ISC/16/PBFWG-1/04

Configurations of selectivity curve: learned from Japanese set net fleet

Shigehide Iwata[1] and Hiromu Fukuda[2]

1. Tokyo University of Marine Science and Technology, 4-5-7, Konan, Minato-ku, Tokyo 108-8477, JAPAN
2. National Research Institute of Far Sea Fisheries, Fisheries Research Agency 5-7-1 Orido, Shimizu, Shizuoka 424-8633, Japan

29 Feb.-11 Mar. 2016

Working document submitted to the ISC Pacific bluefin tuna Working Group, International Scientific Committee for Tuna and Tuna-Like Species in the North Pacific Ocean (ISC), 29 Feb.-11 Mar. 2015, La Jolla, USA. Document not to be cited without author's permission.

Summary

We discuss the possibility of applying cubic spline, age selectivity and time block to length composition data for Japanese set net. Cubic spline is powerful tool to fit the length composition data, but how to set locations of nodes is very difficult. Furthermore, the estimation is affected by the location of nodes. So author suggests not to apply the cubic spline. For the age selectivity, by the analysis of the length composition data, data concentrated into age 0 to 2. So it is not effective to apply age selectivity. For the time block, by using the median value for yearly length composition data and the median for all length composition, time block set appropriately. So author summarized that the median value for yearly length composition data is helpful to judge the time block period. Finally author recommends to set time block appropriately.

Introduction

Various sized Pacific bluefin tuna (PBF) has been caught incidentally by set-net fishery along the Japanese coast (Chikuni 1985). The catch at size data for Japanese set-net fishery have been updated using various method by Kai et al. (2011), Hiraoka et al. (2015) and Sakai et al. (2015).

In previous full stock assessment (Nov, 2012), set net fleet was classified four fleets by the several information (Kai et al. 2012, ISC 2012). And, Hiraoka et al. (2015) and Sakai et al. (2015) suggested another stratification of the size composition data. As a result, in Feb 2016 stock assessment, the method suggested by Sakai et al. (2015) was adopted in the ISC PBF meeting (Nov. 2015). The method was based on multi-stratified raising of size-measurement data using the catch amount. However, the length composition suffer sharp fluctuations. Therefore, in the ISC PBF meeting (Nov. 2015), it is suggested to aggregate fleets with more accurate time-varying selectivity or appropriate selectivity function.

In the PBF stock assessment, Stock synthesis 3 (SS 3) is applied for the stock analysis. SS3 has a several type of selectivity function. Usually, to fit the length composition, double normal selectivity function is recommended (Methot, 2013). Furthermore, age selectivity function can apply. Age selectivity function also has a several types (Methot, 2013). As non-parametric method, there is cubic spline. For large fluctuation, the time-varying selectivity also can be applied (Methot, 2013). However, we have no idea about when we should apply time-varying selectivity, what selectivity curve is appropriate. So, some procedure or knowledge to apply which or how to use selectivity function are required.

In this document, selectivity function and a procedure to set time block are studied.

Especially, the cubic spline, age selectivity and setting of time block are investigated. An objective fleet is restricted to the Japanese set net, since this fleet has been puzzling member of ISC PBF WG by the miss fit to the length composition data. Final object of this document is to provide the information of procedure to set several parameter related to the selectivity curve.

Materials and Methods

Throughout the document, we analyze the model setting based on Table 1 an 2 (Notice: This setting is not for stock assessment. Just a prot-type.). The setting of the selectivity curve for fleet 8 is investigated as to below. The base setting (say prot-type) is double normal. Usually, a double normal selectivity needs 6 parameter (P1 to P6, Methot, 2013). In the prot-type run, three parameters, P1 (beginning size for the plateau), P3 (ln(width), width of ascending slope) and P4 (ln(width), width of descending slope) are estimated.

Choice of settings for selectivity

Cubic spline

This function requires input of the number of nodes (the number of nodes requires at least 3), the positions of those nodes, the parameter values at those nodes, and the slope of the function at the first and last node (Methot, 2013). Stock synthesis have three option to determine the location of the nodes as followings (Methot, 2013);

0: no auto-generation, process parameter setup as read.

1: auto-generate the node locations based on **the specified number of nodes** and on **the cumulative size distribution of the data** for this fleet/survey.

2: auto-generate the nodes and also **the min, max, prior, init, and phase for each parameter**.

We focus on 1) how many nodes are appropriate and 2) procedure of setting location of nodes. In the document, we will analyze 3, 5, 7, 9 nodes runs with option 2 (each run named **CS 3**, **CS 5**, **CS 7** and **CS9**, respectively). For the setting location of nodes, the 3 nodes cases are applied. The option 1 is applied to the **CS3** or **CS7** (named **CS3i** or **CS7i**) and run will repeat until well converge (by using previous results as initial value).

Age selectivity

By using age selectivity, relative age-selectivity is more accurate and flexible than the other age selectivity in the SS3. Since this parameter set for each age group, so the selectivity can cover all age class. Important point is cover rate of length composition for each age class. In figure 1 (a) and (b), the violin and boxplot are illustrated from the inputted length composition data to SS3. From Figure 1, most of data including in the range from Age 0 to Age 1 or 2. Proportion of the data over the age 3 is lower than 5%.

To study the appropriate number of age class by applying relative age-selectivity, we set each age class for one parameter, and change the range applied selectivity parameter. So, we do the following runs; set selectivity parameter applied at 1) age 0 to 2 (model named **AG3)**, 2) age 0 to 3 (model named **AG4**), 3) age 0 to 4 (model named **AG5**), 4) age 0 to 5 (model named **AG6**) , 4) age 0 to 6 (model named **AG7**).

Time block

For setting of the time block, we focus on the median values of yearly size composition data. From the input of SS3, median values of length composition for each year are calculated (see. Table 3). By the setting of threshold, 8 combinations (a to h) of time block are defined as followings;

a) 2011 (run named **TBa**)
b) 1997, 2011 (run named **TBb**)
c) 1997-1998, 2007-2008, 2011 (run named **TBc**)
d) 1993, 1997-1999, 2006-2008, 2010-2011 (run named **TBd**)
e) 1993, 1996-1999, 2003, 2006-2008, 2010-2011 (run named **TBe**)
f) 1993-1994, 1996-1999, 2001, 2003, 2006-2008, 2010-2011 (run named **TBf**)
g) 1993-1994, 1996-1999, 2001, 2003, 2006-2012, 2014 (run named **TBg**)
h) 2000, 2005 (run named **TBh**).

