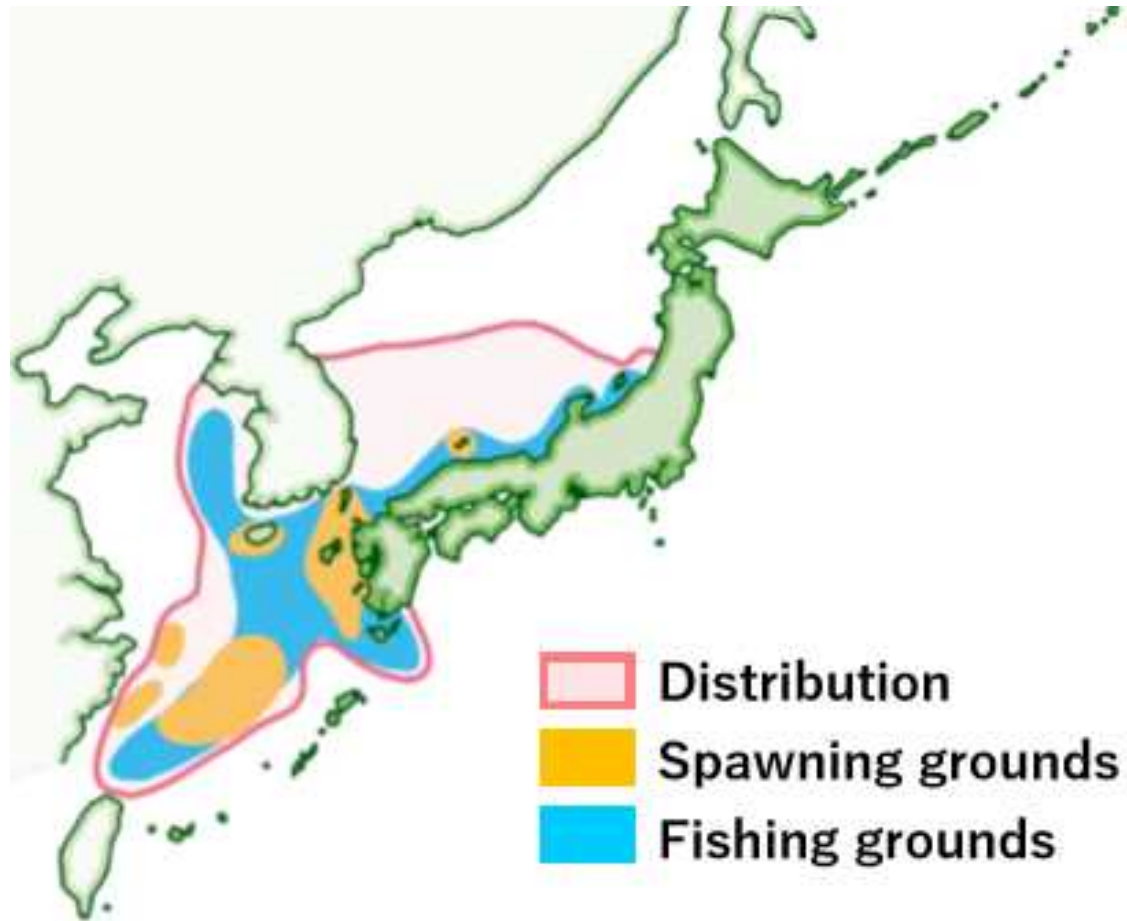


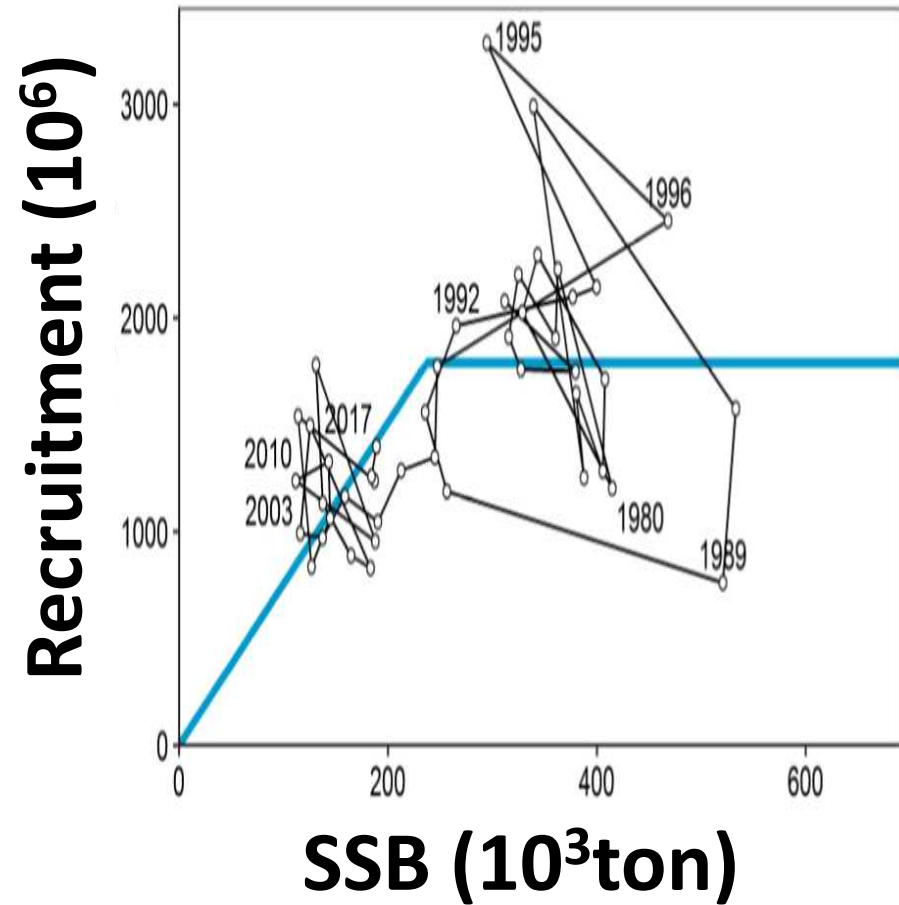
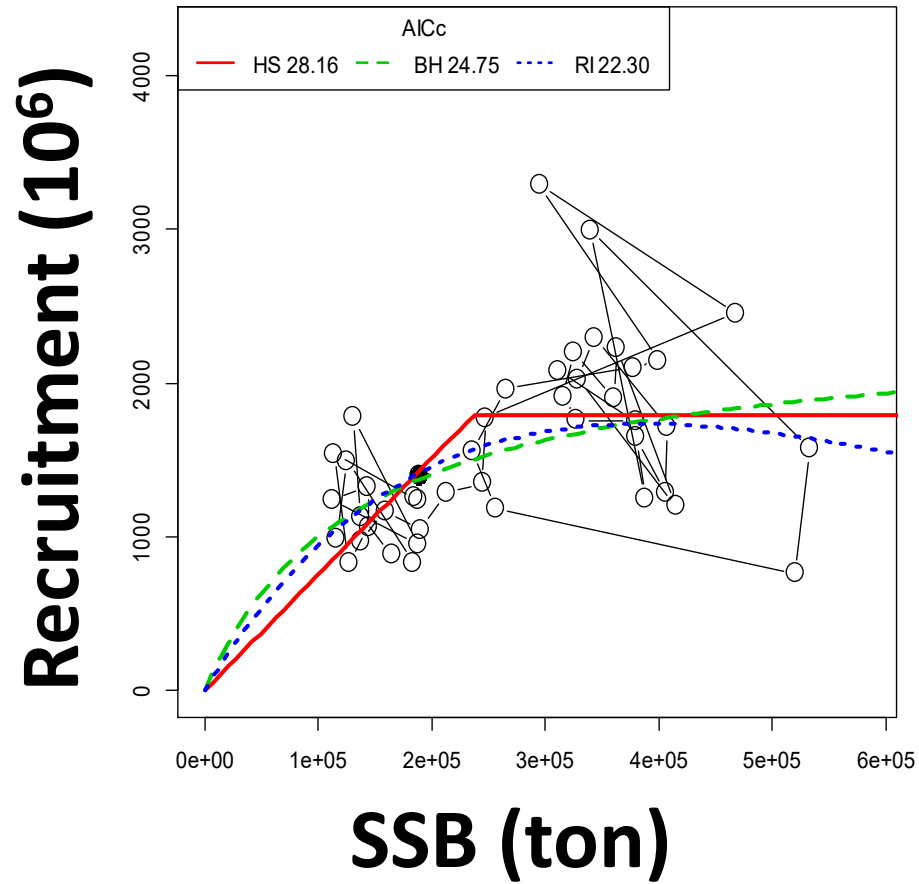


