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Temporal change of Distribution and Abundance estimates on Large baleen whales in Areas IV and V in the Antarctic

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Abstract

Temporal change of distribution and abundance estimates on large baleen whales in Areas IV and V in the Antarctic was examined by use of whale sightings data that were collected by the JARPA surveys. These surveys were covered within south of 60 °S to ice-edge line in Areas IV and V. The distribution patterns of blue whales were divided by the sighted frequency, it was unevenly distributed with low in the sighted frequency and the other was widely distributed with high in the sighted frequency. However, they were most rarely found within Prydz Bay and Ross Sea. Fin and humpback whales were confirmed yearly fluctuation of distribution and abundance estimates in Areas IV and V. Sei whale was most rarely found through the previous surveys. Right whale was widely distributed in Area IV. In the case of Area V, it was found only 1992/93 season. These large baleen whales as such blue, fin, humpback and right whales were confirmed tendencies to increase abundance estimates through previous survey. However, the above large baleen whales except humpback whales were no statistically significant tendency to increase of abundance estimates for standard derivations were widened through the previous surveys.

1. Introduction

Japanese Whale Research Programme under Special Permit in the Antarctic (JARPA) has a non-lethal research component involving sighting surveys. The sighting surveys are conducted to obtain information on the abundance and distribution of the minke and other large Baleen whale species in Areas IV and V during the Austral summer season. The JARPA surveys in limited areas of Areas IV every two year, although only one third of the whole Antarctic is covered by the JARPA.

In order to understanding more about the ecosystem of the Antarctic Ocean, it is necessary to study the abundance of other whale species of whales such as the blue, fin, sei , humpback and right whales, besides of minke whale. In the Antarctic Ocean, catch of right, humpback, blue, fin, and sei whales were prohibited in 1932, 1963, 1964, 1976, and 1978, respectively. Sixty years passed already since right whale has been protected, and more than 30 years have passed since humpback whale and blue whales have been protected. In coastal waters of southeast America, South Africa and east and west coasts of Australia, significant recovery of right whale and humpback whale are reported recently in these breeding areas. On the other hand, the information on the present status of pelagic species, such as blue, fin and sei whales that consist of large part of total biomass of whale community, shows no distinctive recovery after the cease of commercial whaling.

Information on the status of the pelagic species is now provided from the IDCR cruises. The IDCR is not sufficient for the monitoring of ecosystem, as survey covers the same area once in every 6 year. In this situation, the JARPA programme continues providing more useful information about the present status and ever provides the temporal changes of whale stocks including large baleen whales. The sighting data from the previous JARPA surveys are used to investigate abundance in large baleen whales. An outline of these analyses is presented in this note.

2. Methodology

Unique sighting procedures to collect unbiased data was introduced in the JARPA program; (1) the trackline was designed in order to cover the whole area uniformly, (2) the line transect procedure sampled the schools proportionally according to the densities encountered, (3) all the schools sighted were recorded. Details of the sighting procedures are given in the Review of the sighting survey in the JARPA (Nishiwaki *et al.*, submitted to this meeting).

2.1 Sighting data

1) Sighting data of large baleen whales

Total number of schools and whales of primary sighting in which school size were confirmed were used (Table. 1).

2) Research area

Research area of the surveys were covered an area from south of 60 °S to ice-edge line in the Areas IV (70°E - 130°E) and V (130°E - 170°W). Total searching distance of each season are calculated by each strata (Table. 2).

3) Design of the trackline

The full scale research started in 1989/90 with the new design of the trackline (sawtooth type) adopted considering the wider area. The starting point of the sawtooth trackline was randomly selected from lines one n.mile apart on the 60 °S latitude line or on the locus from the 45 n.miles from ice-edge. The following way-points were systematically set on the ice-edge and on the locus from the 45 n.miles from the ice-edge (southern stratum), on the 45 n.mile and 60°S latitude line (northern stratum).

2.2 Estimates of abundance

JARPA have conducted by the Normal Closing Mode (NSC). In this paper, abundance

estimation of large baleen whales "$\hat{P}$" is based on the following formula;

$$\hat{P} = \frac{n A \bar{s}}{2 L \hat{w}} \quad \text{..... (1)}$$

The "n" is the number of the primary sighting of schools while on full searching effort, "A" is the area of each stratum (n.mile^2). "L" is the total searching distance in each strata (n.mile). "$\hat{w}$" is the effective search half width (n.mile) of schools. "$\bar{s}$" is the mean school size of the species of each stratum. Because of the number of large baleen whales in each strata are sometimes small except for humpback whale, "$\hat{w}$" and "$\bar{s}$" are estimated by pooling data in every northern and southern strata.

1) Effective search half width ($\hat{w}$)
"$\hat{w}$" is the effective search half width (n.mile) of schools which estimated by fitting the hazard rate model;

$$g_i(y) = 1 - exp[-(y/a)^{1-b}]$$

(Hayes and Buckland, 1983, Buckland, 1985, 1987), here a and b are free parameters to be estimated. Table. 3 shows the effective search half-widths of each strata.

2) mean school size ($\bar{s}$)
The mean school size of each stratum is estimated using the sighting data which sighted within 1 n.mile from the trackline. Mean school size ($\bar{s}$) were estimated by the following IDCR method (Butterworth *et al.*, 1994);

$$\bar{s} = \frac{n'_w}{n'} \frac{w'_s}{w'_w} \quad \text{..... (2)}$$

"n'" is the number of schools seen. "n'_w" is the number of whales seen. "w'_s" and "w'_w" are the effective search half-width corresponding to the fit of equation (1) to their distribution of perpendicular distance of schools and whales, respectively.

2.3 Variance estimates for $\hat{P}$
Variance calculations for these abundance estimates ($\hat{P}$) in each strata make use of the following. Under the assumptions that the distribution of the perpendicular distances and the number of the schools sighted are independent to each other, the square of the coefficient of variation of $\hat{P}$ can be expressed as the sum of that of sightings per unit effort n/L, that of the estimate of $1/w's$ and that of the estimate of "$\bar{s}$".

$$[\text{c.v.}(\hat{P})]^2 = [\text{c.v.}(\hat{n/L})]^2 + [\text{c.v.}(1/\hat{w's})]^2 + [\text{c.v.}(\bar{s})]^2$$

3. Results

3.1 Distribution of large baleen whales in JARPA surveys

Figure 1 shows geographical positions of large baleen whale schools from primary sighting during 1989/90 - 1995/96 JARPA season.

The distribution of blue whales between Areas IV and V were divided broadly into two categories by these sighted frequency. In the case of 1989/90- 1991/92 and 1995/96 season, it was unevenly distributed with low in the sighted frequency. On the other hand, it was widely distributed with high in the sighted frequency through 1992/93 -1994/95 season. However, they were most rarely found within Prydz Bay and Ross Sea.

Fin and humpback whales were widely distributed between areas IV and V. They were also most rarely found with Prydz Bay and Ross Sea. Fin whales sighted frequency in Area V was higher than that of area IV. On the other hand, humpback whales sighted frequency in Area IV was higher than that of Area V. In addition, it was confirmed that sightings of both species were gradually increased every time spend many surveys.

Sei whales were rarely found through the previous surveys. As for right whales, it was widely distributed between 90°E - 130°E and rarely found only 1992/93 season in Area V.

3.2 Temporal change in abundance estimates of large baleen whales

Table 4 and figure 2 show temporal changes in abundance estimates of blue, fin, humpback and right whales in Areas IV and V (south of 60°S) from the JARPA data.

Abundance estimates of blue whales in Area IV was estimated around 100 animals except 1995/96 season. On the other hand, there is tendency to increase of abundance estimates with the season goes in Area V. These results were inferred by temporal change from the distribution pattern of blue whales in each research area.

As for the temporal change in abundance estimates of fin and humpback whales, they were indicated to gradually increase every survey. Yearly fluctuations in abundance estimates of both species were remarkably in Area IV. On the other hand, it was confirmed that tendency to increase with little fluctuation in Area V.

However, these large baleen whales except humpback whales were no statistically significant tendency to increase of abundance estimates for standard derivations were widened through the previous surveys.

3.3 Segregation between minke whales and humpback whales

Minke whales were most dominant species through the pervious surveys. It was noted that minke whales were widely distributed in Areas IV and V. Humpback whales were second dominant baleen whales. It was confirmed that humpback whales were similar to pattern of distribution of the minke whales except for the Prydze Bay and the Ross Sea. As for the distributions of minke and humpback whales, it was noted that minke whales were mainly sighted in the south part within research area. On the other hand, humpback whales were frequent in the north part of research area but they were scattered in the south part of research area. This is indicative that the two species may segregate their habitats.

4. Reference

Buckland, S.T. 1985. Perpendicular distance models for the line transect sampling, *Biometrics*, 41: 177-195.

Buckland, S.T. 1987. An assessment of the performance of line transect models for fitting IWC/IDCR cruise data, 1978/79 to 1984/85, *Rep. int. Whal. Commn* 37: 277-279.

Burnham, K.P., Anderson, D.R. and Laake, J.L. 1980. Estimation of density from line transect sampling of biological populations. *Wildlife Monograph* No. 72.

Butterworth, D.S.Borchers, D.L. and Chalis, S. Decker De and Kasamatsu, F. 1994. Estimates of abundance for southern hemisphere blue, fin, sei and humpback, sperm, killer and pilot whales from the 1978/79 to 1990/91 IWC/IDCR sighting survey cruises, with extrapolation to the area south of 30 S for the first five species based on Japanese scouting vessel data. Paper SC/46/SH24 presented to the IWC Scientific Committee, May 1994 (unpublished). 129pp.

Hayes, R.J. and Buckland, S.T. 1983. Radial distance models for the line transect method. *Biometrics*, 39: 29-42.

Nishiwaki, S., Matsuoka, K., Kawasaki, M. Kishino, H. and Kasamatsu, F. 1997. Review of the sighting survey in the JARPA. Paper SC/M97/1 submitted to this meeting, May 1997. 42pp.

Table 1. The number of primary sighting in each Areas IV and V.

Area IV

season	species	school	whale
1989/90	Blue	5	9
1991/92	Blue	3	3
1993/94	Blue	4	6
1995/96	Blue	1	1

season	species	school	whale
1989/90	Fin	5	20
1991/92	Fin	12	58
1993/94	Fin	5	10
1995/96	Fin	19	90

season	species	school	whale
1989/90	Humpback	121	210
1991/92	Humpback	187	340
1993/94	Humpback	112	189
1995/96	Humpback	256	447

season	species	school	whale
1989/90	Right	2	2
1991/92	Right	26	30
1993/94	Right	8	10
1995/96	Right	8	8

season	species	school	whale
1989/90	Minke	763	1,977
1991/92	Minke	617	2,060
1993/94	Minke	534	1,176
1995/96	Minke	681	1,545

Area V

season	species	school	whale
1990/91	Blue	4	6
1992/93	Blue	4	5
1994/95	Blue	12	19

season	species	school	whale
1990/91	Fin	33	67
1992/93	Fin	12	22
1994/95	Fin	53	191

season	species	school	whale
1990/91	Humpback	60	92
1992/93	Humpback	23	46
1994/95	Humpback	89	162

season	species	school	whale
1990/91	Right	0	0
1992/93	Right	0	0
1994/95	Right	0	0

season	species	school	whale
1990/91	Minke	741	1,715
1992/93	Minke	657	2,097
1994/95	Minke	757	2,361

Table 2. Searching distance (n.m) and the area ((n.m)^2) of each strata.

