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The distribution and standing crops of Antarctic krill in the Prydz Bay region during the austral summer of 1991/1992 and 1992/1993

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Abstract The horizontal and vertical distributions of Antarctic krill in the Prydz Bay region were investigated in 1991/1992 and 1992/1993. The result showed that the high density distribution area of Antarctic krill was within the area of 63°～67°S、68°E and the waters of above 70 m deep. The standing crops of Antarctic kill was 1.699×10^6 t within the surveyed area of 150533.9 km^2 in 1991/1992 and 4.043×10^6 t within the surveyed area of 125740.7 km^2 in 1992/1993.

Key words Antarctic krill, distribution, standing crops, Prydz Bay.

1 Introduction

A synthetical scientific study was carried out by the Southern Ocean Expedition Team of China in the area of 62°～68°S、68°～103°E in the Prydz Bay region, The eighth survey was composed of two cruises. The ninth survey was also composed of two cruises (Table 1). In this paper, the horizontal and vertical distributions of Antarctic krill were analyzed and the standing crops of the Antarctic krill were estimated.

Table 1. Surveys carried out in the Prydz Bay during the austral summer of 1991/1992 and 1992/1993

Date	Range	Total area /km^2	Echo detected distance/km	Sectors from N to S	Observation stations	Trawling samplings
Dec. 31, 1991～Jan. 5, 1992 Jan. 23, 1992～Jan. 28, 1992	62°～68°S、 68°～103°E	150533.9	3327.5	8	29	36
Jan. 11, 1993～Jan. 15, 1993 Jan. 30, 1993～Feb. 3, 1993	63°～ 68°S、 58°～ 83°E	125740.7	2702.4	6	26	26

2 Materials and methods

In the summer surveys of 1991/1992 and 1992/1993, an Atlas 792 DS coloured vertical fish founder was used as the fish detecting instrument which was the same as used in the previous two same surveys. Since the programme system used in analyzing of distribution images and standing crops of Antarctic krill by fish founder was complex and tedious, the original programming system was modified in these two

surveys, the reflected target detection signals from TVG circuit output was put through A/D transform, then entered the computer for integrating analysis.

The Antarctic krill mainly inhabits in the water layer above 100 m deep (Marr 1962; Mauchline 1980; Hampton 1985; Godlewska and Klusek 1987). The range of vertical fish founder used in surveys of 1991/1992 and 1992/1993 was 0～100 m. Since the founder was fixed on the bottom of "Ji Di" Research Vessel and the vessel had a draught of 8 m, the water layer of 0～10 m could not be detected (Mathisen and Macaulay 1982; Everson 1983; Hampton 1985). So, the image area of Antarctic krill in 0～10 m layer was treated as zero in processing.

The area method, as usually used in the estimations of marine biological resources, was used in the estimations of standing crops of Antarctic krill in the investigations of 1991/1992 and 1992/1993. This method is used to estimate the absolute quantity of aquatic resources through trawling area and catch per unit time. The calculation could be described as:

$$B=\frac{S\cdot Y}{a}\cdot\frac{1}{K_1}\cdot\frac{1}{K_2} \tag{1}$$

Where B is the krill biomass in surveyed area; S is total surveyed area ; a is trawling area per hour. If the velocity is V (km/h) and the width of net mouth is L (km), then the $a=V\cdot L$; Y is average catch per hour of trawling; K_1 is vertical factor of trawling; K_2 is horizontal factor of trawling. The total effect of K_1 and K_2 can be recognized as the equality of escaping rate E of fishing target escaping from trawl. If the sea area investigated is divided into several sub-areas, then Y_i is the catch per hour from the i sub-area, a_i is the area of the i sub-area, d_i is the density of resource in the i sub-area, n is the number of the sub-areas, and the formula (1) can be rewritten as follows:

$$B=\sum_{i=1}^{n}a_i\cdot d_i=\sum_{i=1}^{n}a_i\cdot\frac{Y_i/(V\cdot L)}{1-E}=\frac{1}{VL(1-E)}\cdot\sum_{i=1}^{n}Y_i\cdot a_i \tag{2}$$

In the practical investigations, the resource is usually estimated by formula (2).