Tsushima warm current stock of chub mackerel

Distribution

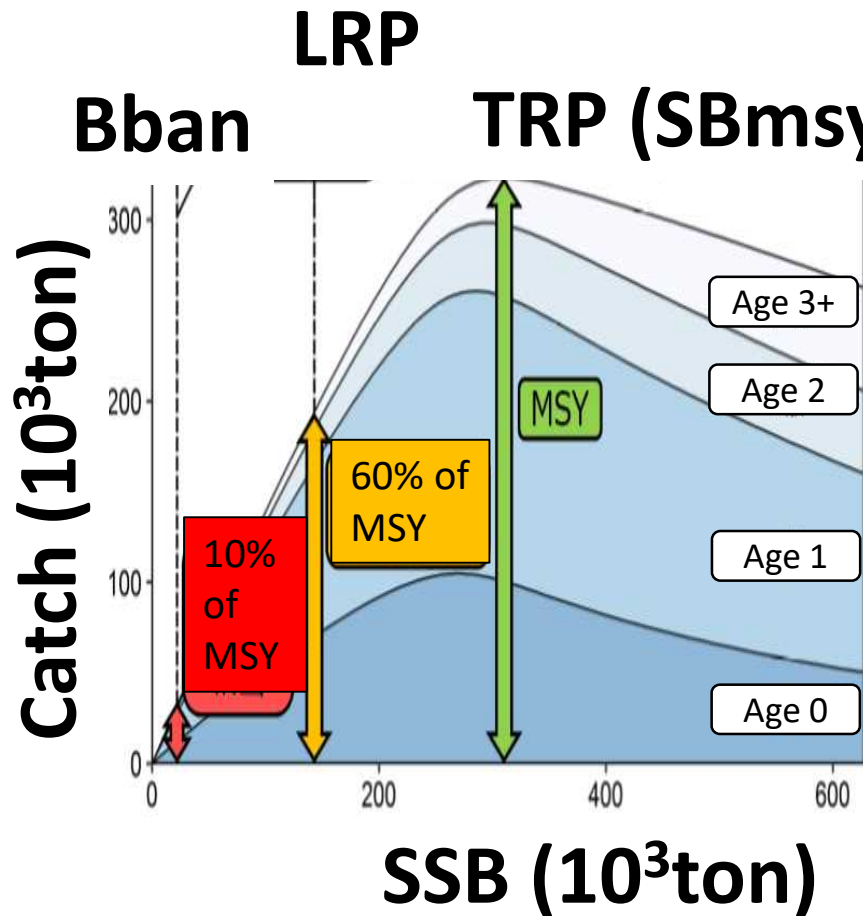


Stock Recruitment Relationship



SSB : Spawning Stock Biomass

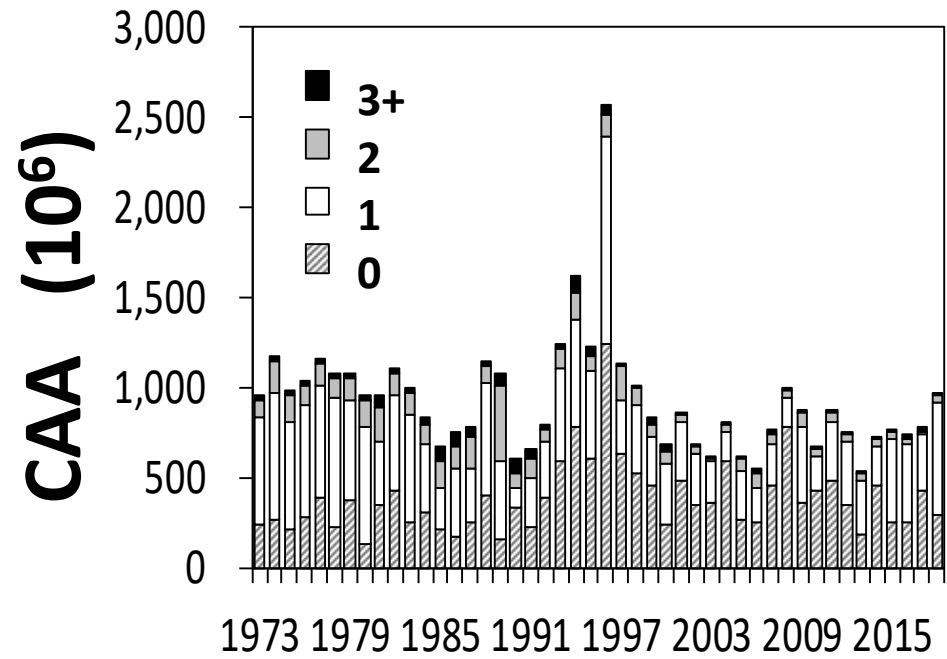
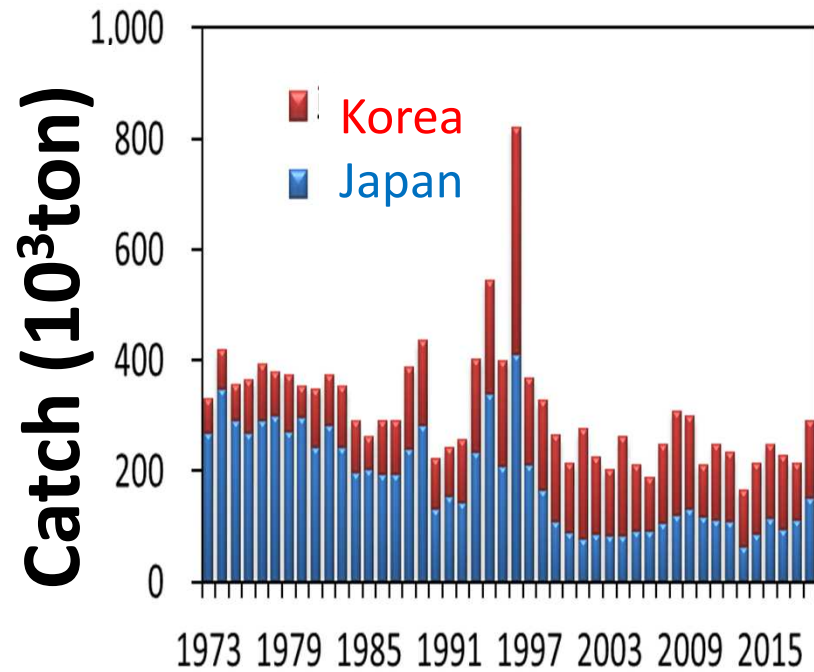
Reference Points



Reference Point	Catch (10 ³ ton)	SSB (10 ³ ton)
TRP	323	310
LRP	194	143
Bban	32	22

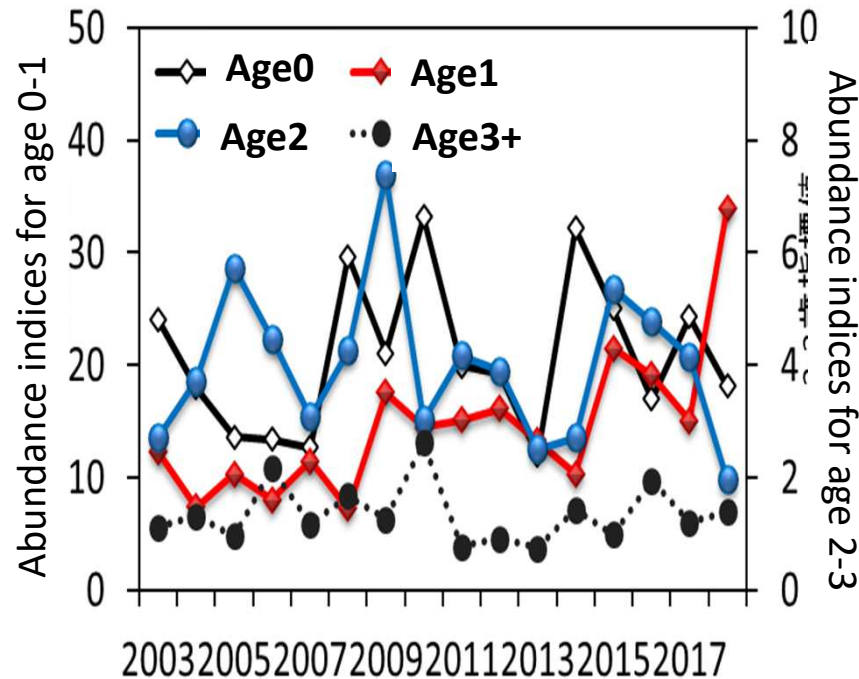
LRP: Limit Reference Point, TRP: Target Reference Point

Catch, Catch at Age

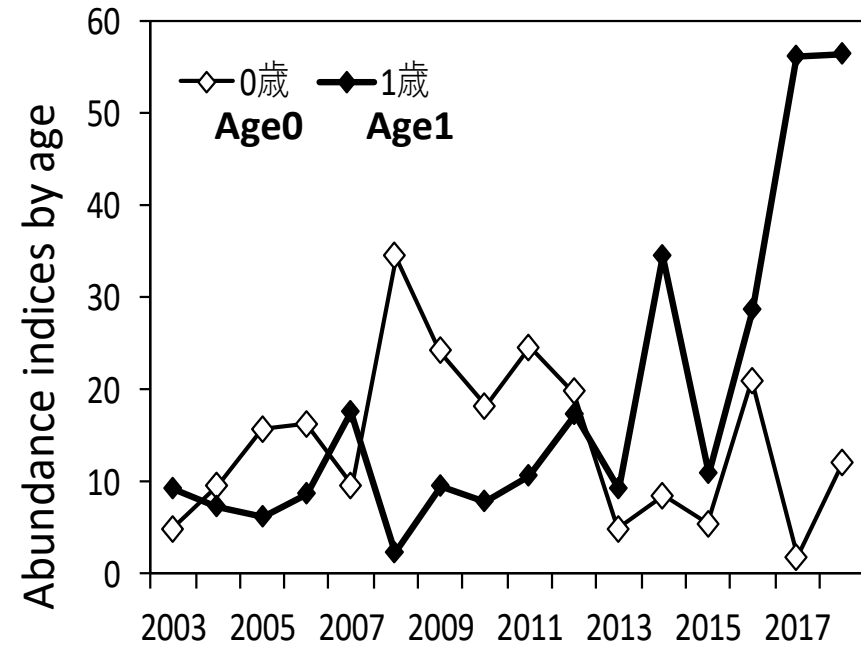


Abundance indices

Catch by size of purse seine operating in the East China sea and Japan sea
CPUE (ton/net)



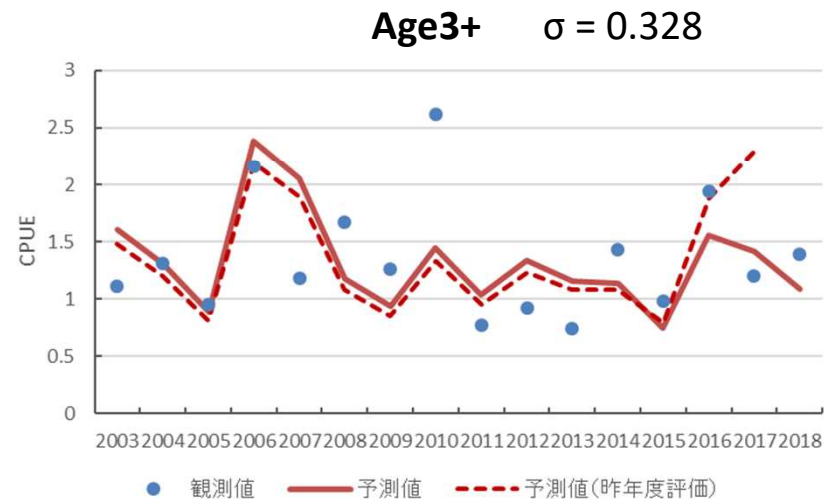
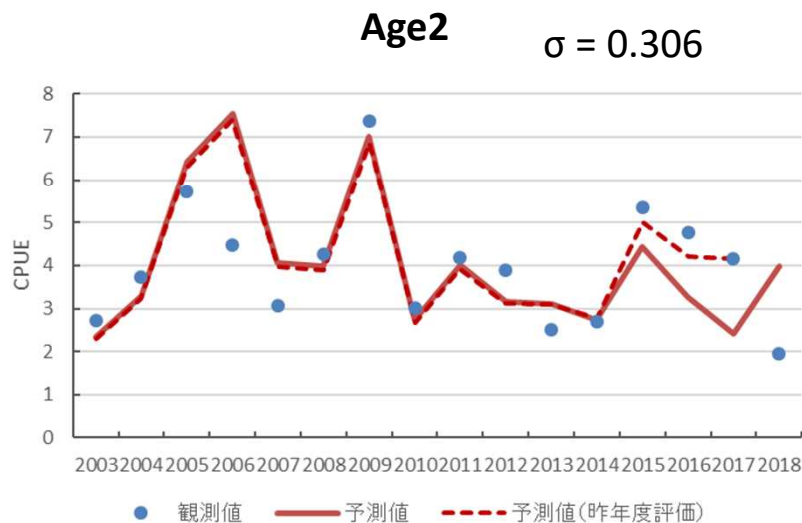
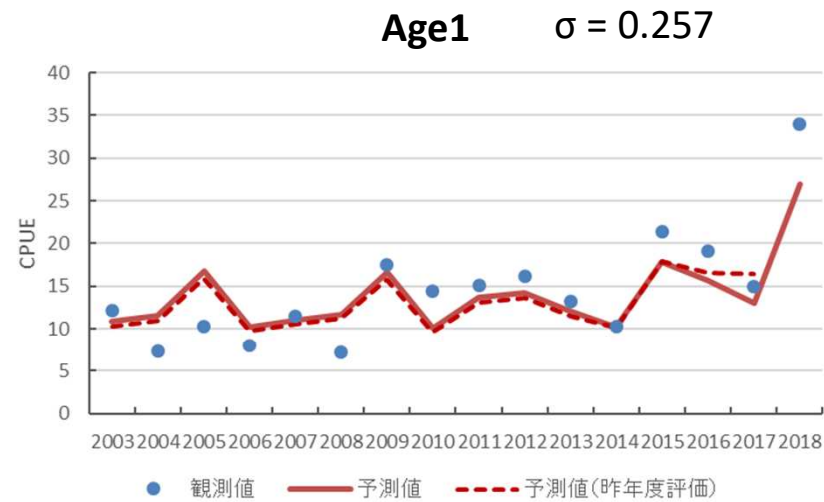
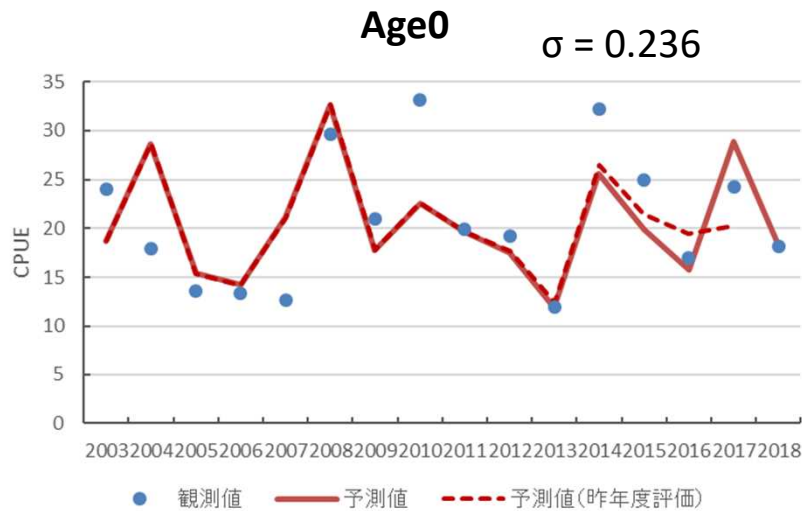
Catch by size of purse seine landed at Sakai port (Japan sea west)
CPUE (ton/ship)



