danish seine (by month / fishing area / ship) filtered by Base port & Depth (42,108 records, 818,751 operations)
Statistical Model	Generalized additive model (GAM)
Response variable	Catches of pointhead flounder per haul (kg/haul)
Explanatory variables	FY (43 cat: 1980-2022 FYs)
	Quarter (4 cat: Aug to Oct, Nov. to Jan., Feb. to Apr., May to Jul.)
	HP_class(11 cat: from 401 hp up to 1500 hp in 100 hp increments)
	Vessel_class(2 cat: below 100 tons、100 tons and over)
	Base port (3 cat: Wakkanai, Esashi, Otaru)
	PC1 (spline: -2.17 to 2.53)
	PC2 (spline: -2.93 to 5.09)
	LatLon(spline: 43.42 to 45.75、139.9 to 144.2)
	Depth (spline: -336 to -34)
	PDO (spline: -3.11 to 2.55)
	Base port : FY (129 cat.)
	Base port : Quarter (172 cat.)
Error distribution	Tweedie distribution
Link function	log
プログラム・パッケージ	R ver.4.3、mgcv ver.1.8-42

Model selection

Type-III Anovaによる検定

Parametric terms	df	F	p-value
FY	42	32.40	<0.01
Quarter	3	274.70	<0.01
HP_class	10	4.35	<0.01
Vessel_class	1	12.18	<0.01
Base port	2	31.85	<0.01
Base port:FY	84	17.08	<0.01
Base port:Quarter	6	69.00	<0.01

Approximate significance of smooth terms	edf	Ref.df	F	p-value
s(PDO)	8.75	8.98	20.17	<0.01
s(PC1)	18.36	18.93	839.61	<0.01
s(PC2)	18.50	18.95	411.24	<0.01
s(Dep)	7.71	8.49	14.55	<0.01
ti(Lat,Lon)	19.26	19.90	147.25	<0.01

All explanatory variables are significant

All possible regression of AIC (※FY、Quarter、PC1、PC2、LatLon are fixed)

Model	excluded variables	df	Loglikelihood	AIC	δAIC
1	not excluded	225	-133124.84	266700.21	0
2	Vessel_class	224	-133130.47	266709.53	9.32
3	HP_class	215	-133147.40	266725.33	25.12
4	Vessel & HP class	214	-133155.74	266740.07	39.85

Models without Vessel and/or HP class are relatively low AIC values

Evaluating estimator performance of adobe four models and last year model (excluded HP_class and Depth) is tested by 5-fold CV

Model selection

Data sets of 5-fold CV

sub sets	No. of data	Scenario					
		Base case	I	II	III	IV	V
1	8,409	Train	Test	Train	Train	Train	Train
2	8,404	Train	Train	Test	Train	Train	Train
3	8,504	Train	Train	Train	Test	Train	Train
4	8,444	Train	Train	Train	Train	Test	Train
5	8,347	Train	Train	Train	Train	Train	Test

Root mean squared error (RMSE)

Model	Scenario					mean
	I	II	III	IV	V	
1. not excluded	306.91	222.34	295.85	270.69	255.31	270.22
2. Vessel excluded	306.85	222.22	295.84	270.52	256.00	270.28
3. HP excluded	307.44	224.56	298.19	271.95	256.33	271.69
4. V & H excluded	307.37	224.14	297.94	271.81	257.13	271.68
5. H & Dep excluded	306.59	229.43	298.36	272.55	259.88	273.35

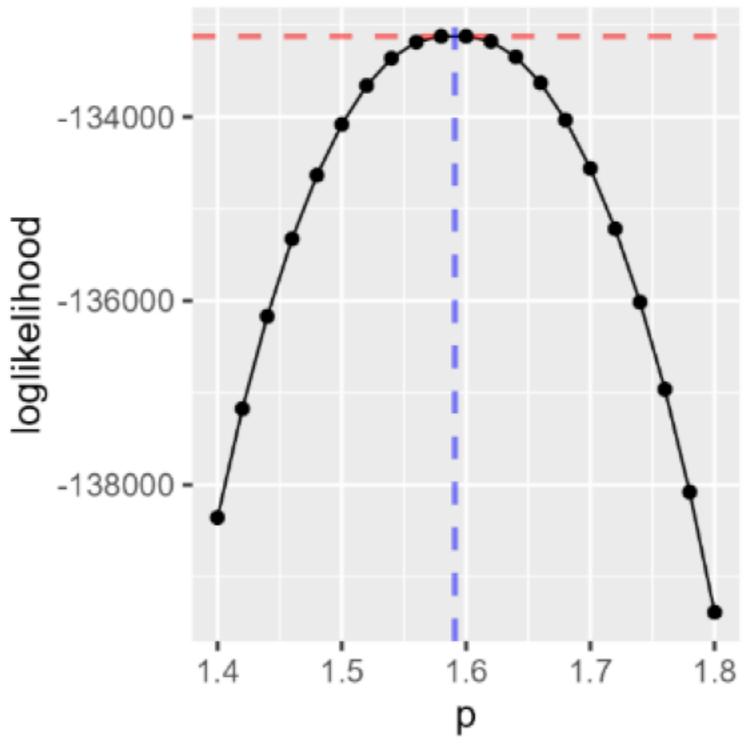
Model 1 with all explanatory variables was selected by AIC and 5-fold CV, albeit by a small margin

Final model

Caluclated by *R* with *mgcv* package

```
Model_1<-bam(CPUE~FY
         +Quarter
         +HP_class
         +Vessel_class
         +s(PDO, bs="cr")
         +s(PC1, bs="cr", k=20)
         +s(PC2, bs="cr", k=20)
         +s(Dep, bs="cr")
         +ti(Lat, Lon, bs="tp", k=c(8,4))
         +Base port
         +Base port : FY
         +Base port : Quarter
         , data=data
         , family=tw(link="log", a=1.1, b=1.9)
         , na.action="na.fail"
         , method="fREML")
```

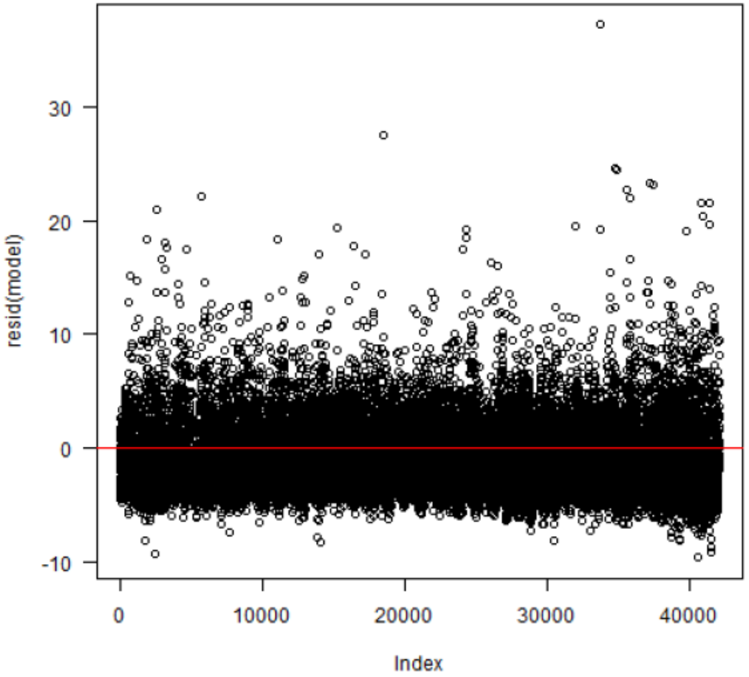
Estimated power parameter



The value of power parameter (p) corresponding to the maximum likelihood estimates was approximately estimated at 1.591

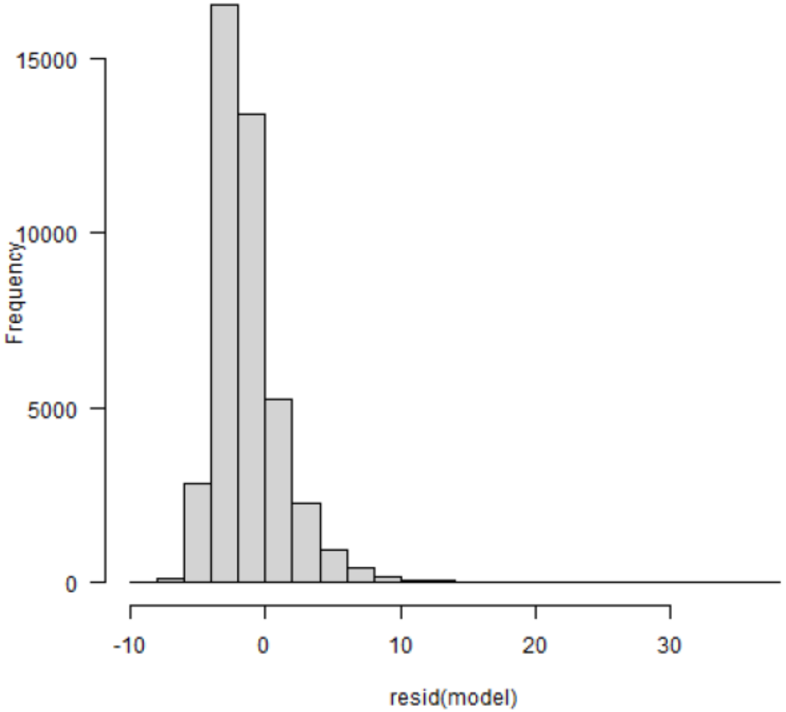
Residuals

Residuals plot



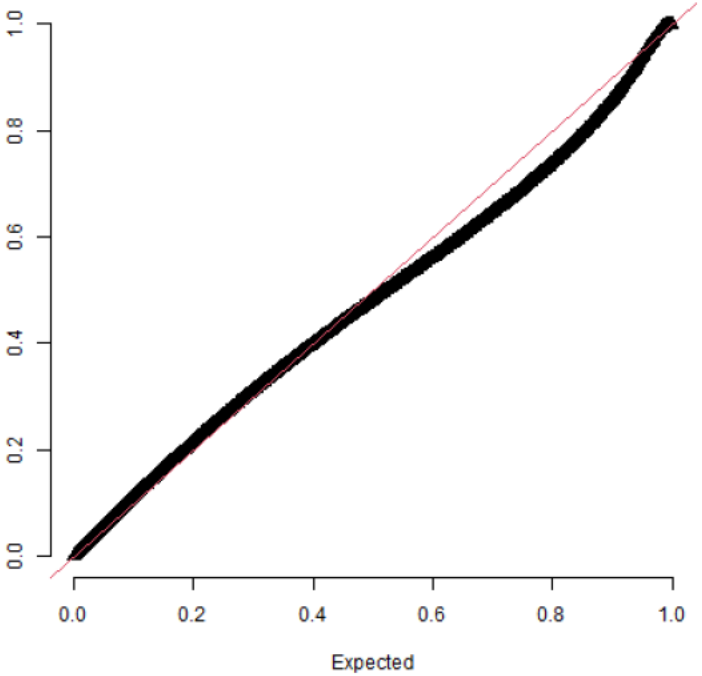
The residual plots appear to be unbiased

Residuals histogram



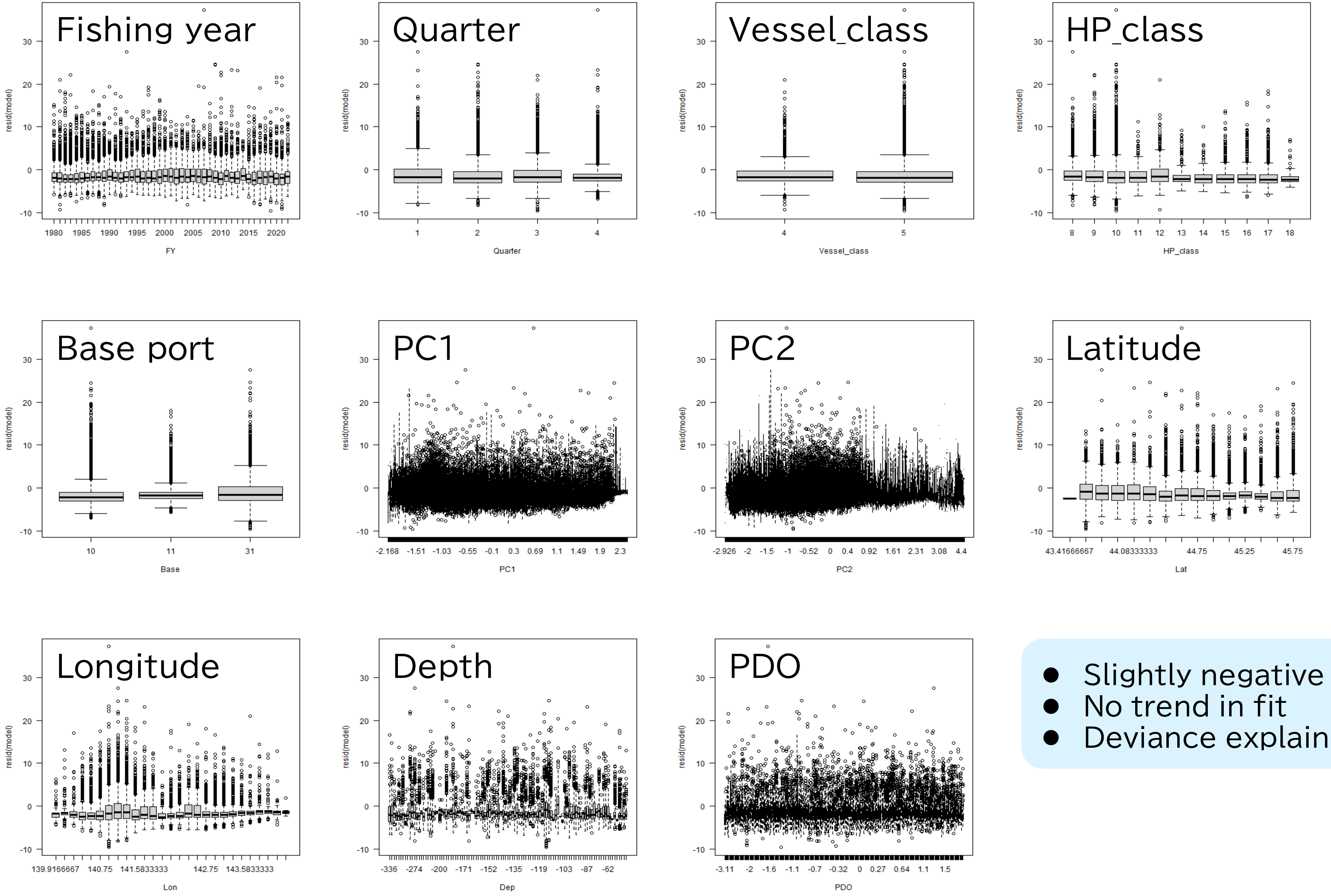
Histogram is biased negative, but this is due to the fact that predictions for zero-catch data may be positive

QQ-plot



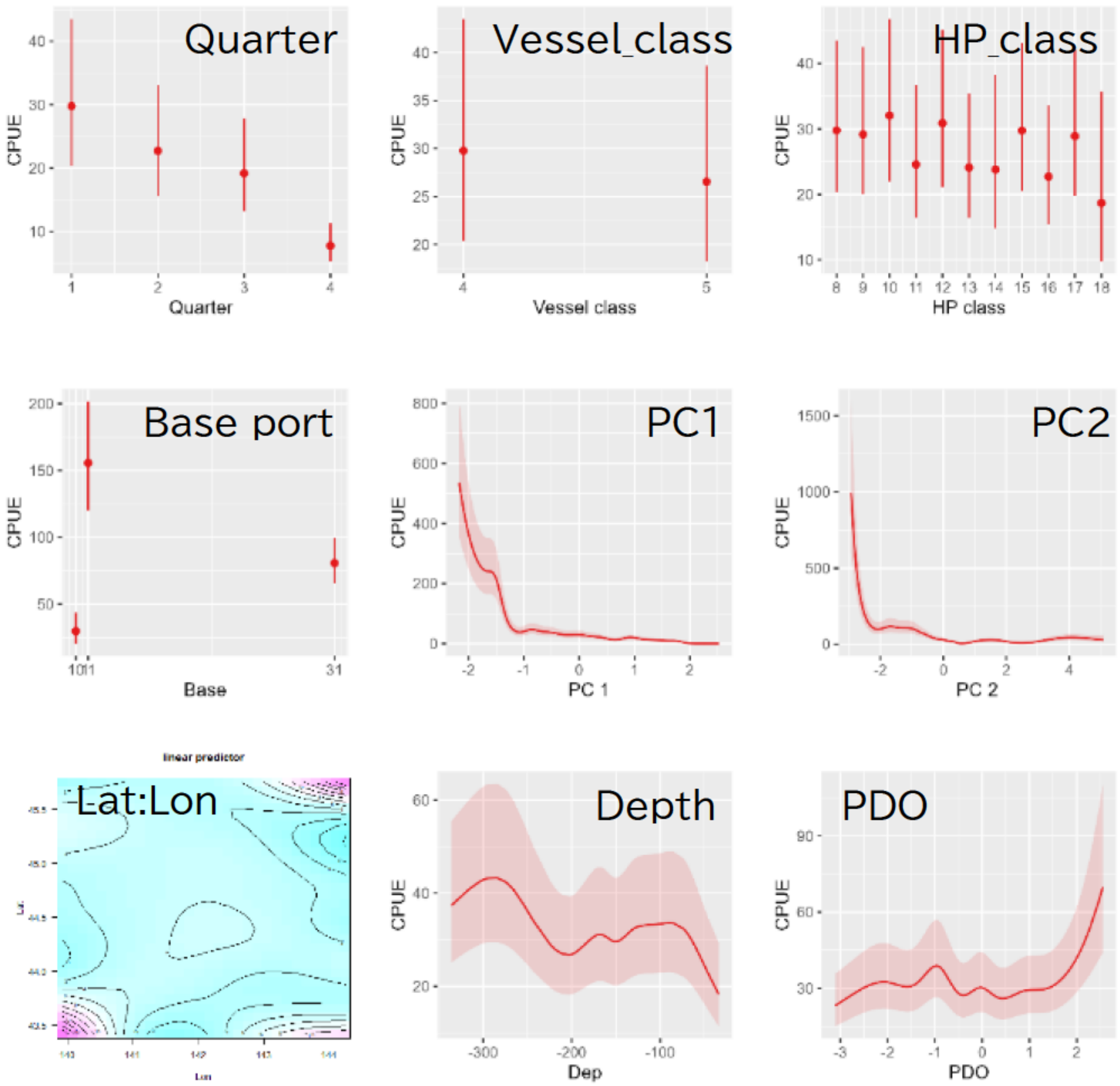
No problematic deviations in the distribution of observed and predicted values

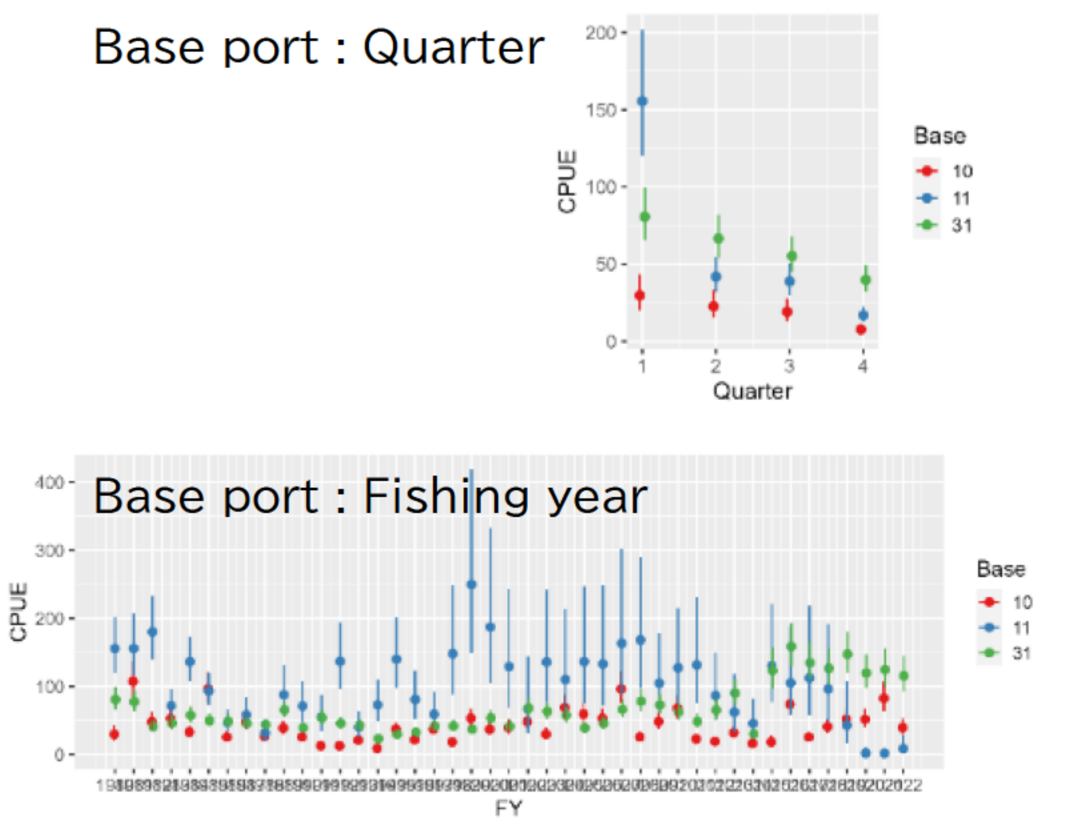
Residual plots



- Slightly negative bias
- No trend in fit
- Deviance explained =69.5%

Effect plots





- Effects of variables were extracted
- No noticeable difference from last year

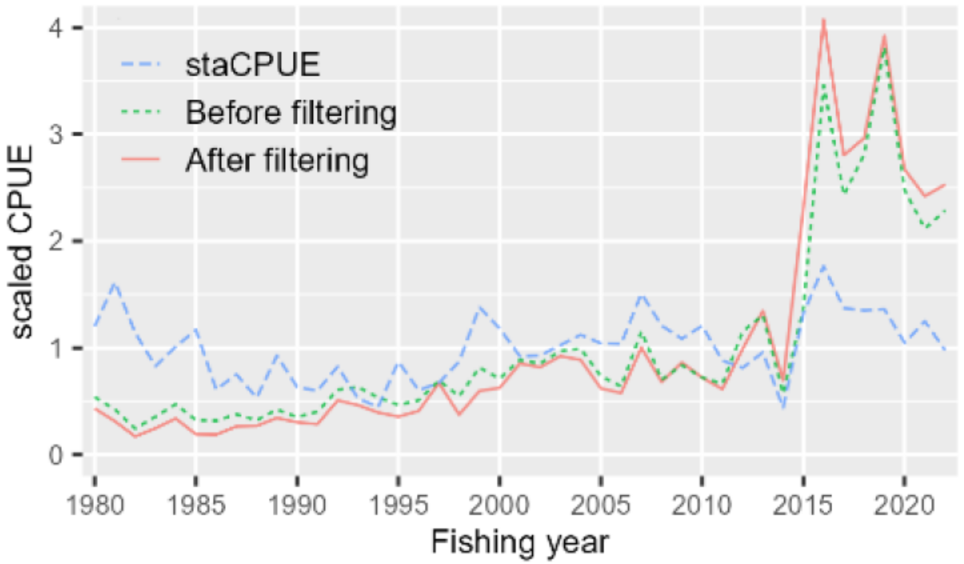
Calculation of standardized CPUE

Combination calculation
- Fishing year: 43 combinations
- Quarter: 4 combinations
- Vessel_class: 2 combinations
- HP_class: 11 combinations
- Base port: 3 combinations
- PC1: Remove top and bottom 1% tiles and divide into 6 equal parts
- PC2: Remove top and bottom 1% tiles and divide into 6 equal parts
- PDO: Divide into 6 equal parts
- Lat·Lon·Dep: 131 combinations (operated fishing area)

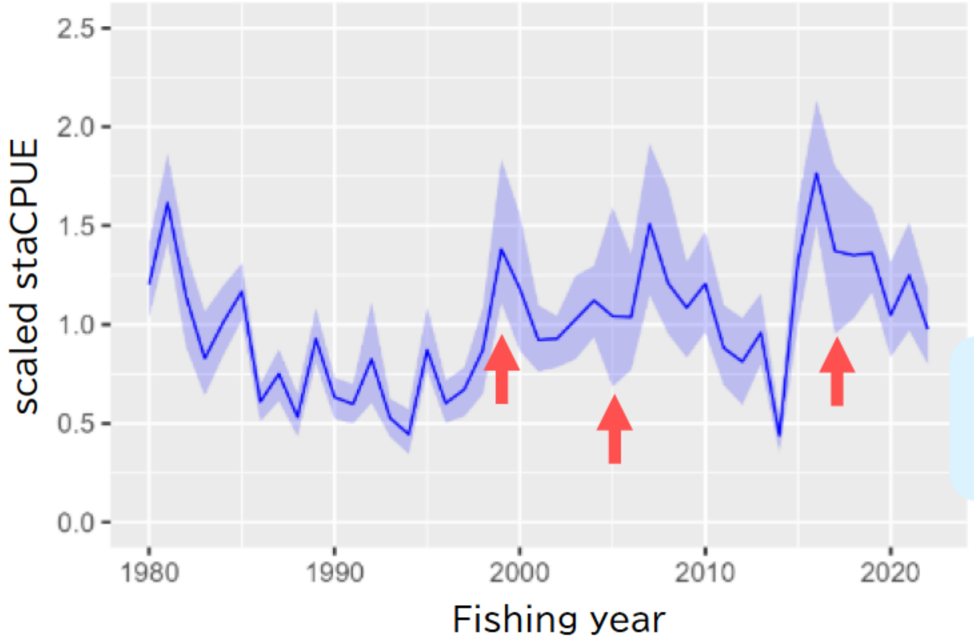
Total 321,216,192 combinations (grids)

Calculation of estimated values and aggregation of annual trends
- Estimate CPUE for each grid from model
- Calculate annual trend by averaging by fishing year

Estimate confidence intervals
- Bootstrapping with 100 data re-samplings



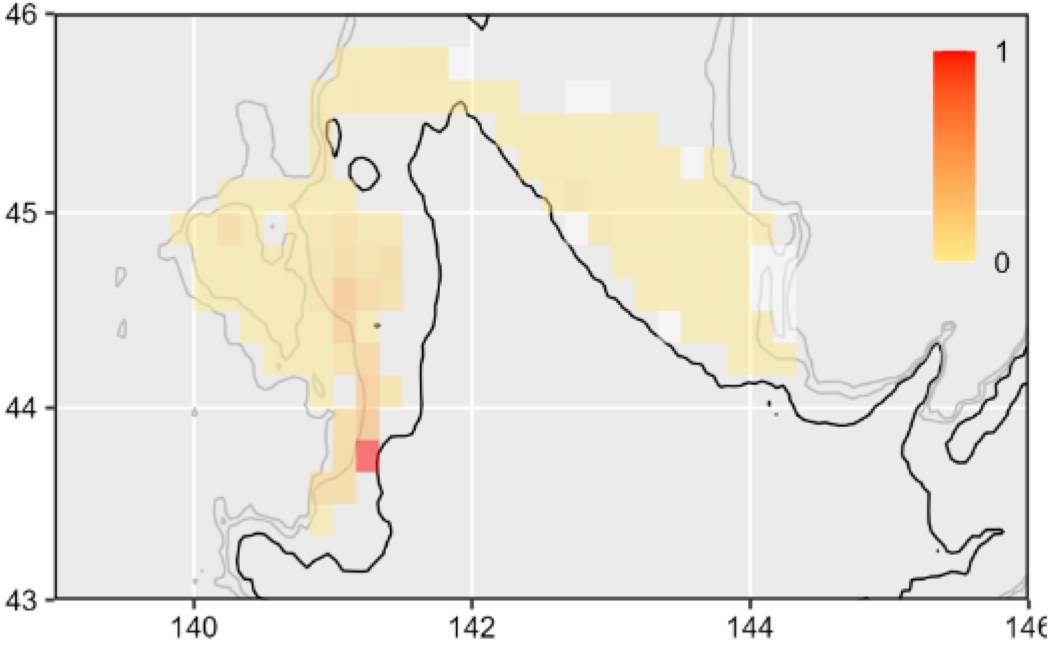
The CPUE spike after 2015 was reduced and the CPUE for older periods was raised