Area IV

Season	stratum	Dist.	Area
1989	NW	3,984	189,507
1989	NE	3,263	218,248
1989	SW	5,342	44,219
1989	SE	2,753	38,983
1989	PB	762	34,628
1989	total	16,104	525,585

Season	stratum	Dist.	Area
1991	NW	4,549	239,005
1991	NE	4,003	220,715
1991	SW	3,603	36,619
1991	SE	4,367	34,808
1991	PB	630	27,733
1991	total	17,152	558,880

Season	stratum	Dist.	Area
1993	NW	4,179	232,782
1993	NE	3,177	161,376
1993	SW	2,391	35,428
1993	SE	2,157	40,813
1993	PB	1,042	35,196
1993	total	12,946	505,595

Season	stratum	Dist.	Area
1995	NW	3,513	217,044
1995	NE	2,982	228,383
1995	SW	2,769	33,433
1995	SE	2,125	29,932
1995	PB	1,295	27,929
1995	total	12,684	536,721

Area V

Season	stratum	Dist.	Area
1990	NW	4,172	244,494
1990	NE	4,069	264,281
1990	SW	2,667	66,135
1990	SE	3,176	120,801
1990	total	14,084	695,711

Season	stratum	Dist.	Area
1992	NW	2,255	332,682
1992	NE	1,475	290,526
1992	SW	1,891	43,572
1992	SE	2,198	180,745
1992	total	7,819	847,525

Season	stratum	Dist.	Area
1994	NW	2,957	189,310
1994	NE	2,529	303,617
1994	SW	2,469	45,685
1994	SE	1,261	175,421
1994	total	9,216	714,033

Table 3. The effective search half-width of schools (Ws) and whales (Ww) of each species.

Species	Ws	(c.v.)	Ww	(c.v.)
Blue	1.234	0.217	1.449	0.097
Fin	1.277	0.049	1.486	0.015
Humpback	1.264	0.019	1.245	0.016
Right	0.805	0.505	0.792	0.613
Minke	0.643	0.054	0.852	0.020

Table 4. Abundance estimation of baleen whales in Areas IV and V. 's' is estimation of mean school size. 'P' is abundance estimation.

Area IV

		Blue whale							Fin whale						
Season	stratum	school	whale	s	P	cv-mss	cv-n/L	cv-P	school	whale	s	P	cv-mss	cv-n/L	cv-P
1989/90	NW	0	0	1.50	0	-	-	-	2	2	1.90	71	0.480	0.694	0.845
1989/90	NE	0	0	1.50	0	-	-	-	2	13	1.90	99	0.480	0.701	0.851
1989/90	SW	1	2	1.40	5	0.310	0.994	1.064	1	5	3.33	11	0.460	0.997	1.099
1989/90	SE	4	7	1.40	32	0.310	0.596	0.706	0	0	3.33	0	-	-	-
1989/90	PB	0	0	1.40	0	-	-	-	0	0	3.33	0	-	-	-
1989/90	total	5	9	-	37	-	-	0.631	5	20	-	181	-	-	0.576
1991/92	NW	1	1	1.50	32	0.500	1.007	1.145	7	46	1.90	274	0.480	0.413	0.635
1991/92	NE	0	0	1.50	0	-	-	-	2	3	1.90	82	0.480	0.706	0.855
1991/92	SW	2	2	1.40	12	0.500	1.009	1.147	0	0	3.33	0	-	-	-
1991/92	SE	0	0	1.40	0	-	-	-	3	9	3.33	31	0.460	1.005	1.106
1991/92	PB	0	0	1.40	0	-	-	-	0	0	3.33	0	-	-	-
1991/92	total	3	3	-	43	-	-	0.895	12	58	-	387	-	-	0.493
1993/94	NW	1	1	1.50	34	0.500	1.002	1.141	1	2	1.90	41	0.480	0.996	1.107
1993/94	NE	0	0	1.50	0	-	-	-	3	7	1.90	113	0.480	0.543	0.726
1993/94	SW	2	4	1.40	17	0.500	1.014	1.151	1	1	3.33	19	0.460	1.015	1.115
1993/94	SE	0	0	1.40	0	-	-	-	0	0	3.33	0	-	-	-
1993/94	PB	1	1	1.40	19	0.500	0.992	1.132	0	0	3.33	0	-	-	-
1993/94	total	4	6	-	70	-	-	0.692	5	10	-	174	-	-	0.555
1995/96	NW	0	0	1.50	0	-	-	-	8	20	1.90	368	0.480	0.394	0.623
1995/96	NE	0	0	1.50	0	-	-	-	5	46	1.90	285	0.480	0.419	0.639
1995/96	SW	1	1	1.40	7	0.500	0.999	1.138	1	3	3.33	16	0.460	0.999	1.101
1995/96	SE	0	0	1.40	0	-	-	-	5	21	3.33	92	0.460	0.715	0.852
1995/96	PB	0	0	1.40	0	-	-	-	0	0	3.33	0	-	-	-
1995/96	total	1	1	-	7	-	-	1.138	19	90	-	760	-	-	0.399

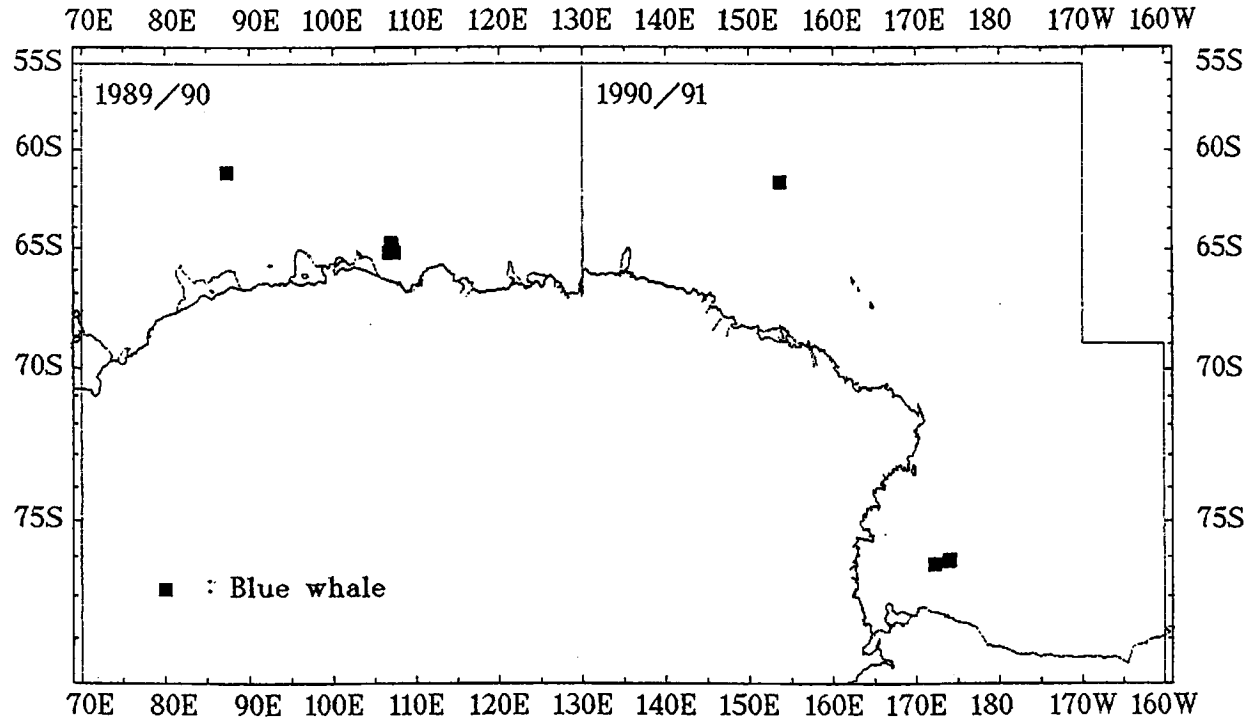
		Humpback whale							Right whale						
Season	stratum	school	whale	s	P	cv-mss	cv-n/L	cv-P	school	whale	s	P	cv-mss	cv-n/L	cv-P
1989/90	NW	47	88	1.73	1530	0.430	0.184	0.468	1	1	1.12	33	0.280	0.986	1.143
1989/90	NE	35	62	1.73	1602	0.430	0.330	0.542	1	1	1.12	47	0.280	0.986	1.143
1989/90	SW	34	53	1.76	196	0.390	0.210	0.443	0	0	1.80	0	-	-	-
1989/90	SE	3	4	1.76	30	0.390	0.566	0.688	0	0	1.80	0	-	-	-
1989/90	PB	2	3	1.76	63	0.390	0.626	0.738	0	0	1.80	0	-	-	-
1989/90	total	121	210	-	3420	-	-	0.330	2	2	-	80	-	-	0.819
1991/92	NW	72	133	1.73	2589	0.430	0.162	0.460	6	8	1.12	219	0.280	0.521	0.778
1991/92	NE	35	61	1.73	1321	0.430	0.318	0.535	0	0	1.12	0	-	-	-
1991/92	SW	24	40	1.76	170	0.390	0.345	0.521	0	0	1.80	0	-	-	-
1991/92	SE	55	104	1.76	305	0.390	0.234	0.455	20	22	1.80	178	0.240	0.427	0.703
1991/92	PB	1	2	1.76	31	0.390	0.942	1.020	0	0	1.80	0	-	-	-
1991/92	total	187	340	-	4415	-	-	0.316	26	30	-	397	-	-	0.532
1993/94	NW	45	72	1.73	1715	0.430	0.201	0.475	3	3	1.12	116	0.280	0.576	0.815
1993/94	NE	31	61	1.73	1077	0.430	0.265	0.505	5	7	1.12	177	0.280	0.577	0.816
1993/94	SW	25	36	1.76	258	0.390	0.343	0.520	0	0	1.80	0	-	-	-
1993/94	SE	7	13	1.76	92	0.390	0.381	0.546	0	0	1.80	0	-	-	-
1993/94	PB	4	7	1.76	94	0.390	0.601	0.717	0	0	1.80	0	-	-	-
1993/94	total	112	189	-	3237	-	-	0.307	8	10	-	293	-	-	0.589
1995/96	NW	124	200	1.73	5242	0.430	0.183	0.468	0	0	1.12	0	-	-	-
1995/96	NE	46	84	1.73	2411	0.430	0.269	0.508	5	5	1.12	266	0.280	0.422	0.715
1995/96	SW	58	110	1.76	487	0.390	0.283	0.482	0	0	1.80	0	-	-	-
1995/96	SE	28	53	1.76	275	0.390	0.248	0.463	3	3	1.80	47	0.240	0.732	0.921
1995/96	PB	0	0	1.76	0	-	-	-	0	0	1.80	0	-	-	-
1995/96	total	256	447	-	8415	-	-	0.327	8	8	-	314	-	-	0.623

