Age Distributions of Minke Whales in the Antarctic Areas IV and V in 1991/92 and 1992/93 Seasons

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ABSTRACT

The present paper examines changes in age distribution of southern minke whales related to year or season using data collected from the Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA) in the 1991/92 and the 1992/93. The Area IV samples showed typical age distribution having a peak in 1-6 years old and the proportion decreased with age, and no specific changes was seen over years, meanwhile the Area V samples showed apparent changes in age distribution however it seemed to be due to bias as low sampling efficiency in smaller animals and the improved sampling efficiency provided similar age distribution of males to that of the 1988/89 survey in Area V. However, the age distribution for females showed a different pattern having a peak of 16-21 year age class, and it seemed to be caused that the older females originated from another stock(s) migrate to the Ross Sea area or luck of youger individuals in this area. It was indicated that younger individuals of the Area IV samples migrated later to the research area than the other, while the younger of Area V arrived earlier.

INTRODUCTION

The Japanese Whale Research Program Under Special Permit in the Antarctic (JARPA) to take southern minke whales, *Balaenoptera acutorostrata*, has been conducted since 1987/88. One of the principal objectives of the research is the estimation of the biological parameters of the minke whales such as natural mortality, net recruitment, age distribution, etc. and their seasonal changes for the components migrating to research area (Government of Japan, 1991, 1992).

We have tried to estimate the age distribution of minke whales which migrate to the research areas using data obtained from the JARPA cruises (Kato *et al.*, 1990, 1991a; Kishino *et al.*, 1991; Fujise *et al.*, 1991, 1992), and seasonal changes of the age distribution in the Area IV have been reported. In Area V, however, a different pattern of age distribution was observed in the 1988/89 and 1990/91 seasons. The possible causes may have three factors: (1) coverage of the research area, (2) sampling efficiency, and (3) timing of migration of minke whale to and from the research area. But, we have not been able to determine what factors mainly affected to this difference of the age distributions between two areas.

Using biological and sighting data obtained from the 1991/92 and 1992/93 surveys (Areas IV and V, respectively), we analyzed the age structure of minke whales, and discussed on the light of questions mentioned above.

Materials and Methods

Whale samples used and their stratification

The research area in Area IV (70°E-130°E) in the 1991/92 survey season, as reported by Fujise *et al.* (1993a), was divided into two sectors of West and East at 100°E. Each sector was further divided into two strata by the contouring line corresponding to 45 n.miles from ice edge line (Middle and South). The survey conducted twice in these four strata as follows:

First period (5 Dec. 1991 - 26 Jan. 1992)

West-North	5 - 6 Dec. 1991
West-Middle	18 - 31 Dec. 1991

West-South	10 - 21 Dec. 1991
East-Middle	1 - 9 Jan. 1992
East-South	14 - 26 Jan. 1992

Second period (26 Jan. - 25 Mar. 1992)

West-Middle	15 - 25 Feb. 1992
West-South	26 Jan. - 6 Feb. 1992
Prydz Bay	9 - 14 Feb. 1992
East-North	24 - 25 Mar. 1992
East-Middle	12 - 23 Mar. 1992
East-South	26 Feb. - 11 Mar. 1992

During the cruise, a total of 288 ordinary minke whales were randomly sampled (Fig. 1).

In the 1992/93 season, the survey was conducted in the Area V (130°E-170°W). The entire research area was surveyed once, and the special monitoring zone (SMZ), which is a part of the research area (130°E-155°E), was surveyed twice. The survey in the entire research area was conducted at the peak of abundant of minke whales in the research area, so as to match the procedure taken by the IDCR cruise as much as possible. The SMZ survey was conducted before and after the survey in the entire research area, to examine the seasonal changes in distribution of minke whales. The survey area was divided into West and East which were divided at 165°E. For the West Sector, the North and South strata were separated by a line of 45 n.miles northward from the ice edge line. For the East Sector, the area between 60°S and 69°S was designed as the North strata, and all the Ross Sea region of south of 69°S was set as the South strata. These surveys were conducted as follows:

First period (3 - 25 Dec. 1992)

North of SMZ	15 - 25 Dec. 1992
South of SMZ	3 - 14 Dec. 1992

Second period (30 Dec. 1992 - 6 Mar. 1993)

West-North	25 Jan. - 5 Feb. 1993
West-South	15 Jan. - 24 Jan. and 8 Feb. -13 Feb. 1993
East-North	30 Dec. 1992 - 11 Jan. 1993
East-South	14 Feb. - 6 Mar. 1993

Third period (10 - 24 Mar. 1993)

North of SMZ	19 - 24 Mar. 1993

South of SMZ 10 - 18 Mar. 1993

During the cruise, a total of 330 minke whales including three dwarf forms were randomly sampled (Fujise *et al.*, 1993b). Geographical distribution of those samples is shown in Fig. 2. The present study excluded the dwarf form minke whales for all analyses. Therefore, 327 whales were used as the basic set of samples.

Table 1 shows the number of samples used in each survey season. To estimate the age distribution, samples in each stratum were further grouped into two school size classes (singleton and ≥2 individuals).

Age determination
Age of whales was determined by counting growth layers appeared on the bisected surface of the earplug core (Kato, 1986; Kato *et al.*, 1990, 1991a). The counting of growth layers was made by Zenitani and Kato using the stereoscopic microscope (10 x 6.4 - 16). No bias in age readings was observed between these two readers (Kato *et al.*, 1991b). Furthermore, we used the baleen plate for age determination of juvenile whales (Kato and Zenitani, 1990). Finally, individual ages were obtained from 241 of the total 288 whales sampled in 1991/92 (141 males and 100 females), and 305 of the total 327 whales sampled (159 males and 146 females) in 1992/93.

A total of 69 individuals were not aged due to obscure formation of laminae of the earplug (31 cases in 1991/92 and 12 cases in 1992/93) and to the lack of earplug core (16 cases and 10 cases in 1991/92 and 1992/93, respectively). Animals without age information were estimated their ages by use of body length and the age-length key which was obtained by the previous data of the JARPA cruises (Fujise *et al.*, 1992).

Estimation of age distribution on the migrated population
The age distribution of a population which migrate to the research area was estimated using the samples collected in the middle of survey period (late December to early March), assuming the period was the peak of migration to the research area. The estimation method of age distribution was reported previously (Kishino *et al.*, 1991). In 1991/92, we used the following strata to

this estimation; East-Middle and East-South in the first period, and West-Middle, West-South and Prydz Bay in the second period. In 1992/93, the data from the survey of the entire research area was used for this purpose.

In order to examine the seasonal changes of the age distributions, we used samples from all strata in 1991/92, and from the SMZ in 1992/93.

Estimating the age distribution in each stratum, the age distribution of the weighted average of these estimates was used. Specifically, the estimated proportion of the individuals at age t (yt) was obtained by

$$y_t = \sum_{i=1}^{n} u_i \cdot y_{it} \qquad (1).$$

where, u_i is the relative size of abundance of the i-th stratum estimated by the sighting data concurrently obtained in the survey (Tables 2 and 3; Nishiwaki *et al.*, 1994), and y_{it} is the estimated proportion of individuals at age t in the i-th stratum.

To estimate variances of the estimated age distribution, we applied the bootstrap method (Efron, 1979) by resampling the legs of the trackline with replacement.