3 Results and discussion

3.1 Horizontal distribution of Antarctic krill

In order to analyze the horizontal distribution of Antarctic krill, the surveyed area was divided into sub-area of 1°S× 1°E to calculate the image area of Antarctic krill. The surveyed areas of 1991/1992 and 1992/1993 were divided into 57 and 47 sub-areas respectively. 1498472.7 m^2 of total image area of krill was detected from the survey in 1991/1992. Table 2 was the regional distribution of the image areas. It could be seen from Table 2 that in the sub-area of 67°S ,68°E, the image area was the largest, which was 334331.6 m^2 and accounted for 22.31% of the total image area, and the image area in the sub-area of 64°S, 68°E was the second, which was 232303.5 m^2 and accounted for 15.50% of the total image area. In the surveyed area of 1991/1992, Antarctic krill in the Prydz Bay region was mainly distributed in 5 sub-areas along 63°～67°S , 68°E and the integrated image area of these sub-areas was 875134.4

m^2, which accounted for 58.4% of the total image area. At 6 o'clock, Jan. 25, 1992, we detected a krill image area of 84952 m^2 in an average vertical thickness of 20 m and 4247.6 m by a horizontal span in the area of 66°42′S、67°49′E, and cached 6 kg krill by IKMT net sampling. In the investigations of 1991/1992, it was rarely to be seen that the horizontal span of krill grouping image area reached hundreds of meters.

Table 2. Regional distribution of the image areas in 1991/1992 and 1992/1993

1991/1992				1992/1993			
No.	Lat. & Lon.	Area/m^2	Percent/%	No.	Lat. & Lon.	Area/m^2	Percent/%
1	62°S,68°E	59.5	0.0040	1	63°S,58°E	10903.6	2.4075
2	63°S,68°E	167258.4	11.1619	2	64°S,58°E	12114.7	2.6749
3	64°S,68°E	232303.5	15.5027	3	65°S,58°E	6057.4	1.3375
4	65°S,68°E	39027.3	2.6045	4	63°S,59°E	2160.3	0.4770
5	66°S,68°E	102213.6	6.8212	5	63°S,60°E	500.9	0.1106
6	67°S,68°E	334331.6	22.3115	6	63°S,61°E	338.8	0.0748
7	62°S,69°E	30133.7	2.0109	7	63°S,62°E	-	-
8	62°S,70°E	27651.7	1.8453	8	63°S,63°E	10340.0	2.2831
9	62°S,71°E	13983.4	0.9332	9	64°S,63°E	12114.7	2.6749
10	62°S,72°E	10349.8	0.6907	10	65°S,63°E	-	-
11	62°S,73°E	8015.1	0.5349	11	66°S,63°E	2422.9	0.5350
12	63°S,73°E	7006.2	0.4656	12	67°S,63°E	3728.5	0.8232
13	64°S,73°E	13380.7	0.8930	13	67°S,64°E	6278.6	1.3863
14	65°S,73°E	174727.8	11.6604	14	67°S,65°E	7992.5	1.7647
15	66°S,69°E	1943.5	0.1297	15	67°S,66°E	12000.4	2.6497
16	66°S,70°E	8594.2	0.5735	16	67°S,67°E	16096.8	3.5541
17	66°S,71°E	9462.3	0.6315	17	66°S,68°E	15739.8	3.4753
18	66°S,72°E	20885.4	1.3938	18	65°S,68°E	12720.9	2.8087
19	66°S,73°E	17097.5	1.1410	19	64°S,68°E	4855.2	1.0720
20	67°S,73°E	8362.9	0.5581	20	63°S,68°E	36391.0	8.0351
21	68°S,73°E	3902.7	0.2604	21	68°S,73°E	5093.8	1.1247
22	62°S,78°E	-	-	22	67°S,73°E	36391.0	8.0351
23	63°S,78°E	-	-	23	66°S,73°E	12124.1	2.6770
24	64°S,78°E	16425.2	1.0961	24	65°S,73°E	60573.7	13.3746
25	65°S,78°E	15778.0	1.0529	25	64°S,73°E	7268.8	1.6049
26	62°S,79°E	8029.1	0.5358	26	63°S,73°E	4845.9	1.0700
27	62°S,80°E	5763.8	0.3846	27	63°S,74°E	4057.3	0.8958
28	62°S,81°E	3049.6	0.2035	28	63°S,75°E	5268.8	1.1634
29	62°S,82°E	3157.5	0.2107	29	63°S,76°E	3211.4	0.7091
30	62°S,83°E	2044.2	0.1364	30	63°S,77°E	8057.4	1.7791
31	63°S,83°E	-	-	31	63°S,78°E	24229.5	5.3498
32	63°S,84°E	-	-	32	64°S,78°E	10903.6	2.4075
33	63°S,85°E	4920.1	0.3283	33	65°S,78°E	62996.7	13.9096
34	63°S,86°E	1763.8	0.1177	34	66°S,78°E	6057.4	1.3375
35	63°S,87°E	2236.2	0.1492	35	67°S,78°E	1211.4	0.2675
36	63°S,88°E	12451.7	0.8309	36	67°S,79°E	3901.9	0.8615
37	64°S,88°E	8362.9	0.5581	37	67°S,80°E	3968.0	0.8761
38	62°S,88°E	11632.5	0.7763	38	66°S,81°E	5834.5	1.2882
39	62°S,89°E	8367.5	0.5584	39	66°S,82°E	2035.4	0.4494
40	62°S,90°E	7086.9	0.4729	40	65°S,83°E	2422.9	0.5350
41	62°S,91°E	3913.1	0.2611	41	64°S,83°E	4845.9	1.0700
42	62°S,92°E	-	-	42	63°S,83°E	4845.5	1.0699
43	62°S,93°E	-	-				
44	63°S,93°E	1498.4	0.0910				
45	63°S,94°E	3735.1	0.2493				
46	63°S,95°E	4766.3	0.3181				
47	63°S,96°E	12358.9	0.8248				
48	63°S,97°E	27641.3	1.8446				
49	63°S,98°E	37531.9	2.5047				
50	62°S,98°E	8734.6	0.5829				
51	62°S,99°E	21292.6	1.4210				
52	62°S,100°E	18529.7	1.2366				
53	62°S,101°E	6401.5	0.4272				
54	62°S,102°E	3169.6	0.2115				
55	62°S,103°E	1899.2	0.1267				
56	63°S,103°E	-	-				
57	64°S,103°E	5240.7	0.3497				