Table 4.(continued)

Area V

		Blue whale							Fin whale						
Season	stratum	school	whale	s	P	cv-mss	cv-n/L	cv-P	school	whale	s	P	cv-mss	cv-n/L	cv-P
1990/91	NW	1	2	1.33	32	0.370	0.992	1.081	18	40	2.33	962	0.630	0.318	0.707
1990/91	NE	0	0	1.33	0	-	-	-	7	8	2.33	415	0.630	0.351	0.723
1990/91	SW	0	0	1.38	0	-	-	-	5	11	3.95	192	1.060	0.575	1.207
1990/91	SE	3	4	1.38	64	0.370	0.752	0.866	3	8	3.95	176	1.060	0.550	1.195
1990/91	total	4	6	-	95	-	-	0.681	33	67	-	1745	-	-	0.430
1992/93	NW	1	1	1.33	80	0.370	1.025	1.111	2	3	2.33	269	0.630	0.676	0.925
1992/93	NE	1	1	1.33	106	0.370	1.003	1.091	7	14	2.33	1258	0.630	0.423	0.760
1992/93	SW	1	1	1.38	13	0.370	1.019	1.106	2	3	3.95	71	1.060	0.687	1.264
1992/93	SE	1	2	1.38	46	0.370	0.986	1.075	1	2	3.95	127	1.060	1.011	1.466
1992/93	total	4	5	-	245	-	-	0.423	12	22	-	1725	-	-	0.189
1994/95	NW	0	0	1.33	0	-	-	-	8	23	2.33	467	0.630	0.382	0.738
1994/95	NE	0	0	1.33	0	-	-	-	25	69	2.33	2738	0.630	0.423	0.760
1994/95	SW	9	15	1.38	93	0.370	0.342	0.549	11	53	3.95	315	1.060	0.326	1.110
1994/95	SE	3	4	1.38	233	0.370	0.585	0.725	9	46	3.95	1936	1.060	0.654	1.246
1994/95	total	12	19	-	327	-	-	0.542	53	191	-	5455	-	-	0.452

		Humpback whale							Right whale						
Season	stratum	school	whale	s	P	cv-mss	cv-n/L	cv-P	school	whale	s	P	cv-mss	cv-n/L	cv-P
1990/91	NW	2	4	1.91	89	0.590	0.698	0.914	0	0	0.00	0	-	-	-
1990/91	NE	7	11	1.91	343	0.590	0.395	0.710	0	0	0.00	0	-	-	-
1990/91	SW	24	35	1.59	374	0.440	0.363	0.571	0	0	0.00	0	-	-	-
1990/91	SE	27	42	1.59	646	0.440	0.269	0.516	0	0	0.00	0	-	-	-
1990/91	A	60	92	-	1452	-	-	0.279	0	0	-	0	-	-	-
1992/93	NW	5	9	1.91	557	0.590	0.852	1.037	0	0	0.00	0	-	-	-
1992/93	NE	9	18	1.91	1339	0.590	0.723	0.933	0	0	0.00	0	-	-	-
1992/93	SW	5	11	1.59	72	0.440	0.495	0.663	0	0	0.00	0	-	-	-
1992/93	SE	4	8	1.59	207	0.440	0.493	0.661	0	0	0.00	0	-	-	-
1992/93	A	23	46	-	2176	-	-	0.275	0	0	-	0	-	-	-
1994/95	NW	14	25	1.91	677	0.590	0.512	0.781	0	0	0.00	0	-	-	-
1994/95	NE	28	57	1.91	2539	0.590	0.368	0.696	0	0	0.00	0	-	-	-
1994/95	SW	42	71	1.59	489	0.440	0.231	0.497	0	0	0.00	0	-	-	-
1994/95	SE	5	9	1.59	437	0.440	0.508	0.672	0	0	0.00	0	-	-	-
1994/95	A	89	162	-	4143	-	-	0.158	0	0	-	0	-	-	-



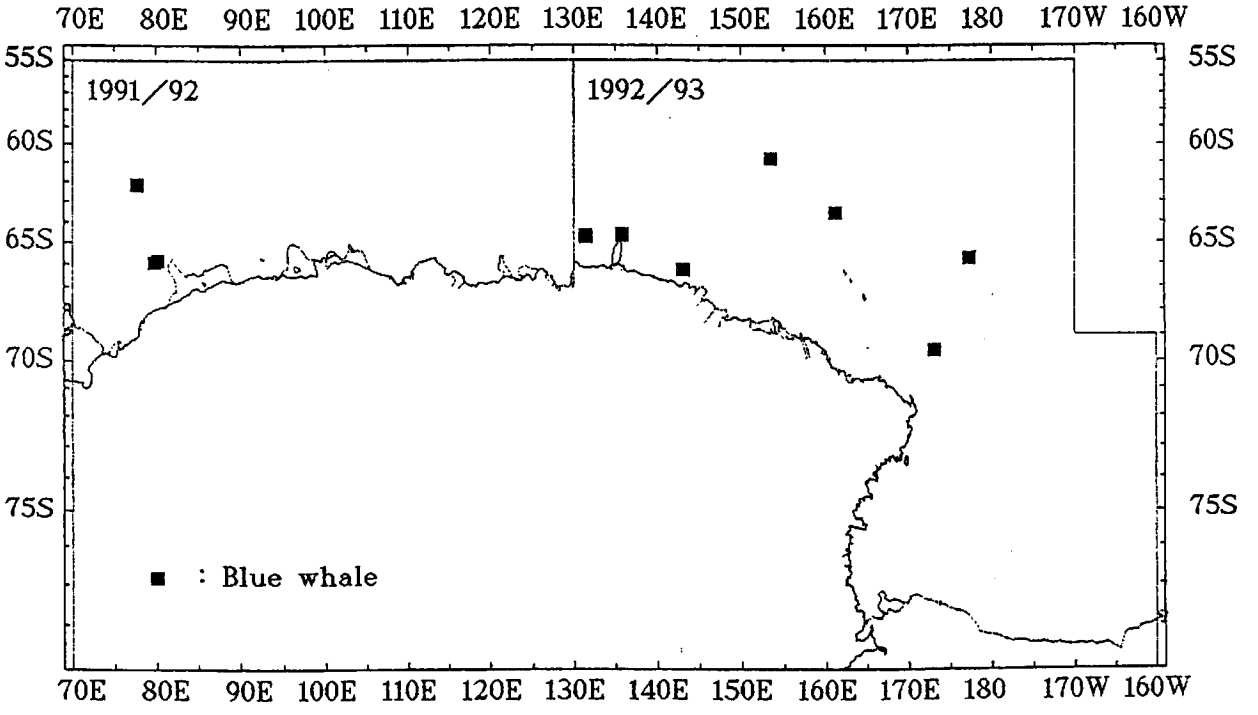
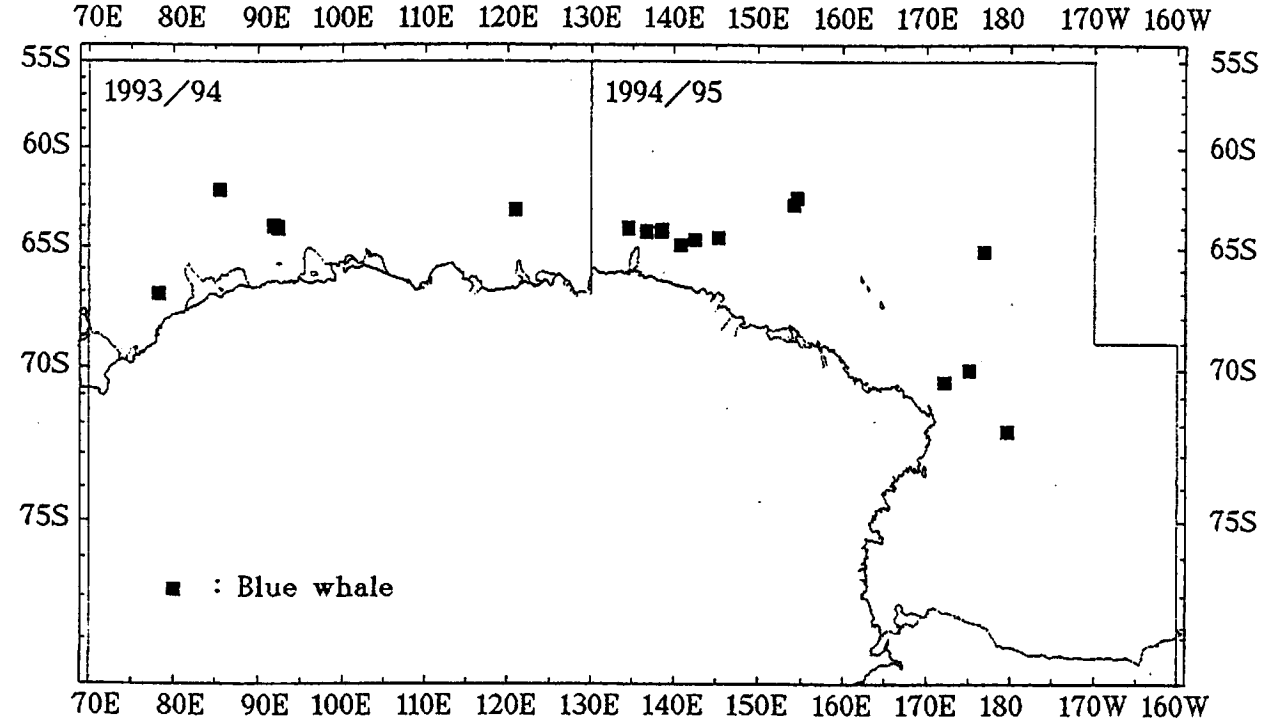


Fig. 1 Geographical positions of primary sighting of large baleen whale schools during JARPA for the period 1989/90-1995/96.