The combinations of time block are judged by the median value in Table 3. We sort the data in Table 3 in ascending order, and gradually pick up the data from small to large median values and corresponding years. Picked up years are grouped as one time block. If the number of the group is larger, we set time block as large group (i.e. **TBh**).

Result

The result for all considerable runs are presented in Table 4.

Firstly, for the cubic spline, the total likelihood is improved by increasing the number of nodes. In the point of the total likelihood, **CS7** or **CS9** (especially **CS7**) is better fit than one for **CS3** or **CS5**. However, runs with option 1, **CS3i** and **CS7i**, does not converge (see. Convergence level in Table 4). Under the option 1, the node locations are determined by the specified number of nodes and on the cumulative size distribution of the data for this fleet/survey (Methot, 2013). The differences of node locations are summarized in Table 5. From Table 5, the differences among locations seems like small. However, runs with option 1 (**CS3i** and **CS7i**) does not converge. From the results, cubic spline is very sensitive to the node location. The Figure 2 (b) – (e) are the selectivity curve of **CS3** to **CS7**. Figure 4 (b) – (e) present the fit of length composition, and the fit looks like good. However, especially for the **CS7** and **CS9**, the shape is very strange and it seems like under over fitting.

Secondly, for age selectivity, by increase of selectivity parameter for age class, the total likelihood will decrease (see. Table 4). This is natural phenomenon, the composition data is mainly concentrated into the range age 0 to 2 (see. Figure 1 (b)), so increase of selectivity parameter does not work well. So the fitting of data looks no change (see. Figure 4 (f) – (j)).

Finally, for the time block, **TBc** presents better performance than other run (see. Table 4). This run based on the judgment of the yearly median value of length composition data. For other judgment, the performance of fitting is not better than **TBc**.

Discussions

For the cubic spline, the performance would change dramatically by the number of nodes. In the case, 7 nodes setting is recommended, but the locations of the nodes are very sensitive to the estimation. So cubic spline is not robust selectivity function. So cubic spline is hard to apply, but it is very strong tool for the stock assessment if there is some method to control the sensitivity of the location of node.

For the age selectivity, the analysis of the length composition is very important and helpful to judge applying age selectivity or not. Since, in the fleet, most of all data concentrate between age 0 to age 2 class. So, we can easily judge to apply selectivity parameter.

Finally, for the time-varying selectivity, the median of length composition is one of the candidate to judge for selecting periods of time block. Time block should be set as yearly unit in SS3, so the median for yearly length composition data would be useful. On the other hand, the median value for combined all year presents the characteristics of the trend of length composition. So, using these index may help us to select the period of time block.

Finally, for the Japanese set net fleet, I recommended to apply time block selectivity. Since each parameter reduce 2.1 likelihood by the increasing of parameter under the **TBc**. This is better than the other runs (see. Table 4)

Reference list

Chikuni, S. 1985. The fish resources of the northwest Pacific. FAO Fisheries Technical Paper 266, 190p.

Hiraoka, Y., H. Uyama, M. Kanaiwa, H. Fukuda, and Oshima, K. 2015. Updated length frequency for Pacific Bluefin tuna caught by Japanese set net with modified method. ISC/15-1/PBFWG/03

ISC 2012. Report of the Pacific bluefin tuna working group intersessional workshop. Annex 8 of Report of the fifteenth meeting of the international scientific committee for tuna and tuna-like species in the North Pacific ocean, plenary session. 19p.

ISC 2015. Report of the Pacific bluefin tuna working group intersessional workshop. Annex 9 of Report of the fifteenth meeting of the international scientific committee for tuna and tuna-like species in the North Pacific ocean, plenary session. 24p.

Kai, M. and Takeuchi, Y. 2012. Update and re-examination of the estimation of catch at size of Pacific Bluefin tuna *Thunnus orientalis* caught by Japanese set-net fishery. ISC/12-1/PBFWG1/05.

Methot, R. 2013. User Manual for Stock Synthesis Model Version 3.24s.

Sakai, O. Y. Hiraoka, H. Fukuda and Oshima, K. Estimation of catch at size of Pacific Bluefin tuna caught by Japanese set net fisheries: Updated up to 2014 fishing year. ISC/15/PBFWG-2/04

Table 1. Model setting of the prot-type in the document.

	Prot-type model in this document
SS version	Latest version on NOAA toolbox
Year definition	July to June (Fishing year)
Time step	Quarter
Stock(spawning population)	Single spawning population
Area	Single for assessment
Number of age	21(0-20) -default; 21- lumped
Ngender	sex-combined
SRR	B-H (h=0.999)
R0	estimated
sigmaR	Compare with estimated variation
R0 offset	estimated
recruitment	option 1
Natural mortality	Age specifc M M0=1.6 M1=0.386 M2+=0.25
Maturity	Age specific Maturity Age3=0.2 Age4=0.5 Age 5+=1.0
Growth curve	Shimose et al. (2009) for single sex model adjust L1=21.5 for optimal fit Shimose et al. (2012) CV(L1); estimate CV(L2);0.05
#of growth patterns	1
#of morphs, sub-morphs	1
Functional form of CV growth	CV=F(L)
Amin Amx	0 3
L-W	Kai et al., 2007
Length bin definition	default; old structure
Weight bin definition	0,1,2,5,10,16,24,32,42,53,65,77,89,101,114,126,138,150,161,172,182,193,202,211,220,228,236,243,273
Population length	2cm for all
Catch unit	Weight/numbers EPO-sport (numbers)
Catch error	0.1
F-method	3 (solve catch eq) - catch exact
upperF	10

Table 2. Model setting of the prot-type in the document.

Fishery definition	Fleet name	Selectivity	Time block	Length/Weight
Fleet 1	Japanese Longline	Double Normal	93-14	Length
Fleet 2	Japanese SPPS	Double Normal		Length
Fleet 3	Korean OLPS	Mirror to Fleet 2		Length
Fleet 4	Japanese Tuna Purse Seine operating in Japan Sea	Double normal	07-14	Length
Fleet 5	Japanese Tuna Purse Seine operating in Pacific Ocean	Double normal		Length
Fleet 6	Japanese troll	Double normal		Length
Fleet 7	Japanese Pole and Line	Mirror to Fleet 6		Length
Fleet 8	Japanese set net (Quarter 1 to Quarter 3)	Double normal		Length
Fleet 9	Japanese set net (Quarter 4)	Double normal		Length
Fleet 10	Japanese Set Net operating in Northern Part of Japan (Aomori & Hokkaido)	Double normal		Weight
Fleet 11	Japanese other fishery(Other fishery in Tugaru channel)	Mirror to Fleet 10		Weight
Fleet 12	Taiwanese long line	Flat top		Length
Fleet 13	1952-2001; US com (fitting data 1952-1982)	Double normal		Length
Fleet 14	2002-2014; Mexican PS for pen (include US catch)	Double normal		Length
Fleet 15	EPOSports	Mirror to Fleet 13		Length
Fleet16	JTroll4Pen	Double normal		Length