452901.9 m^2 of krill image area was detected from the two surveys in 1992/1993. It could be seen in Table 2 that the image area in the sub-area of 65°S、78°E was the largest, which was 62996.7 m^2 and accounted for 13.91% of the total image area. And, the image area in the sub-area of 65°S、73°E was the second, which was 60573.7 m^2 and accounted for 13.37% of the total image area. In the investigated area of 1992/1993, Antarctic krill in the Prydz Bay region was mainly distributed in three sub-areas: the first was 63°～66°S、68 ° E in which the krill image area was 69706.9 m^2 and accounted for 15.5% of the total image area investigated in that year; the second was 65°～67°S、73°E in which the image area was 109088.8 m^2 and accounted for 24.09% of the total image area; and the third was 63°～65°S 、78°E, 98129.8 m^2 and 21.67% respectively. The integrated krill image area of these three sub-areas was 276925.5 m^2 and accounted for 61.15% of the total krill image area investigated in 1992/1993.

The horizontal distribution of krill was related not only to its biological characteristics, but also to the environmental conditions, such as water temperature, salinity, diatom, etc. The thermocline in surveyed area was analyzed with the thermocline strength of $\Delta T/\Delta Z = 0.01$℃ (Zhang and Su 1987). In the surveys of 1990/1991, 1991/1992 and 1992/1993 (Guo *et al.* 1993) , it were founded that not only the thermoclines existed in each observation stations along 63°～67°S 、68°E, but also krill was occurred in sampling nets(Table 3) . It was showed that the distribution of krill grouping along 63°～67°S、68°E sea area was related to the thermocline in that area.

