

## PRODUCTION OF KRILL, *EUPHAUSIA SUPERBA* (DANA 1852) IN THE ANTARCTIC WATERS

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### ABSTRACT

High phytoplankton and bacterial biomass and production are recorded in the Indian Ocean Sector of Antarctica.  $716 \text{ mg Cm}^{-2}\text{d}^{-1}$  is the average primary productivity figure projected for this region. The krill production estimated from these data (1981-85 period, 100 stations) is  $1118 \times 10^6 \text{ t}$  (net) wet weight of krill per year. The figure makes the Antarctic marine biomass system attractive as the world's protein resource available for mankind.

### INTRODUCTION

The existence of large stocks of krill in the Antarctic waters, has been known for many years, but the interest in their commercial exploitation is a recent one. Excessive harvesting pressure on world fishery, 200 miles exclusive economic zone criteria and increased demand for more animal proteins, have forced people to concentrate on the Southern Ocean fishery resources as our last frontier.

Magnitude and distribution of Southern Ocean resources have been the subject of recent reviews<sup>1,2</sup>, where krill is the key organism in the short phytoplankton — whale food chain. Although broad outline of this resource is known the information available relates to particular areas like Weddell Sea, Ross Sea etc. However, the Indian Ocean sector is least known area<sup>3,4</sup> and during the Indian Antarctic Programme (Expeditions I-V), efforts were made to study the magnitude of biological production at different trophic levels including that of the krill.

### MATERIALS AND METHODS

The area surveyed for the krill production during 1981-85 period is shown in Fig.1. Water samples were collected from 100% to 1% light levels for primary productivity and associated parameter. Carbon fixation was measured by  $^{14}\text{C}$  method<sup>5</sup>, chl.

a by fluorometric method<sup>6</sup> and POC, ATP by methods outlined by Strickland and Parsons<sup>6</sup>. Phytoplankton carbon, bacterial carbon and total microbial carbon was calculated by standard conversion factors and from chl.a, ATP and bacterial counts data<sup>7</sup>. The zooplankton biomass was taken from Bongo net collections and bacterial numbers by standard plate counting techniques described earlier<sup>7</sup>.

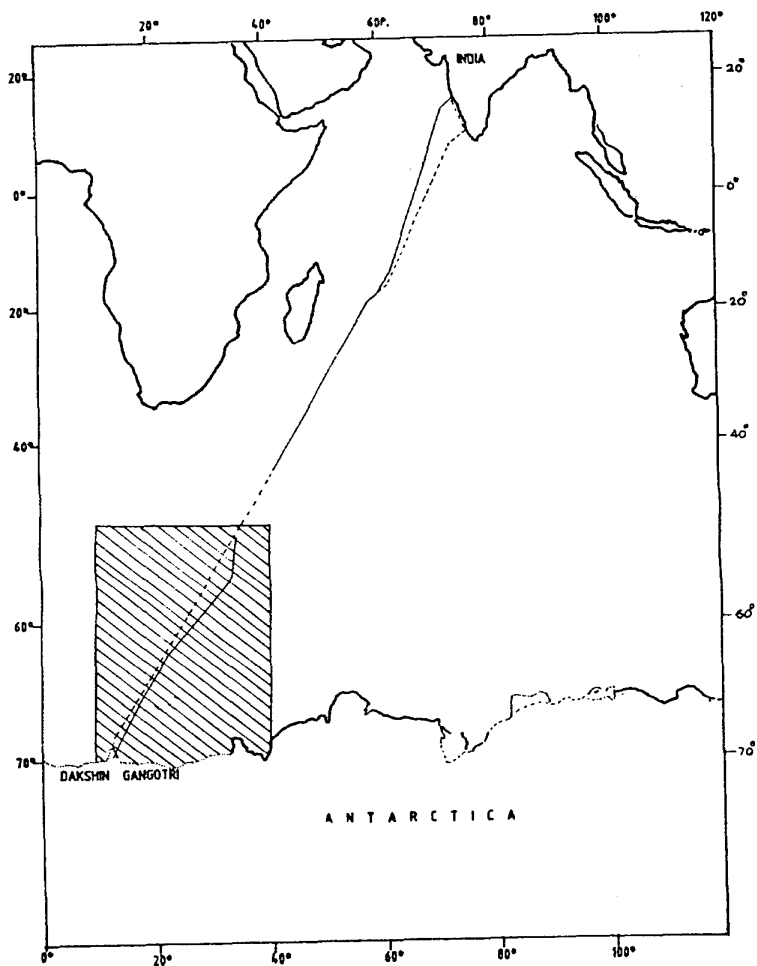


Fig.1. Map showing the area surveyed.