● CPUE – Number at age

East China Sea and Sea of Japan Large/Middle-scale Purse Seine

● = observed, — = predicted, - - - = predicted (last year assessment)

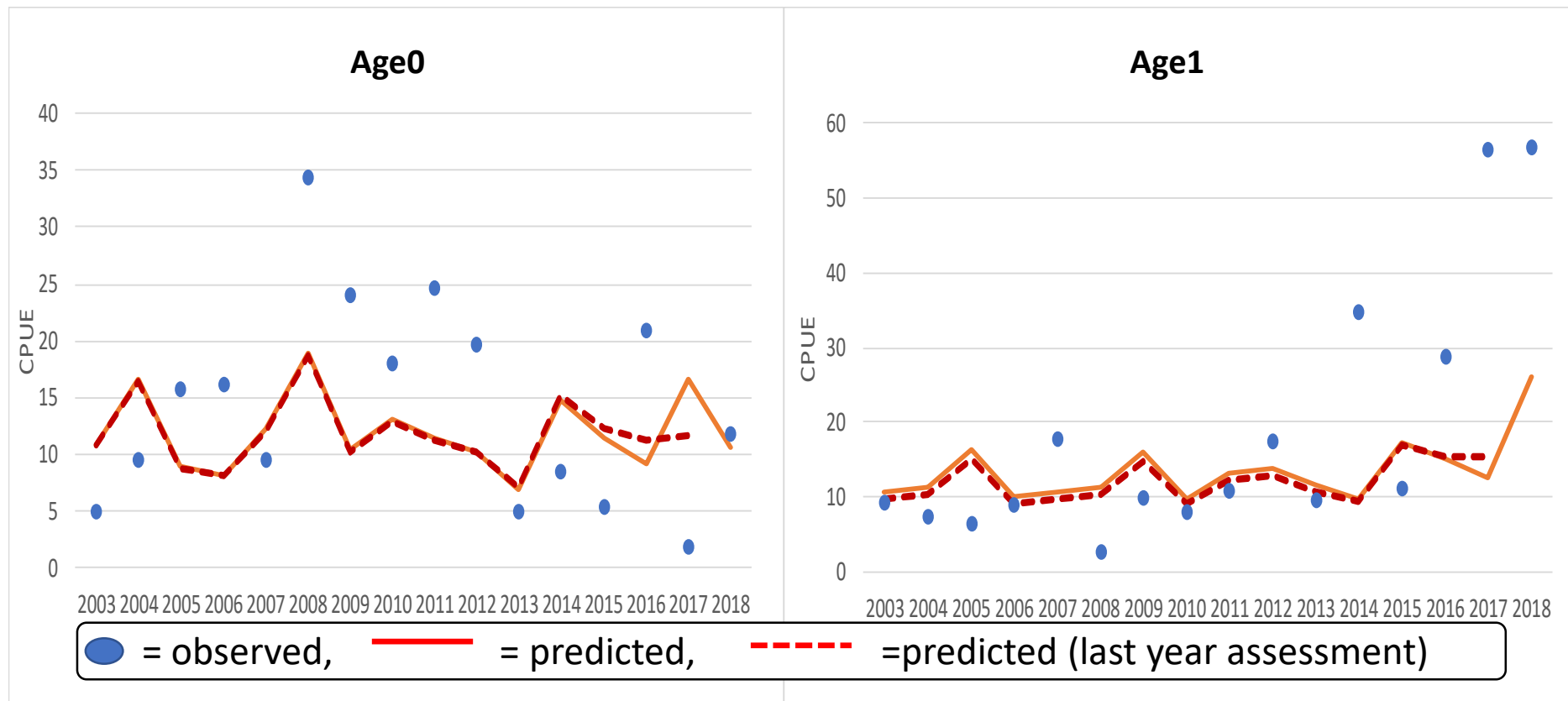


● CPUE – Number at age

Sea of Japan west Middle-scale Purse Seine

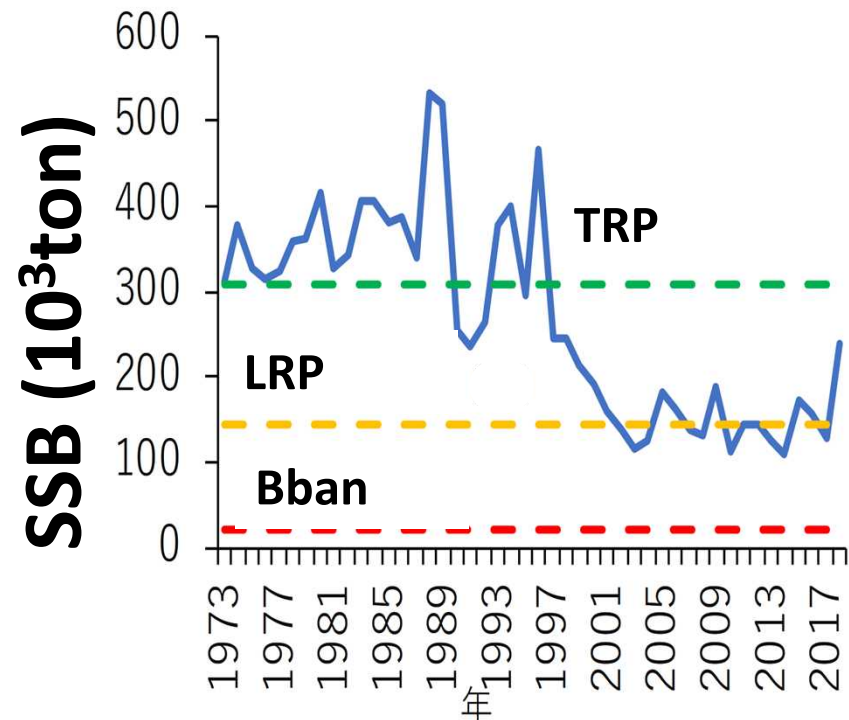
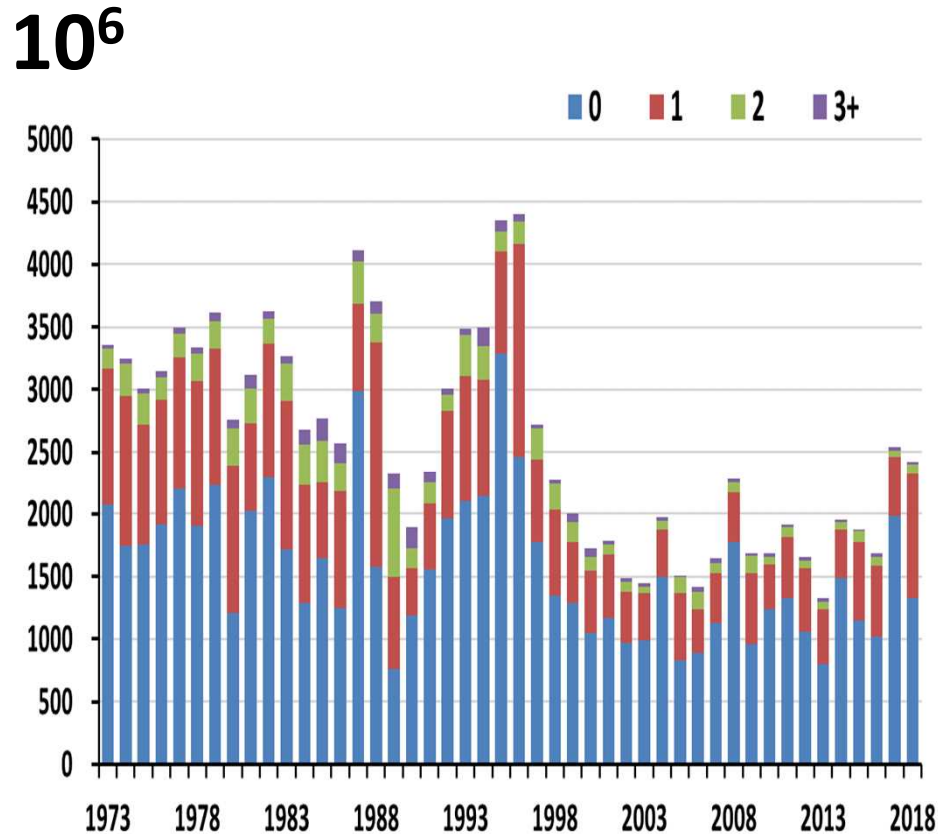
$\sigma = 0.810$ (0.772)

$\sigma = 0.760$ (0.711)