To take into account this error in age reading, the age data of the resampled individuals were further modified as $x_i' = x_i + \epsilon_i$, where x_i ($i = 1,..,n$) is the observed age. Value of ϵ_i ($i=1,..,n$) is an estimate of the deviation from the observed age. Value of ϵ are independent from each other and followed by a normal distribution with mean zero and variances $(0.064xi)^2$ of samples ($i=1,..,n$) (Dr. Takashi Nakamura, pers. comm.). Each of hundred resampled data set was calculated by use of Equation (1).

RESULTS

Estimated age distribution of minke whales at the peak of migrating to the Antarctic

As mentioned in above sections, the age distributions of minke whales at the peak of migration to the research areas, were estimated by use of data in Antarctic Areas IV and V in the

1991/92 and 1992/93. Estimates and their variances of the estimated age distributions for male and female were given in Tables 4 and 5 in Areas IV and V, respectively.

Fig. 3 shows the estimated age distributions of minke whales at the peak of migration to Areas IV and V in 1991/92 and 1992/93. This figure shows the crude age distributions. Both the crude and estimated age distributions in Area IV indicate generally a decreasing pattern with age, and relatively higher proportion of younger animals was noted in both sexes. In contrast, the estimated age distribution of females in Area V had a peak at 15-20 year class, and showed a different pattern from those in Area IV. Age distribution for males in Area V seems to be somewhat different from those in Area IV. These differences are similar to the results of a previous study (Fujise *et al.*, 1992).

Comparison of the age distributions by the survey seasons

Fig. 4 compares the age distributions of minke whales in Area IV in the present and previous seasons by pooling samples into every three age classes. These estimates show a similar pattern of age distribution in all survey seasons, and have generally a decreasing pattern with age and relatively higher proportion of younger animals (1-6 years) in both sexes. It should be noted that the proportion of younger animals (1-3 years) is somewhat lower in the 1991/92 seasons than those in the previous seasons.

Fig. 5 shows the estimated age distributions derived from three surveys conducted in Area V, with pooling every three year age classes. Different pattern was obtained on the age distributions among them. In the 1988/89 season, the age distributions of both sexes showed a decreasing pattern with age. In contrast, the age distributions in the 1990/91 season had a peak of age frequency around the 16-21 year age classes. Similar pattern of the age distribution was observed on females in the 1992/93 season. However, the age distribution of male in this season is similar to those in the 1988/89 seasons rather than those in the 1990/91 season.

Although statistical examination was made among those age distributions (Rao and Thomas, 1989), no differences were detected significantly under consideration of their variance of the estimates.

Seasonal change of the estimated age distributions in 1991/92 and 1992/93 seasons

Figs. 6a and 6b show seasonal changes in the estimated age distributions in Area IV in 1991/92, by stratum and survey period. Data were pooled every five year age class. In these figures, frequency of each age component was expressed as a relative abundance of whales occurring in the research area during the survey period. Most whales migrated to the West-South and Prydz Bay areas in the second period, and few whales were distributed in other strata of Area IV (Fujise *et al.*, 1992, Nishiwaki *et al.*, 1994). It was obvious that the younger males migrated to the West-Middle stratum on the second period, but few individuals migrated to the South and Prydz Bay strata.

Fig. 7 shows seasonal changes in estimated age distribution with pooling data every five years of age in the SMZ of Area V in 1992/93 season. The age frequency is also expressed as a relative abundance of whales which occurred in the SMZ area. A remarkable decreasing pattern was observed for the younger age classes of both sexes. This suggests that immature males and females arrived to the SMZ, and moved out the research area, in the earlier part of the survey season.

DISCUSSION

In a previous analysis (Fujise *et al.*, 1992), we reported different patterns of the estimated age distributions between Areas IV and V, using samples from the cruises of the JARPA conducted in the 1989/90 and 1990/91 seasons. The estimated age distribution in the Area IV showed that the proportion decreased with age having a peak at 2-3 year of age, and was considered to be close to the expected pattern of age distribution of the population. However, the estimates on Area V had a different pattern. Following three factors are possibly caused on this difference: (1) coverage of the research area, (2) sampling efficiency, and (3) timing of migration of minke whale to and from the research area.

In this study, we have obtained new estimates of age distributions of minke whales in Areas IV and V in 1991/92 and 1992/93 seasons, respectively. In Area IV, similar trends of the estimated age distribution were obtained on the previous (1987/88 and

1989/90 samples) and present estimates (1991/92 samples). An obvious pattern of migration was observed on younger males and females which occurred in the northern part of the research area, at least in the western side of this area in late in the survey season. This pattern was similar to that of 1989/90 season. However, we could not obtain the full information on the eastern side of this area, because no or few sampling activities were conducted in the East sector in the second period of both 1989/90 and 1991/92 seasons due to the sampling limitation and rough sea condition. We will examine this aspect using data from the 1993/94 cruise of JARPA which was conducted mainly in the eastern part of Area IV.

In Area V, the age distribution of males seemed to be different in the 1990/91 season. As reported previously, the sampling efficiency was considerably lower for smaller whales than larger whales in the 1990/91 season, and it suggested that the estimated age distributions in the 1990/91 season were biased to older ages (Fujise *et al.*, 1992). The sampling efficiencies in the 1992/93 season were considerably higher than those of the 1990/91 season (Fujise *et al.*, 1993b). By this improvement, the estimated age distribution for males in 1992/93 season indicate a pattern having a peak at the 7-9 year age classes (Fig. 5). However, it still indicated luck of younger ages (1-3 year age class). This supports the previous estimates that younger animals of the population did not migrate to research area of Area V or moved out the research area before the beginning of the sampling activity.

Although the sampling efficiencies was improved in the 1992/93 survey, the age distribution of females in this season was similar to those in 1990/91 season, which have a peak at 16-18 year age class. This may indicate that one of major reasons why higher proportion of age frequencies were observed on the age distribution in Area V, was that older females originated from another stock(s) migrate to the Ross Sea. However, another factor was detected by comparing the age distributions of three SMZ surveys. By carrying out this comparison, it was expected that younger females were arrived in the northern part of research area and moved out the research area before the survey of the entire research area was conducted. Then, it was not incorporated with the component of these younger females to the estimation of the age distribution in the Area V in 1992/93 season, because only samples from the survey in the entire research area were used to estimates the age distribution at the peak of migration to the research area. Further analysis should be taken into account on this components.

It should be also noted that the migration to the research area is different between immature individuals in Areas IV and V. Immature animals were found in the later season in north-western part of Area IV. On the other hand, immature individuals in Area V occurred in earlier season in the northern part of the area. Further analysis would be needed to understand this phenomenon.

ACKNOWLEDGMENTS

We thank to all researchers and crews who were participated in the 1991/92 and 1992/93 cruises of the JARPA. We thank to Seiji Ohsumi, the Institute of Cetacean Research, for his kind review of the document. We also thank to Shigetoshi Nishiwaki, Masahiro Kawasaki and other colleagues of the Institute of Cetacean Research, for their help in calculating the sighting data and assisting artwork of the manuscript.

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Table 1. Number of samples in this study.

