ISC/12-1/PBFWG/01

Estimation of length compositions on pacific bluefin tuna caught by Japanese longline fishery

Akiko N. Mizuno, Momoko Ichinokawa, Kazuhiro Oshima and Yukio Takeuchi

National Research Institute of Far Seas Fisheries, 5-7-1,Shimizu-orido, Shizuoka 424-8633, JAPAN

Corresponding author: mizunoakiko@fra.affrc.go.jp

Jan.-Feb. 2012

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), 31 January-7 February 2012, La Jolla, San Diego, California, USA. **Document not to be cited without author's permission.**

Introduction

Japanese longliners (JLL) targeting spawning population of Pacific bluefin tuna (PBF) is an important fishery for stock assessment because it can provide information about stock status of its spawning population. Also, size frequency data of PBF caught by this fishery is important because it is used for determining age composition of the population; having direct and indirect effects on estimating selectivity. In the past stock assessments of PBF, the size frequency data of JLL fishery described in ISC/07/PBF-1/11 had been used. In this paper, we report the results of improved estimation for the length composition.

Landing ports for Japanese longline fisheries are spread over Japan and sampling are also carried out in many of these ports. However, the sample size at each sampling location is not always proportional to the landing.

For example, large catches have been occasionally reported with samples of small size. Alternatively, small catches were occasionally reported with samples of large size. In other words, the sampling rates have been grossly unbalanced through the time of year and season, and across the landing ports for this fishery. Length composition data for stock assessment can be different from length composition of actual fish caught by JLL fishery. We present catch at size of JLL fishery weighting size data to the catch.

Materials

Catch Data

Currently, in the Pacific Ocean, there are two major types of Japanese longline fisheries; relatively large sized distant and offshore water longliners operating across distant waters and smaller coastal longliners operating adjacent and coastal waters. In 1952-1968, Japanese statistics contain only distant and offshore water longliners which were smaller compared with the current boat licensed as offshore and distant waters. The PBF catches by the coastal longline appeared in the statistics since 1969 and have been increasing over the last few decades. Now, coastal longline catch accounts for large part of the Japanese longline PBF catches (Fig. 1).

There are three data sources to estimate total longline catch of PBF（Table 1）. One is SD report which contains total annual catches in weight by these three types of longline fisheries. Annual total catches in number by coastal longline was calculated as SD report catches in weight divided by mean weight in each year, that is average of weight of fish sampled from this fishery （see bellow, Ichinokawa et al 2007）by multiplied by 1.15, because the weight data is of gilled and gutted fish. The second source is raised logbook data which data base of 5x5/month/year, which was created by aggregating logbook information for set by set and weighted to the total number of set reported for each stratum from other sources. These data cover almost 100 % of distant water and offshore longline operations, but do not cover data from coastal longline. Therefore, basic daily Logbook which keeps records of number of fish caught in individual set with positional information, date of set of coastal longline. However annual coverage rate of logbook may be less than 70% of the total annual catch (in number of fish) of coastal longline fishery, as estimated by converting catch (in weight) reported in SD report. Therefore for the annual catch in number of fish by coastal longline is based on the SD report. We also estimated monthly catch in number of fish by this fishery, according. to monthly proportions of number of fish in the logbook data. Annual catch number of coastal longline and distant water and offshore no and sampling coverage rate are shown in table 3.

Size Sample Data

Our calculation is based on ISC/07/PBF-1/11 that relies on RJB, port sampling data from Kessen-numa and Katsuura ports in 1952-2007. There are three types of data; 1) length of fish without weight, 2) length of fish with weight and 3) weight of fish without length. In ISC/07/PBF-1/11, length data of 1 and 2 were used but weight in types 3 were converted to lengths. In addition to the sampling data from these two ports, we included sampling data for from Tomari port for recent years of 2007-2010. The length data are recorded by month and year, information of locatios of sets, but have no information as to from which lf longline fisheries the samples came from (distant, offshore water or coastal). Information of locations of catches has in most cases with 5 x 5 degree area, and consequently our analysis used 5 x 5 degree as minimal spatial stratum. Especially, the length data from 1969 to 1993 were not used as the data were inadequate (Fig. 2).

Methods

We estimated Catch at Length as follows:. 1) Stratification of size sample data and catch in number. 2): Extrapolating size sample data to catch in number in each stratum. If a stratum has no size sample data, we have substituted by pooled size data from the more aggregated strata. The order of aggregations is Year, month and locations (latitude and longitude). 3) Those catch at length estimated to the minimum strata are combined into quarter/year strata.

However, we did not calculate catch at size for the period of 1969 to 1993, for several reasons. One is that the data during this period were not used in previous stock assessment. This is because converted length data from weight made up a majority of the lengths during this period. The second reason was that the data during this period did not fit well in preliminary SS runs at the last stock assessment (Ichinokawa, personal comm). Another reason is that we cannot stratify coastal longline catch data by months for the above period, since no logbook data from coastal longline had been collected until 1993.

We tested two types of stratification by comparisons of estimated catches at size A) year and month B) year, month and locations of catch. In the next section, we explain the levels of strata where data were pooled and of substitutions for missing data, detailed procedures for stratification, raising, pooling and substitution are also explained.

Selection of pooling and substitution

Our choice of level of strata to which size data were pooled for substitution is based on the followings. We have analyzed the variations of average length by year, month, latitude and longitude using GLM with statistical software R to choose levels of strata for pooling (Table 2). We focused on each deviance (see below footnote).[i] Then, we have chosen spatial information (longitude and latitude) and month levels as pooling levels.

Details of methods for stratification, raising, pooling and substitution for data

1 Year /Month stratification and raising length data by catch in number of fish(1952-2010)

We combined Catch in number and sampled lengths by year/month. After that, we calculated size frequency at 2cm bin for each year/month and raised these sample length frequencies to the catch in number of fish in the corresponding stratum. In a stratum where no size data are available, sample size pooled for the entire corresponding year was used to substitute the missing sample size.

2 Year, Month and area stratification and raising by catch in number (1952-1968)

We combined catch in number of fish and sample lengths for each year/month and by 5 x 5 degree areas. We made length compositions with 2-cm bin every cell. As stated above we used 5x5 degree area as basic unit of resolution of data.

Some sampled length data have finer or coarser spatial information than 5x5. Those which have finer area resolutions are combined to corresponding 5x5 area. The data which have less resolutions than 5x5 were randomly distributed into 5x5 areas which constitute that cell of sample, e.g. 20 lengths were measured in a cell of 10,10, they were randomly allocated to 4 5.x5 cells belonging to that 10.10. And then, we raised length composition in each stratum to catch in number of fish. When catch has no corresponding size sample data, we substituted with length composition from A) adjacent 5x5 degree square of same year/month or at same 5x5 squares in adjacent months, B) if the cells referred in above a lack size sample data, we used pooled length data in the same year/month.

Results and Discussion

We did not find obvious difference between catch at size and actual length composition of fish sampled, throughout the years, i.e. no shifts of peaks or appearance of different peaks are shown between these two sets (Fig. 3). Two sets of catch at size estimated with method 1 (year/month) and method 2 (year/month/5x5 area) have also similar tendencies. Also, we calculate catch at size using all lengths even those converted from weight data, using the same procedures; because preliminary SS runs with estimated length data from weight records did not fit well during previous stock assessment. Compositions of actually measured lengths were very close to the length compositions estimated with data set including lengths converted from weight (refer to Supplementary Information). Therefore, in following section, we discuss the results of length composition including converted length data from weight because it has allowed us to compare with data used in the previous stock assessment.

When we looked at length compositions by quarters, we cannot find much difference between both methods of raising, nor much differences between raised length compositions and raw length samples with a few exceptions, that is 1952-Q4, 1953-Q3 etc (Fig.4A and Supplementary information S1). At few exceptions, we can find difference between length compositions estimated from both methods and raw samples (Fig.S2). Difference of length compositions in many cases derived from low size sample size. Estimated catch at size with method 2 required substantially more substitution of pooled data from other strata than that of method 1. This is because data are combined into finer strata in method 2 than method 1 (Table 4).

We recommend the method 1 because A) no clear difference in results between methods 1 and 2, while B) may introduce different type of strfatifications and thus may cause instability in stock assessments. In general, there are no clear differences between catch at size estimated by methods 1 and 2 and between them and raw sampled size frequencies, because the coverage rate of samples have been high and adequate (Table3). This indicated that length composition of JLL have high representativeness.