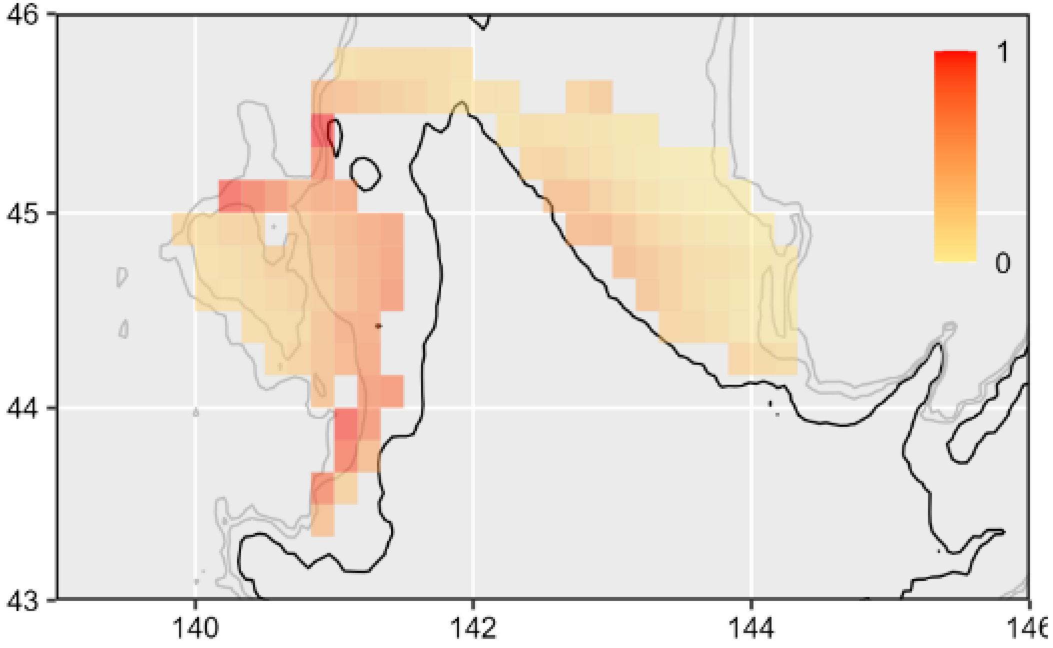
90% CI expanded around 1999, 2005, and 2017 FYs

Geographical distribution of CPUE

Nominal CPUE after filtering



Standardized CPUE

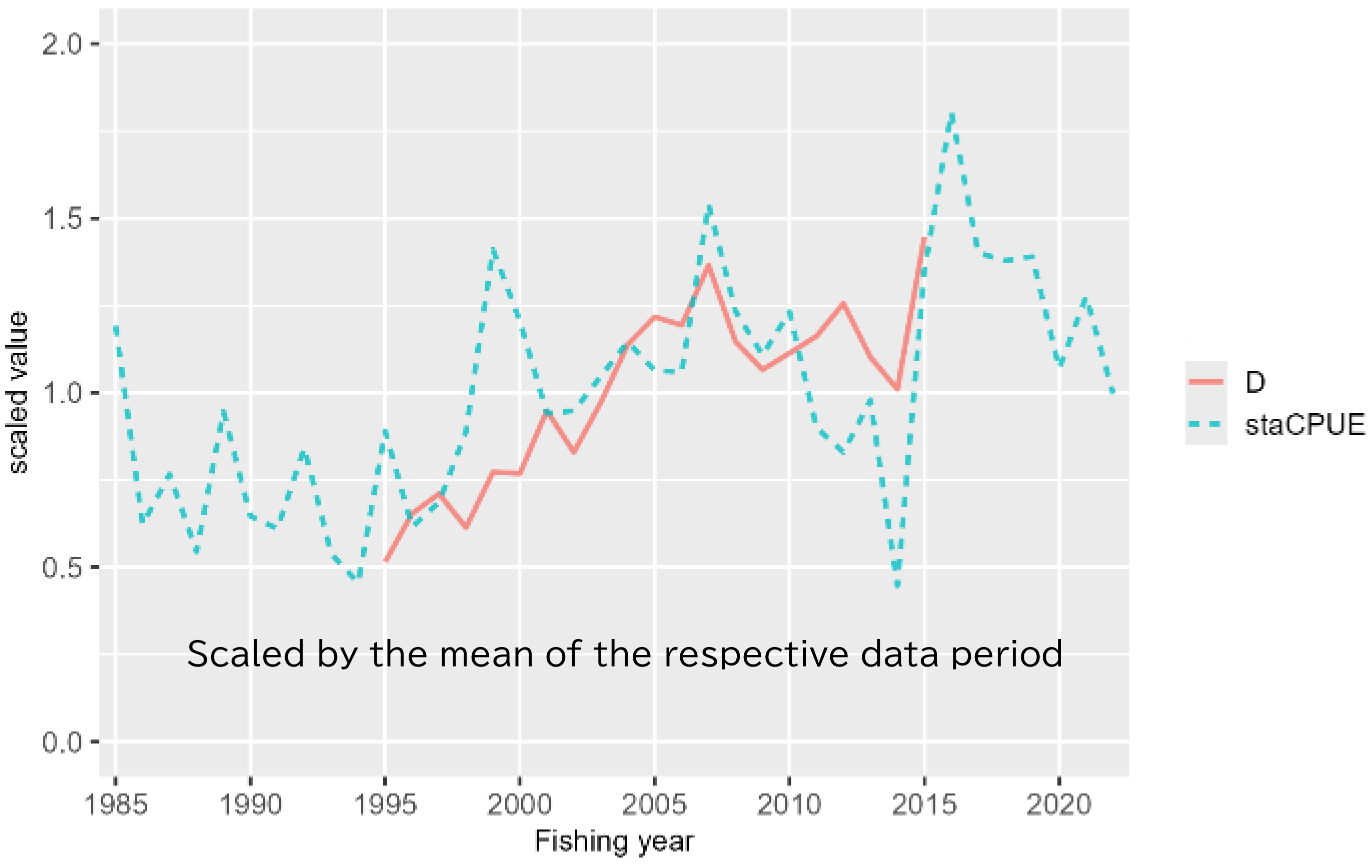


High CPUE is distributed in an area along the Sea of Japan

High CPUE around 200m depth in the Sea of Japan, consistent with ecological characteristics

Bias due to heterogeneity in effort corrected

Comparison of the annual trends of the two index values



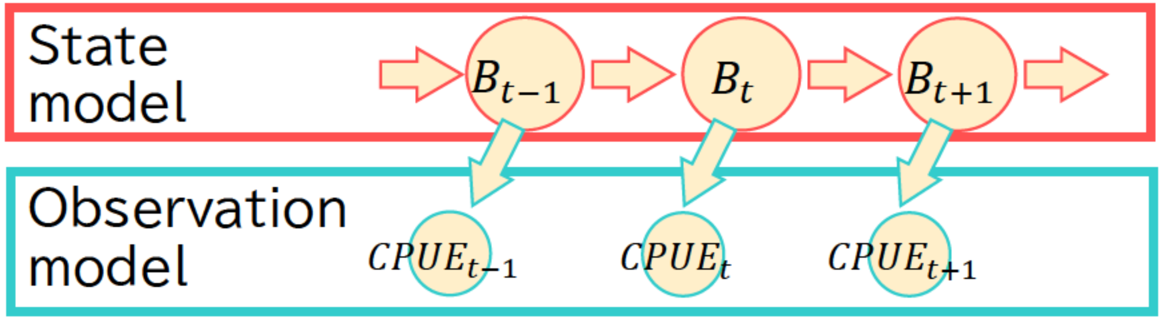
Trends are generally consistent.
The fact that the trends of the two index values from different data sources are so consistent suggests a high possibility that they are reproducing the actual biomass trend.

These index values were used as input values for SPiCT

SPiCT (Pedersen & Berg 2016)

Pella-Tomlinson state-space surplus production model

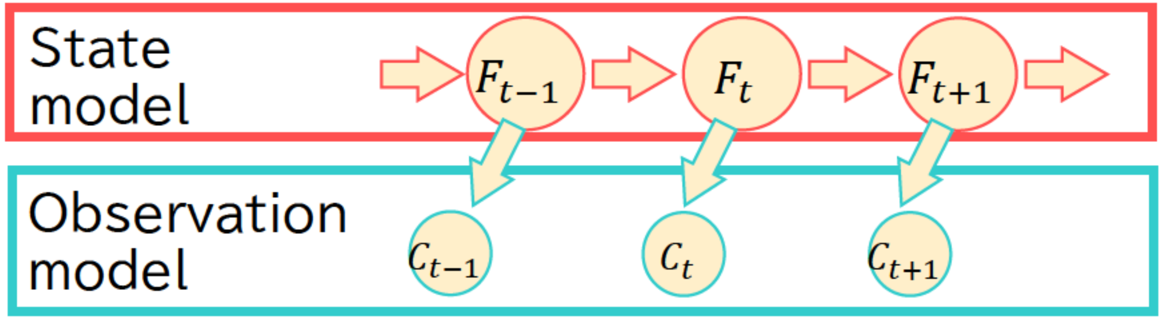
Biomass



$$dB_t = \frac{r}{n-1} B_t \left(1 - \left[\frac{B_t}{K}\right]^{n-1}\right) dt - F_t B_t dt + \sigma_B B_t dW_t$$

$$\log(I_{t,i}) = \log(q_i B_t) + e_{t,i}$$
$$e_{t,i} \sim N(0, \sigma_{I,i}^2)$$

Fishing mortality: Ft∗Bt=Ct



Time step

$$F_t = S_t G_t$$
$$d\log G_t = \sigma_F dV_t$$

$$\log(C_t) = \log\left(\int_t^{t+\Delta} F_s B_s ds\right) + \epsilon_t$$
$$\epsilon_t \sim N(0, \sigma_C^2)$$

$$r = m\left(\frac{K}{n^{(n/(n-1))}}\right)^{-1}$$

Estimation parameter: $n, m, K, q_i, B_t, F_t, \sigma_B, \sigma_{Ii}, \sigma_F, bkfrac$

Parameter estimation in SPiCT is conducted by maximum likelihood method by using template model builder. When assuming prior distributions on parameters, penalized maximum likelihood method is used (by multiplying the prior distributions to the total likelihood distribution)

Input data and Assumptions for candidate models

	Model 1	Model 2	
Input data			
Catch (Total landings)	1985-2022 FYs, annual	1985-2022 FYs, annual	
Index 1 (Surviving biomass)	1995-2015 FYs, annual	1995-2015 FYs, annual	
Index 2 (Standardized CPUE)	1985-2022 FYs, annual	1985-2022 FYs, annual	
Priors			
n (Shape of the production curve)	2.0 (sd=1.0)	2.0 (sd=0.5)	Schaefer prior
r (Intrinsic population growth rate)	0.32 (sd=1.0)	0.32 (sd=0.5)	FishLife
σC (Observation error of catch, standard deviation)	0.01 (sd=0.001)	0.01 (sd=0.001)	Considering the amount of dumping
σI1 (Observation error of Surviving biomass, standard deviation)	0.15 (sd=0.5)	0.15 (sd=0.5)	Considered in assessment in 2022
q1 (Catchability for surviving biomass)	1.0 (sd=0.3)	1.0 (sd=0.3)	Considered in assessment in 2022

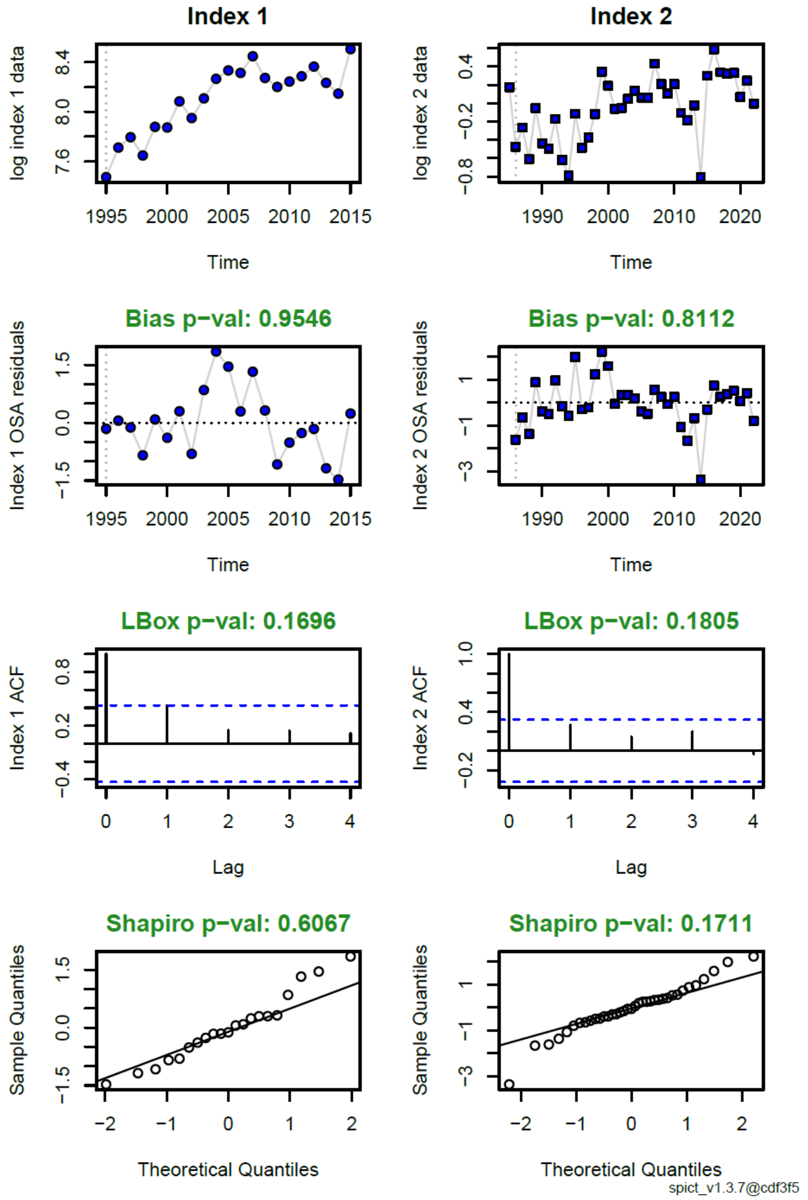
The values of $q_2, \sigma_{I2}, \sigma_B\ \sigma_F, bkfrac$ were estimated without any priors

Model diagnosis

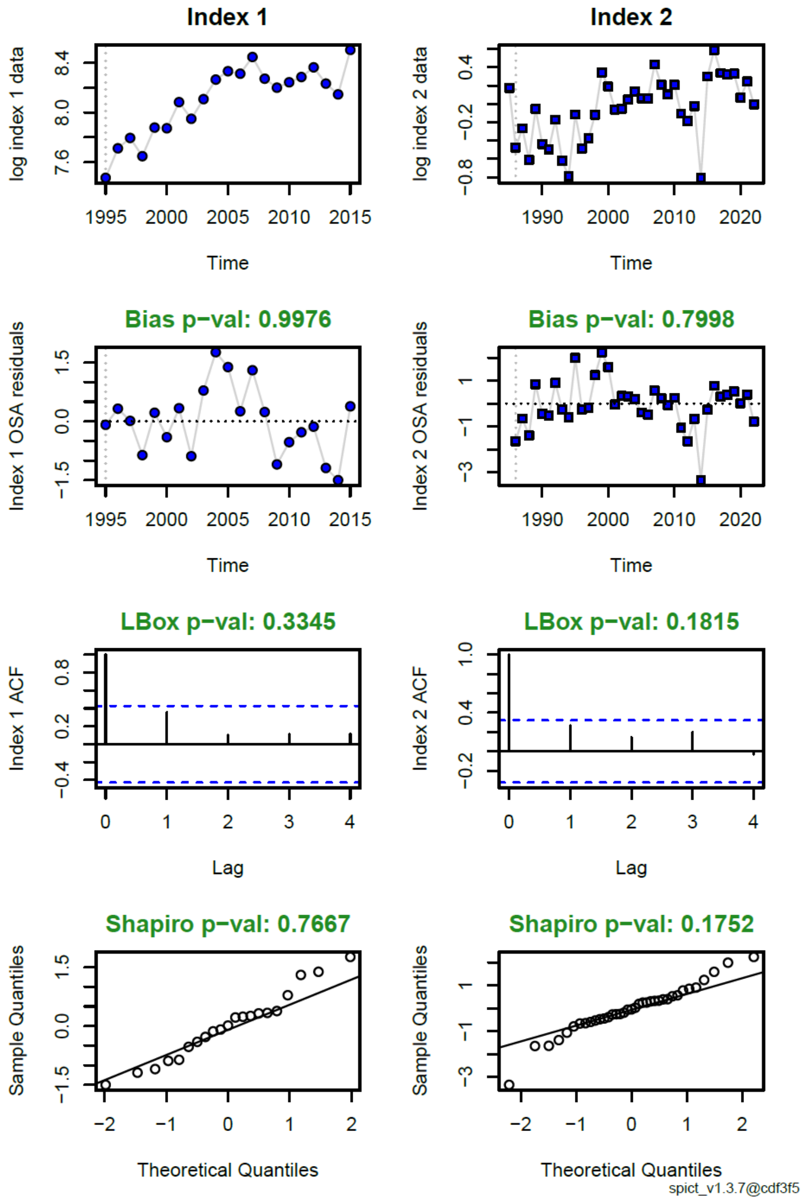
	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis			Residuals fit a normal distribution
④Retrospective analysis			
⑤Assessment uncertainty			Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis			Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis			Initial value influence
⑧Prior - posterior distributions			Dependance on priors

③Residuals

Model 1



Model 2

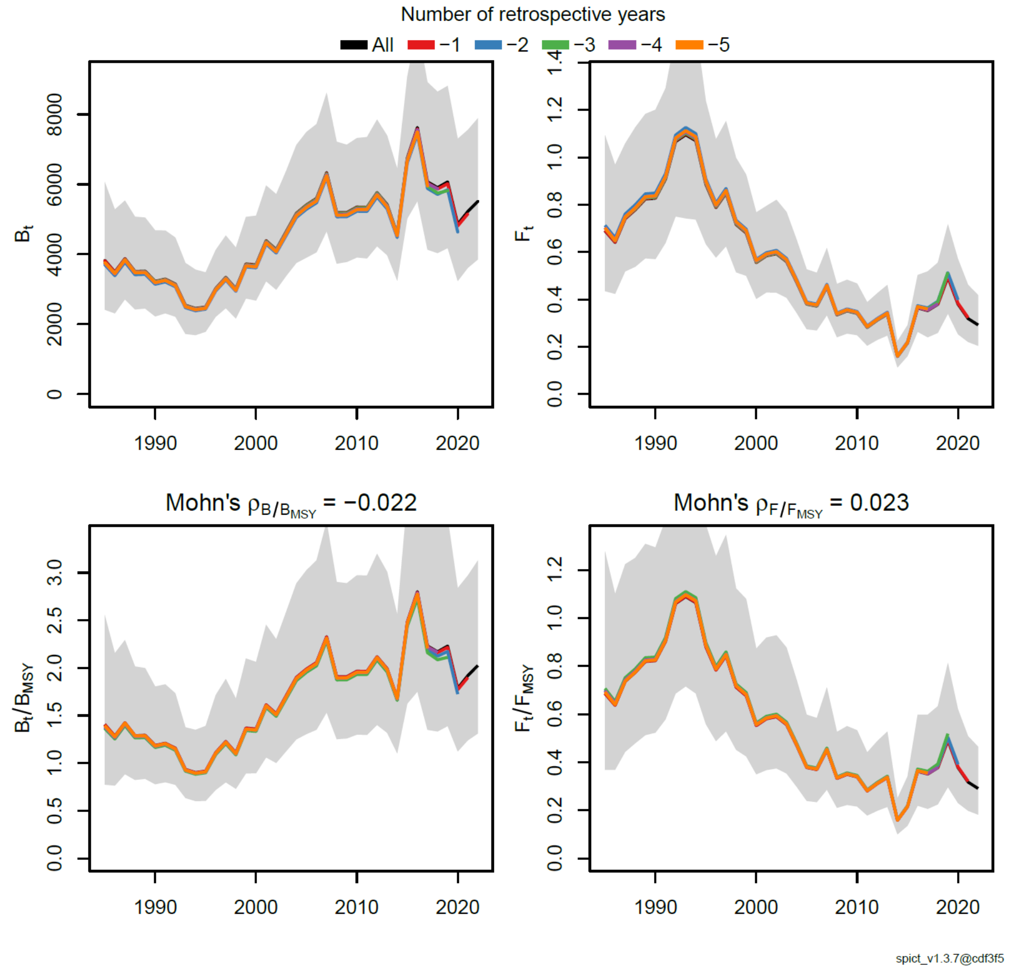


Model diagnosis

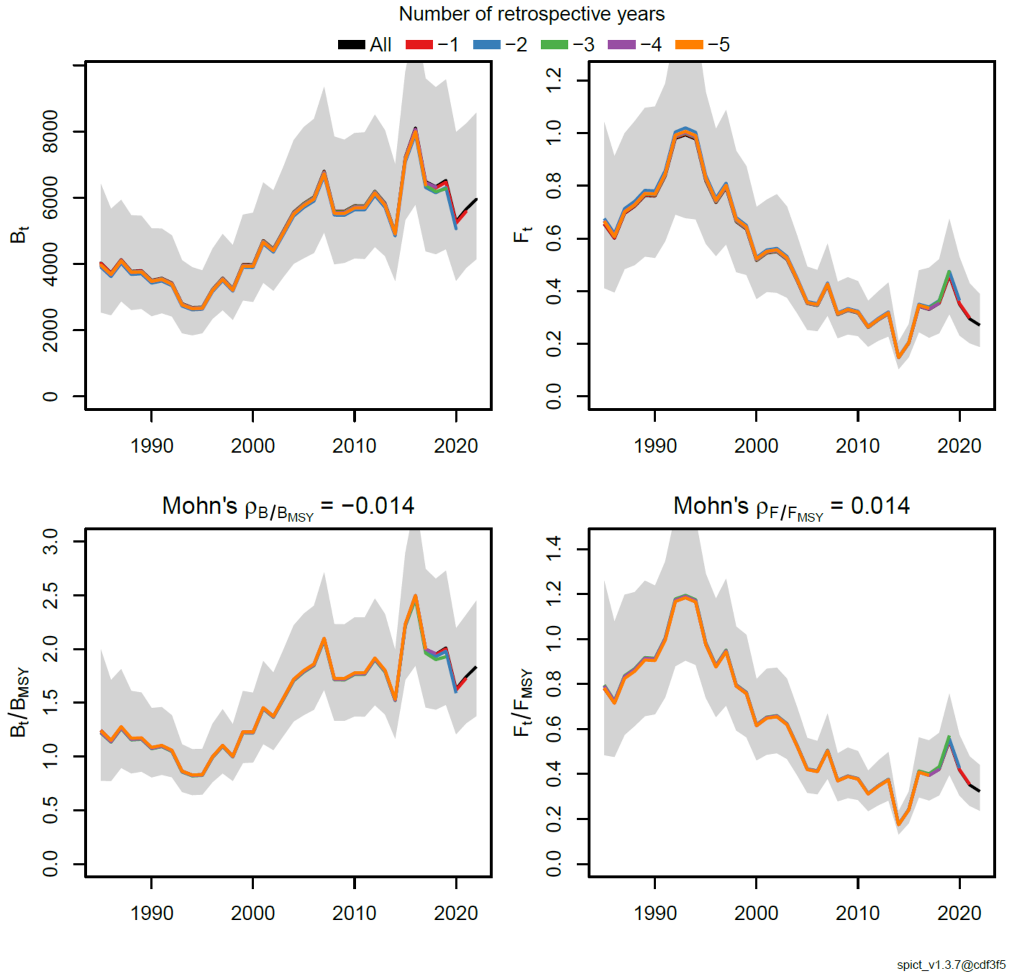
	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis			
⑤Assessment uncertainty			Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis			Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis			Initial value influence
⑧Prior - posterior distributions			Dependance on priors

④Retroactive analysis

Model 1



Model 2



Model diagnosis

	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis	OK	OK	
⑤Assessment uncertainty			Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis			Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis			Initial value influence
⑧Prior - posterior distributions			Dependance on priors

⑤Assessment uncertainty

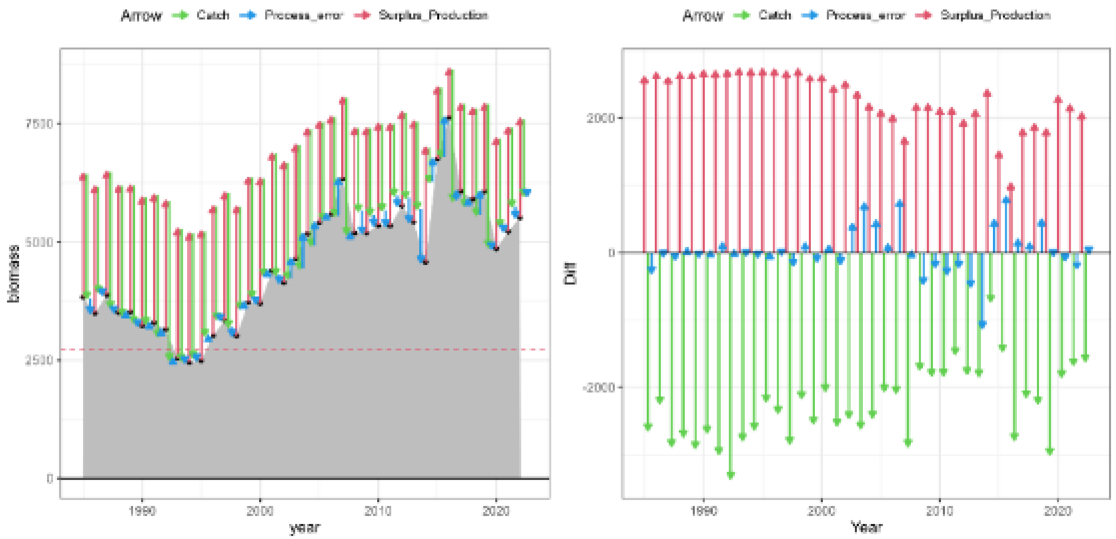
	Model1			Model2		
	lower 5%	Estimates	Upper 5%	Lower 5%	Estimates	Upper 5%
r	0.33	0.66	1.31	0.44	0.72	1.19
K	6,900	9,300	12,600	7,300	9,500	12,500
$ln(q_1)$	-0.57	-0.32	-0.07	-0.66	-0.39	-0.13
$ln(q_2)$	-8.70	-8.44	-8.17	-8.79	-8.51	-8.24
n	0.26	0.65	1.61	0.49	0.86	1.50
σ_B	0.07	0.10	0.13	0.07	0.09	0.13
σ_F	0.17	0.22	0.28	0.18	0.22	0.28
$\sigma_{I,1}$	0.04	0.06	0.11	0.04	0.06	0.11
$\sigma_{I,2}$	0.21	0.26	0.32	0.21	0.26	0.32
MSY	2,600	2,700	2,900	2,600	2,700	2,900
$Bmsy$	1,700	2,700	4,300	2,300	3,200	4,600
$B2022$	4,100	5,500	7,500	4,400	6,000	8,100
$B2022/B_{msy}$	1.41	2.03	2.92	1.44	1.84	2.34
$Fmsy$	0.62	1.00	1.63	0.58	0.84	1.21
$F2022$	0.22	0.29	0.39	0.20	0.27	0.37
$F2022/F_{msy}$	0.20	0.29	0.43	0.25	0.32	0.42