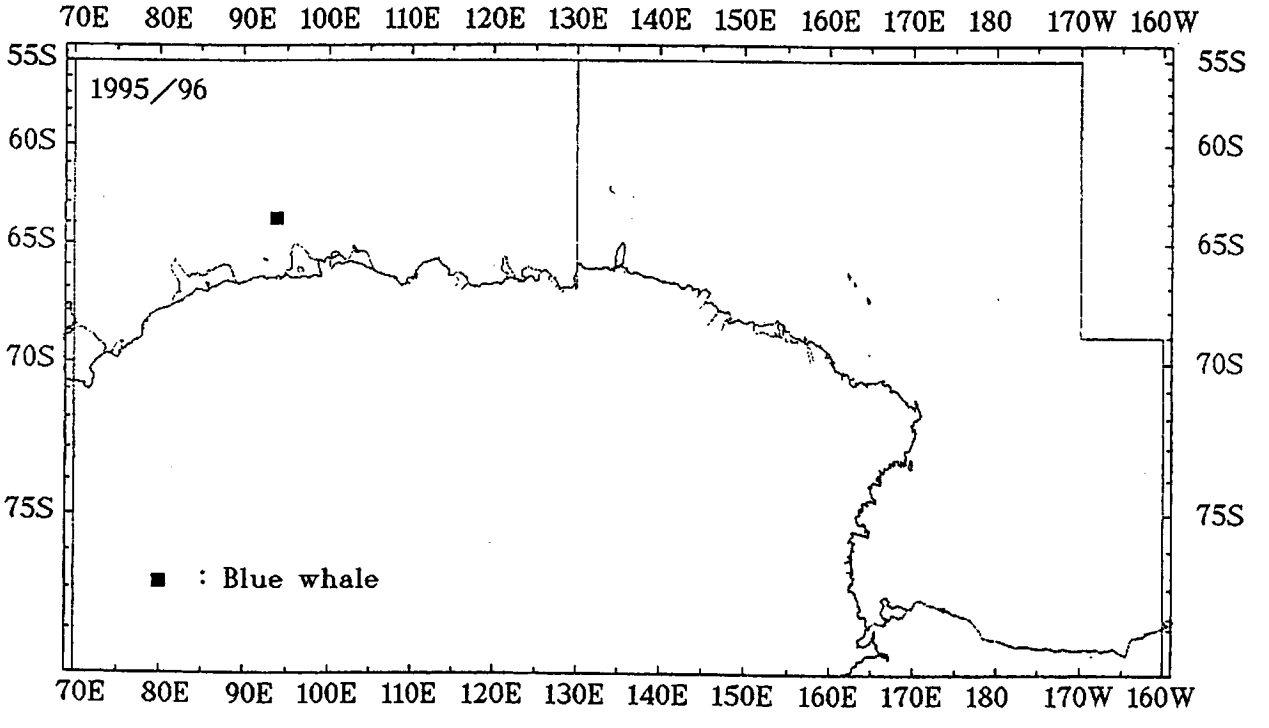
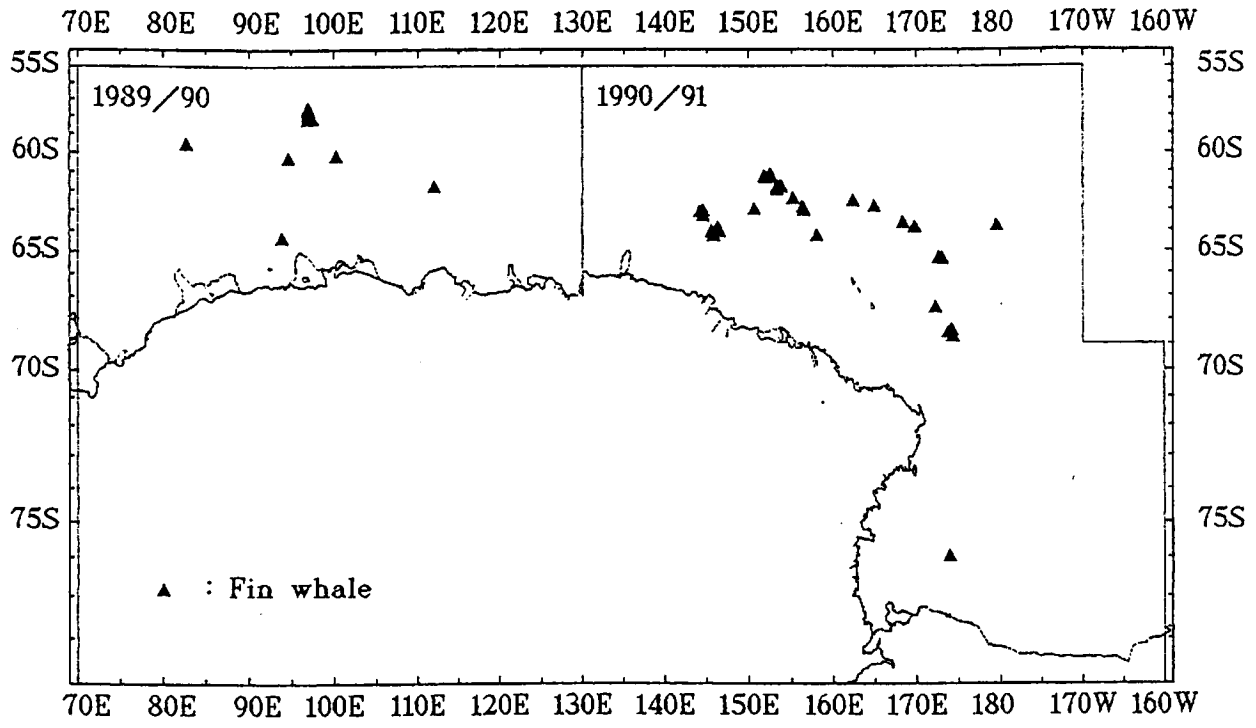


Fig. 1 (continued)



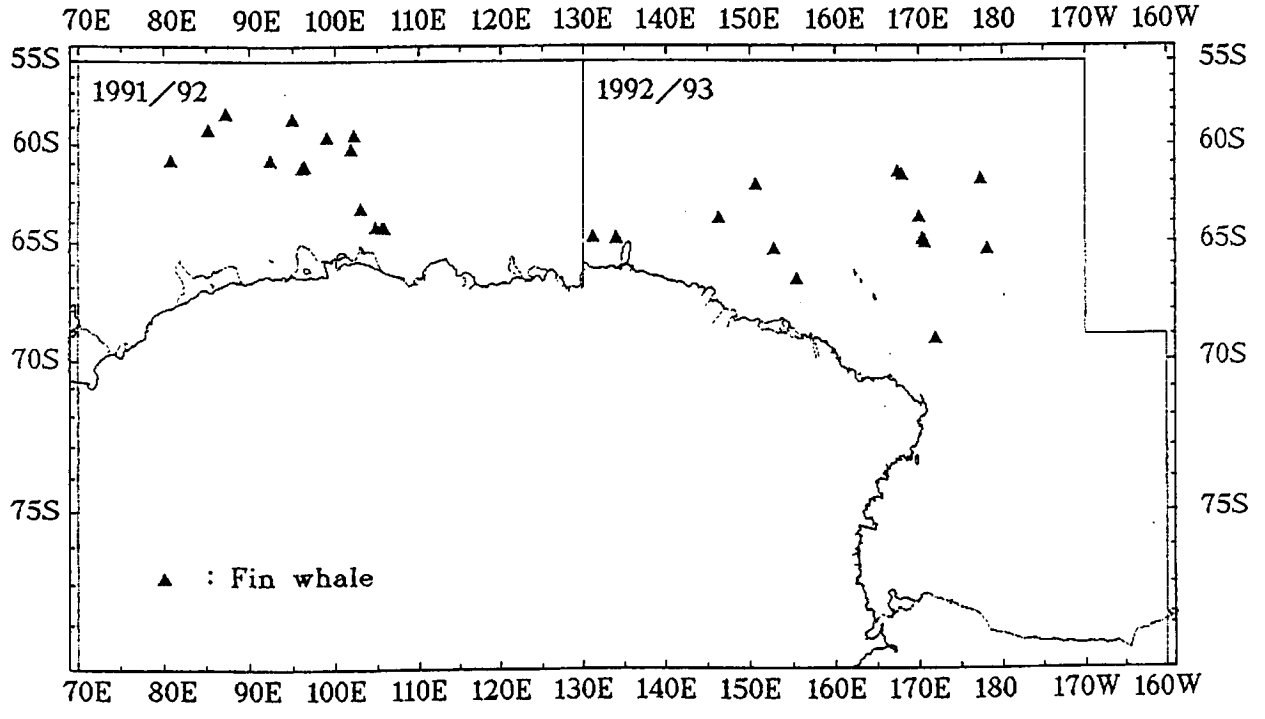
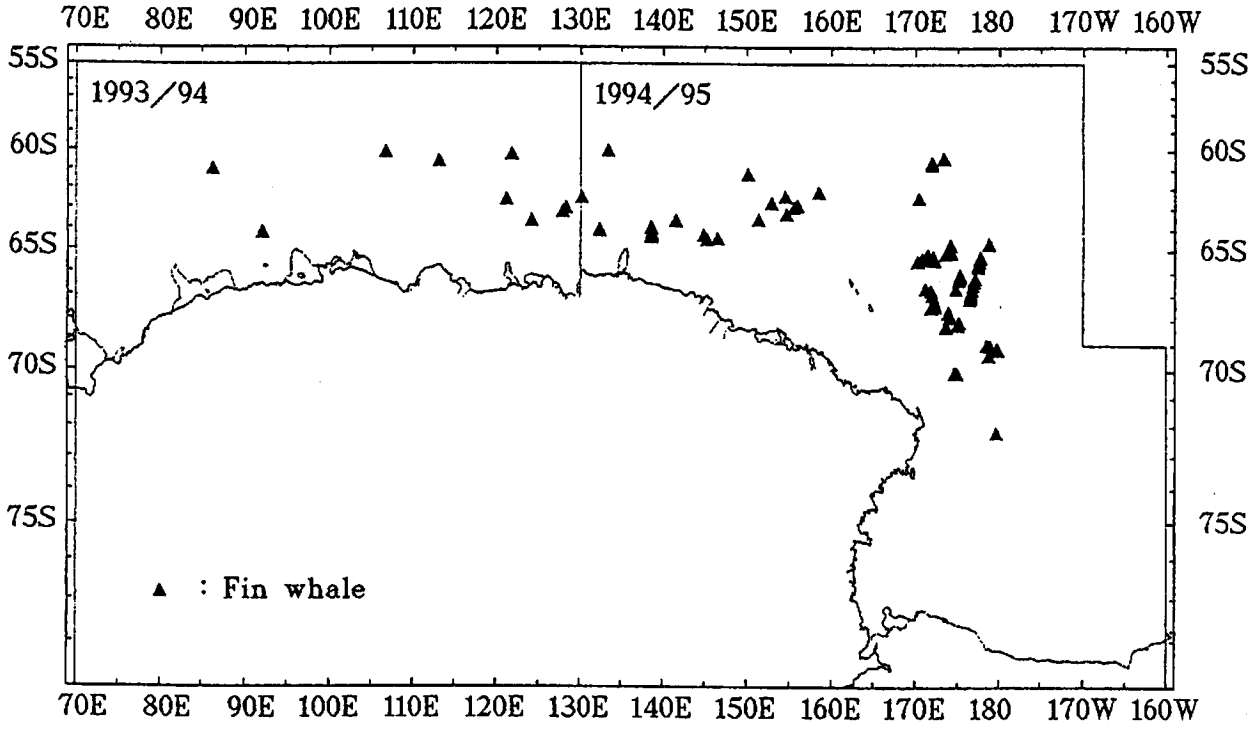
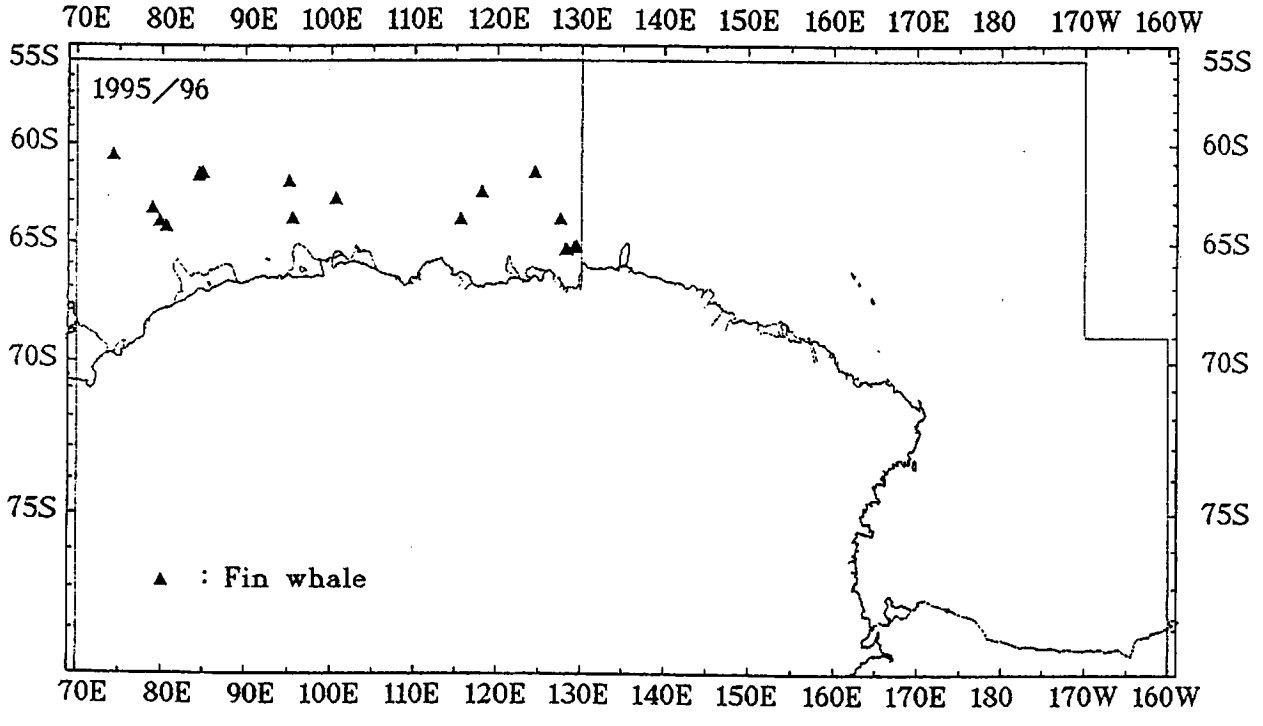