Finally, we discuss criteria of minimum sample size needed as input data for stock assessment. In previous stock assessment, length composition data with sample size over 100 records have been adopted (Ichinokawa, personal comm). We recommend reducing the criteria from 100 to 60 and use catch at length by year/quarter strata (Table 4A). The reasons are that estimated catch at length has no abnormal peaks among years or quarters based on samples with minimum sample size of 60. Alternatively, We can find the distribution of catch at length with sample size less than 60 very often has bins with an extremely high frequency (Fig. 4 2001-Q3 several bins having exactly the same frequency and Fig. 4 2008-Q4, respectively).

Reference

Ichinokawa, M., (2007), Length frequency of Pacific bluefin tuna caught by Japanese longliners, ISC/07/PBF-1/11

---

[i] For example differences of deviance of the model with average length as response variable and explanatory variables year and month from that of the model with variable latitude as well as year and month represent year kind of variability of “latitude”. In other words, an explanatory variable (level) which has smaller difference of deviance should have less differences among length composition data expressed by mean length by that level

Figures and Tables

Table 1 Covering rate of database about catch. We used data of cell filled Gray.

	All fishing of JLL	adjacent and coast fishing		Pelagic fishing	
	Total catch weight per year	Catch weight per year	Catch number per month with position	Catch weight per year	Catch number per month with position
SD report	100	100	-	100	-
Raised logbook data	-	-	-	100	100
Logbook data	-	20-70	20-70	?	?

Table 2 Summary of values of deviance and AIC from GLM analysis in R-software

	Df	Deviance	AIC
Full model		12805295	329277
-(Year)	16	14237991	335789
-(month)	11	13202130	331138
-(latitude)	8	13288629	331547
-(longitude)	12	13358093	331861

Table3. Sampling number, Catch number and covering rate 1952-1968, 1994-2010

year	Sample number		catch number				Covering rate		mean weight
	only length	length and estimated length by weight	pelagic fishing	adjacent and coast	annual total	expected total	only length	length and estimated length by weight	
1952	1067	1365	24012		24012		0.044	0.05685	
1953	2653	3085	22336		22336		0.119	0.13812	
1954	3943	3999	24472		24472		0.161	0.16341	
1955	4142	4604	23268		23268		0.178	0.19787	
1956	2660	3194	22845		22845		0.116	0.13981	
1957	853	1740	11006		11006		0.078	0.1581	
1958	611	1388	6684		6684		0.091	0.20766	
1959	1188	3619	32604		32604		0.036	0.111	
1960	3305	11549	51926		51926		0.064	0.22241	
1961	615	13273	53833		53833		0.011	0.24656	
1962	2203	13423	45715		45715		0.048	0.29362	
1963	1326	12729	44222		44222		0.030	0.28784	
1964	1647	6846	20706		20706		0.080	0.33063	
1965	841	2478	17314		17314		0.049	0.14312	
1966	41	1843	9006		9006		0.005	0.20464	
1967	191	963	6216		6216		0.031	0.15492	
1968	59	254	3756		3756		0.016	0.06763	
1994	4060	4060	2228	8299	10527	10511	0.386	0.38568	117
1995	1890	1890	950	4396	5346	5296	0.354	0.35356	130
1996	4521	4521	1182	6314	7496	7378	0.603	0.6031	123
1997	5923	5923	1324	8855	10179	10032	0.582	0.58189	131
1998	5518	5518	1617	7446	9063	8681	0.609	0.60882	146
1999	4845	4845	1177	7088	8265	8079	0.586	0.58618	145
2000	2575	2575	1078	5598	6676	6452	0.386	0.38571	149
2001	1906	1906	581	5039	5620	5516	0.339	0.33915	144
2002	1537	1537	472	5084	5556	5417	0.277	0.27665	156
2003	2100	2100	928	7077	8005	7673	0.262	0.26234	163
2004	2740	2740	1617	10250	11867	11766	0.231	0.23088	158
2005	3174	3174	790	10930	11720	11658	0.271	0.27081	166
2006	1466	1466	443	5829	6272	6231	0.234	0.23374	182
2007	3362	3362	531	10075	10606	10538	0.317	0.31698	199
2008	1111	1111	185	7767	7952	7909	0.140	0.13972	190
2009	1600	1600	101	5727	5828	5793	0.275	0.27455	228
2010	805	805	83	985	1068	3580	0.754	0.81753	226

Table 4A sample number each quarter and year Gray cell is not used length composition for previous Stock Assessment and black cell is usable data to be judged on new criteria (sample number is over 60).

	sample number each quoter and year					catch number of fish each quoter and year				
	1Q	2Q	3Q	4Q		1Q	2Q	3Q	4Q	
1952	26	566	739	34	1365	1593	10439	10692	1288	24012
1953	55	2895	37	98	3085	1312	14535	4791	1698	22336
1954	143	2699	1123	34	3999	1725	11804	9738	1205	24472
1955	144	3769	529	162	4604	1296	9412	9791	2769	23268
1956	63	2934	161	36	3194	856	7201	13631	1157	22845
1957	16	1600	104	20	1740	1040	5166	4067	733	11006
1958	105	776	184	323	1388	1026	2249	1132	2277	6684
1959	290	2461	229	639	3619	3452	12340	8703	8109	32604
1960	563	10185	295	506	11549	5319	34618	5081	6908	51926
1961	1555	9718	954	1046	13273	6286	30064	12168	5315	53833
1962	886	11090	1270	177	13423	5695	32716	3801	3503	45715
1963	1248	10886	446	149	12729	3366	35090	4069	1697	44222
1964	243	5711	376	516	6846	1823	14951	2250	1682	20706
1965	139	1931	91	317	2478	1993	12245	983	2093	17314
1966	34	799	497	513	1843	664	4784	1856	1702	9006
1967	39	204	671	49	963	1161	2740	1727	588	6216
1968	6	59	170	19	254	1192	1309	789	466	3756
1994	305	3325	357	73	4060	1013	8205	1117	191	10527
1995	86	1751	32	21	1890	378	4299	415	253	5346
1996	247	4155	54	65	4521	855	5539	800	303	7496
1997	341	5201	84	297	5923	820	8587	346	425	10179
1998	222	4571	332	393	5518	484	7455	677	447	9063
1999	270	4354	50	171	4845	551	6973	357	385	8265
2000	149	2279	72	75	2575	446	5675	361	194	6676
2001	134	1713	18	41	1906	324	4777	232	287	5620
2002	46	1397	54	40	1537	538	4234	312	471	5556
2003	63	1883	17	137	2100	637	6068	517	783	8005
2004	201	2434	20	85	2740	927	8576	1034	1331	11867
2005	120	2966	17	71	3174	879	9543	605	693	11720
2006	62	1355	36	13	1466	529	4704	653	386	6272
2007	51	3252	51	8	3362	750	8819	588	449	10606
2008	144	935	11	21	1111	1264	6170	174	344	7952
2009	81	1488	27	4	1600	400	4942	175	311	5828
2010	34	759	10	2	805	86	812	60	26	985

Table 4B Covering rate of sample each quarter and substitution.