Model diagnosis

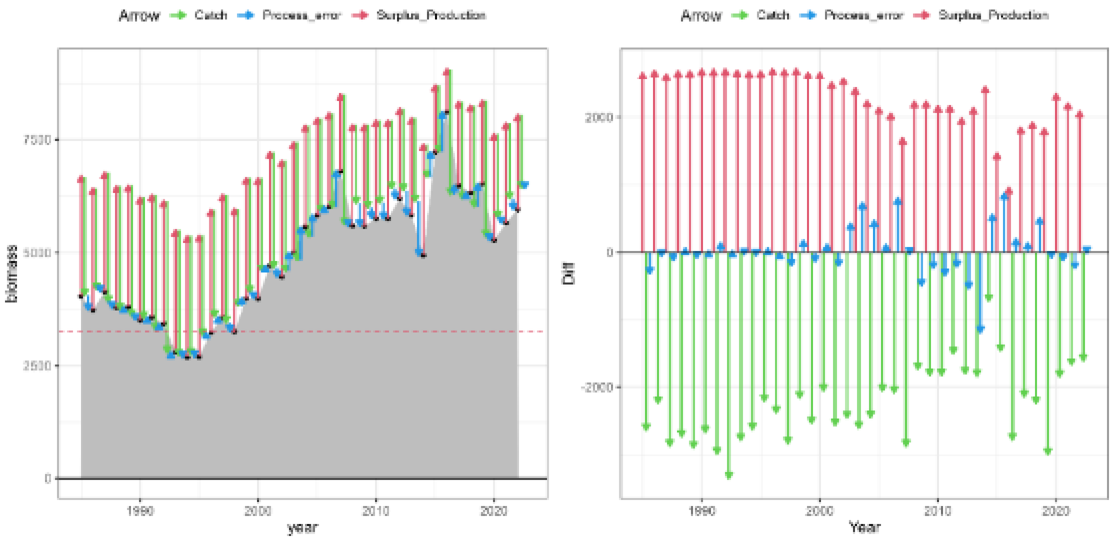
	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis	OK	OK	
⑤Assessment uncertainty	OK	OK	Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis			Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis			Initial value influence
⑧Prior - posterior distributions			Dependance on priors

⑥Factor analysis

Model 1



Model 2



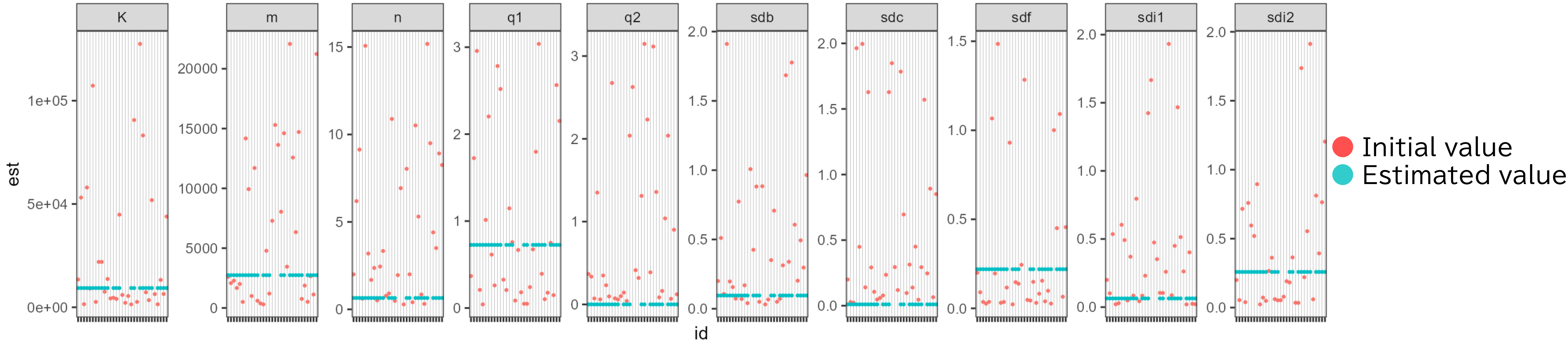
Most of the stock variability was explained by surplus production (red arrow) and catch (green arrow), while the variability explained by process error (blue arrow) is small (σ_B =0.09～0.10)

Model diagnosis

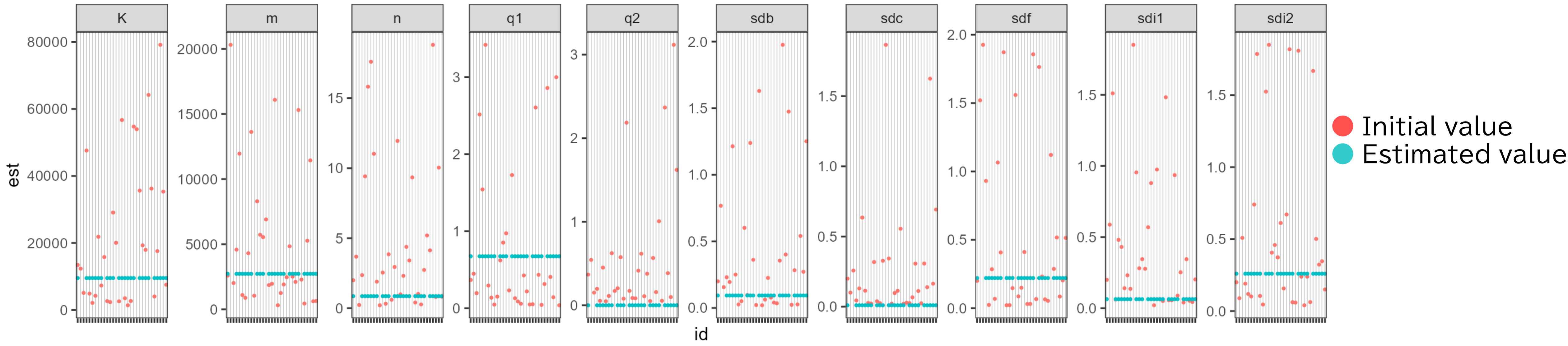
	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis	OK	OK	
⑤Assessment uncertainty	OK	OK	Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis	OK	OK	Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis			Initial value influence
⑧Prior - posterior distributions			Dependance on priors

⑦Jitter analysis

Model 1



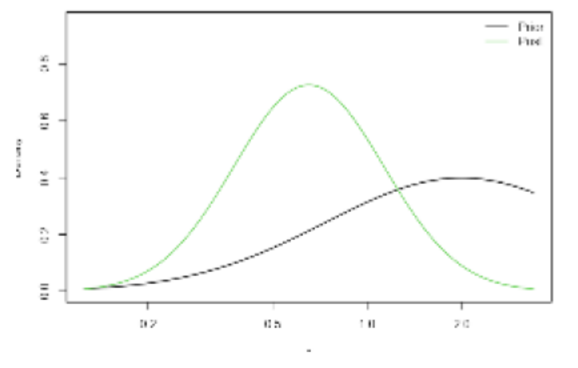
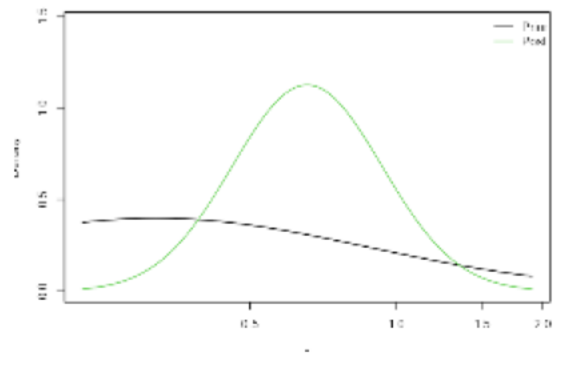
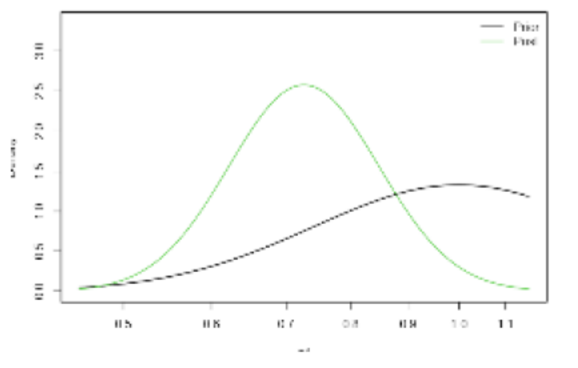
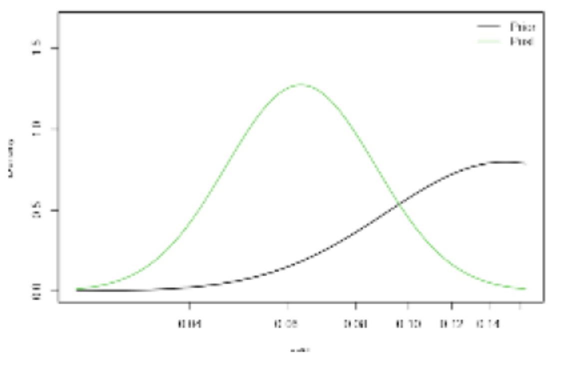
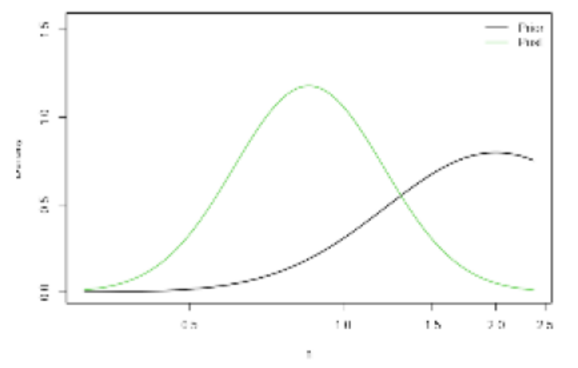
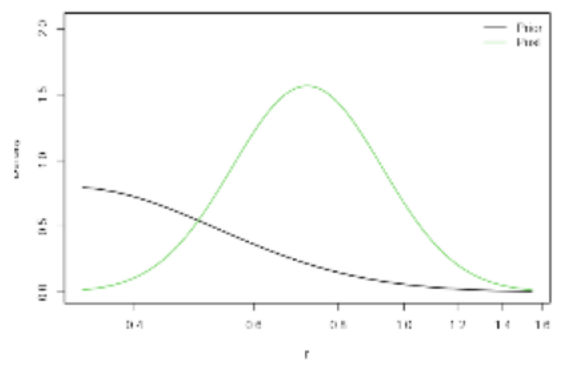
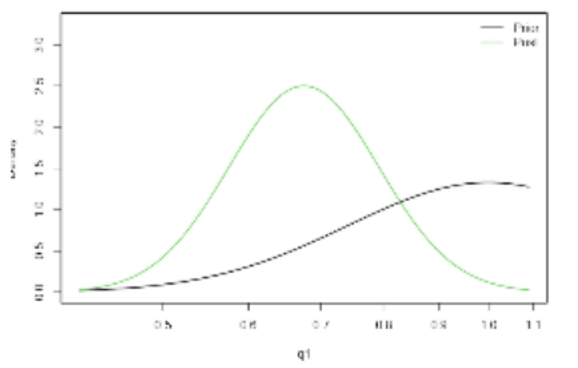
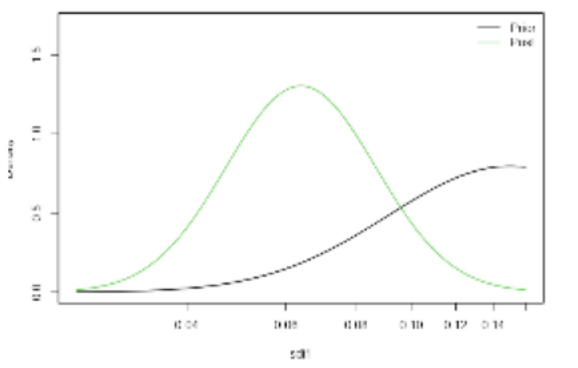
Model 2



Model diagnosis

	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis	OK	OK	
⑤Assessment uncertainty	OK	OK	Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis	OK	OK	Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis	OK	OK	Initial value influence
⑧Prior - posterior distributions			Dependance on priors

⑧Prior - Posterior Distributions

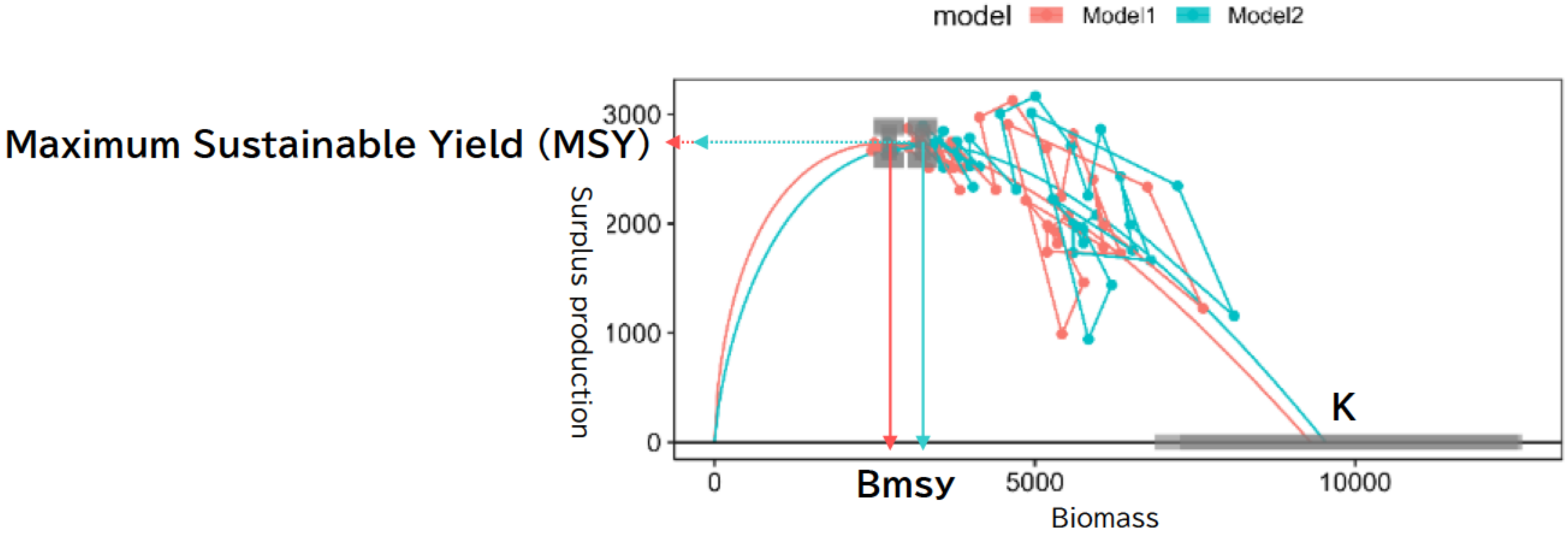
	n	r	q1	σI,1
Model 1				
Model 2				

Model diagnosis

	Model 1	Model 2	
①Convergence	OK	OK	
②All variance parameters are finite	OK	OK	
③Residual analysis	OK	OK	Residuals fit a normal distribution
④Retrospective analysis	OK	OK	
⑤Assessment uncertainty	OK	OK	Credible intervals did not span more than 1 order of magnitude
⑥Factor analysis	OK	OK	Stock dynamics are mainly explained by surplus production and fishing mortality, and process errors are not conspicuously large
⑦Jitter analysis	OK	OK	Initial value influence
⑧Prior - posterior distributions	OK	OK	Dependance on priors

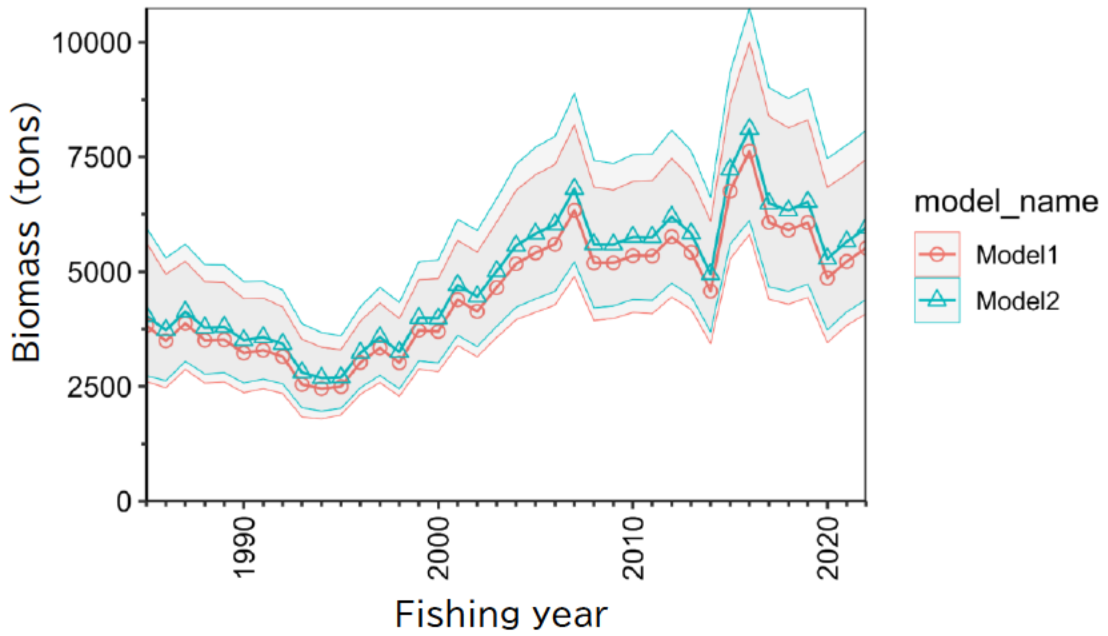
Both models (model 1 & 2) were treated as base case models

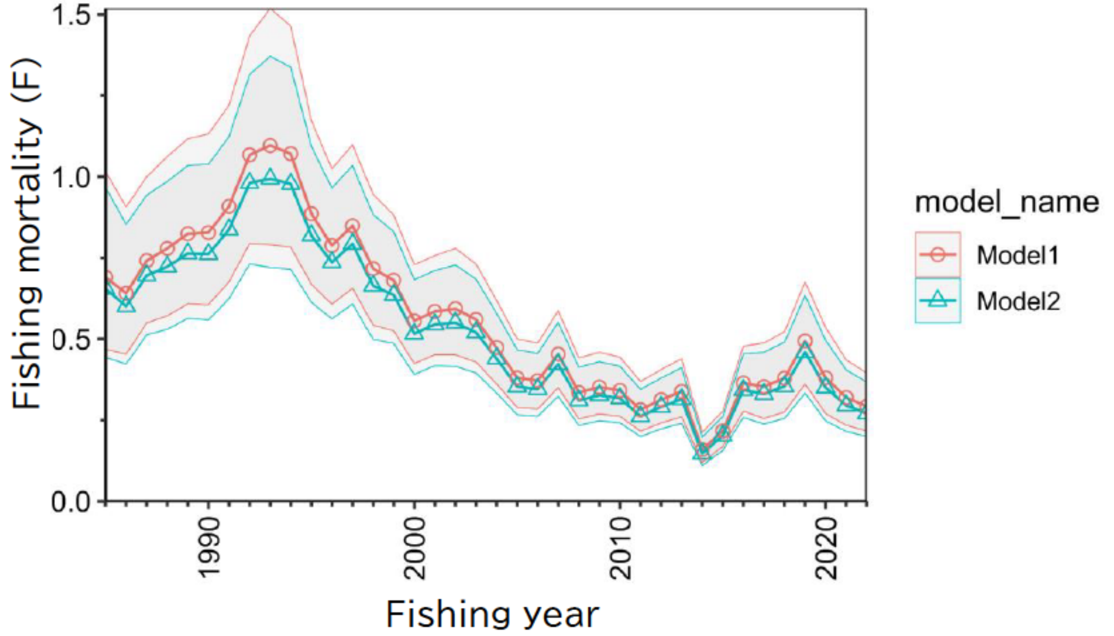
Production Curves and estimated parameters on base-case models

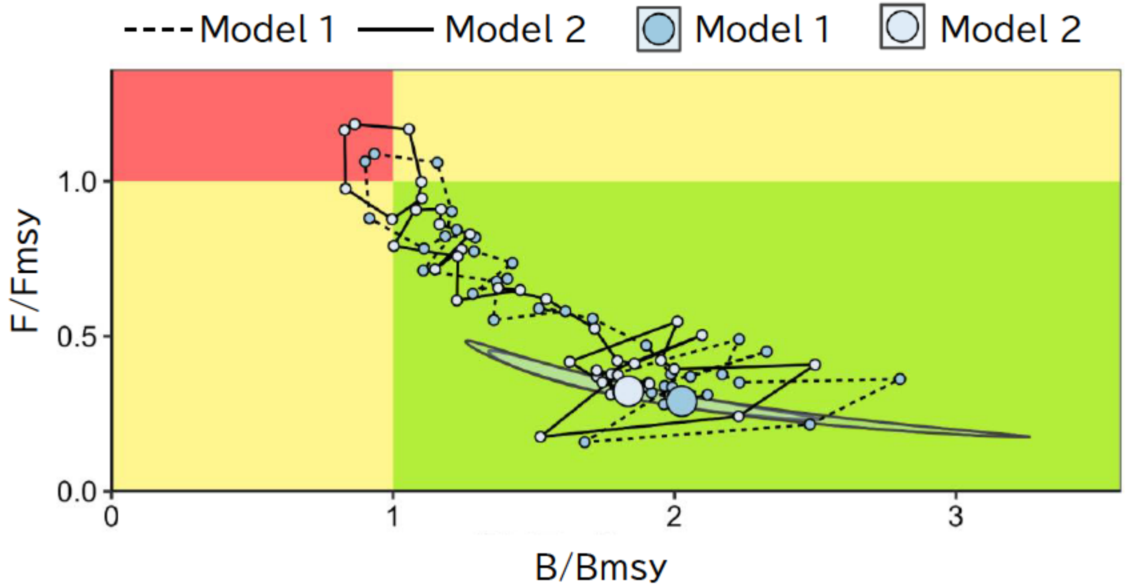


	Model 1 (90% credible interval)	Model 2 (90% credible interval)
r	0.66 (0.33~1.31)	0.72 (0.44~1.19)
K	9.3 ktons (6.9 k~12.6 ktons)	9.5 ktons (7.3 k~12.5 ktons)
n	0.65 (0.26~1.61)	0.86 (0.49~1.50)
Bmsy	2.7 ktons (1.7 k~4.3 ktons)	3.2 ktons (2.3 k~4.6 ktons)
MSY	2.7 ktons (2.6 k~2.9 ktons)	2.7 ktons (2.6 k~2.9 ktons)
Fmsy	1.01 (0.62~1.63)	0.84 (0.58~1.21)

Differences in estimation results between base-case models







It is difficult to decide which model is better, although it is not affected by the SD of the prior distributions of n and r.

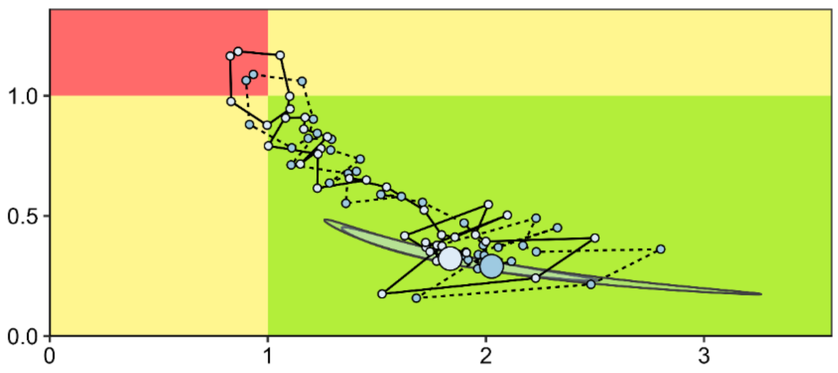
Model merging

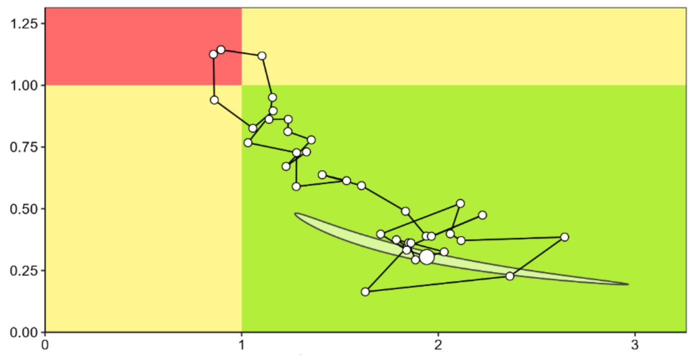
SPiCT estimated **precision matrices** for each model that showing the uncertainty and correlation of the estimated parameters

The parameter sets were randomly generated for the number of iteratives according to **multivariate normal distributions** with the variance calculated from the **precision matrix** estimated om each model

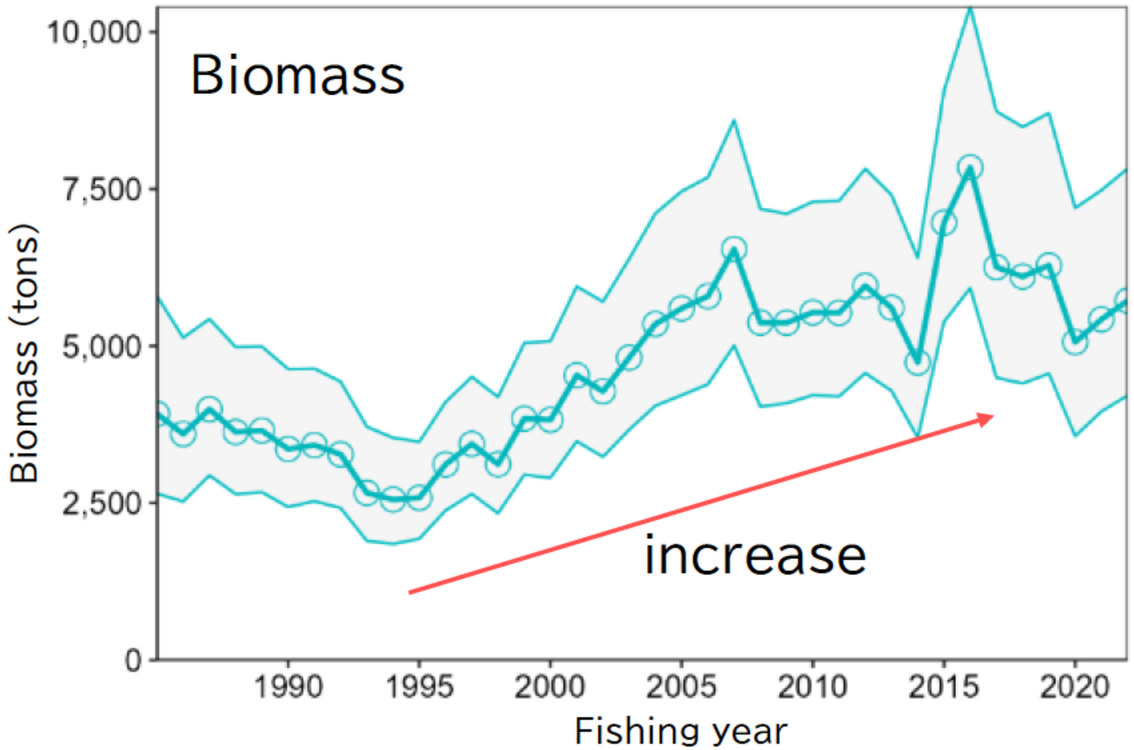
The number of **iterations was 30,000.**
The **median** values, the **5th percentile,** and **95th** percentile of the parameter sets were defined as the **representative values** and the **90% confidence intervals**