Table 3. Thermocline and results of sampling of Antarctic krill along the observation station at 63°～67°S、68°E

Sampling date	Sampling time	Sampling position	Thermal layer/m	Temperature/℃	Sampling weight/g
Jan. 9,1991	13:10～14:00	62°55′S, 68°07′E	10～15	0.49～ －0.62	50
Jan. 9,1991	21:10～22:12	64°01′S, 68°15′E	10～15	0.38～ －0.25	500
Jan. 10,1991	04:15～05:05	64°58′S, 68°17′E	10～15	0.19～ －0.18	540
Jan. 25,1992	12:15～12:45	66°42′S, 67°49′E	45～50	0.46～ －1.55	6000
Jan. 25,1992	06:30～07:00	66°53′S, 67°53′E	30～35	0.45～ －0.83	500
Jan. 26,1992	23:10～23:40	62°06′S, 68°31′E	45～50	1.09～ －0.30	1500
Jan. 26,1992	16:00～16:30	63°06′S, 68°12′E	40～45	0.17～ －1.09	3.5
Jan. 26,1992	08:10～08:40	64°02′S, 68°04′E	30～35	0.07～ －1.00	400
Jan. 26,1992	01:30～02:00	64°58′S, 68°04′E	20～25	1.68～ －0.61	10
Jan. 14,1993	08:29～09:00	66°01′S, 67°57′E	-	-	11
Jan. 14,1993	15:29～16:10	65°01′S, 68°00′E	30～35	0.00～ －0.51	12
Jan. 15,1993	03:36～04:15	64°00′S, 67°51′E	40～45	0.47～ －0.17	12
Jan. 15,1993	08:55～09:55	63°34′S, 67°52′E	45～50	0.77～ －0.65	510

3.2 Vertical distribution of Antarctic krill

In order to analyze the vertical distribution of the krill, 10 sub-layers with 10 m each has been divided in the water layer of 0～100 m. It was showed in Table 4 that in 1991/1992, 80.80% of the krill image areas occurred in the water layer of 20～60 m and 22.67% occurred in the sub-layer of 40～50 m, which took the first place among the sub-layers. It was showed in Table 4 that in 1992/1993, 87.18% of the total krill image areas occurred in the water layer of 10～50 m and 28.22% occurred in the sub-layer of 20～30 m which took the first place among the sub-layers. In table 4 , it could be easily seen that the krill image rarely occurred under the water depth of 70 m. Generally only 2% of the total image occurred beyond this depth. The vertical distribution in these two surveys was similar to that of previous surveys in the Prydz

Bay before. In 1983/1984, the Japanese research vessel "Kaiyo Maku" had a survey on the south of 65°～70°E、61°S by echo sounders and the results showed that the krill groupings were distributed in the water layer of 30～80 m in the daytime (Shirakihara *et al.* 1986).

Table 4. Image area(m^2) of different water layers and depth of central areas by time in 1991/1992 and 1992/1993 (DCA: depth of central area; TA: total area)