	Selectivity
CPUE (JLL)	Same as Fleet 1
CPUE (JpnDWLLRevto74)	Same as Fleet 1
CPUE (JpnDWLLfrom75)	Same as Fleet 1
CPUE (TPSJO)	Same as Fleet 4
CPUE (JpnTrollChinaSea)	Same as Fleet 6
CPUE (JpnTrollPacific)	Same as Fleet 6
CPUE (JpnTRKochi)	Same as Fleet 6
CPUE (JpnTRWakayama)	Same as Fleet 6
CPUE (TWLL)	Same as Fleet 12
CPUE (USPSto82)	Same as Fleet 13
CPUE (MexPSto06)	Same as Fleet 14
CPUE likelihood	lognormal
CPUE lambda	1
CPUE CV	1. Lowest/average is 0.2 add observation error. Flexibility by modelers
Input sample size for LenComps	Submit an input sample size time series with an exolanation, may submit a document in Feb.
1st year of main Rdev	1953
SR auto correlation	no
Initial F	Estimate without fitting to EqC Fleet 1, Fleet 12

Table 3. Yearly median value of the length composition data (unit: cm) (calculated by using input data)

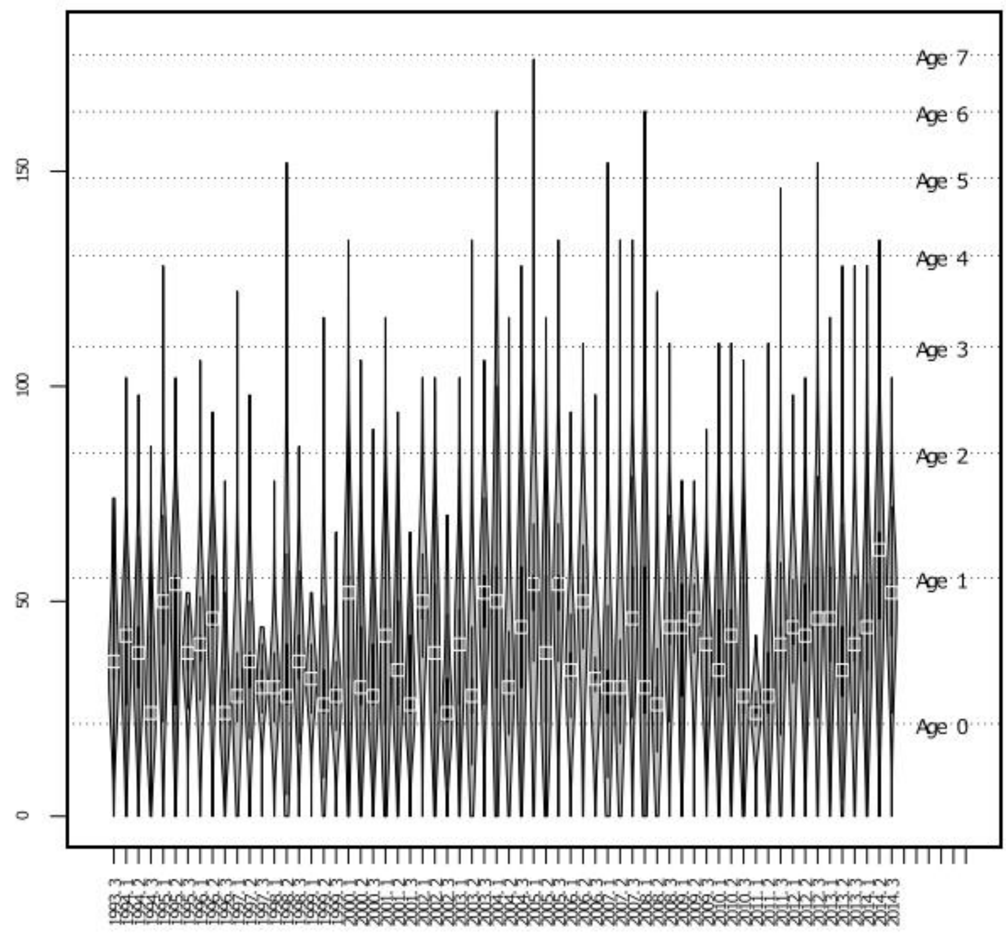
Year	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Median value	36	42	50	40	28	30	32	52	42	50	40
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Median value	50	54	34	30	30	44	34	24	44	46	44

Table 4. The results of each runs

	Prot type	CS3	CS5	CS7	CS9	CS3i	CS7i	
Total negative log likelihood (TNL)	1810.9	1813.8	1810.8	1792.2	1793.4	1811.7	1796.3	
The number of parameters	120	121	123	125	127	125	131	
The # of param. of prot type-The # of param. (A)	0	1	3	5	7	5	11	
TNL of prot type-TNL (B)	0.0	2.9	-0.1	-18.7	-17.5	0.8	-14.63	
(B)/(A)		2.9	0.0	-3.7	-2.5	0.2	-1.3	
Convergence level	5.2E-05	4.0E-04	2.3E-05	1.2E-04	1.5E-04	3.1E+02	3.8E+00	
	AG3	AG4	AG5	AG6	AG7			
Total negative log likelihood	1830.1	1826.3	1825.8	1825.4	1825.3			
The number of parameters	120	121	122	123	124			
The # of param. of prot type-The # of param. (A)	0	1	2	3	4			
TNL of prot type-TNL (B)	19.2	15.4	14.9	14.5	14.3			
(B)/(A)		15.4	7.4	4.8	3.6			
Convergence level	1.9E-04	1.0E-04	4.4E-04	2.3E-03	3.7E-04			
	Tba	TBb	TBc	TBd	Tbe	TBf	TBg	TBh
Total negative log likelihood	1808.8	1803.5	1791.8	1796.6	1798.7	1802.1	1804.8	1810.2
The number of parameters	123	126	129	132	135	138	135	126
The # of param. of prot type-The # of param. (A)	3	6	9	12	15	18	15	6
TNL of prot type-TNL (B)	-2.2	-7.4	-19.1	-14.3	-12.2	-8.8	-6.1	-0.7
(B)/(A)	-0.7	-1.2	-2.1	-1.2	-0.8	-0.5	-0.4	-0.1
Convergence level	3.4E-04	1.5E-05	5.1E-06	1.1E-04	2.7E-04	7.5E-04	1.7E-04	2.9E-05