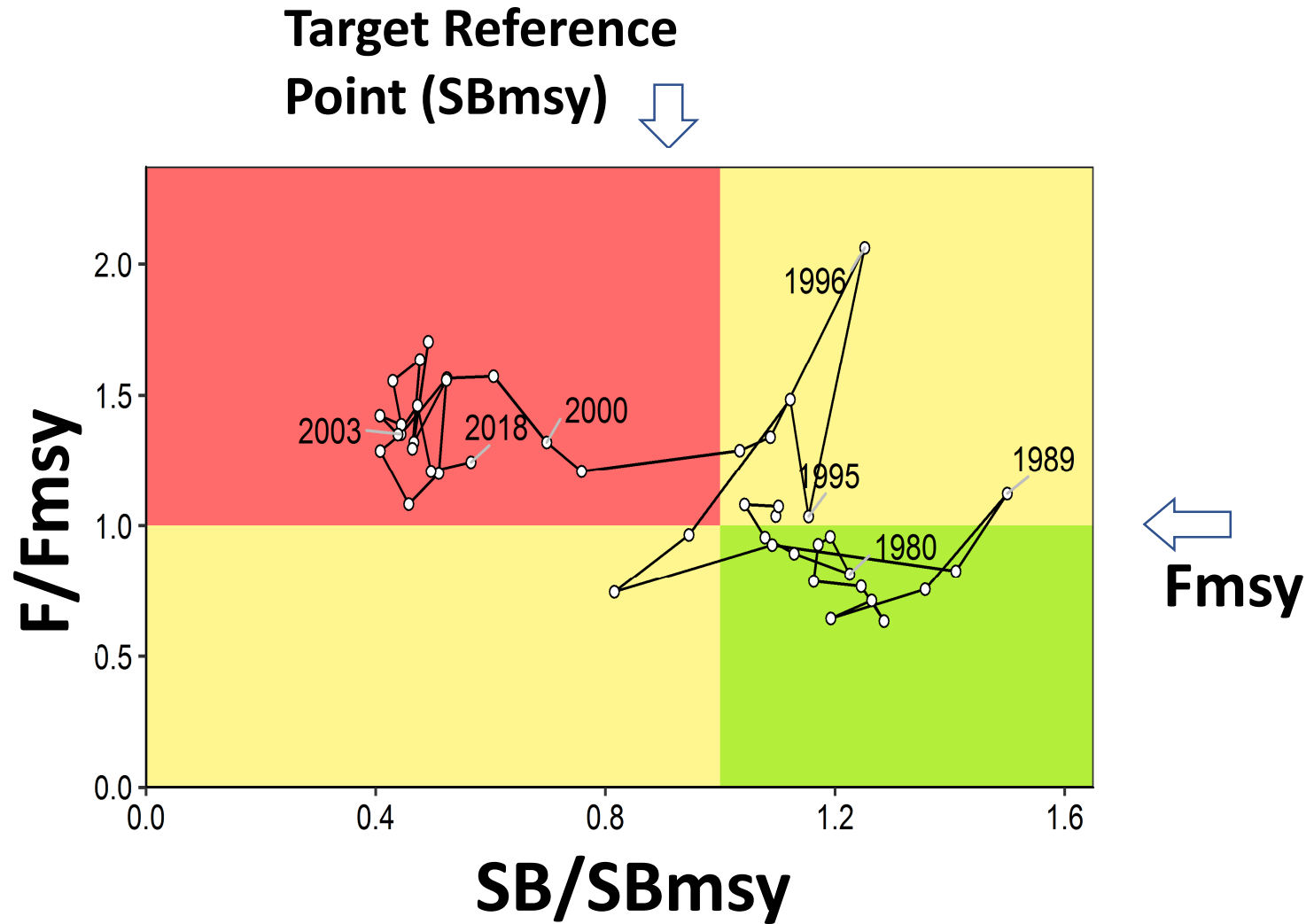
Number at age

SSB

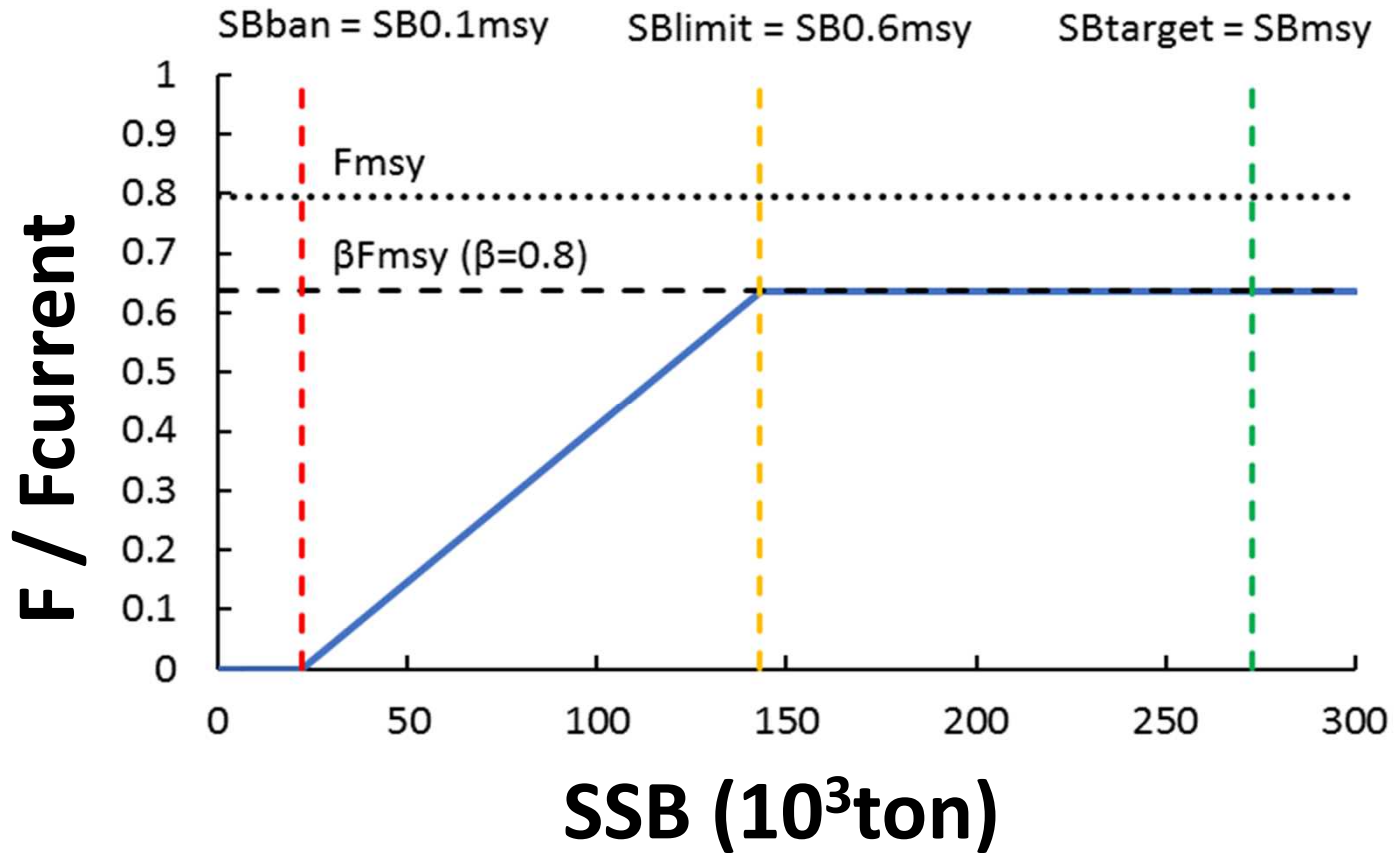


SSB : Spawning Stock Biomass,
TRP: Target Reference Point,
LRP: Limit Reference Point

Kobe-plot

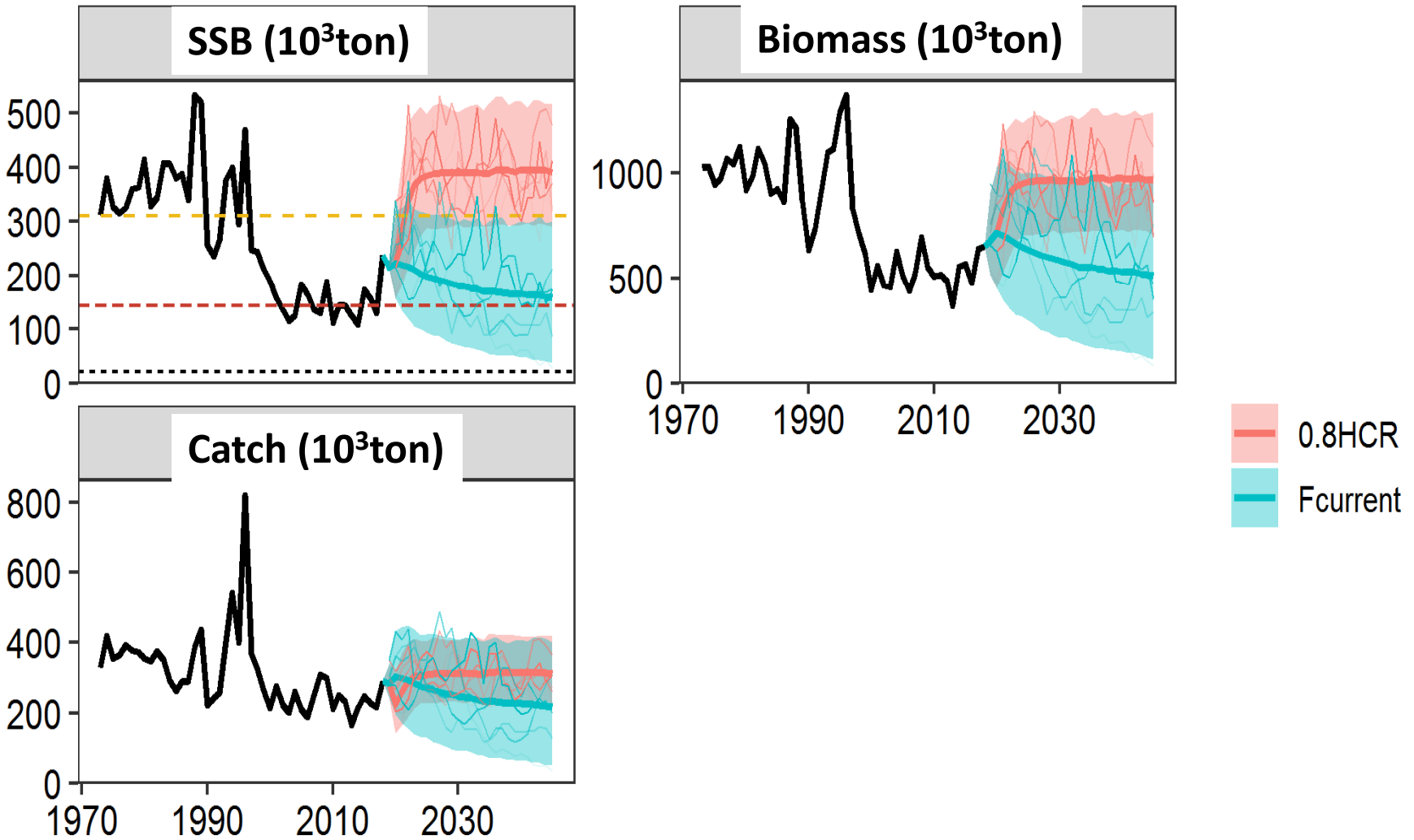


Harvest Control Rule



SSB : Spawning Stock Biomass

Future Projection 1



Future Projection 2

Probability (%) of future SSB exceeding the target reference point

β	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040
1		0	5	17	28	35	42	43	46	46
0.9		0	5	25	44	57	64	67	70	70
0.8		0	5	33	62	78	84	87	88	89
0.7		0	5	44	78	92	96	98	98	98
0.6		0	5	53	89	98	100	100	100	100
0.5		0	5	64	95	100	100	100	100	100

Probability (%) of future SSB exceeding the limit reference point

β	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040
1		100	97	98	98	99	99	100	100	100
0.9		100	97	99	99	100	100	100	100	100
0.8		100	97	100	100	100	100	100	100	100
0.7		100	97	100	100	100	100	100	100	100
0.6		100	97	100	100	100	100	100	100	100
0.5		100	97	100	100	100	100	100	100	100

Future Projection 3

SSB (ton)

β	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	238104	216229	224288	254963	276786	291687	300936	304795	309544	310140
0.9	238104	216229	224288	270212	304585	326609	339200	344226	347721	347833
0.8	238104	216229	224288	286670	335249	365224	381412	387548	390624	390759
0.7	238104	216229	224288	304453	369304	408881	429904	438069	442397	442605
0.6	238104	216229	224288	323687	407386	459195	487201	498878	506257	506612
0.5	238104	216229	224288	344514	450260	517992	555938	573131	586167	586803

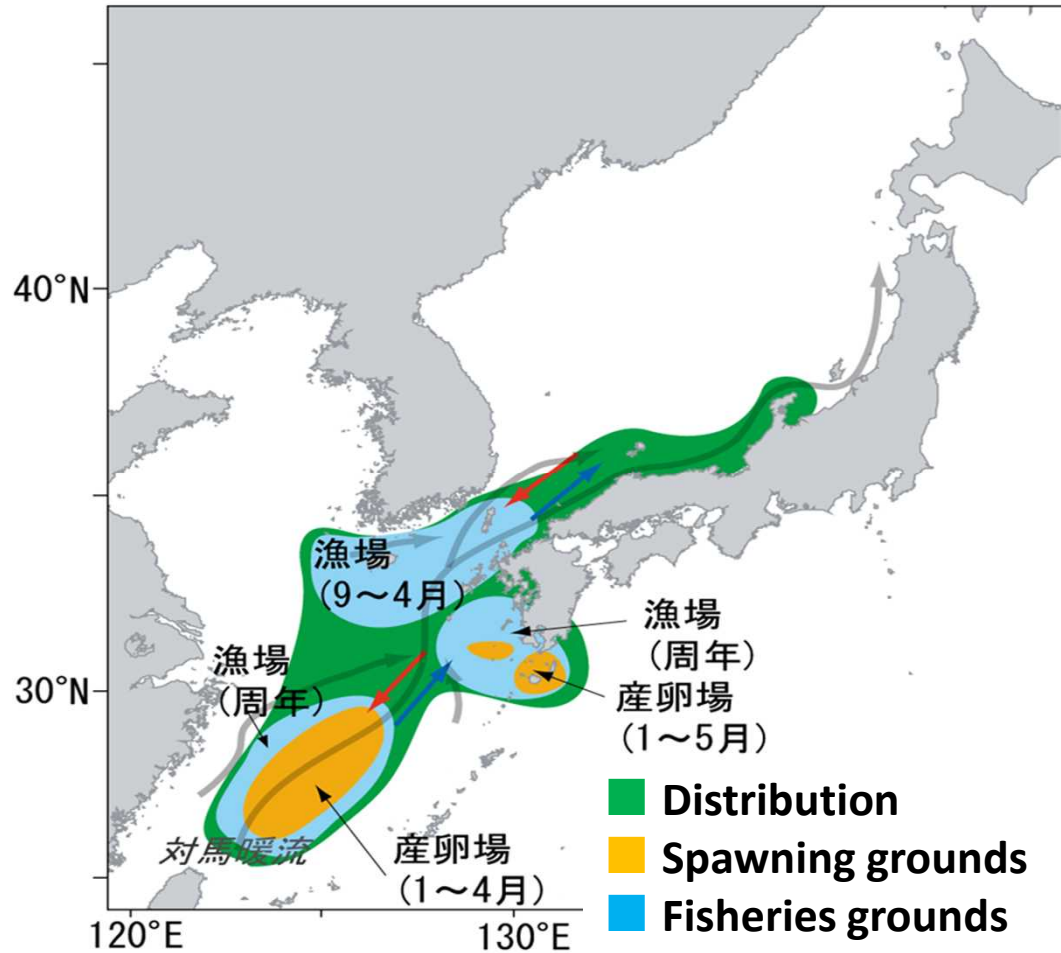
Catch (ton)