Time/h	Water layers/m									DCA /m
	10～20	20～30	30～40	40～50	50～60	60～70	70～80	80～90	90～100	
1991/1992										
0～2	16629.0 41.1%	12857.1 31.8%	9328.5 23.0%	1662.3 4.1%						23.88
2～4	8676.0 38.4%	6849.5 30.3%	2968.1 13.1%	456.6 2.0%	916.3 4.1%	456.6 2.0%	913.3 4.0%	456.6 2.0%	913.3 4.0%	31.38
4～6	27778.4 35.3%	28920.0 36.7%	9893.7 12.6%	3805.3 4.8%	4566.3 5.8%	2283.2 2.9%	1522.1 1.9%			27.25
6～8	17567.3 15.4%	43862.0 38.4%	34864.7 30.6%	6748.0 5.7%	5623.3 4.9%	3374.0 3.0%	2249.0 2.0%			30.86
8～10	45822.1 15.2%	73312.2 24.2%	73312.2 24.2%	45820.1 15.2%	45820.1 15.2%	9164.0 3.0%	9164.0 3.0%			35.89
10～12		64938.5 15.2%	90914.0 21.2%	142864.8 33.3%	103901.7 24.2%	25975.4 6.1%				43.54
12～14	5258.2 8.1%	1971.8 3.0%	3286.4 5.1%	10516.4 16.2%	14460.0 22.2%	13802.7 21.2%	9201.8 14.1%	6572.7 10.1%		55.87
14～16		2560.5 2.1%	34566.5 27.8%	52489.8 42.3%	34566.5 27.8%					44.80
16～18	11568.0 8.1%	17352.0 12.1%	27474.0 19.2%	57840.0 40.4%	20241.0 14.1%	8676.0 6.1%				40.87
18～20	817.0 4.5%	3645.1 20.0%	5832.2 32.2%	5285.4 24.2%	2551.6 14.1%					37.93
20～22	48151.8 46.0%	31403.3 30.0%	24075.9 23.0%	1046.8 1.0%						22.84
22～24	9538.7 17.0%	21882.8 39.0%	13466.3 24.0%	11221.9 20.0%						29.63
TA Percent	191806.5 12.8%	309554.8 20.66%	329982.5 22.02%	339757.4 22.67%	232646.8 15.53%	63731.9 4.25%	23050.2 1.54%	7029.3 0.47%	913.3 0.06%	
1992/1993										
0～2	10319.8 37.3%	6789.3 24.5%	6789.3 24.5%	2172.6 7.8%	1629.4 5.9%					27.24
2～4	3796.2 35.4%	4338.5 40.4%	1301.6 12.1%	867.7 8.1%	325.4 3.0%	108.5 1.0%				25.87
4～6	8209.0 26.0%	12629.2 40.0%	6946.1 22.0%	2525.8 8.0%	1262.9 4.0%					27.45
6～8	25031.9 38.4%	27666.8 42.4%	8563.5 13.1%	3293.7 5.1%	658.7 1.0%					24.23
8～10	13082.9 19.4%	17902.9 26.5%	19280.0 28.6%	7574.3 11.2%	6197.1 9.2%	3442.9 5.1%				33.01
10～12	3766.2 11.0%	6505.3 19.0%	9929.2 29.0%	9929.2 29.0%	3081.5 9.0%	1027.2 3.0%				36.48
12～14			289.2 1.2%	385.6 1.7%	14460.0 62.0%	482.0 2.1%	7712.0 33.1%			61.40
14～16			964.0 12.2%	1446.0 18.3%	1446.0 18.3%	4048.8 51.2%				56.36
16～18	1598.2 7.0%	4338.0 19.0%	8676.0 38.0%	5022.9 22.0%	2511.5 11.0%		684.9 3.0%			37.22
18～20	12652.5 31.8%	14460.0 36.4%	9760.5 24.5%	2892.0 7.3%						24.72
20～22	19972.9 26.0%	24582.0 32.0%	16900.1 22.0%	9986.4 13.0%	3840.9 5.0%	1536.4 2.0%				29.34
22～24	22654.4 50.0%	8608.7 19.0%	7702.5 17.0%	2718.5 6.0%	1812.4 4.0%	1812.0 4.0%				25.83
TA Percent	121084.0 26.74%	127820.7 28.22%	97102.0 21.44%	48814.7 10.78%	37225.8 8.22%	12457.8 2.75%	8396.9 1.85%			

In 1990/1991, echo sounders detection in the seventh survey of China Southern Ocean Expedition in the water area of 65°～75°E 、61°S showed that the habitat of krill groupings were mainly in the water layer of 30～60 m (Guo *et al.* 1993). According to these surveys, it was showed clearly that the krill groupings in the Prydz Bay region were mainly distributed in the water layer above the depth of 70 m.

It can be seen from Table 4 that in 1991/1992 and 1992/1993, the depth of the mass center of the krill was 23.88 m and 27.24 m respectively during 00:00～02:00; as the time elapsed, the larger part of the krill image area moved gradually from the shallower layer to the deeper water; and during 12:00～14:00, the mass center reached its deepest place of 55.87 m and 61.40 m respectively. Afterwards, the larger part of the krill image area moved gradually to the shallower layer. At the time before dawn, it reached the surface or very shallow layer again, where the depth of the mass center of the krill was 29.63 m and 25.83 m respectively. Although the minimum mass center depth was observed in the time of 06:00～08:00, the characteristics of krill vertical migration was obvious.

It could be conclude from the investigating results of 1990/1991, 1991/1992 and 1992/1993 that krill in the Prydz Bay had regular vertical migration i.e., the krill groupings aggregated in the shallow water or surface in the night and submerged to the deep layer in the day. This regular vertical migration of krill in the Prydz Bay was in correspondence with the results attained by other scientific researchers in other sea areas (Kalinowski and Witek 1980; Everson 1982; Godlewska and Klusek 1987; Chen 1989; Guo and Fu 1989). It could also be seen from Table 4 that the time which the krill need to migrate from the shallow water to the deep layer and vice versa were about 12 h in both. Hence, the krill had a 24 h vertical migration. Pavlov (1974) recognized that the vertical migration of the krill was related to the action of bait searching. Kalinowski and Witek (1980) pointed out that the action of bait searching was most active in the night and much obtuse in the daytime, especially in the forenoon. One of the evidences was that the food in the krill stomach was increasing gradually from the afternoon which showed the time of krill starting food intake was around forenoon. In the mean time, they also pointed out that the distribution of krill was related to the distribution of plankton and the amount of food intake.