	covering rate of sample					month number of substitution					fish number of substitution method 1				
	1Q	2Q	3Q	4Q		1Q	2Q	3Q	4Q		1Q	2Q	3Q	4Q	
1952	0.016	0.054	0.069	0.026	0.057	1	0	0	0	1	277	0	0	0	277
1953	0.042	0.199	0.008	0.058	0.138	0	0	1	0	1	0	0	2117	0	2117
1954	0.083	0.229	0.115	0.028	0.163	0	0	0	0	0	0	0	0	0	0
1955	0.111	0.400	0.054	0.059	0.198	0	0	0	0	0	0	0	0	0	0
1956	0.074	0.407	0.012	0.031	0.140	0	0	0	0	0	0	0	0	0	0
1957	0.015	0.310	0.026	0.027	0.158	0	0	0	0	0	0	0	0	0	0
1958	0.102	0.345	0.163	0.142	0.208	0	0	1	0	1	0	0	101	0	101
1959	0.084	0.199	0.026	0.079	0.111	0	0	0	0	0	0	0	0	0	0
1960	0.106	0.294	0.058	0.073	0.222	0	0	0	0	0	0	0	0	0	0
1961	0.247	0.323	0.078	0.197	0.247	0	0	0	0	0	0	0	0	0	0
1962	0.156	0.339	0.334	0.051	0.294	0	0	0	0	0	0	0	0	0	0
1963	0.371	0.310	0.110	0.088	0.288	0	0	0	0	0	0	0	0	0	0
1964	0.133	0.382	0.167	0.307	0.331	0	0	0	0	0	0	0	0	0	0
1965	0.070	0.158	0.093	0.151	0.143	1	0	0	0	1	258	0	0	0	258
1966	0.051	0.167	0.268	0.301	0.205	0	0	0	0	0	0	0	0	0	0
1967	0.034	0.074	0.389	0.083	0.155	0	0	0	0	0	0	0	0	0	0
1968	0.005	0.045	0.215	0.041	0.068	1	1	0	0	2	321	398	0	0	719
1994	0.301	0.405	0.319	0.382	0.386	0	0	0	0	0	0	0	0	0	0
1995	0.227	0.407	0.077	0.083	0.354	0	0	0	0	0	0	0	0	0	0
1996	0.289	0.750	0.068	0.214	0.603	0	0	0	0	0	0	0	0	0	0
1997	0.416	0.606	0.243	0.699	0.582	0	0	0	0	0	0	0	0	0	0
1998	0.458	0.613	0.490	0.880	0.609	0	0	0	0	0	0	0	0	0	0
1999	0.490	0.624	0.140	0.444	0.586	0	0	0	0	0	0	0	0	0	0
2000	0.334	0.402	0.199	0.387	0.386	0	0	0	0	0	0	0	0	0	0
2001	0.413	0.359	0.078	0.143	0.339	0	0	0	1	1	0	0	0	119	119
2002	0.085	0.330	0.173	0.085	0.277	1	0	0	0	1	55	0	0	0	55
2003	0.099	0.310	0.033	0.175	0.262	0	0	0	0	0	0	0	0	0	0
2004	0.217	0.284	0.019	0.064	0.231	0	0	0	0	0	0	0	0	0	0
2005	0.137	0.311	0.028	0.102	0.271	0	0	0	0	0	0	0	0	0	0
2006	0.117	0.288	0.055	0.034	0.234	0	0	0	0	0	0	0	0	0	0
2007	0.068	0.369	0.087	0.018	0.317	0	0	0	1	1	0	0	0	78	78
2008	0.114	0.152	0.063	0.061	0.140	0	0	0	0	0	0	0	0	0	0
2009	0.203	0.301	0.154	0.013	0.275	0	0	0	0	0	0	0	0	0	0
2010	0.393	0.935	0.166	0.077	0.818	0	0	0	2	2	0	0	0	10	10

Table 4B Continued.

	fish number of substitution					Substitution rate				
	method 2					method 2				
	1Q	2Q	3Q	4Q		1Q	2Q	3Q	4Q	
1952	1105	5330	3101	1198	10734	0.6937	0.5106	0.29	0.9301	0.447
1953	322	6436	4754	1574	13086	0.2454	0.4428	0.9923	0.927	0.586
1954	925	1163	3353	1147	6588	0.5362	0.0985	0.3443	0.9519	0.269
1955	318	753	8397	2360	11828	0.2454	0.08	0.8576	0.8523	0.508
1956	345	891	10631	909	12776	0.403	0.1237	0.7799	0.7857	0.559
1957	659	532	1118	643	2952	0.6337	0.103	0.2749	0.8772	0.268
1958	421	173	197	441	1232	0.4103	0.0769	0.174	0.1937	0.184
1959	1221	4500	7238	1617	14576	0.3537	0.3647	0.8317	0.1994	0.447
1960	1142	7499	3996	1108	13745	0.2147	0.2166	0.7865	0.1604	0.265
1961	499	1777	4879	86	7241	0.0794	0.0591	0.401	0.0162	0.135
1962	1446	1779	1950	2636	7811	0.2539	0.0544	0.513	0.7525	0.171
1963	786	884	2788	939	5397	0.2335	0.0252	0.6852	0.5533	0.122
1964	1101	1073	1039	268	3481	0.6039	0.0718	0.4618	0.1593	0.168
1965	813	2179	609	1163	4764	0.4079	0.178	0.6195	0.5557	0.275
1966	377	1101	915	590	2983	0.5678	0.2301	0.493	0.3467	0.331
1967	736	932	659	395	2722	0.6339	0.3401	0.3816	0.6718	0.438
1968	1081	734	394	318	2527	0.9069	0.5607	0.4994	0.6824	0.673

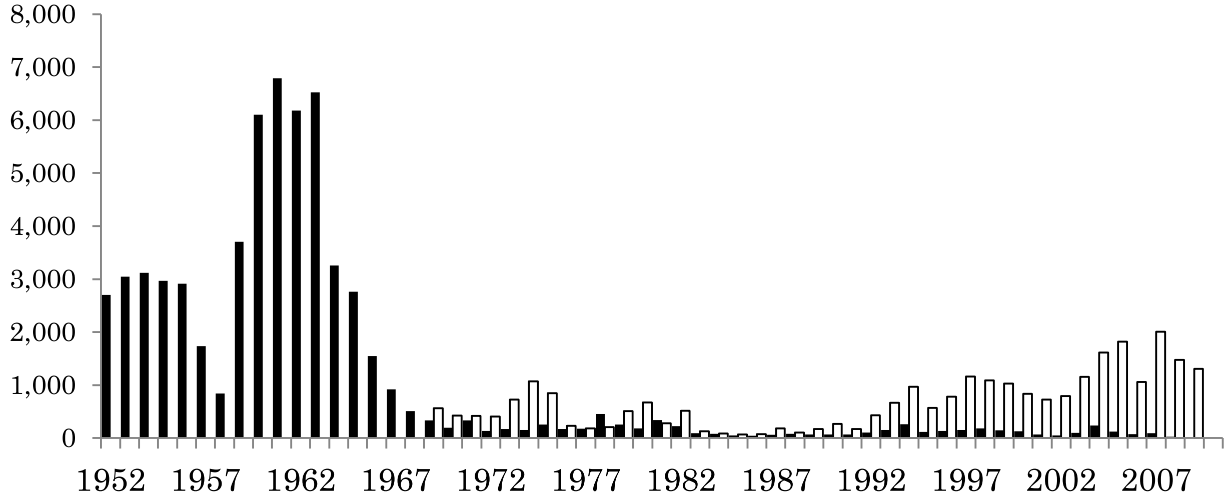

Fig. 1 Catch by pelagic boat (white bar) and adjacent and coast vessel (black bar) each year.

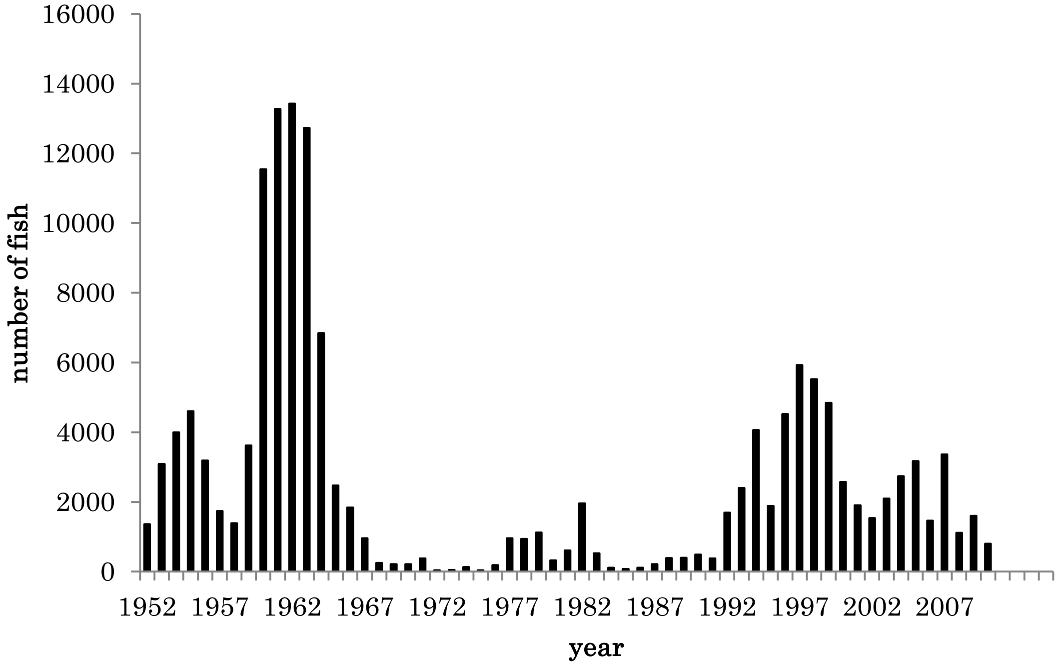

Fig. 2 Sampling number of fish each year.