1991/92 researches (Area IV)

	Number of samples	Number of samples aged		
		Earplug	Baleen plate	Combined
Male	165	129	17	141
Female	123	89	13	100
Total	288	218	30	241

1992/93 researches (Area V)

	Number of samples	Number of samples aged		
		Earplug	Baleen plate	Combined
Male	167	157	2	159
Female	160	142	4	146
Total	327	299	6	305

Table 2. Estimates of abundance* and proportion of males of the minke whales in each startum of the Antarctic Area IV using data from the 1991/92 cruises of the JARPA.

Stratum	School size	First period		Second period	
		Abundance estimate	% of males	Abundance estimate	% of males
West-Middle	1	1,273	0.7273	3,994	0.7000
	>1	2,915	0.7273	6,839	0.8182
West-South	1	541	0.5000	699	0.5000
	>1	929	0.5833	5,188	0.4833
Prydz Bay	1	closed		2,683	0.1000
	>1	closed		16,247	0.3667
East-Middle	1	1,062	0.8182	0	-
	>1	776	0.6667	0	-
East-South	1	1,230	0.6250	242	0.5000
	>1	1,224	0.3889	2,304	0.5909

*: Cited from Nishiwaki *et al.* (1994).

Table 3. Estimates of the abundances* and proportions of males of minke whales in each startum of the Antarctic Area V using data from the 1992/93 cruises of the JARPA.

The entire survey

Stratum	School size	Abundance estimate	% of males
West-North	1	7,712	0.8333
	>1	12,738	0.8571
West-South	1	2,319	0.5000
	>1	9,071	0.5439
East-North	1	2,808	0.5263
	>1	49,722	0.7000
East-South	1	16,910	0.2188
	>1	58,360	0.4083

The SMZ survey

		First period		Second period		Third period	
Stratum	School size	Abundance estimate	% of males	Abundance estimate	% of males	Abundance estimate	% of males
North	1	2,607	0.4286	3,728	0.6667	--	---
	>1	8,413	0.7500	4,859	1.0000	--	---
South	1	1,094	0.5000	1,240	0.5000	941	0.6429
	>1	4,213	0.4200	3,787	0.5135	1,261	0.7857

*: Cited from Nishiwaki *et al.* (1994).

Table 4. Crude and estimated age compositions of southern minke whales taken in the peak distribution period of 1991/92 research (Area IV).

Age class	Male					Female				
	Crude			Estimated		Crude			Estimated	
	E1)	B2)	E+B	Est.	S.E.	E1)	B2)	E+B	Est.	S.E.
1	1	4	5	0.0439	0.0183	0	-	0	0.0016	0.0013
2	5	6	11	0.0774	0.0338	2	7	9	0.0623	0.0620
3	2	-	2	0.0119	0.0129	5	-	5	0.0316	0.0224
4	4	-	4	0.0382	0.0343	2	-	2	0.0207	0.0125
5	1	-	1	0.0273	0.0177	2	-	2	0.0545	0.0199
6	3	-	3	0.0279	0.0244	3	-	3	0.0712	0.0322
7	4	-	4	0.0686	0.0303	3	-	3	0.0490	0.0232
8	5	-	5	0.0353	0.0262	3	-	3	0.0157	0.0171
9	5	-	5	0.0685	0.0292	3	-	3	0.0157	0.0187
10	5	-	5	0.0359	0.0218	6	-	6	0.0709	0.0250
11	2	-	2	0.0314	0.0214	3	-	3	0.0559	0.0197
12	1	-	1	0.0456	0.0199	2	-	2	0.0163	0.0190
13	1	-	1	0.0099	0.0202	1	-	1	0.0166	0.0202
14	2	-	2	0.0132	0.0135	2	-	2	0.0630	0.0217
15	3	-	3	0.0219	0.0144	4	-	4	0.0309	0.0226
16	2	-	2	0.0101	0.0158	1	-	1	0.0236	0.0132
17	1	-	1	0.0107	0.0249	1	-	1	0.0174	0.0107
18	2	-	2	0.0875	0.0251	0	-	0	0.0102	0.0103
19	0	-	0	0.0027	0.0232	2	-	2	0.0570	0.0194
20	3	-	3	0.0195	0.0171	1	-	1	0.0164	0.0124
21	1	-	1	0.0089	0.0113	1	-	1	0.0108	0.0097
22	1	-	1	0.0090	0.0112	1	-	1	0.0167	0.0107
23	3	-	3	0.0263	0.0160	0	-	0	0.0069	0.0129
24	2	-	2	0.0223	0.0183	1	-	1	0.0296	0.0114
25	4	-	4	0.0395	0.0191	0	-	0	0.0052	0.0096
26	4	-	4	0.0358	0.0217	1	-	1	0.0180	0.0088
27	1	-	1	0.0060	0.0158	1	-	1	0.0109	0.0131
28	1	-	1	0.0150	0.0146	1	-	1	0.0167	0.0095
29	1	-	1	0.0079	0.0114	0	-	0	0.0027	0.0200
30	2	-	2	0.0112	0.0125	3	-	3	0.0238	0.0214
31	1	-	1	0.0147	0.0094	0	-	0	0.0019	0.0234
32	1	-	1	0.0041	0.0083	2	-	2	0.0536	0.0230
33	2	-	2	0.0145	0.0081	2	-	2	0.0111	0.0247
34	1	-	1	0.0081	0.0081	1	-	1	0.0100	0.0256
35	0	-	0	0.0004	0.0060	0	-	0	0.0009	0.0249
36	1	-	1	0.0070	0.0055	1	-	1	0.0142	0.0168
37	1	-	1	0.0025	0.0048	1	-	1	0.0095	0.0166
38	0	-	0	0.0003	0.0028	1	-	1	0.0476	0.0145
39	0	-	0	0.0003	0.0037	0	-	0	0.0004	0.0159
40	0	-	0	0.0002	0.0046	0	-	0	0.0003	0.0150
41	0	-	0	0.0002	0.0036	0	-	0	0.0003	0.0126
42	0	-	0	0.0002	0.0057	0	-	0	0.0002	0.0095
43	1	-	1	0.0068	0.0082	0	-	0	0.0002	0.0078
44	0	-	0	0.0001	0.0108	0	-	0	0.0002	0.0021
45	1	-	1	0.0140	0.0132	0	-	0	0.0001	0.0050
46	0	-	0	0.0001	0.0097	0	-	0	0.0001	0.0056
47	0	-	0	0.0001	0.0120	0	-	0	0.0001	0.0048
48	0	-	0	0.0001	0.0127	1	-	1	0.0072	0.0027
49	1	-	1	0.0424	0.0179	0	-	0	0.0001	0.0036
50	1	-	1	0.0139	0.0247	0	-	0	0.0000	0.0050
Total	83	10	93	0.9995		64	7	71	0.9997	

1): determined by earplug, 2): determined by baleen plate.

Table 5. Crude and estimated age compositions of southern minke whales taken in the entire research area of 1992/93 research (Area V).