Fig. 1 (continued)





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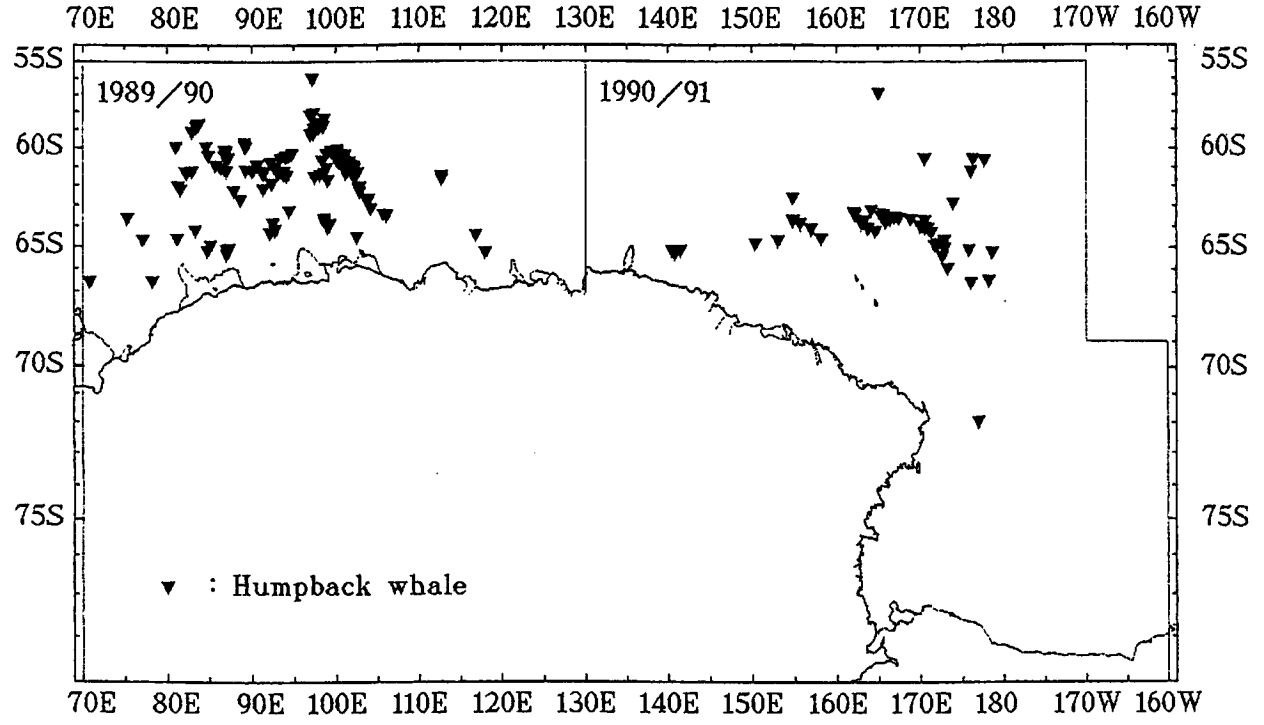


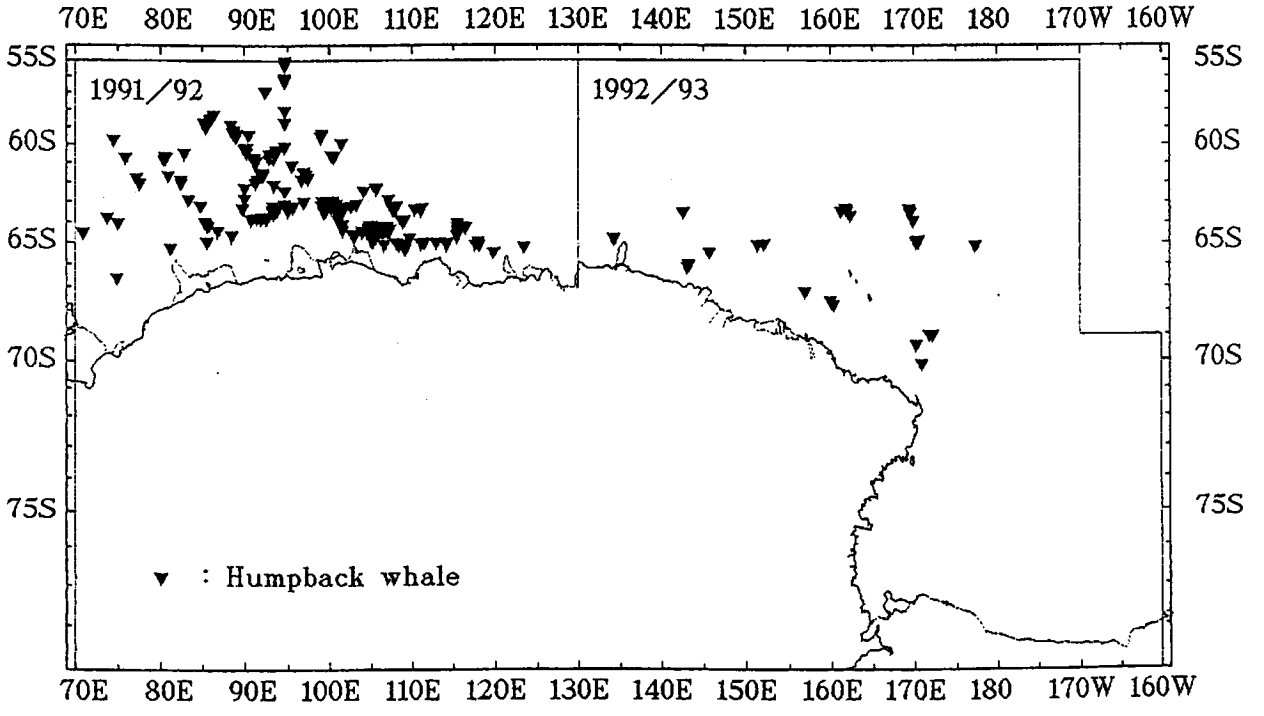
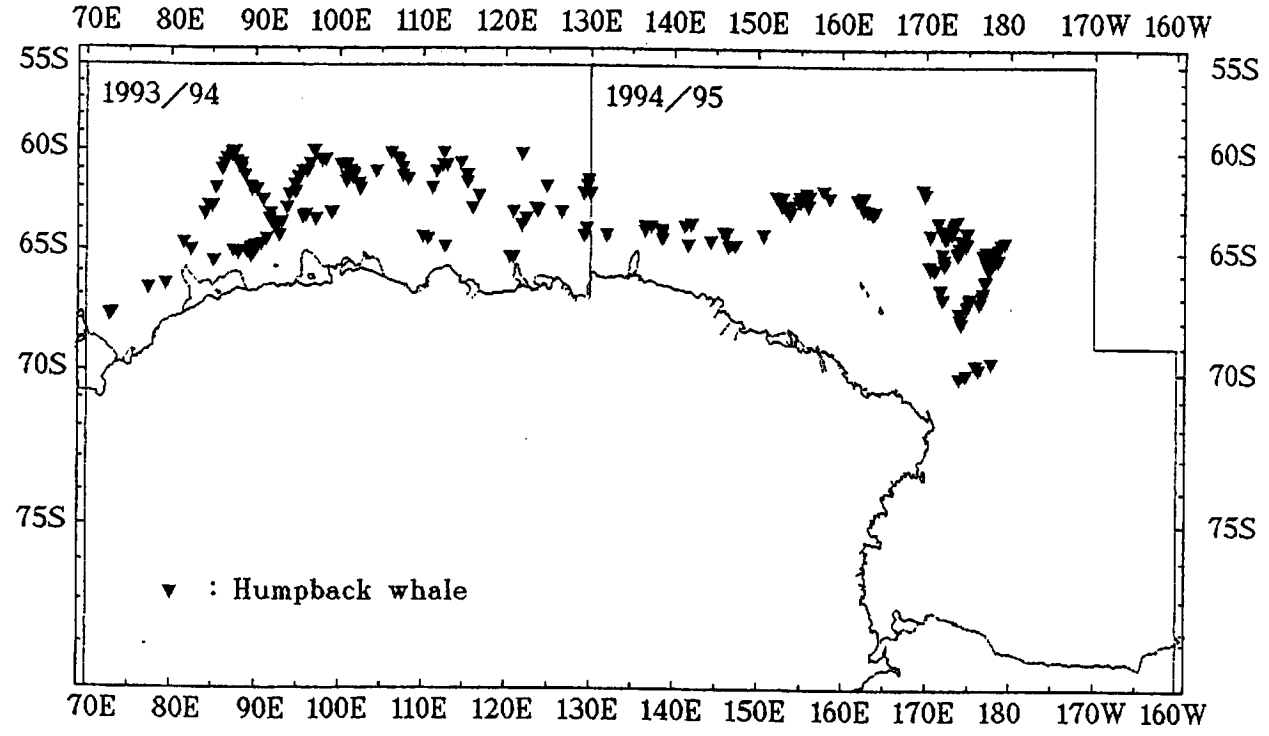