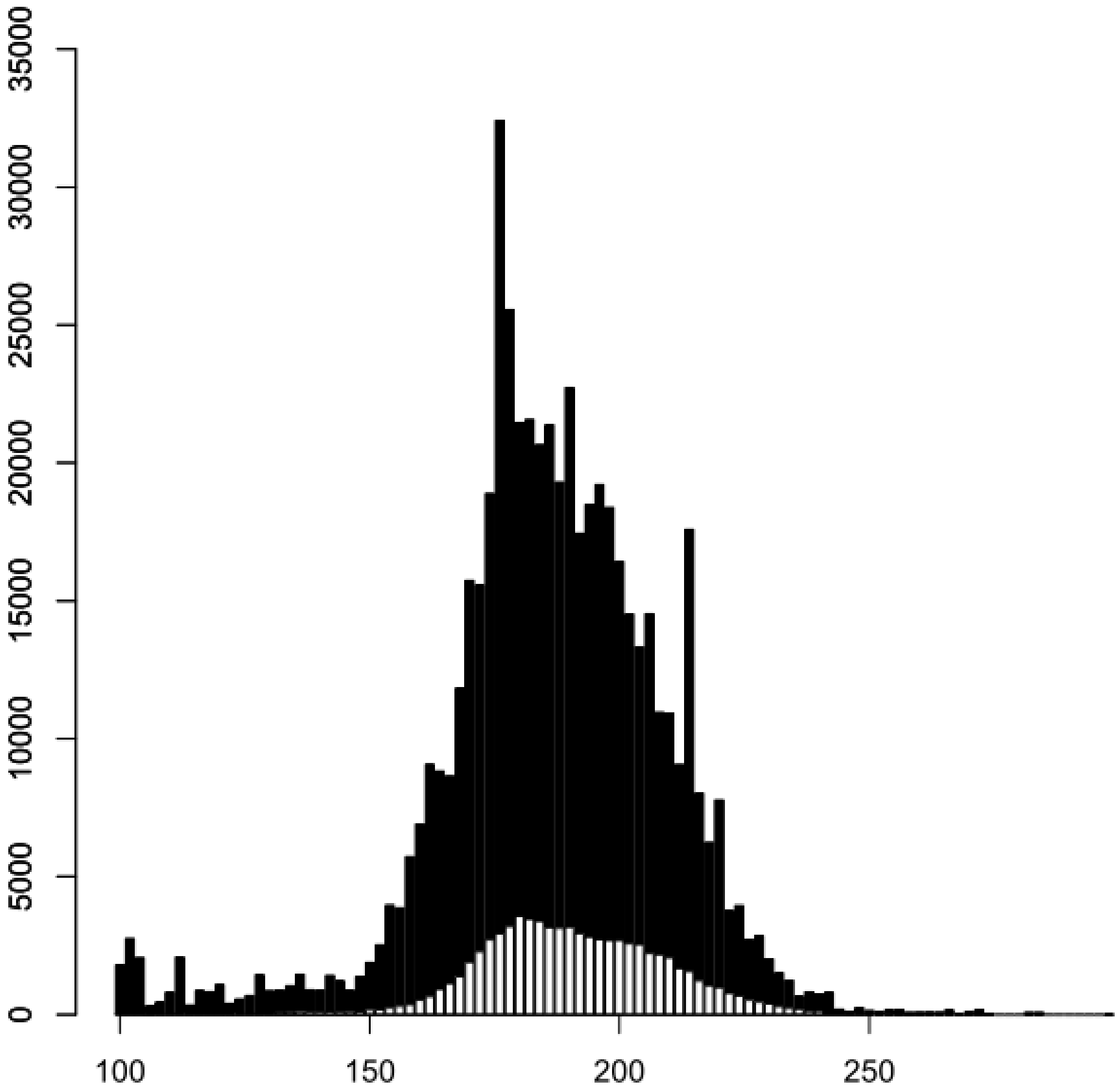

Fig. 3A Length composition estimated data with method1 (to estimate after year, month stratifition) and measurement data. White bar is sample length distribution and Black bar is estimated length distribution.

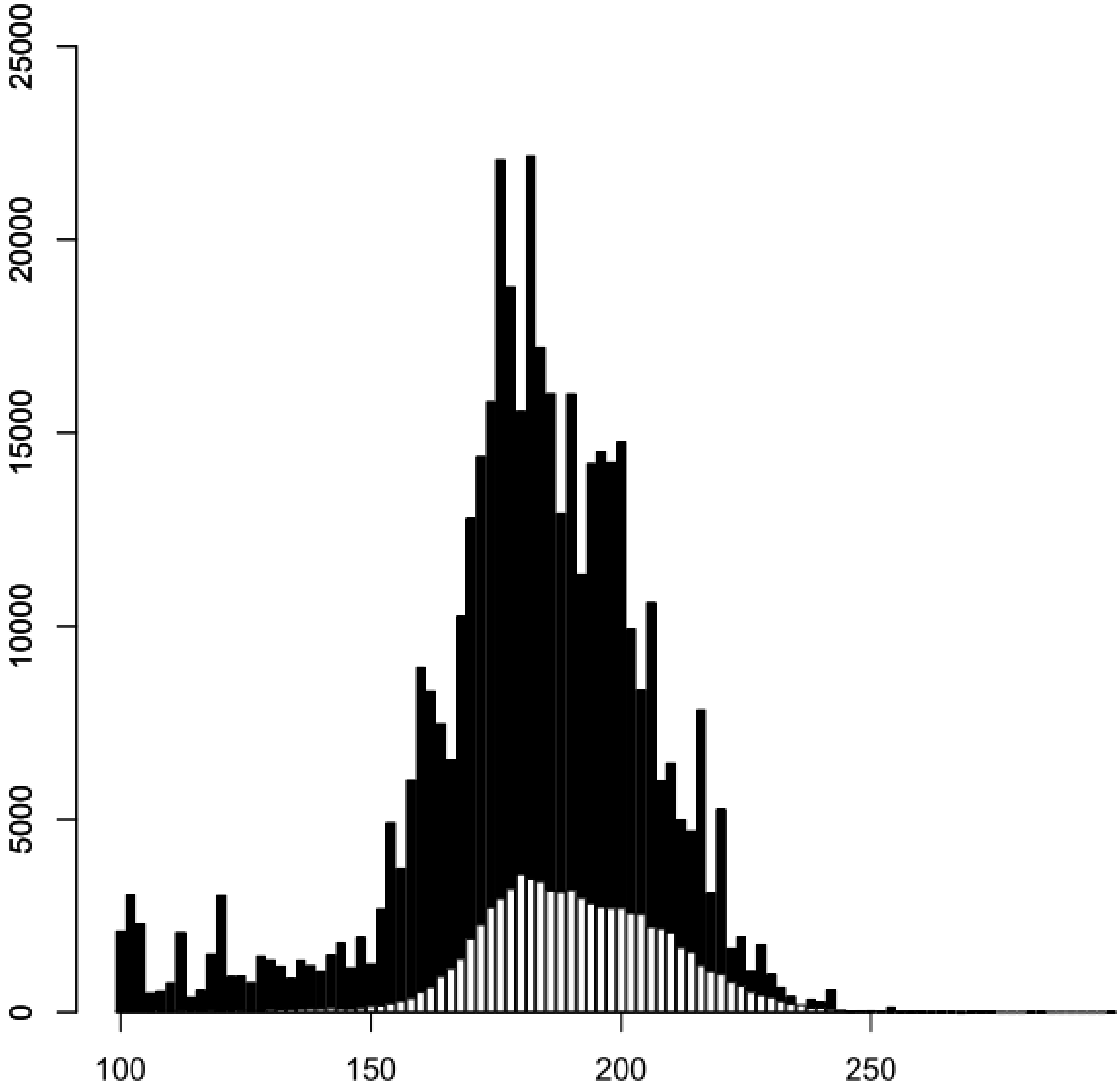

Fig. 3B Length composition estimated data with method 2 (to estimate after position and year, month stratifition) and measurement data. White bar is sample length distribution and Black bar is estimated length distribution.