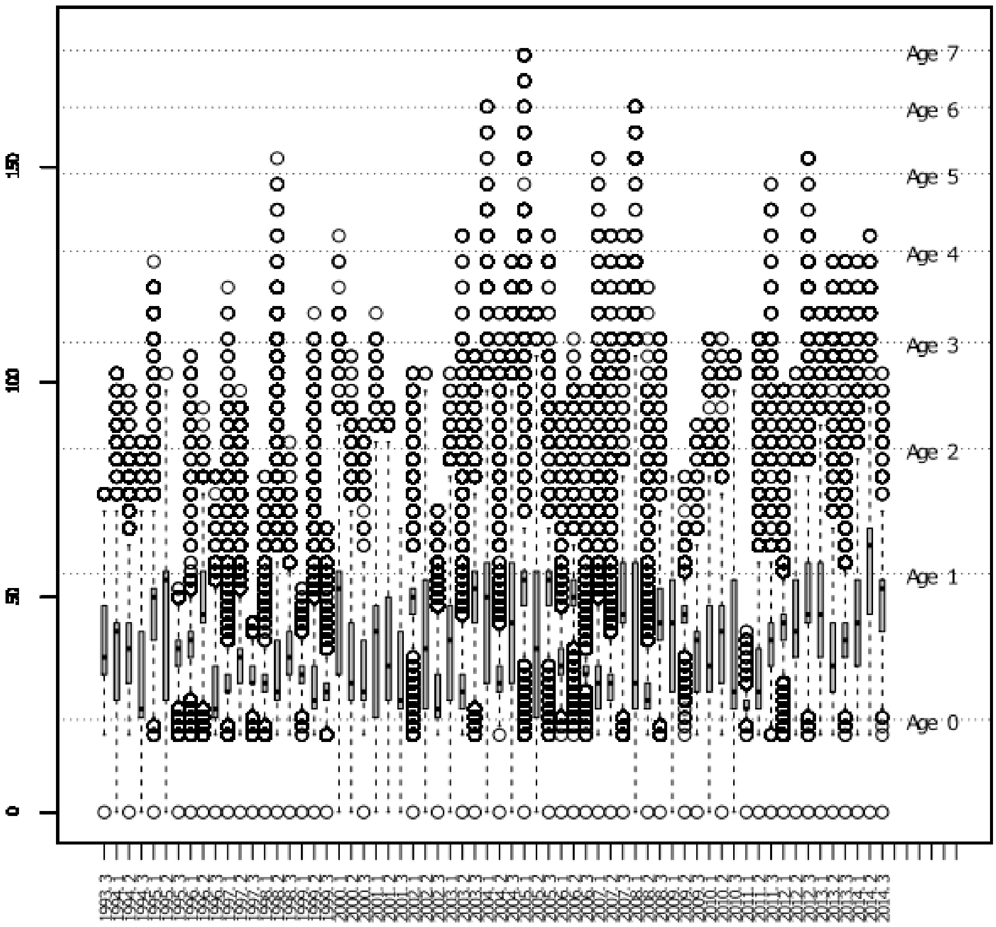
Table 5. The comparison of nodes locations between CS3 (resp. CS7) and CS3i (resp. CS7i)

# of nodes		node's location						
		1st node	2nd node	3rd node	4th node	5th node	6th node	7th node
3	CS3i (Option 1)	18.9	100.4	275.6				
	CS3 (Option 2)	17.3	100.0	280.3				
7	CS7i (Option 1)	17.5	38.4	71.1	100.3	143.9	168.9	278.3
	CS7 (Option 2)	17.3	37.8	58.8	100.0	156.8	218.5	280.3



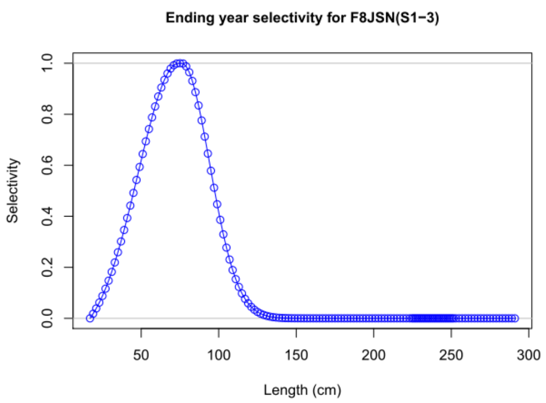
(a)

Figure 1. (a) The violin plot and (b) box plot of the length distribution of Japanese set net for quarter 1 to quarter 3 during 1993 to 2014 (Fleet 8).

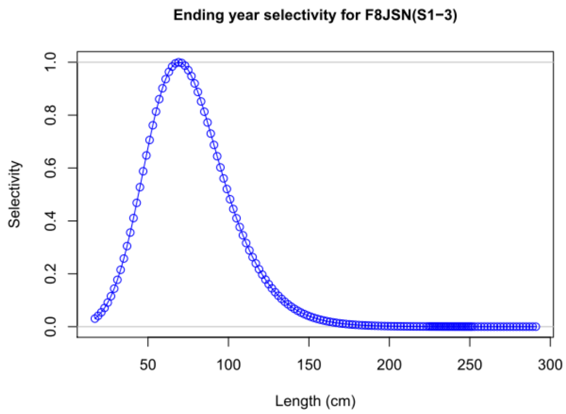


(b)

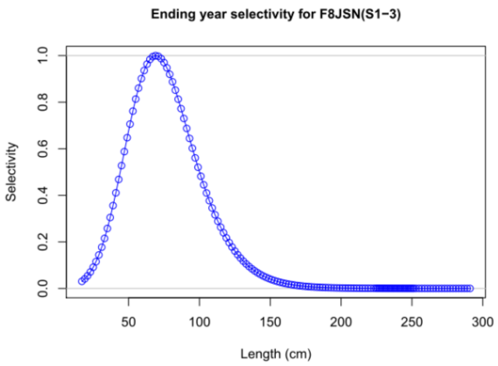
Figure 1 (cont.).