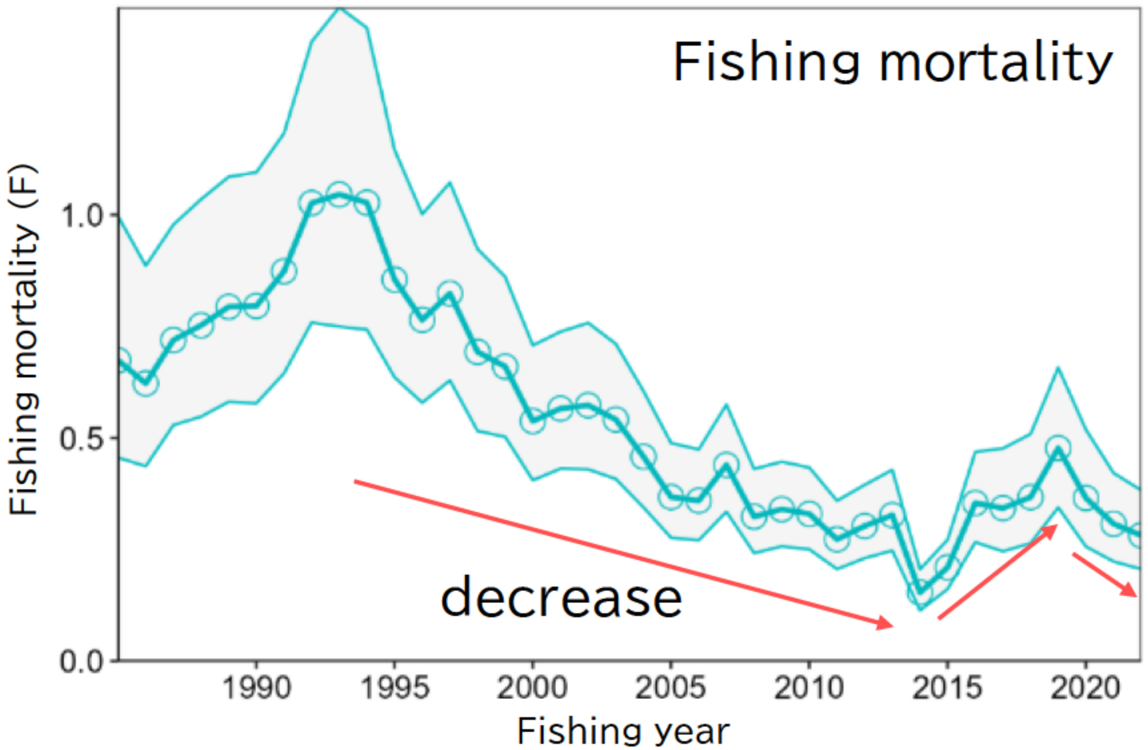
For example,





Trends in Biomass and Fishing mortality





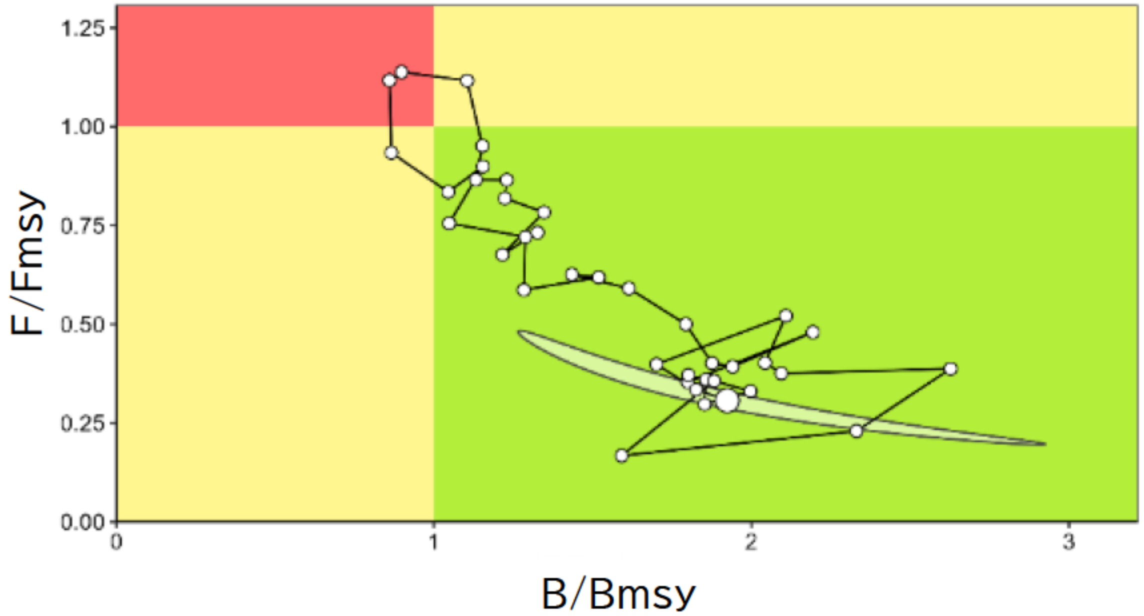
- ●Biomass increased in the long term since the 1995
- ●Fishing mortality increased up to the 1992, and then fell into a decreasing trend, with a slight increase in the 2015 to 2019, declined since the 2020
- ●The increase in biomass since the 1995 is thought to be due to a decrease in fishing mortality since the 1994

Stock dynamics consistent with the results of interviews for fishery stakeholders

- ●In the early 1990s, many fish were shipped to western Japan
- ●Introduction of stock management agreements in 1994, which include catch regulations for smaller fish
- ●Operations in Otaru intensively targeted in the 2016 to 2019 due to a spike in demand from international sales channels. Then, the COVID-19 pandemic caused a drop in demand since the latter half of the 2019

MSY, Biomass Levels and Trends

Kobe plot



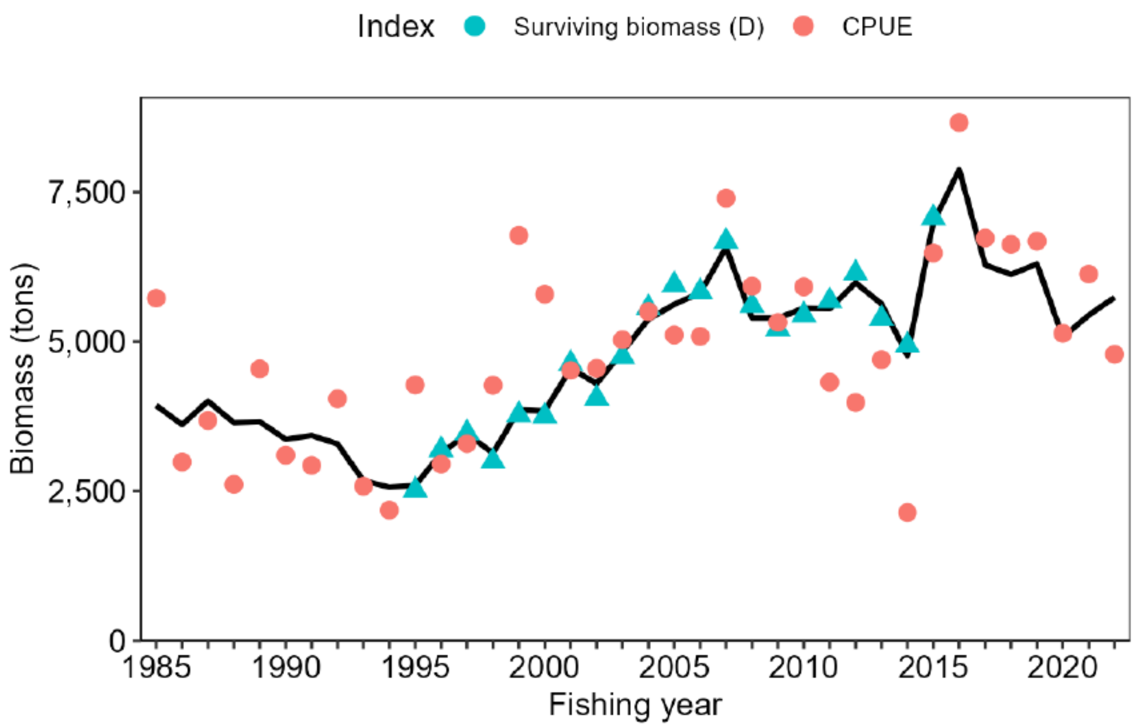
MSY, Biomass, and F	
MSY	2.7 ktons (2.6 k~2.9 ktons)
Bmsy	3.0 ktons (1.8 k~4.4 ktons)
Fmsy	0.92(0.62~1.52)
B2022	5.7 ktons (4.2 k~7.8 ktons)
B2022/Bmsy	1.92(1.48~2.79)
F2022	0.28(0.21~0.38)
F2022/Fmsy	0.31(0.21~0.41)

In the 2022 fishing season,

- Biomass exceeds Bmsy, including 90% CI
- Fishing mortality is lower than the Fmsy, including 90% CI

For the previous 5 years (2018 to 2022 FYs), the biomass is judged to be in a “stable” trend

Fitting of estimated biomass and index values

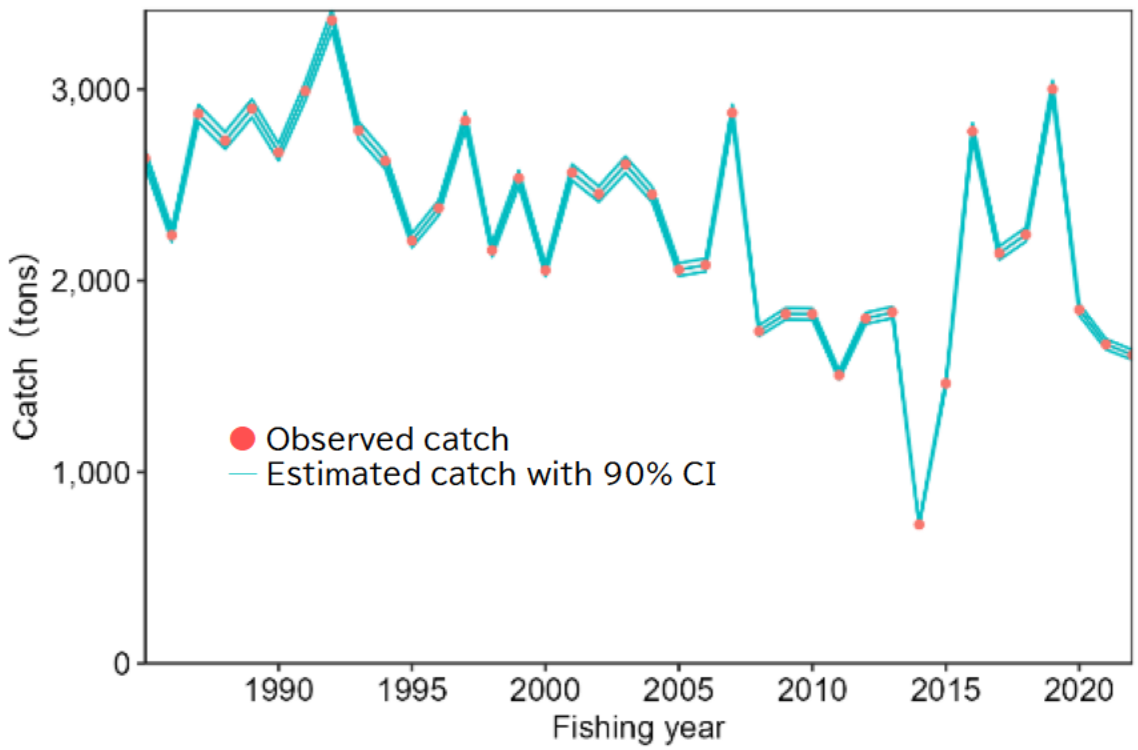


Estimated biomass is a good fit with surviving biomass ($\sigma_{I,1} = 0.06, \sigma_{I,2} = 0.26$)

D

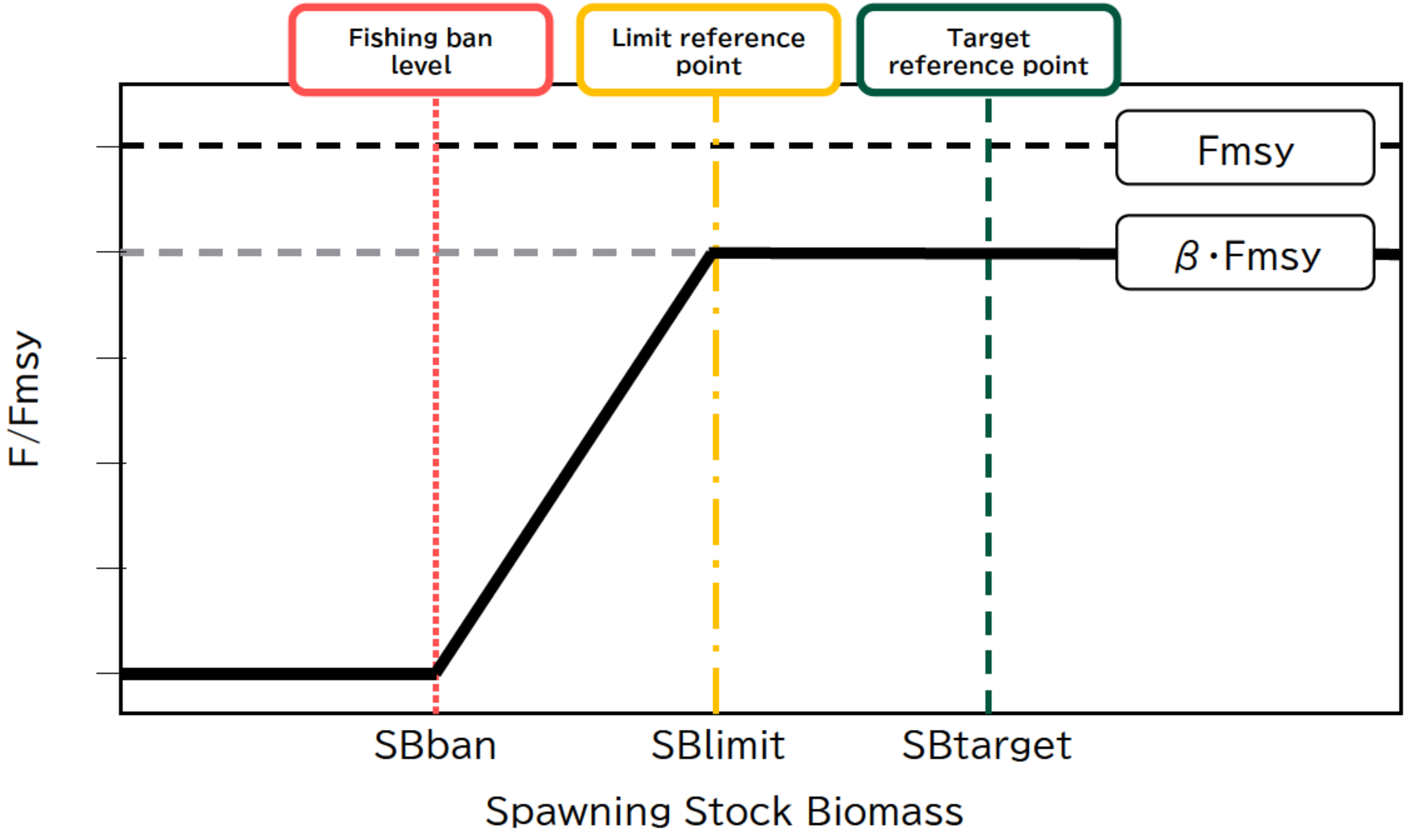
CPUE

Fitting of estimated and observed catches



Catch estimates were not noticeable different from observations.

Gropup 1A (MSY-RPs based on age-structured model)



$$F_t = \begin{cases} 0 & \text{if } SB_t < SB_{ban} \\ \beta\gamma(SB_t)F_{msy} & \text{if } SB_{ban} \leq SB_t < SB_{limit} \\ \beta F_{msy} & \text{if } SB_t \geq SB_{limit} \end{cases}$$

$$\gamma(SB_t) = \frac{SB_t - SB_{ban}}{SB_{limit} - SB_{ban}}$$

Gropup 1C (MSY-RPs based on production model)

Similar to Group 1A, start by proposing HCR with robustness proven according to management strategy evaluation (MSE), then implement future projections as necessary.

SB→B

We developed a simple MSE procedure with SPiCT results

OM is same as the assessment model

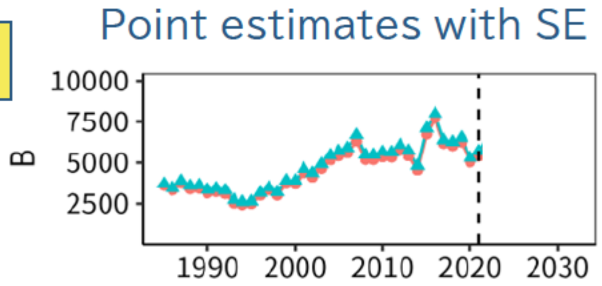
We incorporate various uncertainties as much as possible

- **Uncertainties in the past population** dynamics and prior assumptions are considered by incorporation of **multiple models** and **uncertainties in parameter estimation**
- **Stochastic simulations** based on estimated process error parameter in future projection period
- **Apply SPiCT to pseudo data** generated in future to estimate ABC

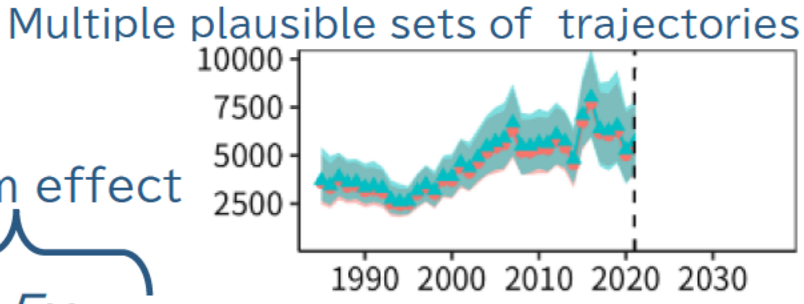
We expect robust specific HCR can be selected based on the OM, which is expected to reflect uncertainties specific to this stock

OM details: Parameter uncertainty

Base models



Conditioned OM



Model 1 (prior 1)

Model 2 (prior 2)

Parameter sets

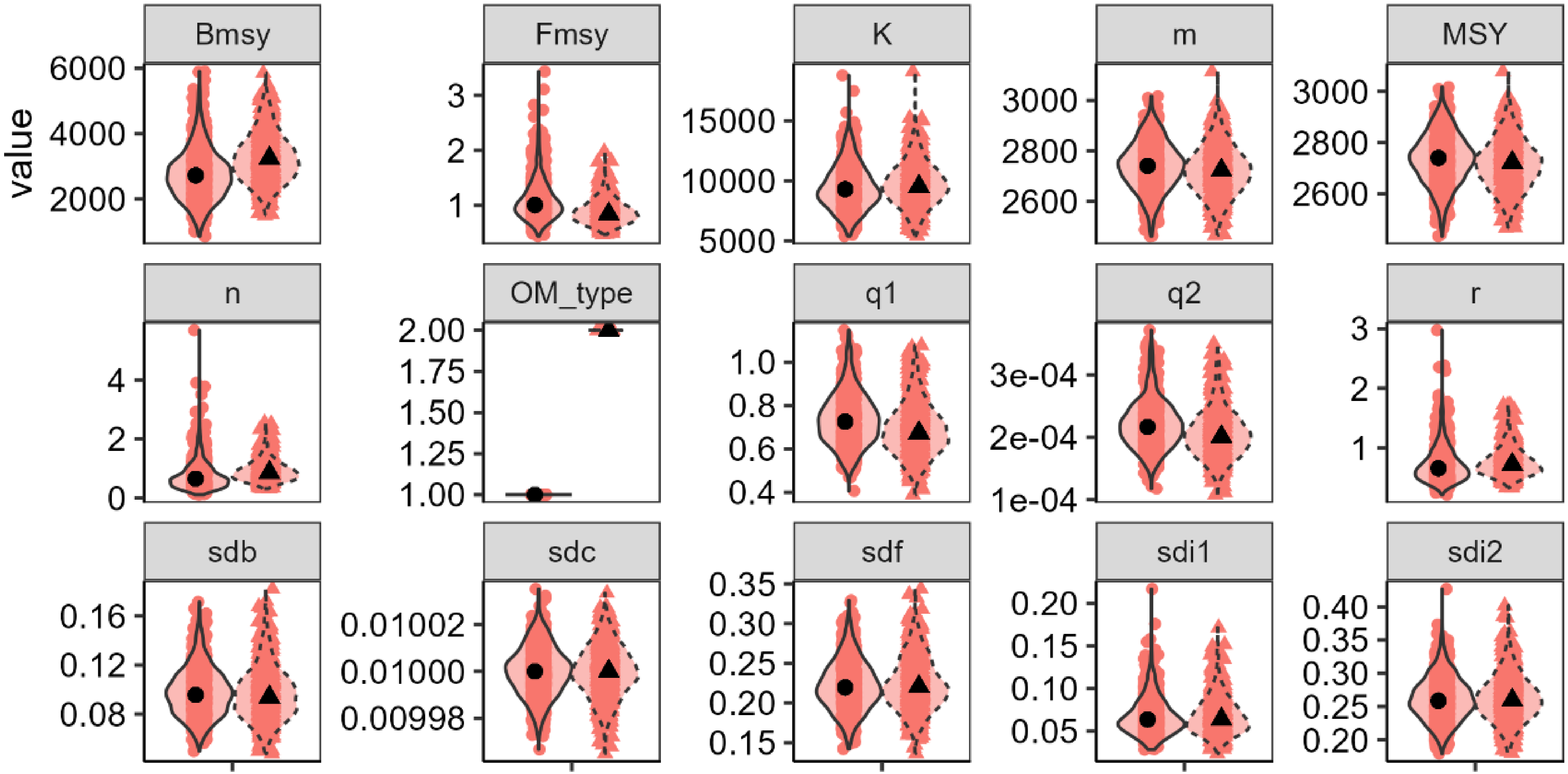
	Fixed effects				Random effect			
	m	*K*	*n*	*sdb*···	*By*	*Fy*		
s=1	120	1310	···	···	521	0.5	···	···
s=2	150	2100	···	···	762	0.42	···	···
s=3	112	1442	···	···	542	0.52	···	···
s=4	130	2014	···	···	611	0.45	···	···
s=5	136	···	···	···	···	···	···	···
s=6	144	···	···	···	···	···	···	···
s=7	95	···	···	···	···	···	···	···
s=8	120	···	···	···	···	···	···	···
s=9	94	···			···	···		
s=10	101	···				···		
s=11	120	···				···		
s=12	110	···				···		

① Generate random values from MVN using covariance matrix

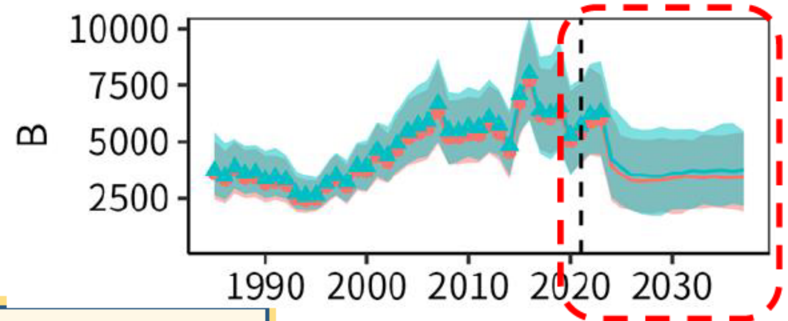
②Each parameter set=each OM

③Parameters from different models are mixed

Randomly generated parameters



OM details: Future projection



Conditioned OM

Fixed effects: m, K, n, sdb… — Random effect: By, Fy

	m	K	n	sdb…	By	Fy	…	…
s=1	120	1310	…	…	521	0.5	…	…
s=2	150	2100	…	…	762	0.42	…	…
s=3	112	1442	…	…	542	0.52	…	…
s=4	130	2014	…	…	611	0.45	…	…
s=5	136	…	…	…	…	…	…	…
s=6	144	…	…	…	…	…	…	…
s=7	95	…	…	…	…	…	…	…
s=8	120	…	…	…	…	…	…	…
s=9	94	…			…	…		
s=10	101	…				…		
s=11	120	…				…		
s=12	110	…				…		

Future projection

By=2021, 2022 …

s=1
s=2
s=3
s=4
s=5
s=6
s=7
s=8
s=9
s=10
s=11
s=12

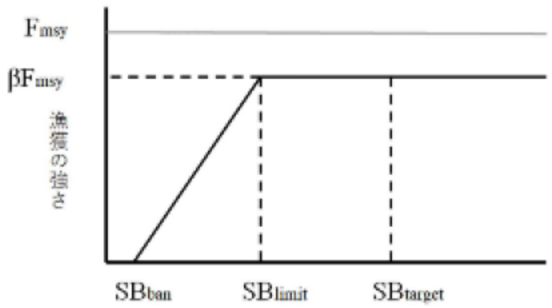
- Population dynamics parameters are different among iterations, that is…
  [i=1: True Fmsy is 0.4, B2022 is 800]
  [i=2: True Fmsy is 0.2, B2022 is 655] …
- B is updated every year as:

$$Bpred_t = f(B_{t-1}, C_{t-1}, \theta)$$
$$B_t = Bpred_t \exp(\varepsilon_t)$$
$$\varepsilon_t \sim N(-0.5sdb^2, sdb)$$

- **Ct-1 is determined from MP**

Management procedures

HCR
(β will be chosen)



② Fit SPiCT with the same configuration of the base models to the catch and CPUE data

③ Calculate ABC by using estimation from each model
$ABC_{y,s,m} = \beta\,\widehat{\gamma_{y,s,m}}\,\widehat{F_{msy_{y,s,m}}},\widehat{B_{y,s,m}}$ (s=iteration, m=N of model)

When determining ABC of 2025 at sth iteration,

① Input data: Catch and CPUE data until y-2

Year	1985	1986	…	2021	2022	2023	…
Catch	230	124	…	234	244	231	
CPUE	0.2	0.12	…	0.4	0.32	0.2	

Actual data (same for all iteration)

Pseudo data (different among iterations)

Fit Model 1 → $ABC_{y,s,1}$

Fit Model 2 → $ABC_{y,s,2}$

Take average → $ABC_{y,s}$ → $C_{y,s}$

④ Determine single $ABC_{y,s}$ from the multiple ABCs (e.g. average)

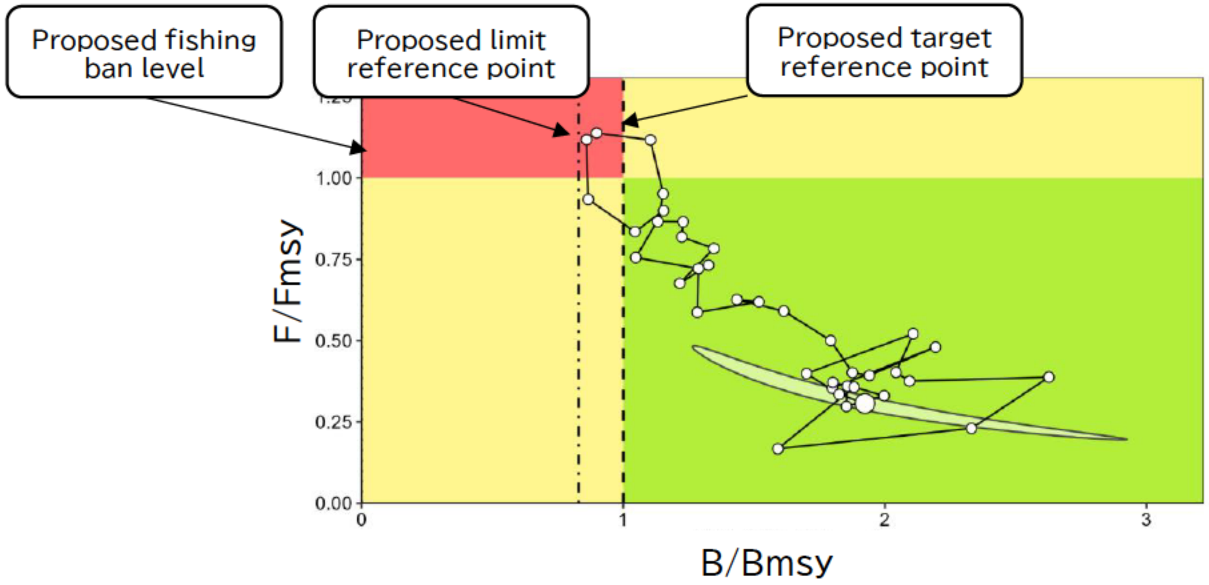
⑤Catch according to ABC

Proposed Reference Points (Appendix 4)

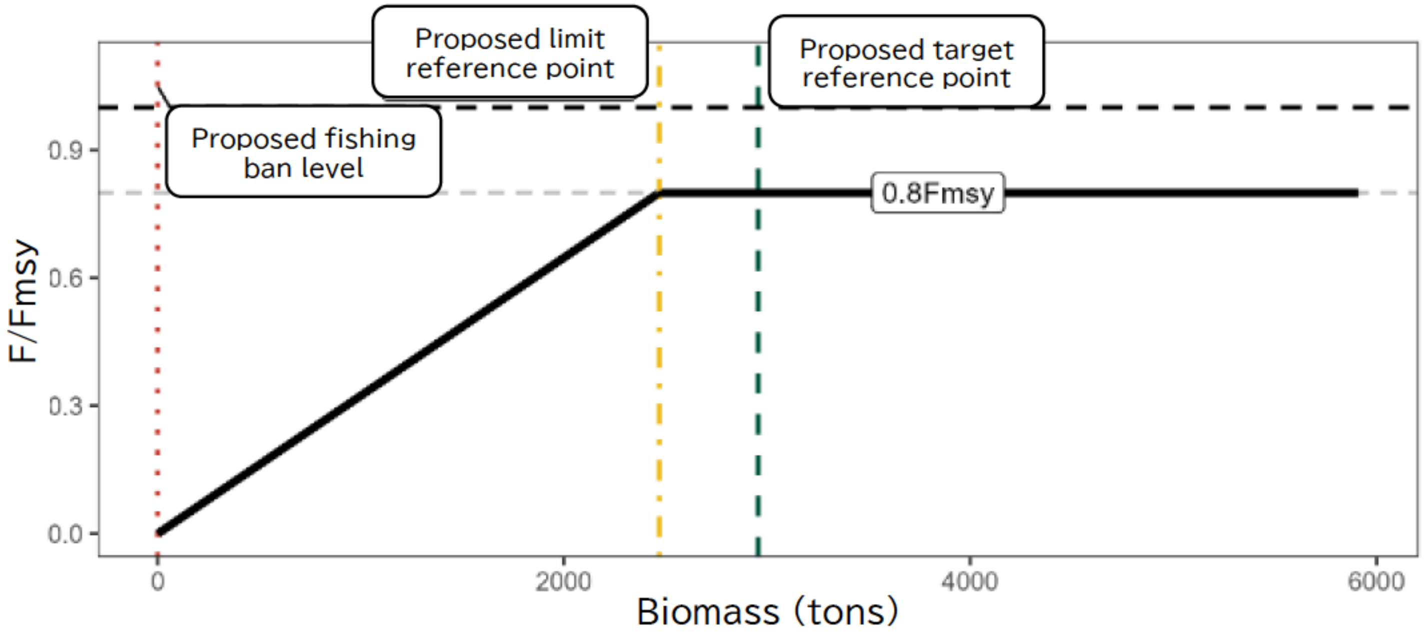
The following proposal was adopted at the “Scientific meeting on reference points in fiscal year 2023” (FRA-SA2023-BRP03-01) held in May 2023.