β	2018	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	292000	299715	261411	284180	300563	311888	317421	320229	322738	323897
0.9	292000	299715	242485	274338	296658	310183	316274	318834	319627	320268
0.8	292000	299715	222303	261587	288568	303466	309734	312002	312190	312784
0.7	292000	299715	200757	245652	276248	292336	299151	301638	302145	302685
0.6	292000	299715	177727	226169	259388	276762	284600	287711	289004	289511
0.5	292000	299715	153081	202685	237349	256000	265107	269082	271555	272050

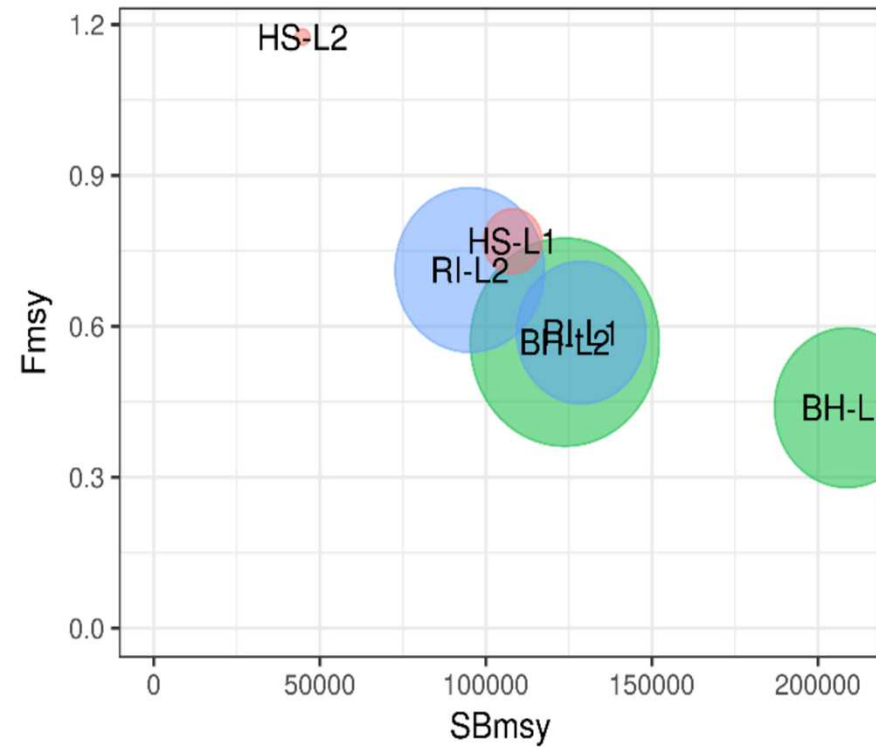
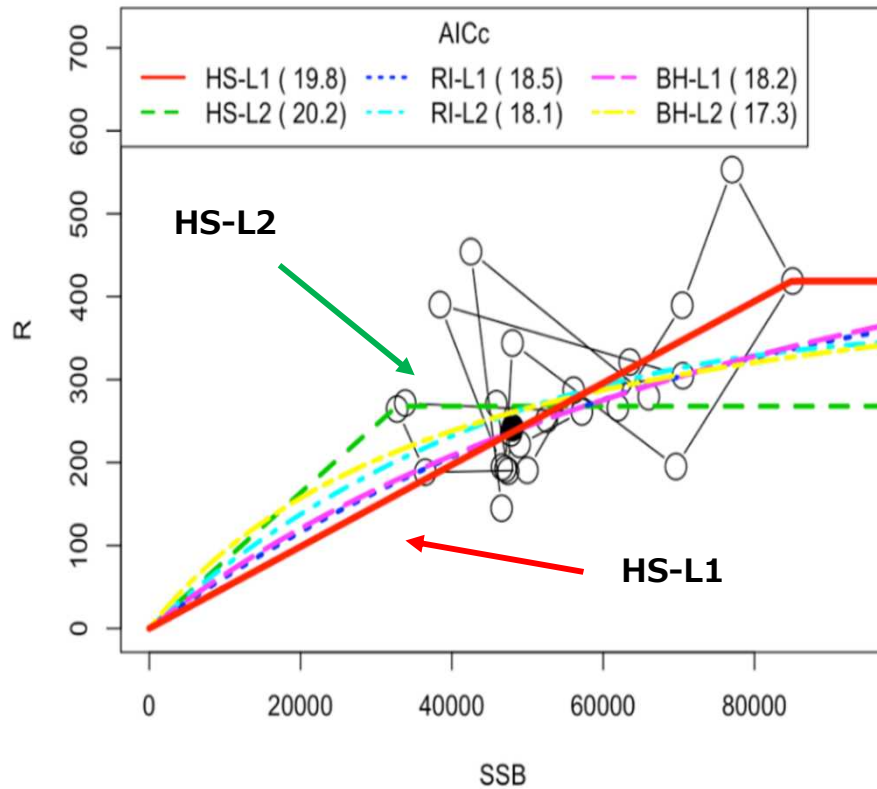