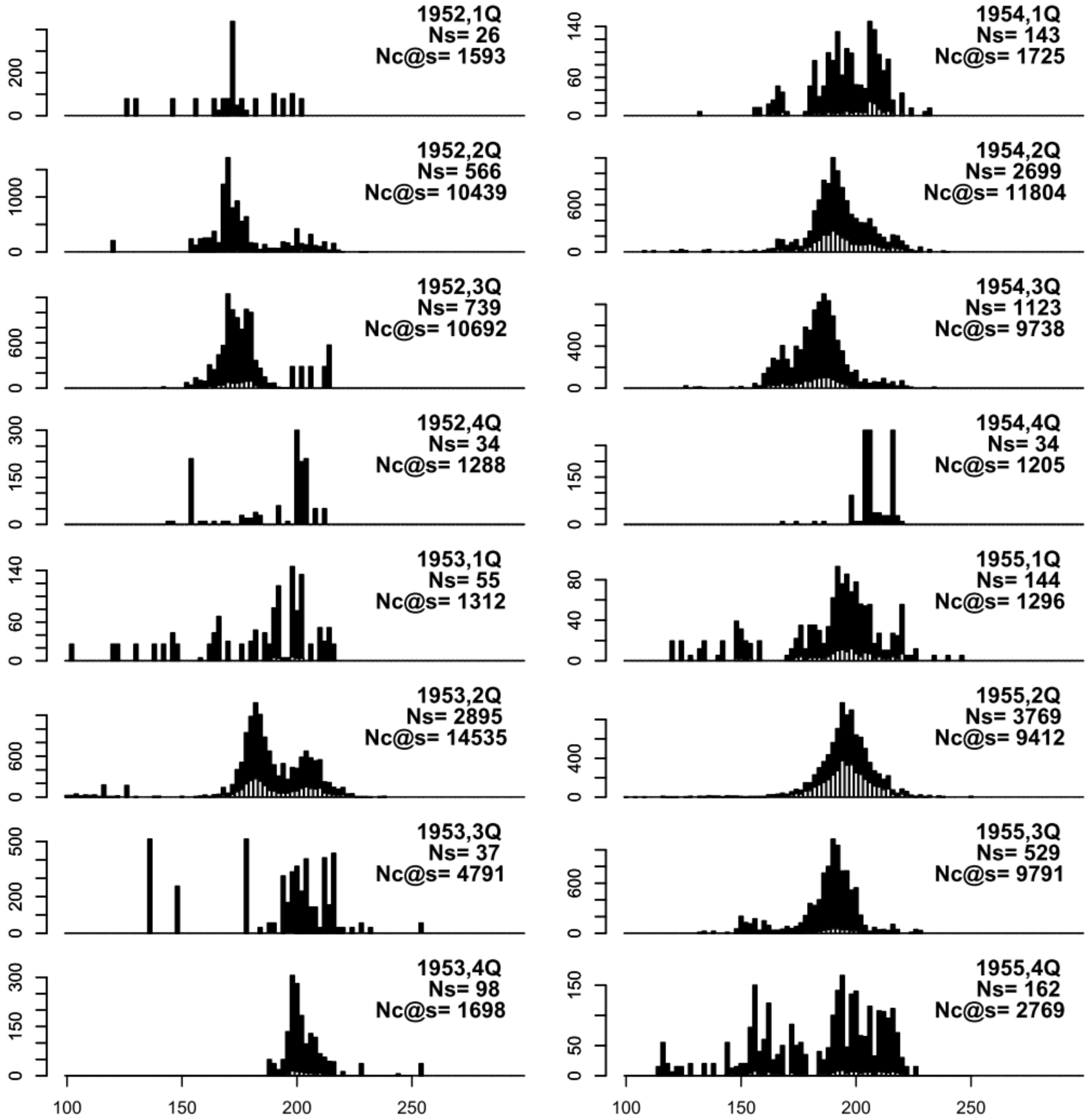

Fig. 4 Length distribution of fish caught by JLL fishery each year estimation by method 1 (to estimate after year, month stratifition) White bar is sample length distribution and Black bar is estimated length distribution.

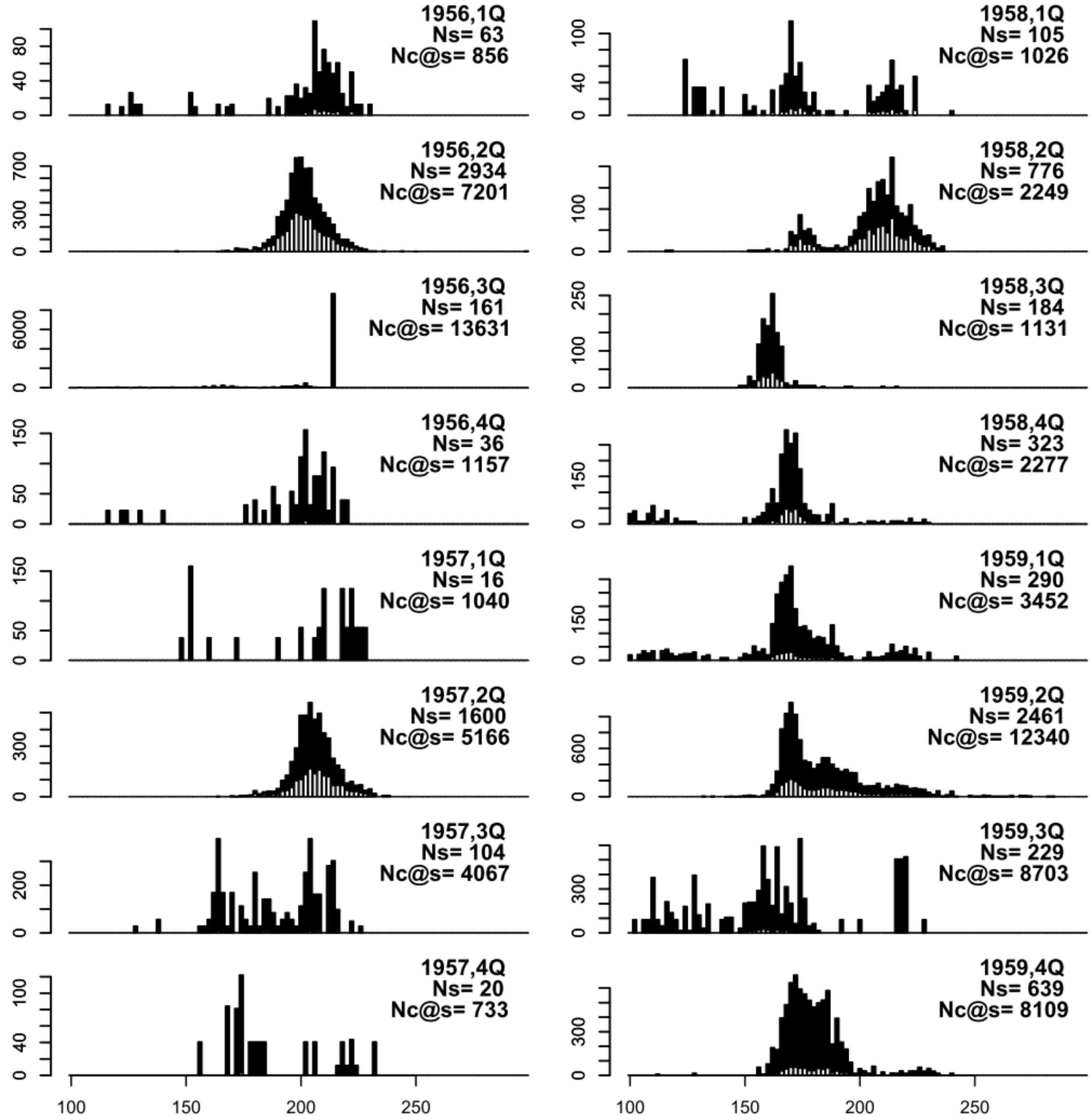

Fig.4　continued.