Age class	Male Crude E[1)]	Male Crude B[2)]	Male Crude E+B	Male Estimated Est.	Male Estimated S.E.	Female Crude E[1)]	Female Crude B[2)]	Female Crude E+B	Female Estimated Est.	Female Estimated S.E.
1	0	1	1	0.0017	0.0010	2	3	5	0.0207	0.0160
2	0	-	0	0.0006	0.0004	2	-	2	0.0041	0.0031
3	2	-	2	0.0105	0.0100	6	-	6	0.0407	0.0242
4	2	-	2	0.0730	0.0430	1	-	1	0.0043	0.0022
5	0	-	0	0.0051	0.0087	2	-	2	0.0070	0.0036
6	2	-	2	0.0119	0.0261	2	-	2	0.0126	0.0053
7	4	-	4	0.0753	0.0492	1	-	1	0.0052	0.0058
8	5	-	5	0.0351	0.0387	4	-	4	0.0169	0.0134
9	5	-	5	0.0220	0.0132	5	-	5	0.0470	0.0206
10	1	-	1	0.0057	0.0152	7	-	7	0.0678	0.0307
11	4	-	4	0.0523	0.0228	1	-	1	0.0166	0.0619
12	8	-	8	0.0588	0.0196	4	-	4	0.1010	0.0663
13	2	-	2	0.0164	0.0172	5	-	5	0.0575	0.0486
14	2	-	2	0.0261	0.0158	2	-	2	0.0244	0.0385
15	1	-	1	0.0141	0.0132	1	-	1	0.0061	0.0645
16	2	-	2	0.0154	0.0199	3	-	3	0.0990	0.0734
17	1	-	1	0.0044	0.0192	4	-	4	0.1062	0.0600
18	2	-	2	0.0060	0.0357	2	-	2	0.0130	0.0382
19	2	-	2	0.0609	0.0431	3	-	3	0.0320	0.0284
20	1	-	1	0.0166	0.0432	4	-	4	0.0391	0.0182
21	1	-	1	0.0033	0.0222	2	-	2	0.0072	0.0110
22	3	-	3	0.0342	0.0159	1	-	1	0.0098	0.0111
23	3	-	3	0.0299	0.0118	2	-	2	0.0176	0.0118
24	3	-	3	0.0063	0.0136	6	-	6	0.0361	0.0131
25	3	-	3	0.0154	0.0176	0	-	0	0.0016	0.0145
26	2	-	2	0.0134	0.0183	4	-	4	0.0552	0.0195
27	3	-	3	0.0614	0.0247	4	-	4	0.0147	0.0250
28	1	-	1	0.0116	0.0236	4	-	4	0.0301	0.0148
29	4	-	4	0.0402	0.0194	3	-	3	0.0346	0.0146
30	2	-	2	0.0084	0.0184	1	-	1	0.0139	0.0129
31	4	-	4	0.0340	0.0143	1	-	1	0.0078	0.0119
32	1	-	1	0.0021	0.0183	1	-	1	0.0077	0.0110
33	4	-	4	0.0296	0.0148	1	-	1	0.0136	0.0100
34	1	-	1	0.0021	0.0156	0	-	0	0.0003	0.0098
35	4	-	4	0.0547	0.0178	3	-	3	0.0230	0.0093
36	0	-	0	0.0002	0.0217	0	-	0	0.0002	0.0066
37	2	-	2	0.0221	0.0218	0	-	0	0.0002	0.0059
38	2	-	2	0.0590	0.0258	0	-	0	0.0001	0.0030
39	0	-	0	0.0002	0.0256	0	-	0	0.0001	0.0035
40	1	-	1	0.0571	0.0246	1	-	1	0.0023	0.0014
41	0	-	0	0.0001	0.0183	0	-	0	0.0001	0.0009
42	0	-	0	0.0001	0.0217	0	-	0	0.0001	0.0017
43	0	-	0	0.0001	0.0092	0	-	0	0.0000	0.0008
44	1	-	1	0.0019	0.0108	0	-	0	0.0000	0.0006
45	0	-	0	0.0001	0.0126	0	-	0	0.0000	0.0009
46	0	-	0	0.0001	0.0047	1	-	1	0.0022	0.0008
47	0	-	0	0.0001	0.0005	0	-	0	0.0000	0.0007
48	0	-	0	0.0000	0.0005	0	-	0	0.0000	0.0007
49	0	-	0	0.0000	0.0003	0	-	0	0.0000	0.0006
50	0	-	0	0.0000	0.0003	0	-	0	0.0000	0.0007
Total	91	1	92	0.9996		96	3	99	0.9999	

1): determined by earplug, 2): determined by baleen plate.

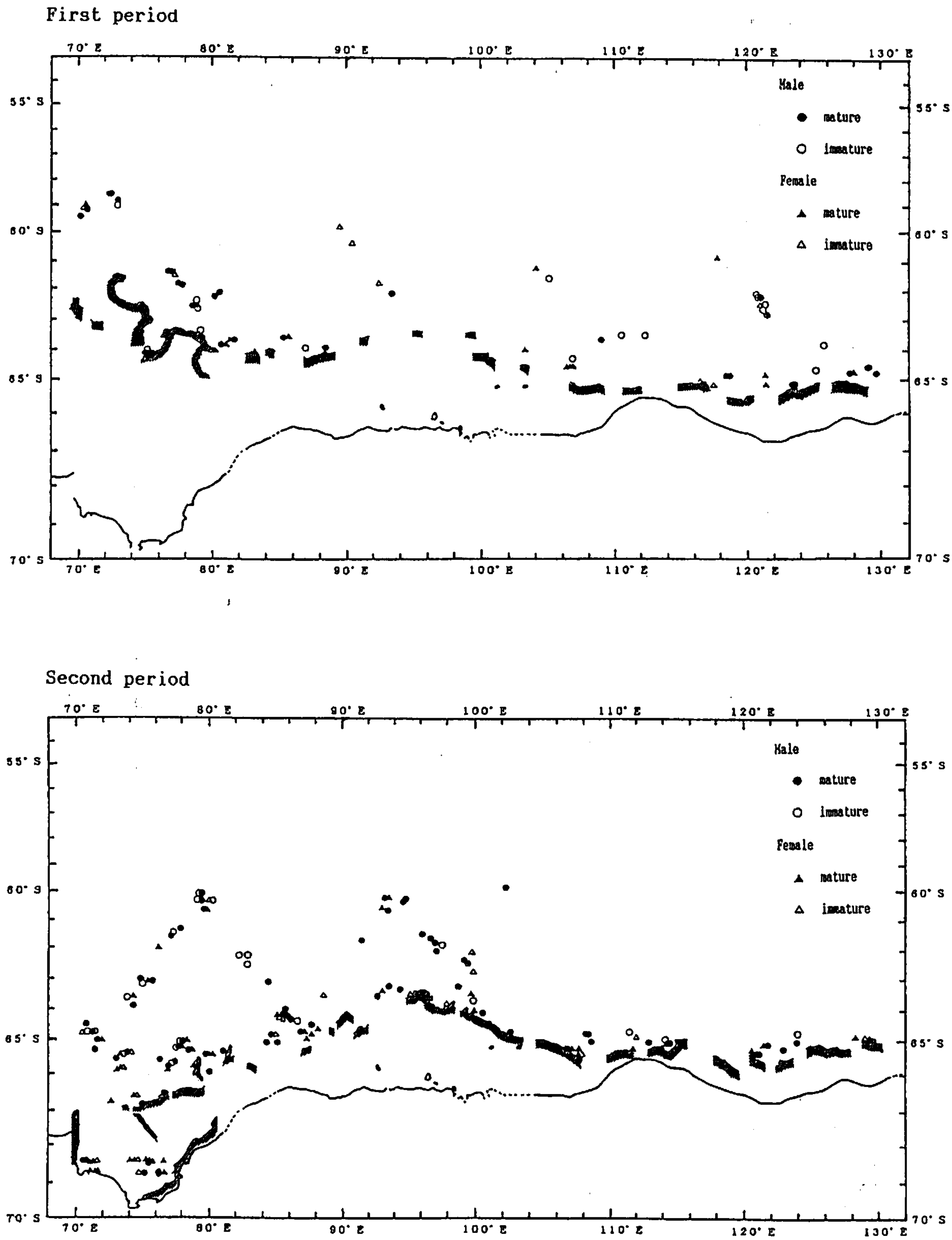

Fig. 1. Distribution of minke whales collected in the 1991/92 JARPA cruise in Antarctic Area IV. Their position was based at the sighting (after Fujise *et al.* 1993a).