East China Sea stock of Blue mackerel

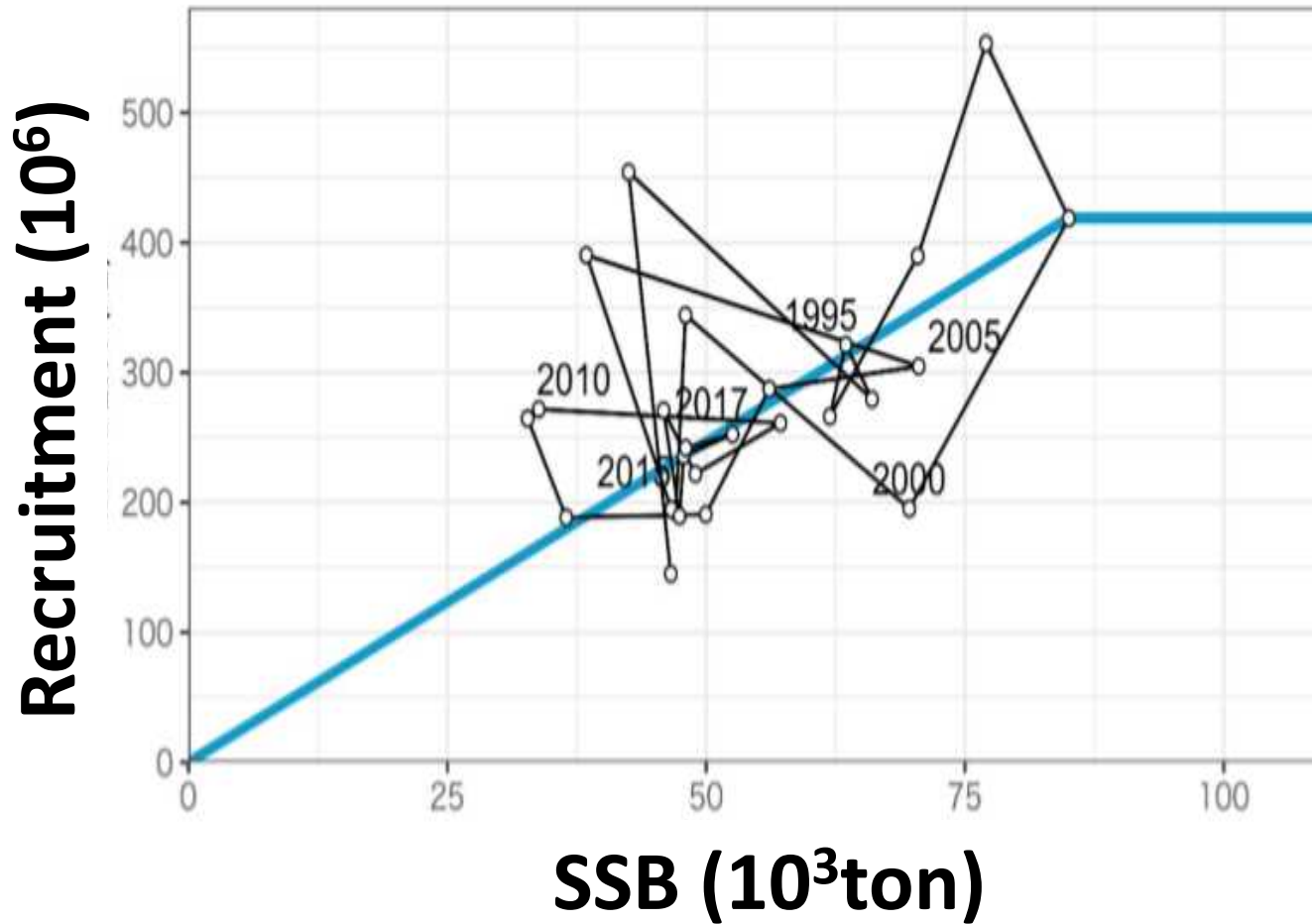
Distribution



Stock Recruitment Relationship

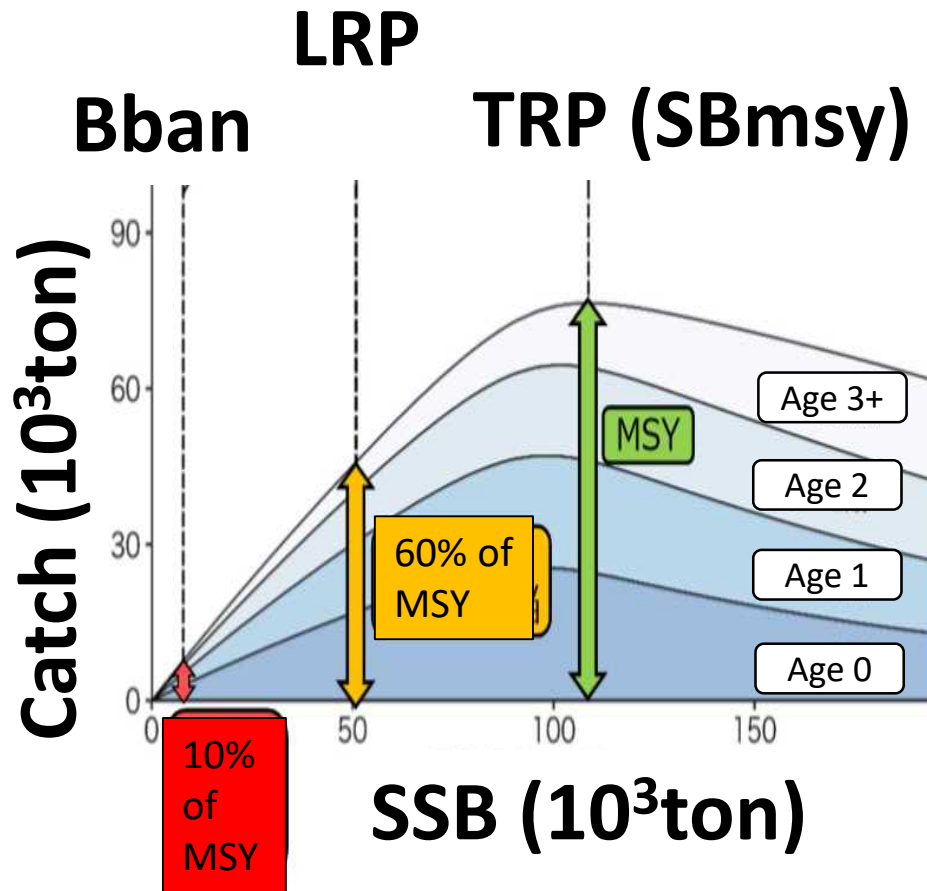


Stock Recruitment Relationship



SSB : Spawning Stock Biomass

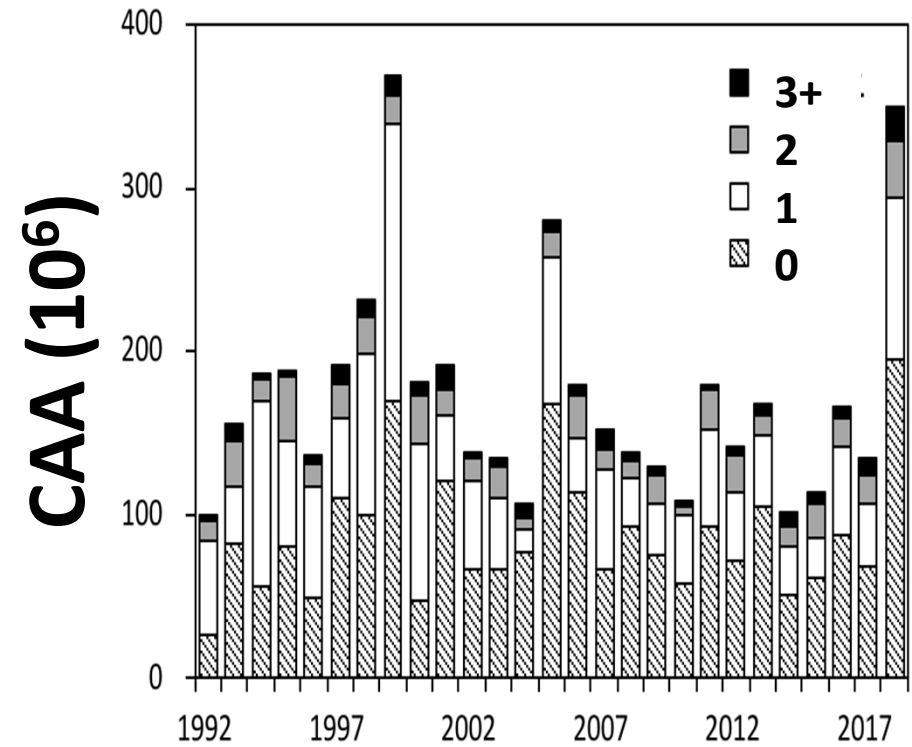
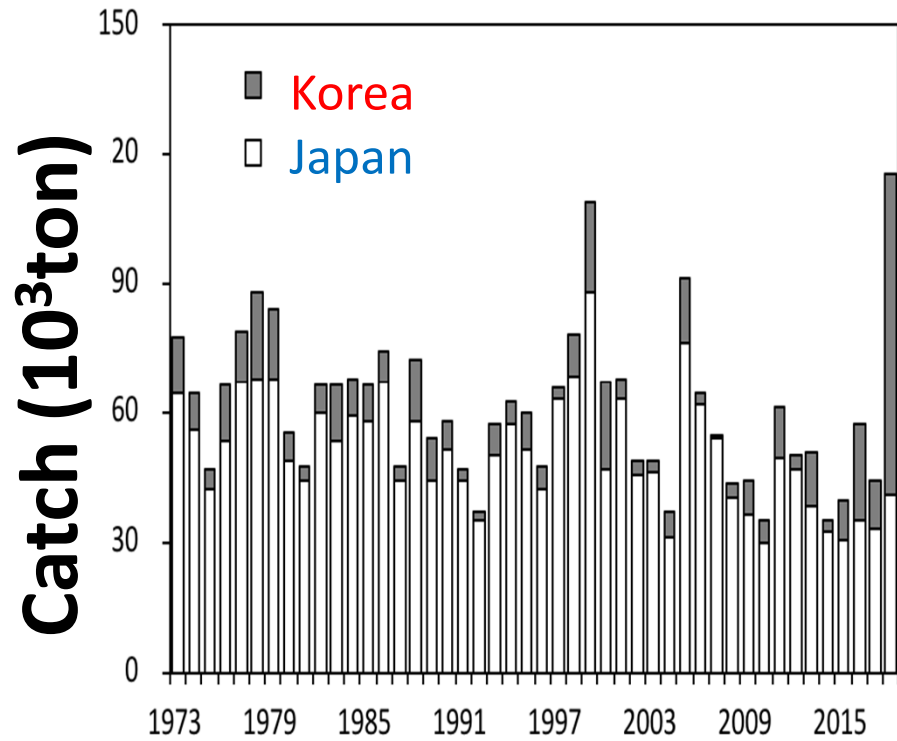
Reference Points



RPs	Catch (10^3 ton)	SSB (10^3 ton)
TRP	76	109
LRP	46	51
Bban	8	8

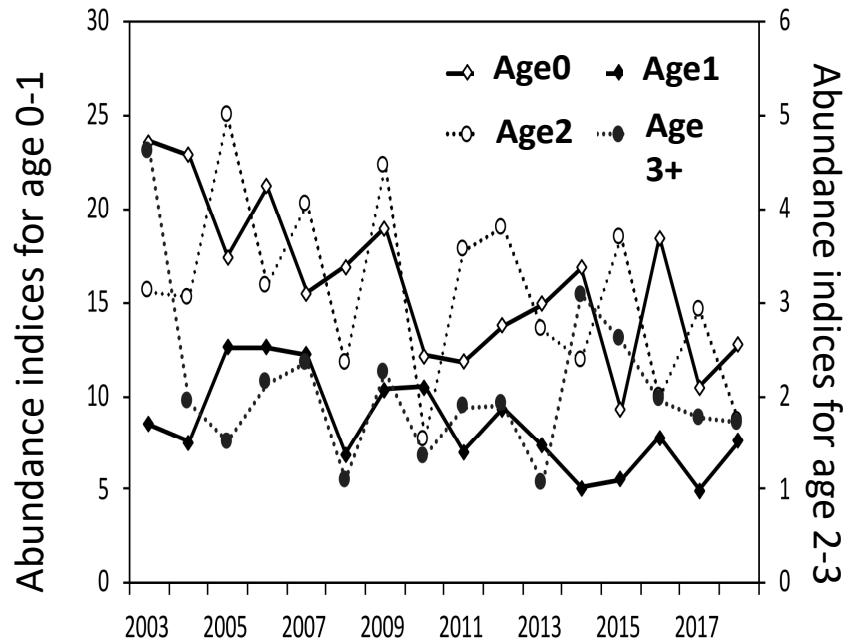
LRP: Limit Reference Point, TRP: Target Reference Point

Catch, Catch at Age

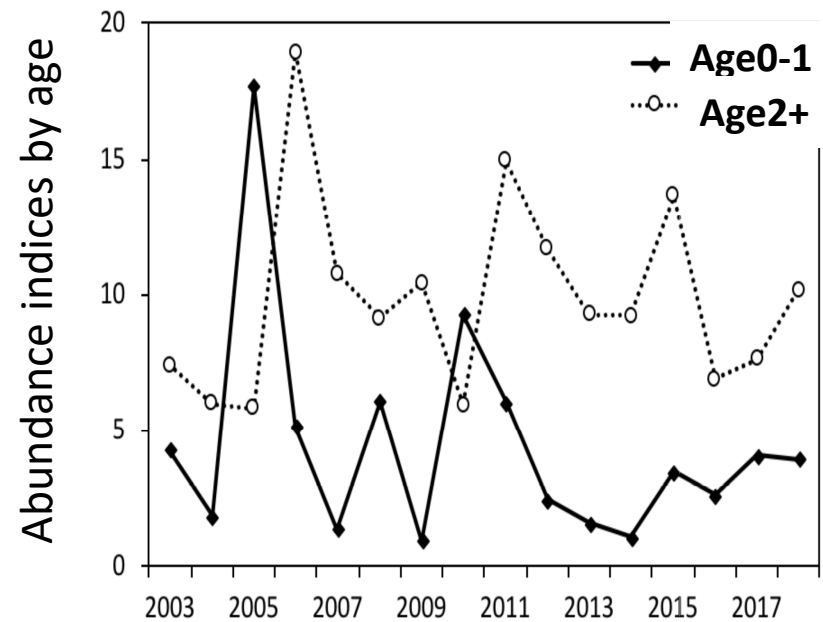


Abundance indices

Catch by size of purse seine operating in the East China sea and Japan sea
CPUE (ton/net)

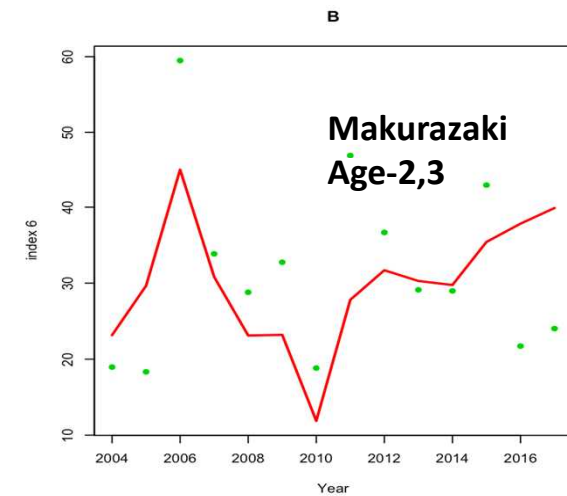
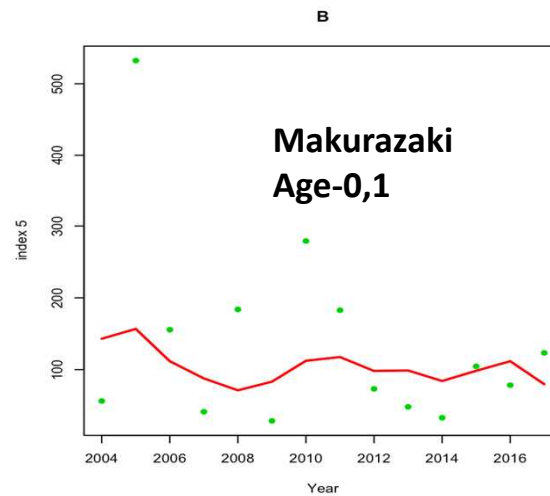
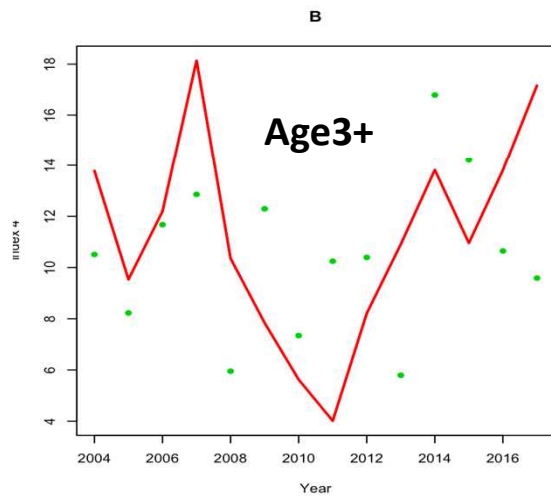
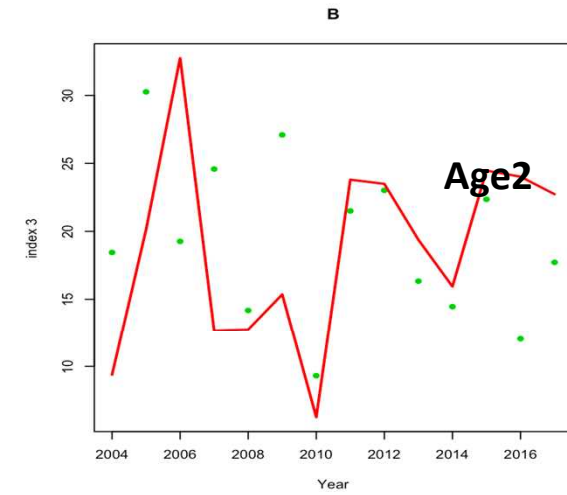
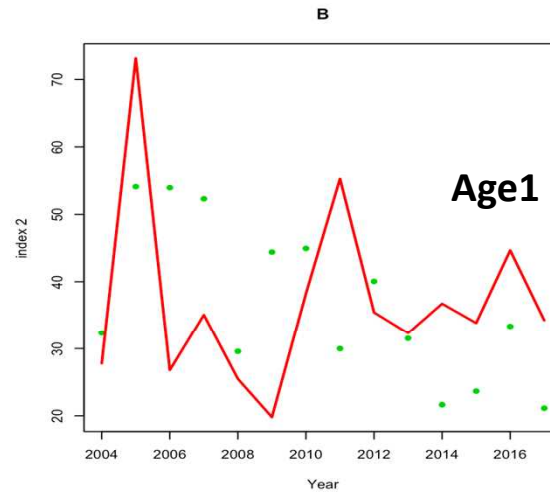
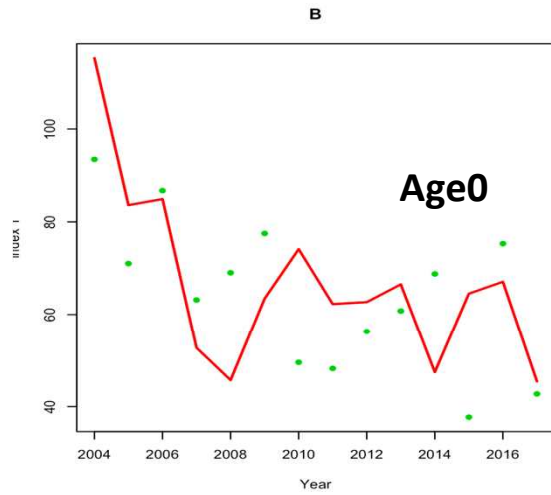