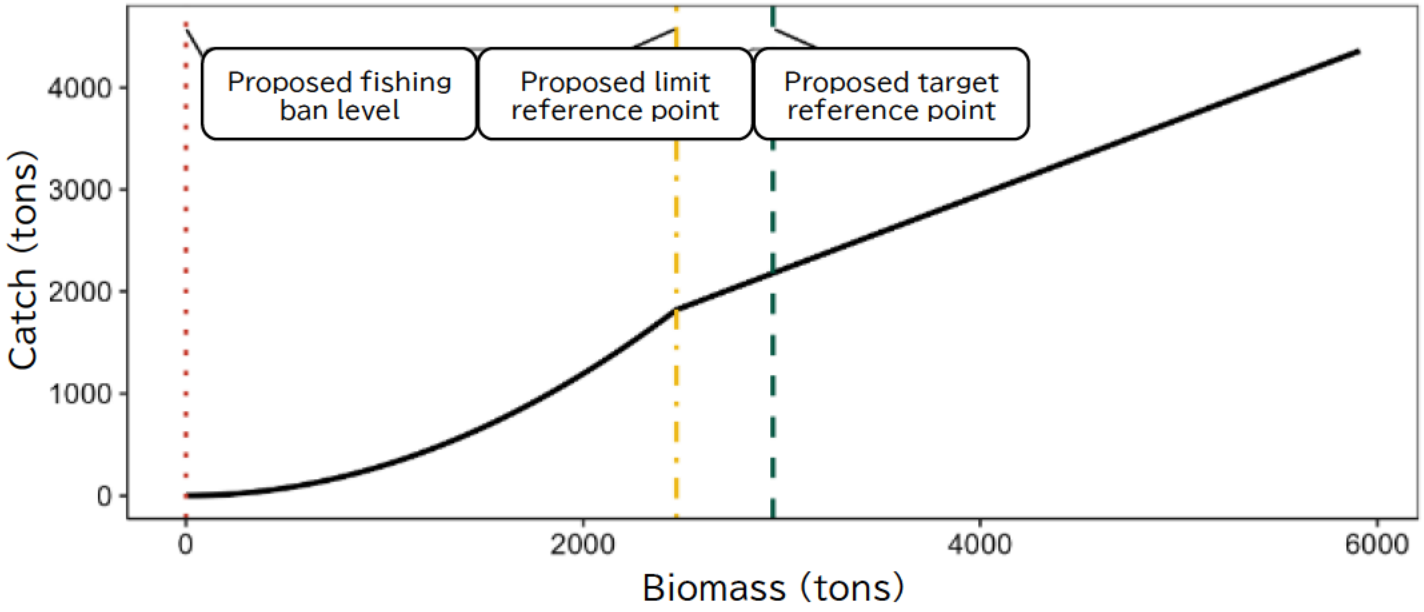
※Proposed reference points are “levels” and estimates (XX tons) will change with updates ton the stock assessment.

Proposed reference points	Biomass (ktons)	Ration to carrying capacity	Fishing mortality	Anticipated Catch (ktons)	Ration current fishing mortality
Proposed target reference points (Bmsy)	3.0 (1.8～4.4)	0.32 (0.19～0.45)	0.92 (0.62～1.52)	2.7 (2.6～2.9)	3.26 (2.44～4.85)
Proposed limit reference points (Bmin)	2.5 (1.8～3.4)	0.26 (0.20～0.33)	1.08 (0.78～1.49)	2.7 (2.4～2.9)	3.83 (3.07～4.79)
Proposed fishing ban level (0トン)	0	0	–	0	–



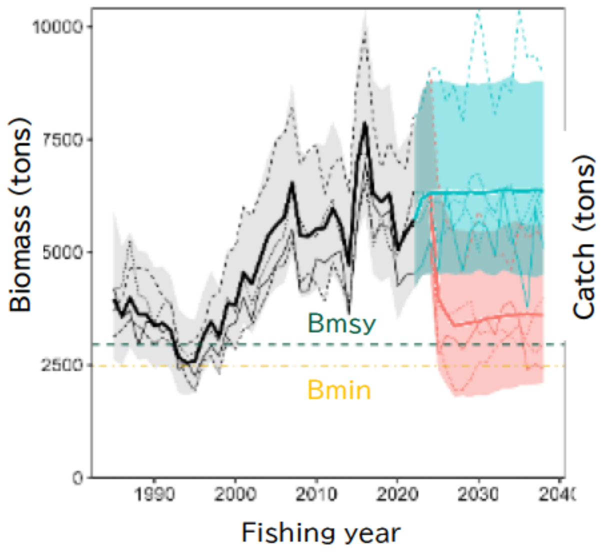
Proposed HCR (case of β=0.8)

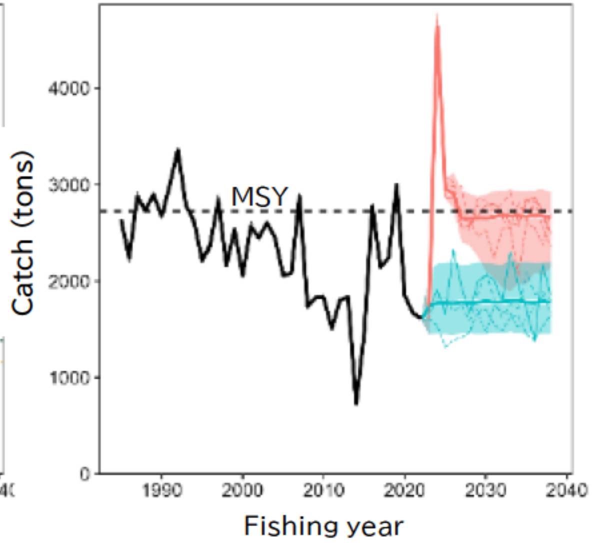


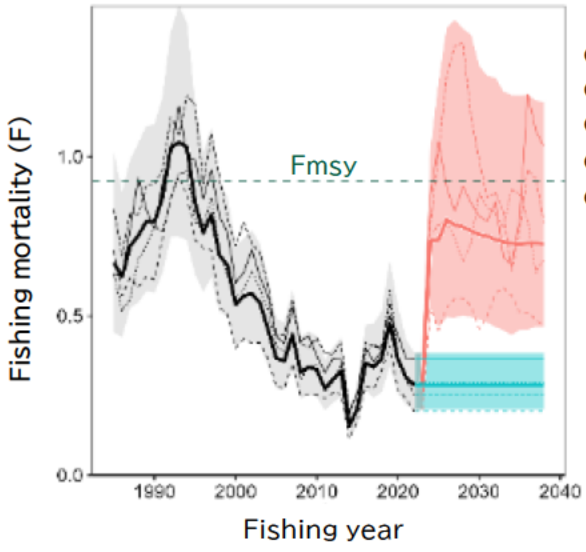


Results of Future Projection

Beta0.8_HCR F2022







- Projections begin in the 2023 FY
- Give observed Catch for 2022 FY
- Give the F^i_{2022} as F^i_{2023}
- Management begins in the 2024 FY
- Current F corresponds to β=0.31

Projections for the 2024 FY

- Biomass exceeded Bmsy, F increased to βFmsy, and Catch sharp increased

Projections for the 2025 FY and after

- Biomass decreased to around Bmsy, Catch also decreased to around MSY

- F varied due to uncertainty in the ABC calculation process for future projections

90% prediction interval

- F often exceeded Fmsy due to uncertainty in the ABC calculations, and in some cases biomass decreased even when managed by βFmsy, and the prediction interval fell below the MSY level

- Widely distributed immediately after the start of management, narrowing around the 2030 FY

  →SPiCT assumes a random walk in F, so it could not follow OM, where F changed significantly immediately after the start of management, and overestimated the amount of biomass by explaining it in terms of changes in B instead of F

Medium/long-term future projections

- Biomass, F, and Catch were projected to hover near MSY levels

Probability of exceeding the proposed RPs

Probability of exceeding the proposed target reference point (%)

β	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1.0	100	100	68	51	35	40	42	48	51	55	56	**58**
0.9	100	100	82	67	52	54	56	59	62	65	66	**67**
0.8	100	100	92	82	73	74	74	76	76	78	79	**81**
0.7	100	100	97	93	89	89	89	90	89	89	91	**91**
0.6	100	100	99	98	97	97	97	97	97	97	97	**98**
0.5	100	100	100	100	100	100	100	100	100	100	100	**100**
Current F	100	100	100	100	100	100	100	100	100	100	100	**100**

Probability of exceeding the proposed limit reference point (%)

β	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1.0	100	100	91	75	58	60	60	65	67	70	72	**73**
0.9	100	100	96	88	74	75	75	77	78	80	82	**84**
0.8	100	100	98	95	90	91	90	90	90	90	92	**92**
0.7	100	100	100	99	97	98	97	97	97	97	97	**97**
0.6	100	100	100	100	100	100	100	100	100	100	100	**100**
0.5	100	100	100	100	100	100	100	100	100	100	100	**100**
Current F	100	100	100	100	100	100	100	100	100	100	100	**100**

Current F corresponds to β=0.31

Trends in projected representive values of Biomass and Catch

Median value of Biomass (ktons)

β	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1.0	6.2	6.3	3.3	3.0	2.6	2.7	2.7	2.9	2.9	3.0	3.0	**3.0**
0.9	6.2	6.3	3.6	3.3	3.0	3.0	3.0	3.1	3.2	3.2	3.3	**3.3**
0.8	6.2	6.3	4.0	3.6	3.4	3.4	3.4	3.5	3.5	3.6	3.6	**3.6**
0.7	6.2	6.3	4.4	4.1	3.8	3.9	3.9	3.9	3.9	4.0	4.0	**4.0**
0.6	6.2	6.3	4.8	4.5	4.4	4.4	4.4	4.4	4.4	4.5	4.5	**4.5**
0.5	6.2	6.3	5.3	5.1	5.0	5.0	5.0	5.0	5.0	5.0	5.0	**5.0**
Current F	6.2	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.3	6.4	**6.4**

Median value of Catch (ktons)

β	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034
1.0	1.7	5.8	3.1	3.1	2.6	2.7	2.6	2.7	2.7	2.8	2.7	**2.7**
0.9	1.7	5.2	3.0	3.0	2.7	2.7	2.7	2.7	2.7	2.7	2.7	**2.7**
0.8	1.7	4.6	3.0	2.9	2.7	2.7	2.6	2.7	2.7	2.7	2.7	**2.7**
0.7	1.7	4.1	2.8	2.8	2.6	2.6	2.6	2.6	2.6	2.6	2.6	**2.6**
0.6	1.7	3.5	2.7	2.6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	**2.5**
0.5	1.7	2.9	2.4	2.4	2.3	2.3	2.3	2.3	2.3	2.3	2.3	**2.3**
Current F	1.7	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	**1.8**

Current F corresponds to β=0.31

Projected Biomass, Catch, and Probability

Projected biomass and catch, and probability that biomass will exceed the proposed reference point

β	Probability of exceeding the target in 10 years		Median value of projected biomass (ktons)		Median value of projected catch (ktons)		
	Probability that biomass will exceed the proposed target reference point	Probability that biomass will exceed the proposed limit reference point	In 5 years	In 10 years	Year 1	Avg. in Year 2 to 5	Avg. in Year 6 to 10
			2029 FY	2034 FY	2024 FY	2025 to 2028 FYs	2029 to 2033 FYs
1.0	**58%**	73%	2.7	3.0	5.8	2.9	2.7
0.9	**67%**	84%	3.0	3.3	5.2	2.8	2.7
0.8	**81%**	**92%**	3.4	3.6	4.6	2.8	2.7
0.7	**91%**	**97%**	3.9	4.0	4.1	2.7	2.6
0.6	**98%**	**100%**	4.4	4.5	3.5	2.6	2.5
0.5	**100%**	**100%**	5.0	5.0	2.9	2.4	2.3
	≧50%	≧90%					

Probability that biomass will fall below the proposed limit reference point 1+ time(s) in the 10-year period

β	Risk that biomass will fall below the limit reference point (probability for 1+ time(s) in the 10-year period)						
	B0.1msy	B0.2msy	B0.6msy	B0.7msy	B0.8msy	B0.9msy	Bmin
1.0	0%	0%	6%	11%	19%	31%	72%
0.9	0%	0%	4%	7%	11%	18%	48%
0.8	0%	0%	2%	4%	5%	8%	**25%**
0.7	0%	0%	1%	2%	2%	3%	**7%**
0.6	0%	0%	0%	0%	0%	0%	**1%**
0.5	0%	0%	0%	0%	0%	0%	**0%**
							<30%

Responses to comments received in advance

K01-General I think that this modeling approach is appropriate given the data available. The state-space surplus production model benefits from having an index of abundance and generates uncertainty estimates of management quantities.
Since the available data is insufficient to implement age-sturactured models such as VPA, we performed an assessment using a state-space surplus production model. As a result, uncertainties not considered in the VPA could be taken into account in this assessment.
K02-Model I was unclear on which parameters had priors in Model 1 and Model 2. The document mentions that the priors are a sd of 1 and 0.5 (L525-526). a. I recommend including a table that has the starting values, prior values (if applicable), and final estimates for each parameter.
We have organized them in this presentation. We would like to improve the presentation in the stock assessment report to be submitted next month.

Responses to comments received in advance

K02-Model (continued)
Please include more details justifying evaluating two models and then combining the parameter estimates.

a. The results between the models are qualitatively similar. This suggests that the sd of 1 vs 0.5 does not seem to have a large impact on the results. This relates back to justifying the need for having multiple models that are then combined. I think I' ve seen this kind of ensemble modeling for highly migratory species like tuna for which there are no data available on movements. In these cases, movement assumptions have a large impact on model results, so analysts will try to integrate the uncertainties in movements across multiple possible models.

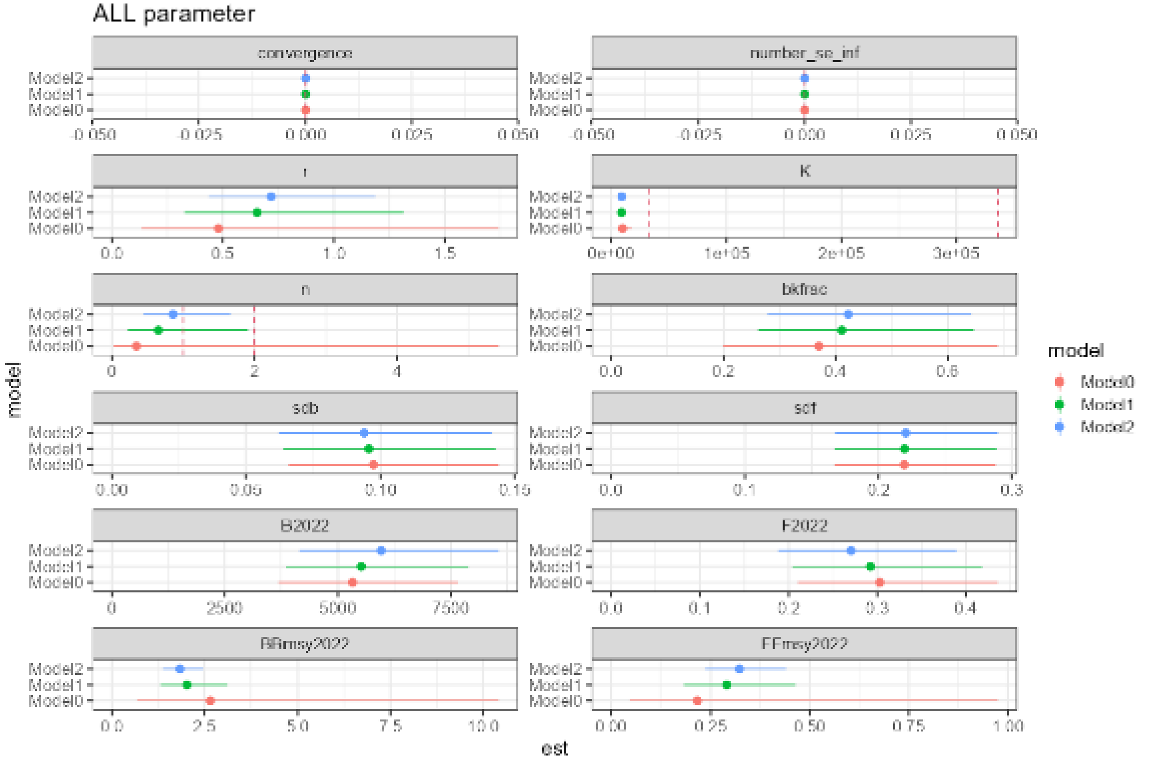
We do not consider that the difference in SD has a significant impact on the results. However, since it is not possible to determine which model is closer to the true one at this time, we have integrated the uncertainties of the two models to present our results.

Responses to comments received in advance

K02-Model (continued) b. Please include more details of how the results of Model 1 and Model 2 are combined. Are they combined into one model that represents the analysts' best estimate of stock status and then applied to the projections? Or are the two models used to sample parameter values for the projections?
SPiCT estimates a variance-covariance matrix that represents the correlation and uncertainty among the parameters of each model. The parameter set was randomly generated from a multivariate normal distribution with this matrix as the variance component 15,000 times from each model, the median of which was used as the representative value, and the 90% confidence interval was calculated from the 5th percentile and 95th percentile values. The median value was used rather than the mean value because extreme outliers are likely to occur, and the median value was used to reduce their impact. The same process is used to regenerate the parameters for the OM used in the future projection.

K02-Model (continued)
c. If the model is run without any priors, where do the estimates land?

We considered a model with no prior distribution for the shape parameter (n) and the intrinsic natural growth rate (r) when we first introduced PM in the 2022 stock assessment. As a result, the calculations converged, but the 95th percentile values of the n and r were about 555 times the 5th percentile value for n and 20 times the 5th percentile value for r, resulting in very large confidence intervals. In our PM guidelines, the condition for a stable estimation is that the estimate is within a factor of 10, so we excluded this model from the base case.



K03-Model The SPiCT model, from my understanding of the document, does not need to start the biomass at equilibrium. It is possible to start the models from a fished state. If this is true, can the authors please include more details regarding the decision to include previous VPA results as Index 2 (1?) in the model?
Although SPiCT can estimate biomass, fishing mortality, MSY, etc., using abundance index and catch as input values, the confidence intervals for absolute biomass become very large in the absence of prior information on the q or K. It has been shown that it is difficult to develop safe and efficient HCR even if future projections, etc. are conducted based on such parameters (Robustness of management procedure using surplus production model. FRA-SA2022-ABCWG02-08 in Japanese). For this reason, the PM guideline (FRA-SA2023-ABCWG02-07) that absolute biomass values can be used in stock assessment only when reliable prior distribution information can be established for q or K. In this stock, the assessment was performed using absolute biomass by using the estimated biomass obtained from the external VPA as input values with a prior distribution of q.

Responses to comments received in advance

K03-Model (continued) a. The q associated with Index 2 is very low, and as a result may not affect the overall results. If the model is run with just Index 1 and a narrower time frame, do the stock status estimates and biomass estimates differ much from Model 1 and Model 2?
Although q for index 2 is very small, q represents the scale between the estimated biomass and the index value. The value of σI is used as an indicator for the fit between the estimated stock び biomass and the abundance index value. In the case of this analysis, σI1 for index 1 is 0.06 and σI2 for index 2 is 0.26. Therefore, it can be said that the index value that fits the estimated biomass better is the surviving biomass of index 1. The results of the calculation using only D (index1) and catch will be shown later.

Responses to comments received in advance

K03-Model (continued) 4. I could not tell from the document if the SPiCT model was implemented as a Bayesian model. Specifically, were the priors included in the likelihood calculation? Was some sort of algorithm like Markov Chain Monte Carlo used to search over the likelihood surface and compute credible intervals? a. For example, I use Stock Synthesis models that are frequentist and use penalized likelihoods in the optimization. We could run MCMC in SS in which the model becomes Bayesian, but we typically don't do this. b. If this is a Bayesian assessment, I believe all references to "confidence interval" should be "credible interval"
SPiCT uses a penalized maximum likelihood method to estimate parameters, and the prior distribution is multiplied by the likelihood function. In addition, as stated in the original SPiCT paper, although there is a philosophical difference between "confidence intervals" and "credible intervals," both are abbreviated as CI because there is no practical difference, and "confidence intervals" is used in this report without distinction.

Responses to comments received in advance

T01-Generel
This assessment was an interesting change from the others. The most important issue is the use of VPA results as an index in the production model, in order to obtain the desired age-structured output (i.e., SSB) for management purposes. This is unusual. Please explain this approach in detail versus using an age-structured or delayed-difference type of model. We would need to discuss this approach in detail during the meeting. Importantly, please show and compare a model run that is fit to just the bottom trawl index.

As mentioned at the beginning of the presentation, the VPA is analyzed by HRO in another project, and the figures of CAA and female biomass and limited materials and methods are published, but not as numerical data. As one of the best available information, numerical values read from the published female biomass figure were used as an abundance index D for PM.

The results of the calculation using only CPUE (index2) and catch will be shown later.

T02-Stock structure and distribution
What is the evidence to support separating this stock (i.e., Fig 2-1) from the other nearby areas (e.g., Kamchatka, Sea of Japan, Korea, Taiwan), where Pointhead flounders are also found? For example, genetics, phenotypic characteristics, tagging or population dynamics?

Genteics; Although partial, mtDNA analysis shows significant genetic differentiation between the Sea of Japan and the Pacific Ocean around Hokkaido (Xiao et al. 2011).

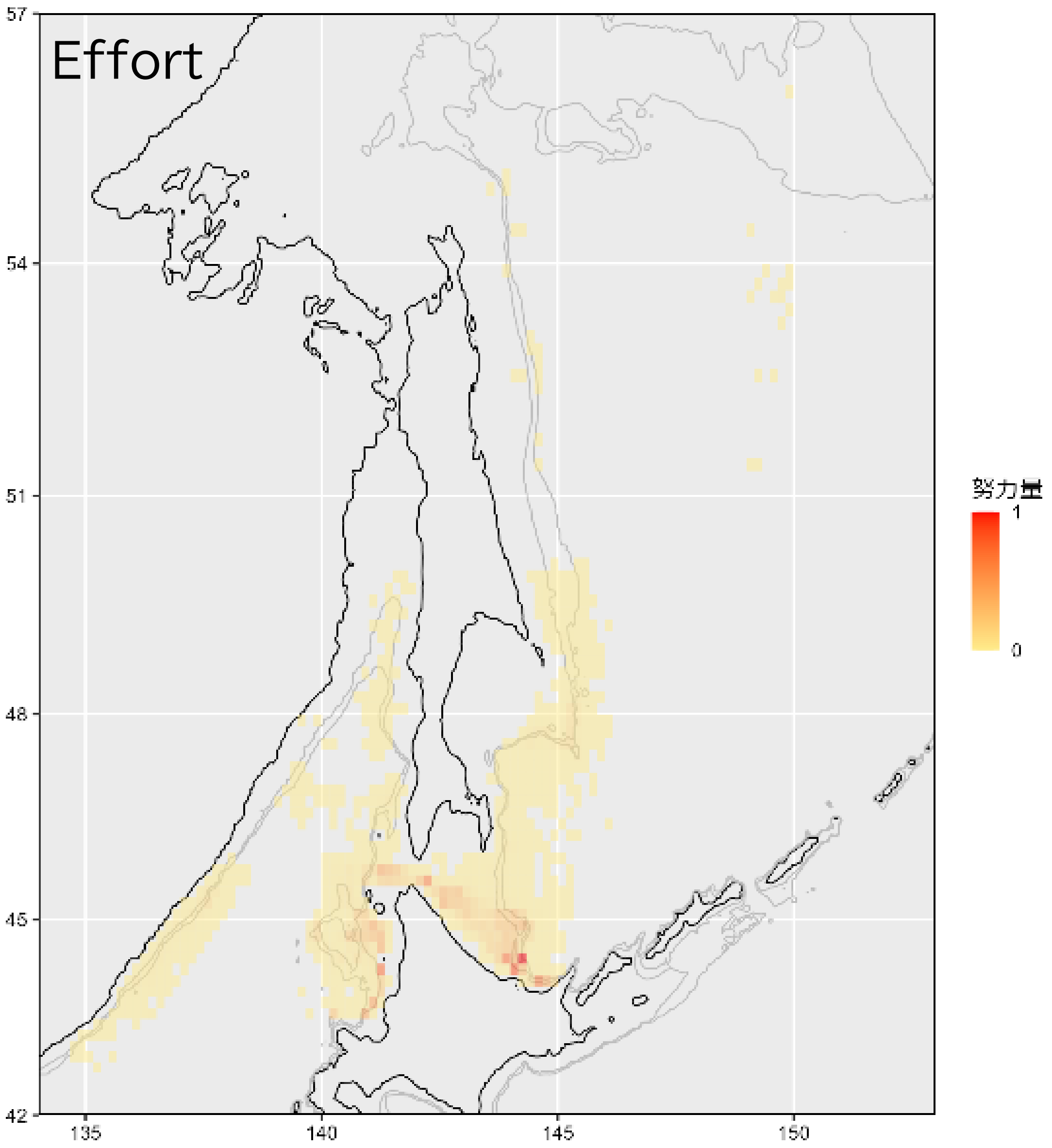
Phenotypic; Differences in growth, maturity, and spawning season are observed in different ocean regions.