## RESULTS AND DISCUSSION

Table I shows the physico-chemical characteristics of the Indian Ocean Sector of the Antarctic studied during 1981-85 period. From these data, area south of Antarctic Convergence can be characterised as of low temperature, high nutrients and variable salinity because of melting sea ice during summer months.

Table I - Physico-chemical characteristics of Southern Ocean areas.

Latitude °S	No. of Observations	Temp. °C	Salinity ‰	Oxygen ml l <sup>-1</sup>	PO <sub>4</sub> -P NO <sub>3</sub> -N SiO <sub>2</sub> -Si		
					(µg.at.l <sup>-1</sup> )		
51-55	6	+ 4.1	34	7.17	1.39	22.43	9.15
56-60	13	+ 2.3	33.39	7.63	1.57	23.75	26.20
61-65	12	+ 0.7	33.91	7.88	1.69	28.6	40.50
66-69.5	69	- 0.55	28.83	7.75	1.63	21.0	45.65

Table II - Phytoplankton, bacteria and zooplankton biomass in study area. (No. of zooplankton stations are shown in paranthesis.)

Latitude °S	No. of Observations	Chl. a mg m <sup>-3</sup>	pp mg C m <sup>-3</sup> h <sup>-1</sup>	Bacterial Cell No. L <sup>-1</sup>	Zooplankton ml/1000 m <sup>3</sup>
51 - 55	6	0.64	1.32	1.29 × 10 <sup>8</sup>	107 (16)
56 - 60	13	1.93	3.2	2.4 × 10 <sup>8</sup>	121 (16)
61 - 65	12	0.48	1.23	3.12 × 10 <sup>8</sup>	81 (24)
66 - 69.5	69	1.81	1.47	1.7 × 10 <sup>9</sup>	99 (21)

The organisms responsible for primary production in the study area are mainly phytoplankton. The chl. a varied from 0.48 - 1.93 mg m<sup>-3</sup>. The rate of primary production also varied in relation to biomass variations (Fig.2). The highest rate of primary production was recorded at stations occupied in 56 - 60°S area (Table II). The average primary productivity figure derived for the study area is 716 mg C m<sup>-2</sup> d<sup>-1</sup>. The reported representative values (mg C m<sup>-2</sup> d<sup>-1</sup>), for other areas are 265;

134; 104-410 and 544 respectively<sup>3,8-10</sup>. The Indian Ocean sector appears to be more productive than other areas<sup>11</sup>.

A sizeable production was also recorded by nanoplankton in the study area (Table III). Since many of these organisms will pass through the filters used routinely for measurements their contribution is accounted in the carbon estimations in different form (Table IV). The phytoplankton communities are photoadapted and substantial primary production is estimated in subeuphotic depths (Table V).

Table III - Contribution of organisms less than 20  $\mu$  to phytoplankton assays in the Antarctic.

Date	Depth	Chl a $\mu\text{g/l}$		ATP $\mu\text{g/l}$		PP $\mu\text{gC/l/hr}$	
		Whole	20 $\mu$ mesh filtered	Whole	20 $\mu$ mesh filtered	Whole	20 $\mu$ mesh filtered
01-1-84	0	2.34	0.63	2.0	0.64	2.0	0.24
	5	3.69	1.1	1.9	0.5	1.8	1.2
	30	2.7	0.72	3.1	1.36	0.25	0.06
13-1-84	0	0.24	0.045	1.8	0.56	0.79	0.21
	5	0.18	0.18	1.7	0.5	0.61	0.31
	30	1.26	0.5	2.7	1.2	0.3	0.21
12-2-84	0	0.54	0.27	2.58	0.67	0.5	0.1
	5	1.35	0.36	1.6	0.22	2.3	0.3
	30	0.54	0.36	0.5	0.33	1.65	0.41

Table IV - Carbon budget of Southern Indian Ocean and Antarctica.