Catch by size of purse seine landed at Makura-zaki port (south Kyushu)
CPUE (ton/ship)



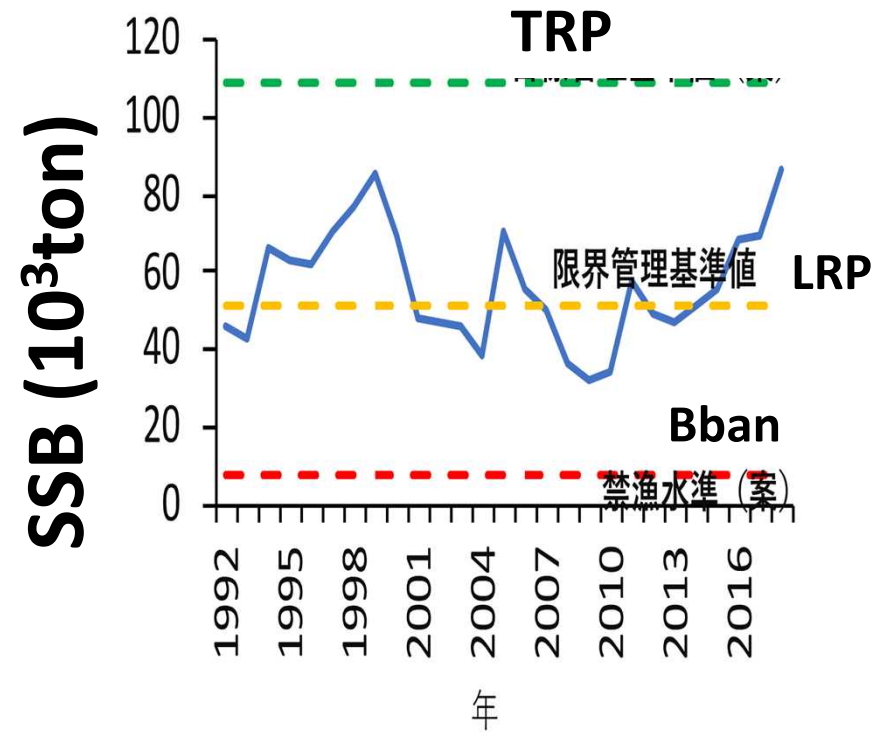
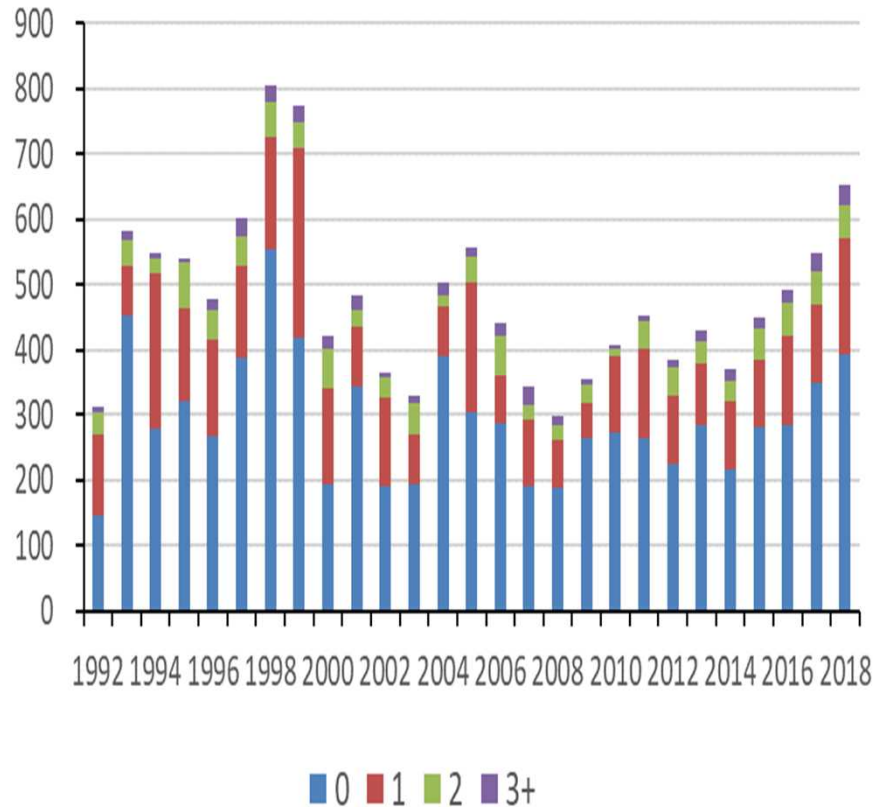
● CPUE