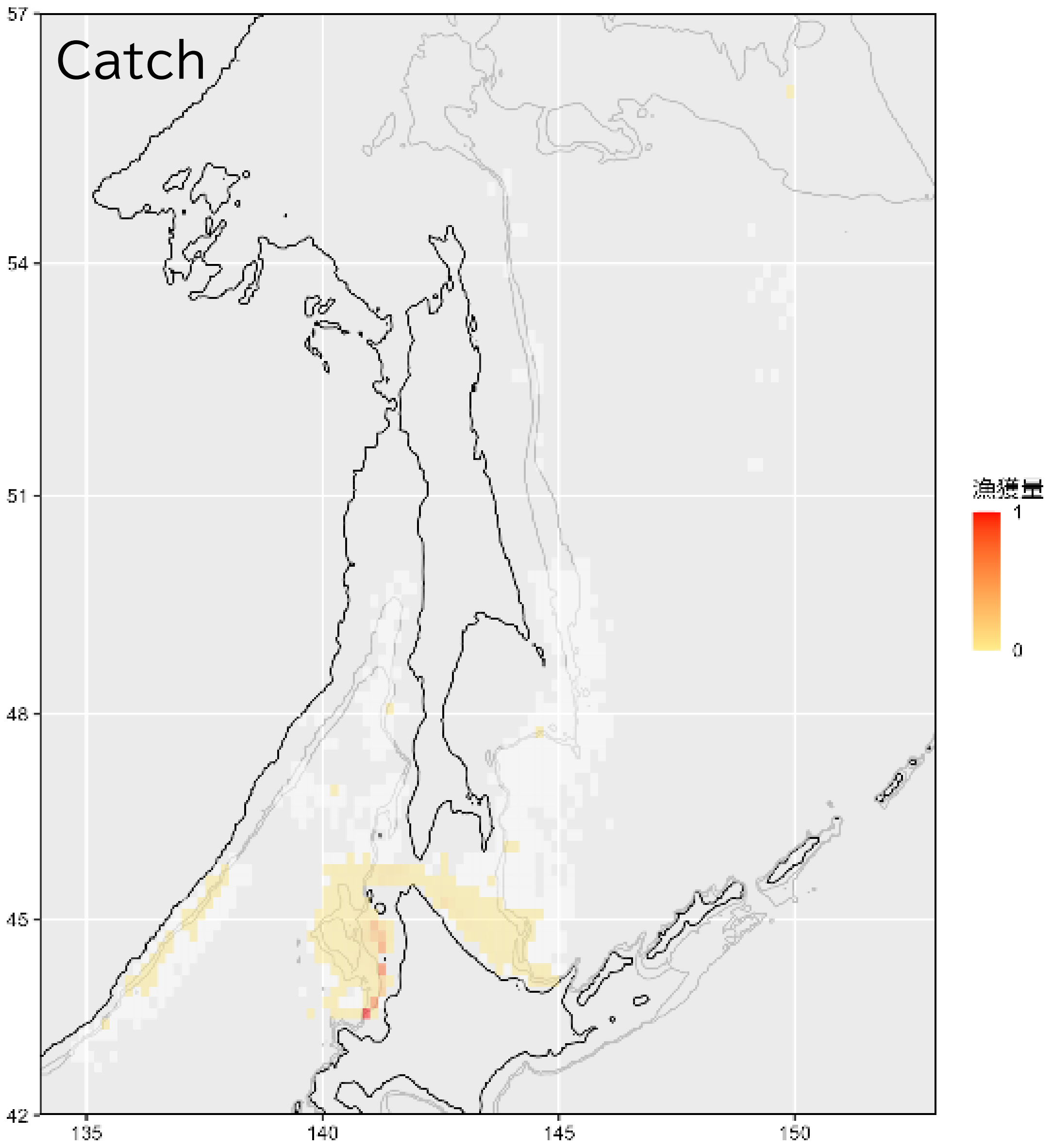
Tagging; Many tagging research are conducted by Hokkaido and prefectural institutes. Most fish are taken close to the release site. Although some records show migration of more than 100 km a year after release, the fish are generally sampled within the range of the stock.

Population dynamics; Population dynamics have been estimated only in three areas, the western Sea of Japan, northern Hokkaido, and the Pacific Ocean of Hokkaido, but the dynamics are different.

Fishery data; Based on information from the period when Japanese offshore trawlers also operated in Russian waters, we consider that the distribution of this stock around Sakhalin and in Primorsky is not continuous, since effort is distributed along the east and west coast of Sakhalin, and coast of Primorsky, but catches outside the distribution area of this stock are minimal.

1980-2020 Japanese offshore bottom trawlers





Responses to comments received in advance

T03-Stock structure and distribution Within this stock, two groups of fish are noted. One that stays within the Sea of Japan for the whole lifecycle and another that is transported into the Sea of Okhotsk. Do these fish share a spawning ground highlighted in Fig 2-1? Please provide supporting evidence.
The existence of the two groups is indicated by Fujioka (2003), but no clear evidence for this is provided, nor is the basis for assuming that the two groups share spawning grounds. We are currently conducting a survey to collect biological information and hope to clarify this in the future.
T04-Biology It is unclear whether Suppl Table 2-1 showed the priors or the posteriors. Legend says “Estimated parameters” but heading in column 1 says “Prior distribution settings”. Please provide tables and comparative plots of both the priors and posteriors for the various biological parms in the model (e.g., r, K, bkfrac, n, …)?
We have organized them in this presentation. We would like to improve the presentation in the stock assessment report to be submitted next month.

Responses to comments received in advance

T05-Biology
How were the above priors developed? Please explain in detail.

T06-Biology
For example, it was stated that "prior mean for the intrinsic growth rate (r) was based on FishLife (Thorson 2020)" but what were the available biological parameters and associated uncertainties? Or were the parameters only from FishBase and RAM?

Parameters assuming prior distribution were n, r, q1, $\sigma I1$, and σC.

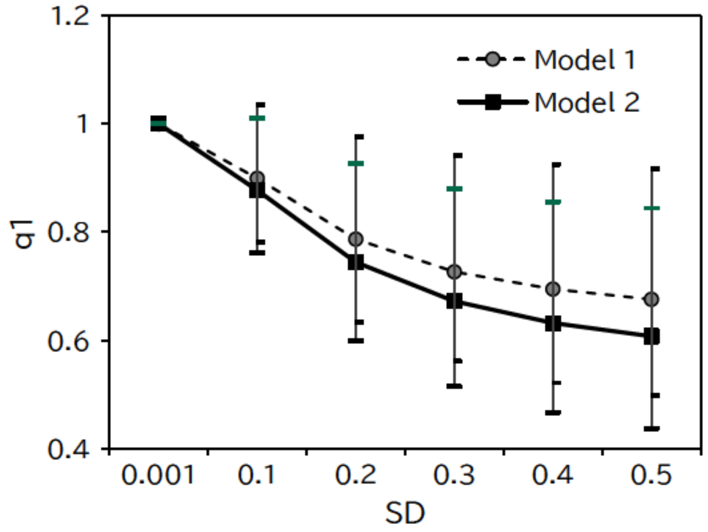
The n was assumed to be Schaeffer type (2.0). The r was assumed to be 0.32, estimated by FishLife; the 90% confidence interval in FishLife ranged from 0.07 to 1.42. No other information available.

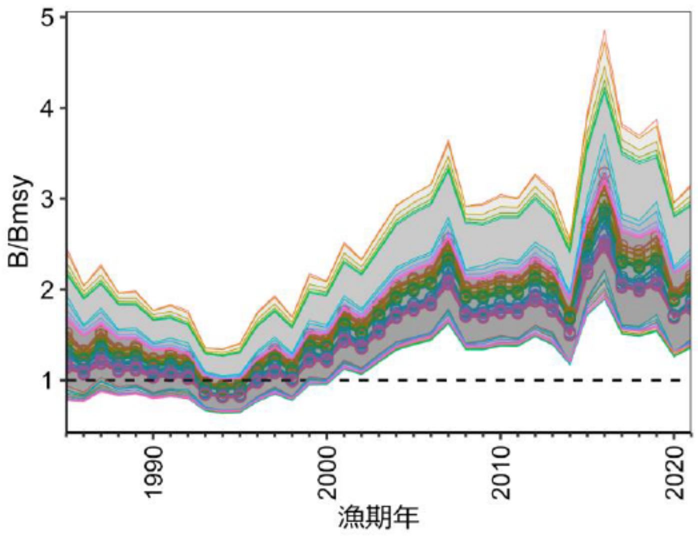
Two patterns of standard deviations for r and n, 1 (Model 1) and 0.5 (Model 2), were used based on the guideline (FRA-SA2023-ABCWG02-07).

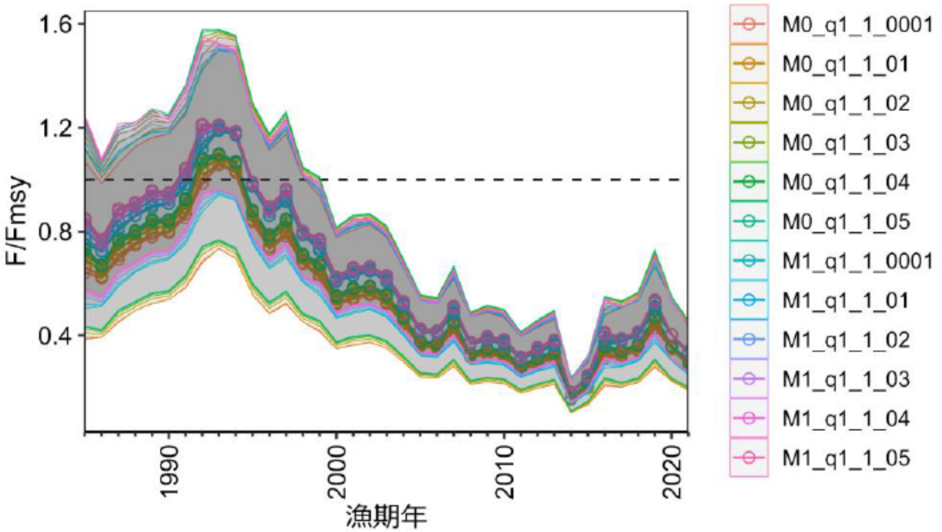
The prior distributions of q1 and $\sigma I1$ were examined in assessment in 2022.
(continued)

(continued)
The results of examining the SD for the prior distribution of q1 at 0.001, 0.1, 0.2, 0.3, 0.4, and 0.5 showed that q1 was below 1 even when the SD was set at 0.1, resulting in a higher estimated biomass (B) than the surviving biomass (D). Because the D was calculated from the female biomass estimated by the VPA, and the total biomass of females and males was calculated by assuming the population and weight ratios of males and females, there is uncertainty derived from these assumptions. For this reason, we considered it appropriate to let the mean of the prior distribution of q1 be estimated to some extent according to the data without fixing it at 1.

We set a standard deviation of 0.3 for the prior distribution of q1 based on the autocorrelation of the residuals, and the presence of retrospective bias. The sensitivity of different SD settings in the prior distribution of q1 is confirmed to be small.

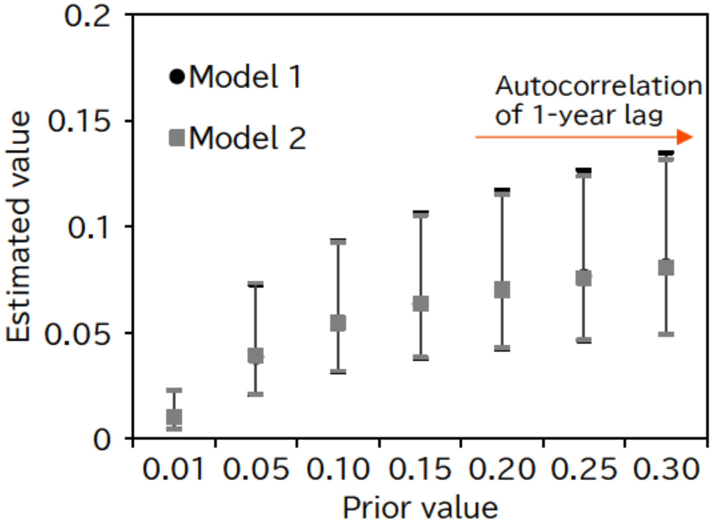


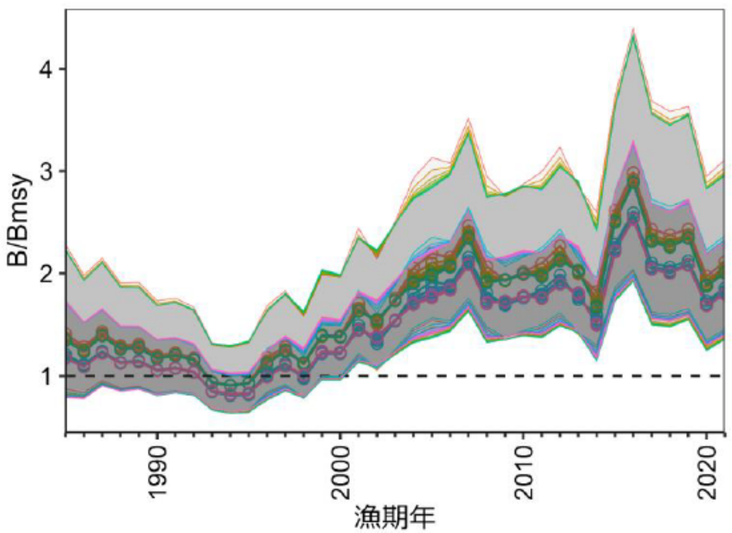


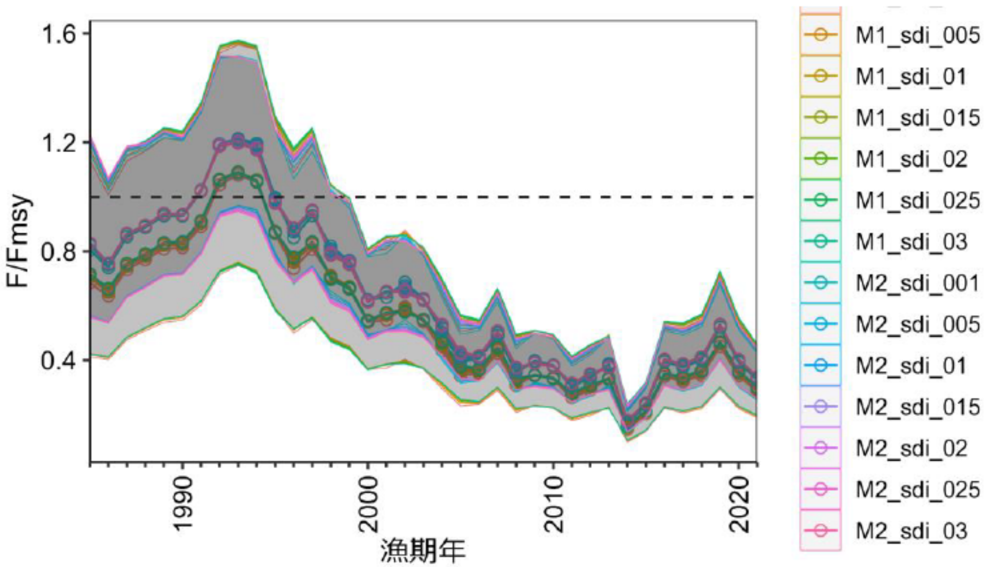


(continued)
The prior distribution of the σI1 was explored in the range of 0.01 to 3 and the SD of 0.5, since estimation without prior information would result in a wide confidence interval for the σI1, making parameter estimation unstable.

As a result, the residuals of the indicator value D showed autocorrelation with a 1-year lag when the mean value of the prior distribution given to greater than 0.2. Since σI1 should not be assumed to be excessively small due to the uncertainty caused by the assumption used to calculate D, the prior distribution for σI1 was set to have a mean of 0.15 and a SD of 0.5, where no autocorrelation in the residuals is observed. The sensitivity of different value settings in the prior distribution of σI1 is confirmed to be small.







Responses to comments received in advance

T07-Biology Has there been any research to estimate biological parameters for this stock? If so, were these results used in the assessment? If so, how were they used?
Research vessel surveys and catch surveys have been conducted for this stock, but they have just started, and sufficient information has not been accumulated. There are no survey results directly used for stock assessment at this stage.
T08-Biology Is there visible sexual dimorphism?
Figure 2-2 shows the sexual dimorphism, in which females are larger, which is often observed in flounder. In flounder, VPA is often performed separately for males and females due to the large size difference caused by sexual dimorphism. The VPA for this stock conducted by HRO also estimates biomass by dividing between males and females. However, due to voluntary regulations to control the catch of small fish, the catch of males became very low in the mid-1990s. As a result, there have been years when male sampling has been inadequate, and the results of male biomass estimates have not been published.

Responses to comments received in advance

T09-Data-Catch & Others How are the catch time series developed for this stock? For example, are the annual total catches by weight from the “Annual Statistics Yearbook”? How are the catches of this species organized in the Yearbook and how are the catches for this stock separated from the other stocks of this species?
Catch of the offshore bottom trawl by month, vessel, and fishing area are available since 1980, along with effort information on the number of hauls. Catch of the coastal fishery is available since 1985 by month, district, and fishing method, but does not include effort information. Older catch information is summarized as flounder.
T10-Data-Catch & Others Is there any uncertainty in the catch?
Since the unit price of this species is low and bycatch is the main source, it is assumed that even if fish are caught, they are discarded or are not sorted by species and recorded as “other” . Uncertainty in catch is assumed to exist, and in SPiCT, a prior distribution with a mean of 0.01 and a standard deviation of 0.001 is given for σC, assuming that an error of about 1% exists in the observation of catch.

Responses to comments received in advance

T11-Data-Catch & Others
How is catch in weight converted into catch in number?

T12-Data-Catch & Others
How is the catch by sex obtained? There is a very large difference in catch by sex (see Fig 3-3) during 1995-2015. What is the cause of that?

The CAA (Fig. 3-3) is cited from the assessment report published by HRO, and the detailed method is not published. We hypothesize that the reason for the decrease in male catch in the 1995-2015 FYs was due to the avoidance of landing small fish with low fish prices, in addition to the avoidance of catching small fish due to voluntary regulations, which led to a large decrease in the catch of smaller males than females.

Responses to comments received in advance

T13-Data-Catch & Others
Given that there was an undescribed VPA model and Fig 3-3 shows catch-at-age by sex, I assume that there is some sort of size or age sampling occurring but this is not described. Please describe any sampling to obtain the sex, size and age distributions of the catch, and show the data?

T14-Data-Catch & Others
Please discuss the catch-at-age data in more detail and explain why it was not used in the primary assessment model. I understand that a production model only uses aggregate catch but an age-structured or delayed-difference model could have been used instead of a production model.

T15-Data-Abundance indices
Most importantly, please explain why the results of a VPA model were used an assessment index. Also please explain the details of the VPA data and model.

The CAA and VPA are cited from an assessment report published by HRO, and the details of the materials and methods are not published. The VPA cannot be implemented in this project because the information necessary to implement the age-structure model is not available at this time. Although this project has just begun to collect biological information, we consider that the implementation of the age-structure model is a medium- to long-term issue.

Responses to comments received in advance

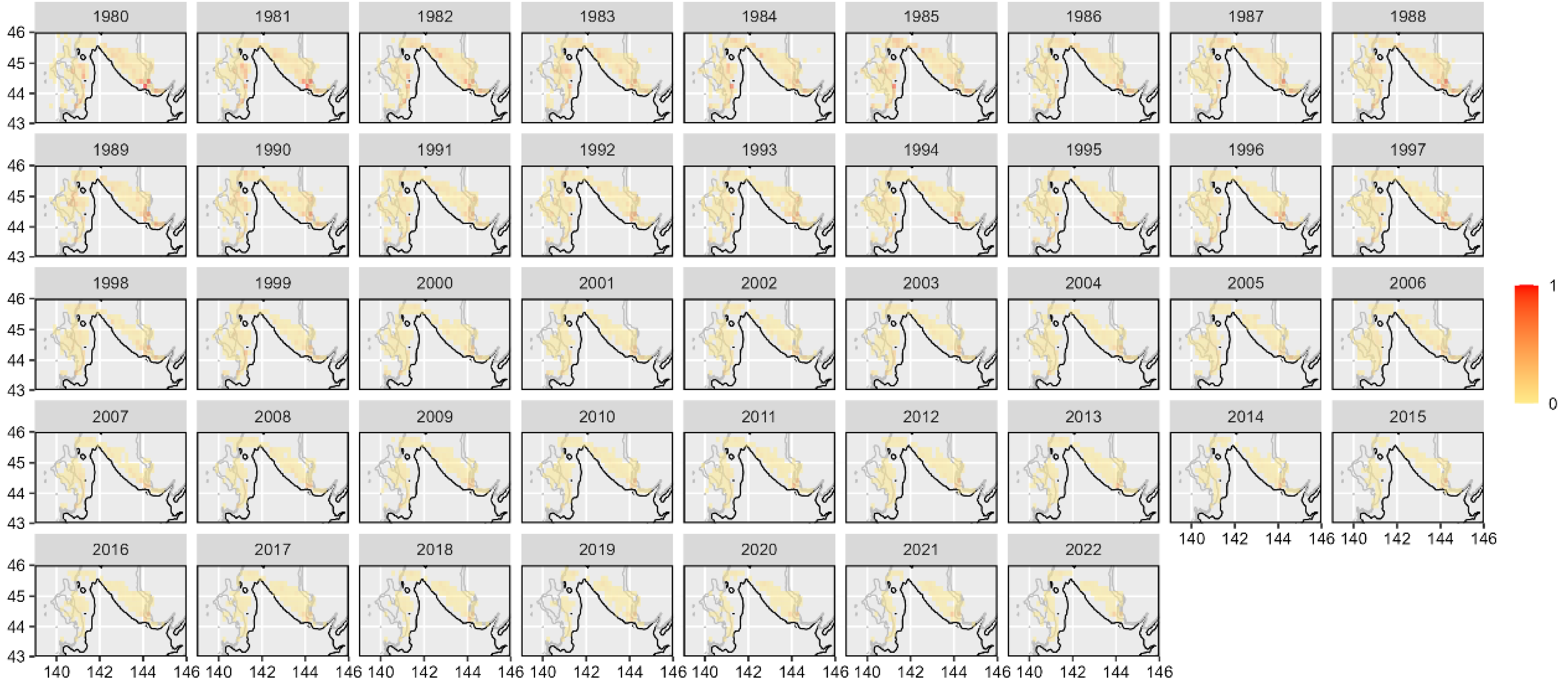
T16-Data-Abundance indices Appendix 3 is not in sufficient detail to review the standardized index. Please provide the document FRA-SA-2023-SC16-101 T17-Data-Abuncance indices Please describe in detail the raw data and standardization of the bottom trawl index.
I have sent you the machine-translated document. The details are shown in the presentation above.
T18-Data Abundance indices What is the size and/or age compositions of the fish in the bottom trawl?
CAA by fishing method are not published by the HRO. Since the majority of the catch of this species occurs on the offshore bottom trawl, especially in recent years, it would be safe to interpret the CAA in Figure 3-3 as they are.
T19-Data Abundance indices Appendix 3 states that the CPUE “was standardized based on aggregated catch reports by month and by vessel for offshore bottom trawl fishery”. Does that mean each line of data is the monthly catch of a single vessel? If so, how is the Lat and Lon obtained?
The description was incorrect. Information on the fishing area was also recorded.

Responses to comments received in advance

T20-Data-Abundance indices How was the effort data obtained? T21-Data-Abundance indices Why were non-zero catch in the lowest 5% water depth excluded? How about the zero catch data? T22-Data-Abundance indices Please explain the DPC model and results, and how that influences the standardized index. T23-Data-Abundance indices Please plot the uncertainty in the standardized index values as well as the observations. Also, please provide details of the model fit. T24-Data-Abundance indices Please plot the nominal CPUE and proportion of zeros. T25-Data-Abundance indices Please plot the relationships between the explanatory variables and CPUE. T26-Data-Abundance indices Is the start year of the index 1980?
The details are shown in the presentation above.

Responses to comments received in advance

T27-Data-Abundance indices
Please plot the locations (or density) of the effort by year.



Responses to comments received in advance

T28-Data Abundance indices Other species and stocks report scientific surveys for demersal fish. Is there any kind of scientific survey for demersal fish in the area?
Last year we began research vessel surveys and catch surveys. Since the accumulation of information is not sufficient, it has not been reflected in the stock assessment.
T29-Model & Diagnostics What is the sensitivity of model and results to the priors used?
Already answered in K02 and T06.
T30-Model & Diagnostics Appendix 2 suggests that the assessment is required to produce SSB estimates rather than total biomass. This suggests that a production model is not appropriate. If a VPA can be performed adequately, it also suggests that a statistical catch-at-age model can also be performed. Please explain why a production model was used instead.
Our guideline (FRA-SA2022-ABCWG02-01) recommend the use of age-structured models when available, but when not available, it is recommended that appropriate stock assessment models be used to evaluate biomass estimates and their uncertainties. As previously explained, the age-structured model is not available for this stock. Before 2021, only relative levels and trends were assessed by CPUE and catch, but starting with the 2022 assessment, biomass can be estimated by PM. Information is being collected on various aspects toward the introduction of the age structure model.

T31-Model & Diagnostics Is there a need (for management or other reasons) to provide SSB or female SSB?
Because male catches are sometimes extremely low and samples are not available, the biomass is estimated for females only in the VPA conducted HRO.
T32-Model & Diagnostics How was the uncertainty in catch represented in the model? T33-Model & Diagnostics Please provide the priors and posteriors of the models.
The details are shown in the presentation above.

Responses to comments received in advance

T34-Model & Diagnostics Given that there is sexual dimorphism in growth after maturity, and growth is related to natural mortality, why assume a 1:1 ratio of male:female for all ages.
There is insufficient information on age-by-sex ratios and a poor basis for making assumptions.
T35-Model & Diagnostics Is the difference between the Models 1 and 2 just the priors? These priors appear somewhat arbitrary. Please explain why and how these prior distributions were developed.
The only difference between models 1 and 2 is the standard deviation of the prior distributions of r and n. As mentioned above, the expected value of r is obtained from FishLife. In FishLife, r is estimated assuming Schaeffer-type shape parameters, and for other shape parameters, the expected value of r must be transformed in some way, but the method is not clear. In using the expected value of r from Fishlife for the prior distribution, if there are no significant problems in matching the data, the Schaeffer type can be assumed because it is consistent with the prior distribution of n and r.
T36-Model & Diagnostics Please explain Suppl Fig 2-5 in more detail. I am not used to looking at these.
The details are explained in the presentation above.