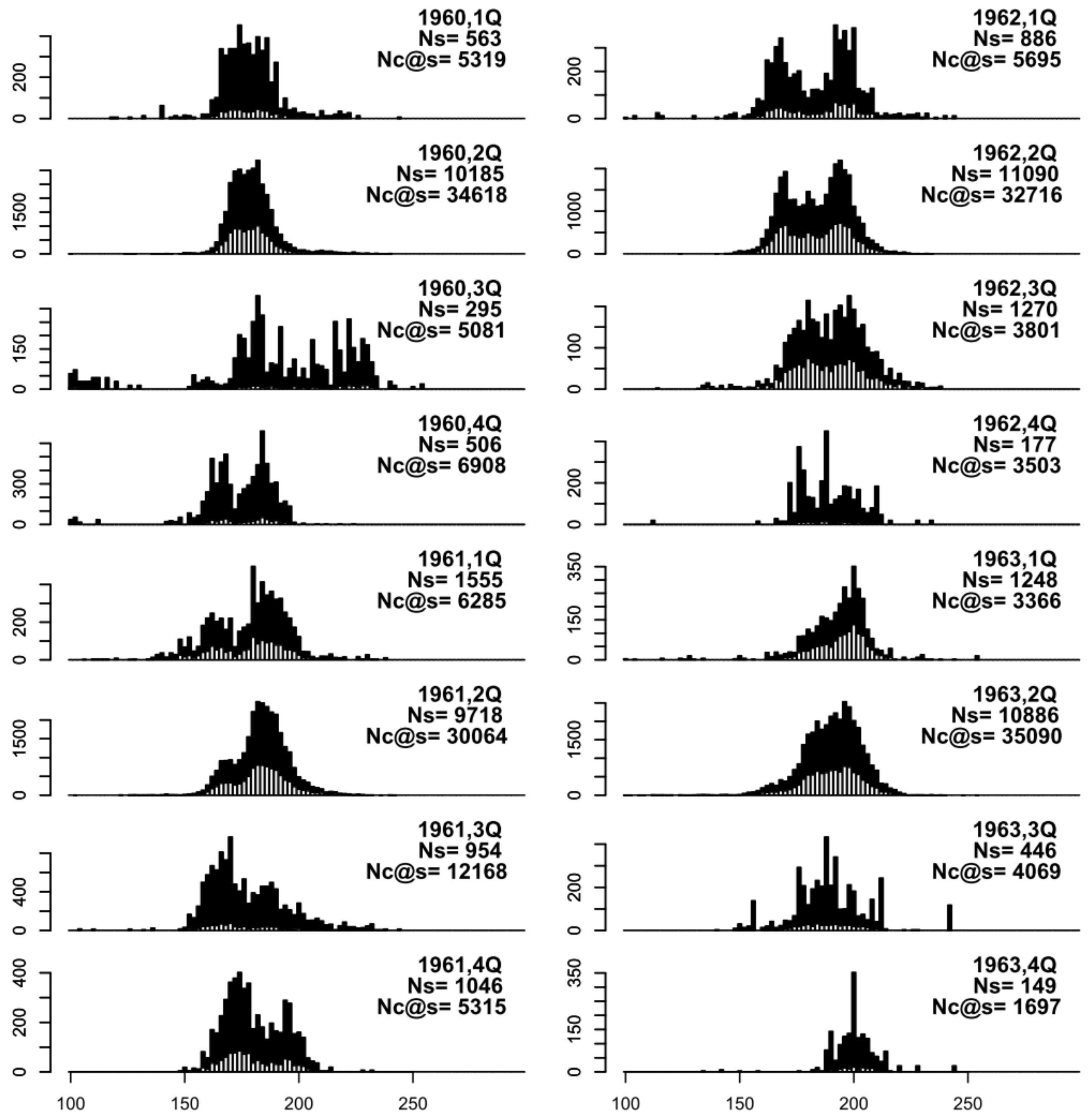

Fig.4 continued.

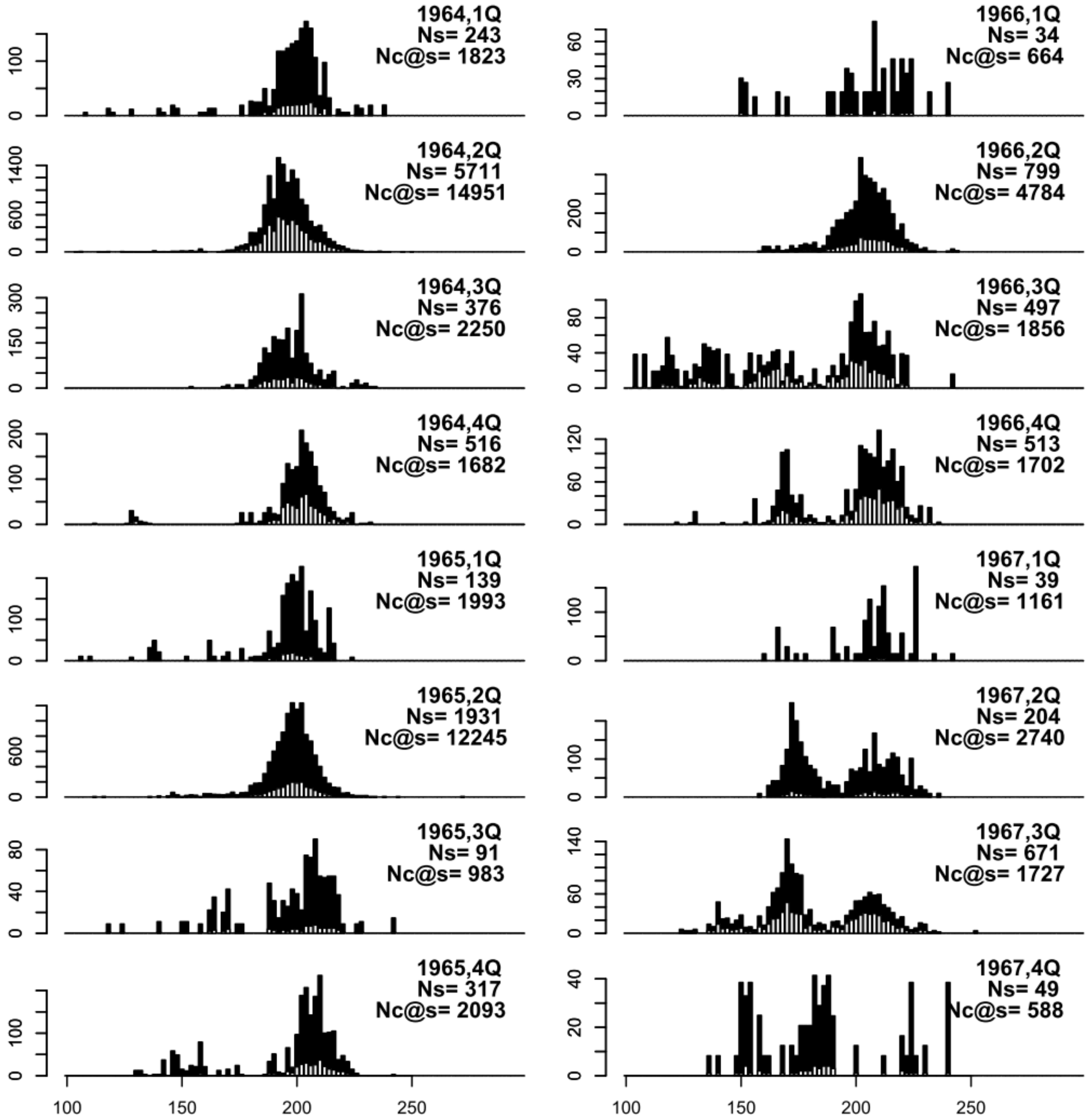

Fig.4 continued.