Region	POC $\text{mg m}^{-3}$		Total micro C $\text{mg m}^{-3}$		% PPC on POC		% Bacterial C on POC		% Detrital C on POC	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Tropical	251	152	68	84	9	17	0.58	1.56	77	21
Temperate	338	206	222	234	15	23	0.58	1.42	69	37
Polar	892	696	297	418	12	16	2.28	7	67	37
Ice Edge	899	519	457	476	5	4.3	2	7.4	50	40

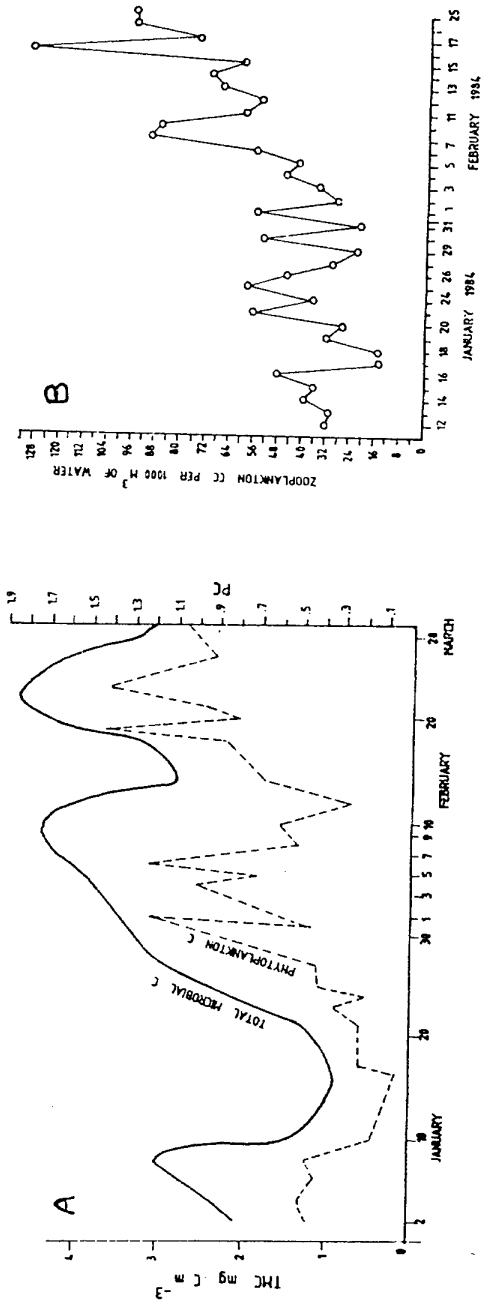


Fig. 2. A, total microbial and phytoplankton biomass (ice-edge) and B, Daily variations in zooplankton in polynaea.

Table V - Primary productivity in sub-euphotic depth samples. All incubations at full surface light intensity.

Depth	P.P. mg C/m <sup>3</sup> /hr			
	7th Jan.	15th Jan.	31st Jan.	8th Feb.
0	1.6	1.14	0.1	2.3
5	2.1	0.6	0.13	3.2
10	1.5	0.5	0.04	1.9
20	2.1	0.6	0.04	1.9
30	1.3	0.2	0.02	2.6
40	1.5	0.1	0.03	2.8
50	-	0.3	0.03	1.8
75	2.0	0.10	0.06	0.7
100	0.2	0.002	0.02	0.9

The seasonal variations in phytoplankton production in Antarctic waters are of vital importance for the understanding of the biological productivity on an year round basis. The effect of photoperiodicity and pack ice was monitored by studying at station (70°S 12°E) off *Dakshin Gangotri*, Antarctica. As depicted in Fig.3, Antarctic phytoplankton appears to possess ability to survive the winter darkness and resume growth with the appearance of spring. Considerably high phytoplankton activity is recorded during spring - summer season. From the data, it is confirmed that the active production period extends for about 3 months.

Data collected were further used for estimating the krill production in the Southern Ocean. The method described by Bakus<sup>12</sup> and Knox<sup>1</sup> is used for the same. The estimates of krill production for Southern Ocean are shown in Fig.4. The value of  $1718 \times 10^6$  t wet weight of krill is almost same as that of average value derived from all reports available on krill production, which is  $1682 \times 10^6$  t of wet weight<sup>13</sup>. However the FIBEX estimates are  $650 \times 10^6$  t of krill which is much low<sup>2</sup>. The recent figure for krill consumption by all predators is  $500 \pm 100 \times 10^6$  t of Krill<sup>2</sup>. From the above data the  $1118 \times 10^6$  t of krill can be projected as available krill fishery for exploitation purpose. The present krill catch figure ( $0.5 \times 10^6$  t of krill)<sup>14</sup> is negligible and can be increased considerably without any long term ecological imbalance in the Southern Ocean.

