

Table 2—Percentage Food Items in Stomach Contents of Young *P. chinensis* in Various Size Groups (cm SL) during 1972 and 1973

[Number of fish examined each month is given in parentheses]

	Size group								
	2-3 (2)	3-4 (4)	4-5 (7)	5-6 (11)	6-7 (18)	7-8 (20)	8-9 (21)	9-10 (14)	10-11 (19)
Diatoms	100	100	100	76	28	10.5	—	16	—
Copepod*	—	—	—	24	72	23.5	—	—	50
Ctenophores and medusae	—	—	—	—	—	66	21	84	33.34
Acetes	—	—	—	—	—	—	—	—	—
Decapod remains	—	—	—	—	—	—	74	—	16.66
Fish scales	—	—	—	—	—	—	5	—	—

*Copepod eggs and nauplii are not found

of *P. chinensis* supplemented mostly by smaller jelly-fishes, decapods and diatoms. Amphipods, cuttle fish, chaetognaths, crustacean larvae, polychaete larvae, fish scales, fish eggs and larvae occur in minor quantities. Ostracods, cladoceran, marine insects and molluscan larvae are occasional in the diet. From the nature of the food organisms, it is evident that *P. chinensis* remains strictly pelagic throughout its life.

Of all the food elements, the fish has a preference for copepods and feeds actively in the night when these organisms occur in the surface waters. The migration of copepods into deeper waters during the daytime compels the fish to thrive on other planktonic organisms. The intensity of feeding is high from April to October, coinciding with the southwest monsoon, during which higher zooplankton biomass has been observed from the coastal waters of Orissa¹² with 3 copepod maxima in the inshore waters¹¹. Naturally the feeding index was high during this period.

Stromateid fishes generally change their larval habitat while attaining maturity and this is often associated with morphological changes¹³. In the silver pomfret the early juveniles are surface dwellers, and the adults are benthopelagic¹⁰. The nature of diet reveals that Chinese pomfret (*P. chinensis*) appears to be somewhat conservative in this respect, sticking mainly to its early surface feeding habitat throughout life.

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Distribution of Urea in the Waters of the West Coast of India

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Urea concentrations at the surface are high both in coastal and offshore waters in the region north of 15°N (0.3-7.76 µg at N/litre) and low in the region south of this latitude (0-1.5 µg at N/litre). Vertical distribution shows peak at some levels and very low concentrations at others. Urea concentration increases towards the central west coast of India. Comparison with the other inorganic nutrients indicates that urea constitutes > 10% of the available nitrogen in the euphotic zone (0-100 m). This shows that urea forms a significant nitrogen source for marine phytoplankton in the west coast of India.

Nitrogen and phosphorus are the principal nutrients limiting primary production. Maximum inflow of inorganic nitrogen into marine organisms results from ammonia and nitrate assimilation¹, but studies on uptake and utilization of urea-nitrogen have suggested the possible importance of this compound as a source of nitrogen in the sea. Carpenter *et al.*² reported that

species of diatoms (*Skeletonema* sp., *Chaetoceros* sp. and *Chaetoceros simplex*) from the Sargassao Sea and *Stephanopyxis costata* and *Amphiprora alata* and a hapatophyte flagellate, *Chysochromulina* sp., from an inshore area near Woods Hole grew well on urea-nitrogen. McCarthy³ and McCarthy and Eppley⁴ determined the uptake rate of ¹⁵N labelled urea and showed the importance of urea as a nitrogen source in the sea. Mitamura and Saijo⁵ reported that urea decomposition, associated with photosynthesis by phytoplankton, plays a significant role in the nitrogen supply for phytoplankton in coastal waters.

Distribution of urea in coastal and oceanic waters elsewhere has been studied⁵⁻⁷, but so far, no data are available on its distribution in the coastal and oceanic waters around India. Distribution of urea and other inorganic nitrogen compounds along the west coast of India from Okha to Trivandrum is presented in this communication.

Water samples from surface and from different depths up to 1000 m were collected either by rosette samplers of C.T.D. recording instrument or by Nansen Cast from 44 stations during the 12th (15-28 Nov. 1976) and 16th (3-17 March 1977) cruises of *R V Gaveshani* (Fig. 1). Unfiltered samples were analysed soon after collection on board the ship. Urea concentration was measured by the method of Newel *et al.*⁸. The reaction is quantitative for urea and citrulline and to a lesser extent for allantoin, thiourea and biurea⁶. The coefficient of variation for 10 replicate samples was $\pm 4.3\%$ at $2.6 \mu\text{g}$ at N/litre and $\pm 14\%$ at $0.75 \mu\text{g}$ at N/litre^{6,8}. The coefficient of variation in the present analysis was $\pm 3.02\%$ and 11.6% at 3 and $0.6 \mu\text{g}$ at N/litre respectively. Ammonia and nitrate were analysed according to the methods described by Verlenkar and D'Silva⁹.