Fig. 1 (continued)



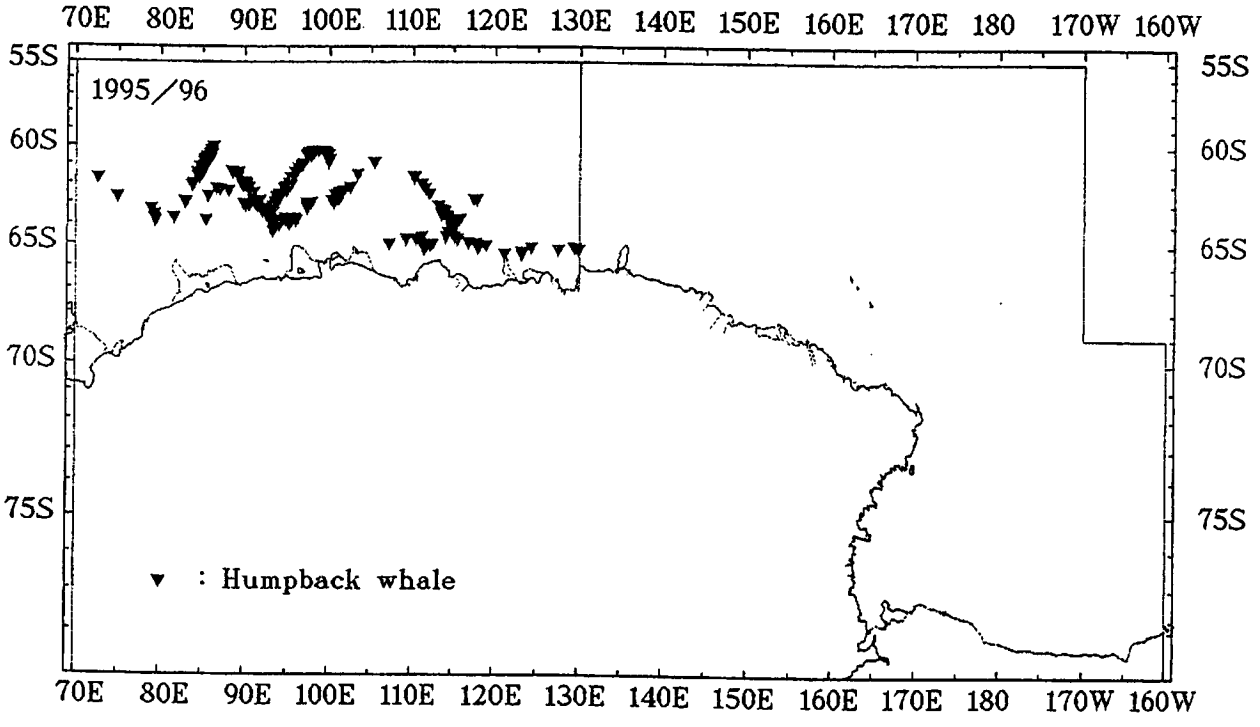
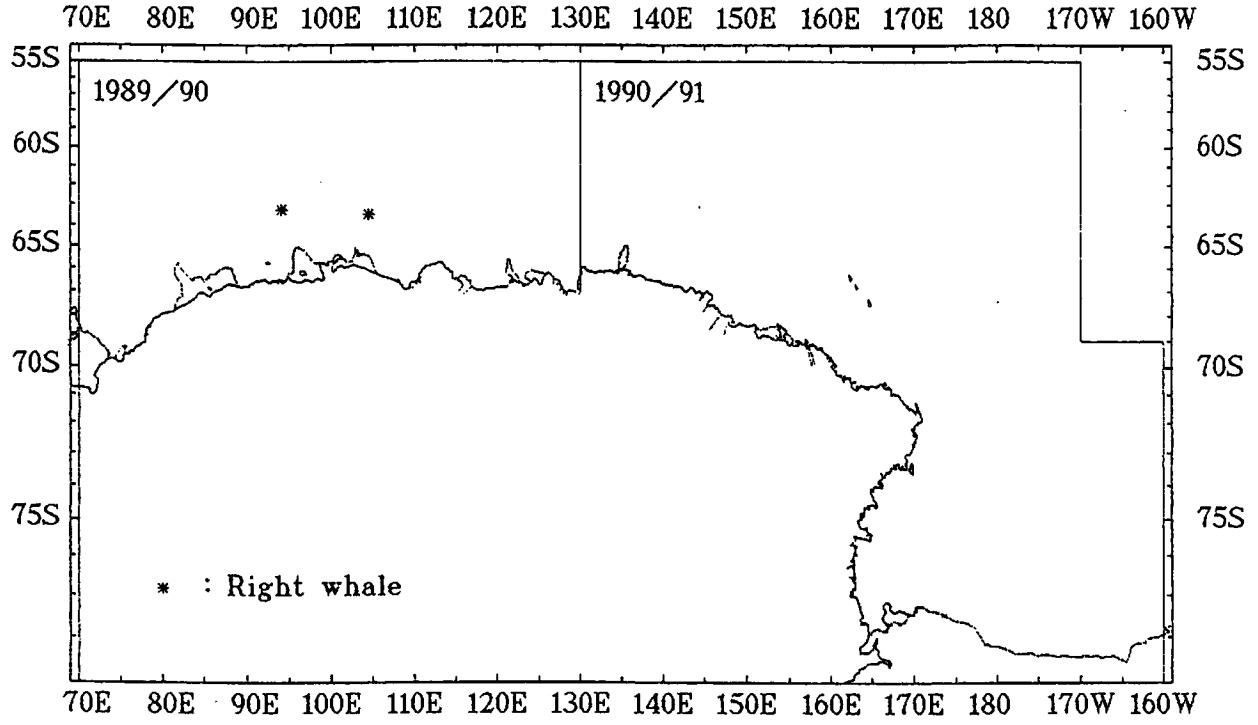


Fig. 1 (continued)



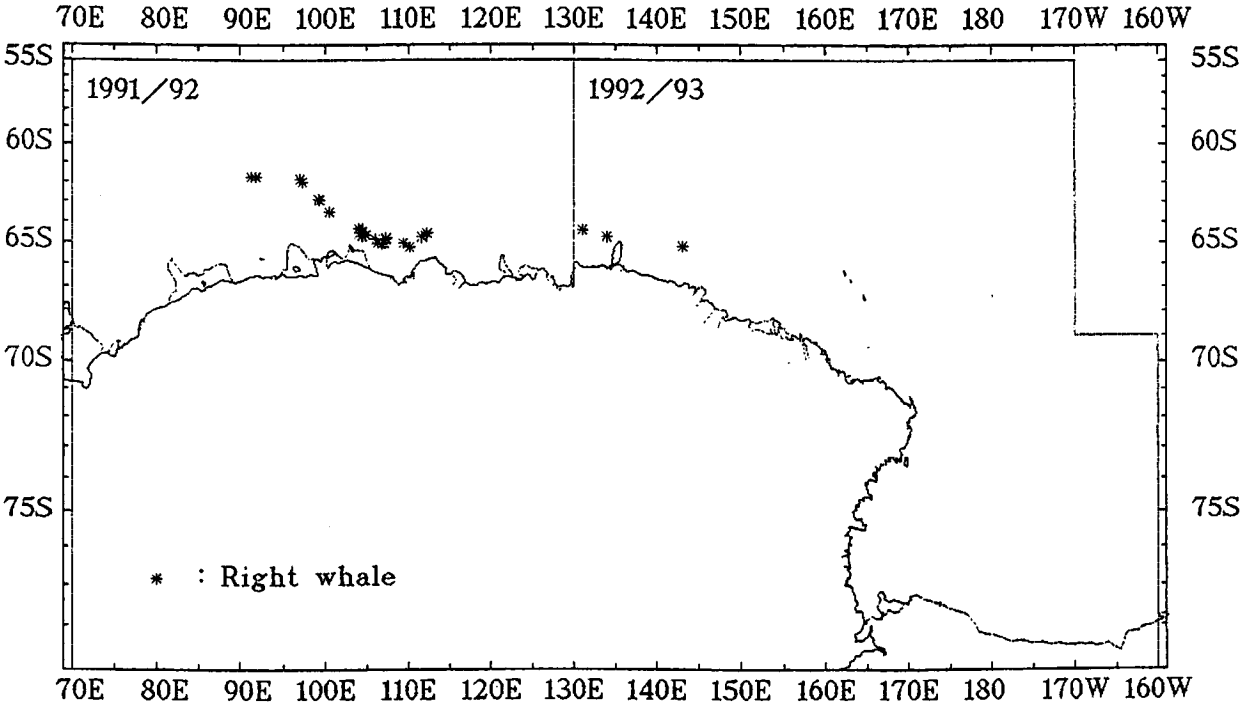
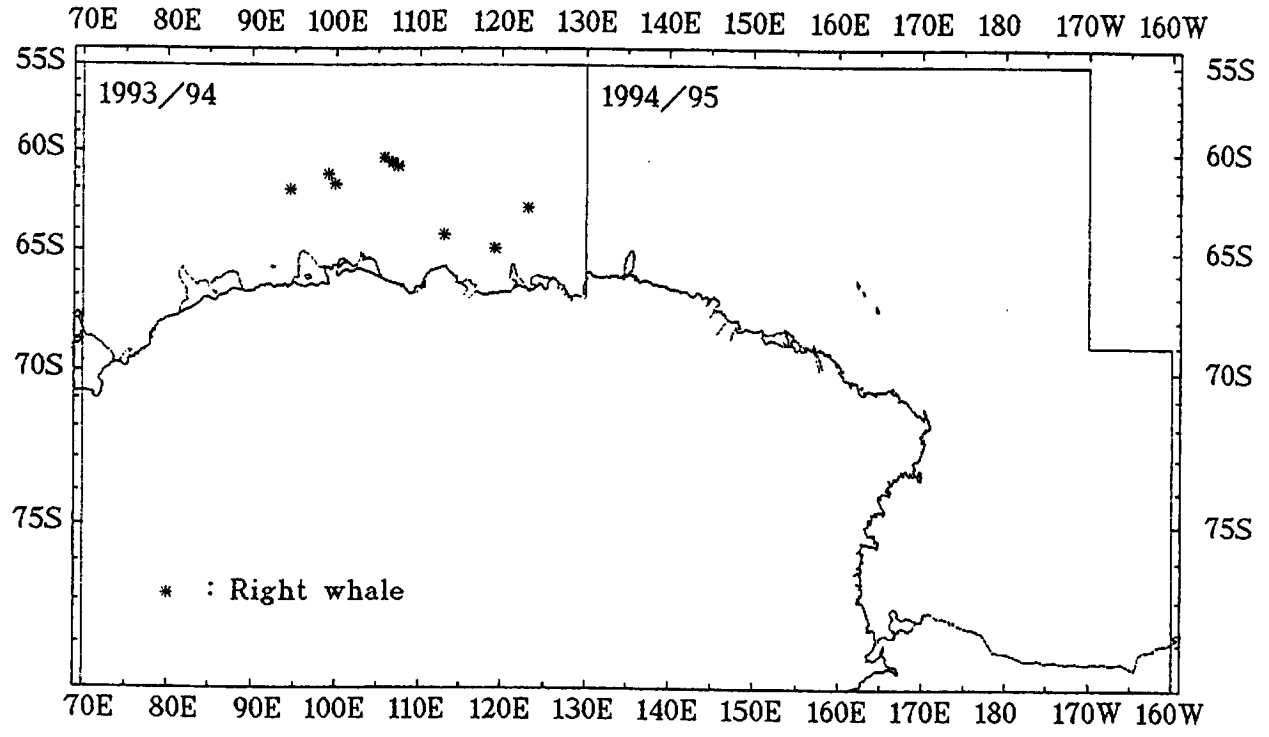