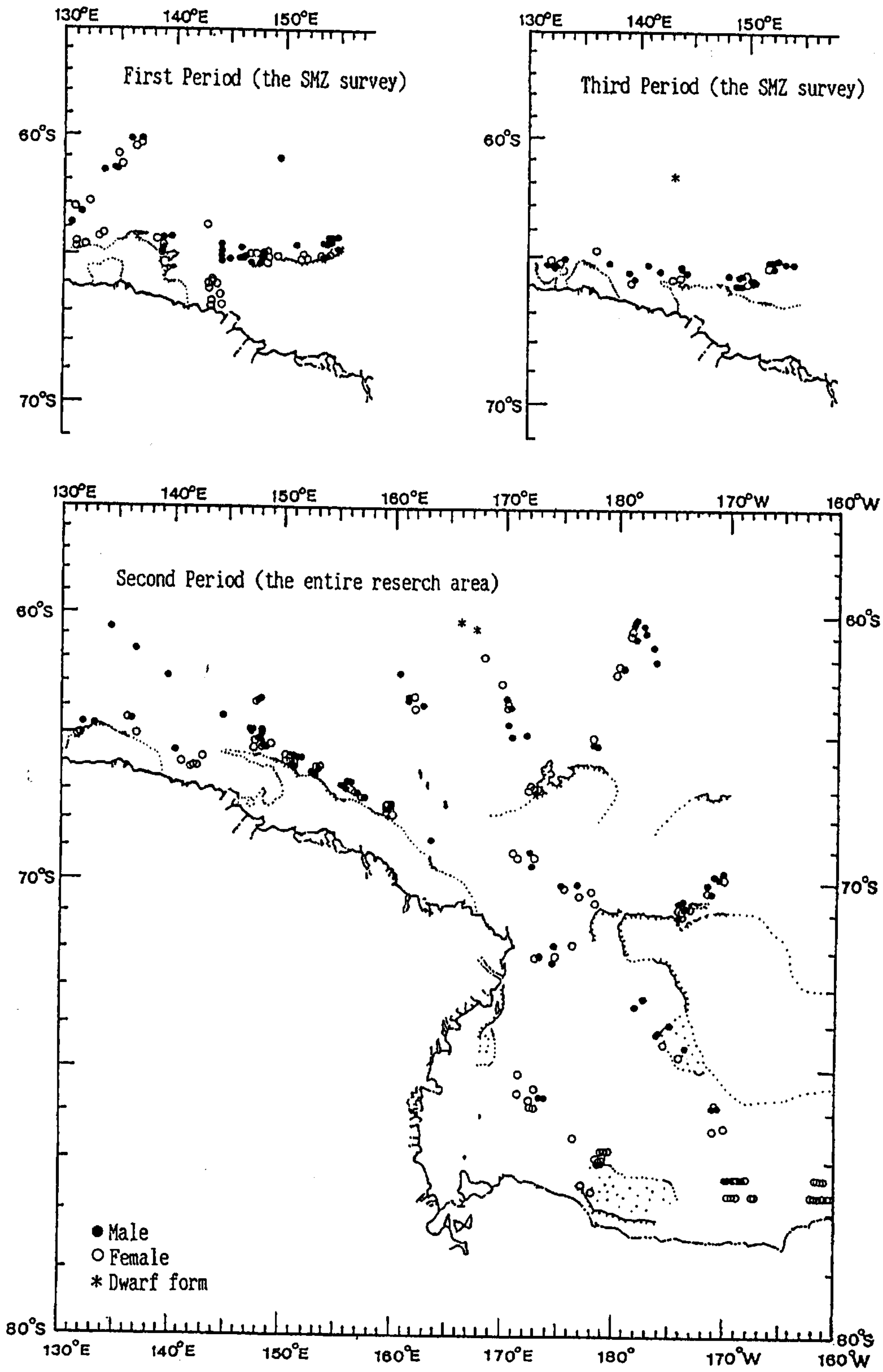

Fig. 2. Distribution of minke whales collected in the 1992/93 JARPA in Antarctic Area V. Their position was based at the sighting (after Fujise *et al.* 1993b).