For convenience, the area under investigation was divided into region A (cruise 12, Fig. 1) and B (from Trivandrum to Mormugao, cruise 16, Fig. 1).

Surface urea concentrations of coastal waters in region A varied from 0.3 to 5.9 (av. 2.58) μg at N/litre and in offshore waters from 0.42 to 7.76 (av. 2.4) μg at N/litre. Compared to these, very low concentrations, 0-0.63 (av. 0.22) and 0.4-1.5 (av. 0.95) μg at N/litre, were observed in the coastal and offshore surface waters respectively of the southern region. The urea concentrations along the west coast of India are comparable to those reported by Remsen⁶ in the continental shelf waters off northeast United States and off Peru and are slightly higher than those observed by McCarthy³ off southern California.

Since the 2 cruises were carried out during 2 different seasons the low surface urea value observed in region B could be attributed to the *Trichodesmium* bloom which was noticed at several places along the cruise track¹⁰.

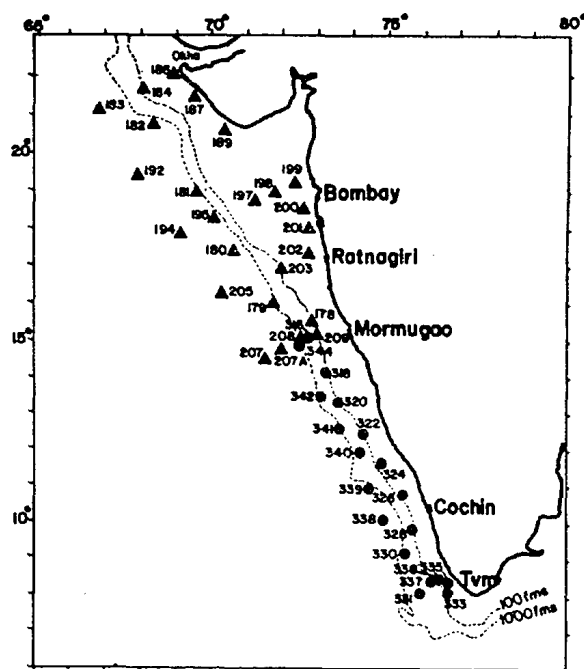


Fig. 1—Stations covered during 12th (▲) and 16th (●) cruises

No such bloom was noticed during November in region A and the high urea values observed here may be either due to atmospheric precipitation or due to excretory product of sea birds which usually excrete nitrogen in the form of uric acid¹¹. The concentration of urea in the rain water collected on board the ship varied between 1.2 and $1.5 \mu\text{g}$ at N/litre. Uric acid which is unstable is rapidly degraded to urea and may form an additional source of urea nitrogen in the coastal waters¹².

Vertical profiles of urea in 6 different areas are given in Fig. 2. Urea concentrations off Okha varied from 0 - $2.25 \mu\text{g}$ at N/litre while off Mormugao, it varied from 0.21 - $5.9 \mu\text{g}$ at N/litre, thus showing an increase towards the central west coast. The southern region showed more or less a uniform pattern of distribution with some increase between Mangalore and Cochin. In the marine environment urea originates through excretion of higher organisms and/or through microbial degradation of organic matter¹². Shrimps, cray fish and mussels excreted up to 14% of the total nitrogen in the form of urea¹³. High zooplankton biomass varying from 100 to $200 \text{ ml}/100 \text{ m}^3$ was noticed around Bombay during the period of these observations¹⁴. Herbivorous zooplankton are known to excrete substantial quantities of urea which could also contribute to high urea concentrations observed in that area as shown by Corner and Newell¹⁵.

Relative percentages of urea and inorganic nitrogens in the water column in regions A and B are given in Table 1.

Average surface urea values in the coastal waters of region B in March 1979 was low ($0.34 \mu\text{g}$ at N/litre) but