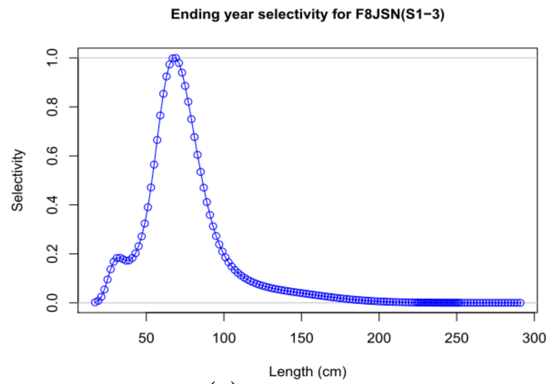


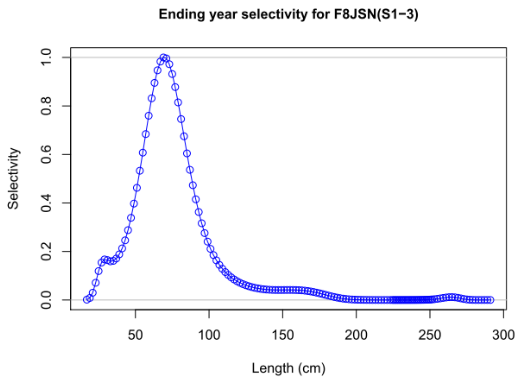
(a) Prot type



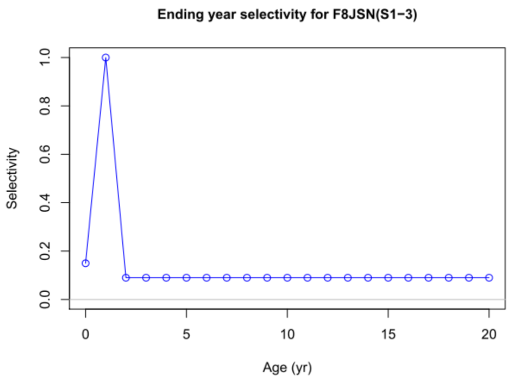
(b) CS3





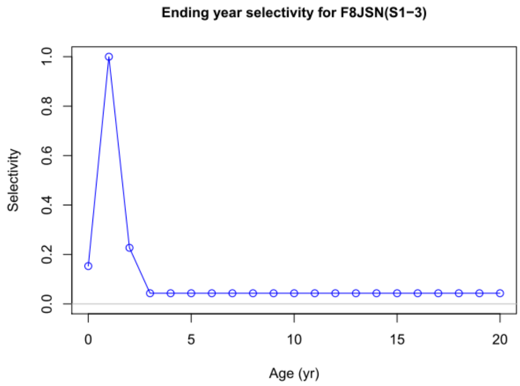


(e) CS 9

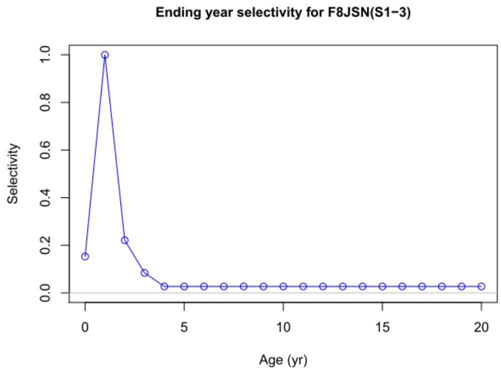


(f) AG3

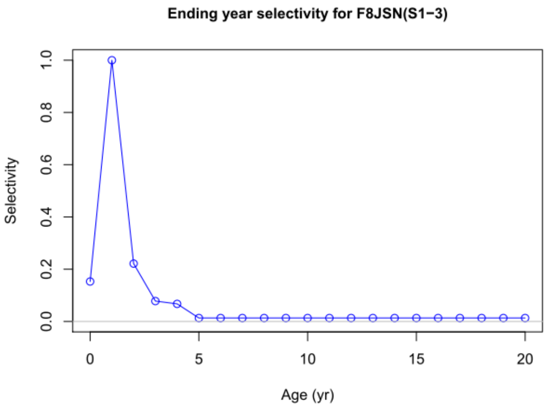
Figure 2. Selectivity curve for (a) Prot type, (b) CS3, (c) CS5, (d) CS7, (e) CS9, (f) AG3, (g) AG 4, (h) AG 5, (i) AG6, (j) AG7



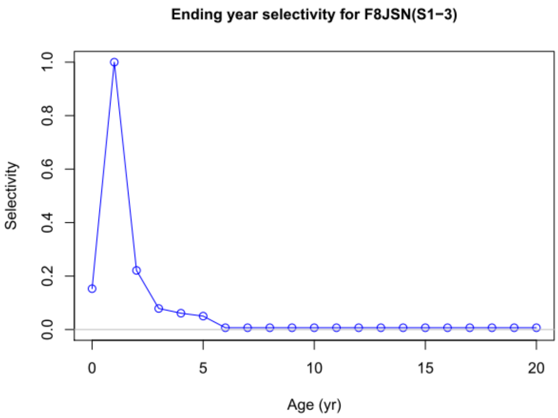
(g) AG 4



(h) AG 5

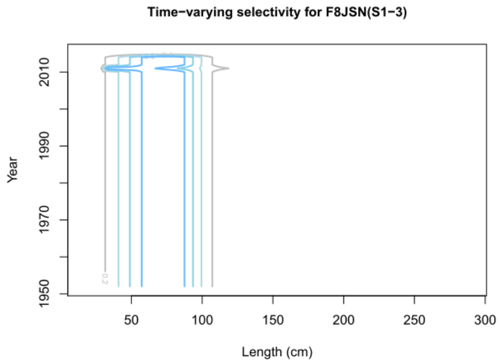


(i) AG 6

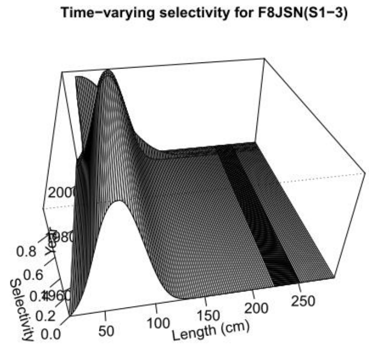


(j) AG 7

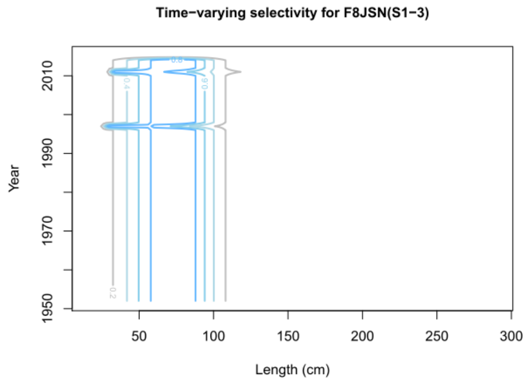
Figure 2. (cont)