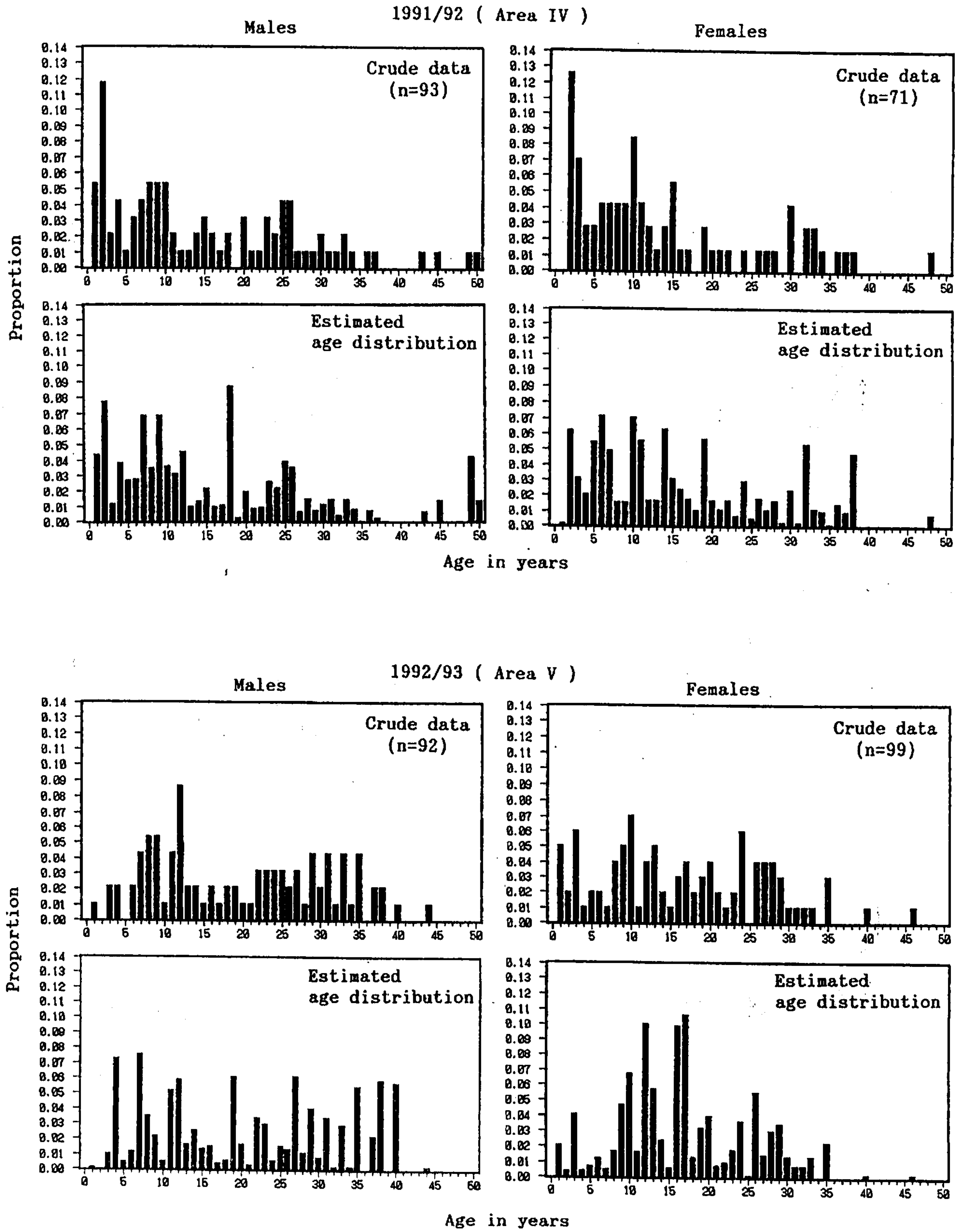

Fig. 3. Comparison of age compositions between crude data and the present correction procedure by sex. Upper half: 1991/92 season (Area IV), lower half: 1992/93 season (Area V).

Area IV

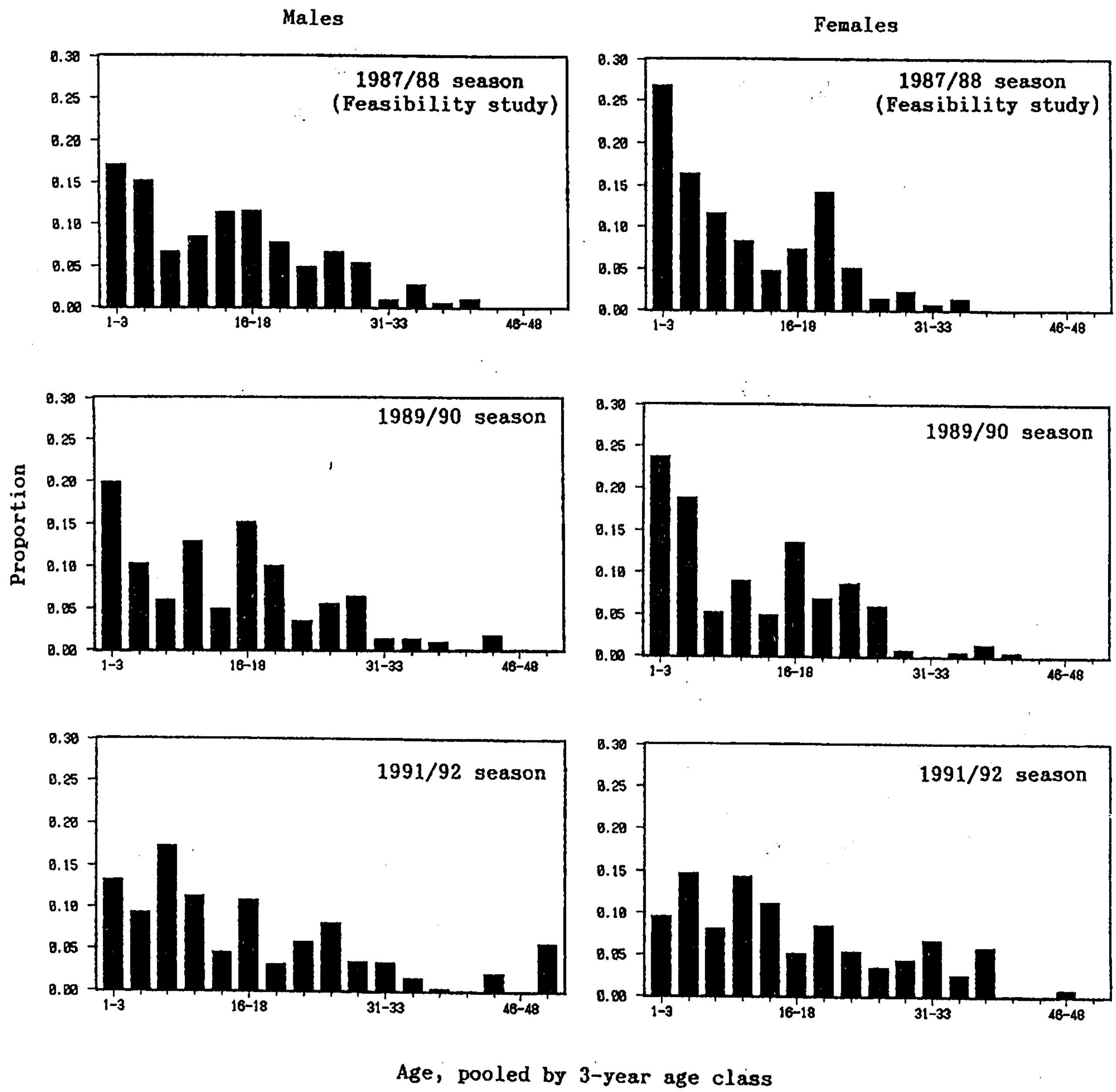

Fig. 4. Comparison of estimated age compositions of minke whales in Area IV, using data from three cruises of JARPA conducted from 1987/88 to 1991/92 seasons.