3.3 The estimation of krill standing crops

In order to estimate the standing crops of krill, 6 and 4 sub-areas were divided by the voyage line of our "JiDi" Research Vessel in 1991/1992 and 1992/1993's surveyed areas respectively (Fig. 1) and the results of the survey were showed in Table 5.

Three of six sub-areas in 1991/1992 had the krill by IKMT net sampling. The sea area of these 3 sub-area was 108921.6 km^2, accounted for 72.36% of the total area of the six sub-areas. The krill standing crops in these areas was 1.699×10^6 t and the average krill biomass was 15.60 t/km^2. In the investigation of 1991/1992, the krill mainly distributed in the area of 62°～65°S、78°E and the average standing crop in this area was 22.99 t/km^2.

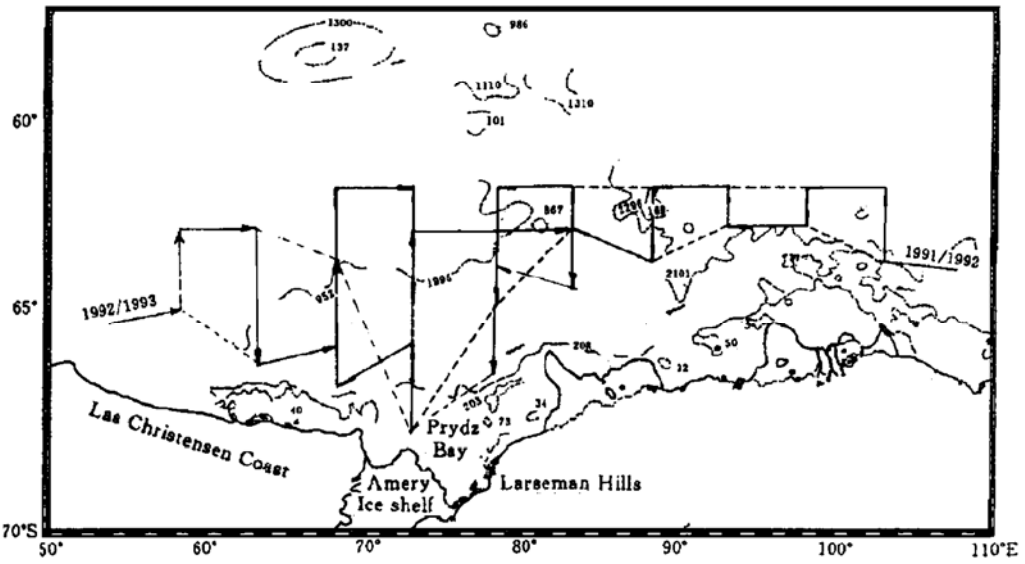

Fig. 1. The division of areas for estimating the resources of Antarctic krill off the Prydz Bay in 1991/1992 and 1992/1993.

Table 5. The standing crops of Antarctic krill in the investigation waters in 1991/1992 and 1992/1993

No.	Position	Area/km^2	Investigation date and time	Distance /km	Standing crops/t	Density/ t·km^{-2}
1991/1992						
1	62°～64°S,98°～103°E	15171.5	1991.12.30.21:00～1992.1.1.09:00	375.5	2.73×10^3	0.18
2	62°～63°S,93°～98°E	10492.4	1992.1.1.03:00～1992.1.2.08:00	295.2	-	-
3	62°～64°S,88°～93°E	17195.8	1992.1.2.03:00～1992.1.3.09:00	401.5	-	-
4	62°～64°S,83°～88°E	13924.1	1992.1.3.19:00～1992.1.4.08:30	392.0	-	-
5	62°～65°S,78°～83°E	28530.0	1992.1.4.01:30～1992.1.5.18:30	569.4	6.56×10^5	22.99
6	62°～68°S,68°～73°E	65220.1	1992.1.23.22:00～1992.1.28.06:30	1293.9	1.04×10^6	15.95
Total		150533.9		3327.5	1.699×10^6	
1992/1993						
1	62°～64°S,58°～63°E	30200.3	1993.1.11.14:30～1993.1.13.21:02	660.7	3.32×10^5	10.99
2	63°～66°S,63°～68°E	33350.5	1993.1.12.16:37～1993.1.14.08:55	755.2	4.67×10^5	14.00
3	63°～68°S,73°～78°E	47069.1	1993.1.3010:35～1993.2.3.23:31	924.9	2.73×10^6	58.00
4	63°～64°S,78°～83°E	15120.8	1993.2.1.11:48～1993.2.3.01:56	361.6	5.14×10^5	33.99
Total		125740.7		2702.4	4.043×10^6	