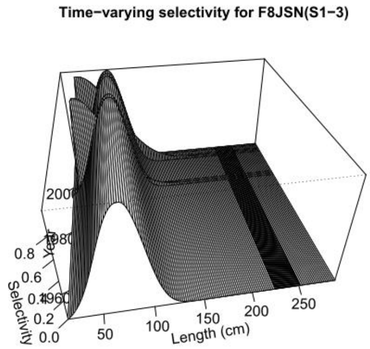
(a1) TBa



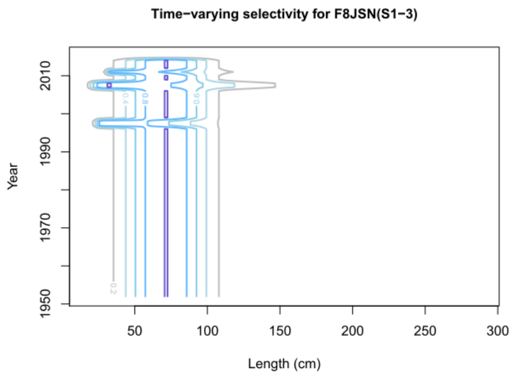
(a2) TBa



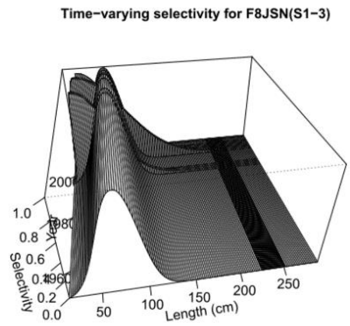
(b1) TBb



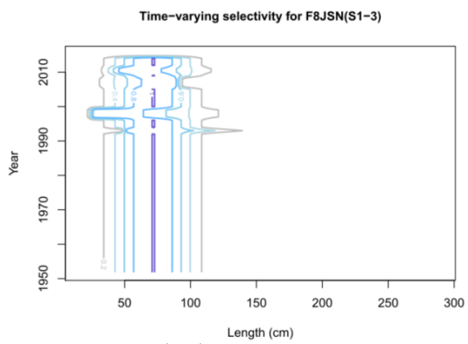
(b2) TBb



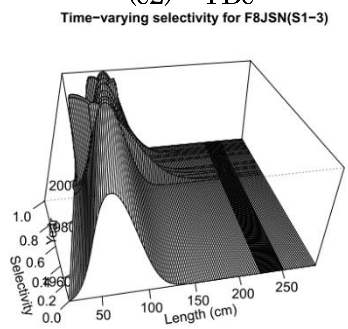
(c1) TBc



(c2) TBc



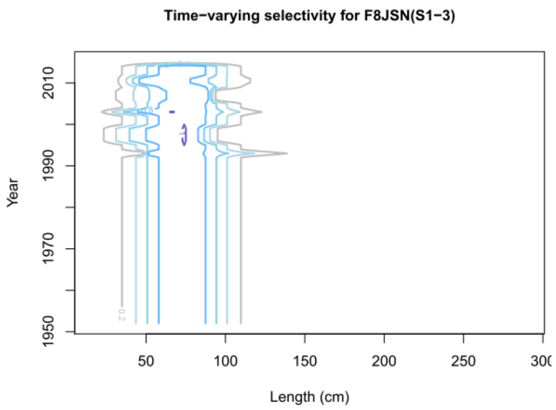
(d1) TBd

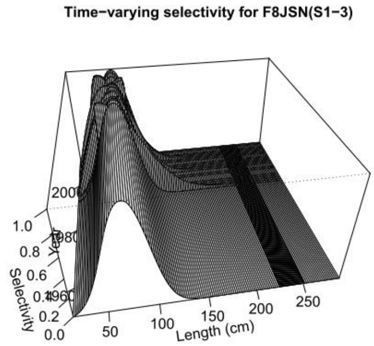


(d2) TBd

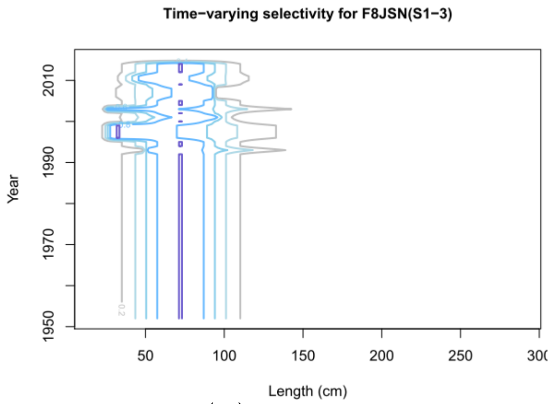
Figure 3. Selectivity curve for (a) TBa, (b) TBb, (c) TBc, (d) TBd, (e) TBe, (f) TBf, (g) TBg, (h)