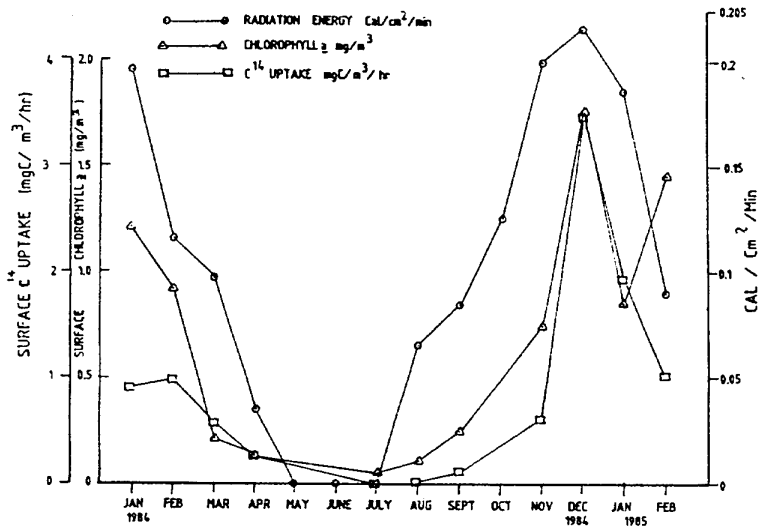


Fig.3. Productivity in Antarctica (1984-85)

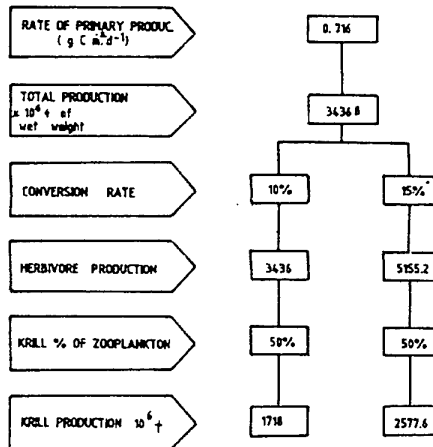


Fig.4 Krill production deduced from primary production estimates (from 1981-85 data)

The high biomass which is stored in the form of krill, whales, seals, squids, fish and marine birds have made the krill system attractive as resource to mankind. History has, however shown that none of the above living resources have been able to sustain long-lasting exploitation after the depletion of the virgin stock. Antarctic organisms are with late and low reproduction, long life span, large body size and high total biomass with variable (high and low) net production. The environmental conditions in seasonal pack ice zone are also highly variable.

After the 18th century whaling and sealing operations, the present ecosystem appears to be setting a new equilibrium e.g., high bacterial secondary production is recorded during present investigations<sup>13</sup>.

The reduction of whale population means that some 150 million tons of krill formerly eaten by whales and now surplus is available for exploitation by allowing the depleted stocks of whales to increase to a reasonable level. However, the surplus may have been taken up already by increase in the population of other consumers<sup>2</sup>.

Similarly there has been an increase in the pregnancy rates of fin and sei whales and an apparent but striking decrease in their age of maturity<sup>15</sup>. This is the indirect effect of abundant krill available. Similarly, the crabeater seal populations off the west coast of the Antarctic Peninsula like those of the baleen whales appear to have experienced a decrease in the age of sexual maturity from about 4 years in the 1950 to two and a half years by the 1960s<sup>2</sup>. The chinstrap, adeli and macaroni penguins have also shown increase in population<sup>16</sup>. The reported work for last 10 years (BAS) indicate an increase in growth rate, increase in reproduction rate, increase in numbers, slight lowering of age of maturity (may be original level) with an estimated rate of annual population increase about 7.5%<sup>2</sup>. The population of minke whale, crabeater seal, fur seal and penguins have increased reasonably for last 30 years<sup>2</sup>. This appears to be due to availability of abundant krill as food for them. However, the present agreeable figure of krill consumption by predators is  $500 \pm 100$  million tons<sup>2</sup>. The annual krill mortality rates other than predation, needs to be investigated for further characterization of the ecosystems in Antarctica.

As from the projected world marine fish yield of not more than  $70 \times 10^6$  t per year<sup>17</sup> the present estimates of krill production of  $1118 \times 10^6$  t (net), opens new avenues for wider exploitation of Southern Ocean marine living resources.

In view of the short food chain and effect of the most variable environmental factors on productivity, exploitation



must be slow enough to allow krill - system to come gradually to a new balance. It is expected that, krill consumers like whales, seals, birds, fish, squids (other than man) should move towards their original levels of abundance. This besides management and conservation practices also requires. In depth information of the food chain leading to krill production in the Southern Ocean.

#### ACKNOWLEDGEMENTS

It is befitting to record the happiness of authors, for being invited to contribute a paper to the commemoration volume, for Dr. S.Z. Qasim, who by pioneering the Antarctic research expedition programme in India, made opportunity available for us to undertake scientific investigations in Southern Ocean. To him, we shall always be grateful.

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