– Number at age



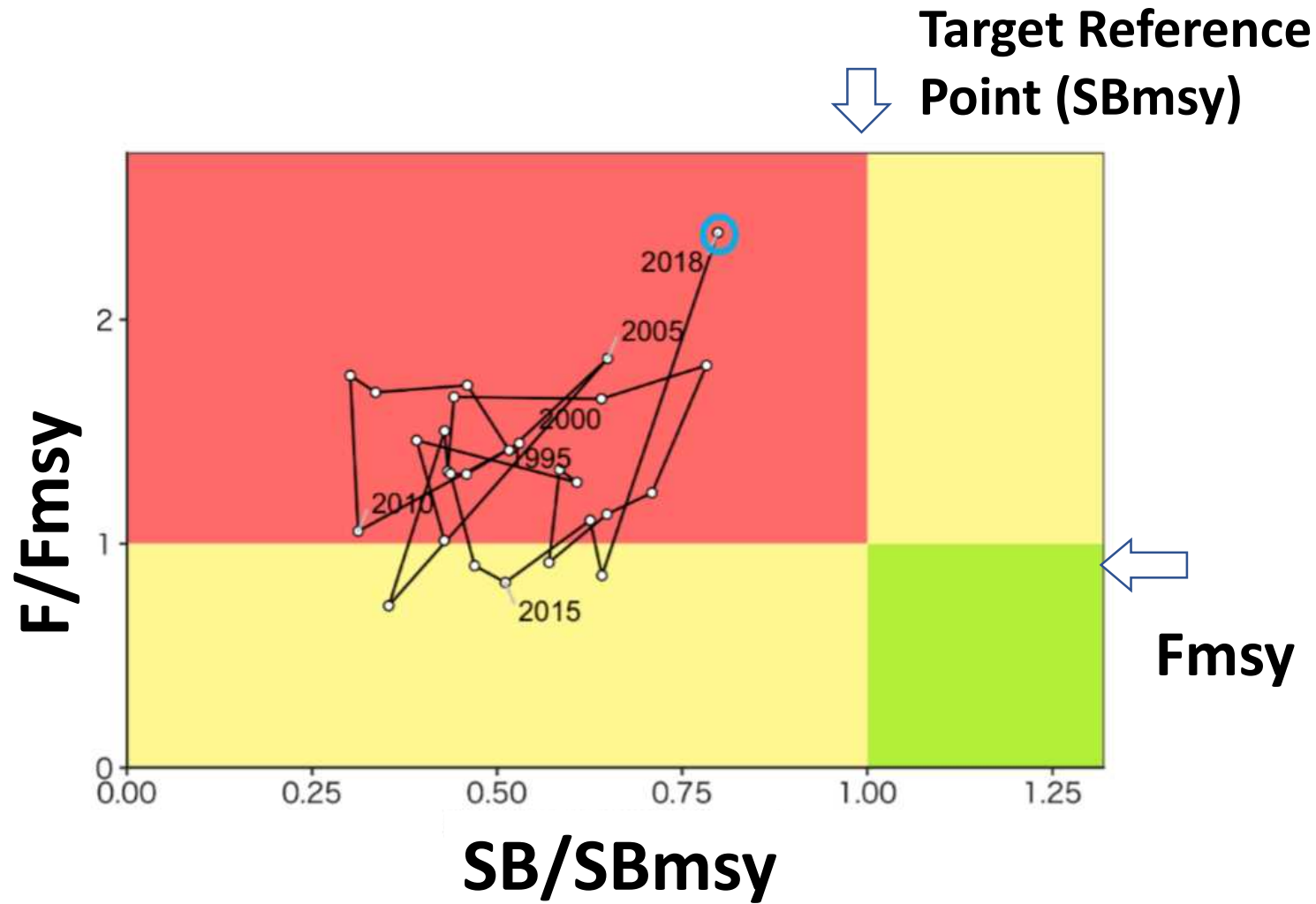
Number at Age, SSB

10^6

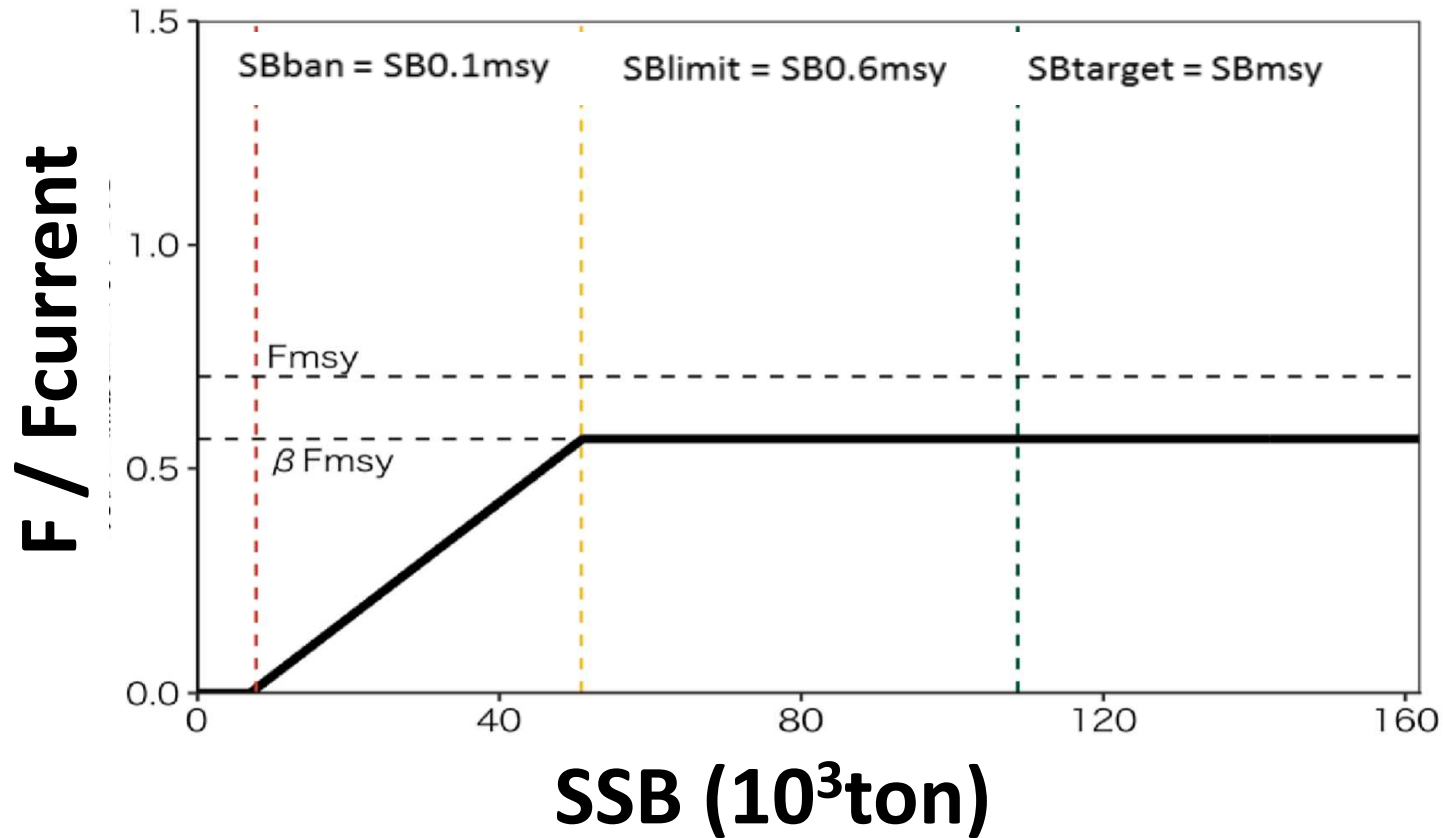


LRP: Limit Reference Point, TRP: Target Reference Point

Kobe plot

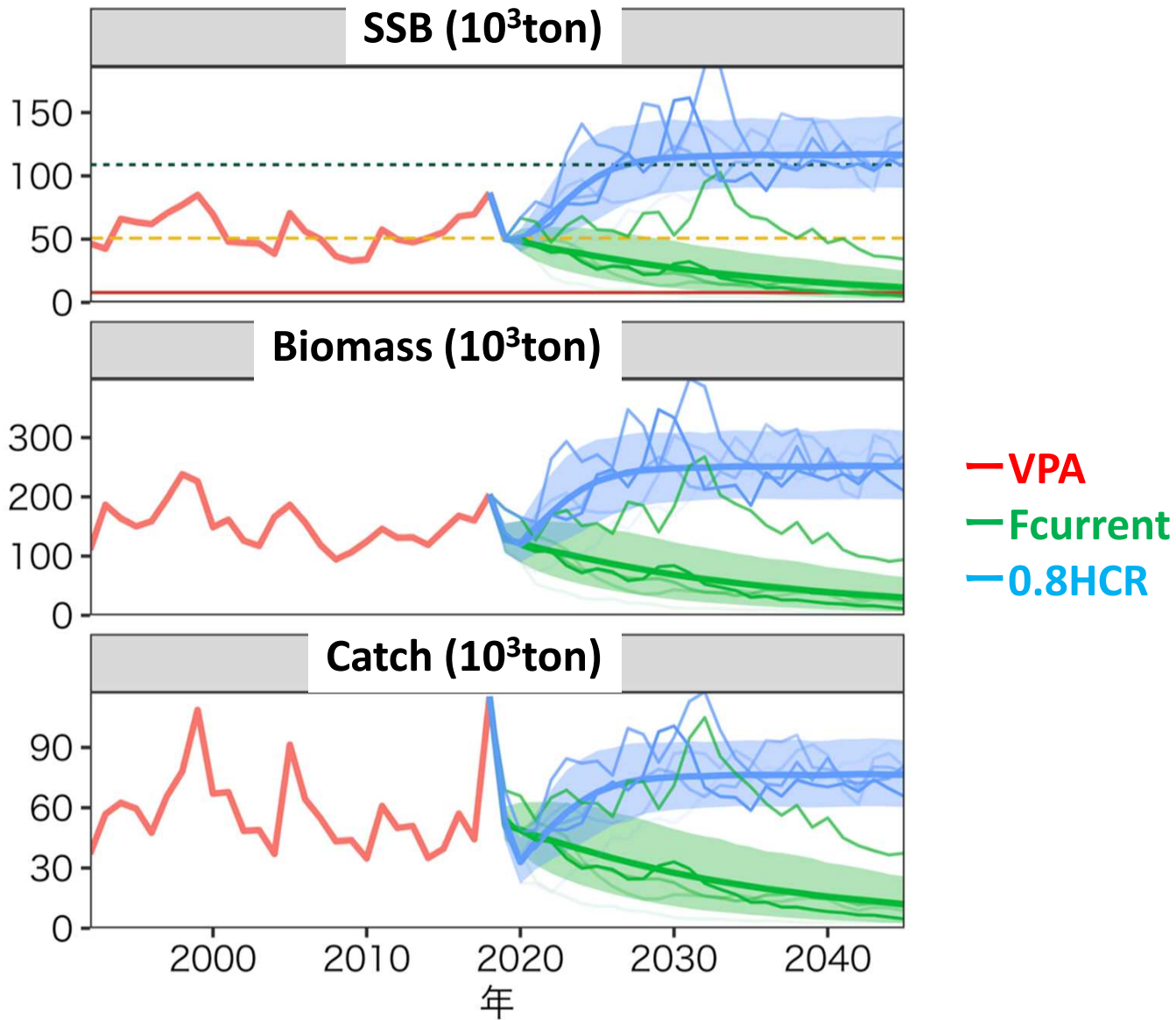


Harvest Control Rule



SSB : Spawning Stock Biomass

Future Projection 1



Future Projection 2

Probability (%) of future SSB exceeding the target reference point

β	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	0	0	0	3	8	16	24	43	47
0.9	0	0	0	4	15	30	43	67	69
0.8	0	0	0	8	27	49	65	85	86
0.7	0	0	1	14	43	70	85	96	96
0.6	0	0	1	23	61	86	96	99	99
0.5	0	0	2	33	77	95	99	100	100

Probability (%) of future SSB exceeding the limit reference point

β	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	0	30	70	83	90	94	97	99	100
0.9	0	30	78	91	96	98	99	100	100
0.8	0	30	84	95	99	100	100	100	100
0.7	0	30	89	98	100	100	100	100	100
0.6	0	30	93	99	100	100	100	100	100
0.5	0	30	96	100	100	100	100	100	100

Future Projection 3

SSB (10^3ton)

β	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	50	48	58	66	75	84	90	106	109
0.9	50	48	60	72	84	96	105	120	121
0.8	50	48	63	78	95	110	120	133	134
0.7	50	48	66	85	106	124	136	149	149
0.6	50	48	69	92	118	140	154	167	167
0.5	50	48	72	101	132	158	173	188	189

Catch (10^3ton)

β	2019	2020	2021	2022	2023	2024	2025	2030	2040
1	51	35	44	51	57	62	66	75	77
0.9	51	32	42	50	58	64	68	75	76
0.8	51	29	40	49	58	64	69	74	74
0.7	51	26	38	47	56	63	67	71	71
0.6	51	23	34	44	53	60	64	67	68
0.5	51	19	30	40	49	56	60	63	63

Missing catch data. EastChinaSea Sea of Japan

Land Area	Species	2014	2015	2016	2017	2018
China	<u>Pacific chub</u> mackerel	480 425	471 211	448 603	444 839	432 504
Taiwan	<u>Pacific chub</u> mackerel	64 481	68 063	64 473	71 865	92 490

FAO FishSTAT
NorthKorea NA

Natural mortality

Table 1. Estimators selected to calculate the natural mortality rate (M) for Chub mackerel in the North Pacific Ocean.

Estimator identifier	Equation	Reference
"Pauly"	$M = 0.9849L_{\infty}^{-0.279}K^{0.6543}T^{0.4634}$	Pauly 1980
"Pauly update"	$M = 4.118L_{\infty}^{-0.33}K^{0.73}$	Then et al. 2015
"Jensen"	$M = 1.5K$	Jensen 1996
"Hoenig"	$M = 4.3/A_{max}$	Hoenig 1983
"Hoenig update"	$M = 4.899A_{max}^{-0.916}$	Then et al. 2015
"Gislason1"	$M = 1.73L^{-1.61}L_{\infty}^{1.44}K$	Gislason et al. 2010
"Gislason2"	$M = K(L/L_{\infty})^{-1.5}$	Charnov et al. 2013

L_{∞} : asymptotic fish length (cm)

K: Brody growth rate parameter of von Bertalanffy growth curve

T: mean environmental temperature (degree C)

A_{max} : maximum observed age (longevity)

L: individual fish length (cm)

Estimator	M value	L_{∞}	K	T	A_{max}	L	Input data source
"Pauly"	0.44	44.6	0.20	16.7	-	-	Kamimura in preparation
"Pauly update"	0.36	44.6	0.20	-	-	-	Kamimura in preparation
"Jensen"	0.30	-	0.20	-	-	-	Kamimura in preparation
"Hoenig"	0.43	-	-	-	10	-	Kamimura in preparation
"Hoenig"	0.39	-	-	-	11	-	Iizuka 2002
"Hoenig update"	0.59	-	-	-	10	-	Kamimura in preparation
"Hoenig update"	0.54	-	-	-	11	-	Iizuka 2002
"Gislason1"	0.36	44.6	0.20	-	-	29	Kamimura in preparation
"Gislason2"	0.38	44.6	0.20	-	-	29	Kamimura in preparation
"FishLife"	0.44-0.52 (0.48±SD)	-	-	-	-	-	FishBase (Froese 1990)

Indices of abundance. Acoustic survey EastChinaSea Kyushu

(1) The abundance indices obtained from the distribution survey “Pelagic fish acoustic survey using quantitate fish detector” conducted western Kyusyuu and eastern water of Tsushima are shown below. The chub and blue mackerels are shown as mackerels. The separation by species has been examined.

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005
mackerels	0.2	2.2	1.6	0.9	0.3	0.3	0.05	1.0	2.7
Year	2006	2007	2008	2009	2010	2011	2012	2013	2014
mackerels	1.7	0.9	8.3	0.8	0.4	0.8	7.8	1.6	1.7
Year	2015	2016	2017	2018					
mackerels	1.3	2.3	4.8	4.6					

(2) The estimated abundance (tons) obtained by biomass survey using bottom trawl conducted in the continental shelf break of East china sea in May to June “The biomass survey of bottom fish in the East china sea” are shown below. (The survey area was 138 thousand km², fishing efficiency assumed 1). Because of the nature of bottom survey, it is considered the survey is not cover all distribution depth of mackerels. Therefore, the survey results used as reference.

Year	2000	2001	2002	2003	2004	2005	2006	2007
Chub mackerel	26,100	14,513	4,951	2,715	3,645	1,062	9,363	213
Year	2008	2009	2010	2011	2012	2013	2014	2015
Chub mackerel	22,479	515	12,553	57,162	29,869	257	3,351	3,630
Year	2016	2017	2018	2019				
Chub mackerel	4,701	2,692	23,733	2,279				

Stock Recruitment. Cross relation -1 ~-2 lag