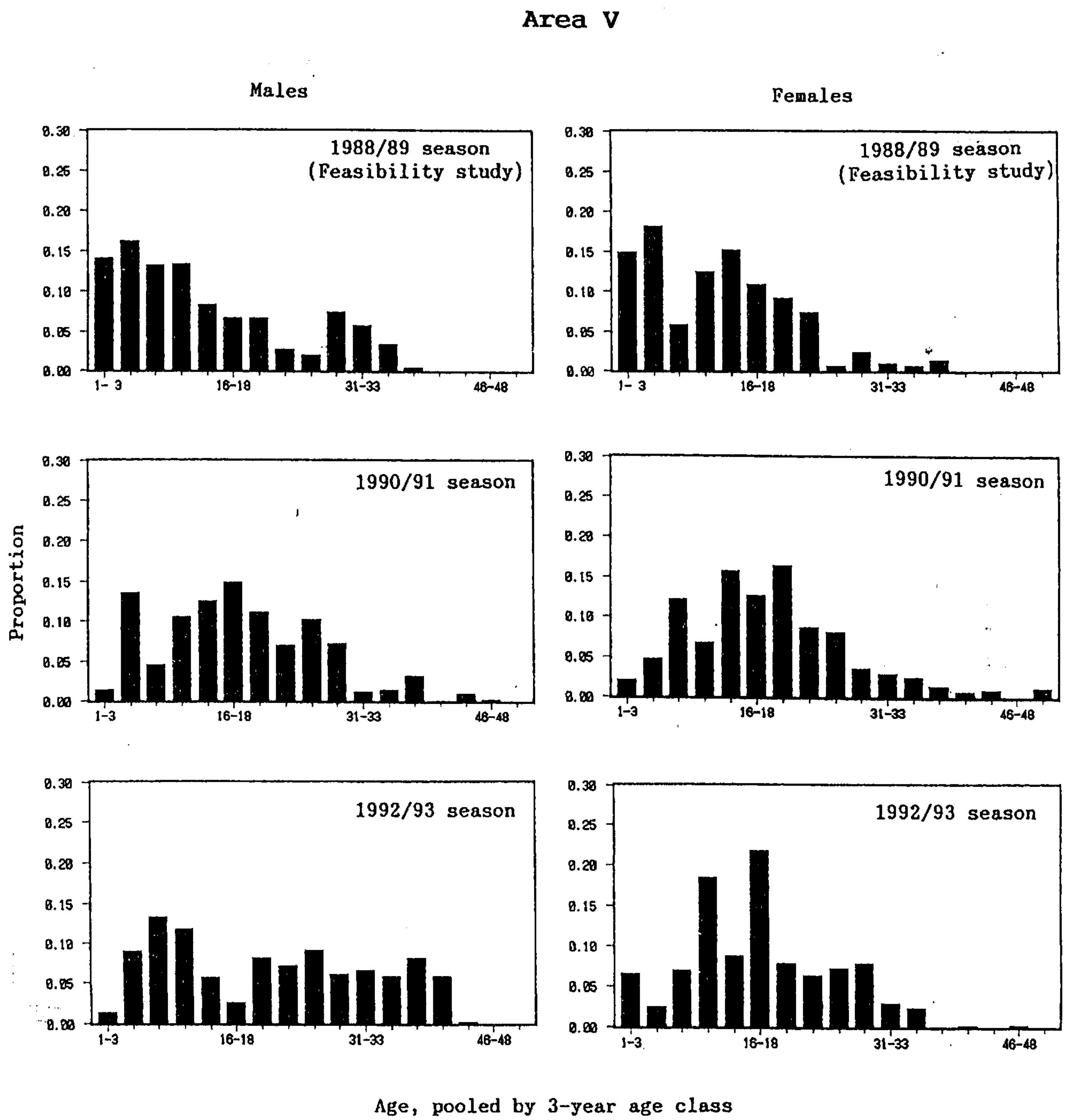

Fig. 5. Comparison of estimated age compositions of minke whales in Area V, using samples of three JARPA cruises from 1988/89 to 1992/93 seasons.

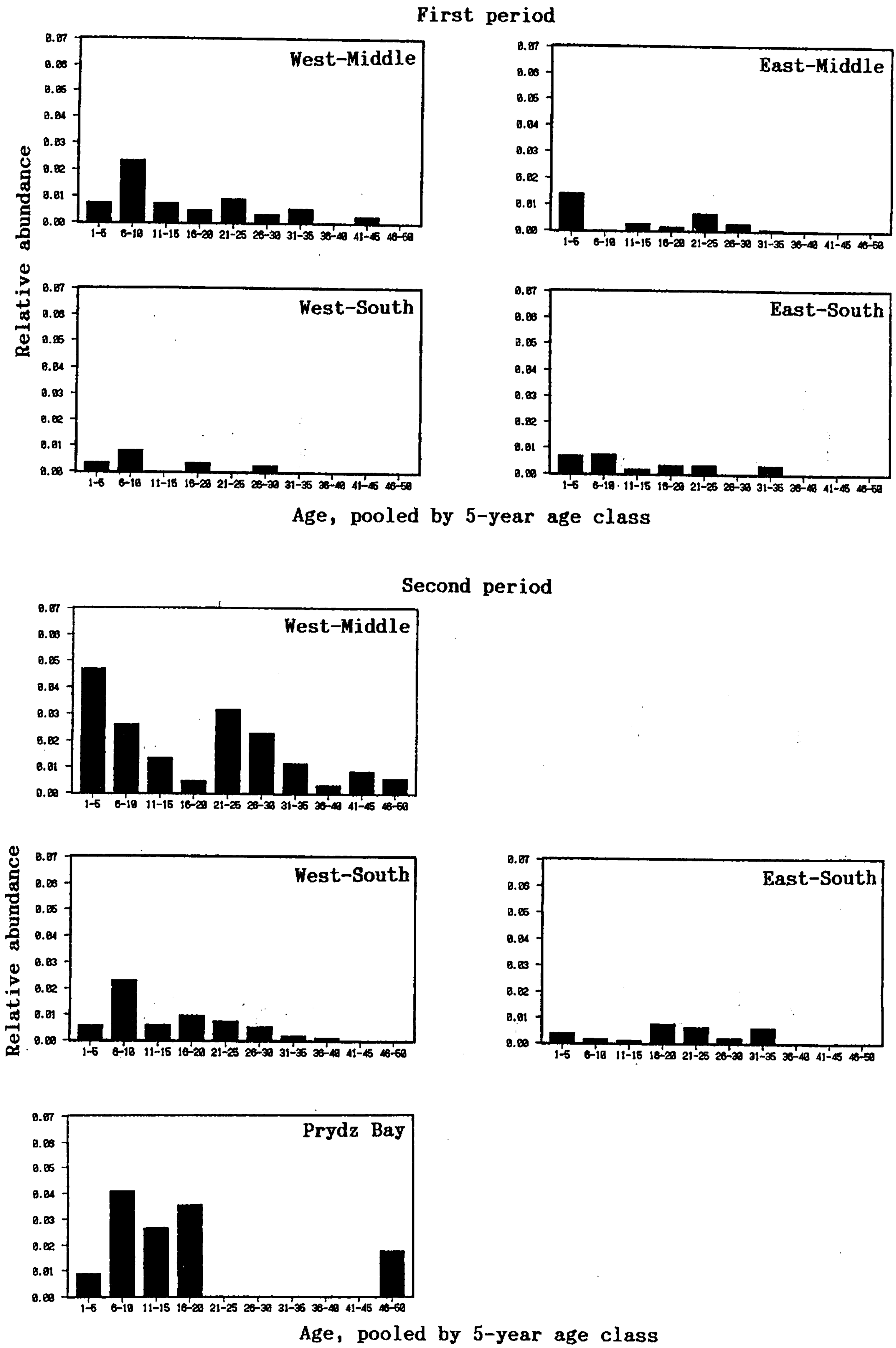

Fig. 6a. Seasonal changes of the estimated age distributions of males in each stratum of Area IV in the 1991/92 survey of JARPA.