Fig. 1 (continued)



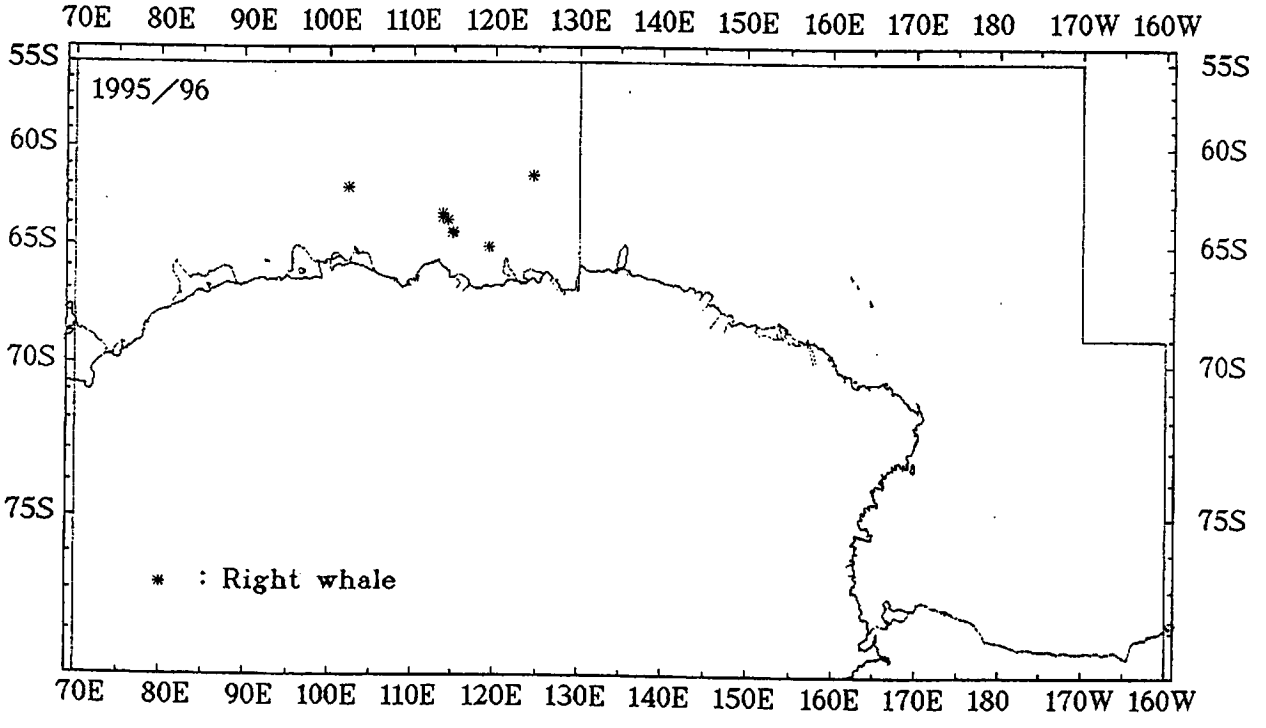
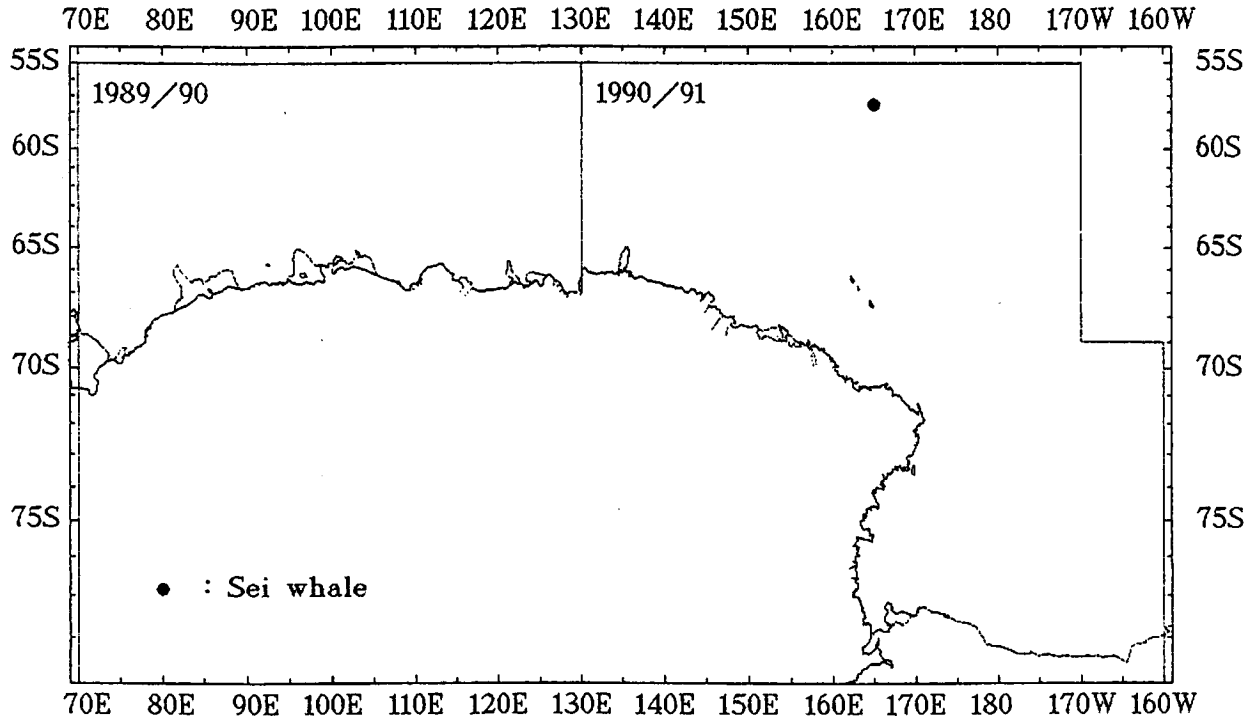


Fig. 1 (continued)



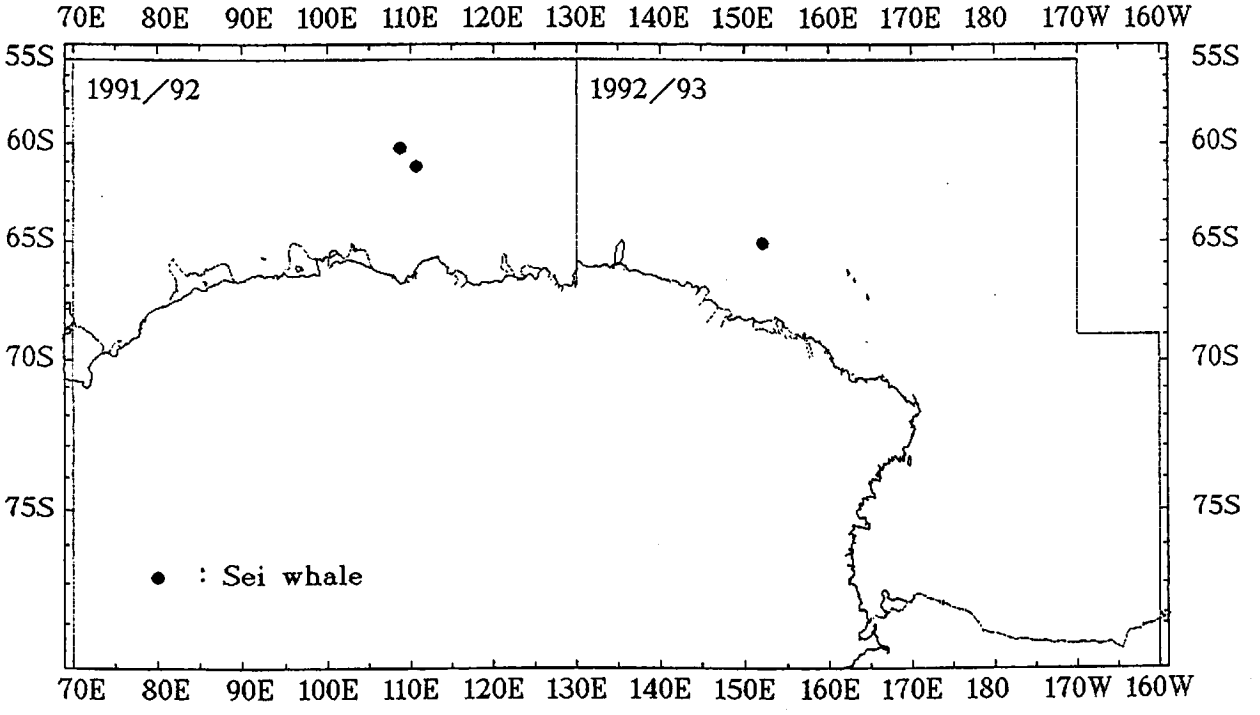
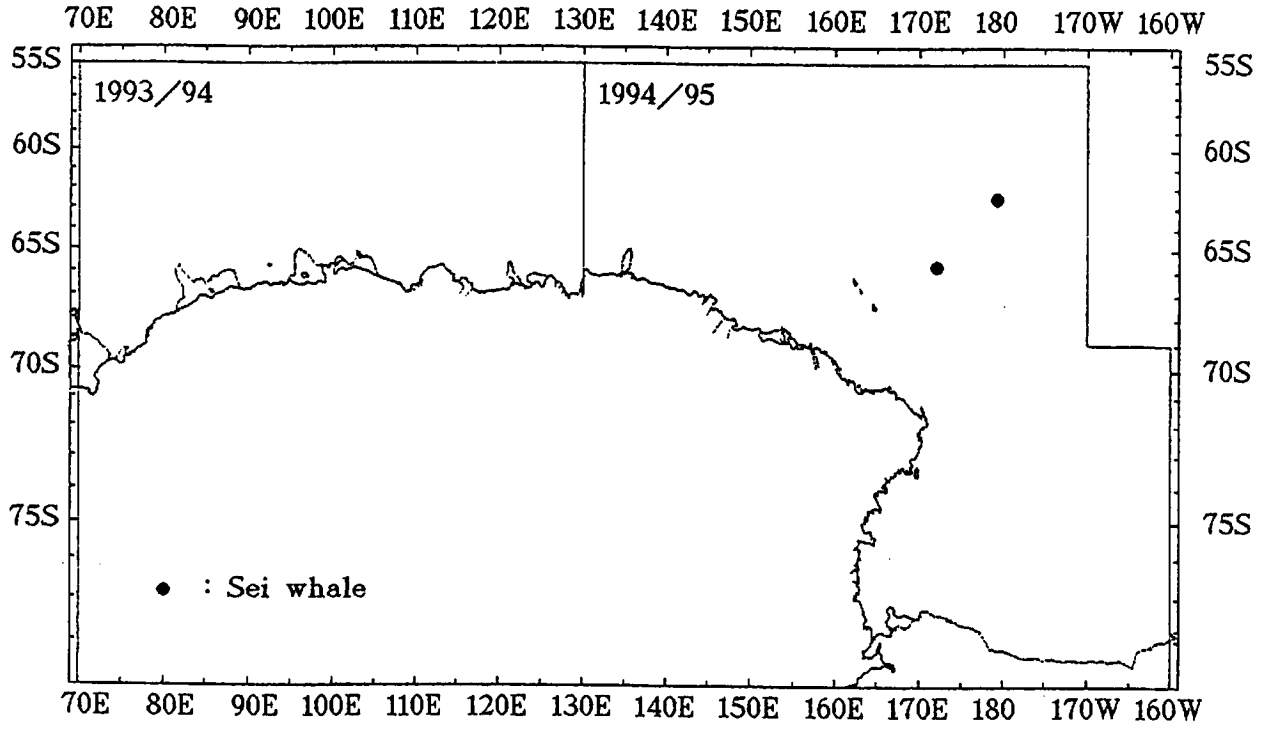