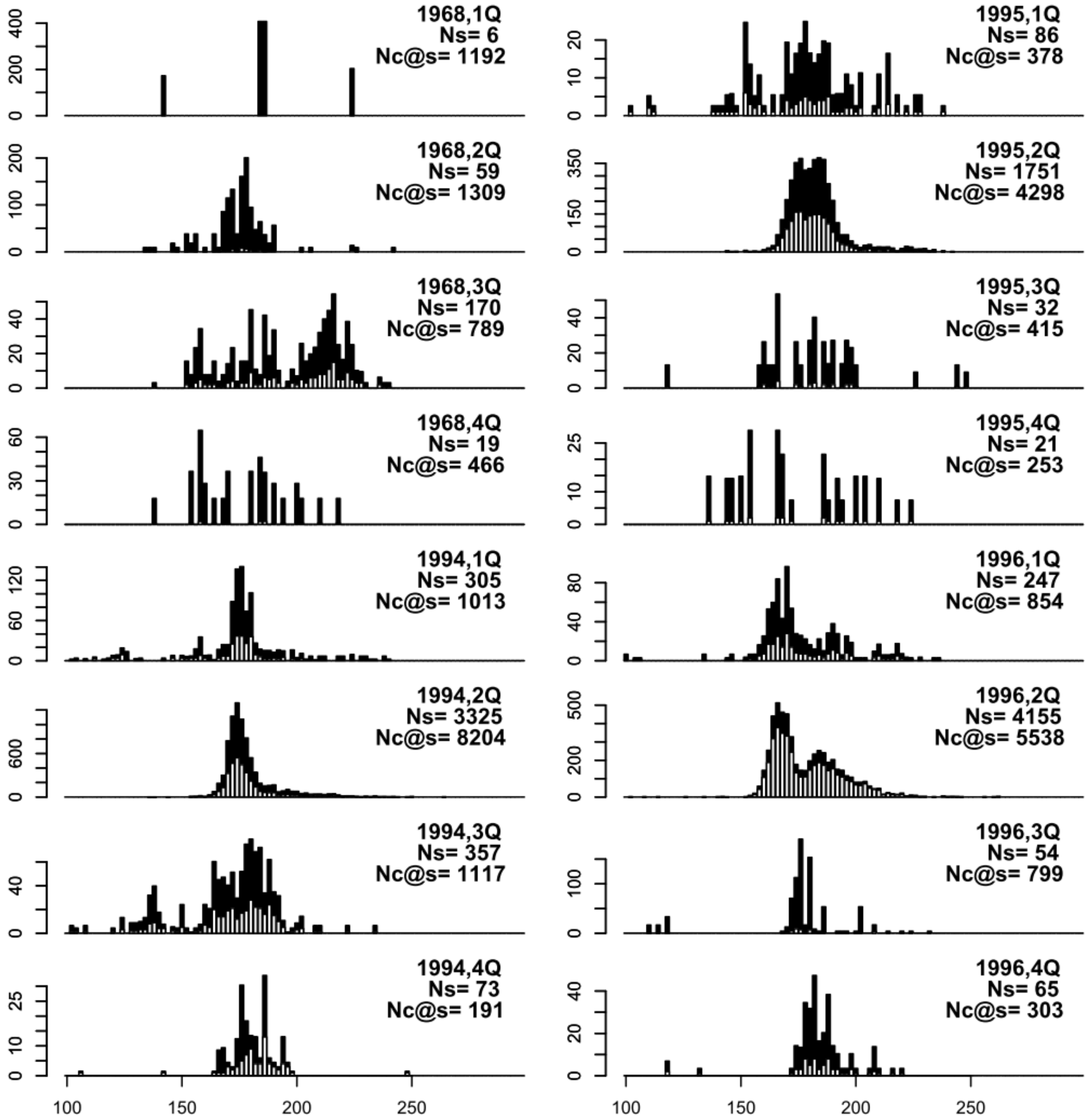

Fig.4 continued.

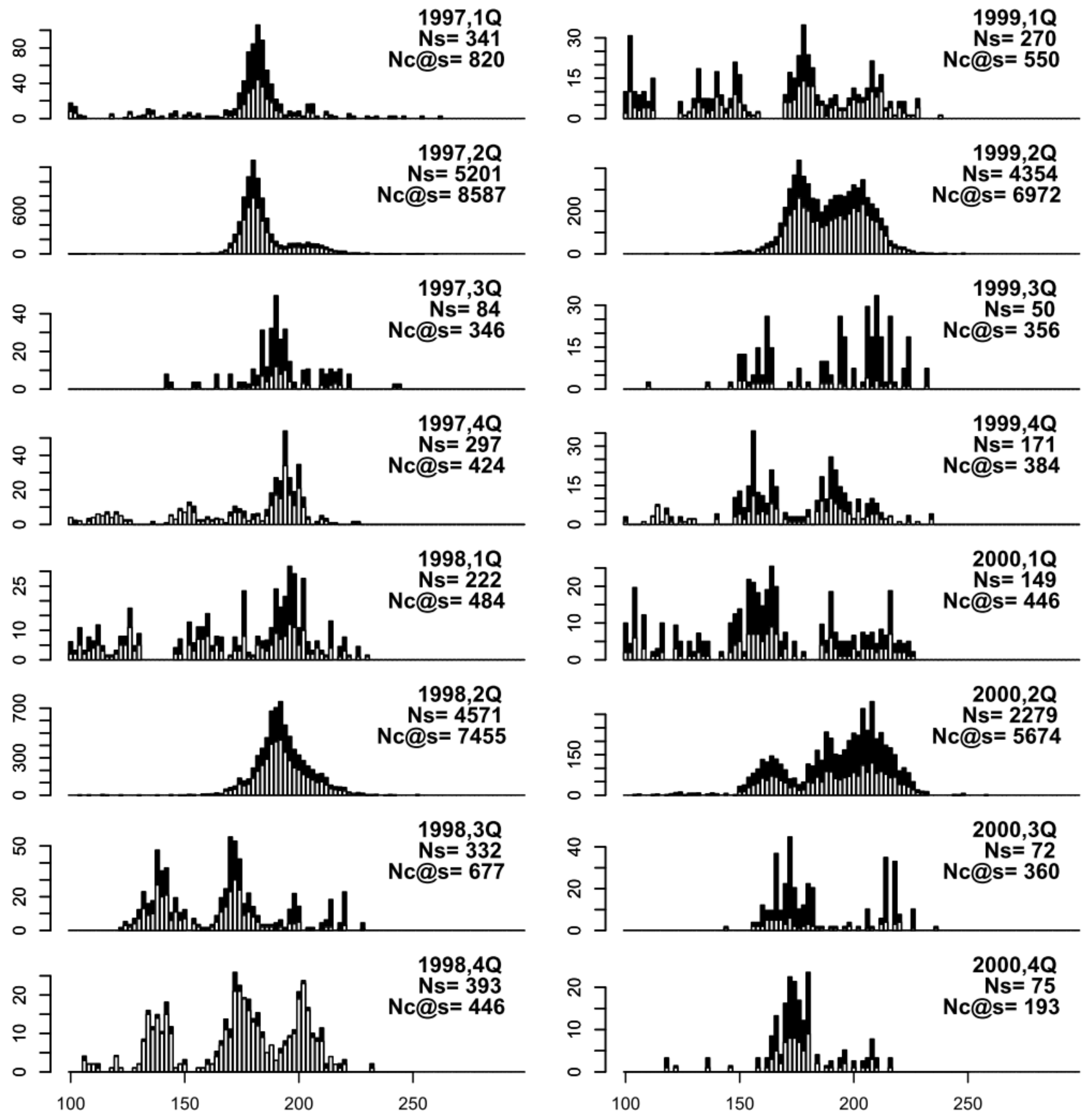

Fig.4 continued.