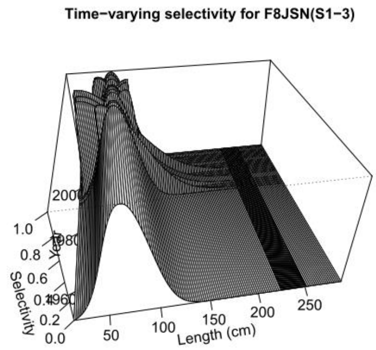
TBh



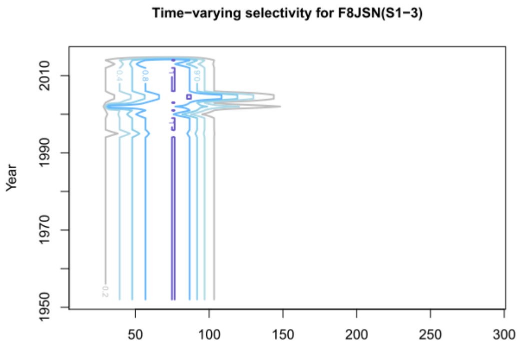


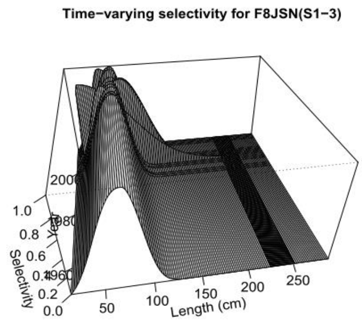
(e1)　TBe　　(e2)　TBe



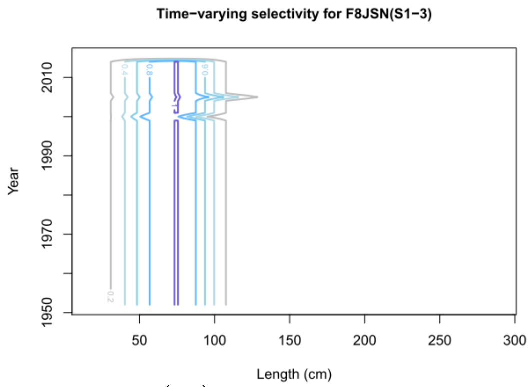


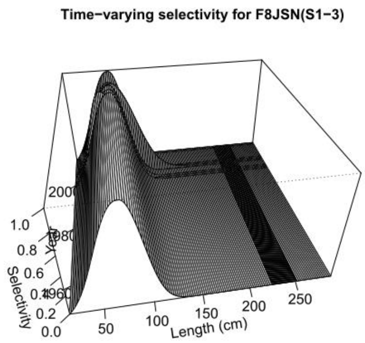
(f1)　TBf　　(f2)　TBf





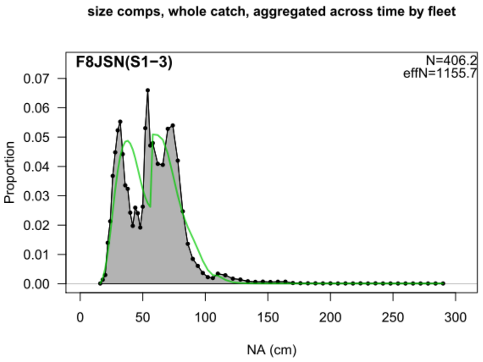
(g1)　TBg　　(g2)　TBg



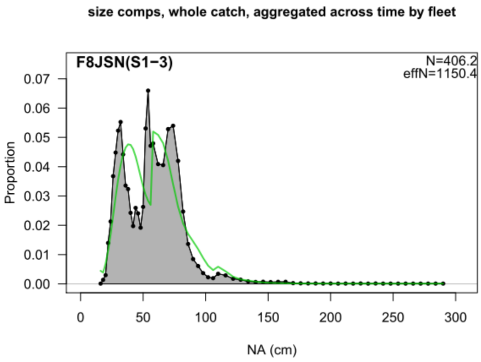


(h1)　TBh　　(h2)　TBh

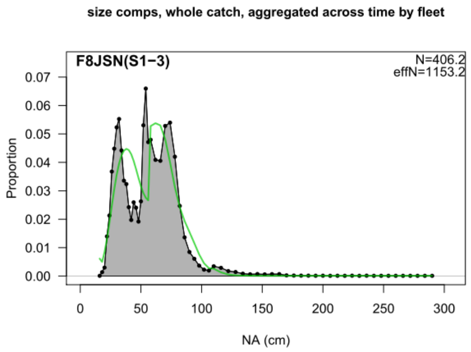
Figure 3. (cont)