Responses to comments received in advance

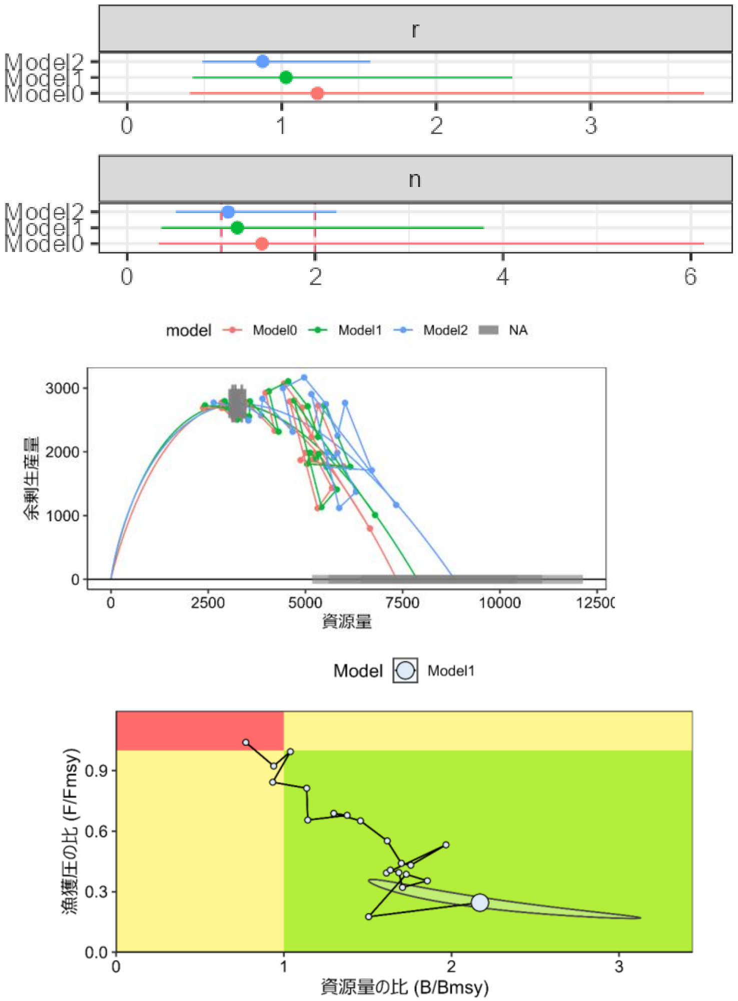
T37-Model & Diagnostics Please show the model fit to both indices, together with uncertainties.
The details are shown in the presentation above.

T38-Model & Diagnostics Importantly, please show and compare a model run that is fit to just the bottom trawl index.
In conjunction with comment K03, here are the results of the PMs that were adapted for D or CPUE only.

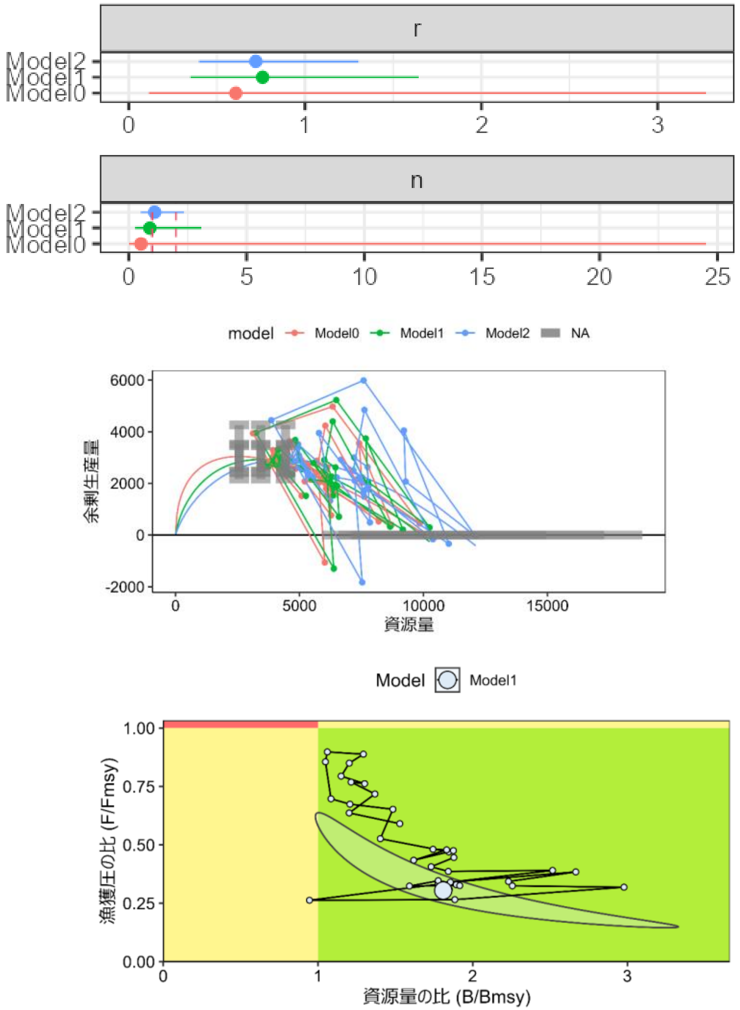
Data	Surviving biomass (D)	Standardized CPUE	D and CPUE (base-case)
Data period	1995-2015	1985-2022	1985-2022
Prior settings			
q	1.0 (SD=0.3)	w/o prior	q1=1.0 (SD=0.3), q2 w/o prior
σI	0.15 (SD=0.5)	w/o prior	σI1=0.15 (SD=0.3), σI2 w/o prior
σC	0.01 (SD=0.001)		
Model 0	w/o priors for n and r		
Model 1	n=2.0 (SD=1.0), r=0.32 (SD=1.0)		
Model 2	n=2.0 (SD=0.5), r=0.32 (SD=0.5)		

Responses to comments received in advance

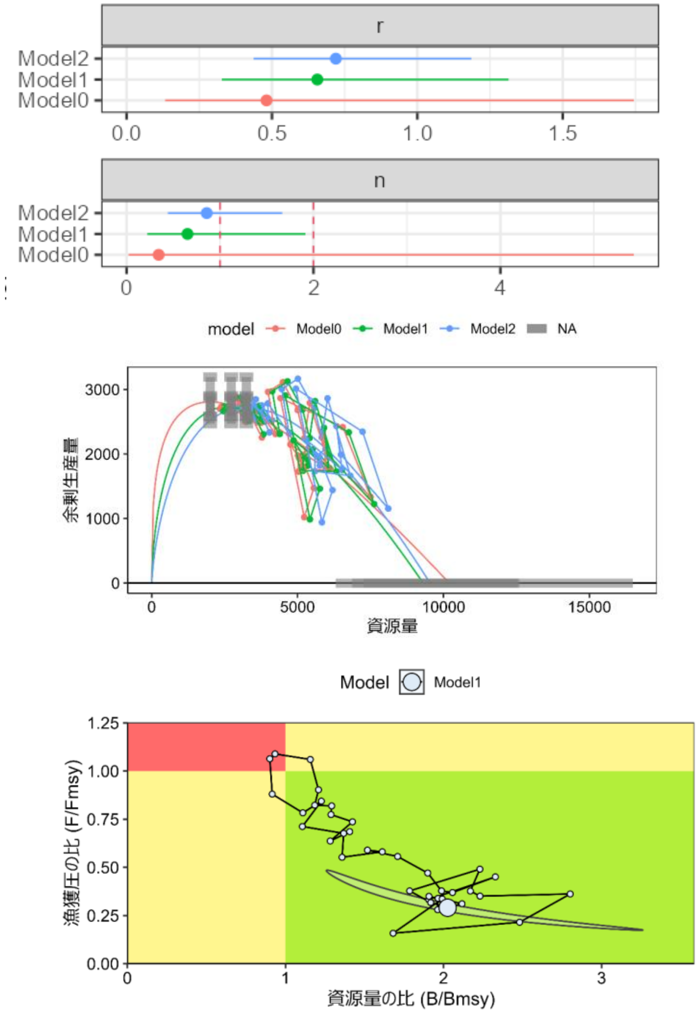
Surviving biomass only



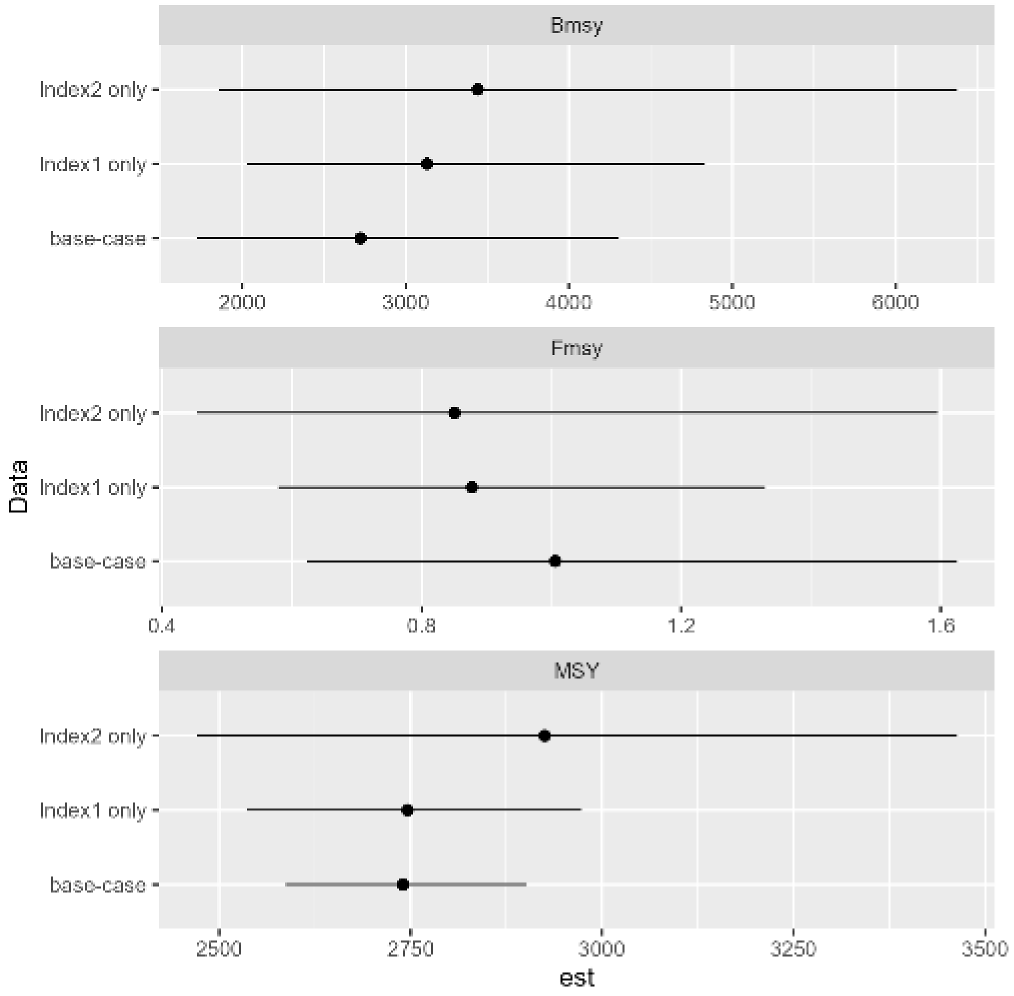
CPUE only



Base-case



Responses to comments received in advance

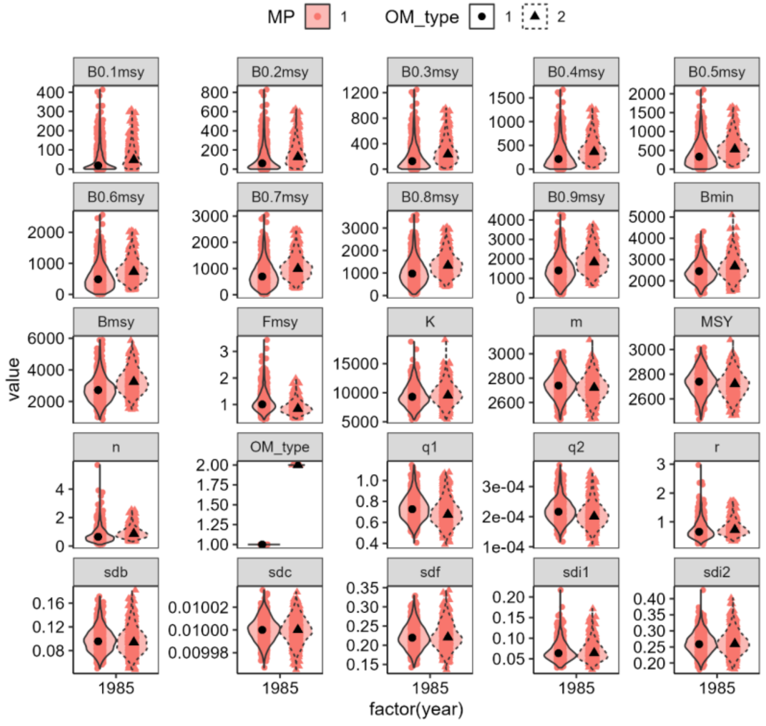


Responses to comments received in advance

T39-Model & Diagnostics Please show the model convergence statistics.
The calculations are convergent for all models.
T40-Model & Diagnostics Did you do posterior predictive checks? If so, please show the results.
Not performed because of maximum likelihood estimation by TMB.
T41-Model & Diagnostics Why start the model in 1985, when the index starts in 1980 and the catch data even earlier?
This is because catches from offshore bottom trawl fisheries are available from 1980, but catches from coastal fisheries are only available from 1985.

Responses to comments received in advance

T42-Projections
Overall, this assessment has done a better job in propagating uncertainties from the estimation model into the projections. However, the documentation is a bit unclear. Seems like some uncertainty was included but not others. Given that the model produces uncertainties in the estimated biomass and productivity parameters, how were these uncertainties included in the projections?



Both fixed and random effects uncertainties, as well as correlations among the estimated parameters, are considered in the future projections. When *l* parameters estimated (fixed and random) by the production model are expressed as $\hat{\theta}_t$ and its precision matrix as $\hat{\Sigma}_t$, random sets of parameters of $\theta^j = \left(\theta_1^j, \theta_2^j, \dots, \theta_L^j\right)$ are produced by multinomial distribution of $\theta_l^j \sim MVN\left(\hat{\theta}_l, \hat{\Sigma}_l\right)$.
In this case, $\hat{\theta}_l = \left(\widehat{m_l}, \widehat{n_l}, \widehat{K_l}, \widehat{q_{1l}}, \widehat{q_{2l}}, \widehat{\sigma_{I,1,l}}, \widehat{\sigma_{I,2,l}}, \widehat{\sigma_{C,l}}, \widehat{\sigma_{F,l}}, \widehat{\sigma_{B,l}}, \widehat{B_t}, \widehat{F_t}\right)(t < 2022)$. The produced random sets of $\hat{\theta}_j$ are used for the jth iteration of the stochastic population dynamics in the future projection, after filtering out unrealistic sets of parameters. The resulting uncertainty reflected in the future projection is shown in Supplementary Figure 6-1, which shows the distribution of each parameter. More detailed explanation of the method is explained in FRA-SA2023-BRP03-101-MSE.pdf.

Responses to comments received in advance

T43-Projections
What is the prediction skill of the projections, especially the 1 to 2 year projections.

	2-year projection Assessment data set of FY2022	1-year projection Assessment data set of FY2023	Estimation Assessment data set of FY2024
B2023	6.2 ktons (4.4 k-8.6 ktons)	6.2 ktons (4.5 k-8.6 ktons)	6.0 ktons (4.5 k-8.0 ktons)

Hindcast is considering it as a future issue.

T44-Others
What are the potential improvements for this assessment?

Considering transition to an age-structured model in the medium to long term.

T45-Others
Given the contrast in the catch, effort, and CPUE of this stock appears higher in the early part of the data and model. Is there a possibility to extend the data and model to an earlier period?

This is difficult because total catch information of this stock is not available before 1984.

Responses to comments received in advance

T46-Others Were there uncertainties or sensitivities not included here?
The results of some sensitivity analyses are presented additionally.
Y01 本種はカムチャツカ半島西岸, 北千島にも分布しているとのことだが, 本系群との関係は？（連続していない？　また, 樺太（サハリン）南部には分布しない？　いわゆる「跨り資源」と考える必要はないか？） This species is also known to occur on the west coast of the Kamchatka Peninsula and the Northern Kuril Islands, but what is its relationship to this stock? (Is it not continuous? Is it not distributed in the southern part of Sakhalin? Is it necessary to consider it as a so-called “straddling stock”?)
T02への回答の通りで、跨がり資源とは考えていません。 As per the response to T02. It is not considered a straddling resource.
Y02 他の魚種・系群と同様に, 年齢に対する成熟割合のグラフを示しておいてはどうか？ As with other stocks, why not show a graph of the percentage of maturity versus age?
現時点では齢構成モデルによる資源計算を実行していないため掲載していません。板谷・藤岡（2006）で年齢別成熟率は調べられているので、掲載について検討します。 At this time, the stock assessment based on the age-structured model have not been performed, so the data is not shown. Itaya and Fujioka (2006 in Japanese) have examined the maturity rates by age, and we will consider indicating the information.

Responses to comments received in advance

Y03 2014年以降, 沿岸での漁獲量が大きく低下したが, それはなぜか？ Since 2014, the coastal catch has declined significantly; why is that?
数値データはありませんが努力量が減少したためと考えています。刺網では網揚げ後の魚を網から外すのに手間がかかりますが、魚価安が進んで人件費がかけられずソウハチを狙った操業が行われなくなったと考えています。 Although no numerical data is available, it is assumed that this is due to a decrease in the amount of effort. Since gill nets require labor to remove the nets after landing, we consider that the low price of fish has made it difficult to spend on labor costs and operations targeting this species are no longer conducted.
Y04 1990年代後半以降, 2014年頃まで, 雌の漁獲量に比べて雄の漁獲量が極端に少なくなっているが, それはなぜか？雌雄別の分布域の変化？ Since the late 1990s until about 2014, male catches have been extremely low compared to female catches, why? Changes in the distribution area by sex?
自主規制と魚価安による小型魚の漁獲回避が生じたためと考えられます。性的二型によって雄は小型であるため、小型魚の漁獲回避によって雄の漁獲量が極端に減少しました。同時期に雌でも小型若齢の割合が減少しています。 This is thought to be due to avoidance of fishing for small fish due to voluntary regulations and low fish prices. Because males are small according to sexual dimorphism, the avoidance of catching small fish has resulted in an extreme decrease in the catch of males. At the same time, the catch of small young fish decreased for females as well.

Y05
また, 2015, 2016年から雄の漁獲量が急激に増えているが, それはなぜか？

Male catches have increased dramatically since 2015 and 2016, why is that?

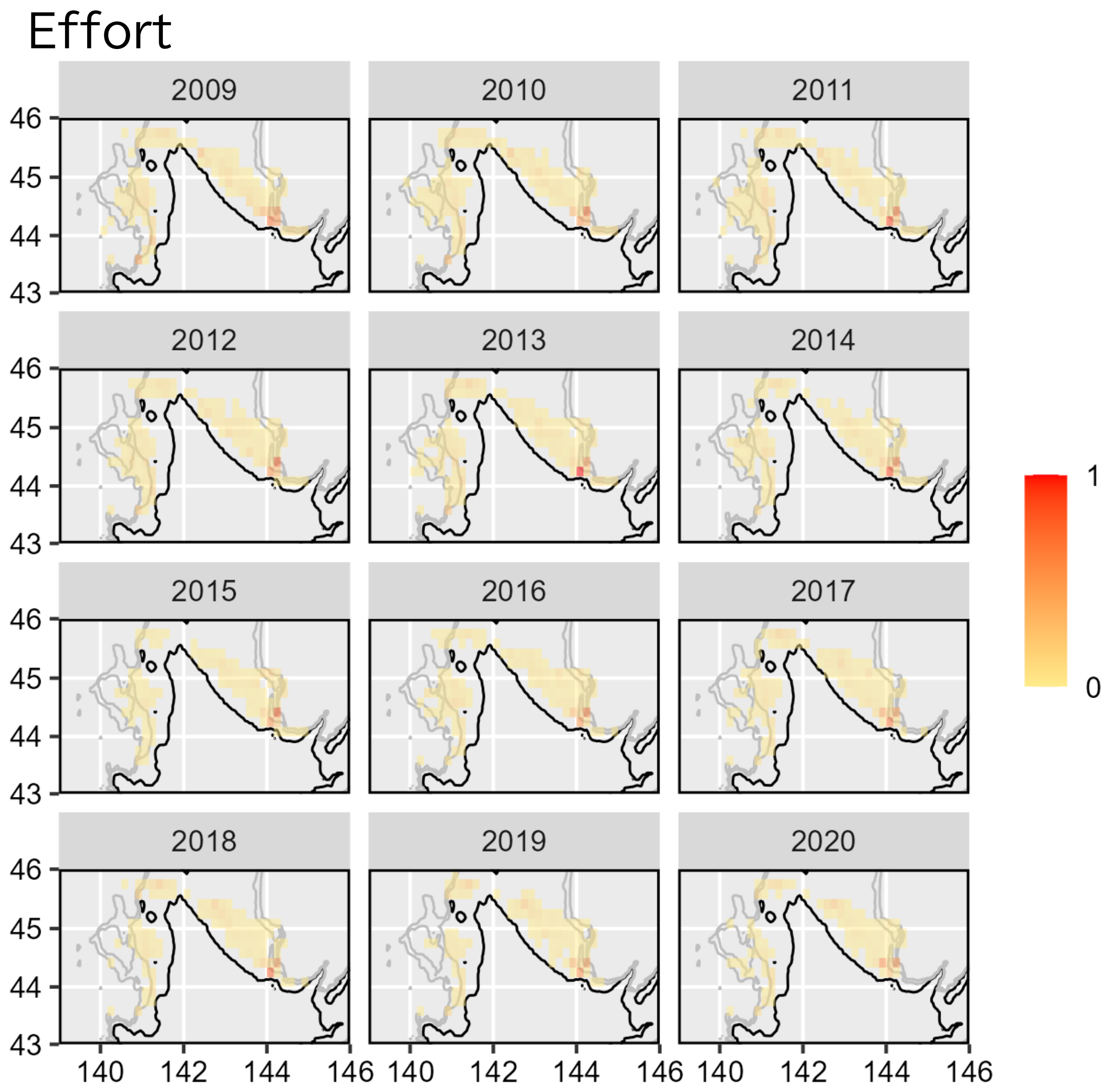
Y06
本文中には「2016～2019年漁期は, 小樽において海外向けの販路拡大で需要が高まったことから積極的にソウハチを狙う操業が行われた」とあり, 確かに, 雌の漁獲量の変化を見ると, 図4-4で示された漁獲係数Fの変化に相当するであろうと思われる程度の漁獲量変化があるように思えるが, 雄についてはそれだけでは説明しきれないようにも思える。何か, 分布域の急激な変化や, 操業する漁場の変化のようなものは想定されないか？

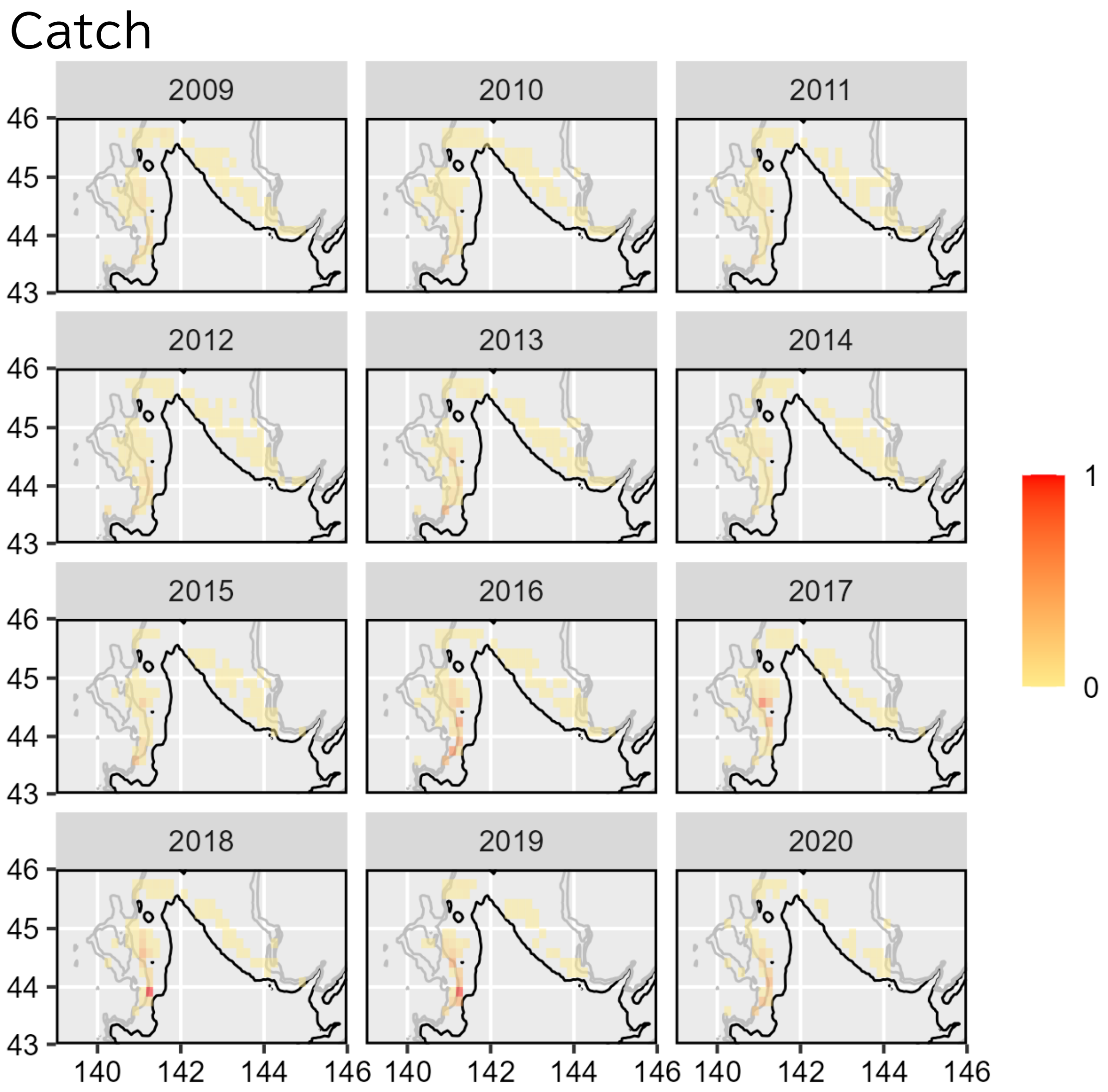
In the text, it is stated that “During the 2016-2019 fishing season, operations were aggressively conducted in Otaru to target pointhead flounder as demand increased due to the expansion of overseas sales channels,” and indeed, looking at the change in catch of females, there seems to be a change in catch to a degree that would correspond to the change in catch coefficient F shown in Figure 4-4. However, this does not seem to be enough to explain the change in the catch of males. Is there anything that can be assumed, such as a sudden change in the distribution area or a change in the fishing grounds in which they operate?