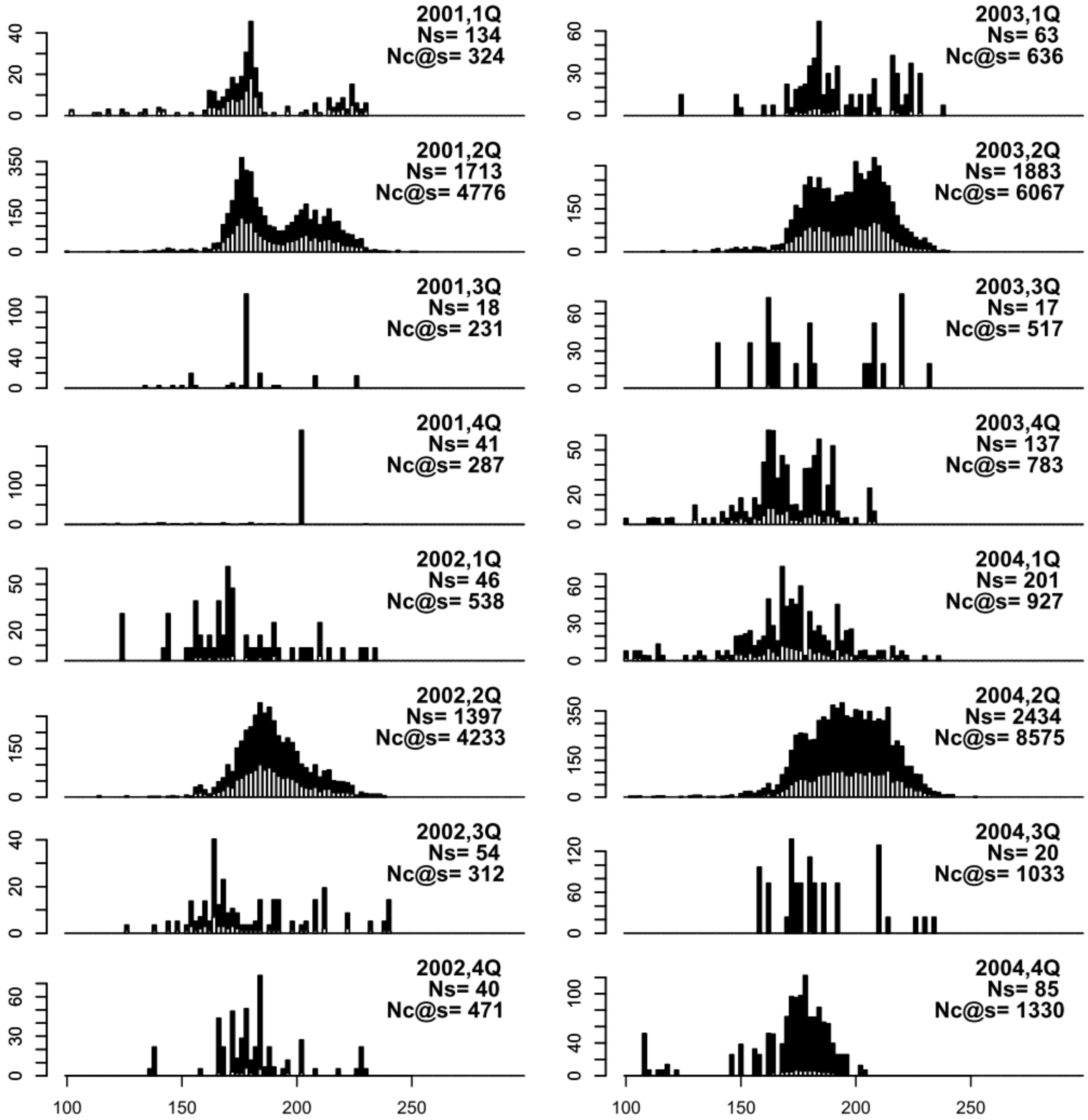

Fig.4 continued.

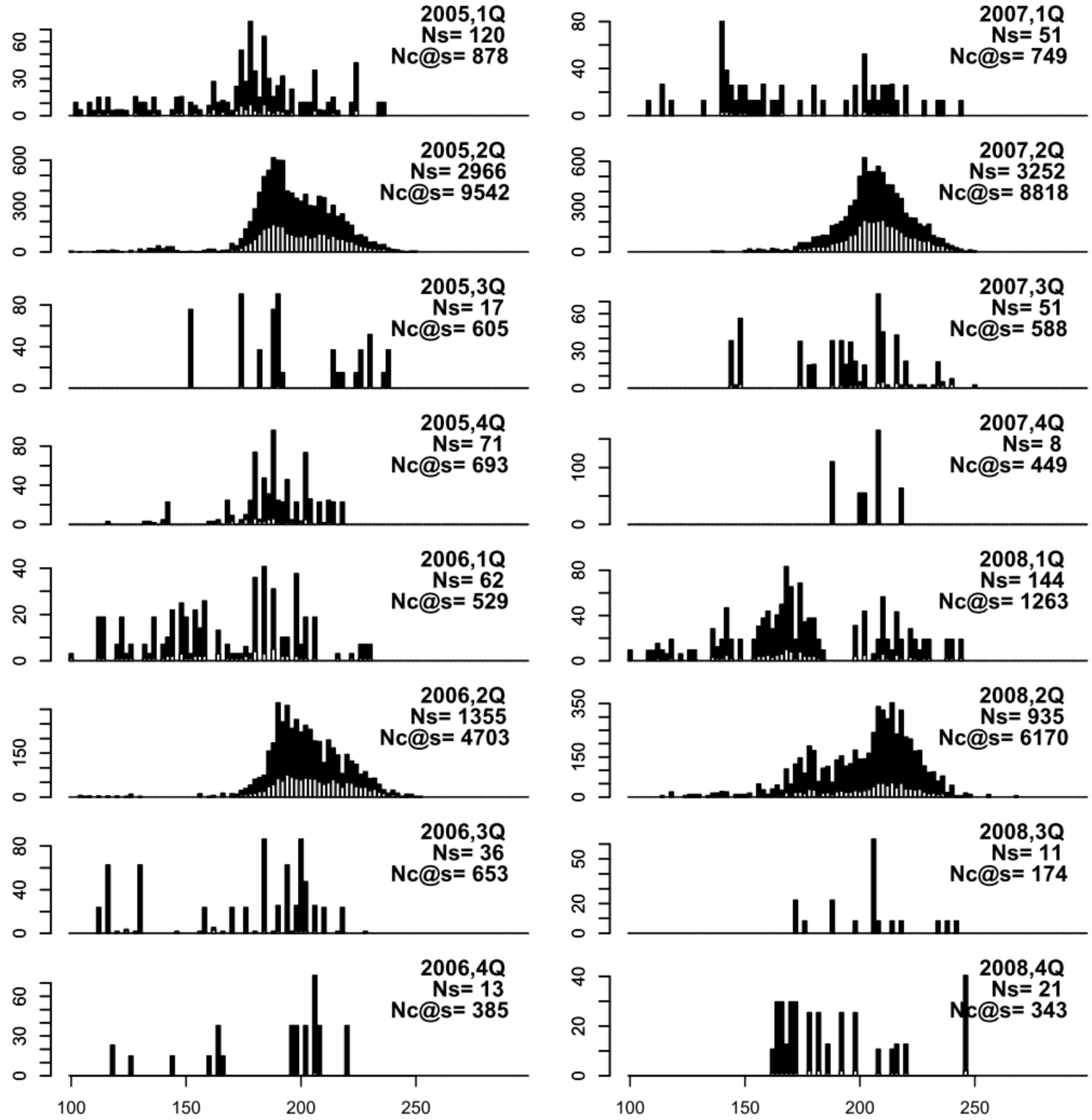

Fig.4 continued.

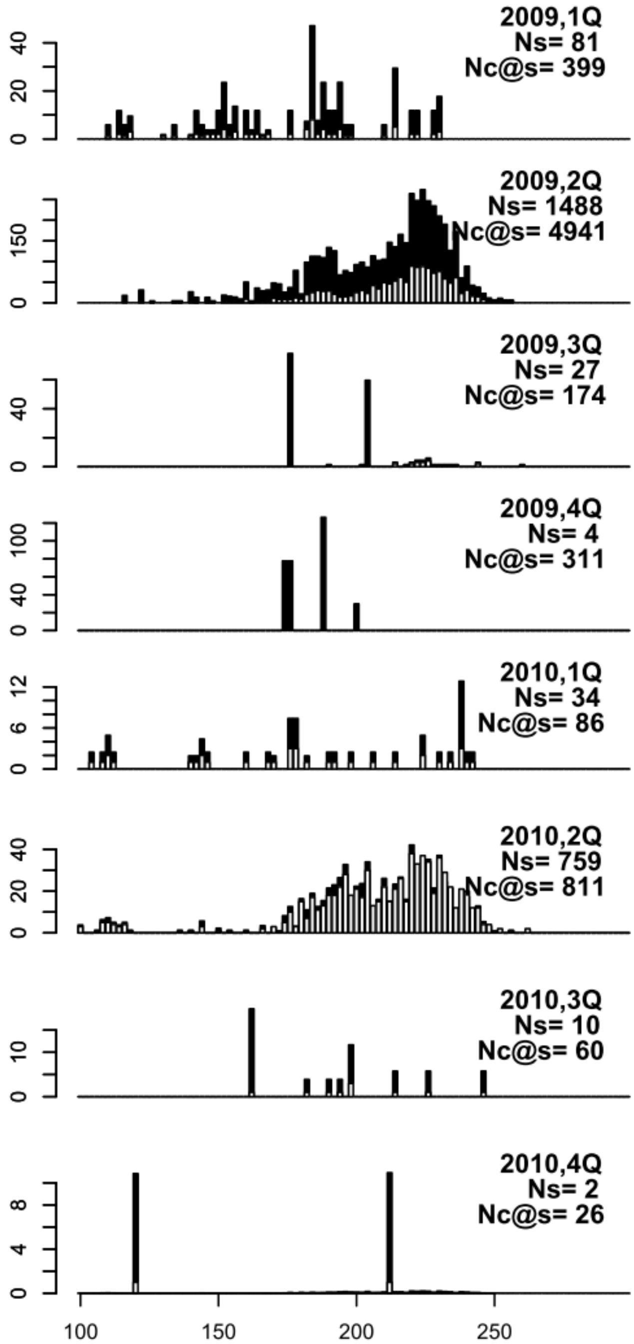

Fig.4 continued.