Fig. 1 (continued)



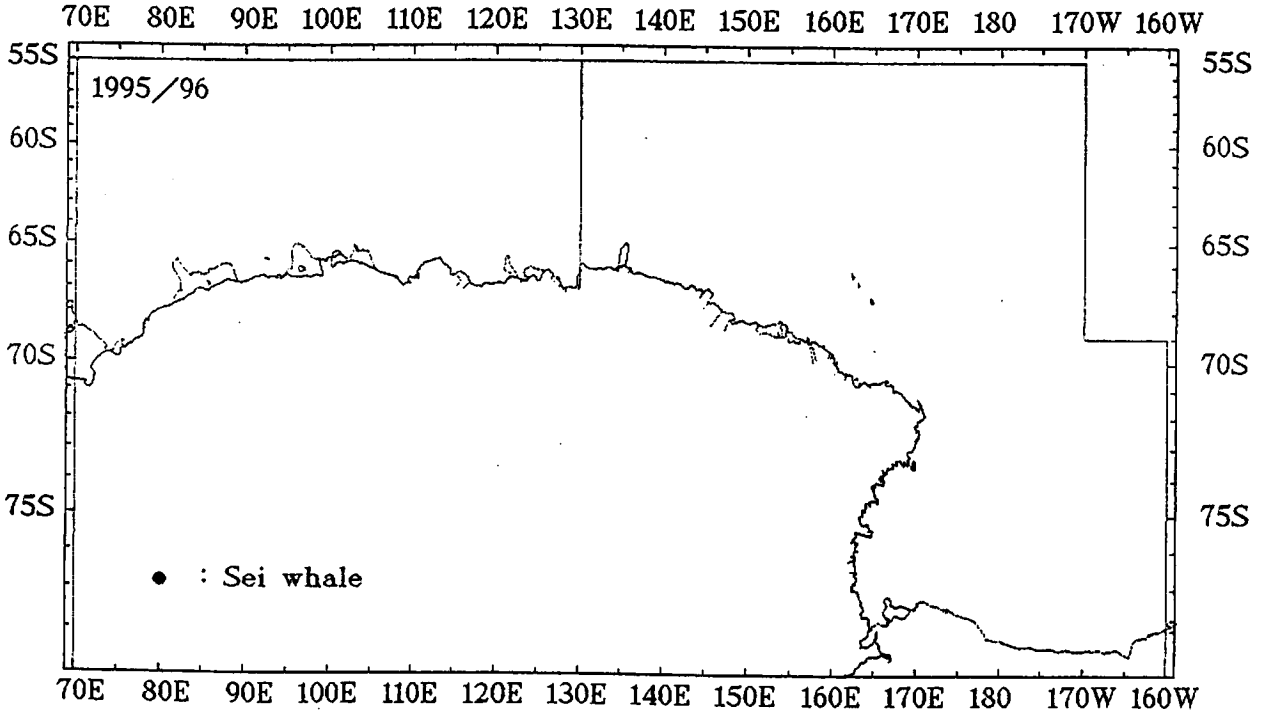
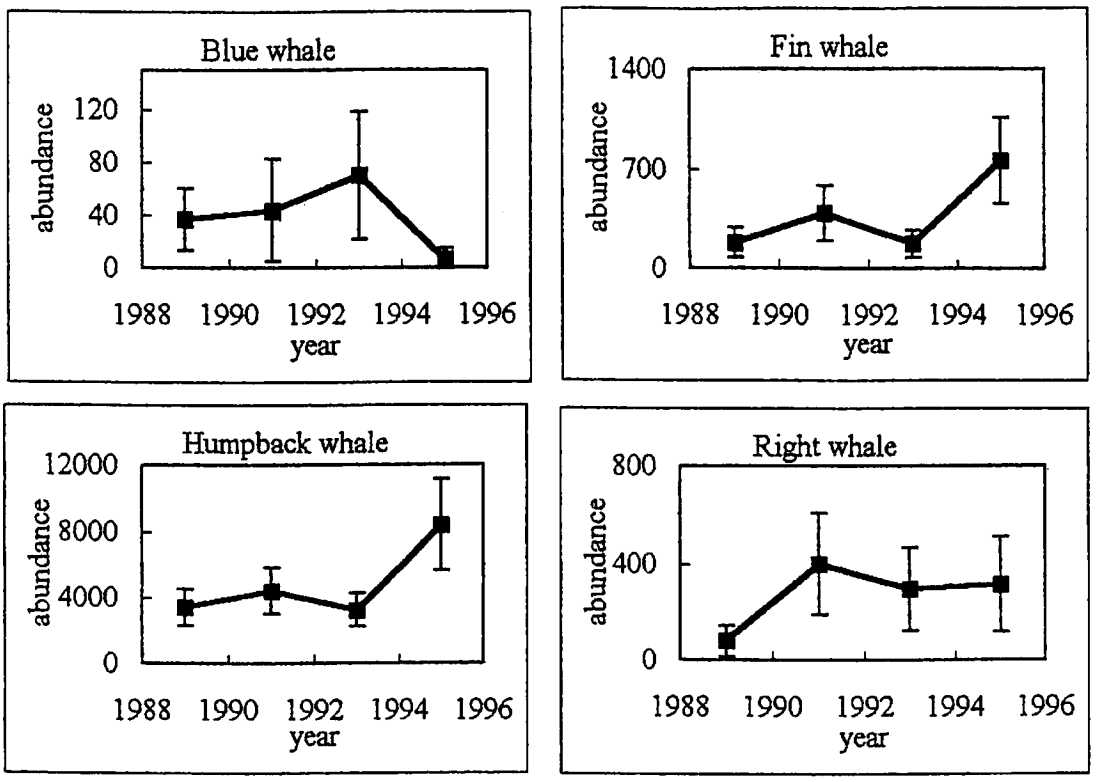


Fig.1 (continued)

Area IV



Area V

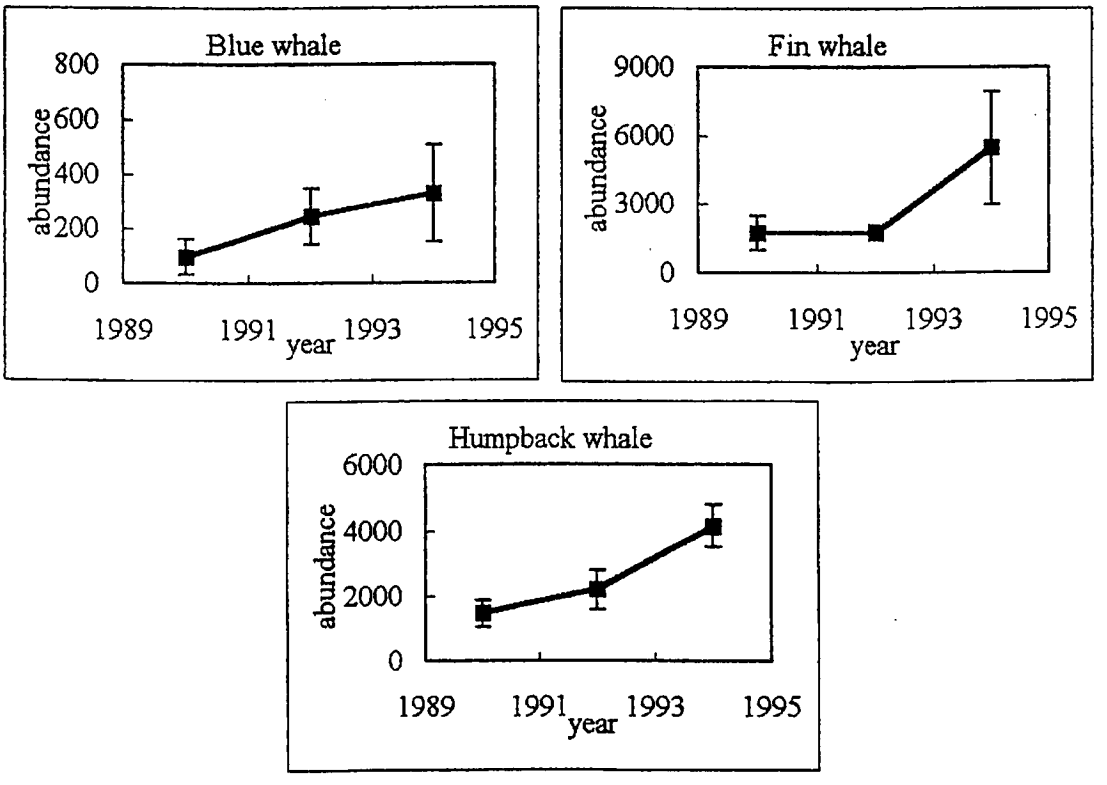


Fig. 2 Temporal change in abundance of baleen whales in Areas IV and V from the JARPA data. Vertical lines show standard derivations.