沖合底びき網漁業の主要なターゲットであるスケトウダラやホッケの漁獲規制と漁獲不振に加えて、ソウハチの海外向け販路拡大があってソウハチ狙いの操業が行われて漁獲圧が上昇したことによって小型魚が再び漁獲されたと考えられます。また、無選別サイズの銘柄“バラ”が新設されたことによる影響もあると考えています。

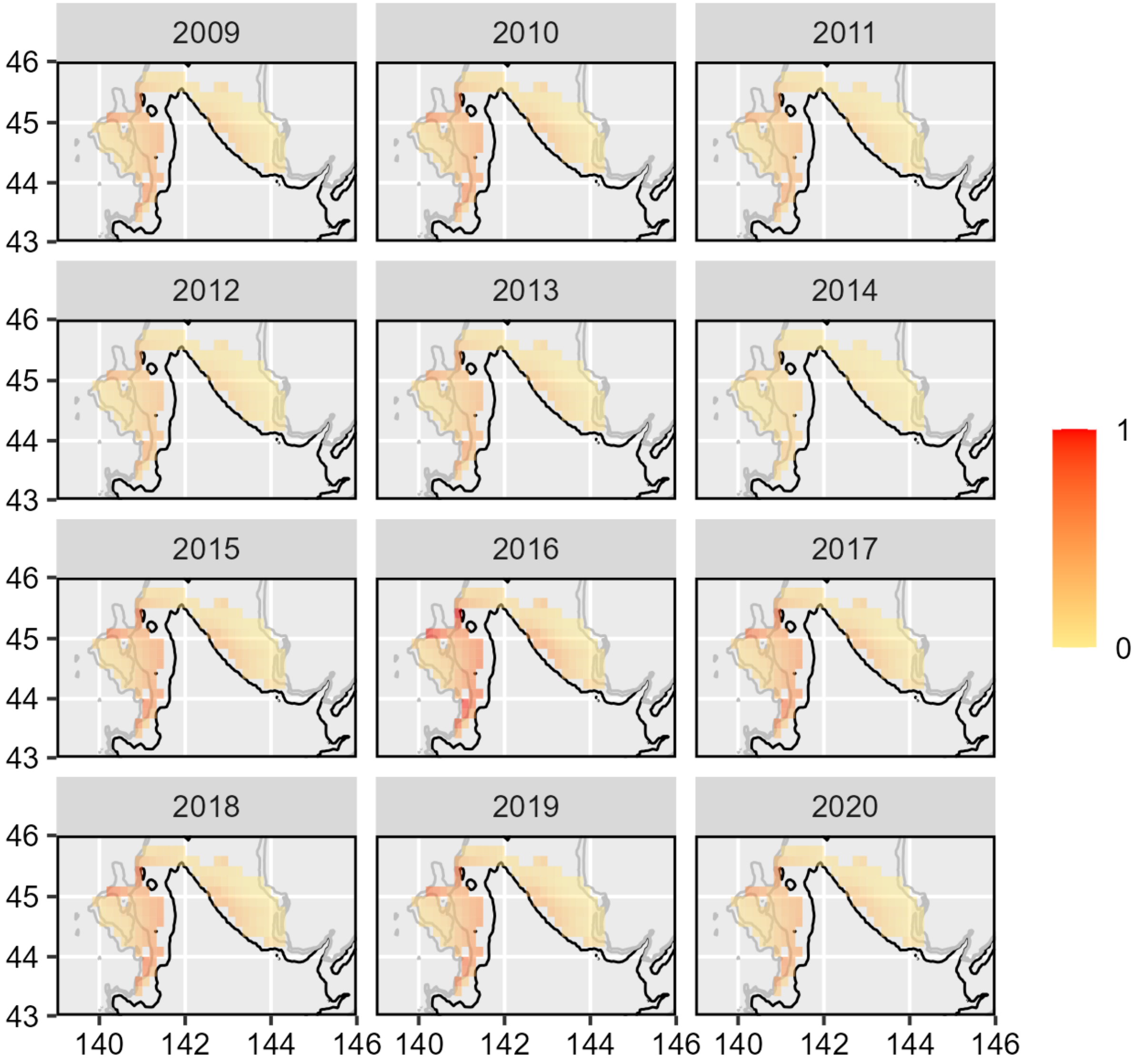
The catch restrictions and poor catches of walleye pollock and arabesque greenling, the main targets of the offshore bottom trawl fishery, and the expansion of sales channels for PF to overseas markets led to operations targeting PF and increased F, which again led to catches of small fish. We also consider that the establishment of the “bara” brand of non-selected sizes has also had an impact.

Responses to comments received in advance





Standardized CPUE



2009～2020年の努力量、漁獲量、標準化CPUEをマッピングして確認しましたが、分布や漁場の顕著な変化は認められませんでした。オスの漁獲量増加は、資源量の増加と漁獲圧の上昇によるものと考えられます。

Effort, catch, and standardized CPUE were mapped from 2009 to 2020, but no significant changes in distribution or fishing grounds were observed. The increase in male catches can be attributed to increased biomass and fishing mortality.

Responses to comments received in advance

Y07 積み上げ棒グラフだけではなく、年ごとのヒストグラムを縦に並べる等により、漁獲物の年齢組成の経年変化（あるいは体長組成の経年変化）をより明瞭に見通すことができるような図も作成してみてはいかがか？ Why not create not only a stacked bar chart, but also a vertical histogram for each year, etc., so that we can more clearly see changes in the age composition of the catch over time (or changes in length composition over time)? Y09 Catch at ageデータを使用せずSPiCTで評価を行っている理由は？ Why are you using SPiCT instead of Catch at age data for assessment?
年齢別漁獲尾数の図は道総研の出版物から引用しており改変することはできません。生データの利用もできません。 CAA cannot be modified as it is cited from a publication of HRO. Raw data is also unavailable.

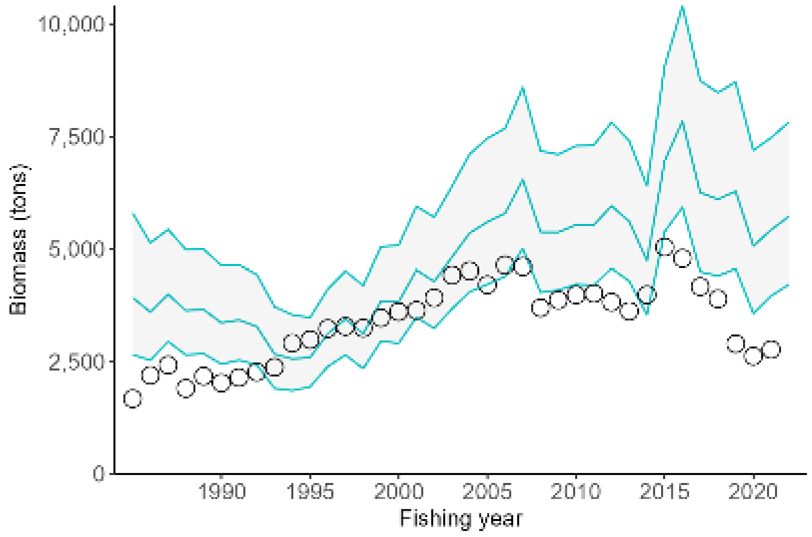
Y08

図4-1に, VPAから推定された雌資源量から換算した残存資源量の推移折れ線グラフが2015年頃まであって, これは道総研による結果とのことだが, それ以後については道総研はVPAを行っていない？ また, 道総研の資源評価結果と本評価結果の間に違いは見られるか？

In Figure 4-1, there is a line graph of the surviving biomass converted from the estimated female biomass based on the VPA until around 2015, which was the result by HRO. Are there any differences between the results of this assessment and those of HRO's VPA?

2023年度の道総研の資源評価では2021年漁期までの雌資源量が推定されています。

The VPA of HRO has estimated female biomass through the 2021 fishing season in 2023 year's assessment.

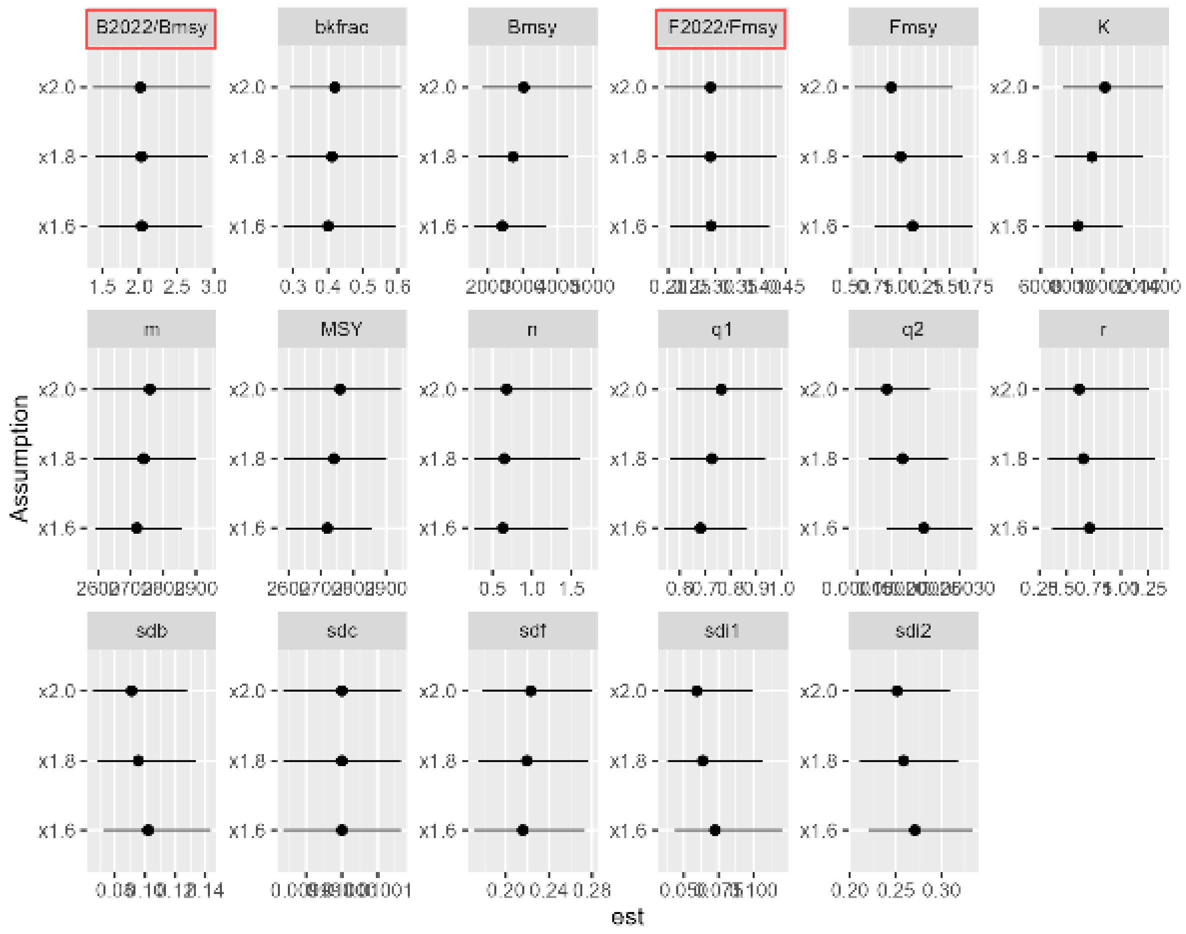


Blue: Biomass estimated using SPiCT

○: Female biomass estimated using VPA (by HRO)

Responses to comments received in advance

Y10
指標値I1を作成するにあたっての雌雄比等に関する仮定が全体の資源評価結果に与える影響はどうか？
What is the sensitivity of the assumptions made regarding sex ratio, etc. in developing the index I1 to the results of the overall stock assessment?



雌資源量を1.8倍にするベースケースのほか、1.6倍と2.0倍の場合の推定結果を示しました。性比と体重比を一定と仮定している限りは、q1を固定せずにデータにフィットさせて推定させることでBの推定結果に対する仮定の感度は小さいと考えています。特にB2022/BmsyやF2022/Fmsyは頑健であり、資源評価結果への影響はほぼありません。

In addition to the base case with a 1.8-fold increase in female biomass, we present estimation results for two patterns, 1.6-fold and 2.0-fold. We assume constant sex and weight ratios and q1 is estimated by fitting the data without fixing, so we consider that the sensitivity of the assumption on the estimation of biomass is small. In particular, B2022/Bmsy and F2022/Fmsy are robust and have almost no impact on the assessment results.

Y11
太平洋十年規模振動(PDO)指数が資源量変動そのものに影響を与えるのだとすると，CPUE標準化の説明変数にPDOを入れることによって，標準化の結果として抽出された経年的な資源量変動傾向(年効果)にバイアスをもたらしてしまうことになりはしないか？

If the Pacific Decadal Oscillation (PDO) index affects the variability of abundance itself, wouldn't the inclusion of the PDO as an explanatory variable in the CPUE standardization introduce a bias in the trend in abundance variability over time (year effect) extracted as a result of the standardization?

PDOは気候変動によって魚の季節的な移動による漁場形成の変化(漁獲効率の変化)を考慮するための説明変数として入れています。当初は月または四半期と漁期年の交互作用項をこのための説明変数の候補として検討していましたが、これらの場合は欠測が生じるためにPDOを説明変数の候補としました。資源量変動そのものの影響を与える可能性もゼロではありませんが、PDOを説明変数から除いても結果に大きな変化はありません。

PDO is included as an explanatory variable to account for changes in the formation of fishing grounds (changes in fishing efficiency) due to the seasonal movement of fish due to climate change. We initially considered an interaction term between month or quarter and fishing year as a candidate explanatory variable for this purpose, but because of the missing data in these cases, the PDO was chosen as a candidate explanatory variable. There is no possibility that the PDO could have an effect on the stock fluctuations themselves, but removing the PDO from the explanatory variables does not significantly change the results.

Y12
資源量変動傾向そのものに関する魚種間の相関がある場合, 魚種組成の第1主成分スコア, 第2主成分スコアを説明変数に入れることによって, 標準化の結果として抽出された経年的な資源量変動傾向(年効果)にバイアスをもたらしてしまうことになりはしないか？

If there is a correlation between fish species regarding the trend of stock fluctuation itself, won't the inclusion of the first and second principal component scores of fish species composition as explanatory variables lead to a bias in the trend of fluctuation in stock abundance over time (annual effect) extracted as a result of standardization?

平方根処理はおこなっていますが漁獲物の魚種組成を用いているため影響が全くないとは言えないと思いますが、Winker et al. (2014)においてシミュレーション検証がおこなわれており、問題ないことが示されています。

Although the square root treatment is used, the species composition of the catch is used, so it cannot be said that there is no impact at all, but Winker et al. (2014) conducted a simulation verification and found no problem.

Y12 (continued) CPUE標準化法と, Biseauの抽出法によるDirected CPUEを用いて計算する方法の, 両手法による結果を比べてみるとどうだろうか？ How would you compare the results from both the CPUE standardized method and the Directed CPUE with Biseau's extraction method?
本資源は混獲がメインとなるためBiseauの方法によるフィルタリングを行うと極端にデータ数が少なくなります。標準化CPUEの検討過程でDirected CPUEも候補にあがりましたが、ソウハチ狙いの操業がおこなわれたと考えられる2016-2017年漁期のCPUEの増加がノミナルCPUEの場合を大きく上回る非現実的な結果となり不採用となりました。 Because this stock is mainly bycatch, filtering using Biseau's method results in an extremely low number of data. Directed CPUE was also a candidate in the process of considering standardized CPUE, but was not adopted because the increase in CPUE for the 2016-2017 fishing season was unrealistically much greater than for nominal CPUE.
Y13 報告書におけるModel1とModel2の違いの記述が分かりにくい。 The description of the difference between Model 1 and Model 2 in the report is confusing.
Model1とModel2ではnとrにおける事前分布の標準誤差のみが異なります。分かりやすくなるように報告書の体裁を再検討します。 Model1 and Model2 differ only in the standard deviation of the prior distribution at n and r. We will reexamine the report style for clarity.

Responses to comments received in advance

Y14
形状パラメータnの値の推定結果は信頼区間も勘案するとほぼ1に近い値。つまり本系群の資源動態モデルはほぼGompertz増殖曲線に従うとみなしても良いのではないか？　Pella-Tomlinsonモデルよりもパラメータ数が1つ少ない節約的モデルとしてのGompertz増殖モデル(=Fox余剰生産量モデル)での当てはめも行ってみて, WAIC, WBICでモデル選択を行ってみてはどうか？

The estimated result of the value of the shape parameter n is close to 1 when the confidence interval is also taken into account. In other words, can we assume that the stock dynamics model for this stock follows almost the Gompertz growth curve. How about fitting the Gompertz growth model (= Fox surplus production model) as a parsimonious model with one less parameter than the Pella-Tomlinson model, and then selecting the model by WAIC and WBIC?

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計算上はGompertzやFoxモデルとすることで推定パラメータは節約的になるとは考えられますが、それらのモデルに基づいた計算プログラムの選定や開発には長い時間と大きな労力を必要とします。また、将来予測やMSEもSPiCTの使用を前提に開発されています。現在使用しているPella-Tomlinsonモデルに基づくSPiCTを本事業の資源評価で利用するにあたり、学術論文としてピアレビューを受けた上で公表されているプログラムであること、海外での利用実績があること、汎用性が高いことなどから選定がおこなわれました。SPiCTに重大な問題や、その他のモデル・プログラムに大きな優位性がない限り、新たなモデルやプログラムの選定や開発は現実的ではありません。また、shape parameterは資源量や管理基準値の推定に大きな影響を与えながらも、推定が難しい不確実性の高いパラメータです。shape parameterを1に固定したモデルを用いることはnの不確実性、ひいては、プロダクションモデルによる資源量推定値の不確実性の過小評価に繋がる恐れがあるため、nは（緩い事前分布は与えるものの）推定パラメータとして扱っています。それによって、nの不確実性を将来予測や管理方策の選択において考慮できるという点で利点があります。

Although it is thought that the estimated parameters can be parsimonious estimated by using the Gompertz or Fox model, the selection and development of a calculation program based on those models requires a long time and a great deal of effort. Future projections and MSEs have also been developed based on the use of SPiCT. SPiCT based on the Pella-Tomlinson model, which is currently in use, was selected for use in the stock assessment of this project because it is a program that has been peer-reviewed and published as an academic paper, has been used overseas, and is highly versatile. The selection and development of a new model or program is not realistic unless there are serious problems with SPiCT or significant advantages in other models or programs. Although the shape parameter is a highly uncertain parameter that has a large impact on the estimation of biomass and reference points, it is also difficult to estimate. Since using a model with the shape parameter set to 1 may lead to an underestimation of the uncertainty of n, and thus of the uncertainty of the biomass estimates from the production model, n is treated as an estimation parameter (although a week prior distribution is given). This has the advantage that the uncertainty of n can be taken into account in future projection and in the selection of management procedure.

Y15
図4-2に示した余剰生産量曲線に，補足図5-1bの漁獲管理規則案（縦軸が漁獲量）を重ねて描画し，さらにその図中に各年の（Bt, Ct）をプロットして示すようにしてはいかがか？　そのような図は，神戸プロットの縦軸を漁獲量Ctに変換して示したバージョンとして，歴史的な（Bt, Ct）の変遷を，余剰生産量曲線，漁獲管理規則と対比しながら概観する図として用いることができる。
　さらに，横軸を資源量Btではなく，I=qB の関係を使って資源量指数Itに変換して表示するようにすれば，各年の標準化資源量指数Itの値と漁獲量Ctの値の組み合わせを直接プロットすることが可能となる。この場合，横軸・縦軸の両軸ともに実際のデータを使ったプロットであり，推定に伴う不確実性をさらに低減した，直接的な表示が可能となる。

The diagram showing the surplus production curve shown in Figure 4-2 overlaid with the proposed HCRs in Supplementary Figure 5-1b, and then plotting (Bt, Ct) for each year in the diagram, is a version of the Kobe plot with the vertical axis converted to catch Ct. This figure can be used to overview the past trends of (Bt, Ct) in comparison with the surplus production curve and HCRs. Furthermore, if the horizontal axis is converted to a abundance index It using the relationship I=qB instead of biomass Bt, it is possible to plot directly the combination of the value of the standardized abundance index It and the value of catch Ct for each year. In this case, both the horizontal and vertical axes are plotted using actual data, which further reduces the uncertainty associated with estimation and allows for a direct display.

Y15 (continued)
さらに，このような図によるアウトプットを前提とする場合，資源評価モデルにも以下のような改良が考えられるのではないか。

Furthermore, if we assume the outputs from such a diagram, the following improvements to the resource assessment model may be possible.

例えばGompertz増殖モデル(=Fox余剰生産量モデル)の場合，

For example, in the case of the Gompertz growth model (= Fox surplus production model)

$$\frac{\mathrm{d}B}{\mathrm{d}t} = rB(\ln K - \ln B) - C$$

この式はB_{MSY}およびMSYをパラメータとして，以下のように変形できる。

This equation can be transformed with BMSY and MSY as parameters as follows

$$\frac{dB}{dt} = MSY\frac{B}{B_{MSY}}\left(1 - \ln\frac{B}{B_{MSY}}\right) - C$$

さらに，この式を離散型モデルとして書き直すと以下のようになる。

Furthermore, this equation can be rewritten as a discrete-type model as follows

$$B_{t+1} - B_t = MSY\frac{B_t}{B_{MSY}}\left(1 - \ln\frac{B_t}{B_{MSY}}\right) - C_t$$

Y15 (continued)
この式は，パラメータ(B_{MSY}, MSY)にもとづく式であり，パラメータ(r, K)の組み合わせよりもパラメータ間の相関が小さいと期待できる。また，管理基準値を直接のパラメータとしているため，SPiCTで用いられるようなパラメータ変換の段階を経るよりも，管理基準値の推定誤差をさらに軽減できる可能性がある。

This equation is based on the parameters (B_{MSY}, MSY) and is expected to have a smaller correlation among the parameters than the combination of parameters (r, K). In addition, since the reference point values are used as direct parameters, the estimation error of the reference point values may be further reduced rather than going through a parameter transformation step as used in SPiCT.

さらに，この式に $I = qB$ の関係を代入して

Furthermore, substituting the relation $I=qB$ into this equation

$$\frac{I_{t+1} - I_t}{q} = MSY \frac{I_t}{I_{MSY}} \left(1 - \ln \frac{I_t}{I_{MSY}}\right) - C_t$$

とすれば，上で提案した横軸をIとする管理図とともに用いることで，各年における資源量B_tの推定を経ることなく，資源量指標値Iと漁獲量Cの関係にもとづく，より直接的な(データに直接的に基づく)管理が可能となるのではなかろうか？(ここでI_{MSY}はMSYを与える資源量指標値の水準である。)

By using the management chart proposed above, it may be possible to manage more directly based on the relationship between the abundance index value I and the catch C, without having to estimate the biomass Bt in each year. (where I_{MSY} is the level of abundance index value that gives MSY).

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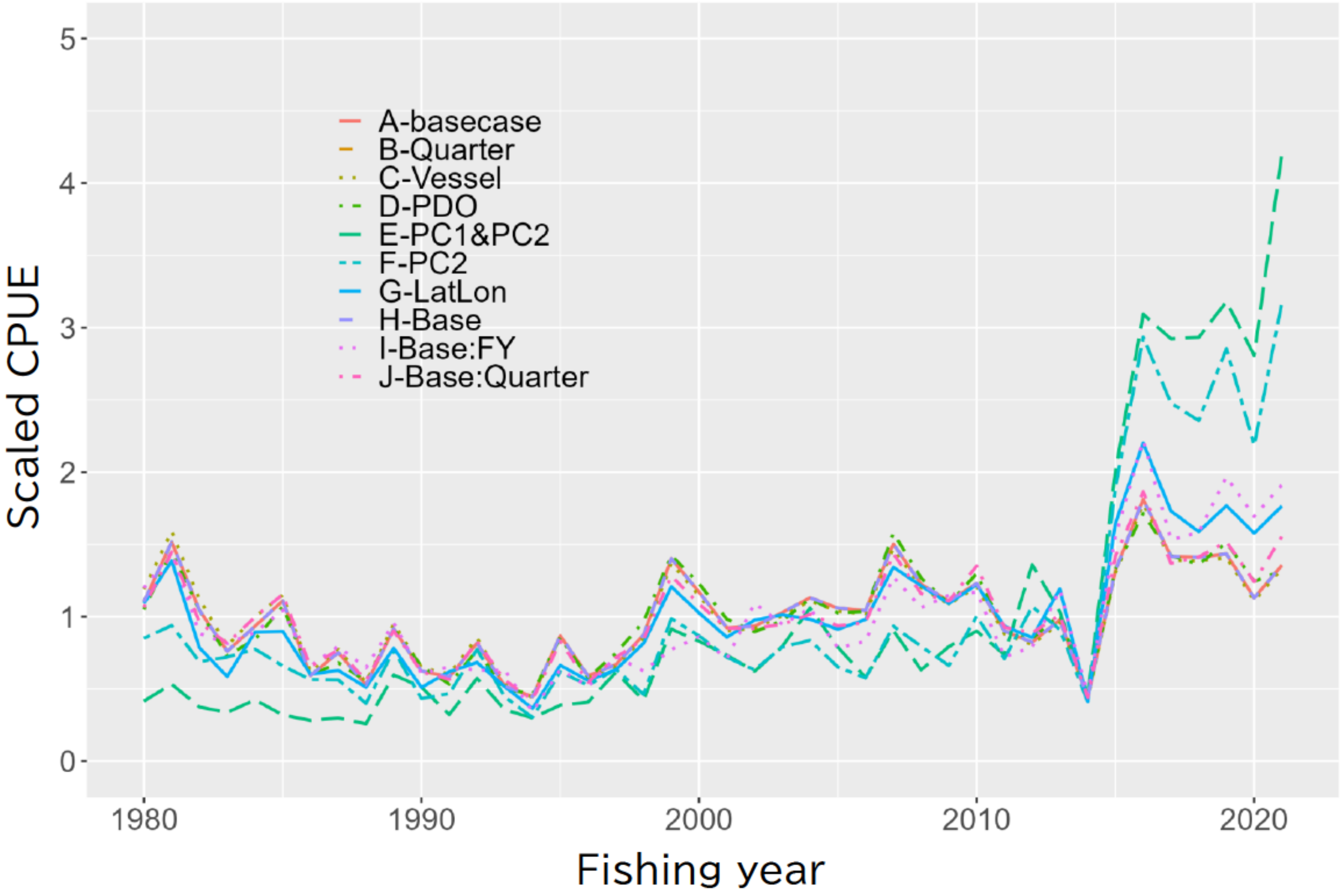
新たなモデルの式と漁獲管理規則のアイディアありがとうございます。前述したように、現状では、資源評価モデルとしてはSPiCTを今後とも継続して利用することが良いと考えています。一方、漁獲管理規則については、算定指針において1C系の漁獲管理規則が明示的に示されておらず、MSEで頑健性が確かめられたものを用いることとのみ書かれています。現状は1Aに似た漁獲管理規則を採用しましたが、ご指摘のように資源量指数等の不確実性を考慮したより頑健な漁獲管理規則の検討の余地は大いにあると考えています。本資源で実施しているMSEでは、将来予測年において、プロダクションモデルを毎年適用してABCを計算するプロセスを再現しておりますが、その部分をより推定が容易なGompertzモデルに変えるなどの工夫もできると思います。具体的には、真のnは1ではないが、1を仮定したGompertzモデルによって推定されるI_MSYを用いた、漁獲量ベースのHCRでABCを計算したときのパフォーマンスなども評価できると思います。ただ、漁獲管理規則の決定については、ステークホルダーからの要望も考慮する必要があるため、現場のニーズも踏まえて、必要であれば将来的に検討したいと思います。

Thank you for the new model equation and ideas for HCRs. As mentioned above, under the current situation, we believe that it is better to continue to use SPiCT as the stock assessment model in the future. On the other hand, our guideline does not explicitly state the HCRs for the 1C stock, but only that those that have been confirmed to be robust by MSE should be used. Currently, we have adopted HCRs similar to 1A, but as you pointed out, there is much room to consider more robust HCRs that take into account uncertainties such as stock abundance indices. In the MSE conducted for this resource, the process of calculating ABC is reproduced by applying the production model every year in the future projection year, but I think we can devise a way to change that part to the Gompertz model, which is easier to estimate. Specifically, I think we could evaluate the performance, for example, when ABC is calculated with a catch-based HCR using I_MSY estimated by the Gompertz model, which assumes 1, although the true n is not 1. However, we need to take into account the needs of stakeholders in determining catch management rules, so we would like to consider this in the future, if necessary, based on the needs of the field.

Additional figure



CPUE annual trends when some explanatory variable(s) is(are) removed.