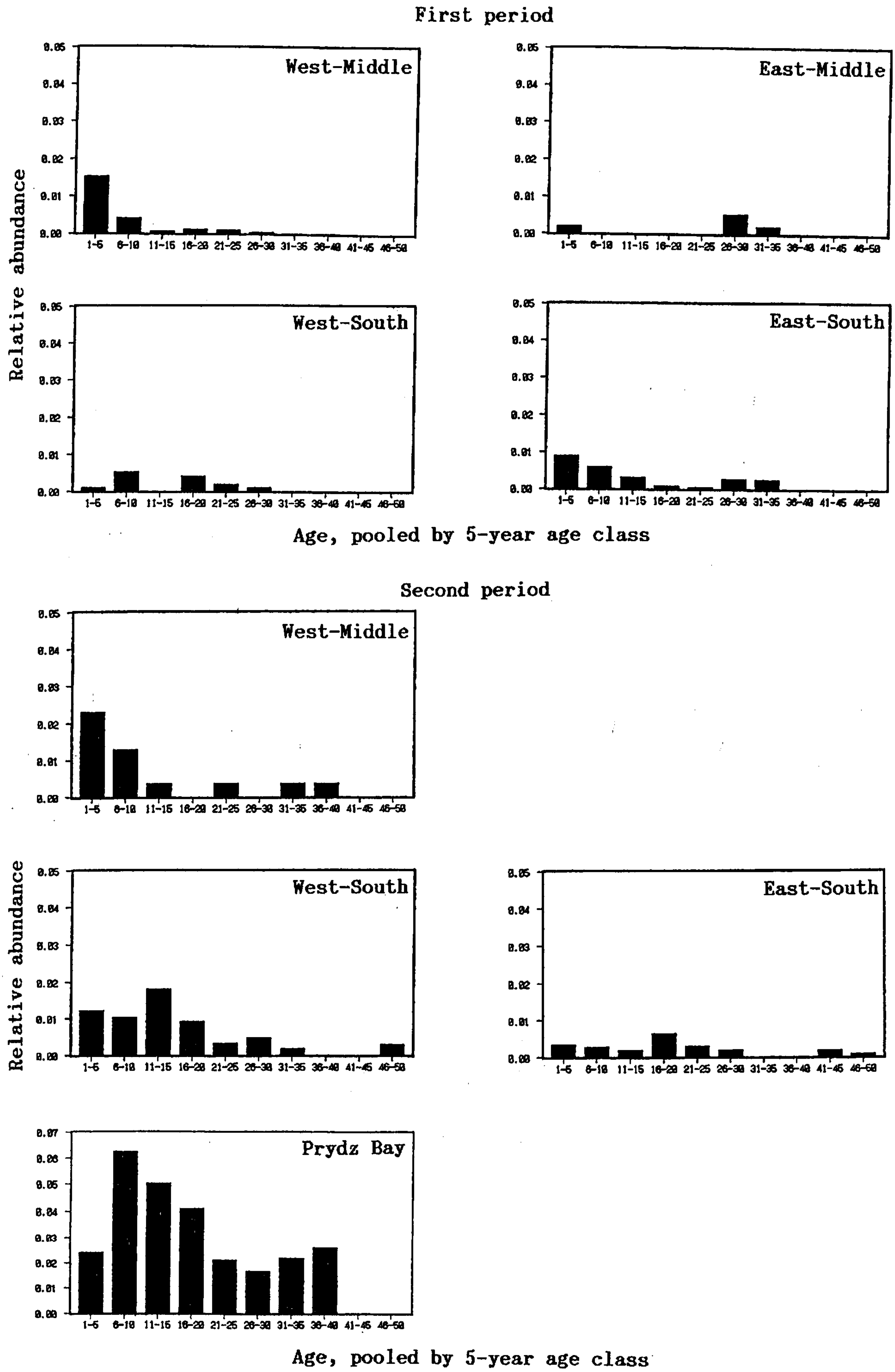

Fig. 6b. Seasonal changes of the estimated age distributions of females in each stratum of Area IV in the 1991/92 survey of JARPA.

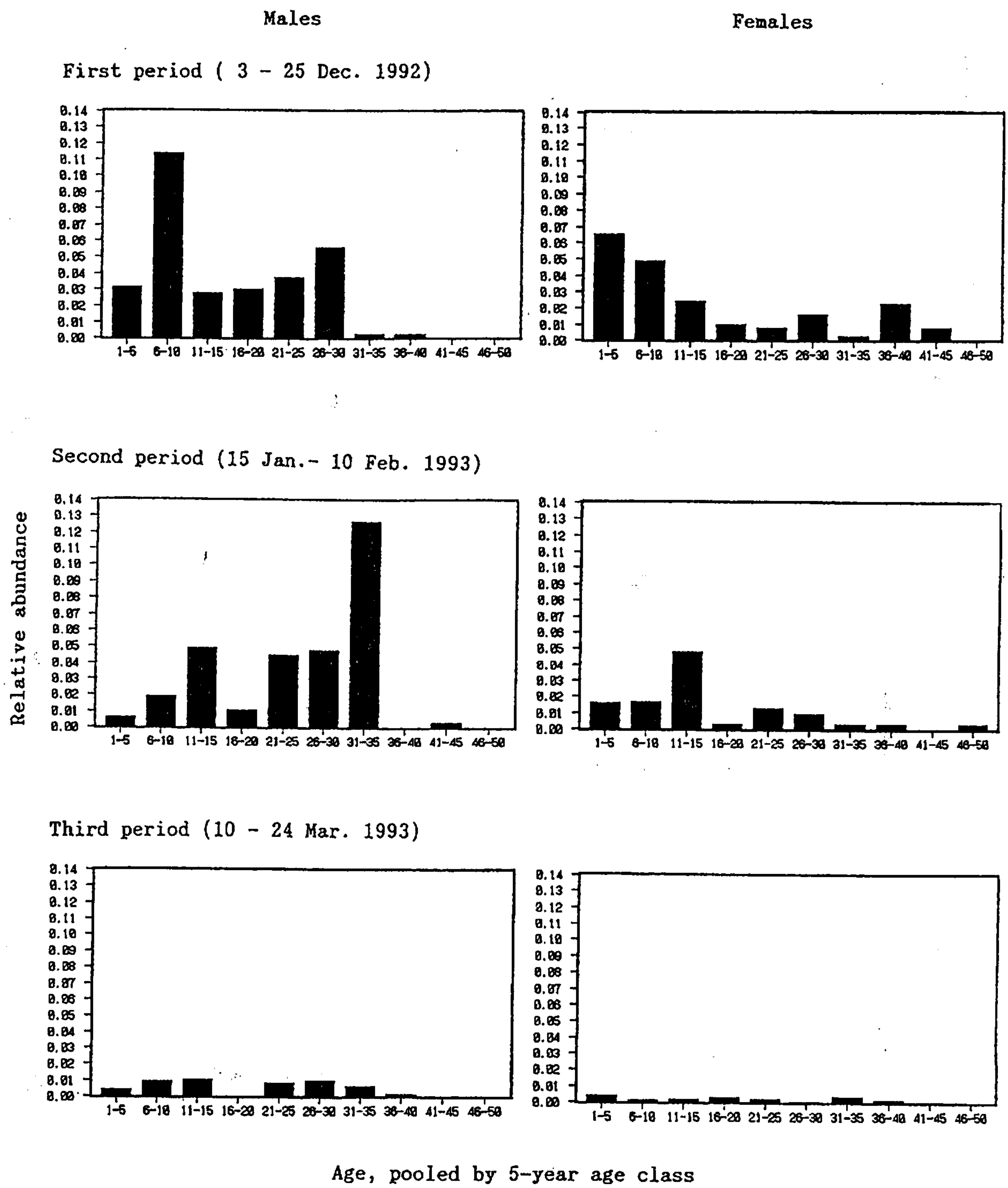

Fig. 7. Seasonal changes of age distribution of minke whales by sex in the special monitoring zone (SMZ) of Area V in the 1992/93 survey of JARPA.