In the surveyed area of 125740.7 km^2 in 1992/1993, the krill standing crop was 4.043×10^6 t and the average krill biomass was 32.15 t/km^2, which was almost as same as the result (32.56 t/km^2, Guo *et al.* 1993) in 1990/1991. In the survey of 1992/1993, the krill was concentrated to the sub-area of 63°～68°S、73°～78°E, which was only 47069.1 km^2 and accounted for 37.43% of the total area. However, the standing crop was 2.73×10^6 t, a very high level, which accounted for 67.52% of the total standing crops and reached 58.00 t/km^2 of the average krill biomass.

The application of catch per unit area to estimate standing crops needs two kinds of data: (1) the distribution area. (2) The catch rate of the investigating net. Practically, the first kind data might be easily obtained, because the scope of fish distribution could be known from the activities of our investigation and fishing trawlers. However, our survey was a multi-work Antarctic expedition, it was impossible to trace the krill groupings for a long period. The second kind data could be obtained

from some experiments, since some kinds of fish have the characteristics of avoiding from nets and the others may be opposite. In our case it was estimated from experience. The escaping rate E of krill was about 0.5 (Guo *et al.* 1993).

It was assumed that the fisheries resources should be distributed evenly in the sea (Shindo 1973). For a long time this assumption was not verified by strict mathematics method. Along with the application of ecological method in the work of resources investigations, some scholars began to use math ecology to study the principles and methods of space distribution of animal group in order to verify the even characteristics of resources distribution. It was believed that the state of Southern Ocean krill resources distribution could be understood and verified in future work of expedition.

Because of above mentioned reasons the accuracy of the estimation might not be very good. And, since the uneven characteristics of distributions in space and in time, the estimation might be different from time to time, e.g. the results from the three times investigation of krill standing crops in the Prydz Bay region by fish founder in 1980/1981 (FIBEX), 1983/1984 (ADBEXII) and 1984/1985 (SIBEXII) conducted by Australian were quite different (Higginbottom *et al.* 1888).

4 Conclusion

(1) The Antarctic krill were mainly distributed along the area of 63°～67° S、68° E during the period of investigation in austral summer of 1991/1992. The total area of the images of krill obtained from sonar in the five sub-areas were 875193 m^2, which accounted for 58.4 % of the total area of the image. In 1992/1993, the main distribution of krill was in the areas of 63°～66° S、68°E; 65°～67°S、73°E and 63°～65°S、78°E, in which the total area of the images of krill aggregation were 276925.5 m^2, 61.14% of the total area of images of krill aggregation. The results of these two investigations and those of 1990/1991 showed that the denser area of krill aggregation was along the area of 63°～67°S、68°E off the the Prydz Bay. The reason for its aggregation might be related to the existence of thermocline.

(2) The investigation in 1991/1992 showed that the Antarctic krill aggregation was mainly in the layers between 20 m and 60 m, with its image area representing 80.88% of the total image area. In 1992/1993, the survey indicated that the main distribution of Antarctic krill aggregation was in the layer between 10 m and 50 m, with its image area accounting for 87.18% of the total image area. The main krill aggregation occurred in the layer above 70 m deep and had a regular pattern in vertical movements, that was, concentrating in the surface at night and submerged to deeper layer in the daytime.

(3) The standing crops of Antarctic krill was 1.699×10^6 t in the surveyed waters of 150533.9 m^2 in area, and the distribution density was 22.99 t/km^2 in average krill biomass within the three krill-living sub-areas in the year of 1991/1992. The standing crops in the surveyed areas of 125740.7 m^2 was 4.043×10^6 t, with an average of distribution density 32.15 t/km^2 in 1992/1993.

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