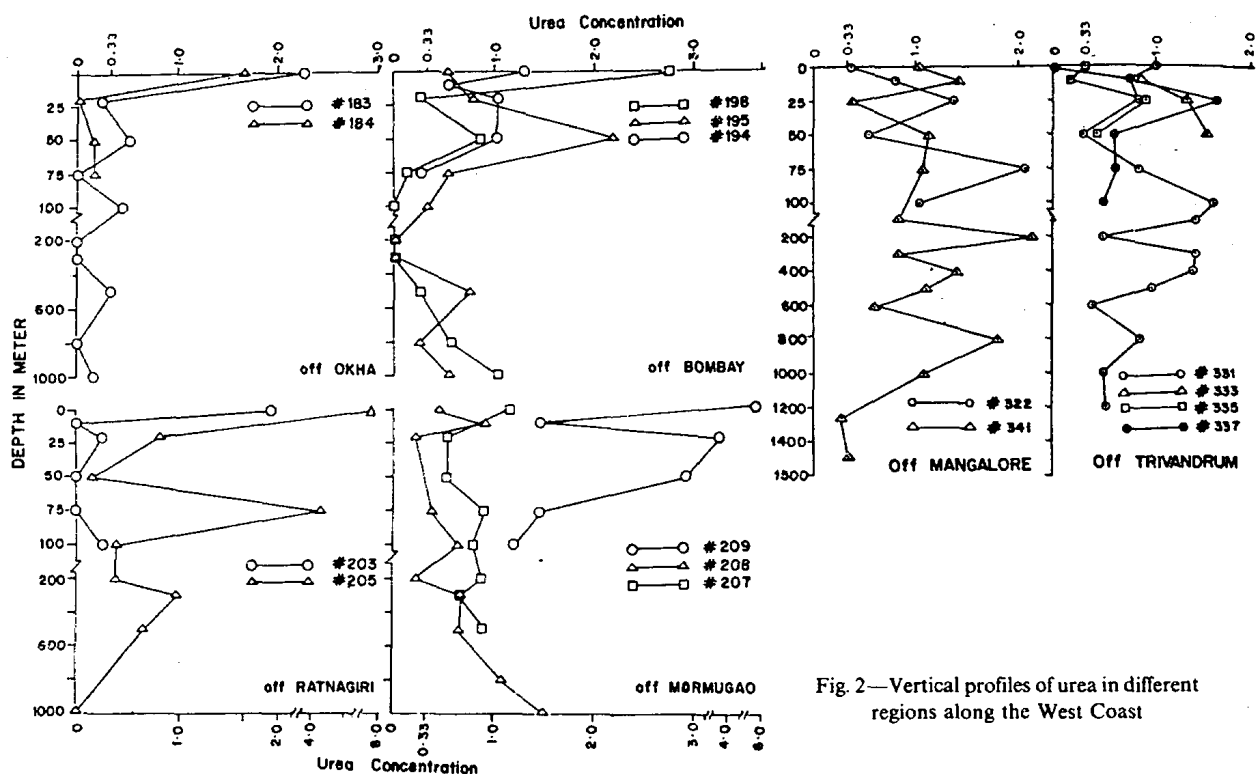


Fig. 2—Vertical profiles of urea in different regions along the West Coast

Table 1—Urea Nitrogen Values Compared with Those of Inorganic Nitrogen along Regions A and B

	Surface		20 m		50 m		100 m		500 m		1000 m	
	Conc.	%	Conc.	%	Conc.	%	Conc.	%	Conc.	%	Conc.	%
Region A												
Inshore												
Urea - N	2.58	32.49	0.81	15.81	0.9	12.51	0.95	9.32	—	—	—	—
NH ₄ ⁺ - N	4.64	58.43	3.94	76.80	4.05	56.33	3.51	34.45	—	—	—	—
NO ₃ ⁻ - N	0.72	9.07	0.38	7.41	2.24	31.15	5.73	56.25	—	—	—	—
Offshore												
Urea - N	2.41	31.75	0.65	18.41	0.56	9.48	0.61	7.54	0.746	6.57	0.58	3.66
NH ₄ ⁺ - N	4.48	59.03	2.56	72.52	2.89	48.49	2.23	23.82	3.94	34.71	3.49	22.09
NO ₃ ⁻ - N	0.7	9.22	0.32	9.07	2.51	42.11	6.52	69.66	6.67	58.76	11.74	74.30
Region B												
Inshore												
Urea - N	0.22	4.3	0.91	16.19	0.63	11.71	1.10	9.93	—	—	—	—
NH ₄ ⁺ - N	2.07	40.50	2.79	49.64	2.28	42.38	4.04	36.49	—	—	—	—
NO ₃ ⁻ - N	2.82	55.18	1.73	30.78	2.47	45.91	5.93	53.56	—	—	—	—
Offshore												
Urea - N	0.95	17.02	0.63	11.18	1.09	14.32	0.94	9.33	0.73	6.30	0.87	7.38
NH ₄ ⁺ - N	3.31	59.31	2.49	40.55	2.56	33.63	1.47	14.59	2.28	19.69	1.32	11.62
NO ₃ ⁻ - N	1.32	23.65	3.03	39.35	3.96	52.02	7.66	76.07	8.57	74.01	9.55	81.00

Concentration = $\mu\text{g at N/litre}$

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appreciable amounts of ammonia (2.07 μg at N/litre) and nitrate (2.82 μg at N/litre) were found in these waters. High ammonia and nitrates could have resulted due to new inputs of nitrogen to the ecosystem during nitrogen fixation and subsequent decay of *Trichodesmium*¹⁶, and the bacteria associated with the decay process could have hydrolysed the urea content of these waters¹².

Except for the low surface water values in the coastal waters of region B, it has been observed that urea forms sufficiently high percentage of the available nitrogen in the coastal and offshore water in the euphotic zone (0-100 m). Therefore, it can be said that urea in the euphotic zone forms a large reserve of nitrogen both in coastal and offshore waters, which may be significant in effecting growth of phytoplankton that has the necessary enzyme complex to utilize urea^{3,4,17,18} as nitrogen source.

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