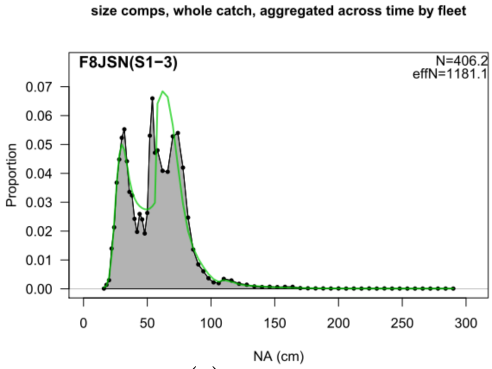
(a) Prot type



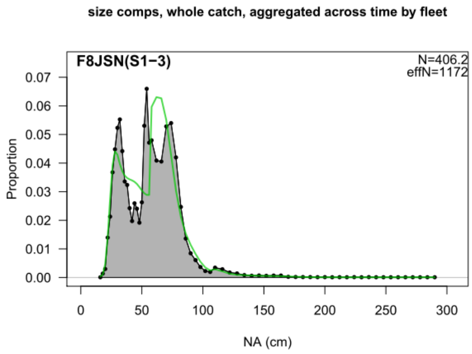
(b) CS3



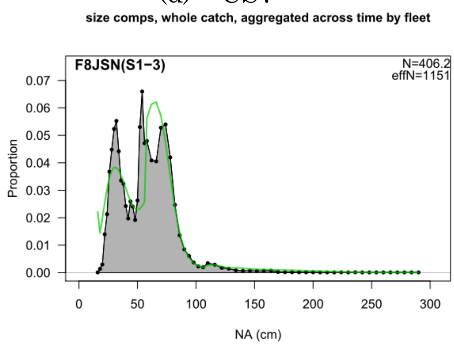
(c) CS5



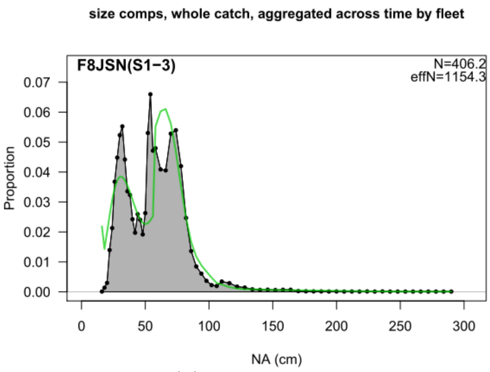
(d) CS7



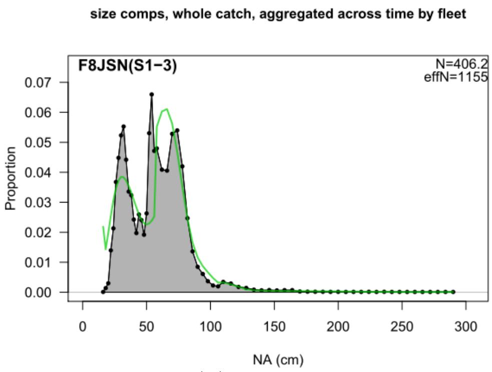
(e) CS9



(f) AG3

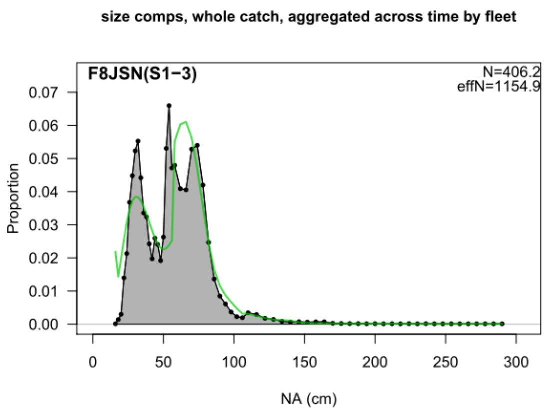


(g) AG4

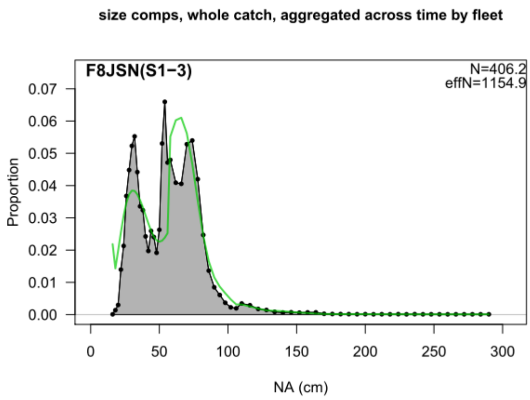


(h) AG5

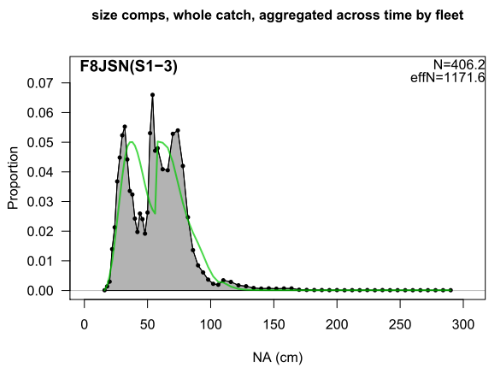
Figure 4. Fitting to the composition data.



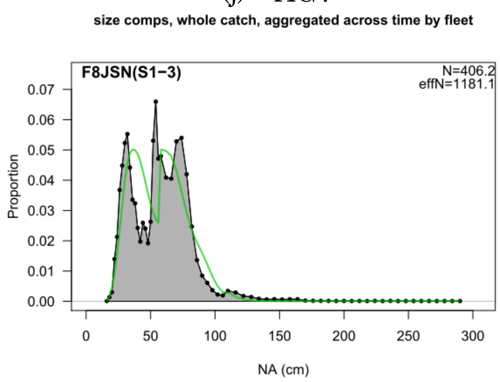
(i) AG6



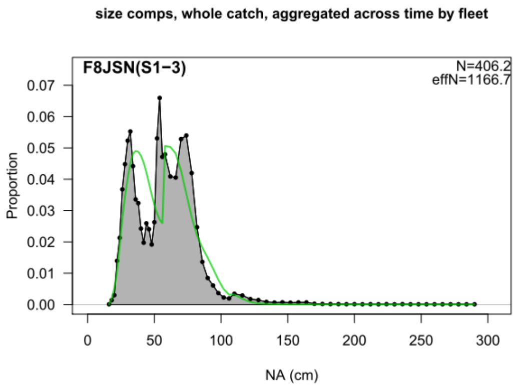
(j) AG7



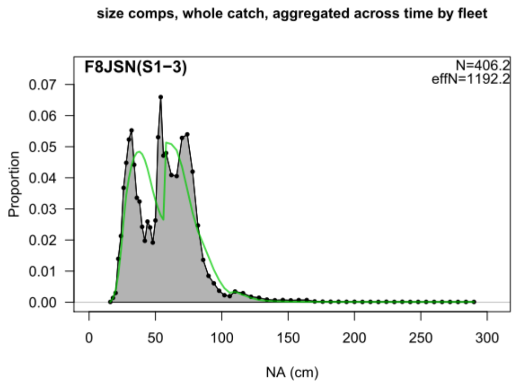
(k) TBa



(l) TBb

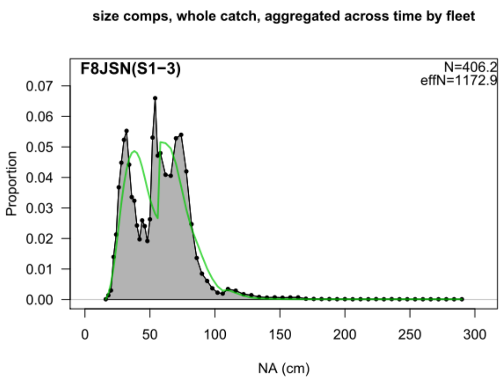


(m) TBc

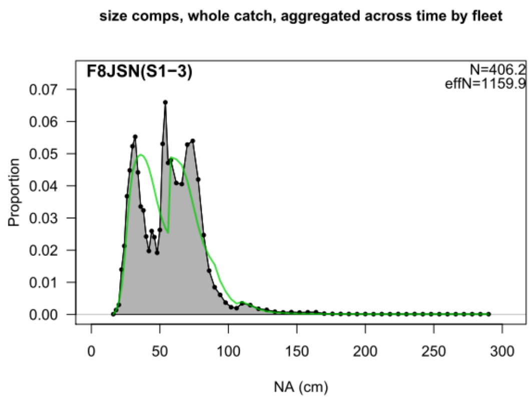


(n) TBd

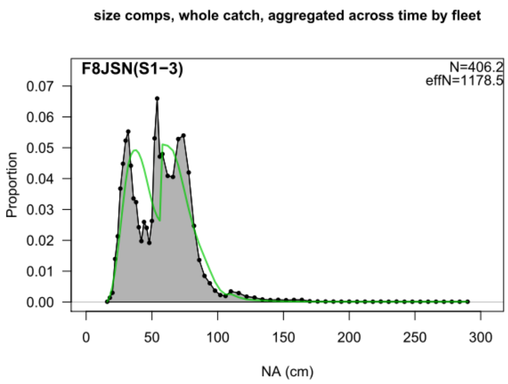
Figure 4. (cont.)



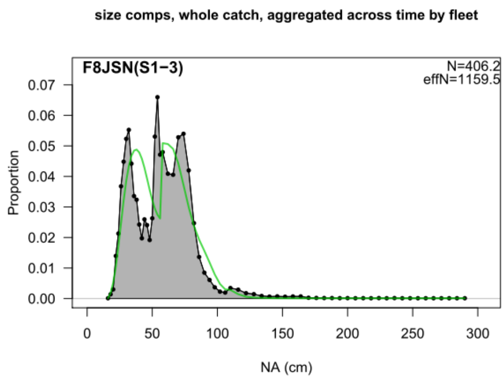
(o) TBe



(p) TBf



(q) TBg



(r) TBh

Fig 4. (cont)